SEELift SYMPOSIUM 2026

Safety functions of elevator machines and electronics

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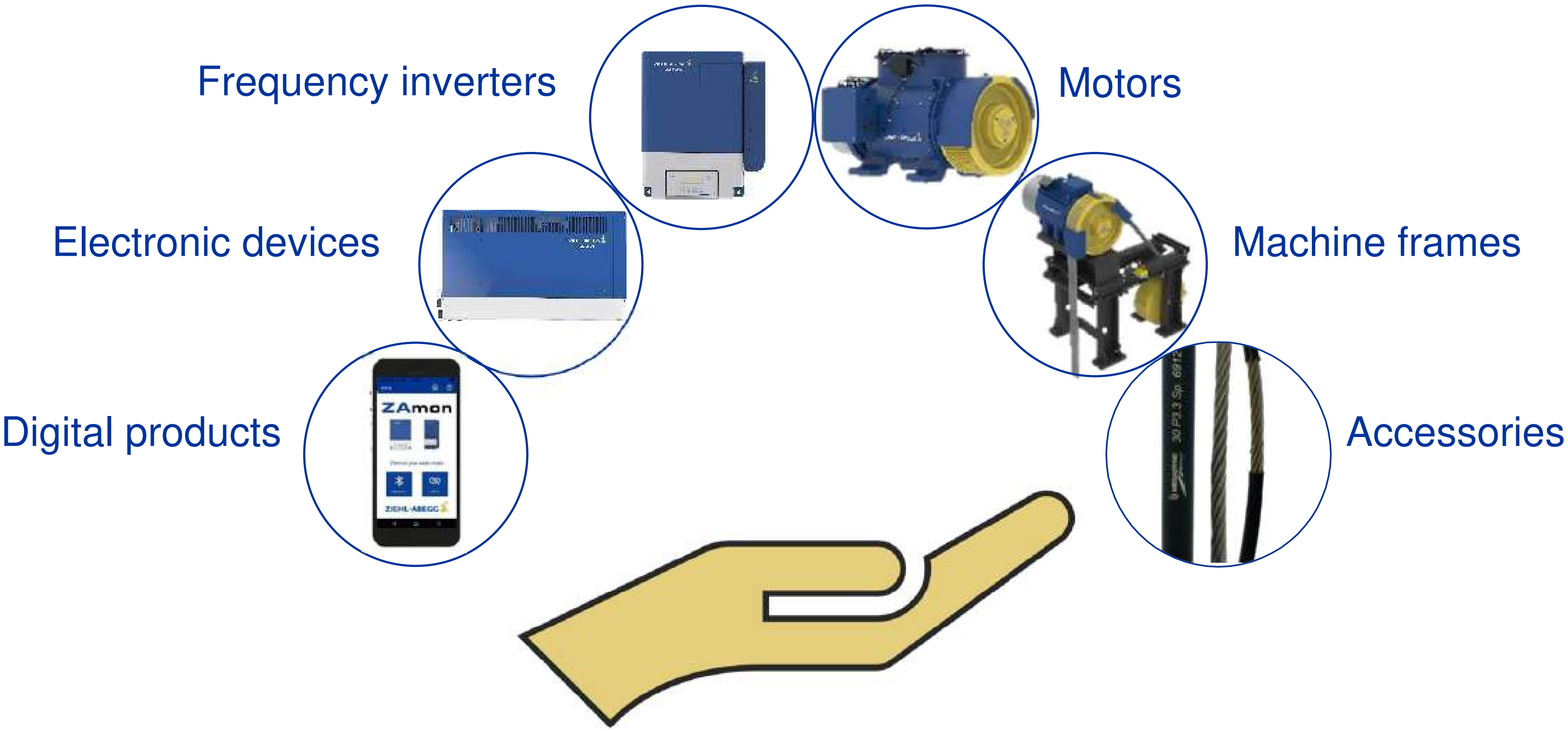
Movement by Perfection

Introduction ZIEHL-ABEGG

Legal form:	Privately owned SE
Chairman board:	Dennis Ziehl
Founded:	1910 in Berlin
Sales locations:	114
Turnover:	> 1 Bil. € in 2025
Export turnover:	75 %
Employees:	5.800 worldwide

ZIEHL-ABEGG as a single source supplier



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Electro-mechanical brakes - Basics

Elevator Machine: Brakes

EN 81-20: 5.9.2.2.2 Electro-mechanical brake

- **5.9.2.2.2.1** This brake on its own shall be capable of stopping the machine when the car is travelling downward at rated speed and with the rated load plus 25 %. In these conditions the average retardation of the car shall not exceed that resulting from operation of the safety gear or stopping on the buffer.
- All the mechanical components of the brake which take part in the application of the braking action on the braking surface shall be installed at least in two sets. If one of the brake sets is not working due to failure of a component a sufficient braking effort to decelerate, stop and hold the car, travelling downwards at rated speed and with rated load in the car and upward with empty car shall continue to be exercised.

These requirements must be tested by a notified body.

Elevator Machine: Brake

Common features of brakes requested by EN81

1. **Elevator brakes must operate under the „fail-safe“ principle**
   - Means that the elevator brakes must be normally closed (in current-less operation) and only open if current flows through the brake coil.

2. **Redundancy of safety**
   - There must be at least two separate brake circuits, which can operate independently from another. Each circuit has to provide enough torque to decelerate the car.

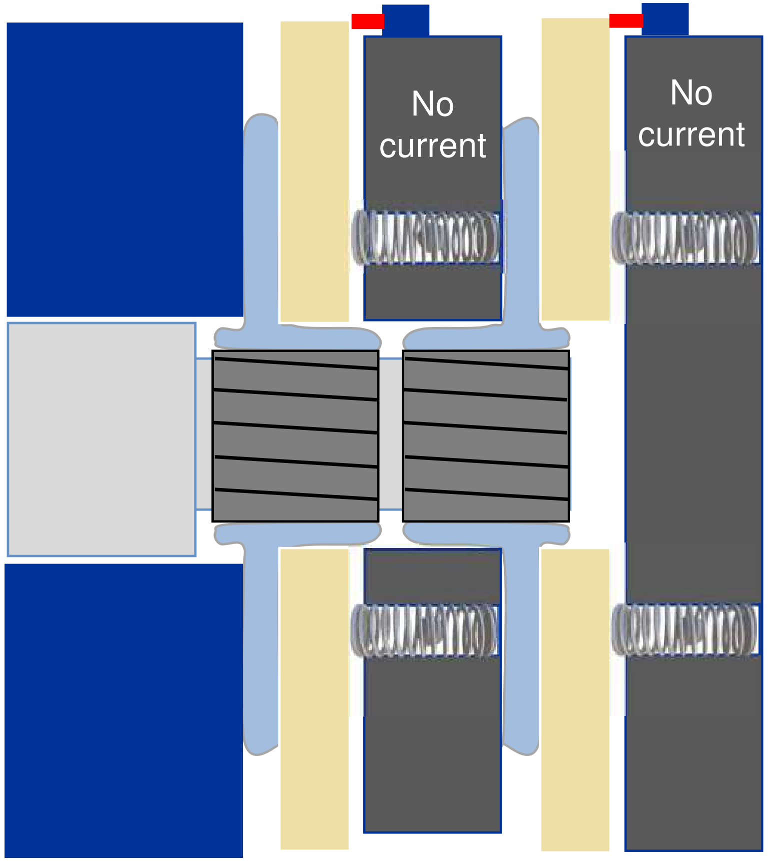
3. **Monitoring of the condition of brakes***
   - *For specific requirements (UCM compliance) montoring is crucial to detect UCM

Closed brake

Functionality of closed brakes

- Springs inside of the brake apply mechanical force on the armature disc, which is pushed against the friction pad to build up braking torque.

- Microswitches monitor the air-gap between the coil carrier and the armature disk and hand the signal over to the elevator control.



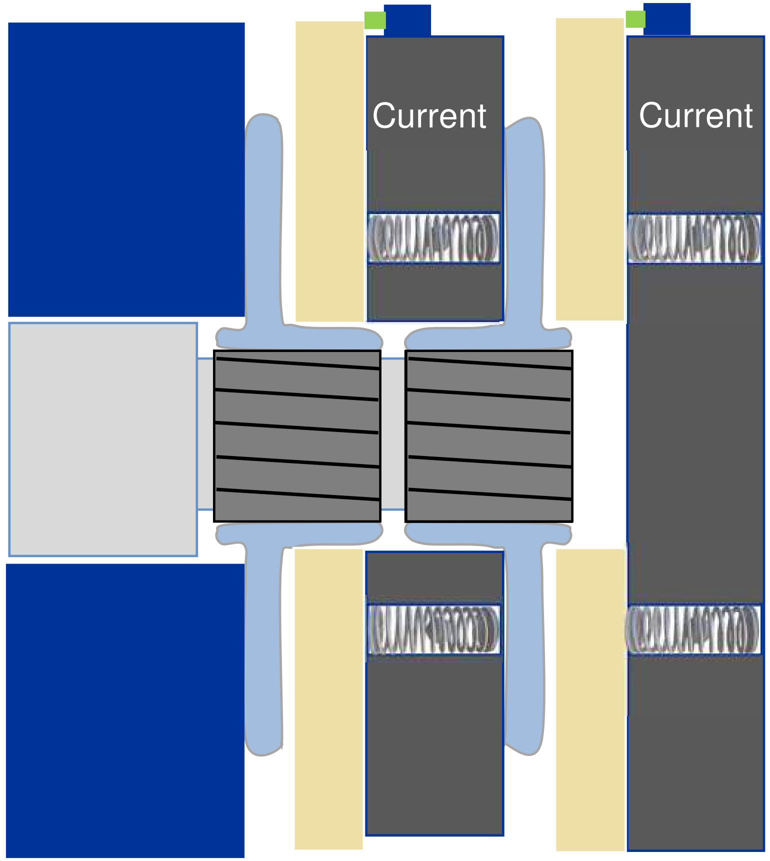
Exemplary brake of an SM250 Machine

Opened brake

Functionality of opened brakes

- The coil inside of the coil carrier can build up an electromagnetic field, which overcomes the springs mechanical force and attracts the armature disk. The friction pad can rotate freely.

- The airgap between the armature disk and the coil carrier is closed. This condition is monitored by the microswitch and the signal of an opened brake is handed over to the controller.



Exemplary brake of an SM250 Machine

Did you know?

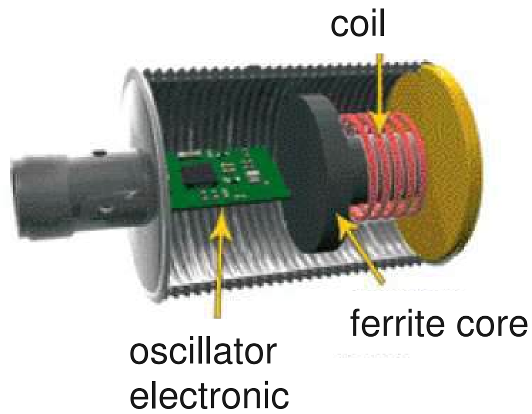
Minimal additional costs increase the service life

A release monitoring system prevents impermissible operating states on the lift motor, such as such running against a closed brake and is therefore an essential element.

Due to heat, materials tend to expand and microswitches must monitor a small movement. In addition, there is hysteresis of the mechanical microswitch due to its internal structure.

Malfunction of the microswitch (temporary failure) or complete failure generates a service and corresponding costs.

Proximity switches solve this problems



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Electro-mechanical brakes – UCM & ACOP

Elevator Machine: Brake

EN81-20: UCM

- **Definition:**
  - Unintended car movement: non-commanded movement of the car with doors open within the door zone away from the landing, excluding movements resulting form loading/unloading operation

- **When is a detection against UCM needed?**
  - Only in case that a relevelling of the car with opened doors is allowed.

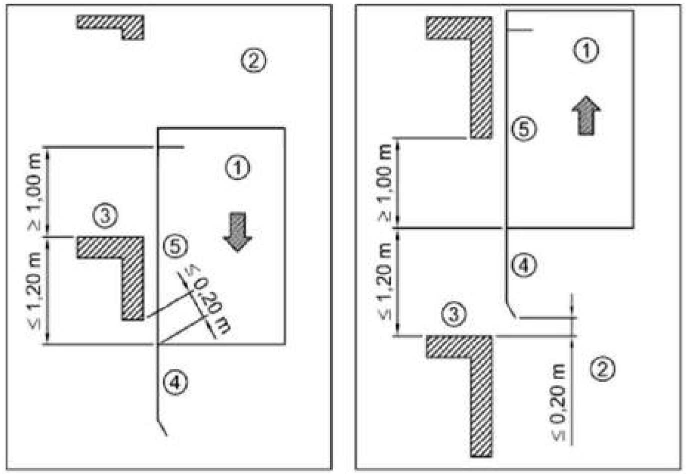
EN 81-20 Rules for UCM distances

Maximum dispositioning distance (EN 81-20)

- During UCM, the maximum distance of car travel shall not exceed 1,2 m in both upwards or downwards direction.

- The safety measures installed should bring the car to a stop within this range!

These values shall be obtained with any load in the car, up to 100 % of rated load, moving away from a standstill position at landing level.



Key
① car
② well
③ landing
④ car apron
⑤ car entrance

Brake certification: To use the electro-mechanical brake as a device against UCM

Example: How to interpret the values in the certification

1.2 **Use as braking element – part of the protection device against unintended car movement (acting in up and down direction) – permissible brake torques, tripping rotary speeds and characteristics**

1.2.1 Nominal brake torques and response times with relation to a brand-new brake element as well as type designation 8012. _ 0 _ _ _, 8012. _ 1 _ _ _, 8012. _ 2 _ _ _, 8012. _ 3 _ _ _

Size	Min. nominal brake torque* [Nm]	Max. nominal brake torque * [Nm]	Diameter of rotor [mm]	Max. tripping rotary speed [rpm]	Maximum response times** [ms] without overexcitation		
					t_0	t_{50}	t_{90}
150	2 x 90 = 180		222,5	981	40	70	95
		2 x 200 = 400			20	40	80
200	2 x 120 = 240		235	979	85	145	190
		2 x 250 = 500	253		30	60	110
250	2 x 185 = 370		253	800	50	75	110
		2 x 320 = 640			25	45	85
350	2 x 250 = 500		273	800	60	100	125
		2 x 460 = 920			30	50	85
450	2 x 320 = 640		253	600	90	130	190
		2 x 500 = 1000	253		35	60	100
		2 x 550 = 1100	281				

Interim values can be interpolated

- **tx values**: Time difference between power-outage on the brake and establishing X% of the nominal brake torque
- T50 means 50% of the braking torque is established after xx ms of power-outage on the brake

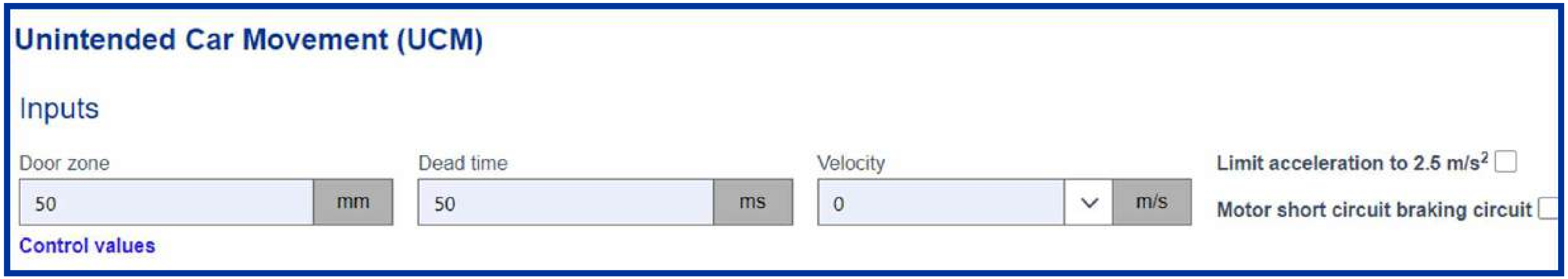
Unintended car movement protection (UCMP)

What UCMP does

- **1. Detect Unintended Movement**
  - The system monitors the elevator for any movement away from the landing **with open or unlocked doors**.
- **2. Stop the Elevator Immediately**
  - Upon detection, UCMP applies a **dedicated emergency brake** to stop and hold the car, even with full rated load.
- **3. Stay Locked Out Until a Technician Resets It**
  - After activation, the UCMP system must remain engaged until manually reset by qualified personnel; the elevator cannot run again automatically.

UCM calculations with ZAlift Web

Data input for calculating UCM



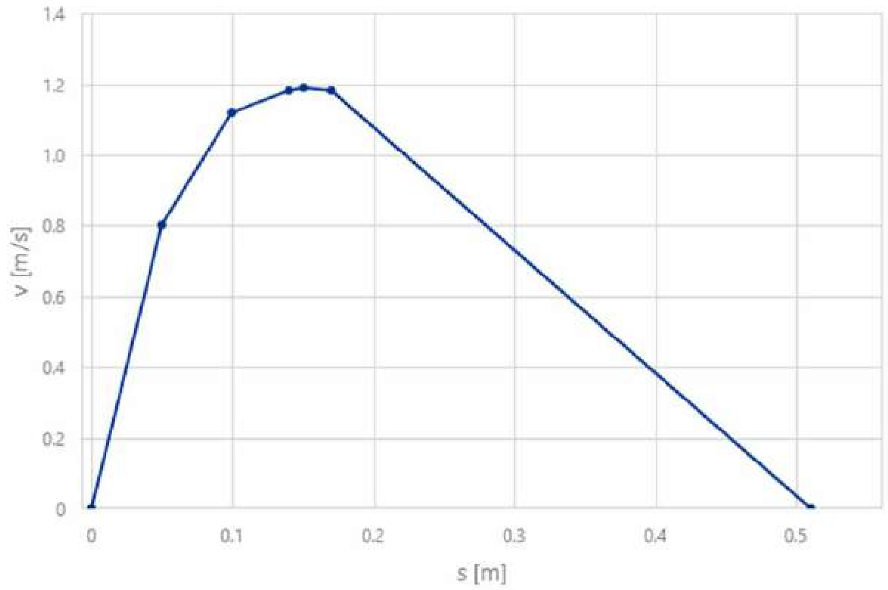
- The inputs for calculating UCM are values from the control manufacturer.
  - **Door zone** = Distance of detection, when a UCM occurs
  - **Dead time** = Time it takes for the signal to initiate shut-off
  - **Velocity** = Additional speed detector to monitor the speed at open doors (optional)

UCM calculations with ZAlift Web

Considerations for UCM calculations

- Based on the inputs, internally the two least favourable scenarios are compared:
  - Empty car travelling in upwards direction
  - Loaded car travelling in downwards direction

- The least favourable scenario out of these two will be calculated by ZAlift:



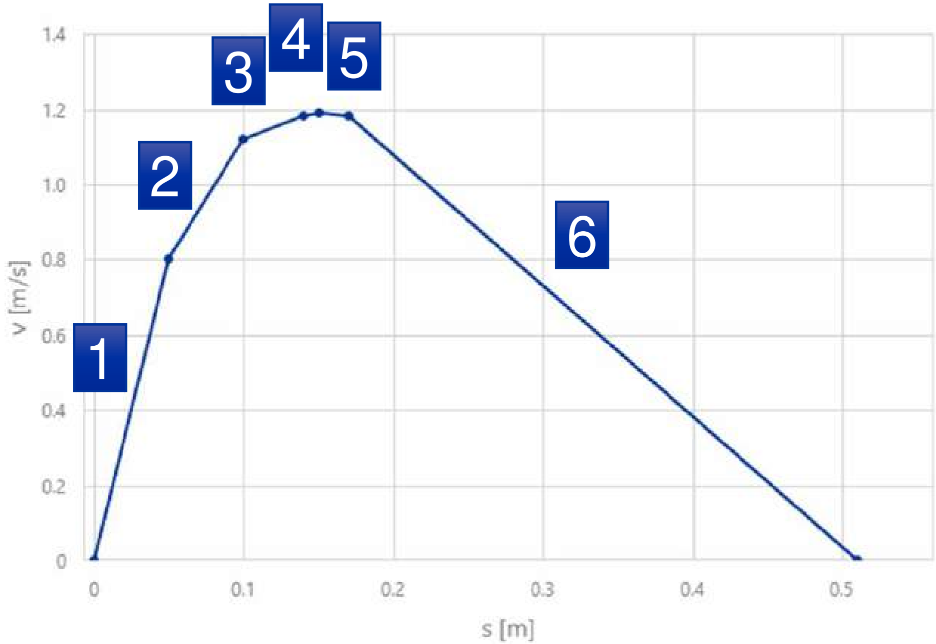
UCM calculations with ZAlift Web

Explanation of the 6 phases of UCM calculations

1
Start: Car moves with open doors
End: UCM detected

2
Start: UCM detected
End: Elevator dead time overcome

3
Start: Elevator dead time overcome
End: First deceleration by brake



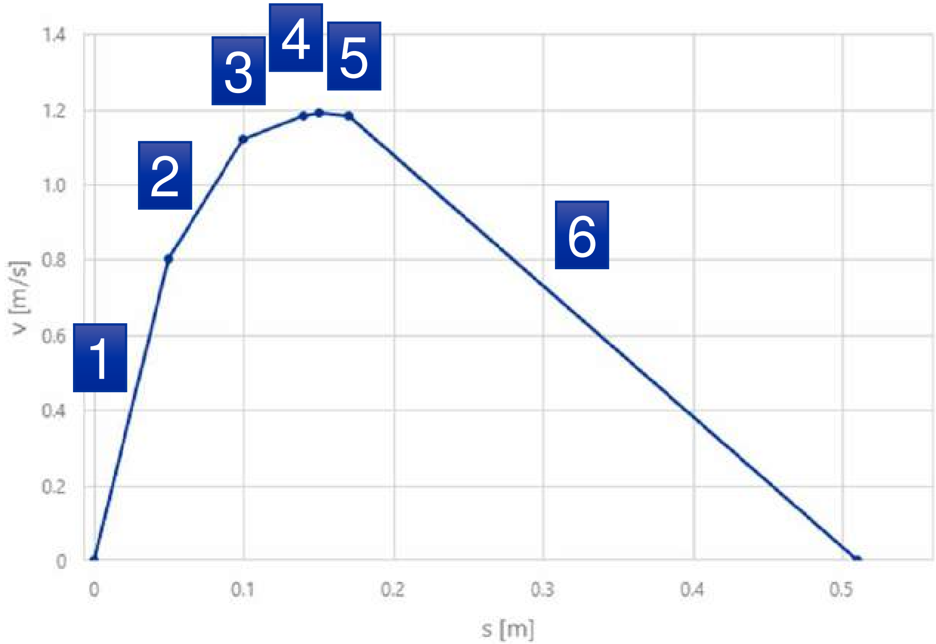
UCM calculations with ZAlift Web

Explanation of the 6 phases of UCM calculations

4
Start: First deceleration by brake
End: Maximum speed of car

5
Start: Maximum speed of car
End: 90% of nominal brake force reached

6
Start: 90% of nominal brake force reached
End: Car standstill



Elevator machine: Brake ACOP function

What is Ascending Car Overspeed Protection (ACOP)?

- ACOP is a safety function designed to prevent the lift car from accelerating upwards beyond its permitted speed.
- Typically, only overspeed in downward direction is protected by the safety gears on a car.
- This function is certified by notified bodies with the manufacturer of the brakes.

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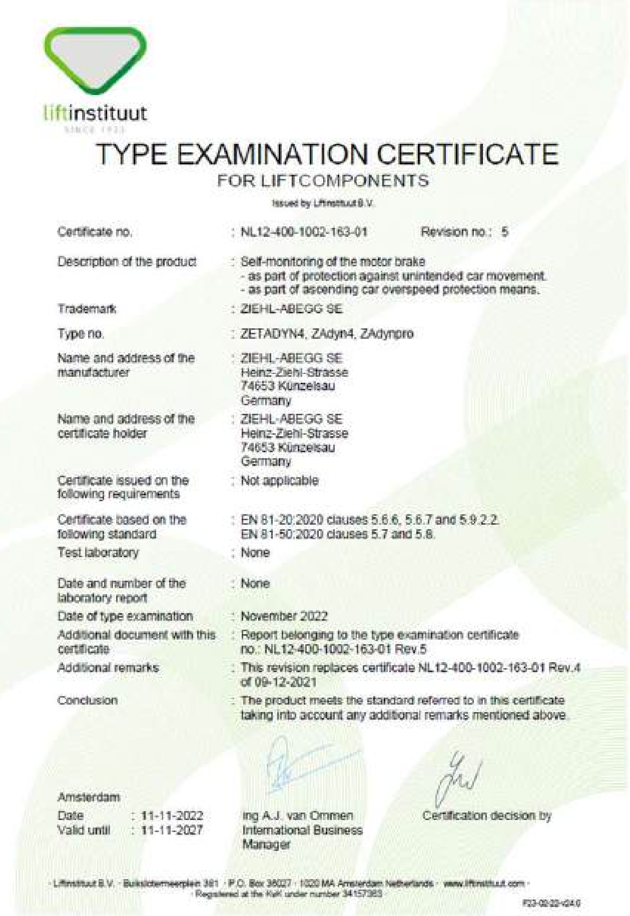
Functional safety of electronic products

Certified safety functions of electronic components

Brake self-monitoring (UCM and ACOP)

- Protective devices (e.g. brakes) for UCM are considered as a safety component and must be verified according to the requirements of chapter 5.8. of EN81-50.
- The brake-selfmonitoring is required by a certified device or function.
- Regular check-up for the brake self-monitoring function (with every software update the function has to be tested again).
- This function is also tested during commissioning of the elevator by a notified body.


liftinstituut

TYPE EXAMINATION CERTIFICATE
FOR LIFTCOMPONENTS
Issued by Liftinstituut B.V.

Certificate no.	: NL12-400-1002-163-01 Revision no.: 5
Description of the product	: Self-monitoring of the motor brake - as part of protection against unintended car movement. - as part of ascending car overspeed protection means.
Trademark	: ZIEHL-ABEGG SE
Type no.	: ZETADYN4, ZAdyn4, ZAdynpro
Name and address of the manufacturer	: ZIEHL-ABEGG SE Heinz-Ziehl-Strasse 74653 Künzelsau Germany
Name and address of the certificate holder	: ZIEHL-ABEGG SE Heinz-Ziehl-Strasse 74653 Künzelsau Germany
Certificate issued on the following requirements	: Not applicable
Certificate based on the following standard	: EN 81-20:2020 clauses 5.6.6, 5.6.7 and 5.9.2.2. EN 81-50:2020 clauses 5.7 and 5.8.
Test laboratory	: None
Date and number of the laboratory report	: None
Date of type examination	: November 2022
Additional document with this certificate	: Report belonging to the type examination certificate no.: NL12-400-1002-163-01 Rev.5
Additional remarks	: This revision replaces certificate NL12-400-1002-163-01 Rev.4 of 09-12-2021
Conclusion	: The product meets the standard referred to in this certificate taking into account any additional remarks mentioned above.

Amsterdam
Date : 11-11-2022
Valid until : 11-11-2027

ing A.J. van Ommen
International Business Manager

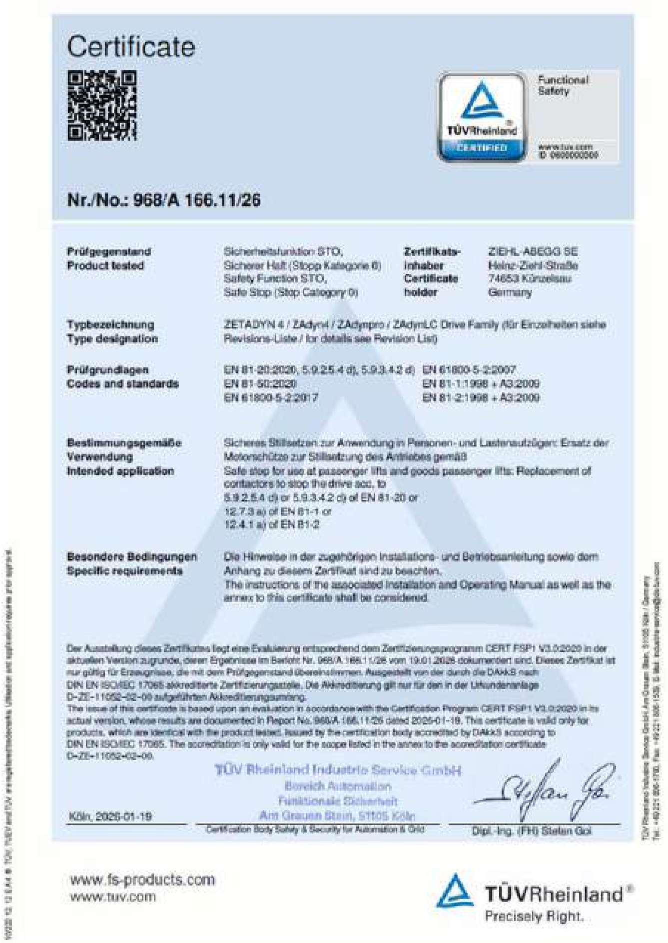
Certification decision by

Certified safety functions of electronic components

Safe Torque Off (STO)

- Required function to ensure a safe stop by the elevator.

- This function is integrated and certified within our ZETADYN / ZAdyn / ZAdynpro frequency inverters. No additional safety devices needed.



Certificate

Nr./No.: 968/A 166.11/26

Prüfgegenstand **Product tested**	Sicherheitsfunktion STO, Sicherer Halt (Stopp Kategorie 0) Safety Function STO, Safe Stop (Stop Category 0)	**Zertifikats-inhaber** **Certificate holder**	ZIEHL-ABEGG SE Heinz-Ziehl-Straße 74653 Künzelsau Germany

Typbezeichnung **Type designation**: ZETADYN 4 / ZAdyn4 / ZAdynpro / ZAdynLC Drive Family (für Einzelheiten siehe Revisions-Liste / for details see Revision List)

Prüfgrundlagen **Codes and standards**: EN 81-20:2020, 5.9.2.5.4 d), 5.9.3.4.2 d); EN 81-50:2020; EN 61800-5-2:2017; EN 61800-5-2:2007; EN 81-1:1998 + A3:2009; EN 81-2:1998 + A3:2009

Bestimmungsgemäße Verwendung **Intended application**: Sicheres Stillsetzen zur Anwendung in Personen- und Lastenaufzügen: Ersatz der Motorschütze zur Stillsetzung des Antriebes gemäß
Safe stop for use at passenger lifts and goods passenger lifts: Replacement of contactors to stop the drive acc. to 5.9.2.5.4 d) or 5.9.3.4.2 d) of EN 81-20 or 12.7.3 a) of EN 81-1 or 12.4.1 a) of EN 81-2

Besondere Bedingungen **Specific requirements**: Die Hinweise in der zugehörigen Installations- und Betriebsanleitung sowie dem Anhang zu diesem Zertifikat sind zu beachten.
The instructions of the associated Installation and Operating Manual as well as the annex to this certificate shall be considered.

Der Ausstellung dieses Zertifikates liegt eine Evaluierung entsprechend dem Zertifizierungsprogramm CERT FSP1 V3.0:2020 in der aktuellen Version zugrunde, deren Ergebnisse im Bericht Nr. 968/A 166.11/26 vom 19.01.2026 dokumentiert sind. Dieses Zertifikat ist nur gültig für Erzeugnisse, die mit dem Prüfgegenstand übereinstimmen. Ausgestellt von der durch die DAkkS nach DIN EN ISO/IEC 17065 akkreditierte Zertifizierungsstelle. Die Akkreditierung gilt nur für den in der Urkundenanlage D-ZE-11052-02-00 aufgeführten Akkreditierungsumfang.
The issue of this certificate is based upon an evaluation in accordance with the Certification Program CERT FSP1 V3.0:2020 in its actual version, whose results are documented in Report No. 968/A 166.11/26 dated 2026-01-19. This certificate is valid only for products, which are identical with the product tested. Issued by the certification body accredited by DAkkS according to DIN EN ISO/IEC 17065. The accreditation is only valid for the scope listed in the annex to the accreditation certificate D-ZE-11052-02-00.

TÜV Rheinland Industrie Service GmbH
Bereich Automation
Funktionale Sicherheit
Am Grauen Stein, 51105 Köln

Köln, 2026-01-19 — Certification Body Safety & Security for Automation & Grid — Dipl.-Ing. (FH) Stefan Goi

www.fs-products.com
www.tuv.com

TÜVRheinland®
Precisely Right.

Certified safety functions of electronic components

Trip counter

- Certified function to monitor the number of direction changes.
- Especially needed for traction means that are not considered by the EN81. (PU-ropes, belts, steel-ropes < 8 mm)

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SINCE 1933

Declaration for trip direction change counter

Date of issue of original declaration	: June 24, 2011
Revision number	: 4
Revision date	: 21-01-2022
Requirements	: EN 81-20:2020
Project no.	: P210323

1. General specifications

Name and address manufacturer	: ZIEHL-ABEGG SE Heinz-Ziehl-Strasse 74653 Künzelsau Germany
Description of the reviewed component	: Safe trip direction change counter
Frequency inverter type	: Type series ZETADYN and ZAdyn
Data of examination	: April 2011 - June 2011, May 2016, November 2016, January 2022
Examination done by	: A. van den Burg
Laboratory	: None

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Traction calculations

Traction calculation

General things about traction calculations

- To determine the traction, the following two values always have to be calculated:
  1. Traction which the sheave with its grooves can provide
  2. Traction which is needed by the elevator installation for a certain case

It has to be made sure that the groove provides more traction than needed by the elevator in normal operation.

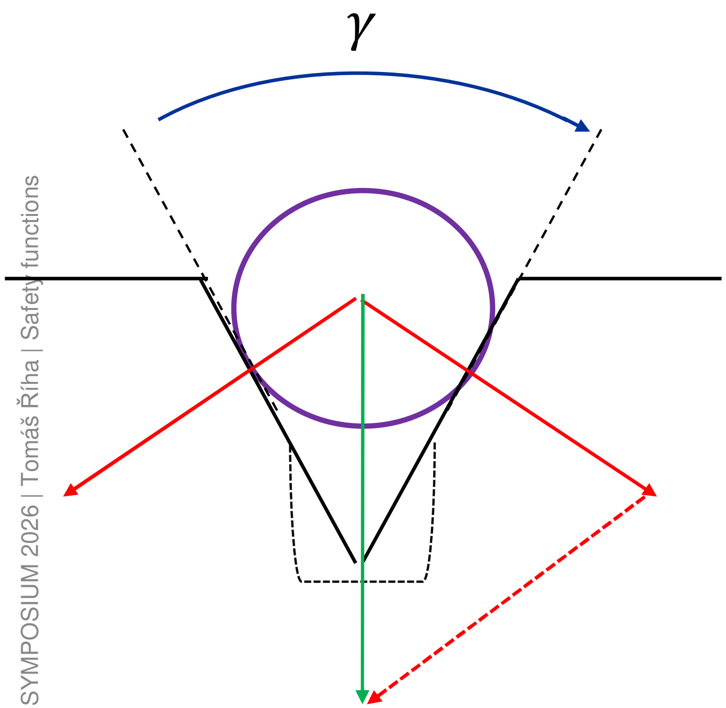
Groove shapes

General information

- Usually a circular round groove shape does not provide enough traction.
  - Therefore a specific groove shape is necessary which increases the
    - Contact pressure and also the traction.

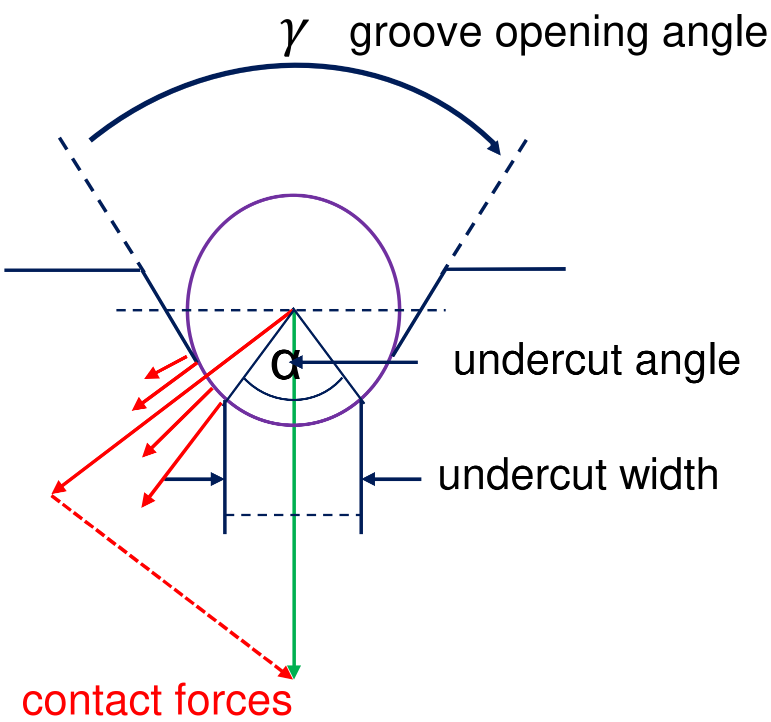
- Generally, there are 2 different groove shapes:
  - V-groove
  - U-groove with undercut

V-groove

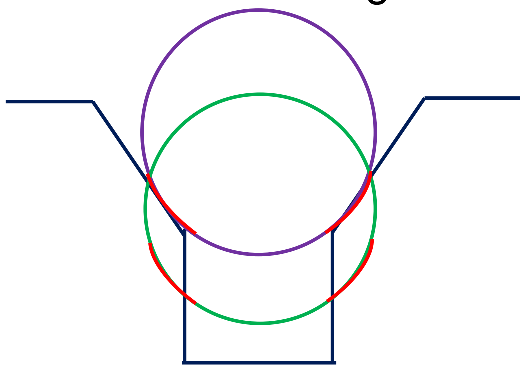


- The rope has 2 contact points. The triangle build by the contact forces (red) are equal to the force which pulls the rope into the groove (green).
- The V-groove angle must not be less than 35°. Typical values are 35°, 40°, 45° and 50°.
- Wear on the groove does change the traction, therefore the V-groove is normally hardened to at least 50 HRC to avoid any wear and keep the traction constant for the entire lifetime.

U-groove with undercut



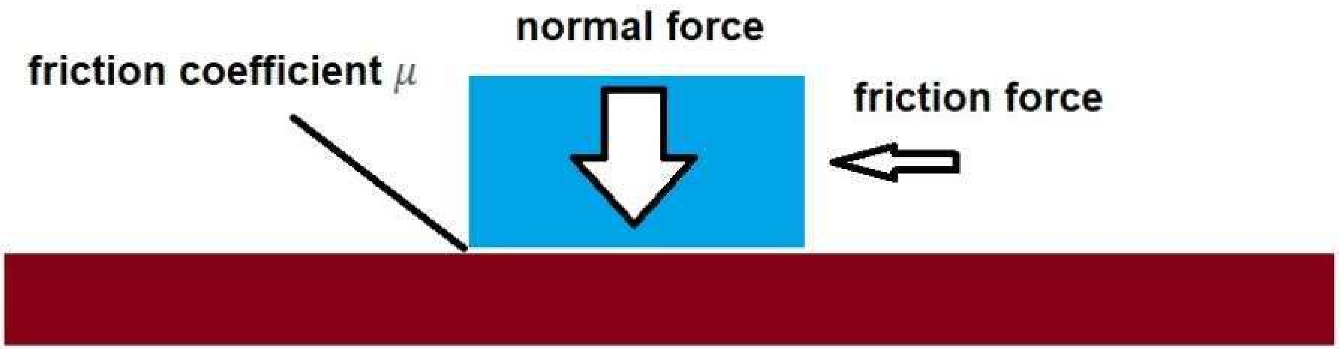
- The undercut angle must be 106° or less.
  106° = undercut width 80 % of rope diameter
- Typical angles are from 105° in 5° steps down to 70°.
- Wear on the groove does not change the traction, see picture below.



- Therefore, the U-groove does not need hardening.

Friction

What does friction mean



μ = Friction coefficient
F_n = normal force
F_f = friction force

If $F_f > \mu * F_n$ Object will slip

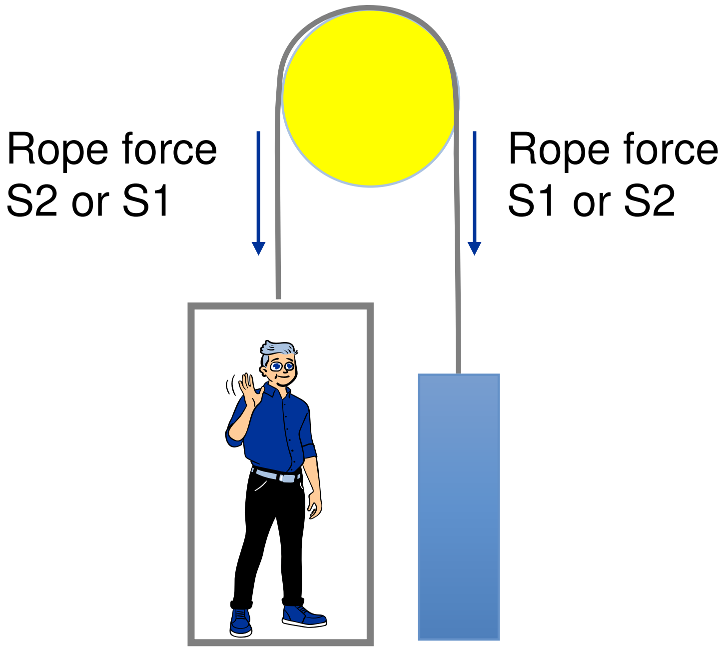
If $F_f \leq \mu * F_n$ Object will not slip

Combination steel ropes with steel or casted sheave:
μ = 0.1 (EN81-20)
μ = 0.09 (TRA = technical rules for elevators – old german normative)

μ is different for static and dynamic case. For steel ropes, dynamic value is lower that static value.
-> friction is lower, when ropes are slipping

Traction - Calculation

General information

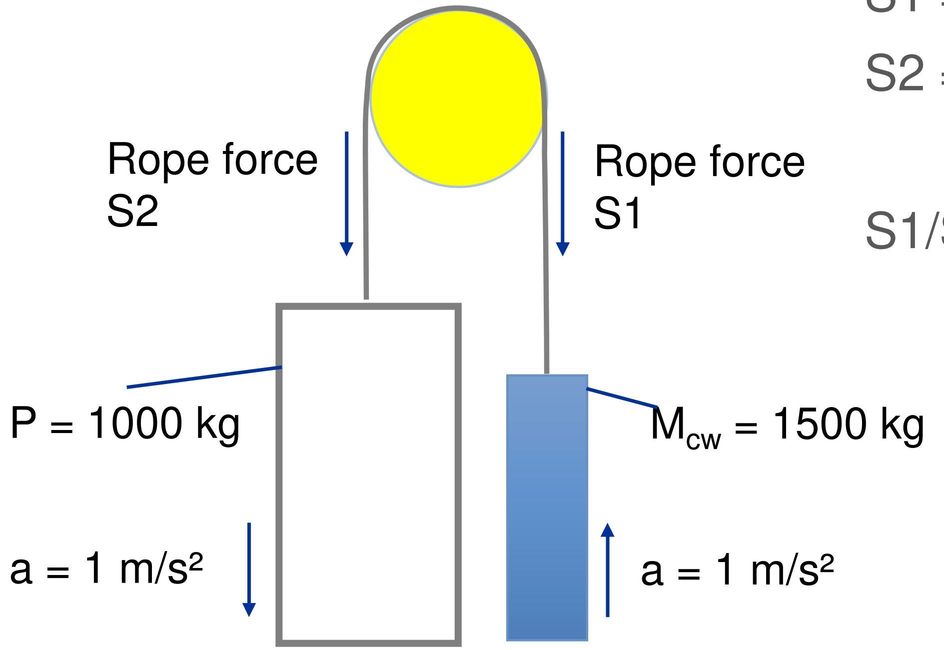


- The traction, which is needed by the elevator is calculated by dividing the rope forces S1 / S2, where S1 is always the higher value

Traction - Calculation

Example: Dynamic calculation

Case 1: Empty car



$S1 = M_{cw} * (gravity + a)$

$S2 = P * (gravity – a)$

$S1/S2 = (M_{cw} * (gravity + a)) / (P * (gravity – a))$

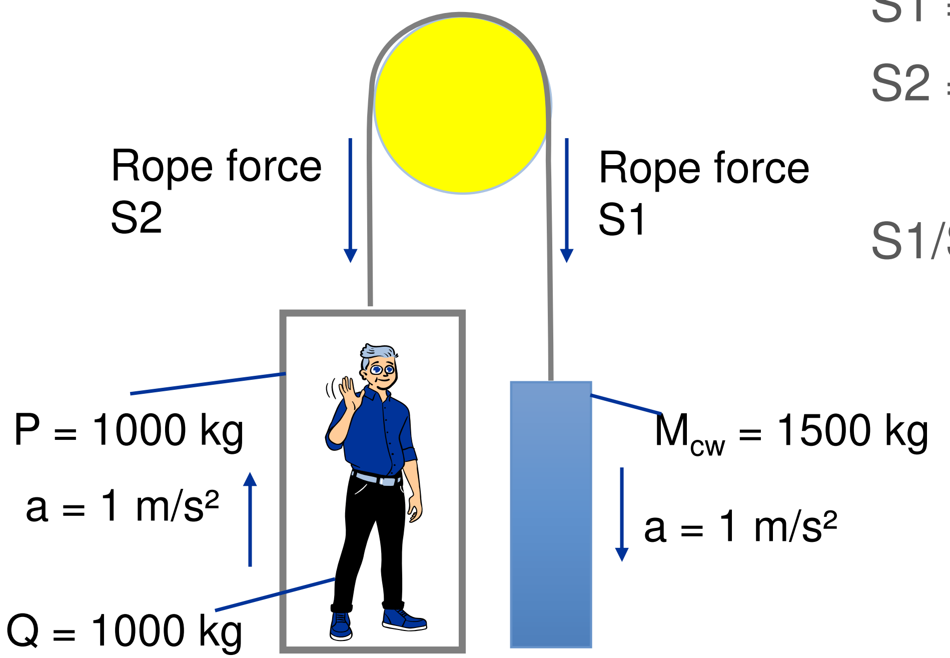
$= (1500\ kg * 10.81\ m/s^2) / (1000\ kg * 8,81\ m/s^2)$

$= 1.84$

Traction - Calculation

Example: Dynamic calculation

Case 2: Loaded car



$$S1 = (P + Q) * (gravity + a)$$

$$S2 = M_{cw} * (gravity - a)$$

$$S1/S2 = ((P + Q) * (gravity + a)) / (M_{cw} * (gravity - a))$$

$$= (2000\ kg * 10.81\ m/s^2) / (1500\ kg * 8{,}81\ m/s^2)$$

$$= 1.636$$

Calculation of the various traction conditions

Traction conditions according EN81

- EN81 only considers “emergency” situation which could lead to a dangerous situation.

1. Loading (125 %)

considers 125 % static load assumed friction coefficient: 0.1 (steel ropes)

There must be enough traction to hold the car in position.

Example: Q = 1000 kg; F = 1000 kg; Mcw = 1500 kg; s = 55 kg; 1:1; car at bottom position

S1/S2 = (1,25 * Q + F + s) / Mcw = (1250 kg + 1000 kg + 55 kg) / 1500 kg

= 1.5367

friction coefficient μ = 0.1; U-groove with undercut angle β = 90° -> $\boldsymbol{e^{f \cdot \alpha} = e^{0.1892 \cdot \pi} = 1.8119}$

1.5367 < 1.8119 -> ok!

Calculation of the various traction conditions

Traction conditions according EN81

2. emergency stop

considers an emergency stop for all cases empty and full, up and down

there must be enough traction to reach a deceleration of at least 0.5 m/s²

to consider different elevator speeds, the friction coefficient to be assumed is depending on the rope speed:

Calculation of the various traction conditions

Traction conditions according EN81

2. emergency stop

Example: Q = 1000 kg; F = 1000 kg; Mcw = 1500 kg; s = 55 kg; HK = 20 kg; 1:1; 1 m/s

empty car at top position

S1/S2 = (Mcw + s) * (g + a) / ((F + HK) * (g – a))

= (1555 kg) * (9,81 + 0,5) m/s² / (1020 kg * (9,81 – 0,5) m/s²)

= 1.688

friction coefficient μ_dyn = 0.1 / (1 + v / 10) = 0.0909

U-groove with undercut angle β = 90° -> $\boldsymbol{e^{f \cdot \alpha} = e^{0.172 \cdot \pi} = 1.7166}$

1.688 < 1.7166 -> ok!

Calculation of the various traction conditions

Traction conditions according EN81

3. blocked

in case the counterweight is blocked, for example it rests on the buffer when the car is at upmost position, the car must not be lifted up any further.

There must not be too much traction to lift the car when the counterweight is blocked.

Assumed friction coefficient: 0.2 (steel ropes)

S1 = car weight; S2 = rope weight

Example (empty car at top position):

S1 / S2 = 1000 kg / 55 kg = 18.18

friction coefficient μ = 0.2; U-groove with undercut angle β = 90° -> $\boldsymbol{e^{f \cdot \alpha} = e^{0.3784 \cdot \pi} = 3.283}$

18.18 > 3.283 -> ok!

Calculation of the various traction conditions

Traction conditions on basis of TRA (old german normative which has long been expired)

1. empty, top, accelerated
   calculates the worst case of regular operation
   considers a reasonable amount of acceleration, depending on elevator speed

2. 150 % loaded, not moving
   this case is not important as today's elevators need an overload device which should prevent a 150 % loading

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