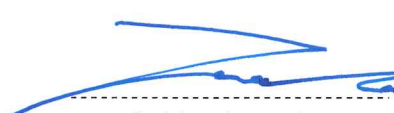




Industrie Service

Certificate concerning the examination of conformity

Certificate No.:	CA 584
Certification Body of the Notified Body:	TÜV SÜD Industrie Service GmbH Westendstr. 199 80686 München – Germany
Certificate Holder:	Usha Martin UK LTD Brunton Shaw UK Sandy Lane, Worksop, Nottinghamshire, S80 3ES – United Kingdom
Manufacturer of the Test Sample: (Manufacturer of Serial Production - see Enclosure)	Usha Martin UK LTD Brunton Shaw UK Sandy Lane, Worksop, Nottinghamshire, S80 3ES – United Kingdom
Product:	Rope drive, for use as part of the machine for traction drive lifts resp. indirect acting hydraulic lifts with and without reduced number of travels
Type:	ELSTAR 8WS 6.5 mm
Directive:	2014/33/EU
Basis of examination:	- EN 81-20:2014 - EN 81-50:2014
Test Report:	CA 584 of 2018-07-30
Outcome:	The product fulfills the requirements of the test specifications for the respective scope of application stated in the annex of this certificate, keeping the mentioned conditions.
Date of issue:	2018-07-30
Date of validity:	until 2023-07-29


 Achim Janocha
 Certification Body "lifts and cranes"



Annex to the certificate concerning the examination of conformity No. CA 584 of 2018-07-30



1 Scope of application

1.1 Traction drive lifts and indirect acting hydraulic lifts, falling within the scope of validity of the Directive 2014/33/EU (Lifts Directive) or whose rope drive / drive according to EN 81-20:2014, Number 5.9.2.1.1 a) resp. Number 5.9.3.1.1 b) will be renewed.

According the following definitions:

Traction drive lifts according EN 81-20:2014 and EN 81-50:2014

Traction drive lifts <u>without</u> reduced number of trips	Rope safety factor (S_r) calculated according to EN 81-50:2014, Number 5.12 or equally good
--	--

Traction drive lifts <u>with</u> reduced number of trips	Rope safety factor (S_r) determined deviating from EN 81-50:2014, Number 5.12
---	--

Indirect acting hydraulic lifts according EN 81-20:2014 and EN 81-50:2014

Indirect acting hydraulic lifts <u>without</u> reduced number of trips	Predicted number of trips ≥ 600.000
---	--

Indirect acting hydraulic lifts <u>with</u> reduced number of trips	Predicted number of trips < 600.000
--	---------------------------------------

1.2 Technical Data

Ungalvanized steel wire ropes of type **ELSTAR 8WS**

Characteris- tics	Nominal diameter of the rope	d_{Nom}	6.5 mm ¹⁾
	Minimum breaking load	F_{min}	31.5 kN
	construction / type		8x19W + IWRC sZ
Traction sheave	Tensile strength of the wire	R_0	1770 N/mm ²
	Minimum diameter ²⁾	D_{Tmin}	≥ 120 mm
		D_T/d_{Nom}	≥ 18.46
	V-angle in case of V-groove		$\gamma = 35^\circ$ to $\gamma = 60^\circ$
Diverting pulleys	U-angle in case of semi-circular undercut groove (U-groove)		$\beta = 70^\circ$ to $\beta = 105^\circ$
	Minimum diameter ²⁾	D_{Umin}	≥ 120 mm
		D_U/d_{Nom}	≥ 18.46

¹⁾ deviating from EN 81-20:2014, Number 5.5.1.2 a) (< 8 mm)

²⁾ deviating from EN 81-20:2014, Number 5.5.2.1 (< 40)

Annex to the certificate concerning the examination of conformity
No. CA 584 of 2018-07-30



Industrie Service

2 Conditions

2.1 For the determination of the minimum rope-safety-factor in case of lift installations with reduced number of trips, the document "BSUK 4" (8 pages) dated 2018-07-27 with certification stamp dated 2018-07-30 must be observed and are basis for the calculation of the permitted number of trips.

2.2 Conditions for traction lifts according to EN 81-20:2014 and EN 81-50:2014

2.2.1 The intended use of the lift installation must be coordinated between the rope manufacturer, the manufacturer of the lift and the person who makes the purchasing order (in case of new lifts) or operator (in case of modifications of the lift).

Especially a statement must be given with regard to the following points:

- The intended use of the lift
- The environmental conditions (e.g.: air moisture; area of operations; toxicity of the atmosphere; temperature on the area of operation;...)
- The expected yearly number of trips
- The expected number of trips up to the moment when having reached the limit at which the steel wire ropes have to be discarded – for lift installations with a reduced number of trips –
- The rope safety factor which is required with respect to the lift installation

These statements and the calculations based on the statements must be documented and must be enclosed to the technical documents.

See number 3.3 of this certificate.

2.2.2 The rope safety factor must be determined

- In case of traction drive lifts without reduced number of trips
According to EN 81-50:2014, Number 5.12 or equally good

or

- In case of traction drive lifts with reduced number of trips
Corresponding to
"BSUK 4" (8 pages) dated 2018-07-27 with certification stamp dated 2018-07-30.

2.2.3 The rope safety factor must be at least $S_f = 12$.

2.2.4 In case of lift installations with reduced number of trips, the trips must be registered by a safe and reliable automatic counter device (e. g. by a power-fail proof, non-resettable electric counter).

When the number of trips after which the ropes have to be discarded is reached, the lift must be safely stopped in the next landing by the control system and the suspension ropes must be replaced.

See number 3.3 and 3.4 of this certificate.

2.2.5 The suspension ropes must be discarded in case of (for all lift installations)

- 26 broken wires within a length of $30 \times d$ or
- 13 broken wires within a length of $6 \times d$ or
- a diameter reduction of more than 6% related to the nominal rope diameter

and (for lift installations with a reduced number of trips)

- When reaching the maximum number of trips which has been determined by calculation.

2.2.6 The rope traction of the suspension ropes must be calculated according to EN 81-50:2014, Number 5.11 or equal.

Annex to the certificate concerning the examination of conformity
No. CA 584 of 2018-07-30



Industrie Service

- 2.2.7 The ratio between the diameter of the traction sheave and the rope must be at least ≥ 18.46 .
- 2.2.8 The traction sheave must be designed with a semi-circular undercut groove (U-angle $\beta = 70^\circ$ up to $\beta = 105^\circ$, hardened or non-hardened) or with a hardened V-groove (V-angle $\gamma = 35^\circ$ up to $\gamma = 60^\circ$) made of steel or cast iron.
- 2.2.9 The ratio between the diameter of the diverting pulley and the rope must be at least ≥ 18.46 .
- 2.2.10 The diverting pulleys must be designed with a semi-circular groove made of steel or cast iron (hardened or non-hardened) or made of plastics.
- 2.2.11 All additional requirements of EN 81-20:2014 regarding rope drives must be kept, e.g. like:
- junction of the rope termination (80% of the minimum breaking load)
 - distribution of load of suspension
 - protections at traction sheaves and pulleys (bracket against derailing of the rope, nip guards)
 - visual examination on the traction sheave is guaranteed
- 2.3 Conditions for indirect acting hydraulic lifts according to EN 81-20:2014 and EN 81-50:2014
- 2.3.1 The intended use of the lift installation must be coordinated between the rope manufacturer, the manufacturer of the lift and the person who makes the purchasing order (in case of new lifts) or operator (in case of modifications of the lift).
- Especially a statement must be given with regard to the following points:
- The intended use of the lift
 - The environmental conditions (e.g.: air moisture; area of operations; toxicity of the atmosphere; temperature on the area of operation;...)
 - The expected yearly number of trips
 - The expected number of trips up to the moment when having reached the limit at which the steel wire ropes have to be discarded – for lift installations with a reduced number of trips –
 - The rope safety factor which is required with respect to the lift installation
- These statements and the calculations based on the statements must be documented and must be enclosed to the technical documents.
- See number 3.3 of this certificate.
- 2.3.2 The rope safety factor must be at least $S_f = 12$.
- 2.3.3 In case of lift installations with reduced number of trips resp. with a pulley made of plastic (at the piston), the trips must be registered by a safe and reliable automatic counter device (e. g. by a power-fail proof, non-resettable electric counter).
- When the number of trips after which the ropes have to be discarded is reached, the lift must be safely stopped in the next landing by the control system and the suspension ropes must be replaced.
- See number 3.3 and 3.4 of this certificate.
- 2.3.4 The suspension ropes must be discarded in case of (for all lift installations)
- 26 broken wires within a length of $30 \times d$ or
 - 13 broken wires within a length of $6 \times d$ or
 - a diameter reduction of more than 6% related to the nominal rope diameter
- and (for lift installations with a reduced number of trips)
- When reaching the maximum number of trips which has been determined by calculation.
- 2.3.5 The ratio between the diameter of the diverting pulley and the rope must be at least ≥ 18.46 .
- 2.3.6 The diverting pulleys must be designed with a semi-circular groove made of steel or cast iron (hardened or non-hardened) or made of plastics.

Annex to the certificate concerning the examination of conformity No. CA 584 of 2018-07-30



Industrie Service

2.3.7 All additional requirements of EN 81-20:2014 regarding rope drives must be kept, e.g. like:

- junction of the rope termination (80% of the minimum breaking load)
- distribution of load of suspension
- protections at pulleys (bracket against derailing of the rope, nip guards)
- visual examination on the traction sheave is guaranteed

3 Remarks

3.1 A sign with particulars for identification, containing the name of the manufacturer and the type specification must be attached at the product, to be able to check the conformity of the examined product with the series production.

3.2 The certificate concerning the examination of conformity may be used only in connection with the pertinent Annex.

3.3 The following installations will be regarded as lifts with a reduced number of trips.

3.3.1 Traction lifts according EN 81-20:2014 and EN 81-50:2014 with a deviating rope safety factor (smaller) than the rope safety factor which is defined in EN 81-50:2014, Number 5.12.

The deviant rope safety factor (smaller than the rope safety factor which is defined in EN 81-50:2014, Number 5.12) is the result of the determined maximum number of trips, after which the steel wire ropes has to be discard.

In the case of a change of the intended use of the lift installation (using the lift more frequently), an improvement of the lift installation may become necessary.

3.3.2 Indirect acting hydraulic lifts according EN 81-20:2014 with a determined maximum number of trips of less than 600.000 trips, after which the steel wire ropes have to be discarded.

In the case of a change of the intended use of the lift installation (using the lift more frequently), an improvement of the lift installation may become necessary.

3.4 Each change of direction is regarded as a trip which shall be registered by the automatic counting device.

Re-levelling movements should be avoided as far as possible. Re-levelling movements exceeding the range of $l/d_{\text{Nom}} > 10$ (bending length ratio = *bending length / nominal diameter of the rope*) – in case of a preceding change of direction – must be evaluated as a trip.

3.5 The following equivalent number of traction sheaves will be taken as basis:

N _{equiv (t)}	V-groove with groove angles γ of								
	35°	36°	38°	40°	42°	45°	50°	55°	60°
	18.5	16	12	10	8	6.5	5	3.7	3
	Semi-circular groove with undercut and undercut angles β of								
		70°	75°	80°	85°	90°	95°	100°	105°
		2.3	2.5	3	3.8	5	6.7	10	15.2

Deviating from EN 81-50:2014, Number 5.12 table 2 some additional V-grooves (V-angle γ 55° and 60°) and one additional U-Groove (U-angle β 70°) will be used, the corresponding equivalent number of traction sheaves N_{equiv(t)} has been determined by extrapolation.

3.6 For each lift installation arrangements shall be made between the rope manufacturer, the lift installer and the operator to ensure proper operation and safe use of the lift. Also assistance in calculating the number of permitted trips (calculation tools or support) shall be provided to the lift installer.

3.7 The test results refer to the test specimen and the corresponding examination of conformity only.

Annex to the certificate concerning the examination of conformity
No. CA 584 of 2018-07-30



Industrie Service

- 3.8 The list of safety components (annex III of Directive 2014/33/EU) doesn't contain rope drives. For that reason no EU-type examination certificate according to annex IV part A (EU-type examination for safety components for lifts) of the Directive 2014/33/EU, can be issued for that.
- 3.9 This certificate is based on the state of the art, which is documented through the current harmonized standards. Changes resp. extensions of these standards or a further development of the state of the art may make a revision of this report necessary.
- 3.10 If new knowledge should occur, the test laboratory reserves the right, to give additional conditions concerning the use of the rope drive, or to modify existing conditions.
- 3.11 The certificate about an examination of conformity number CA 584 can be added to the required reading technical dossier as a help for decision of the notified body.

**Enclosure of the certificate concerning the examination of conformity
No. CA 584 of 2018-07-30**



Industrie Service

Authorised Manufacturer of Serial Production – Production Sites (valid from: 2018-07-30):

Company	Usha Martin UK LTD Brunton Shaw UK
Address	Sandy Lane, Worksop, Nottinghamshire, S80 3ES – United Kingdom

- END OF DOCUMENT -

Base: Information of the manufacturer dated 2018-07-03

Note: The English text is a translation of the German original. In case of any discrepancy, the German version is valid only.

Page 1 of 1

Elevator rope Test Report

Report : BSUK 4
Issue: 1
Revision: 1
Dated: 27/07/2018

Contents: -

1. Introduction.
2. Product Data Sheet.
3. Annex A. Determining number of trips.

Elevator rope Test Report


Report : BSUK 4
Issue: 1
Revision: 1
Dated: 27/07/2018


1. Introduction.

To increase the portfolio of products Brunton Shaw UK have designed and developed 6.5mm 8x19w IWRC sZ Ungalvanised Elevator hoisting rope for the suspension of traction drive lifts steel in the scope of application in Annex1 Essential Health & Safety requirements of EC Directive 2014/33/EU. Other applicable standards EN81-20:2014 & EN81-50 :2014 however deviations from these standards are 5.12.2.2 additional groove profiles were included for 70° U Undercut groove & V groove 55° & 60° also 5.12.3 safety factor additional sheave D/d ratio 18.5-33 were included in the simple bendings table & the subsequent test plan.

2. Product Data Sheet.

The product that is this under test is an
6.5mm 8x19w IWRC sZ Ungalvanised Elevator hoisting rope.



A Division of  Usha Martin UK Limited

Sandy Lane Worksop Nottinghamshire S80 3ES
Telephone: 01909 537600 Fax: 01909 500199
E mail: info@brunton-shaw.co.uk
Web: <http://www.brunton-shaw.co.uk>

PRODUCT DATA SHEET
ELSTAR 8WS
6.5mm Dia. 8x19w IWRC sZ 1770 Ungalvanised.



Product Standards	BS EN 12385-5
Nominal Diameter (mm)	6.5
Construction	8x19w
Lay Type	sZ
Core Type	IWRC
Nominal Tensile Grade (N/mm²)	1770
Finish	Ungalvanised
Lubrication	T55
Minimum Breaking Force	31.5 kN
Approximate mass in Air	0.17 kg/m

Issue: - 3

Date: 02/07/2018



Manufactured under a
ISO 9001:2015
Registered Quality
System.
Reg. No. FM 01267

3. Annex A. Determining number of trips

$$N_{eq(t)}$$

Additional undercuts-U grooves (U-angle $\beta=70^\circ$) and V-grooves (V-angle $\gamma=55^\circ$ and 60°) have been added to table 1, this is a deviation from the standard DIN EN 81-50: 2014, the equivalent number of traction sheaves $N_{eq(t)}$ has been calculated by graphical extrapolation. These values are shown in table 1.

Table 1: Equivalent number of traction sheaves $N_{eq(t)}$

V-Grooves	$\gamma [^\circ]$	35	36	38	40	42	45	50	55	60
	$N_{eq(t)}$	18.5	16	12	10	8	6.5	5	3.7	3
U-Undercut Grooves	$\beta [^\circ]$	0	70	75	80	85	90	95	100	105
	$N_{eq(t)}$	1	2.3	2.5	3	3.8	5	6.7	10	15.2

Decision formula

The rope in this study is a Brunton Shaw Elstar 8WS $d_{Nom}=6.5\text{mm}$ which is designed for application in elevators, both inside and outside the requirements of the DIN EN81-50 and EN81-20.

Traction elevator

The calculation of the safety factor is based on the calculation of within the standard DIN EN 81-50: 2014 The minimum number of trips ($Z=6 \times 10^5$) was determined by a technical committee when deviating from the standard DIN EN 81-50: 2014 relative to the safety factor and the bending ratio, the below must be taken into consideration.

Example 1: In this example the safety factor has been calculated on the DIN EN81-50 standard and the number of expected trips is higher than the minimum number of trips $Z=6 \times 10^5$

No added measures are required as all previously stated criteria have been met.

Example 2: The safety factor is not the same as calculated from the standard DIN EN 81-50:2014 and/or the expected number of trips is less than the minimum $Z=6 \times 10^5$

In example 2 with the criteria not being met the elevator is now considered to have a “limited number of trips.” A trip is defined as the total number of starts in a single direction which is countered as ‘One Trip’ before the reversing in the opposite direction. A trip is considered as a movement of $> 100\text{mm}$. Where this is the case a trip counter device has to be installed on the system.

The expected number of trips can be calculated with the use of **Formula 1**. The starting point is the number of “simple bendings” that a rope could withstand on a plain-U groove: this data is reported on table 2 for different diameter ratios (D/d) and safety factor (S_f)

Intermediate values can be interpolated.

Indirect Hydraulic elevators

The S_f value in this application is considered to be of a fixed value ($S_f \geq 12$) the only criteria that can now deviate from the standard DIN EN 81-20:2014 is the bending ratio of the reflection sheave to rope D/d

Example 1: Safety Factor $S_f \geq 12$, D/d is outside the standard DIN EN81-20 requirement and the expected number trips is greater than the minimum number of trips $Z=6 \times 10^5$.

No added measures are required as all previously stated criteria has been met.

Example 2: $S_f \geq 12$, D/d is outside the standard DIN EN81-20 requirements and the expected number of trips is lower than the minimum $Z=6 \times 10^5$.

In example 2 with the criteria not being met the elevator is now considered to have a “limited number of trips.” A trip is defined as the total number of starts in a single direction which is countered as ‘One Trip’ before the reversing in the opposite direction. A trip is considered as a movement of $> 100\text{mm}$. Where this is the case a trip counter device has to be installed on the system.

The expected number of trips can be calculated with the use of **Formula 1**. The starting point is the number of “simple bendings” that a rope could withstand on a plain-U groove: this data is reported on table 2 for different diameter ratios (D/d) and safety factor (S_f)

Intermediate values can be interpolated.

If a **plastic deflection sheave** is used on indirect hydraulic elevators, the number of trips shall increase with accordance to the formula as $F_N = 1.2$.

It is necessary in all cases to use a trip counter in indirect hydraulic lifts when using plastic deflection sheaves.

Decision formula: Application and use.

Elevator rope Test Report

Report : BSUK 4
Issue: 1
Revision: 1
Dated: 27/07/2018

To calculate the number of trips of the elevator in service, a simplified calculation can be used; this is to be as general as possible whilst also giving conservative values.

Table 2 shows the number of simple bendings (N_A) that the rope could withstand on a sheave with a plain-U groove. This represents the simplest form of theoretical information to calculate the expected number of trips (Z_A)

Table 2: Number of simple bendings over a plain-U groove sheave

	Sf = 12	Sf = 14	Sf = 16	Sf = 18	Sf = 20	Sf = 22	Sf = 24	Sf = 26	Sf = 28	Sf = 30
Bending Ratio D/d	N_A	N_A	N_A	N_A	N_A	N_A	N_A	N_A	N_A	N_A
18.5	78,000	101,000	126,200	154,000	183,700	216,000	250,000	285,000	322,000	362,000
20	141,125	201,250	255,000	311,500	368,250	467,000	564,125	649,500	737,150	842,250
21	219,250	311,000	396,250	485,125	577,500	729,000	880,125	1,014,250	1,153,000	1,317,000
22	296,000	422,500	541,650	669,000	818,000	1,010,000	1,226,500	1,417,000	1,616,000	1,850,000
23	378,000	544,000	705,000	872,000	1,087,000	1,335,000	1,630,000	1,887,500	2,165,000	2,485,000
24	463,000	670,000	869,000	1,08,200	1,365,000	1,665,500	2,045,000	2,378,000	2,730,000	3,141,000
25	530,000	755,000	965,000	1,179,000	1,415,000	1,774,000	2,149,000	2,474,000	2,813,000	3,218,000
26	615,000	885,000	1,135,000	1,405,000	1,730,000	2,137,000	2,605,000	3,015,000	3,449,000	3,956,000
27	700,000	1,016,000	1,313,000	1,636,000	2,045,000	2,512,000	3,077,000	3,575,000	4,105,000	4,720,000
28	767,000	1,108,000	1,448,000	1,812,000	2,316,000	2,780,000	3,420,000	3,971,000	4,558,000	5,243,000
29	895,000	1,300,000	1,720,000	2,168,000	2,800,000	3,380,000	4,185,000	4,895,000	5,645,000	6,525,000
30	955,000	1,400,000	1,833,000	2,305,000	2,975,000	3,590,000	4,440,000	5,200,000	5,990,000	6,915,000
31	1,086,000	1,605,000	2,113,000	2,673,000	3,465,000	4,210,000	5,238,000	6,140,000	7,108,000	8,245,000
32	1,120,000	1,657,000	2,182,000	2,760,000	3,580,000	4,348,000	5,405,000	6,340,000	7,340,000	8,510,000
33	1,238,000	1,840,000	2,421,000	3,066,000	3,985,000	4,853,000	6,050,000	7,102,000	8,235,000	9,565,000
34	1,237,500	1,895,000	2,495,000	3,160,000	4,105,000	5,001,000	6,235,000	7,318,000	8,485,000	9,855,000
35	1,616,000	2,415,000	3,248,000	4,172,000	5,496,000	6,740,000	8,485,000	10,045,000	11,706,000	13,682,000
36	1,735,000	2,637,000	3,528,000	4,575,000	6,055,000	7,455,000	9,422,000	11,185,000	13,095,000	15,325,000
37	1,885,000	2,825,000	3,835,000	4,955,000	6,555,000	8,057,000	10,185,000	12,090,000	14,115,000	16,535,000
38	1,940,000	2,900,000	3,935,000	5,850,000	6,732,000	8,275,000	10,460,000	12,415,000	14,498,000	16,985,000
39	1,990,000	2,978,000	4,040,000	5,219,000	6,910,000	8,492,000	10,735,000	12,742,000	14,880,000	17,430,000
40	2,405,000	3,702,000	5,000,000	6,595,000	8,813,000	10,925,000	13,925,000	16,625,000	19,575,000	23,005,000

When a formed traction sheave is used, (an undercut – U or V groove) then the simple bending values have to be corrected by the use of a coefficient value. These coefficient values are shown in Table 3.

Elevator rope Test Report

Report : BSUK 4
Issue: 1
Revision: 1
Dated: 27/07/2018

Table 3: Correction coefficient to obtain the number of bendings over a formed traction groove

U-Undercut grooves		V-Grooves	
β	f_{N3}	γ	f_{N3}
70	0.43	35	0.054
75	0.4	36	0.066
80	0.33	38	0.095
85	0.26	40	0.14
90	0.2	42	0.18
95	0.15	45	0.25
100	0.1	50	0.33
105	0.066	55	0.4
		60	0.45

It is important to consider the complete roping arrangement when calculating the number of trips (Z_A) that the elevator could withstand. Thus, the sheaves within the arrangement must also be considered and when passing these sheaves what is the most stressed section in the rope.

According to DIN EN81-50:2014, is the distance between two rope sheaves is less than 200 times the diameter of the rope, the calculation must also consider the reverse bending.

The number of reverse bend can be calculated by using formula 6.

The calculation is a simplified one and is as follows

Formula 1 Decision formula for the number of trips:

$$Z_A = \frac{1}{\underbrace{\frac{1}{f_{N3} \times N_A(D_T)}}_A + \underbrace{\frac{1}{N_A(D_{R1})}}_B + \underbrace{\frac{1}{N_A(D_{R2})}}_C + \dots + \underbrace{\frac{1}{N_A(D_{Ri})}}_{i\text{-th}}}$$

Where:

- Z_A = Number of trips for the elevator
 f_{N3} = Reduction factor from Table 2
 D_T = Diameter of the traction sheave in mm
 D_{R1} = Diameter of the first deflection sheave in mm
 D_{R2} = Diameter of the second deflection sheave in mm
 D_{Ri} = Diameter of the i-th (additional) deflection sheave in mm
 $N_A(D_T)$ = Number of simple bending for the sheave diameter D_T , taken from Table 2
 $N_A(D_{R1})$ = Number of simple bending for the sheave diameter D_{R1} , taken from Table 2
 $N_A(D_{R2})$ = Number of simple bending for the sheave diameter D_{R2} , taken from Table 2
 $N_A(D_{...})_{kor}$ = Number of reverse bendings determined from the number of simple bendings for the corresponding sheave
 S_f = Safety factor:
 1. Safety factor calculated according to DIN EN81-50:2015-02
 2. Safety factor Table 2 determined deviating from DIN EN81-50:2015-02

For specific cases, further simplification can be arranged:

1) Formula 2. Indirect Hydraulic Elevator:

$$Z_A = N_A(D_R)$$

In this scenario, the previously mentioned traction sheave isn't present. There is only one sheave on top of the piston. The number of trips (Z_A) corresponds to the number of simple bends (N_A) as shown in Table 2. When there are 2 sheaves on top of the piston, the number of trips (Z_a) will be halved.

2) Formula 3. Traction Elevator 1:1 Without any deflection sheave:

$$Z_A = f_{N3} \times N_A(D_T)$$

Both previously mentioned terms regarding the deflection sheaves are ignored, the traction sheave is the only thing that needs to be considered.

3) Formula 4. Traction Elevator 1:1 or 2:1 with one deflection sheave:

$$Z_A = \frac{1}{\frac{1}{f_{N3} \times N_A(D_T)} + \frac{1}{N_A(D_{R1})}}$$

Only the terms relevant to the traction sheave and the first deflection sheave have to be considered.

4) Formula 5. Traction Elevator 1:1 or 2:1 with two deflection sheaves of equal diameter:

$$Z_A = \frac{1}{\frac{1}{f_{N3} \times N_A(D_T)} + \frac{2}{N_A(D_{R1})}}$$

As previously mentioned, the deflection sheave now has to be considered twice to factor in that there are two sheaves equal in diameter.

5) Formula 6. Traction elevator 1:1 or 2:1 with two or more deflection sheaves of different diameter:

In this case the most generic **Formula 1** must be applied.

Number of reverse bendings calculated from the number of simple bendings:

According to: Feyrer, Klaus; Drahtseile: Bemessung, Betrieb, Sicherheit; 2., revised and extended edition Springer- Verlag 2000; p.269

$$N_A(D_{...})_{korr} = 2670 \times N_A(D_{...})^{0.671} \times (D/d)^{0.499}$$

Example – Calculation based on a 2:1 roped elevator

Elevator Data:

Elevator suspension:	2:1
Rope diameter:	6.5mm
Safety factor:	26
Traction groove:	V-hardened/ $\gamma=55^\circ$
Traction sheave ϕ :	208mm (D/d = 30)
Deflection sheave ϕ :	221mm (D/d = 34) – one sheave on counterweight side

Identification of the most stressed rope part:

The highest stress point on a rope is usually when the elevator carriage starts from or goes to the main floor (the main floor is usually the ground floor) the section of the rope that passes over the sheave at this point is at the highest stress. During suspension 2:1 the highest stressed section is over both the traction sheave and the counterweight sheave. The two bendings per trip from or to the main floor are simple bendings. One of the bendings is in a sheave with formed grooves, the other with round grooves.

Data from Table 2 and Table 3:

$N_A (D_T) = 5,200,000$

$N_A (D_{R1}) = 7,318,000$

$F_{N3+} = 0.40$

Number of trips based on formula 4:

$$Z_A = \frac{1}{\frac{1}{f_{N3+} N_A(D_T)} + \frac{1}{N_A(D_{R1})}}$$

$$Z_A = \frac{1}{\frac{1}{0.40 \times 5200000} + \frac{1}{7318000}} = 1616278 \text{ Trips}$$