Even rope set load distribution

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Finding just the right setting for suspension ropes has never been the easiest of tasks, and this is becoming an increasingly complex challenge as the ever more pressing need to guarantee top quality lift installations with minimal wear and excellent ride comfort is placing ever greater importance on the right rope tension.

The trend towards suspension ropes with ever decreasing rope diameters and increasing diversity of suspension conditions in lift systems continues unabated. Driven by demand for lift systems with an ever smaller space requirement and growing cost pressure, drive systems are becoming smaller and more compact, against a background of rising motor speeds and sinking torque levels.

Because of the generally low torque levels they entail, high motor speeds call for traction sheaves with a relatively small diameter. To ensure the right traction sheave diameter to rope diameter (D/d) ratio, suspension ropes must of necessity become thinner.

In order to guarantee adequate rope safety and high duty load, the number of ropes, or in other words the suspension ratio has to be increased. New installations with 12 or even 14 suspension ropes and extreme reducing suspension ratios have now become an established feature of the lift market.

Rope research has shown that the bending performance of ropes diminishes steadily in line with their diameter. A lower traction sheave diameter to rope diameter ratio (D/d) additionally reduces the bending performance, as do multiple rope deflection points.

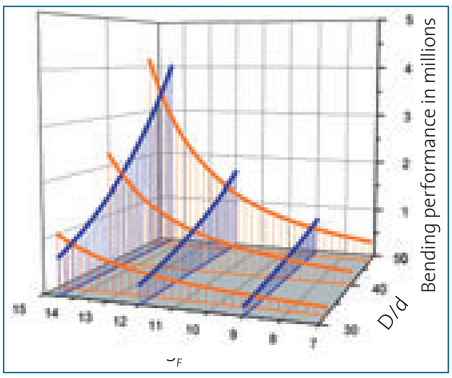


Fig. 1: Impact of the rope diameter (S_F) and sheave diameter to rope diameter ratio (D/d) on bending performance[1)]

If one rope of a rope set is bearing a significantly higher load than the other ropes, the it is evident that this rope will be subject to faster wear, while at the same time potentially causing enormous damage to the traction sheave and deflection roller: The service life of the rope set is substantially further reduced, in some cases even necessitating premature wear-related exchange of traction sheaves. Added to this is the fact that high-strength wires can be used in thin ropes in order to achieve a good loading capacity. Unless specially hardened traction sheaves and deflection rollers are used with this type of wire, impressions and wear are inevitable.

As illustrated in Fig. 1, ropes with a small diameter are destined for a shorter service life from the start. In order not to shorten it still further, the overall load must be distributed in such rope sets as evenly as possible.

Anyone who has ever attempted to adjust a rope set will appreciate the difficulties it can entail. Because modifying the tension of one rope will directly affect the rope tension in another rope of the set, setting a rope set of just four or six ropes is relatively complex and time consuming, even if it is possible to measure the tension of each individual rope using a measuring device. The human brain is only capable of taking an iterative approach to solving the problem. The ideally adjusted rope set is achieved by a gradual process of trial and error in which the tension of each rope is repeatedly increased or reduced in small increments (often several times). Even for rope sets comprising around half a dozen ropes, this involves an enormous amount of time, and when doubling the number of ropes per set, the time required does not just double but actually rises at an exponential rate.

Fig. 2: Mobile rope load measuring system MSM12 and rope load sensor LSM1 from the WeightWatcher measurement system

Henning GmbH was the first supplier to the lift market to offer scope for the precise, documentable, effective and consequently cost-effective performance of this adjustment process. A software solution guides the installer step by step through the rope adjustment process (Fig. 3 and Fig. 4), adjusting each rope of the set to an optimum tension calculated by the software. This means that each rope only has to be handled once by the installer, permitting complete adjustment of the whole rope set, even sets comprising 12 ropes, within just a few minutes.

As indicated at the outset, this type of rope set adjustment process is particularly important in systems with small rope diameters. However, an adjustment aid such as the one described above or others available in the market only permits effective, low-cost adjustment of ropes under optimum conditions or where lift cars are suspended directly. In lift systems involving multiple rope deflection of the type often used in systems with small rope diameters, added difficulties arise: If the axles of the traction sheave and deflection rollers are not aligned in precisely parallel formation, where tolerances exist in the groove profiles and/or deflection angles are present, different load distributions prevail in the rope set, depending on the present vertical rise of the car and which of the rope sections limited by deflections is currently under observation.

A lift system entailing different possible load distributions in the rope set does not have a load distribution which can be considered ideal or which can be ideally adjusted. However, there is a method of ensuring that distribution is adjusted to the optimum possible. If it is known how the total load is distributed across the individual ropes when travelling the entire vertical rise of the total load depending on the current position of the car, then the optimum individual rope adjustment can be calculated to prevent individual ropes from bearing an excessive share of

1) Outline conditions for the deployment of suspension ropes below 8 mm in lifts, Dr. W. Scheunemann, Symposium Schwelm 2007

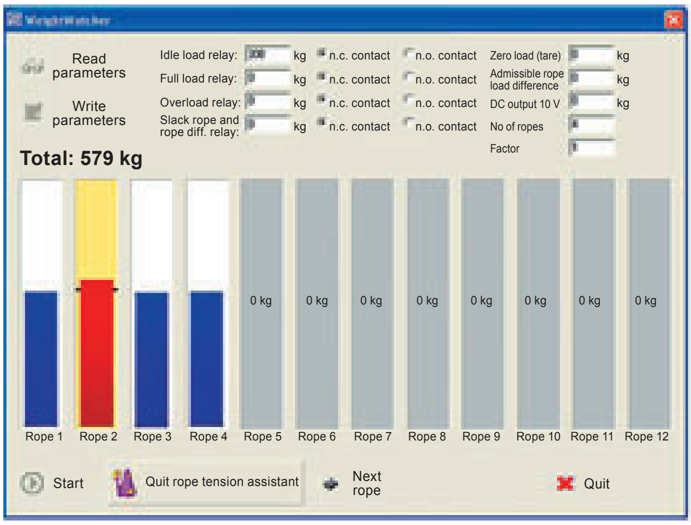


Fig. 3: The setting software of stationary load measuring system AE12 provides a rope tension value (red limiting line on the red bar) which has to be set by the user ...

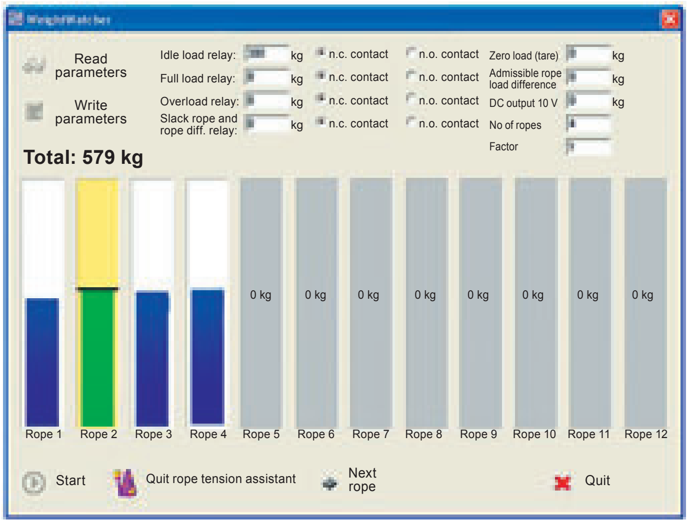


Fig. 4: As soon as the user has set the prescribed rope tension, this is visually confirmed (green bar) and the user is guided to the next rope and its target value. Once the user has arrived at the last rope of the set, the rope adjustment process is complete without any of the ropes having to be adjusted more than once.

the load at certain points in time, and instead ensuring the greatest sustainable and harmonious possible load distribution within the set.

By integrating the load measurement system "WeightWatcher" in the lift diagnostic software suite "LiftPC mobile diagnosis", Henning GmbH permits this type of measurement to be performed over the entire vertical rise of the car. The signals supplied by load sensors in each rope of the set are continuously

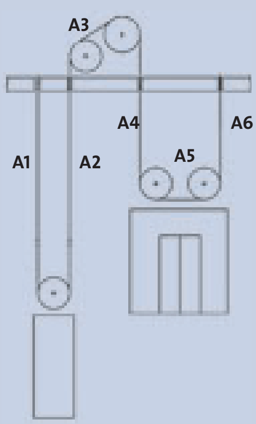
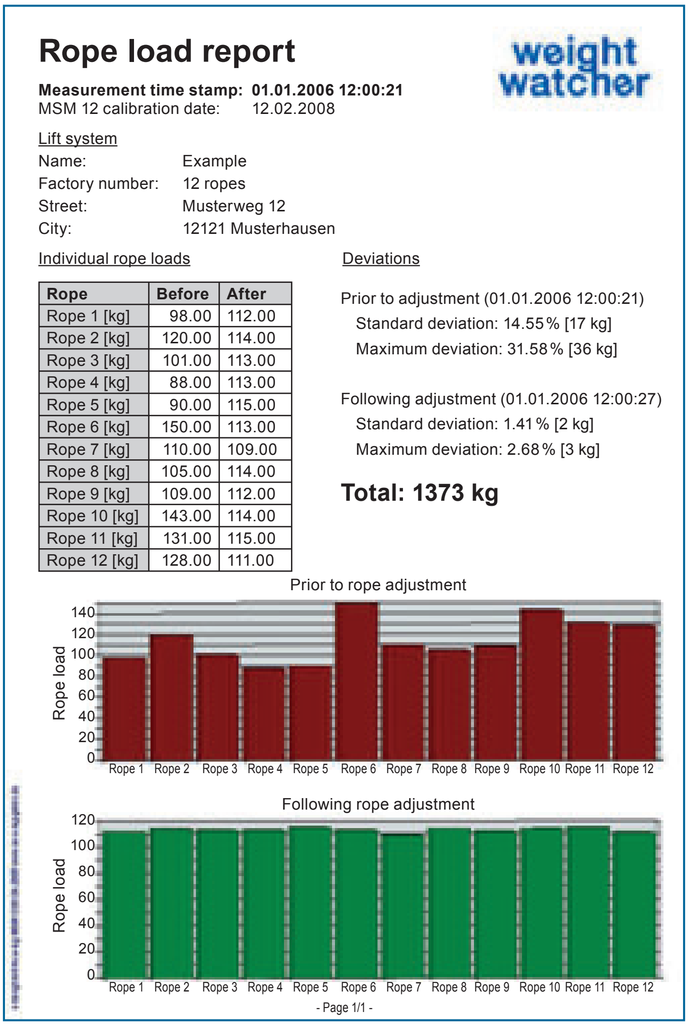


Fig. 5: Diagram of a lift system with 2:1 roping ratio. In each of the sections of rope limited by deflection points (A1 – A6) different load distribution can prevail in the rope set, which can also change depending on the current position of the car in the shaft.



Rope load report

weight watcher

Measurement time stamp: 01.01.2006 12:00:21
MSM 12 calibration date: 12.02.2008

Lift system
Name: Example
Factory number: 12 ropes
Street: Musterweg 12
City: 12121 Musterhausen

Individual rope loads

Rope	Before	After
Rope 1 [kg]	98.00	112.00
Rope 2 [kg]	120.00	114.00
Rope 3 [kg]	101.00	113.00
Rope 4 [kg]	88.00	113.00
Rope 5 [kg]	90.00	115.00
Rope 6 [kg]	150.00	113.00
Rope 7 [kg]	110.00	109.00
Rope 8 [kg]	105.00	114.00
Rope 9 [kg]	109.00	112.00
Rope 10 [kg]	143.00	114.00
Rope 11 [kg]	131.00	115.00
Rope 12 [kg]	128.00	111.00

Deviations

Prior to adjustment (01.01.2006 12:00:21)
Standard deviation: 14.55 % [17 kg]
Maximum deviation: 31.58 % [36 kg]

Following adjustment (01.01.2006 12:00:27)
Standard deviation: 1.41 % [2 kg]
Maximum deviation: 2.68 % [3 kg]

Total: 1373 kg

Fig. 6: Example of a setting report from the mobile rope load measurement system WeightWatcher. In this case, a 12-rope set is in use. The system permitted improvement of the maximum deviation between the ropes from 17 % to just 1 %, so effectively preventing premature wear.

recorded by a cable or radio link during the entire travel time of the lift and visualized in a diagram.

This ensures that all shifts in the load distribution are recorded, and can be used by the software to calculate the above-mentioned ideal load distribution. This can then be set immediately at the system by the user, with the aid of a software-assisted adjustment aid (similar to Fig. 3 and Fig. 4).

This rope set adjustment requires regular checking, as the load distribution within the rope set can easily change over time. This applies both to old systems and in particular to new ones in which ropes have yet to be fully run in.

For users, the archiving and documentation of measurement data are naturally of extreme importance, no matter whether this is derived from pure monitoring measurement processes or when adjusting the load distribution in the rope set.

Traceability and quality assurance as defined by DIN EN ISO 9001 for such an important criterion as correct/optimum rope adjustment in determining wear, service life and maintenance costs provides an important basis for lift system evaluation both for contractor and client, whether in the capacity of a maintenance or servicing company, an installer, operator, component supplier or surveyor.

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