EDUCATIONAL FOCUS: ELEVATOR SUSPENSION SYSTEMS

THE CARE OF AND FEEDING OF WEDGE SOCKETS

by Mark L. Lane

This material is directed at wedge sockets because of their use in replacing almost all the babbitt sockets in new elevator installation, as well as in service, repair and modernization. Some of the things mentioned have a commonality to both babbitt and wedge sockets and will be apparent to mechanics everywhere.

To start, hang the car carefully and securely. Next, install and connect the wedge sockets with the wire rope (Figures 1-3). After all rope ends have been terminated correctly, the most important thing to do before the car is run in any direction is to tie down all the sockets, and make certain the nuts are tight and the cotter pin is in its hole in the rod (Figures 3 and 5). Do not run the car unless the tie down, nuts and cotter pins are installed, because you don’t want to have the rope turn, as it will, and unwind the socket from the hitch plate holes, if not fixed down.

An elevator with 1:1 roping has only approximately one-half the length of wire rope than a 2:1 roped car, which makes the chance of unwinding or unraveling of the rope lower than the 2:1 car. However, all suspension sockets, wedge or babbitt, must be tied down regardless of the type of the roping. Most, if not all, elevator manufacturers have the above tie down, nuts installed, and cotter-pin-in-hole requirement in the safety section of any rope and socket installation procedure.

STEP 1: Insert the end of the lift rope down through the wedge clamp body, taking up all the slack in the rope; STEP 2: Thread the end back up through the front side of the wedge clamp body, leaving just enough loop to install the rope wedge; STEP 3: Insert the wedge into the loop; STEP 4: While pulling down on the hoist rope with one hand to keep it taut, pull up on the loose end with a quick pull until the rope loop and the wedge are seated; STEP 5: After all ropes are installed, let the weight of the car and counterweight rest on the ropes. The rope and wedge will rise about 1 inch to the final “set” under load. Cut the surplus rope off the tail end after binding so as to leave approximately a 6-inch tail. Install a retainer clip to prevent the rope wedge from slackening in the event the car or counterweight lands on the buffers. Install a second retainer clip to retain the tail end; STEP 5A: (WHEN REQUIRED – initial equalizing): Any rope or ropes tighter than the rest can be slackened and equalized by tapping the wedge down until the rope slides, using a hammer and a drift pin, which is inserted into the top of the clamp body between the rope and the tail end. Repeat on all tight ropes until all have equal tension; STEP 6: Equalize final rope tension by adjusting rod nuts while holding the wedge clamp body to prevent rotation.

Figure 1

Figure 2

Figure 3

Figure 4
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It is quite apparent that all ropes in an elevator installation should be equally tensioned for better wear on ropes and sheaves. If only three ropes in a six-rope installation are properly tensioned, adverse loads greater than designed are present on the three tensioned ropes, which creates greater load wear on the three ropes and the grooves on the sheave. In other words, three ropes are supporting the entire load designed for six ropes. Not only will adverse wear be noticed, but safety is also an issue.

There are mechanical tension testing devices, as well as load cell devices, that are in use to determine equal tension on all ropes installed. The mechanical device tests one rope at a time. The load cell device tests all ropes at the same moment of time and, since the load cells are permanently installed, routine inspections can very easily determine the tension of the ropes and adjust the ropes that are not equal to its mates. Compression springs must be used in all sockets, babbitt or wedge, to keep tension equalization as much as possible, as well as to help smooth the stops and starts of the elevator car. It may not be necessary for all ropes but certainly for either the counterweight or cab side, depending on load, speed and other factors.

An additional desired feature is isolation bushings. These are usually high-impact Delrin®, which are on the socket rods. One will go into the hitch plate hole. Others will be used to isolate the spring from the socket rod to insure no metal-to-metal touching, which results in a noiseless socket, spring and elevator installation. One method of isolation bushings and springs is illustrated in Figure 5 for both babbitt and wedge sockets.

The “care and feeding” of wedge sockets after installation is quite easy. Just check the rope tension as a rope installation requirement. The socket does not go bad, shall we say, during the life of the rope. When the time comes to shorten the rope because of rope stretch, two things must be done after hanging the car. First, never install a shortened rope into the socket and wedge if the rope is not round and has been compressed by the wedge before. Before shortening the rope, determine that when the extra length is removed, the remaining rope end is in good shape and has not been wedged previously.

Second, it is good practice to install a new wedge for the correct rope diameter. Usually, the used wedge will be hammered out using a drift pin, which will damage the wedge’s narrow tip. The wedge will also bear the impression of the rope because of the load, especially in the 3/4-, 11/16-, 7/8- and 13/16-inch rope diameters. This impression will corrugate the wedge and, if used again, will lower the load bearing ability of the rope. It has been determined by the Wire Rope Technical Board that the use of babbitt sockets at one end of the wire rope and wedge sockets at the other is quite permissible and safe and is not against ASME A17.1 Section 20.2 or B44 Canadian Code. In fact, it makes good sense when one has to shorten ropes in an existing babbitt socketed car. Cut the ropes from one babbitt end and replace with wedge sockets. From this installation time to re-roping time, one has the advantage of the ease of rope shortening or adjustment of the wedge socket. When re-roping is required in the future, the use of wedge sockets on both ends is easily performed.

Wedge sockets are now being used more and more with independent wire rope core (IWRC) ropes throughout the world. The installation procedures are the same. The use of a wedge socket for 3/8-inch and 1/2-inch governor ropes is increasing. Instructions pertaining to governor wedge sockets are the same as suspension rope sockets, except for loading and tying down.

Even with the advent of Kevlar, Aramid and flat-belt ropes, the basics are the same. Due to their slow entrance into the American market, most U.S. mechanics and installation crews, except those of the major elevator makers, will not encounter these new ropes. However, it is certain that these makers will have specific installation instructions for the type rope, as well as the sockets. When these new concepts take hold as they will, then another article on specific set of installation, “care and feeding” instructions will be written and published for all to see in ELEVATOR WORLD.

Please do not take wedge or babbitt sockets installation for granted. Remember, sockets and ropes are the primary element in creating a complete elevator system of cab and counterweight. The sockets and ropes were the first items to be mandated to have certificated test data to meet the safety codes of ASME A17.1 and to make certain that both items were extra safe the use of HIGH safety factors are part of the ASME A17.1 Section 20.2. The above installation re-roping and tie down procedures are mandated for safety and must be followed in the pursuit of safety to the riding public.

Mark L. Lane is the founder of Elevator Motors/Materials Corp. (EMCO) and president of Global Elevator Products.
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ELEVATOR ROPE INVESTIGATION

Part 1: The Machine Room

Williamsport Wirerope Works, Inc. (WWW) new Service Bulletin provides a guideline for investigating elevator problems believed to be wire-rope related. Utilizing a common investigative procedure ensures the investigator (certified inspector, service mechanic, field sales representative) has covered all bases before leaving the jobsite. Following this outline may resolve many questions in the field. However, it should be noted that not all issues can be resolved quickly. In some cases, the information gathered will be used by the wire-rope manufacturer to aid in additional analyses.

Getting Started

Prior to beginning the inspection, conduct some preliminary groundwork. Documentation is very important to current and future traceability. Record:

- Jobsite and address
- Elevator car number(s)
- Number of floors serviced by the subject car(s)
- Type of hoist rope reeving, such as 2:1 Double Wrap
- Rope description, length and manufacturer’s reel number, if known
- Customer purchase order number
- Date of rope installation
- Groove configuration of primary and secondary sheave, if applicable
- Previous service problems or car history, if available
- Nature of problem, providing as much detail as possible, including seemingly insignificant items

Tools Needed for Inspection

WWW recommends the following tools for rope inspection and investigation.

- Dial or digital gauge caliper for measuring rope diameter
- Lay paper (adding machine paper) and keel for layer length measurements
- Circumference tape to measure drum diameter
- Metal straightedge and feeler gauges for determining groove depth
- Level to check drum balance
- Chalk for performing a slippage test
- Magnet to determine metallic content of throw off
- Flashlight
- Groove gauges to check groove contours
- Watch with second hand to help in measuring rope tension
- Camera for documentation purposes

In the Machine Room

Record Machine Plate Information

Before inspecting the ropes, note and record the information on the machine plate – rope requirements, car weight, etc. This information is very important in the event the elevator OEM needs to be contacted for clarification.

Modernization

Has the car undergone a modernization? If so, when and to what extent? If the car weight has increased as a result of a modernization job, compare its new weight with that recorded on the machine plate. An increase in car weight may cause rope slippage, particularly if the new weight requires a change in rope specification (construction of grade) that has not yet been addressed. In the event the car has become heavier, contact the OEM to verify the correct rope specification for the new weight of the car.

Observe Ropes in Operation

From the machine room, observe the ropes in operation. When investigating a wear problem, ask that the car be taken to the lobby. Typically the worst area of wear is visible at the drive sheave when the car is in the lobby. To help in locating this section of wear when on top of the car, mark the ropes with chalk in this area while still in the machine room. As a reminder, always make sure that the car is clear before touching the ropes of any part of the elevator system.

Inspect the Drive Sheave

Using the sheave groove gauges, place the respective gauge into the first groove. Obviously, this needs to be in an area where the rope is not seated. Begin with the groove closest to the machine, and record this groove as Rope Groove 1. Hold the flashlight behind the gauge. If light passes beneath the gauge, a tight sheave condition is indicated. Light shining on either side of the gauge signals an oversized groove. Standard sheave gauges work best for U-grooves, but with a little practice can also be used with undercut U and progressive grooves.

To measure for differential groove depths, place a metal straightedge across the ropes at the drive sheave. Make sure the straightedge is a length which will not hinder its ability to properly indicate groove depths. The straightedge should sit neatly on all of the ropes without teetering or wobbling. A seesaw movement may signify differential groove depths. To verify the findings, measure the amount of space or clearance between the ropes and straightedge using the feeler gauges. Record the findings and mark the sheave and rope where the readings were taken. Move the car to


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rotate the drive sheave to a new section and repeat the procedure. If the findings are consistent with the first measurement, differential groove depths are present. If the readings are different, run the car through a few cycles and return to the original area on the sheave where the first reading was taken. Make sure that a different section of rope is in groove area to be remeasured. Remember, this area was marked with chalk and should be easy to locate. Using the straightedge and feeler gauges, run through the procedure a third time. If the findings verify the first test, a differential groove depth condition exists. If, however, the results are different from the first two readings, this points to a wire-rope diameter problem requiring the attention of the manufacturer's engineering department. Finally, place the level on top of the drive sheave to determine its horizontal alignment. Misaligned or skewed sheaves may cause unusual wear patterns, vibration and premature wire breakage.

Conduct a Slippage Test
To determine slippage, place the car at the top or bottom of the shaft. Using the straightedge and chalk, draw a straight line across the ropes, and also mark both sides of the sheave. Run the car through two complete cycles and measure the distance between the lines on the rope and the lines on the drum. If after operation, the lines do not match as originally marked, the ropes are slipping. Record and report the findings.

Check for Proper D/d Ratios
Using the circumference tape, measure the drum to determine the D/d ratio. Keep in mind that the minimum D/d ratio required, per code, is 40:1.

Look for Signs of Throw Off
Check the floor around the drive sheave for throw off. Also look in the less obvious places where a broom cannot reach. Placing a piece of lay paper over the magnet, run the magnet through the debris. A high metallic content, which will be picked up by the magnet, is indicative of a number of problems, including tight sheaves, improper tensioning and differential groove depths. After completing these steps, the inspection may be moved to the car top.

Part 2: Inspection From the Car Top
The most accurate rope measurements will occur from the car top. Because car tops are not designed for passenger travel, the utmost care is required to ensure your safety. Be careful where you step. Work your way to the counterweight side of the car. Make sure that there is sufficient light (drop light or flashlight) to maneuver and to take measurements.

In taking measurements, look for the area of the ropes that is showing the worst condition. If this area was marked in the machine room it may be easy to locate. If not, move the car to the position that will allow you to observe this area. If all else fails, you will have to observe the entire length of rope to find the worst area. Always check the area where the ropes are on the traction sheave with the car in the lobby. Many times this is the worst area.

When you find the worst area of wear/breakage, it is a wise idea to mark the wall (with chalk) for quicker inspection next time. You may want to draw a sketch or note the number of breaks and the date. Since wire breakage and diameter reduction are the most common reasons for rope retirement, make sure the readings are accurate. For wire breaks, inspect all planes of the ropes. Oversized U-grooves may only have a single wear plane whereas undersized grooves may have a two-plane wear pattern. Also note if valley breaks are visible. Be careful to distinguish a true valley break. In some cases, the outer wire may have failed on the crown and through the normal bending may have had a secondary break in the valley. Generally the length of the remaining wire will determine where the primary break occurred. Keep in mind the applicable retirement criteria is based on the pattern and number of wire breaks observed in a lay length.

Rope diameters should be measured in two planes at 90%. By working to the same pattern as noted in the machine room, call out the diameter readings to someone recording the values. Apply enough gauge pressure to ensure that readings are accurate. By looking for wear patterns, it may be desirable to ensure that the diameter readings are taken in the proper plane to illustrate this condition. If the rope is condemned due to excessive wire breaks and/or minimum diameter readings, your reading may be challenged. This is where the mark on the wall is critical. If the inspector marked the wall at the site of the wear/breaks, you should take your readings at this site. Too much documentation is never the problem, too little can be. Before leaving this area, it would be advisable to check the lay length of the ropes. Tear off a section of lay paper (adding machine paper) approximately 24 inches in length for each rope. Start with rope number one by placing the paper over the crowns of the rope. Use your keel to mark the crowns of the rope and note the car number. Repeat for all the ropes. Because of working constraints, it may be best to wait until you are out of the car hatch before you determine the actual lay lengths. Make sure you mark off at least five lay lengths on each rope. Measure the distance over the five lay lengths and multiply by 0.2
to determine the actual lay length. Record this information and note if the lay length of one or more ropes is considerably different than the other ropes. Extended lay readings may indicate loss of core support and corresponding diameter reduction readings or may also be caused by the ropes being “spun” out.

Not only is it important to determine if breakage is heavier to certain strands, but the pattern of breakage to the other ropes is also important. If one or two ropes are showing the prominent breakage, the ropes may not be equalized. If abrasion and wear are all to one side of the rope it may be a case of improper alignment. If the breakage is throughout, the problem may be related to groove problems, heavy loading, worn out rope or rope quality. The best place to inspect the entire circumference of the rope is from the car top. Look for uneven wear between the ropes. Note which rope(s) appear to be worn more or less than the others. Wear patterns as confirmed by the groove differences and inconsistent tensions may be the answer. Generally, the heavier the rope appears to be worn, the lower the rope tension since the ropes are sliding through the sheave groove. Another scenario may be that the tight rope may wear excessively for a while, seating itself deeper in the grooves, then it will be the loose one and start slipping.

Another area to check for diameter variations is where the ropes do not travel over a primary or secondary drive such as near the shackles. Since the shackles will not be in a perfect line, you may need to verify which rope corresponds to rope #1, #2, etc. In addition, since these ropes cannot be turned very easily, you may only get one good diameter reading.

Now is an ideal time to document the information on the car frame head plate. This will usually indicate the car weight, and the number of required ropes with their minimum breaking strength. Determine how much counterweight is being used. Look for rope tags at the hitch plate and note accordingly.

Finally, before leaving the car top, it is beneficial to record tension readings of the hoist ropes for the car being inspected. Theoretically, the rope tension should be the same anywhere within the system. However, the easiest location to measure rope tension in most elevator applications will be in the area halfway between the counterweight and the secondary sheaves. In actuality, any section of the rope in which the ropes can be easily handled will work fine. Most WWW service personnel are equipped with an Interface Product IP300 tensioning device. This simple gauge uses two points of contact six inches apart. There is a bubble inset in the gauge. The gauge is attached to the first rope and the device is attached to a torque wrench. By pushing down on the torque wrench, the tensioning device deflects the rope in the six-inch length. Since the bubble is at a precise offset angle, a set tension can be determined when the bubble is level. At this point, the tension on the torque wrench is recorded. It is best to record tensions on all the ropes and then repeat the procedure. The intent is to record readings within 10% of the two readings. By averaging out the two readings, each rope has a measured tension in foot-pounds. For the ropes to perform equally, they should be tensioned to within 10% of the highest to the lowest reading. As an example, a car with six ropes is measured using the prescribed technique. The values (ft/lbs) are recorded in the table below.

The values between the first and second readings were averaged out and were within 10%. However, of the six ropes recorded, the difference between the lowest reading (69) and highest reading (83) is more than 10%. In this case, it would appear that rope number six is taking a greater load than the other ropes. Over time, this could lead to uneven groove pressures along with shortening the service life of both the ropes and sheaves. At all times, care should be taken when measuring tensions. Position yourself in such a way that there is proper footing when you apply the pressure to the torque wrench. Never exceed the rated capacity of the torque wrench. It is best to pull down on the torque wrench rather than push up.

<table>
<thead>
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<th>Trail</th>
<th>Rope #1</th>
<th>Rope #2</th>
<th>Rope #3</th>
<th>Rope #4</th>
<th>Rope #5</th>
<th>Rope #6</th>
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<td>1</td>
<td>72</td>
<td>69</td>
<td>75</td>
<td>77</td>
<td>70</td>
<td>85</td>
</tr>
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<td>73</td>
<td>75</td>
<td>73</td>
<td>68</td>
<td>81</td>
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<tr>
<td>Avg.</td>
<td>73</td>
<td>71</td>
<td>75</td>
<td>75</td>
<td>69</td>
<td>83</td>
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</table>
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WWW does not sell the tensioning device described, however, tensioning devices are recommended for installing wire rope and for verifying tensions. If there is no tensioning device, rope tensions can be verified by the plucking method.

Plucking Method: Have someone with a watch with a second hand assist you in measuring tension. If you must rely on the harp method follow this procedure. Push the first rope approximately two-to-six inches in a plane 90% to the other ropes (so as not to effect the readings). Release the rope and count the time it takes to have the ropes complete 10 cycles. If done properly, the rope will visibly make a defined wave. At the 10th wave, stop the test and record the time. Dampen the first rope with your hand as much as possible. Do the second rope in a similar manner. Where a test rope is obviously interfered by an adjacent rope or if for any reason the test value is questioned, move on to the next rope and come back to the rope in question after the other ropes are checked. Trying to measure the tension to a rope several times in a row can create errors because of the interference from previous tests. Keep in mind that you are looking for obvious differences in readings, maybe 10% or more. The greater the time, the lower the tension. Use this data to confirm your other observations (rope diameter and/or wear patterns). Confirm that ropes are normally tensioned as part of the elevator service. Also note that you are measuring the rope frequency (length of wave) and not amplitude (depth of wave). Therefore the differences in the amount of displacement to the ropes is not an issue in case you displace one rope three inches and the next six inches. Try to stay consistent as much as possible. Obviously the longer the distance between the end points, the longer it will take to get a reading. For tall buildings, you may only get five readings before you have to do the next rope.

If an elevator rope needs to be removed due to a potential quality issue and a claim or complaint is to be entered, most manufacturers request a representative sample of the rope in question. Usually 20 feet on either side of the problem area is sufficient to perform an analysis. In addition, a 20-foot section of the same rope away from the area of damage and a 20-foot section of the adjacent rope will help tremendously in the technical investigation. Use a tag and include any notes pertaining to the problem when you return the rope to the manufacturer.

For more information on Williamsport Wirerope Works, Inc. service and technical bulletins, visit its website at www.wwrope.com.

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1. Wire Ropes in Elevators

The question is why, in the 110 years that electric elevators have been in existence, nothing better than steel wire ropes has been found when looking for a flexible suspension means. The advantages of steel wire rope include (a) its redundancy and (b) the possibility of determining the degree of bending fatigue in running ropes by visual inspection.

Redundancy means the parallel operation of many individual elements (wires) so that, even after the breakage of some of these individual elements, the assembly as a whole (the rope) can remain in operation. Chains would obviously not work. Fatigue occurs in ropes that are bent over sheaves (running ropes) by a combination of pressure and bending, tension and torsional stress. The rope is also subject to wear and corrosion. As fatigue increases, a growing number of external wire breaks makes it possible to estimate the remaining safe service life.

1.1 The Composition of Steel Wire Ropes

Why are the wires in the rope wound helically (Figure 1)? A bundle of parallel wires, held together by a plastic sheath, would probably have a much greater breaking force. However, as soon as such a bundle of wires is bent over a sheave, the disadvantage becomes obvious (Figure 2). If the wires closest to the sheave are too long, the external wires are then too short and the bundle fails immediately. A wire rope behaves differently (Figure 3). When the rope moves over the sheave, the sections of each strand, which are too long or too short, are very close together, so the strand needs only to shift slightly to compensate. The same goes for the individual wires in the strands.

1.2 The Strands

The strand structures in common use for elevator hoist ropes are:

- Seale (1-9-9) (Figure 4).
- Warrington (1-6-6+6) (Figure 5).
- Filler wire (1-6-6F-12) (Figure 6).
- Warrington-Seale with a cross section (Figure 7).

These structures are multilayer strands and are referred to under the generic term “parallel lay strands,” because all the wires run parallel to one another and are thus in linear contact with one another. This avoids the nicking of wires lying on top of one another and reduces wear within the strand.

The most common strand construction for elevator ropes worldwide is Seale. This is mostly because elevator ropes are known to get usage abrasion, and the big outer Seale wires have a large metallic area to go through before
the wires will break. However, when a comparison of the fatigue bending life of ropes on sheaves with round grooves is made, ropes of Warrington strands beat Seale ropes with 20-to-40% more lifetime. This is due to more and smaller wires per strand. Not only is there abrasion in elevator ropes, there is also a lot of fatigue bending, especially in elevators with double-wrap drives or in roped-hydraulic elevators where the latter is more important.

**Filler wire** strand construction withstands fatigue bending better. Suspension ropes, up from 16 millimeter (5/8 inch) with six-to-nine outer strands should have at least Filler wire strands because of better flexibility. The disadvantage of this strand construction is that it is very vulnerable to geometry distortion, especially when the Filler wire itself does not have the correct diameter. The recommendation is not to use Filler wire strands for ropes below a 10-millimeter diameter.

**Warrington-Seale** rope construction is normally unsuitable for suspension and governor ropes, because of a vulnerability to geometry faults and/or a lack of inner lubrication and/or distortion by drive sheaves with V-grooves or undercut U-grooves. However, well-lubricated Warrington-Seale 6x26 ropes have proven to be a solution for drives with a lot of narrowly arranged sheaves and reverse bendings. Also, for bigger rope diameters, ropes of this strand construction should be chosen, since compensating ropes up from 24 millimeter are not flexible enough with accustomed strand constructions.

### 2. Elevator Ropes

#### 2.1 The “Ideal Elevator Rope”

The layman presumes that there has to be “the ideal elevator rope.” However, in a traction-drive elevator, a rope suffers from the bendings (over the sheaves) on the one hand and by wear (slippage on the traction and deflection sheaves) on the other. The solution in the first case would be a rope construction with thin wires, and in the second case, a rope with relatively few, but thick wires. Depending on which of the two forms of strain the observer considers to be more important, he selects the appropriate rope or strand construction, e.g., Warrington (12 outer wires per strand) instead of Seale (nine outer wires per strand). Therefore, the ideal elevator rope does not exist, just as there is not one elevator. In terms of price and performance, it is not advisable to use just one rope design for low- and high-rise drive sheave elevators, roped-hydraulic elevators, small goods elevators, together with other rope applications in elevators, tensioned balance ropes and governor ropes. It is also understandable when a user thinks very carefully about the financial aspects of using high-performance ropes for his slow-moving, seldom used elevator.

The simplest elevator rope is made by closing six strands in the above mentioned strand constructions. Nowadays, there have been several developments regarding elevator ropes made with a steel core instead of a fiber core. A lot of these rope constructions are relatively new on the market, considering the long rope service life. A few of them have proven to be successful for a long time, some for over 40 years. One of them, the DRAKO 300 T, was probably the first elevator rope in the world with a steel core. It was designed in 1955 by DRAKO. After this rope was nationally and internationally successful in demanding building projects, ropes with steel core are not covered in relevant European and International Organization of Standardization (ISO) standards.

#### 2.1.1 Steel Core Elevator Ropes

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#### 2.2 Typical Elevator Ropes

The following is a short overview about well-known rope designs used for elevators. The statements are based on DRAKO’s experiences as a partner to the elevator industry during the last several decades of special elevator rope production.

Unfortunately, the expectations are contrary to one another:
- Ropes should develop only small wear (which could be solved by big wires or high tensile strength).
- Ropes should have a high fatigue bending life when running over sheaves (which could be solved by small diameter wires).
- Ropes should not cause wear of the drive sheave (to be solved by wires of low tensile strength grade).
- Ropes should elongate only in a small amount for less rope shortenings and for better ride quality (to be solved by a high metallic cross-section or a high quality fiber core).
- Ropes should be cheap (to be solved by as few as possible steel wires in the rope and a low quality fiber core).
To fulfill all these expectations is not currently possible. So the user should determine which characteristic is the most important. When it comes to higher and higher shafts involving rope lengths, rope construction will be selected more and more according to its elongation characteristics.

2.2.1 Six-Strand Ropes with Fiber Core (Figure 8)

Advantages:

- Big metallic cross-section: i.e., high-breaking force compared to diameter.
- Relatively small permanent and elastic elongation.
- Low price per meter.

Application: For low-speed goods elevators and low-duty elevators for persons.

Note: These ropes are generally not suitable for grooves with big undercuts.

2.2.2 Eight-Strand Ropes with Fiber Core

Advantages:

- Rounder than six-strand ropes: i.e., more contact points in rope to groove.
- Slightly deformed in cross-section: i.e., the new rope adapts a little bit to slightly worn out grooves.
- Wires smaller in diameter: i.e., more flexible, good fatigue bending characteristics.
- Medium price per meter.

Application: The rope construction 8x19 Seale with fiber core (Figure 9) is without doubt the world’s most common traction drive suspension rope. However, the rope construction 8x19 Warrington with fiber core (Figure 10) has its market share in Germany and the U.K. due to better fatigue bending properties. Eight-strand ropes with natural fiber core are the best solution for normal drive sheave elevators.

Note: The rope quality of this rope construction depends on the quality of the fibers and the resulting fiber core.

2.2.3 Eight-Strand Ropes with Steelcore

The eight-strand rope with steelcore has most of the advantages and only a few of the disadvantages of the eight-strand rope with fiber core (Figure 11).

Advantages:

- Rounder than six-strand ropes.
- Flexible: i.e., good fatigue bending characteristic.
- Low permanent and elastic elongation.
- Low reduction in diameter.
- High breaking force compared to diameter.
- Remains round: suitable for grooves with wide undercut.

Application: This is ideal for the medium-duty elevator, requiring only minimum maintenance, especially for rope lengths from 50 to 100 meters.

Note: Rope terminations must be secured against rotation. This is valid for all types of ropes in elevators. For greater shaft heights, prevent ropes from untwisting during installation.

2.2.4 Nine-Strand Ropes with Steelcore

The lift rope with nine outer strands only comes with steelcore (fiber core is too deformed for use) and was developed in 1955 in Germany, and slowly became familiar to elevator companies outside Europe (Figure 12).
Advantages:
- Very round cross-section: i.e., small pressure in the groove.
- Many wires: i.e., flexible, very good fatigue bending life.
- Reduction of non-visible inner wire breaks: it is possible to avoid wire crossings inside the rope by a special configuration of the wires in the strands and of the strands in the rope.
- Small permanent and elastic elongation: the car is better connected to the machine (important in high shafts) and results in easy, quick and correct approaches to the floors.

Application: This is the most efficient solution for suspension rope in high-rise elevators and all drive sheave elevators with several deflection sheaves.

Note: Rope terminations must be secured against rotation. This is especially important for long shaft heights. To control and secure against rotation, it would be useful to have a marking line along the rope. At rope replacement, the grooves of the drive sheave should be controlled (gauge).

2.2.5 Parallel Closed Ropes

All the full-steel ropes previously discussed are manufactured by producing a steelcore and then closing the outer strands around this core in a second step. This rope type is called “... with steelcore.” The result is a stable rope, relatively insensitive against opening up because of outer influences. However, it is also possible to close all the strands of a full-steel rope (Figure 13, cross-section of Figure 14). This is another type of full-steel rope. The result is a rope with a big breaking force, possibly with a high number of cycles in a fatigue bending test machine with short ropes. On the other hand, it is very sensitive to incorrect mounting (which can easily happen with this rope type) and deflection, for instance, in installations with a 2:1 suspension. Application together with polymer sheaves may also seem critical. Parallel closed ropes of 40 meters and less have no reported problems, but whether or not longer ropes will work satisfactorily, depends on the experience of the respective rope manufacturer and to a high degree on the elevator design.

2.3 Suspension Ropes for Roped-Hydraulic Elevators

The difference between a roped-hydraulic unit and an elevator with drive sheave is that the roped-hydraulic can use ropes with different characteristics. Higher specific rope loads (no undercut grooves) and better lubricated ropes (no friction factor to consider) are possible. The traditional rope used by this unit is a six-strand rope with fiber core (Figure 8) very often heavily prestretched. However, eight-strand ropes with steelcore (Figure 11) and even nine-strand ropes (Figure 12) can be used. The common rope grade is 1770. The ropes with steelcore can sometimes be 1570 or 1570/1770.

2.4 Compensating Ropes (Balance Ropes)

Very often, for compensating ropes and suspension ropes, the same rope type and diameter is used. But the purpose and operating conditions of these two applications differ considerably. A 20-year experience nudges toward the use of special balance ropes. The gain is a higher service life, better ride comfort and stable rope lengths. The use of special compensating ropes includes a higher amount of lubricant and a smaller number of bigger ropes reducing the number of tensioning sheaves. Since big ropes at a low D/d-ratio are used, ropes with a more flexible rope construction should be used (Figure 15). Often when two tensioning sheaves are arranged in tandem, rope deflection and rope twisting is possible in the case of inexact alignment of the two sheaves. This will lead, together with the low rope tensions of this application, to possible early rope damage, when using ropes with steelcore.

Ropes with natural fiber core at the prevailing low tensions react to changes in humidity within the hoistway (construction phase, monsoon rains, etc.) with considerable changes in length. Synthetic fiber cores have proven a valuable solution to this problem. The recommendation for compensating ropes is a six-strand rope with synthetic fiber core, strand construction dependant on rope diameter, with 6x25 filler for diameters 13 to 25 and 6x36 WS for the bigger ropes. Also, ropes 8x25 Filler + fiber core are used periodically. (Advantage: flexibility. Disadvantage: low unit weight.)
2.5 Ropes for Governors

These ropes are important functional components of overspeed controllers and safety gears. The force is mainly transmitted by friction, so it is essential that the lubrication of governor ropes is carefully dosed. Since the introduction of safety gears for both directions, governor ropes with higher breaking forces are required, which can be achieved by bigger rope diameters by the use of higher rope grades or by full-steel ropes.

The common governor rope is six-strand with fiber core, mostly 6x19 Warrington + FC (Figure 8), with diameters of 6.0 and 6.5 millimeters and rope grades 1770 and even 1960. EN81 has no such restriction for the rope grades of governor ropes as there is for suspension ropes.

With increasing shaft heights and the necessary increasing loads, ropes of 8- to 10- (and even 13) millimeter diameter, construction 8x19 Seale or Warrington with steelcore (Figure 11), are typically in use.

For governor ropes with fiber core in high-rise buildings, the choice of ropes with synthetic fiber core and in a heavily prestretched condition should be considered. In the U.S., there is a certain amount of governor ropes with rope grade “IRON” in application. This low rope grade, leading to outer wires of approximately 700 Npmm², becomes necessary in case of brass brake shoes. It is assumed they will wear out too quickly with ropes of higher grade.

Some of the modern governors do not grip the governor rope by the blocked governor sheave, but by closing brake shoes. For this special application, the rope should not have too small of wires and too fine of strands. The above described types of governor ropes are working well in most types of governors. However, the supplier of the governor should have the last word about which rope should be selected.

2.5 Conclusion

For the normal everyday business, the 8x19 rope with fiber core is an excellent choice. For more sophisticated jobs, the user should have knowledge about approved possibilities.

Note: When new and so-called better rope constructions are advertised, the user should take into consideration that it needs at least 10 years of successful running in installations of different types to be certain to have an approved elevator rope.

3. Elevator Ropes in Operation

3.1 Supply and Installation

Elevator ropes are very often supplied ready for the individual elevator installation concerned. The ropes are usually bright steel ropes with relatively little lubrication. As such, they must be protected against corrosion, if they are to be stored for a longer period, before installation. It is recommended that the ropes be stored on a wooden pallet, protected against moisture and dust, particularly cement dust, in a room, which should be at least slightly heated. Covers should not hermetically enclose the ropes to allow air to have access to the rope. If not, the resulting greenhouse climate would quickly cause corrosion.

3.2 Possible Damages at Rope Installation

The basic rules of rope handling (Figure 16) must be observed. Pulling the rope sideways off the reel or off the coil will cause the rope to open up or tighten. This twisting alters the structure of the rope, which cannot be remedied later. The forced twists lead to different lengths in the strands of ropes with steelcore. Consequently, the load is distributed unevenly through the rope. Strands, which have become too long, protrude from the rope shortly after going in service.

3.2.1 Kinks

A kink is the result of unreeling the rope incorrectly during installation, of a certain amount of spin left over from the manufacturing process or of a lack of care and attention when mounting the ropes. If kinked (Figure 17), the rope should be returned to its original shape only by twisting it at one of its ends. Trying to cure the rope by twisting the kink itself or by loading the rope will inevitably result in damage (Figure 18). The rope is then permanently damaged and must be replaced.
3.2.2 Opened Up Ropes

In the case of longer lengths (over approximately 80 meters), the rope, hanging free in a shaft, will untwist due to its own weight. The same thing happens when it is drawn upward by a thin auxiliary rope. Lang lay ropes, ropes with steelcore and especially parallel closed ropes are already in an opened-up condition and their structure has become loose. This is why the experienced elevator rope manufacturer has a marking line along those ropes. The marking line enables the installer to return the rope to its original condition. These are usually used in high-rise applications.

3.2.3 Pulling Ropes Over Sharp Edges

If a rope is pulled over a sharp concrete or steel edge, it will inevitably be damaged; its own weight is enough to have a negative effect. A corkscrew-shaped deformation in one section of the slack rope is typical for this kind of damage can be prevented, if auxiliary rollers or rounded wooden beams are used to deflect the rope.

3.2.4 Pulling Ropes Over the Ground

Ropes should not be pulled over dusty or sandy ground, as the exterior lubrication will pick up the loose particles of dirt. This gives the rope a rough surface, which results in uneven running and an increase in wear on ropes and sheaves (abrasion). The dust will also soak up the lubricant.

4. Rope Elongation

A lot of misunderstanding is found around the phrase “rope elongation,” mainly because ropes have no clearly defined modulus of elasticity (E-modulus), that remains more or less constant throughout the service life as is the case for steel rods. Also confusing is the problem that people in the elevator industry ask for values of rope elongation from different perspectives. Furthermore, how much ropes of a similar construction stretch depends greatly on the rope manufacturer.

4.1 Rope Load – Rope Elongation Diagrams

When it comes to higher shafts, i.e., rope length, the rope construction will be selected according to its elongation characteristics. Often, requests for the E-modulus of the rope are requested, however, there is no such thing, at least not without additional explanations and assumptions. An explanation of the elongation of ropes is found in Figures 19-23, which is also dependent on rope construction and the rope manufacturer. Elongation test results on new ropes with a 13-millimeter diameter are found in Figures 19 to 22. Curve 1 is always the first loading of the new rope up to 10% of Minimum Breaking force (MBL). Then the rope is loaded 10 times up to 50% of MBL. Curve 2 follows with the same load as Curve 1. The steepness of the curves is a measure for the elastic elongation (bouncing of the car, etc.) and the horizontal difference between Curve 1 and 2 is a certain measure for the permanent elongation (number of the rope shortening operations, etc.).
Load-elongation curves are not straight lines (Figure 22), which is why describing the elongation characteristic by an E-modulus number is only possible within small load sections. It is also obvious, that the first loading curves (1) are shallower than the later ones (2), i.e., elongation decreases with ongoing loadings. Permanent elongation has also taken place, visible by different elongations of Curve 1 and 2 at zero load. This trend will go on and on with reduced speed. To give an approximate value of the whole permanent rope elongation would only be possible for elevator maintenance personnel by adding up all rope shortenings within a rope’s service life.

Figure 19 compares six- and eight-strand ropes with fiber cores. Figure 20 demonstrates the differences in the elongation characteristics of eight-strand ropes with fiber core (FC) and with steelcore (IWRC). There is an extraordinary difference in elongation between eight-strand ropes with fiber core and a nine-strand steelcore rope (Figure 21). Figures 20 to 22 also show the dependence of rope elongation on rope construction.

Ropes of the same metallic cross-section (Figure 22) influence elongation due to the rope construction. The influence of the rope manufacturer is also considerable. Figure 23 shows a comparison between 8x19 Seale + FC ropes of different origin. One rope is of DRAKO production, the other one has been produced by an established elevator rope manufacturer. With the help of such load-elongation tests, the most frequent rope elongation questions can be explained.

### 4.2 Precautionary Shortening Before Fixing the Ropes

How much shorter should new, untensioned ropes be mounted in order to have the correct rope length after a number of runs up and down? The question is especially important with high-rise installations (Figure 22), which shows the elongation between point zero and a point (for instance point A) with a certain service load on Curve 2, i.e., a mixture of permanent stretch and elastic elongation. In the U.S., there are traditional existing values (preformed ropes) of 6x19 + FC: nine inch per 100 feet=0.75% or 8x19 + FC: 12 inch per 100 feet=1.0%.

The figures are much lower for ropes with a less compressible fiber core (with a lower level of lubrication) and where a certain amount of prestretching is carried out while the rope is manufactured (e.g., approximately six-strand ropes + FC: 0.45% and eight-strand ropes + FC: 0.55%). For ropes with steelcore, the values are once more much smaller: approximately 0.15-0.35%, depending on the structure of the steelcore. These generalized reference values are all based on “normal” rope tension. The rope manufacturer is hardly in a position to give exact information, as the real elongation is dependent on the actual installation, rope safety factors, car load, pay load, and in the case of a high rise, the rope’s own weight.

### 4.3 Sagging of the Car When Loaded

The amount of car sagging when loaded is mostly a matter of rope length, for example, the additional length of a basement machine (not of a 2:1 suspension). In high-rise buildings, which are the most prestigious projects, there are great expectations concerning ride quality. In such cases, the experienced elevator engineer or consultant is planning one rope more than he would have installed in a conventional elevator. This leads to fewer activities of the re-leveling device. The car sagging portion, which is caused by rope elasticity, is illustrated in Figure 22. It is the difference in elongation between point B and point A on Curve 2. The rope manufacturer can supply figures, but they only give a clue because of the dependence of the E-modulus on the load and service time of the rope (Figure 24).

<table>
<thead>
<tr>
<th>Rope construction</th>
<th>“Modulus of Elasticity”</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>New rope</td>
</tr>
<tr>
<td>6 x 19 + natural fiber core</td>
<td>ca. 70.000</td>
</tr>
<tr>
<td>8 x 19 + natural fiber core</td>
<td>ca. 65.000</td>
</tr>
<tr>
<td>Ropes with steel core with or with only few fiber material</td>
<td>ca. 70.000</td>
</tr>
</tbody>
</table>

Figure 24

Changing 8x19 + FC ropes to those with a full-steel core, but in all other items maintaining the parameters of the installation, the elastic elongation of the ropes drops by 50%. This considerable difference is due to the different E-moduli, on the one hand, and to the substantially larger metal cross-section of the ropes with steel core on the other. Rope elasticity is the most important, but not the only reason for the sagging of the car. Apart from the compression of the springs at the rope terminals, the elasticity of the car frame has a surprisingly great influence on the sag of the car when loaded. It is easy to verify this by measuring the latter on the ground floor and on the top floor.

Note: When ropes are showing elongation behavior, the ropes should be checked for possible incorrect mounting, i.e., opening up. Also, non-rotation secured rope terminations can lead to opened up ropes. Ropes with steelcore, parallel closed ropes and lang lay ropes show, when opened up, considerable higher elasticity. There is a rumor, that elasticity can be “improved,” i.e., reduced, by closing even well-mounted ropes. This is wrong. Rope elasticity may be reduced for a short time, but the rope’s service life will be drastically reduced.

### 5. Relubrication

Elevator ropes are lubricated during manufacturing in order to reduce corrosion and abrasion in service. The quality of lubricant in the rope on delivery must be such that even elevators with sufficient traction capability do...
not slip. It is very rare that the initial lubrication will last for the entire service life of the rope, mostly due to dust and abrasion. Therefore, it is advisable to relubricate elevator ropes from time to time. Relubrication is not necessary if a finger run over the rope, picks up a slightly greasy film.

5.1 Intervals Between Relubrication
No advice can be given because intervals are dependent on:

- The frequency of use.
- The environment (temperature, dust, shaft climate).
- Sheave material and sheave wear (with hardened drive sheaves ropes needing more lubrication, as with no sheave wear, no graphite surfaces).
- The amount of slip between rope and drive sheave.

5.2 Methods of Lubrication
Relubrication can be carried out using an oil can and a brush or a paint roller. Spray cans should only be used for short lengths of rope. Only small quantities of lubricant should ever be applied, and the elevator should then be run up and down several times. Observe the slip behavior of the elevator. If necessary, apply more lubricant. When there are any doubts that there will be enough traction capability after relubricating, a roundtrip should be performed before and after the lubrication action. (Roundtrip: i.e., with the car on top, marking the ropes and the drive sheave with chalk and run car to basement and back to top.) The displacement between the marking on ropes and on sheave should not be altered significantly by the relubrication. Permanent lubrication devices can cause problems when used for longer periods and on systems with a low-traction reserve. However, such devices are successful with some types of double-wrap machines (sufficient friction) when used only one day at a time.

5.3 Lubricants for Relubrication
The lubricant should not be too fluid, but should be able to creep into the rope. Lubricants which contain a solvent are most suitable. Caution use (good ventilation) and careful dosing (a solvent which is not fully evaporated reduces the friction factor) is the preferred combination.
In some countries, lubricants with solvents are prohibited by labor safety regulations. In such cases, as well as in all cases of doubt, use of an elevator rope oil of an experienced supplier or, if not available, a machine oil of medium viscosity is recommended. Hydraulic oils and worm gear oil are not suitable.

Lubricants, containing solid lubricating additives (e.g., molybdenum sulphide) are unsuitable at least for use on traction drive elevators, as these substances reduce friction between the rope and the sheave to an unacceptable level. Ropes for roped-hydraulic lifts and compensating ropes should be lubricated more often. It is possible on these applications to use rope grease as a lubricant. The common lubricants for drive sheave ropes should also be used for these ropes.

5.4 Relubrication of Installations in Unusual Environments

5.4.1 Humidity in the Hoistway
This does not require any special precautions, just more frequent controls or perhaps the use of galvanized ropes.

5.4.2 Open Air Elevators
Except for dry climates, the use of galvanized ropes is recommended. A water-resistant lubricant is recommended in these applications. Galvanized ropes also need relubrication. In outdoor environments, lubricants with solvents should be used (if not prohibited by national regulations), applied when the weather is not hot and when ropes have not been exposed to rain in some days.

5.4.3 Installation Exposed to Extreme Temperatures
There are few installations which have hot or cold environments consistently, however, no special lubrication at temperatures of 0° to 50°C is necessary. Temperatures between 40° to 50°C installations should be checked more often, as the lubricant will become more liquid and more consumable. The lubricating capability is also reduced.

5.4.4 Permanent Very Low Temperatures (Cold Storage)
It is suggested that the mechanic use a standard lubricant without a solvent in an open saucer in permanent, low-temperature environments. The lubricity and viscosity should be checked after one day (not with warm fingers as this would give incorrect results). If the lubricant becomes solid under these conditions, a lubricant of lower viscosity should be used. The wrong lubricant can cause the ropes to stiffen and reduce rope life.

6. Development of Rust
If rust, especially powder-like red rust, is noticed in the valleys between the strands, the first step is to measure the rope diameter of these sections carefully.

6.1 Rust as a Result of Insufficient Lubrication
If the diameter measured is a maximum of 3-4% below the nominal diameter, the ropes can generally be saved with expert relubrication, using a suitable lubricant. In this case, very often rust develops as a result of insufficient lubrication/relubrication in a humid or aggressive hoistway atmosphere. Another reason is the use of unsuitable relubrication substances, which seal the surface of the rope and prevent further penetration with increased internal abrasion as a result of the strands rubbing against one another and against the core. This abrasion appears as a red rust powder. For outdoor installations of bright steel wire elevator rope, even relubrication is not a help against internal rusting; high-speed
winds normally blow around high buildings and force rain deep into the inside of the rope. In such cases, galvanized elevator ropes with a special waterproofed lubrication should be used.

6.2 Rust Due to High Friction Between the Outer Strands

In this case, measuring the diameter of the ropes reveals a decrease in the nominal diameter of 5% and more, relubrication cannot help, and the ropes will have to be replaced. The diameter decrease is caused by a reduction in the diameter of the rope core. The outer strands, then, press on each other so strongly (Figure 25) that the wires on the contact lines strand to strand become nicked. The resulting abrasion is not metallically bright, but red-brown. This is called “rope bleeding,” also known as “red dust” in the U.S. The inherent danger here is the possibility of inner wire breaks, which only become visible once the rope is unloaded and bent (Figures 26 and 27). Long wire break ends are typical (valley breaks). Here, the negative effect of a thin fiber core becomes obvious.

7. Prospects

From time to time, there is news about new high-rise buildings and even super-high-rise projects. It begs the question, if elevators for full building height would make sense with a traffic capacity analysis, but at least until now, the rope manufacturer is able to do his part. According to the high requirements made on the fatigue resistance of the wire material, today’s upper limit for the tensile strength grade for elevator rope wire is 1960 Npmm². This makes it possible to build elevators with a shaft height of up to 600 meters. Note: The EN81 does not allow rope grade 1960 for suspension ropes, but as it is normal practice that elevator companies get special allowances from Notified Bodies for their special designs, it may not be such a problem to demonstrate the suitability of 1960-grade suspension ropes, especially as there are already 1960 grade governor ropes in use.

European lift rope Standard EN 12385, Part 5 [2] provides tables with preferable rope diameters to reduce the great variety of diameters. The biggest diameter for hoist ropes used today is 22 millimeters (7/8 inch). There is a trend toward suspension ropes of a small diameter, i.e., rope diameters of 8 to 10 millimeters (3/8 inch) or smaller.

8. Conclusion

Elevator manufacturers, rope suppliers, maintenance companies and authorities are traditionally linked with the rope-suspended elevator. The lessons of errors and accidents have been learned and calculation methods, design and regulations have been altered and supplemented accordingly. This has led to the elevator becoming one of the safest methods of transportation.

Nevertheless, one still occasionally finds systems, where the designer, customer or architect has taken the function of the rope for granted. When ropes are made to pass over more than a dozen sheaves, ropes are twisted and deflected in the most exotic fashion, when people are convinced, that 10, 12 or more parallel ropes are all of equal tension, when an ultra-light or extremely heavy car (compared with the payload) is installed, then it must perhaps later be admitted, that new territories have been entered and the result will be a shorter service life of the rope. Once more, in those cases, some people have forgotten that the conventional, simple elevator with the overhead drive machine is so economic and safe because there is a long-lasting and broad-based experience with this type of elevator.

Dr.-Ing. Michael Molkow is a member of CEN TC/168/WG2 (Ropes and Rope Terminations) and chairman of ISO TC/105/WG4 (Revision of ISO 4344 Steel Wire Ropes for Lifts). He retired May 2000. Molkow earned his doctorate degree in 1982 and then joined Drahtseilerei Kocks (DRAKO) in Germany, where he later held the position of managing director.

Dr.-Ing. Wolfgang Scheunemann is the technical director of DRAKO and works on several national and international standardization working groups. He holds a doctorate degree from the University of Bochum.
COMPENSATION WEIGHT: A NEW SOLUTION TO BALANCING THE HOIST ROPE WEIGHT

by Markus Grüter and Michael Pohle

Introduction

The weight of the hoist ropes has to be balanced in order to reduce the maximum power of the machine. Especially in mid-rise and high-rise applications, the weight of the hoist ropes cannot be neglected. If the car is on the top floor, the mass of the steel wire ropes adds up to the counterweight. If the car is on the first floor, the mass of the steel wire ropes adds up to the cabin weight. For example, for an elevator with a height of 300 feet and ropes with a mass of four pounds per feet, a total mass difference of 1,200 pounds occurs without compensation.

There are many different solutions on the market to compensate the weight of the steel wire ropes. We would like to introduce a new solution, which is based on the construction principles of flat traveling cables. Today, available products are based on chains or ropes. The principle of all the solutions is the same: Balancing the steel wire ropes weight by a link between the elevator car and the counterweight (Figure 1).

The demands on such a balancing weight includes:

- High flexibility (continuously in motion)
- No swinging or twisting
- Long-lasting (life span of 10,000,000 flex cycles)
- Low-noise (ride comfort)
- Easy to install (saving time and money)

The compensation weight from Dätwyler Inc. meets all these requirements.

Product Design

This product is designed similar to traveling cables. Compensation weight (Figure 2) has the form of a flat traveling cable which comprises steel supporting members in combination with weight elements in a flexible sheath. The weight elements contain a mixture of plastics materials and powdered metal salts with a mass density of $\geq 2.3$ grams per centimeter cubed, and the outer sheath is made of a plastic material (PVC compound).

This construction leads to high flexibility and a very smooth motion. Compared to ropes, there is no noise during the operation of the elevator. The same aesthetics of the traveling cable and the compensation weight gives a similar appearance especially in panoramic elevators. Furthermore, the kind of installation is similar to the installation of traveling cables. Therefore no additional tools for the installation are needed (see Installation). Due to the very smooth movement of the compensation weight, no additional bearings are required. This results in a very short installation time. Because of the flat construction, no torsion of this compensation weight can occur. After the installation, no further adjustment is needed. Optionally, the weight elements are provided at the center with electrical wires.

Product Properties

The standard compensation weight as well as the one with electrical conductors is available in eight sizes from 1.1 kilogram per meter ($\approx 0.75$ pounds per feet) up to six kilograms per meter ($\approx$ four pounds per feet). This fits to all of the commonly used steel wire ropes. Compensation weight provides smooth operation at temperature of -15°C to +70°C and can be used up to a free suspension length of 220 meters ($\approx$ 722 feet) and a running speed of 10.0mps ($\approx$ 33fps). It has to be mentioned that the standard allows weight compensation systems without look down only up to a velocity of 3.5mps. Elevators with a running speed of more than 3.5mps need to have a look down. Then, mostly wire ropes are in use for compensation. As a result of the high flexibility, the necessary loop diameter is very small. The chemical properties of weather, water, acid and alkaline resistance are good.

Installation

Compensation weight is typically mounted between the elevator car center and the counterweight, where each end is terminated (Figure 3).
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Determination of Size

To determine the right size of compensation weight, the following information is necessary:

- Number of hoist ropes per car.
- Weight per meter (feet) of the hoist ropes.
- Car roping.
- Number of compensation weights per car.
- Length of compensation weight needed.

The equation for the calculation of the mass of the compensation weight is:

\[ m_c = \frac{m_s - m_t}{2} \]

where:

- \( m_c \): Mass of compensation weight
- \( m_t \): Mass of traveling cable
- \( m_s \): Mass of all ropes
- \( m_{s1} \): Mass of one rope
- \( n \): Number of ropes

Benefits

Using compensation weight provides several benefits:

- Absolutely silent and perfectly balanced compensation of tensile forces.
- Time- and money-saving installation including preparation, extremely simple stripping of support members.
- No need of roller guides.
- Smooth operation because of excellent flexibility with no twisting of the compensation weight.

Conclusion

A number of different solutions to compensate the tensile forces over the traction sheave are available. Each of these solutions has advantages and disadvantages, and it is up to the elevator contractors to insure the use of the best product for the application. The presented solution offers the lift manufacturer an easy, safe and efficient method for balancing the hoist wire ropes. The compensation weight has a smooth movement, a short installation time without the need of additional adjustment and an attractive total cost of ownership.

Markus Grüter is manager of Product Management of Lift Cables+System since 2002. Prior to joining Dätwyler, he was manager of Product Management at Electrolux Professional. A native of Switzerland, Grüter holds a BA degree in Electrical Engineering.

Michael Pohle is the manager of research and development of Lift Cables+Systems at Dätwyler Inc. since 2001. Prior to joining Dätwyler, he was manager of Strategic Technology Development at ABB Asea Brown Boveri. A native of Germany, Pohle holds a master’s degree in Electrical Engineering.
Educational Focus: Elevator Suspension Systems

How to Correctly Order Wire Rope

by Howie Frank

The Problem:
The high cost and customer inconvenience of ordering the wrong type of wire rope.

A common complaint is excessive rope stretch (beyond the maximum of 12 inches per 100 feet), usually shown by improper leveling and/or releveling. In many cases, traction ropes are ordered when extra high strength ropes should have been ordered. If this occurs, the safety factors required by American Society of Mechanical Engineers (ASME) Codes have not been met, and the ropes must be replaced.

Why This Happens:
The major cause is placing an order by using information taken from a rope tag.

Although most rope tags reflect accurate information, the high cost of the labor and material required to replace a set of ropes makes it imperative that the right ropes are ordered the first time.

The Solution:
Don’t rely on information on the rope tag when ordering.

To place a proper rope order, you will need to determine:
1. Number of reels or pieces
2. Feet per reel
3. Diameter
4. Construction
5. Rope grade, e.g., iron, traction or extra high strength traction
6. Right Regular lay or Right Lang lay
7. Preformed or non-preformed
8. Core type

Ordering Hoist Ropes:

To order hoist ropes for a traction elevator without using the rope tag, you must:
1. Determine how many ropes are on the elevator (e.g., six).
2. Measure the length of each rope (e.g., 550 feet each).
3. Check the diameter of the ropes (e.g., 1/2 inch). If you don’t have a measuring tool, go to the Crosshead Data Plate on top of the car where you will find the diameter and the breaking strength of the ropes.
4. Construction refers to the number of strands per rope, the number of wires per strand and the rope design (e.g., 8 x 19 Seale, 8 X 19 Warrington or 6 x 25 Filler Wire) (Figure 1). Again, the Crosshead Data Plate will give you the breaking strength of the ropes. Example: for an application with a breaking strength of 14,500 pounds, refer to Table 1 and choose a rope with a minimum breaking strength of 14,500 pounds.

Confirm whether the rope is six or eight strands by looking at the shackles (count the number of rosettes in a babbitted shackle or the number of strands in the dead end of a wedge shackle).

A six-strand rope will be 6 x 25 Filler Wire construction with Right Regular lay. An eight-strand rope will be 8 x 19 Seale rope. You will still need to determine if it is Regular lay or Lang lay (see number 6 below).

5. Rope grade refers to iron, traction or extra high strength traction.

Iron grade is normally used for governor and compensation ropes.

Traction rope can be used for hoist, governor and compensation application.

Extra High Strength rope is needed under high-rise and high-speed conditions.

6. Determine the lay of the rope. Compare a Right Regular lay rope to a Right Lang lay rope (Figure 2). You will note that the direction of the strands in both cases is clockwise around the core, or spiraling to the right. But look at the direction of the wires in the strands. In Right Regular lay rope, the wires go in the same direction as the rope. In a Right Lang lay rope, the wires do not go in the same direction as the rope. If lay is not indicated on your order, Right Regular lay is assumed.

7. Preformed rope is the industry standard (non-preformed ropes are becoming more expensive and harder to find) and provide superior fatigue life while being much easier to work with. We assume that all rope orders are for preformed rope unless otherwise indicated.

A preformed rope has the strands formed into place around the core when it is manufactured. You can tell a preformed rope on a wedge shackle if the dead end of the rope is not seized or just has tape around it. If a rope is non-preformed, the wire will flare out. On a babbitted shackle, you cannot tell if rope is non-preformed.

8. Except for specialty ropes, all standard elevator ropes are Vegetable Fiber Core (VFC).

NOTE: If there is not a Crosshead Data Plate and the building is 50 years or older, the ropes used at that time were 6 x 25 Filler Wire.
**EDUCATIONAL FOCUS: ELEVATOR SUSPENSION SYSTEMS**

Ordering Governor or Compensation Ropes

You may have to rely on the rope tags to a greater degree, because there is no Crosshead Data Plate for the governor or compensation ropes. However:

1. Measure the diameter of the ropes with a caliper or micrometer.
2. Go to the shackles and count the number of strands (six or eight) in the rope to confirm how many strands you need. Almost all compensation and governor ropes have eight strands (Figure 3). Look at the rope tag to determine breaking strength and compare this to the information in Table 1 to determine if the rope is traction or iron grade.
3. Determine the rope grade. Governor and compensation ropes are either iron or traction grade and never extra high strength.
4. Governor and compensation ropes are always Right Regular lay and never Lang lay. If your tag says Lang lay, take extra care to visually inspect it using Step 8 in the Ordering Hoist Ropes section.
5. Preformed rope is preferred. You will get better fatigue life, as well as a rope that is easier to work with. Governor and compensation ropes have not been converted to preformed should be.

Howie Frank is Draka Elevator Product’s resident expert on wire rope. For more information, contact him at e-mail: hfrank@drakausa.com.

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### Table 1: Rated breaking strength of elevator wire ropes

<table>
<thead>
<tr>
<th>Diameter</th>
<th>8 x 19 &amp; 6 x 19 EHS traction</th>
<th>8 x 19 EHS traction</th>
<th>6 x 19 EHS traction</th>
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</thead>
<tbody>
<tr>
<td>1/4 • 6.5</td>
<td>1,800</td>
<td>3,600</td>
<td>4,500</td>
</tr>
<tr>
<td>5/16 • 8.0</td>
<td>2,900</td>
<td>5,600</td>
<td>6,900</td>
</tr>
<tr>
<td>3/8 • 9.5</td>
<td>4,200</td>
<td>8,200</td>
<td>9,900</td>
</tr>
<tr>
<td>7/16 • 11.0</td>
<td>5,600</td>
<td>11,000</td>
<td>13,500</td>
</tr>
<tr>
<td>1/2 • 13.0</td>
<td>7,200</td>
<td>14,500</td>
<td>17,500</td>
</tr>
<tr>
<td>9/16 • 14.5</td>
<td>9,200</td>
<td>18,500</td>
<td>21,100</td>
</tr>
<tr>
<td>5/8 • 16.0</td>
<td>11,200</td>
<td>23,000</td>
<td>27,200</td>
</tr>
<tr>
<td>11/16 • 17.5</td>
<td>n/a</td>
<td>27,000</td>
<td>32,800</td>
</tr>
<tr>
<td>3/4 • 19.0</td>
<td>16,000</td>
<td>32,000</td>
<td>38,900</td>
</tr>
<tr>
<td>13/16 • 20.6</td>
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<td>46,000</td>
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<td>7/8 • 22.0</td>
<td>21,400</td>
<td>42,000</td>
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<tr>
<td>1 • 25.4</td>
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<td>61,000</td>
<td>77,000</td>
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