Tensioning

Tensioning of ropes is the single most important maintenance factor in extending rope and sheave life, improving the quality of ride, meeting ASME A17.1-2004 safety factors (refer to ASME A17.1-2004 Table 2.20.3) and increasing cost savings.

When ropes are installed, they must be adjusted so that each rope takes its equal share of the total load. If ropes in a set operate under varying degrees of tension, optimum service life will not be obtained since, obviously, some ropes are performing more work than others. Ropes under the greater load will usually deteriorate first due to the load/fatigue ratio. However, due to the differential action and slippage that occurs during operation, eventually the ropes under the lighter load will wear more rapidly.

Improper tensioning not only induces short service life, but also creates uneven wear in the sheaves. Unequal tensioning causes some grooves to wear deeper than the others, creating a condition that cannot be remedied without regrooving or replacing the equipment. If this condition is not corrected immediately, the damage to subsequent sets of ropes will become progressively worse.

It is also important to note that before new ropes are installed, it should be made certain the condition of the grooves meets specifications (for the reasons cited above and those outlined in Bethlehem Elevator Rope Technical Bulletin No. 7 on sheave hardness). Otherwise rope and sheave life will continue to deteriorate and costs will escalate.

Effects of Improper Tensioning

Figure 1 shows the varying effects on six ropes under differential tensioning.

Ropes 2, 4 and 6 show similar torque measurements and loads. Ropes 1 and 5 have the greatest torque and loads. Rope 3 has the least torque and load.

ROPE NO.	TORQUE (ft./lb.)	TIME IN SECONDS (10 cycles)	LOAD (lbs.)	% OF TOTAL LOAD
1	96	12	2,070	20.8%
2	80	14	1,473	14.9%
3	76	15	1,276	12.9%
4	80	14	1,473	14.9%
5	100	11	2,142	21.6%
6	80	14	1,473	14.9%
			9,907	100.0%

Figure 1: Differential Tensioning

Wirerope Works, Inc.
100 Maynard St. Williamsport, PA 17701 USA tel 570-326-5146 fax 570-327-4274 www.wireropeworks.com

Tensioning

Compare the extremes: ropes 3 and 5. Rope 3 holds 1,276 lbs. or approximately 13% of the total load. Rope 5 holds 2,142 lbs or almost 22% of the load. The difference in load is dramatic. This type of unequal tensioning may cause:

- unequal groove wear
- unequal rope wear
- slippage
- vibration
- slapping
- short rope and sheave life
- a change in safety factors

Unequal Groove Wear and Slippage

Each rope must take its equal share of the total load. Improper tensioning not only induces short service life, but also creates uneven wear in the sheave grooves, resulting in differential groove depths. This causes the ropes to operate at different speeds to compensate f or the varying groove depths.

Figure 2 shows the effect of uneven tensioning on the sheave. A tight rope condition causes ropes to quickly reduce in diameter, placing excessive pressure on the sheave. If this situation is not corrected immediately, the loose ropes will slip across the groove in an attempt to adjust to the ropes that are carrying the load, resulting in extreme abrasion or a sawing effect as the loose ropes slide over the groove, as shown in Figure 3. This sliding also negatively impacts the sheave groove. In **Figure 1**, ropes 1 and 5 hold approximately 42% of the load, as compared with 33% for properly adjusted ropes. In time, the loose ropes will actually pass more of the load to the two carrying the greater load, due to the continued slippage and increased groove depth.

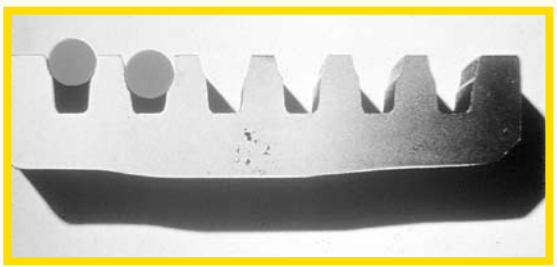

Figure 2: **Uneven Sheave Wear Caused by Differential Tensioning**

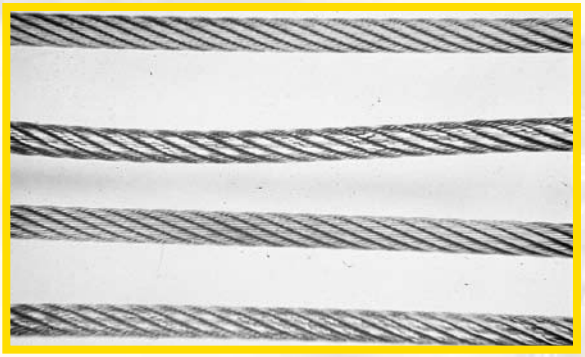

Figure 3: **Rope Wear Caused by Improper Tensioning**

Vibration and Slapping

Due to the rope's excessive load and diameter reduction, rope and sheave wear initially occurs in the heavily-loaded ropes. The loose ropes will not reduce in diameter at the same rate, and at this time will remain closer to nominal. This is due to the difference in constructional stretch between the heavily- and lightly-loaded ropes; remember, each rope stretches in relationship to the load placed upon it (refer to Bethlehem Elevator Rope Technical Bulletin No. 5 on Stretch). In this stage the heavily loaded ropes will seat themselves more deeply into the groove, causing slight abrasion. Tight ropes will eventually adjust to their "condition" and operate comfortably in conjunction with their grooves, and the rate of deterioration will slow down. At this critical juncture, proper tensioning will still resolve any future problems and operate comfortably in conjunction with their grooves, and the rate of deterioration will slow down. At this critical juncture, proper tensioning will still resolve any future problems.

After this adjustment period, however, the loose ropes will begin to slip across the grooves in an effort to equalize themselves with the tight ropes. In time, due to the sawing effect, the grooves will wear deeper than those of the heavily-loaded ropes, causing excessive abrasion on the loose ropes. Eventually the damage in the form of rope abrasion and diameter reduction will surpass that of the tight ropes. The ropes will become progressively loose, increasing the potential for slapping and further rope and groove damage. This situation cannot be corrected with tensioning.
If the sheave is not regrooved or replaced prior

to installation of a new set of ropes, excessive vibration will occur due to the larger diameter ropes' being installed onto a sheave with differential groove depths and differently-seated grooves. **Improperly tensioned ropes create differential groove depths and differential groove profiles.**

Short Rope LIfe

Ropes passing over a sheave with various groove depths and profiles can never be tensioned properly. The new or replacement ropes will only last a fraction of their expected service life. Each set of ropes will have progressively shorter life due to the differential grooving. **Figure 3** shows four ropes that were removed after one year of service. The damage to the ropes was actually caused by poor tensioning on prior ropes; the new ropes could not be tensioned due to differential grooving. The two ropes showing extreme wear and wire breaks were loose. If new ropes are installed on a differentially-worn sheave, the ropes will continue to saw into the grooves and a significantly shorter rope life may result.

ASME Specification

ASME A17.1-2004 Paragraph 8.11.2.1.3(cc)(1)(d) states, *"if in the judgement of the inspector, any unfavorable condition, such as fretting; corrosion (red dust or rouge), excessive wear of individual wires in the strands, unequal tension, poor sheave grooves; etc., the criteria for broken wires will be reduced by 50% of the values indicated in Table 8.11.2.1.3(cc)(1)"* Refer to 8.11.2.1.3(cc)(1) for the code in its entirety.

Excessive wear of the individual wire in the strand, unequal tension and poor sheave grooves will reduce the number of allowable broken wires by 50%, causing premature rope removal (see Figure 4).

When to Tension Ropes

Ropes must be tensioned immediately after installation; adjusted at six weeks and six months after installation, and checked annually. Tensioning is especially important during the rope's initial constructional stretch period (refer to Bethlehem Elevator Rope Technical Bulletin No. 5) and during the adjustment periods when problems can still be corrected. It is also important that the necessary adjustments are made by shortening the loose ropes, and not by twisting or unwinding the end of the rope, thus causing a change of the rope lay. A rope can be damaged easily in this manner, and many causes of short service have been traced to this type of misuse.

How to Tension Ropes

Prior to the removal of existing ropes and installation of new ropes, check for differential groove depths. Place a straight edge across the ropes. If the straight edge wobbles, the ropes in the middle are higher in the groove than those at the ends. If the straight edge sits across the ropes without movement, look for gaps between the ropes and the straight edge. A flashlight held behind the straight edge will aid in detecting any gaps.

The use of a small level as a straight edge is recommended. The bubble will show if the ropes are level, seated evenly and if the sheave is plumb. If the level shows that the ropes are even but not level, the sheave is on an angle. This will have

Figure 4: **ASME A17.1-1993 Table 1001.2(c)(29)(a)**

CONSTRUCTION	A	B	C
6x19 Class	24-30	8-12	12-20
8x19 Class	32-40	10-16	16-24

The upper limits may be used when inspections are made at least monthly by a competent person.

Tensioning

the same effect on the ropes and grooves as unequally tensioned ropes. Again, in this instance, the ropes are not traveling the same distance and will try to equalize with one another.

There is only one type of tensioning method recommended by Wirerope Works, Inc. (WW).

Torque Wrenches

Some of the OEM's have designed torque wrenches and pressure gauges that are available to their branches. Commercially-marketed torque wrenches are also available from many suppliers. Any of these tools are acceptable and will provide accurate readings of the tension on each rope. Needed adjustments can then be made. Unfortunately, even with the availability of these inexpensive tools, many service technicians and inspectors are not aware of their existence.

Feel Method

The feel method of pushing and pulling on each rope is an unacceptable and inaccurate method of tensioning for the majority of the industry. Tensioning by feel requires a skill which can only be likened to that of a piano tuner who can expertly adjust the piano strings merely by listening to the tones produced by striking the keys. This is not a practice which can be learned; it is an innate talent.

WARNING: If a set of ropes is not properly tensioned early in its life, tensioning will become increasingly difficult and time-consuming. Multiple adjustments may be required to properly adjust a set of poorly-tensioned ropes having undergone their initial constructional stretch period.