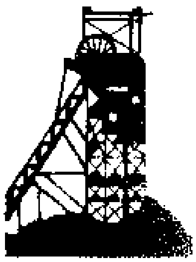
"Haggie Hints"



by George Delorme
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Haggie North America Inc. - *Meeting your hoisting needs!*

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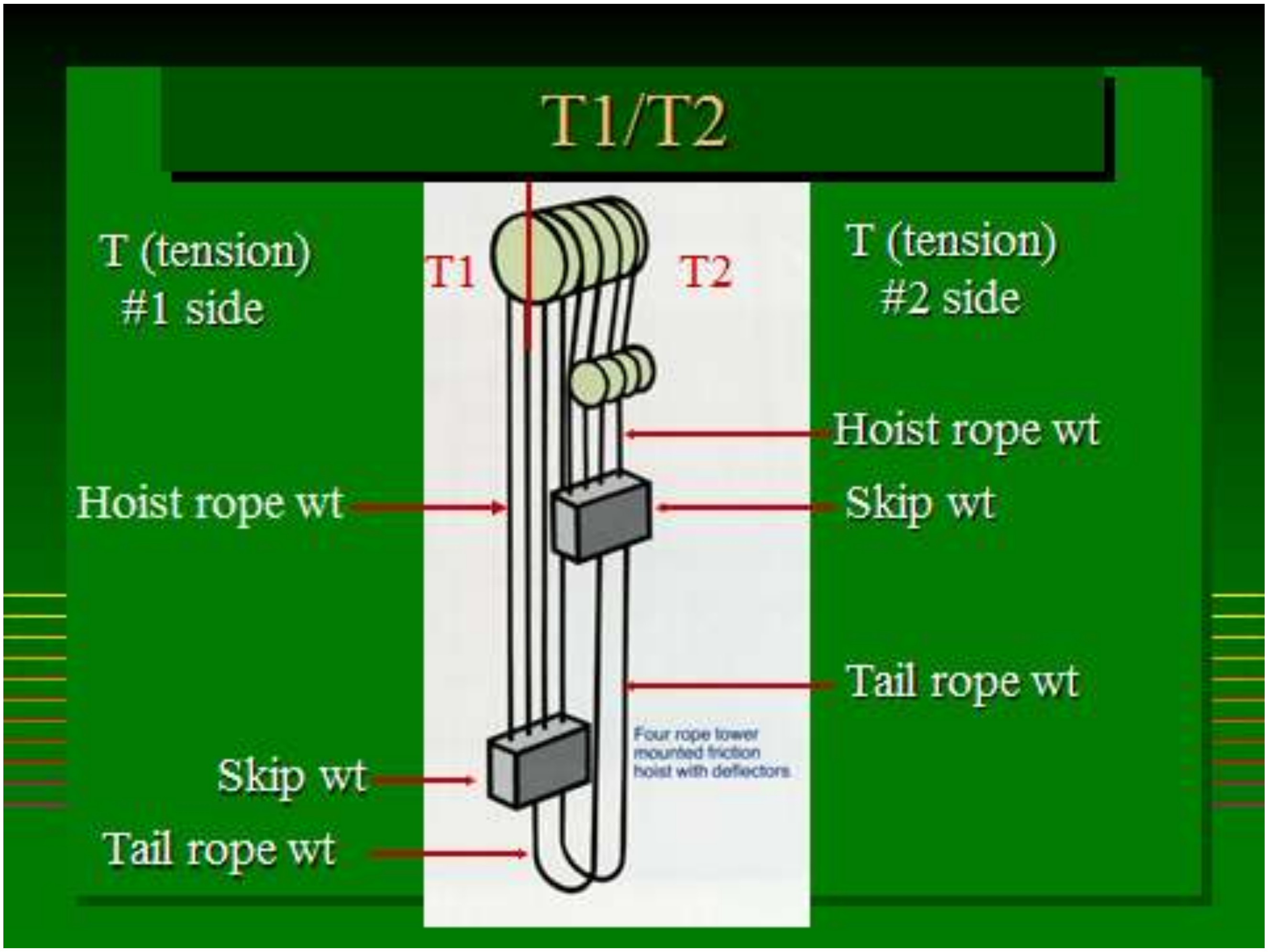
Friction (Koepe) Hoisting - the most common reason for premature rope failure on a multi- rope system and how to avoid it.

DISCUSSION:

The challenge with a multi-rope friction winder system is to ensure that all ropes experience the same loads and stresses through the hoisting cycle. With a single rope system, this is obviously not a problem however with multiple hoist ropes, ensuring they work in unison is a different matter. In general, the greater the number of hoist ropes, the more difficult this is.

In order to ensure the ropes experience the same loadings, virtually the identical amount of rope must pass over the drum from the T1 side to the T2 side on each revolution. If this does not happen, some ropes on the T1 side will lose tension while others will gain to compensate. Also remember that the ropes losing tension on the T1 side of the hoist will be gaining tension on the T2 side.

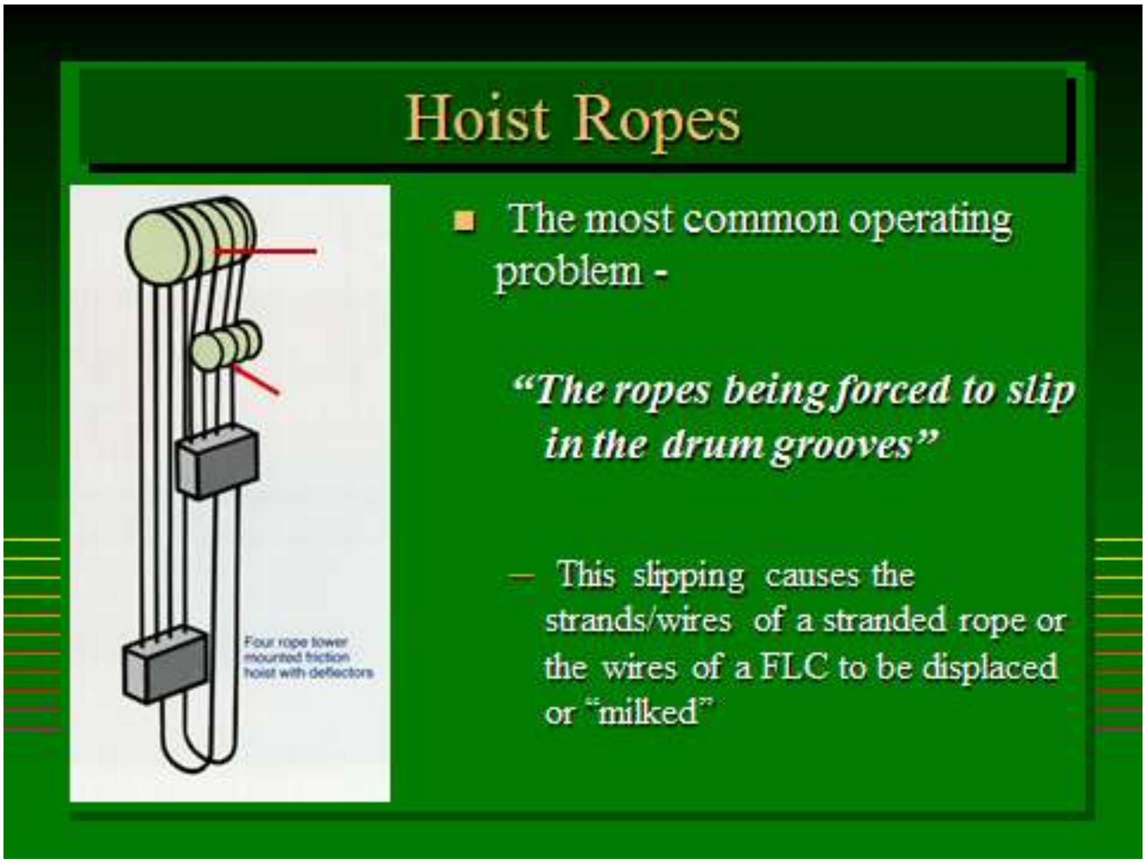
This loss of tension on the T1 side and the gain on the T2 side may reach a point where the Coefficient of Friction offered by the drum grooves is exceeded and therefore, slip of that rope will occur. This is the main cause of rope upset.



ROPE REACTION:

Any type of hoist (head) rope will perform poorly when one or more of the ropes slip in the hoist drum grooves. Since the tread liners are specifically designed to have a high coefficient of friction to avoid all ropes from slipping during normal operation, it is this very characteristic that causes the problem when slip does occur. Under slip conditions, the wires or strands in the rope are forced out of position. Unless the cause of the slipping is eliminated, the ropes may eventually become structurally upset or certainly decreased rope life will result.

The most common type of upsets as a result are a “wave” (corkscrew), “bird-cage” or significant shortening/lengthening of rope lays. These upsets will usually occur at the tangent points of the drum or the deflector sheaves when the conveyance on that side is in the uppermost “normal position”.



While it is possible that all ropes will slip in unison (a system slip) due to emergency stops, rope or groove contamination, excessive moisture or lubricant etc. which may result in rope upset, most often, it is when individual ropes slip that will cause a problem.

Individual ropes slip when the amount of rope being passed over the drum from the T1 side to the T2 side is not exactly the same for each drum groove on each drum revolution. As a starting off point, we will say that the circumferential groove lengths are not equal.

If this situation exists, the T1/T2 differential accumulates until it surpasses the coefficient of friction offered by the tread liners.

In a sentence, this event happens when:- ***During an ascending trip, the accumulated loss in "elastic stretch" caused by unequal groove lengths (different amounts of rope being passed over the drum) is greater than the available elastic stretch when the conveyance is in its highest normal position.***

The actual dynamics happening during a hoisting cycle are complex and to better understand what the ropes experience, we should think of them being "elastic bands" as opposed to steel rods. Throughout this bulletin, I will refer to a 4 rope system but the same reactions are in play for any multi-rope system. To demonstrate, let's consider the following scenario using the hoisting parameters outlined below:-

- Rope diameter – 2"
- Type – stranded non-spin
- Breaking load – 455,000 lbs Min.
- Weight – 8.1 lbs/ft
- Conveyances - Skip/Skip
- Skip weight – 70,000 lbs
- Payload – 70,000 lbs
- Suspended rope – 3,600'
- Hoisting distance – 3,515'
- Drum diameter – 210"
- Center line of drum to skip in dump – 85'
- Center line of drum to collar – 180'
- Modulus of elasticity (based on the area of a circle the same diameter as the rope) – 10,100,000 PSI

- Three grooves are passing exactly the same amount of rope over the drum while one groove is passing 0.010" less (0.003" on diameter).
- The drum will revolve 63.9 times during one trip from load to dump (drum circumference is 54.978 ft).
- All ropes are exactly equal in length and each will be stretched by 23.8" at the loading pocket with a 70,000 lbs payload (17,500 lbs each).
- In the dump, if each rope is still equally sharing the 70,000 lbs load, the elastic stretch with the 85ft of suspended rope will be 0.562"

As mentioned above, each rope is stretched by 23.8" due to the load of 17,500 lbs with 3600 ft of rope suspended. On the first revolution, three ropes pass over 54.978 ft from one side of the drum to the other but one rope passes over 0.010" less or 54.968 ft. If we were to stop the hoist in this position, we would have about 3,545 ft of rope suspended and the loss of 0.010" in stretch due to the load would represent a loss in tension on that rope of 7.46 lbs or virtually nothing.

On the second revolution, this rope would have passed 0.020" less than the others and now with 3,490 ft suspended, the loss in tension on that rope would still be insignificant at 15.15 lbs.

After 10 revolutions, we would loss 0.1" of stretch in that rope and with 3050 ft of suspended rope, the loss in tension on that rope would be still be low at 86.7 lbs.

After 50 revolutions, this rope would have passed 0.5" less rope to the other side than its neighbors and with 850 ft of rope suspended, the tension loss would be 1,556 lbs versus the starting tension of 17,500 lbs or an 8.8% loss.

As the dump is approached or after 60 revs, this rope would have lost 0.6" and with 300 ft suspended, the tension lost on this side in this rope would be 5,289 lbs or 30% loss. In real life, this is point at which deceleration may start and when rope movement may be noticed. Depending on the actual discrepancy between grooves, this may also be the point at which a rope or ropes will commence to slip. In most cases, it is the rope that is losing tension on the ascending trip that will slip and will be troublesome.

If we now move to the dump, the hoist has made 63.9 revs and this rope has lost 0.639" of elastic stretch. Since we know as mentioned above that each rope would only stretch 0.562" if it was carrying ¼ of the load, it is obvious that this rope would have lost all of its tension before reaching this point and would have slipped somewhere in the last 300 ft of travel. Over time and if conditions do not change, the slipping of this rope will continue at random during this distance and eventually, an upset will appear at the tangent point of the drum.

Again, I must reinforce that this tension differential is **not** due to the rope lengths and the reaction to unequal groove lengths as described above cannot be rectified by performing a rope length adjustment. The subject of unequal rope lengths and the resulting tension differences is a completely different subject.

ROPE LENGTHS

Rope lengths should be maintained to fairly close tolerances, say to within an inch or so, but I want to mention again, that the tension difference due to unequal rope lengths is not the same as unequal circumferential groove lengths nor can adjusting rope lengths compensate for the latter.

A variation in rope lengths will result in a tension difference however this difference remains constant throughout the winding cycle.

When loaded, ropes will stretch elastically based on the formula shown below. Using the parameters above and assuming the ropes are equal in length, they will stretch equally when the skip is loaded.

EXAMPLE	
When the skip is loaded, the elastic stretch will be:- (P x L x12)/(N x E x A)	
P	Load (pounds)
L	Suspended length (feet)
N	Number of ropes
E	Modulus of elasticity
A	Area of circle the same as the rope diameter ….
OR	
(70,000 x 3600 x 12)/(4 x 10,100,000 x 3.142) = 23.8"	

As shown, each rope will stretched 23.8" as a result of sharing the 70,000 lbs payload or 17,500 lbs on each.

If one of the ropes was 1" longer at the bottom, then that rope would stretch 22.8" which would represent a load of 16,748.6 lbs or 751.4 lbs less i.e.22.8=(?x3600x12)/1x10,100,000x3.142).

The other three would be carrying 17,750 lbs each or 250lbs more. This differential does not change and remains constant throughout the winding cycle and will only change is there is a different constructional stretch between ropes or until another rope length adjustment is made.

While large length differences can influence other factors to force a rope to slip, it is unlikely to cause it on its own. While hydraulic fine adjustment linkages are now the norm and are very convenient, it can be seen that to adjust rope lengths to ¼" may be unnecessary as this amount will actually represent a very small difference in load sharing.

A slight "down side" of the hydraulic fine adjustment linkage is that rope length adjustments can be performed with the system under tension i.e. without disconnecting the ropes. With "non-spin" rope constructions, it is a good idea to allow the ropes to occasionally be released at the shaft bottom to relieve/balance torque discrepancies between the outer cover and inner rope. This "Torque Release" of non-spin ropes should be part of the ongoing maintenance program and should not be forgotten.

UNEQUAL CIRCUMFERENCE GROOVE LENGTHS

Rope reaction has already been covered when this condition exists but now correcting this situation will be discussed.

To repeat, the objective is to ensure that the same amount of rope passes from one side of the drum to the other. Factors that influence this from happening are:-

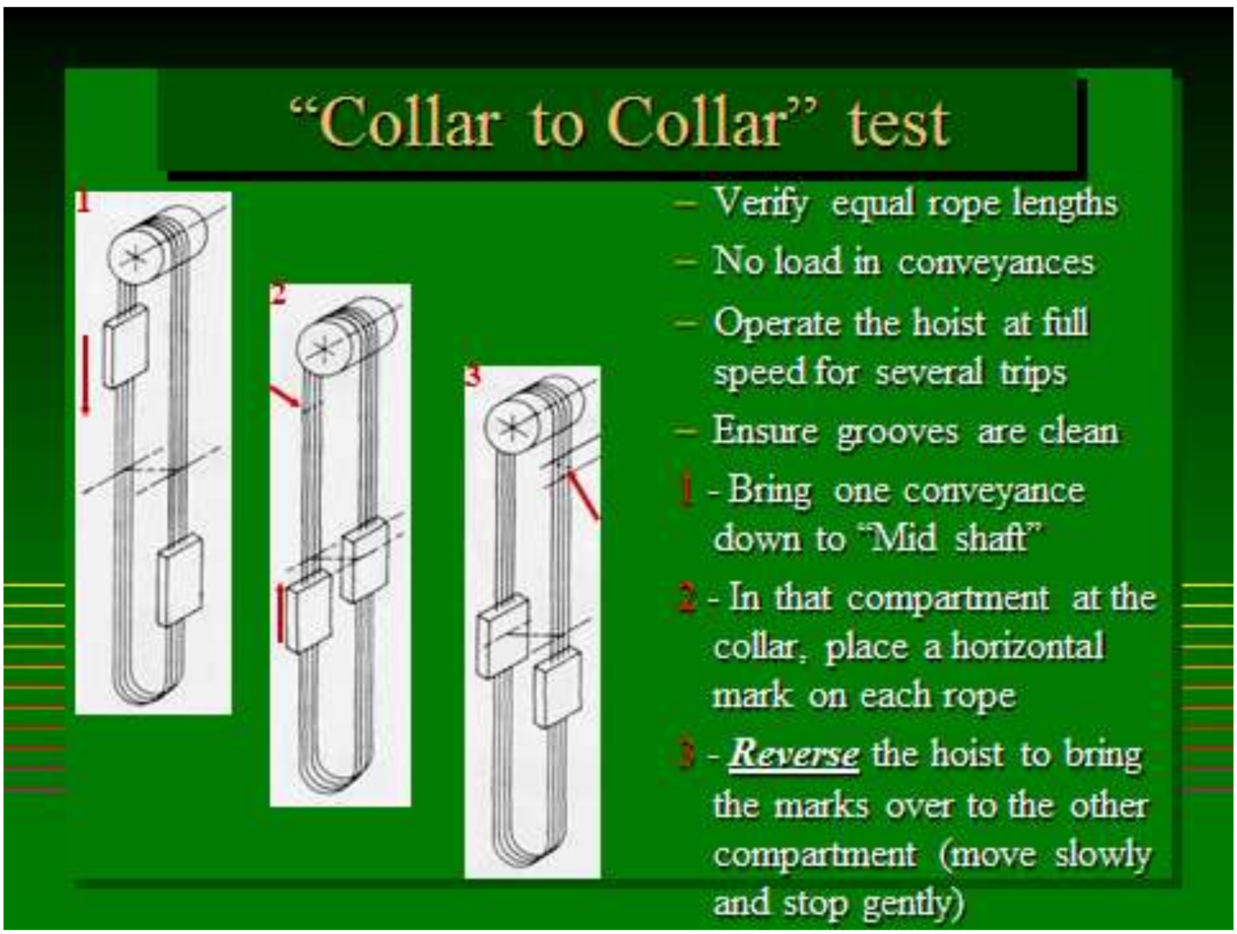
- Different groove circumferences
- Rope diameters and/or cross sectional compression resistance are not the same (most often the right hand lay ropes will differ slightly from the left hand lay ropes)
- The compression rate of the tread liner material may vary.
- Flexing of the drum structure may not be symmetrical.

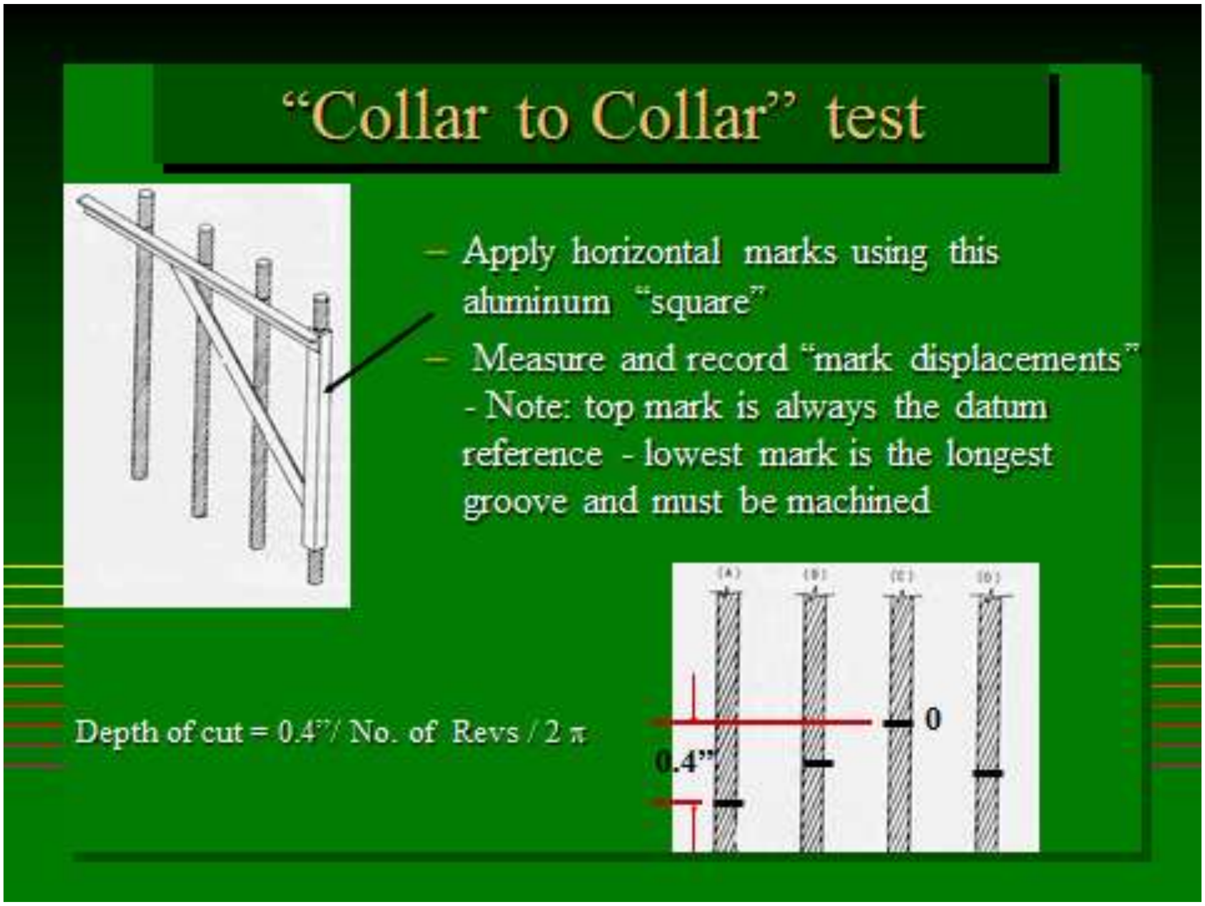
Taking all these factors into consideration, the simplest and best method to rectify the situation is to perform the "Collar to Collar" test.

COLLAR TO COLLAR TEST

The advantage of the Collar to Collar test is that it takes all the variable mentioned above and shows us the actual amount of rope that is being passed over the drum.

These slides from our training seminar illustrate the method of performing the "Collar to Collar" test correctly.





Using the parameters shown in our scenario, the maximum allowable mark displacement during the test is 0.322" and in order to correct this mark displacement, we would in theory have to cut the groove by 0.023". Normally, it is good practice to cut the long groove (the lowest shown) by half of the theoretical value and perform another test.

SUMMARY;

As mentioned before, the actual dynamics and load sharing that occurs during the winding cycle are complex and this bulletin covers the subject in only a simplified manner, however years of practical experience have shown that severe rope problems will be avoided if we understand and follow these practices.