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SPECIAL WIRE ROPES

New wire rope designs for multi layer drums

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by Dipl.- Ing. Roland Verreet

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The steel wire rope of a properly designed and maintained crane should have a reasonably long service life and one day be discarded because of fatigue, the wire rope equivalent of old age.

But often wire ropes don´t get very old: they might die prematurely because of excessive abrasion or corrosion (the wire rope equivalents of skin cancer). Here, proper wire rope relubrication might be the answer.

Wire ropes might also die prematurely because of mechanical or structural damages (the wire rope equivalents of being run over by a bus). Improved crane design and proper wire rope and crane usage will help to avoid these problems.

But what about drum crushing? If a wire rope dies because of damages received when spooling on and off a drum, is that part of normal rope life? Many crane designers and users think so.

But they are wrong: When drum crushing occurs, the wire rope damages itself. Drum crushing is the wire rope equivalent of suicide. This paper explains the mechanisms and shows how drum crushing can be avoided.

The bending fatigue mechanism

If a wire rope is subjected to repetitive bending, small cracks will form in the surface of individual rope wires, especially at the points of contact with other wires or with the groove of a sheave or drum. With increasing number of bending cycles, the crack will grow, reducing the load brearing wire cross section. Once the remaining wire cross section is no longer able to carry its share of the load, the wire will fail.

A typical fatigue break is characterized by a break section perpendicular to the wire axis. Figure 1 shows a rope with fatigue breaks. Figure 2 shows the cross section of a rope wire broken due to fatigue.

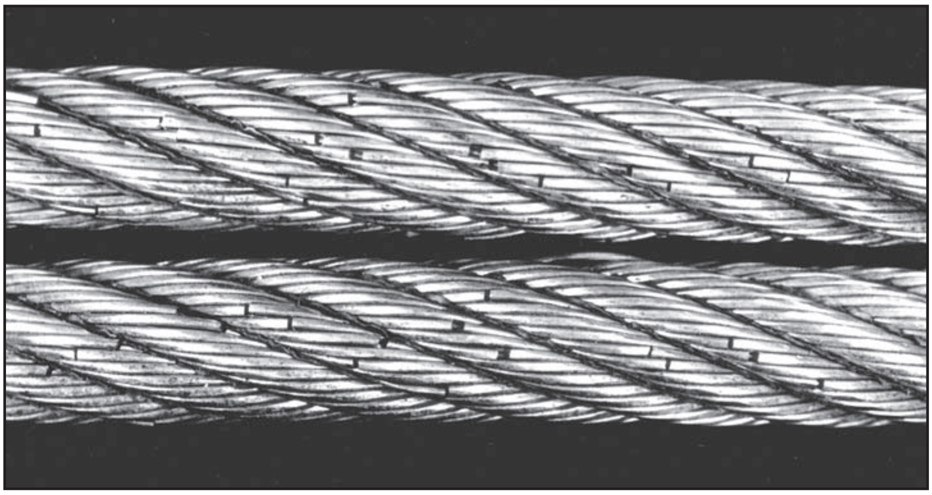


Fig. 1: Steel wire ropes with fatigue breaks

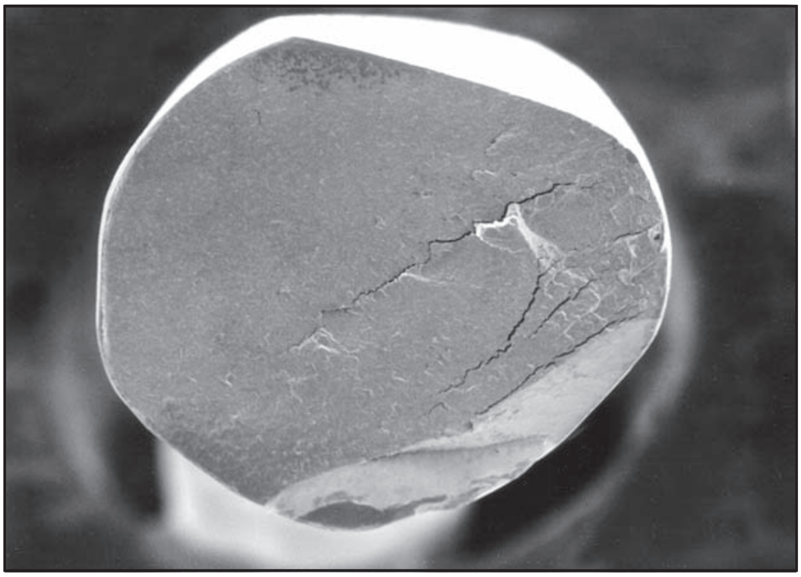


Fig. 2: Break section of a rope wire broken due to bending fatigue

Bending cycles over sheaves

One bending cycle for a given rope section is defined as a change from a straight to a bent and back to a straight condition (Fig. 3a) or from a bent to a straight and back to a bent condition (Fig. 3b). Every time the rope section travels over a sheave, it is subjected to one bending cycle. Of course, during a typical lift, not every rope section will travel over the same number of sheaves and onto the drum. Therefore, along the rope length, the wire rope will fatigue the most in those sections which travel over the greatest number of sheaves, i.e. where it is subjected to the greatest number of bending cycles.

Fig. 3: Definition of one bending cycle

Bending cycles over single layer, grooved drums

If a rope section travels on and off a grooved single layer drum, it will also undergo a change from a straight to a bent and back to a straight condition, i.e. according to the definition, it will also undergo one bending cycle.

But is a bending cycle on a drum comparable to a bending cycle on a sheave? For a grooved single layer drum, the answer is Yes. Tests and practical experience have shown that a bending cycle on a grooved single layer drum will cause the same amount

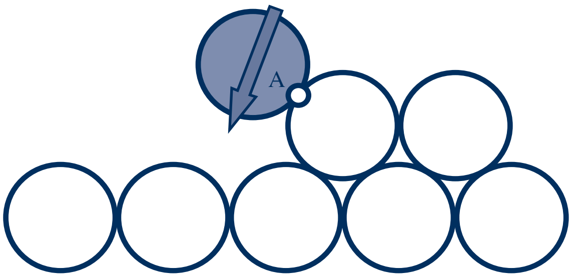


Fig. 5: First damage

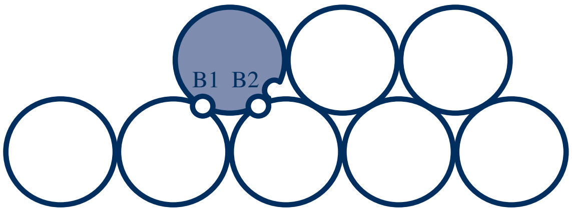


Fig. 6: Second damage

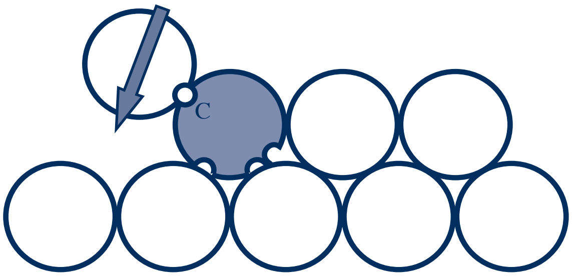


Fig. 7: Third damage

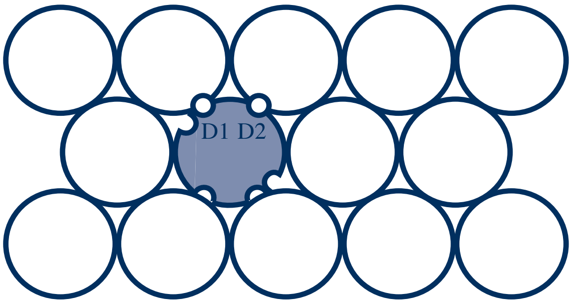


Fig. 8: Fourth damage

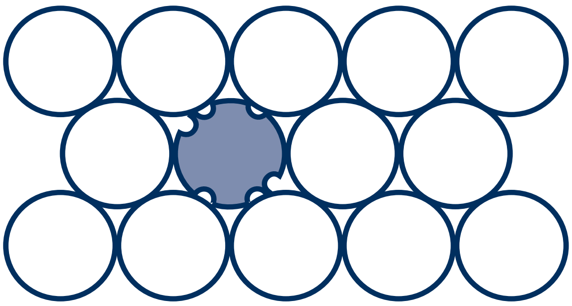


Fig. 9: Final situation

of rope fatigue as a bending cycle on a sheave, provided the line pulls and diameters are the same. In both cases, the rope will be bent around smooth, curved surfaces of the same geometry. We could say that the rope „does not know“ if it is bent around a sheave or a drum.

Bending cycles over multi layer drums

If a rope section travels on and off a grooved multi layer drum, it will also undergo a change from a straight to a bent and back to a straight condition, i.e. according to the definition, it will also undergo a bending cycle. But here, the conditions are different (Fig. 4):

Rope sections spooling in the first layer will also be bent around a smooth drum surface, but when the second layer comes in they will be spooled over, compressed and damaged on the upper side by the second rope layer.

Rope sections spooling in the second and higher layers will be damaged on all sides: first they will be damaged in Zone A during the contact with the neighbouring wrap when entering the drum (Fig. 5).

Then they will be bent around a very rough surface created by the previous rope layer, leading to wire damage in Zones B1 and B2 (Fig. 6).

Then the next wrap will come in, damaging the rope section in Zone C, and displacing the rope section, leading to additional damage in Zones B1 and B2 (Fig. 7).

Finally the next layer will damage the rope section in Zones D1 and D2 at the side, or, if we are looking at a crossover zone, on the top (Fig. 8).

It is obvious that by these mechanisms the rope section will be damaged far more than by one bend on a single layer drum (Fig. 9). But by how much more?

Fig. 4: Problems during multi layer spooling

In Germany, two multi-layer test stands (one at University of Stuttgart and the other at Casar Drahtseilwerk Saar GmbH) have been built to find out. Fig. 10 shows the Casar test stand.

Let us introduce a multi layer damage factor, defined as the number of bending cycles until discard on a single layer drum or on a sheave versus the number of bending cycles until discard on a multi layer drum. First tests performed at the two locations seem to indicate that (surprisingly?) this multi layer damage factor increases with increasing design factor, i. e. with decreasing wire rope line pull.

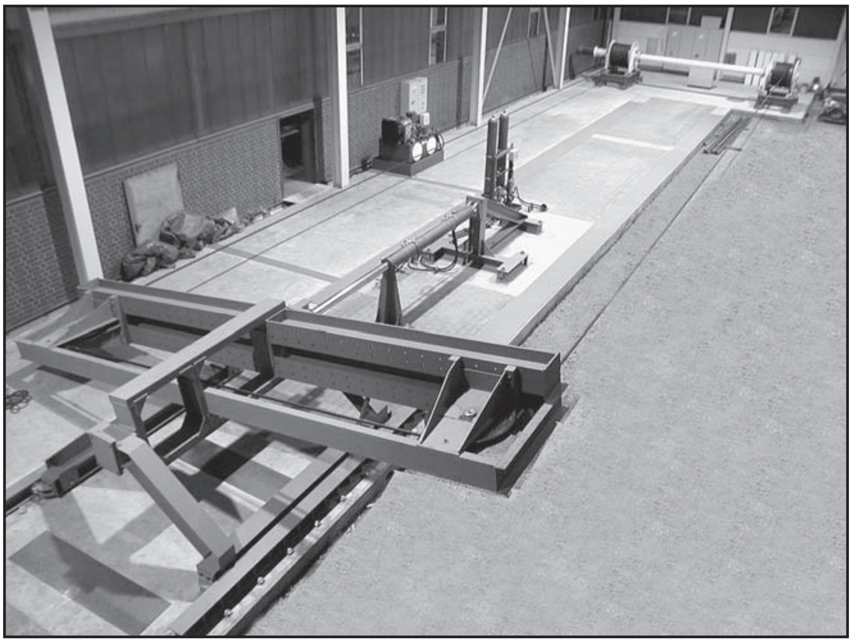


Fig. 10: Multi layer test strand at Casar. Two multi layer drums can be seen in the background. The rope spools from one drum to the other via the sheaves in the 45t tensioning unit in the foreground. This unit can slide, pivot and vary the fleet angles between the rope and the drums.

Figure 11 shows the multi layer damage factor as a function of the rope design factor. Based on the first results, for a D/d ratio of about 25 the multi layer damage factor (or suicide factor) can be approximated by

$$\text{Multi layer damage factor} = 2.85 + 0.65 \cdot \text{Rope design factor}$$

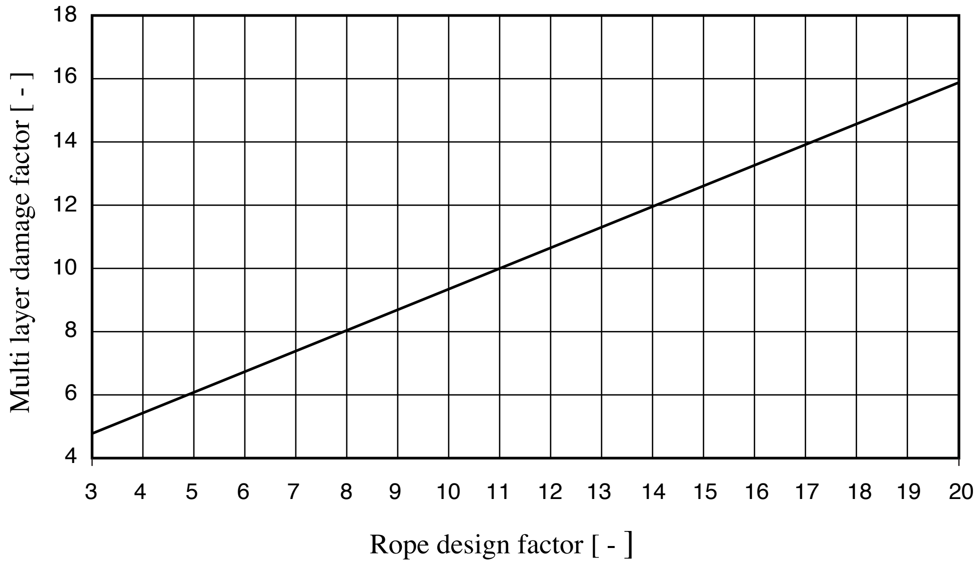


Fig. 11: Multi layer damage factor as a function of the rope design factor

Bending fatigue damage distribution in reeving systems with a single layer drum

It is not possible to predict the bending fatigue damage distribution along the hoist rope even for simple crane with a four part reeving system and a drum without knowing its operating conditions.

Let us suppose the crane picks up a load in the lowest hook position (Fig. 12a), lifts it to the highest hook position (Fig. 12b) and then lowers it back to the starting position (reverse bends in Fig. 12 for illustration only). This action will create a bending fatigue distribution as in Figure 13.

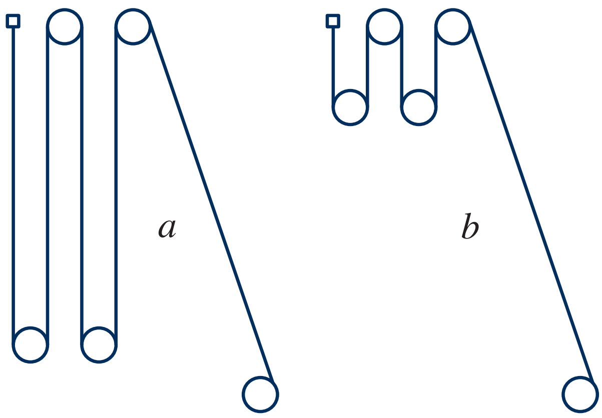


Fig. 12: Crane configuration, lowest (a) and highest (b) hook position

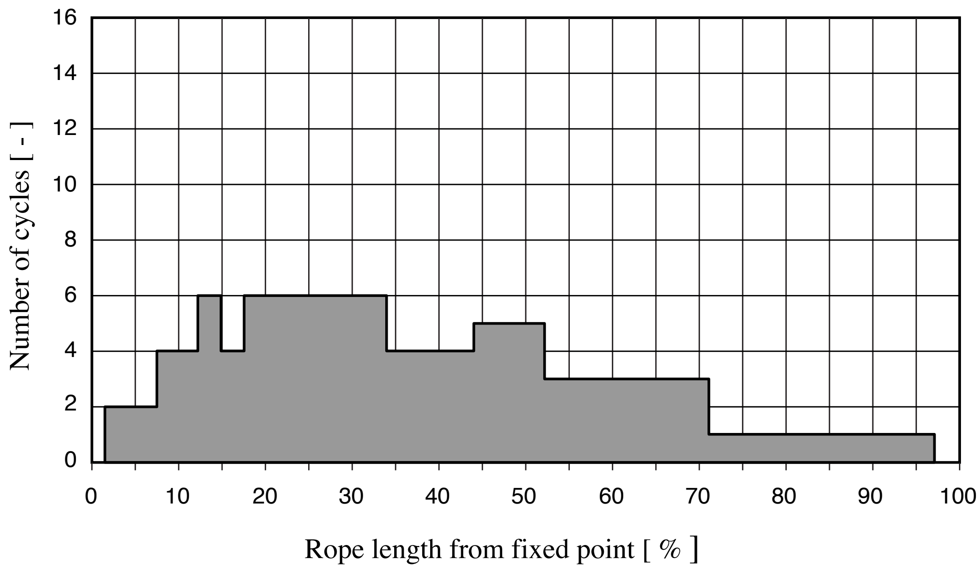


Fig. 13: Damage distribution along the rope length (single layer drum)

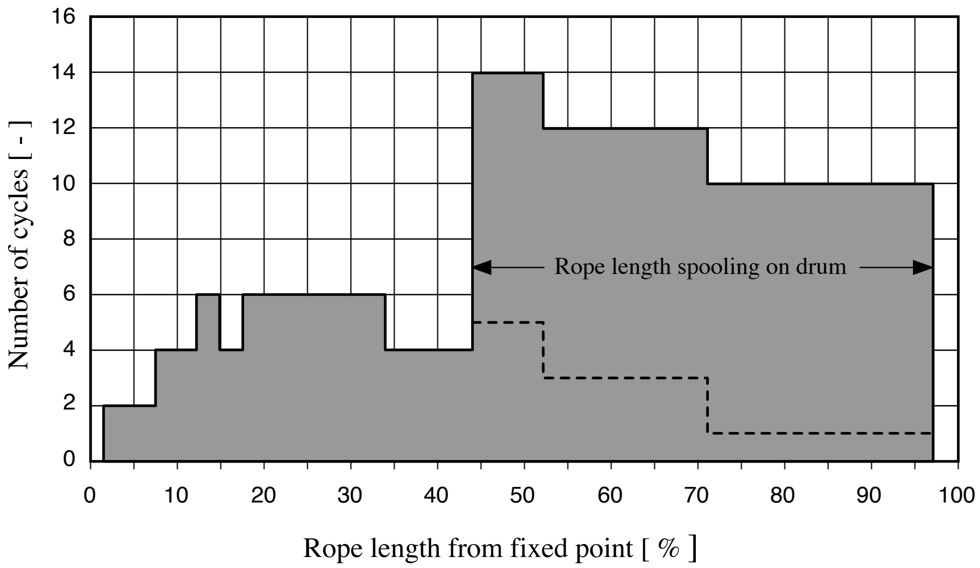


Fig. 14: Damage distribution along the rope length (multi layer drum)

The highest fatigue damage does not occur on the fastest moving part of the rope, the fall going to the drum, but at the opposite end: It accumulates on the slower falls which stay in the reeving system and never get to the drum.

If the same crane randomly lifts loads to varying heights, the bending fatigue damage distribution might look completely different. The damage maximum will be difficult to locate, but it will normally not be in a rope section which will spool onto the drum.

Bending fatigue damage distribution in reeving systems with a multi layer drum

If the above crane has a multi layered drum, every bend on the drum will be as much as 4 to 40 times as detrimental to rope life as on a single layer drum or on a sheave. When adding up the damages caused by the bending cycles, every bend on the drum will have to be multiplied by the multi layer damage factor, and that will change the damage distribution completely.

As an example, Fig. 14 shows the damage distribution for the above crane for a multi layer damage factor of 10. As we can see, now the zone with the greatest amount of damage is part of the rope length which will spool onto the drum.

Multi layer spooling on helical drums

On helical drums, wire ropes are expected to spool from one flange to the other in a perfect helix, climb into the second layer and spool back again in a perfect helix (Fig. 15).

The wire rope, however, will behave completely differently (Fig. 16): After having spooled from one flange to the other, the rope will climb into the second layer and then spool away from the flange only for a short distance. It will cross over one wrap of the first layer, then fall into the gap between two adjacent wraps and follow the bed formed by those two wraps of the first layer (going the wrong direction). It will then violently hit the wrap climbing up into the second layer and be kicked to the side. After crossing over another wrap it will again fall into a gap between two wraps of the first layer, and the process will start again. This way, the rope will zig-zag around the drum barrel: During every revolution of the drum the rope will

- be kicked to the side by 1 rope diameter (= -1 d),
- spool in the wrong direction for half a rope diameter (= +1/2 d),
- be kicked to the side by 1 rope diameter (= -1 d), and
- spool in the wrong direction for half a rope diameter (= +1/2 d).

Now, add this up: - 1 d + 1/2 d - 1 d + 1/2 d = - 1d !!!

This means that in the second layer, during every revolution of the drum, the rope really spools back by one rope diameter! But couldn´t that be done better?

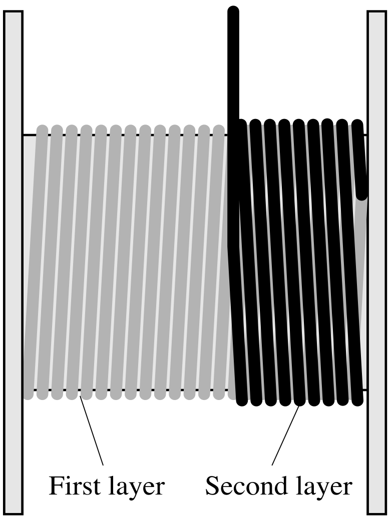


Fig. 15: Helical drum, theoretical spooling behaviour

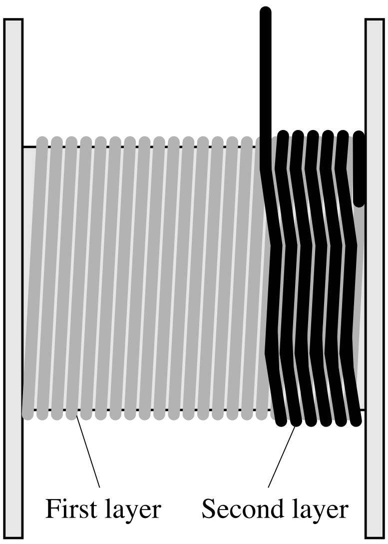


Fig. 16: Helical drum, real spooling behaviour

Multi layer spooling on Lebus drums

Lebus improved the spooling tremendously by eliminating the helix in the first layer. On Lebus drums the rope first spools parallel to the flange, then is guided to the side by half a rope diameter (Fig. 17). It then spools parallel to the flange again, until it is guided to the side by half a rope diameter (exactly on the opposite side of the first event).

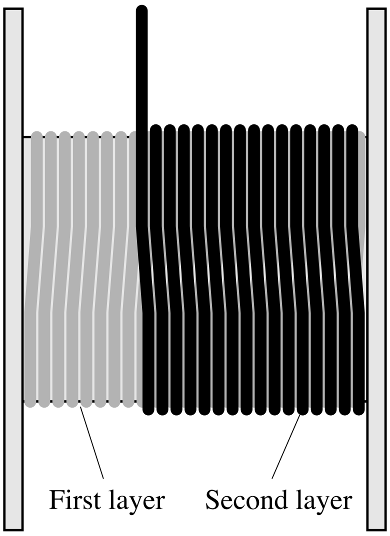


Fig. 17: Lebus drum

Therefore, in the first layer during every revolution of the drum the rope will

- spool parallel to the flange (= ±0 d),
- be guided to the side by 1/2 rope diameter (= +1/2 d),
- spool parallel to the flange (= ±0 d) and
- be guided to the side by 1/2 rope diameter (= +1/2 d).

Now, add this up: ± 0 d + 1/2 d ± 0 d + 1/2 d = + 1 d !!!

So during every revolution the rope really spools forward by one rope diameter! The real advantage, however, only shows in the second and consecutive layers.

After climbing into the second layer, the rope will spool parallel to the flange until it crosses over the last wrap of the first layer exactly at the point where this one is moving half a rope diameter against the flange. After crossing this wrap, the rope will fall over on the other side (displacing by another half a rope diameter. The story will repeat itself after every half a turn of the drum.

Therefore, in the second layer during every revolution of the drum the rope will

- spool parallel to the flange (= ±0 d),
- be kicked to the side by 1/2 rope diameter (= -1/2 d),
- spool parallel to the flange (= ±0 d) and
- be kicked to the side by 1/2 rope diameter (= -1/2 d).

Now, add this up: ± 0 d - 1/2 d ± 0 d - 1/2 d = - 1 d !!!

So during every revolution of the drum the rope really spools backward by one rope diameter. But what is the difference to the helical drum? There, in the second layer the rope was also kicked to the side repeatedly!

Look at the figures: On the helical drum, every time the rope is kicked to the side it is by one *full* rope diameter. On the Lebus drum the displacement is only *half* a rope diameter, the layer underneath does the second half.

The zones where the rope is kicked to the side are called crossover zones, because here the rope crosses over a wrap of the previous layer. Figure 18 shows a rope spooling in the parallel zone of a Lebus type drum. Figure 19 shows the rope entering the crossover zone.

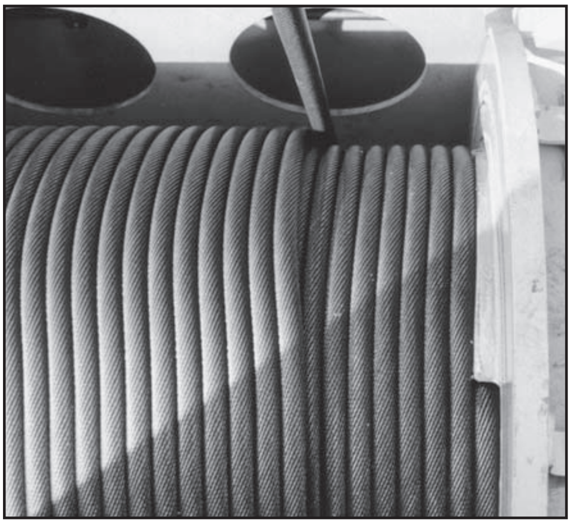


Fig. 18: Lebus drum, rope spooling in parallel zone

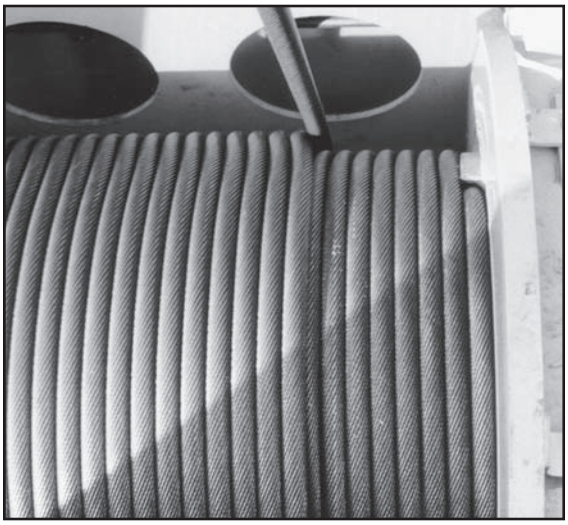


Fig. 19: Lebus drum, rope spooling in crossover zone

The influence of the D/d ratio

The influence of the D/d ratio (ratio drum diameter versus nominal rope diameter) on the rope damage has not yet been tested in the laboratory. Practical experience, however, suggests that the rope damage increases considerably with decreasing D/d ratio. Because of the bending stiffness of the wire ropes D/d- ratios below 20 should by any means be avoided, especially if the rope might spool with low tension in the lower layers.

Fig. 20 shows a two layer drum with a small D/d ratio. The width of the drum causes severe fleet angles, resulting in bad spooling. Fig. 21 shows a modern crane with multi layer drums. The D/d ratio in the first layer is about 20.

Fig. 22 shows the author in front of a double drum winder installation in South Africa. The D/d ratios greater than 100 considerably reduce the damage caused by the multi layer spooling. They also allow for very high rope speeds.

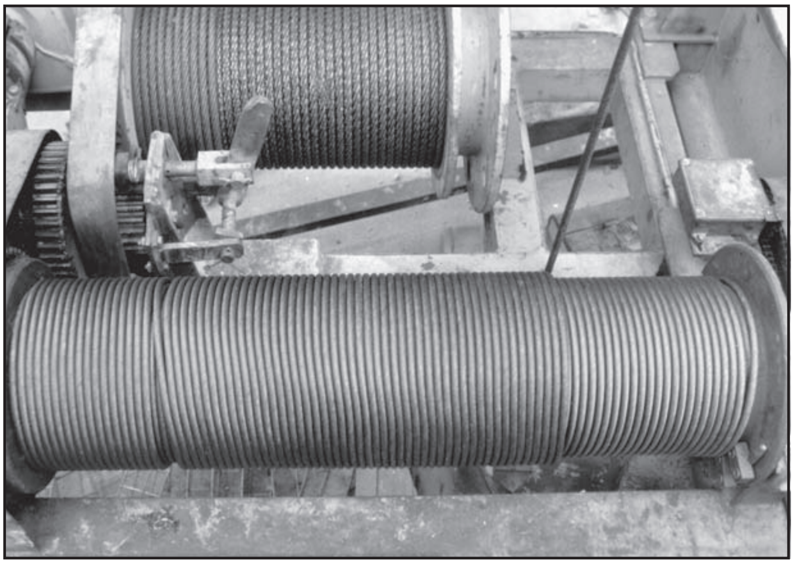


Fig. 20: The worst solution: Small diameter, great width

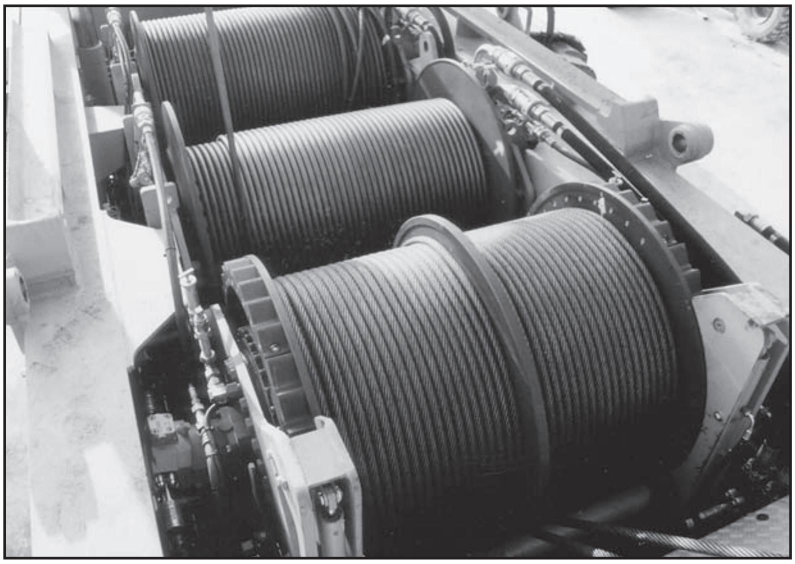


Fig. 21: Modern cranes operate with D/d ratios between 20 and 30.

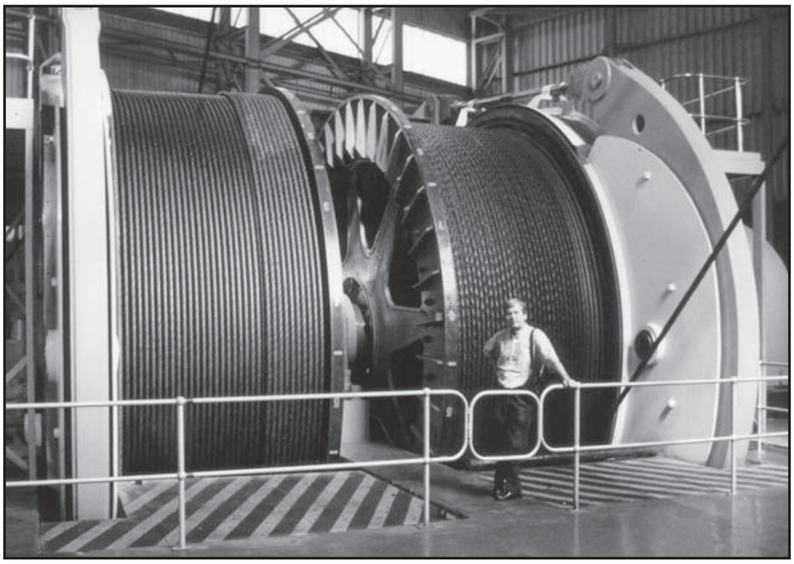


Fig. 22: Mine hoist drum winders have D/d ratios greater than 100.

The influence of rope pretension

If the lower layers have not been spooled onto the drum under high tension, the lower wraps will be displaced by the incoming rope section, allowing it to slide down between them, leading to severe rope damage.

This effect is especially pronounced on ungrooved multi layer drums. Fig. 23 shows the force pyramid of an ungrooved drum. If the lower layers are not sufficiently tensioned, the incoming rope section will slide along the drum circumference (in an attempt to tension the neighbouring wraps) and at the same time cut into the lower layers (Fig. 24).

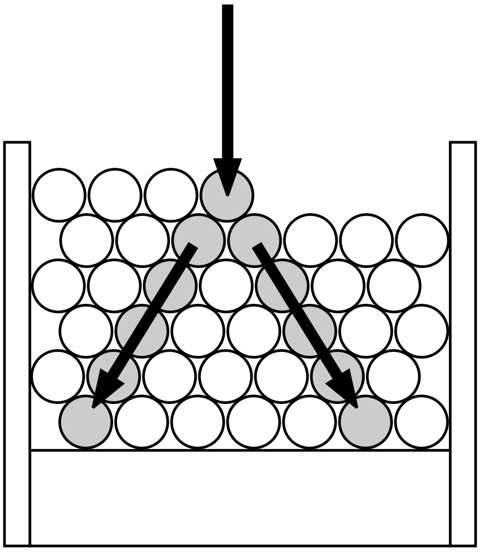


Fig. 23: Force pyramid on ungrooved drum

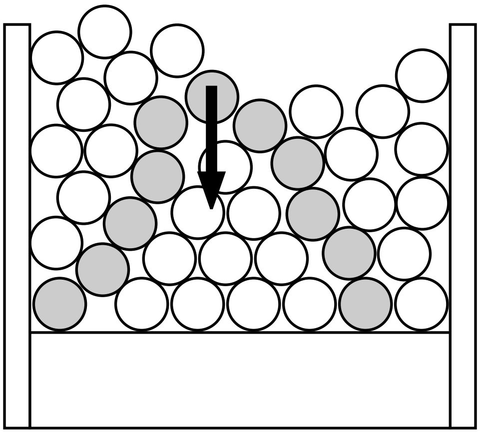


Fig. 24: The pyramid collapses and the incoming rope cuts in.

Figs. 25 and 26 show rope damage created by spooling the wire rope onto the second layer of an ungrooved drum only once!

The crane operator might not always be aware of the fact that the rope has cut into deeper layers on the drum. He might just cover the problem by two additional rope layers, slew the crane and start lowering the load. The cut-in rope section might act like a new fixed point: it might not come off the drum. As the drum continues to turn, the downward motion of the load will be reversed abruptly to an upward motion, leading to a high shock load which will severely damage and might even break the rope. Fig. 27 shows a cut-in rope.

The proper force pyramid is shown in Fig. 28: The drum is grooved to stabilize the lowest layer, the voids at the flanges are filled with a riser helping the rope climb from the first to the second layer and the lower layers are pretensioned.

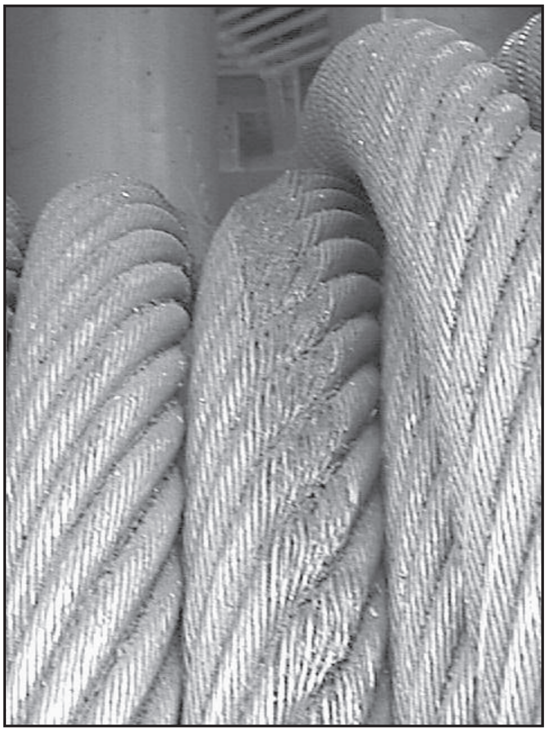


Fig. 25: Severe relative motion has destroyed the rope during the first lift

Fig. 26: Consequences of a rope "cutting in"

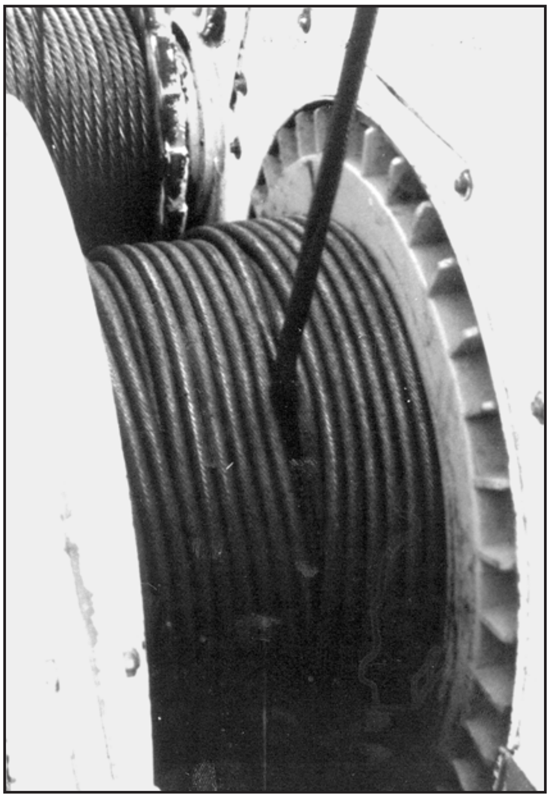


Fig. 27: Cut- in wire rope

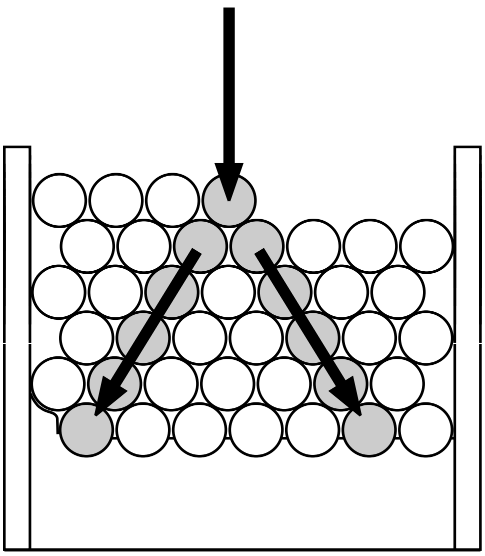


Fig. 28: Correct drum layout

The influence of the rope diameter tolerance

In the first layer and in the "parallel sections" of the consecutive layers the rope will be guided by the drum grooves or the parallel rope sections below it, regardless of its diameter tolerance. In the crossover zones, however, it will be guided by the neighbouring wrap only. If the rope diameter matches the drum pitch, the crossover on the drum surface will take place in a band parallel to the drum axis (Fig. 29).

If, however, the rope diameter is too small, the second wrap will spool at bit further than intended before being kicked to the side by the first wrap. The third wrap will again spool a bit further before being kicked by the second etc, resulting in an inclined crossover zone (Fig. 30 and 31). The next layer will not accept the crossover points defined by the previous one, resulting in rope displacements and severe rope damage in this area.

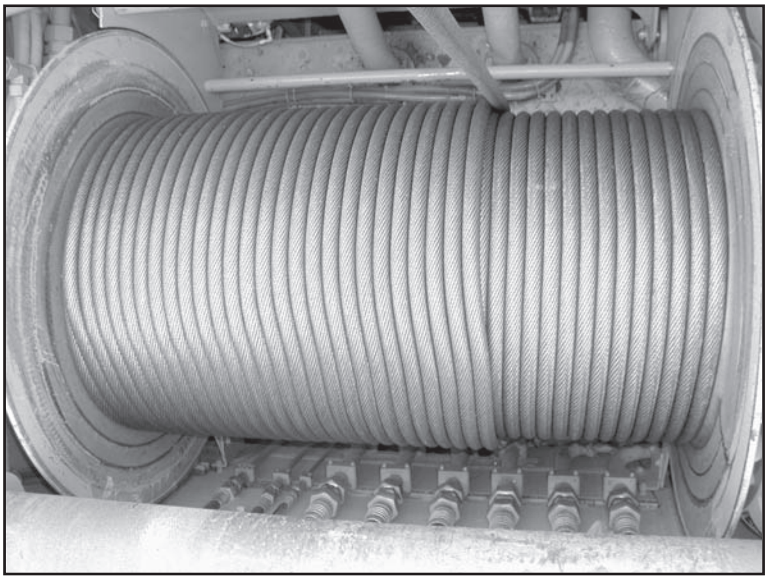


Fig. 29: Rope diameter correct: The crossover zone is parallel to the drum axis.

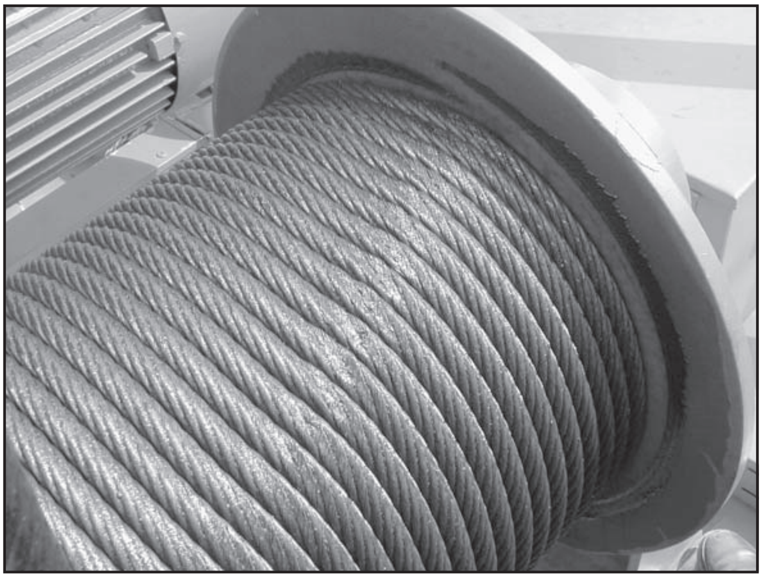


Fig. 30: Rope diameter too small: The crossover zone is inclined towards the drum axis (causing severe rope damage)

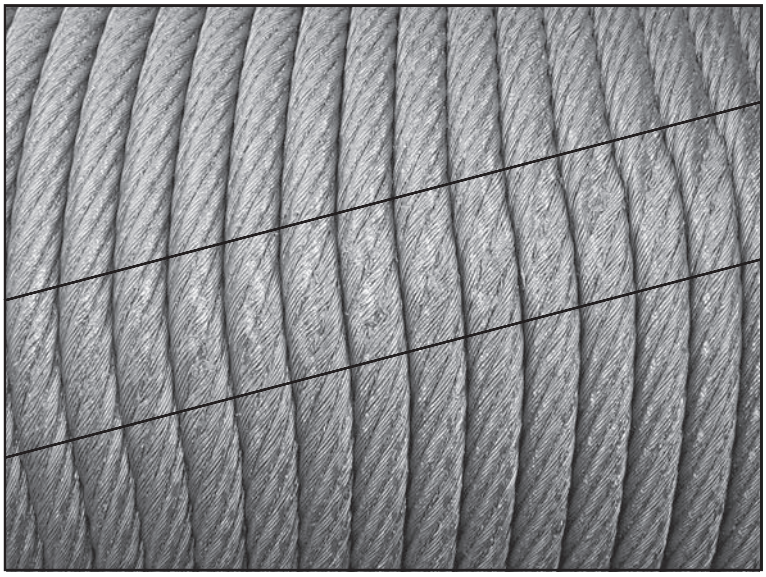


Fig. 31: Rope damage caused by instable support (the crossover zones are no longer parallel to the drum axis)

If on the other hand the rope diameter is too big, the second wrap will be kicked to the side by the first wrap at bit earlier than intended. The third wrap will again be kicked too early by the second etc, resulting in a crossover zone inclined in the opposite sense.

The normal range of the wire rope diameter tolerances is 5%. ISO, e.g. allows wire rope diameters from nominal dia. -1% to nominal dia. +4%. For proper spooling, this range must be reduced to about 2%.

Lebus usually uses drums with a pitch of

drum pitch = 1.04 ÷ 1,05 • nominal rope diameter.

The wire rope diameter range of tolerance is limited to 2% (nominal dia. +2% to nominal dia. +4%).

Remedy 1: Shifting the crossover zones

As discussed above, even with correct rope diameters and even when using sophisticated drum designs, the wire rope will have to be kicked to the side by the neighbouring wrap twice with every revolution of the drum. This will inevitably lead to wire rope damage.

The bad news is, this damage is very much concentrated on the crossover zones. Fig. 32 shows a typical rope section from a crossover zone (Zone A of Fig. 5) of a rope tested on the Casar test stand.

The good news, however, is that the damage is periodical: we will always have a short damaged zone followed by a long undamaged zone followed by a short damaged zone etc.... And that gives us the opportunity to spread the damage by cutting off a rope section a bit longer than the length of the damaged zone at the drum end of the rope well before the discard state of the rope is reached (Fig. 33).

This action will move all the damaged rope sections out of the damaging crossover zones on the drum into comfortable positions in the parallel zones. Relatively undamaged rope sections will move into the crossover zones instead. This action can easily double or even triple the life of the wire rope.

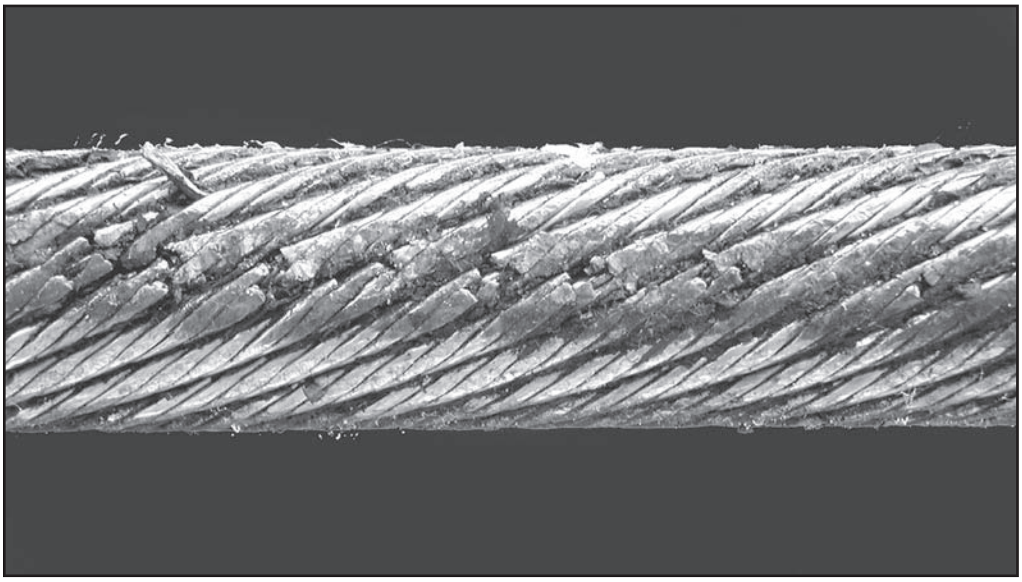


Fig. 32: Typical rope damage in the crossover zone

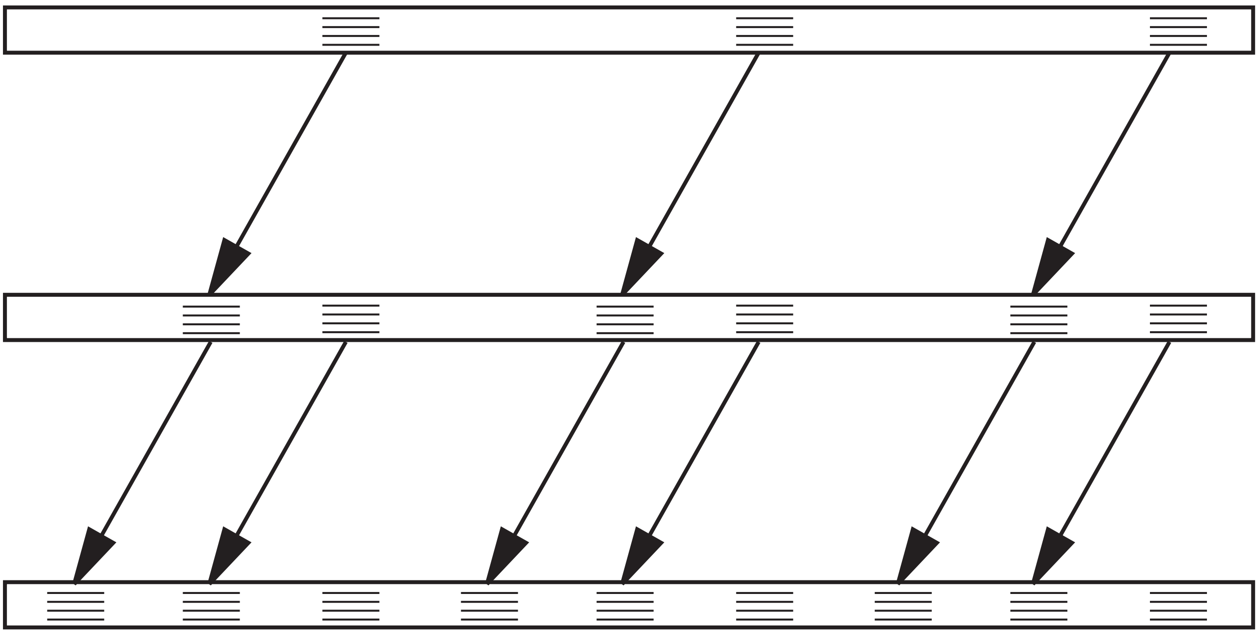


Fig. 33: Shifting of the damaged rope zones on the drum

Remedy 2: Spooling aids

As explained above, the rope is destroyed on multi layer drums by spooling against adjacent rope wraps. A spooling aid can help guide the rope during spooling and can prevent it from constantly hitting its neighbouring wrap.

It must be guaranteed, however, that the spooling aid is calibrated to the effective rope diameter. An incorrectly calibrated spooling aid might just do the opposite of what it is supposed to do: it might constantly guide the incoming rope against its neighbouring wrap and destroy the rope in very short time.

And don´t forget: the wire rope diameter will reduce over time!

Rope solutions

We have seen that during drum crushing, the wire rope is not damaged by other objects. No, the rope is destroyed by constantly hitting itself! Spooling on a multi layer drum is a constant hammering of one rough rope surface against another rough surface of the same rope! Drum crushing really is the wire rope equivalent of suicide!

How can we prevent this self- destruction?

Rope solution 1: Langs lay ropes

Practical experience has shown in the past that during multi layer spooling Langs lay ropes (Fig. 34) perform much better than regular lay ropes (Fig. 35). This is because the outer wires of neighbouring wraps cannot form indentations which would inevitably lead to mutual destruction.

Rope solution 2: Ropes with bigger outer wires

It is also a known fact that ropes with bigger, more robust outer wires perform better in multi layer spooling. The diameter of the outer wires of a Seale 19 strand (Fig. 36) is 42 % bigger than those of a Warrington- Seale 36 strand (Fig. 37). Their metallic cross- section is 100 % bigger and therefore much more robust and abrasion resistant. Of course, the fatigue performance of a Seale 19 strand is worse than that of a WS 36 strand, but who cares if not fatigue but drum crushing is the problem?

Rope solution 3: Ropes with compacted outer strands

A great deal of the damage caused during multi- layer spooling is caused by individual outer wires forming indentations with the outer wires of the neighbouring wrap (Fig. 38). If, however, the rope has compacted outer strands (Fig. 39), indentations cannot occur so readily and the damage is greatly reduced.

Rope solution 4: Hammered ropes

As we have seen above, most of the damage a wire rope will be subjected to during multi layer spooling is caused by the rough outer surface of the rope itself. So it would only seem logical to smoothen the rope surface in order to reduce the damage.

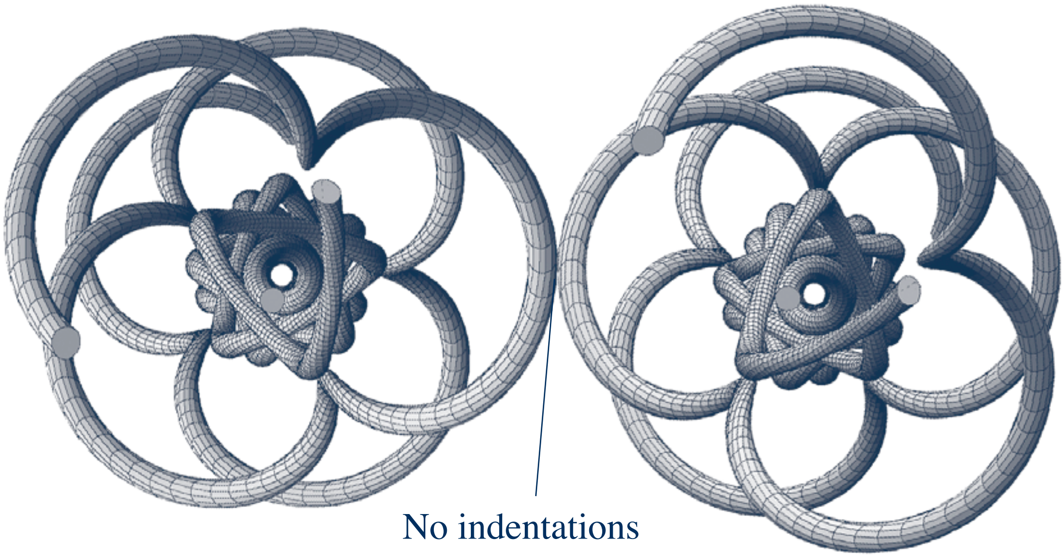


Fig. 34: Langs lay ropes: No indentations of outer wires

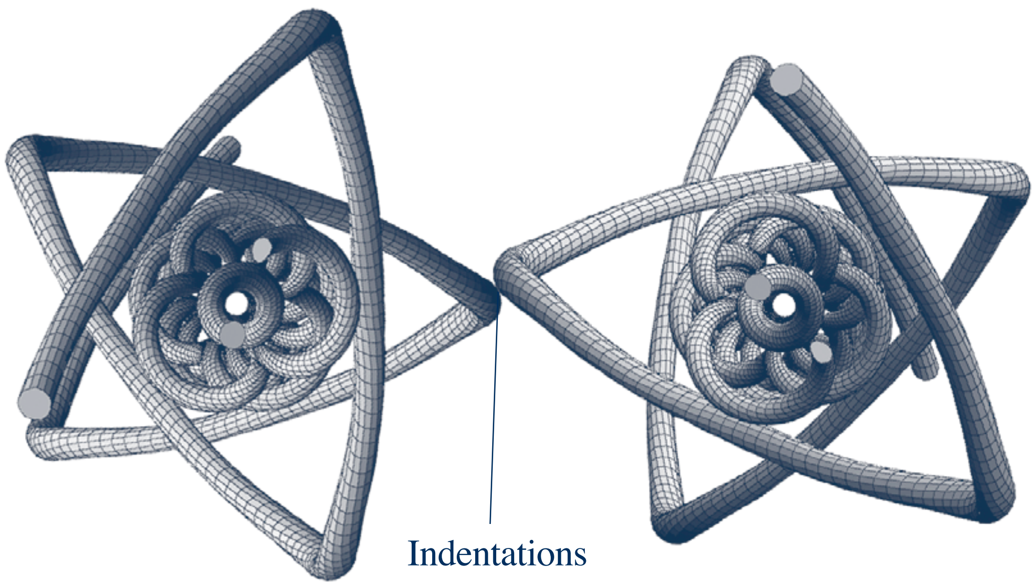


Fig. 35: Regular lay ropes: Indentations of outer wires

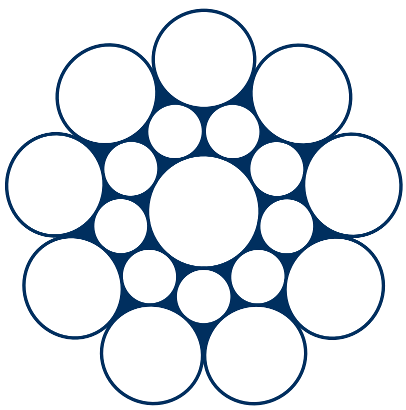


Fig. 36: Seale 19 strand, a very robust strand design

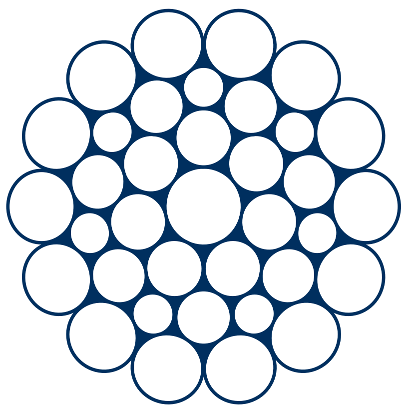


Fig. 37: Warrington- Seale 36 strand, a very fatigue resistant strand design

Steel wire ropes cross sections are often referred to as being “round”. But they are not round at all! Depending on the number of outer strands of the rope, the cross sections resemble a hexagon or an octogon much more than a circle! The sequence of crowns and valleys along the circumference is the main cause for all the problems we have discussed above! So, in order to avoid the problems, we must really make the rope cross section round!

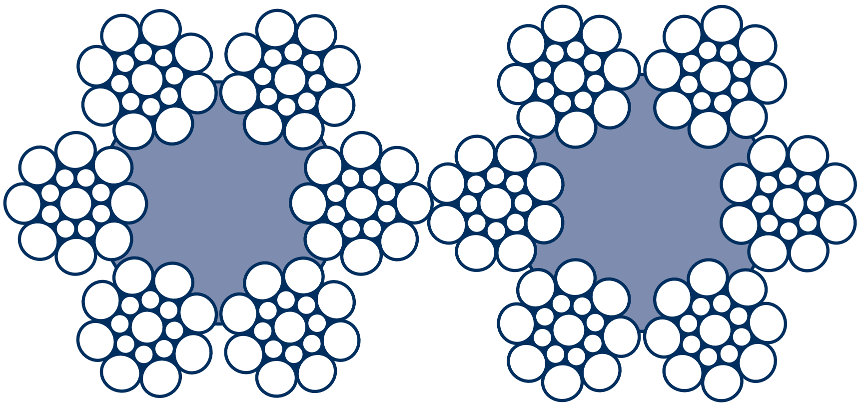


Fig. 38: Conventional outer strands allow for indentations between outer wires

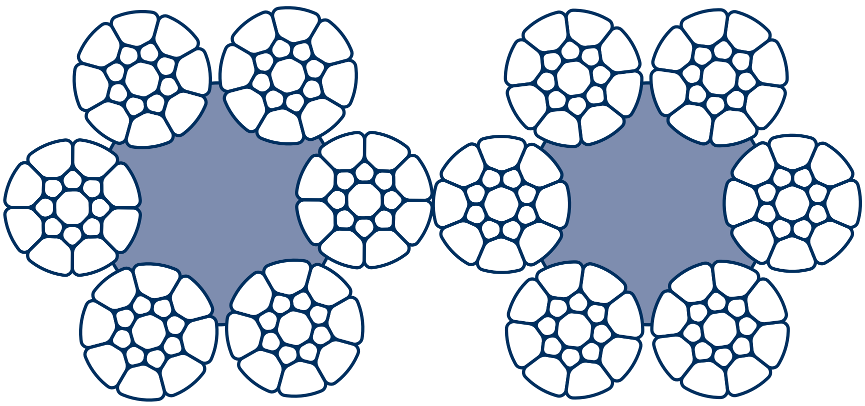


Fig. 39: Compacted outer strands prevent indentations between outer wires

Casar Drahtseilwerk Saar has achieved tremenduously round cross sections and extremely smooth wire rope surfaces by hammering different types of steel wire ropes using a rotary swager. Great care has been taken to avoid internal wire rope damage caused by the swaging process itself. Figure 40 shows a conventional steel wire rope in unswaged condition (top) and with two different degrees of diameter reduction.

The hammered ropes have been tested on normal bending fatigue machines and on the Casar multi-layer test stand shown in Figure 10. The results have been very encouraging: On the multi-layer test stand, on average the swaged ropes achieved about 3 times the life of the comparable unswaged designs.

Hammered ropes have much greater contact areas with the grooves of sheaves and drums than conventional steel wire ropes with a “rough” surface. This leads to much lower bearing pressures and as a consequence to much lower sheave, drum and rope wear.

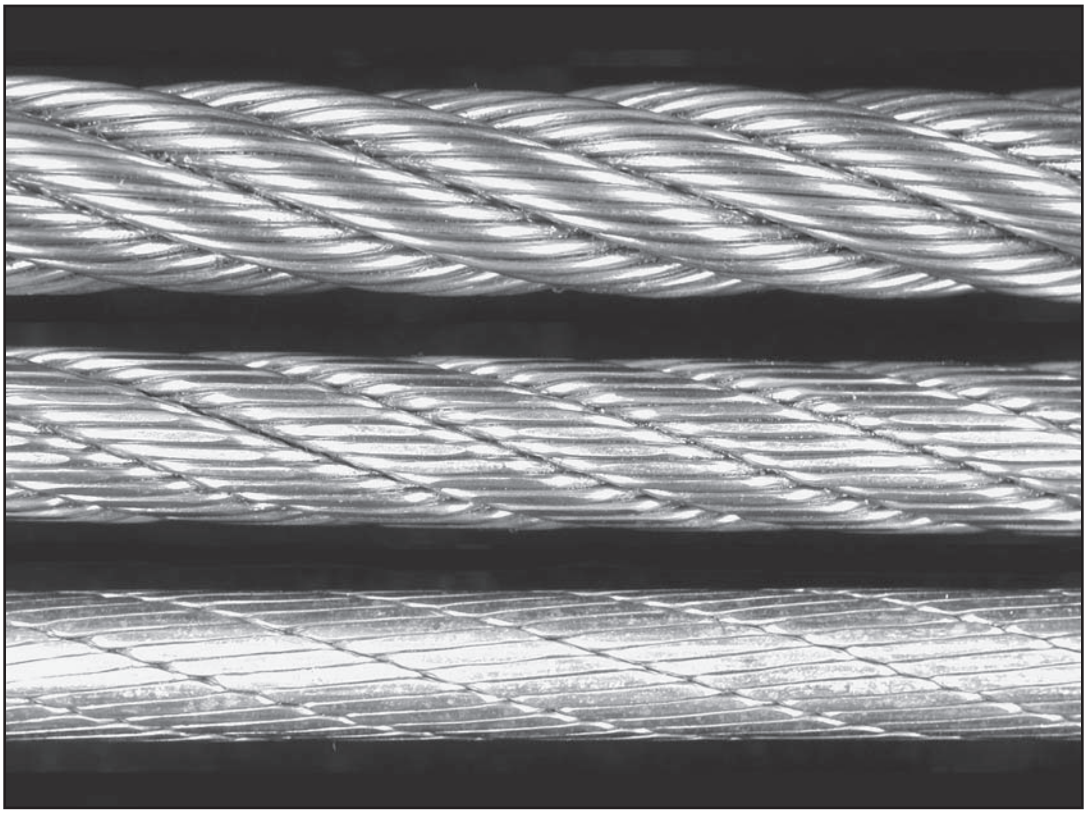


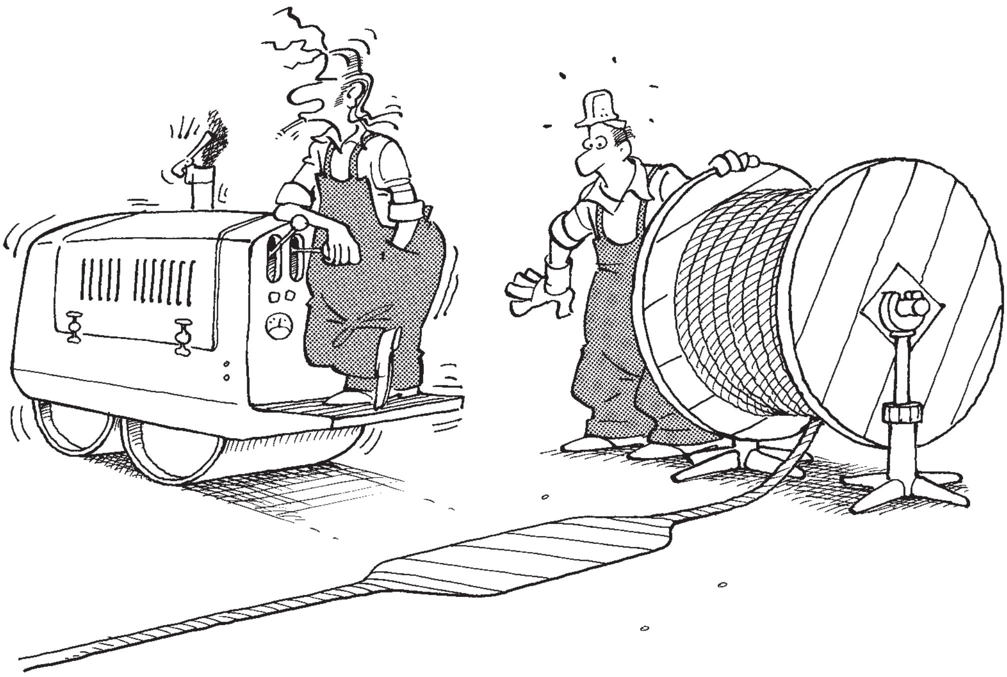
Fig. 40: The same rope before swaging (top), after swaging (normal reduction, middle) and after swaging (severe reduction, bottom).

Casar offers a variety of hammered steel wire ropes. They can be identified in the Casar rope catalogues by the name ending “fit”. The following pages show a 14 strand rotation resistant rope (Casar Starfit) and two non rotation resistant ropes (Casar Ultrafit and Casar Parafit). Compared with conventional steel wire ropes, these rope designs offer an increased breaking strength and excellent rope life on multi layer drums.

CASAR

	STARFIT	ULTRAFIT	PARAFIT
Average fill factor	0,72	0,70	0,74
Spinning factor 1960 N/mm^2	0,85	0,85	0,87
Spinning factor 2160 N/mm^2	0,84	0,84	0,86
Average weight factor	0,87	0,88	0,85
Total number of wires	217	244	298
Number of wires in outer strands	98	133	208
Discard number on 6 x d *	8	11	18
Discard number on 30 x d *	16	22	35

* DIN 15020, Group of mechanisms 2m - 5m, Regular lay



April 27, 2000. Joe Bloggs (left) invents the swaged rope.

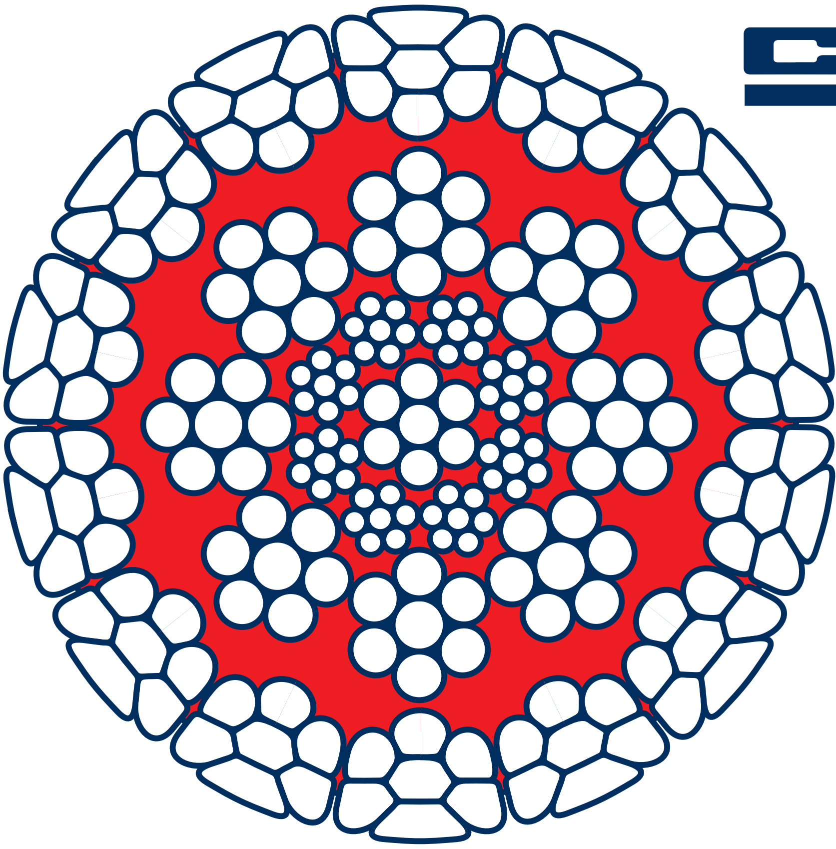
CASAR® **STARFIT**

Nominal diameter	Metallic area	Weight	Calculated aggregate breaking load				Minimum breaking load			
			with tensile strength of wire							
			1960 N/mm² (200kp/mm²)		2160 N/mm² (220kp/mm²)		1960 N/mm² (200kp/mm²)		2160 N/mm² (220kp/mm²)	
mm	mm²	kg/%m	kN	t	kN	t	kN	t	kN	t
12	81,17	70,6	159,1	16,22	175,3	17,88	135,22	13,79	147,27	15,02
13	94,89	82,6	186,0	18,97	205,0	20,90	158,09	16,12	172,18	17,56
14	110,23	95,9	216,1	22,03	238,1	24,28	183,65	18,73	200,01	20,40
15	125,72	109,4	246,4	25,13	271,5	27,69	209,44	21,36	228,10	23,26
16	145,90	126,9	286,0	29,16	315,2	32,14	243,08	24,79	264,73	26,99
17	163,28	142,1	320,0	32,63	352,7	35,96	272,03	27,74	296,26	30,21
18	183,93	160,0	360,5	36,76	397,3	40,51	306,43	31,25	333,72	34,03
19	203,94	177,4	399,7	40,76	440,5	44,92	339,76	34,65	370,03	37,73
20	226,56	197,1	444,1	45,28	489,4	49,90	377,45	38,49	411,07	41,92
21	247,40	215,2	484,9	49,45	534,4	54,49	412,17	42,03	448,88	4577
22	271,50	236,2	532,1	54,26	586,4	59,80	452,31	46,12	492,60	50,23
23	303,59	264,1	595,0	60,68	655,8	66,87	505,78	51,58	550,83	56,17
24	324,61	282,4	636,2	64,88	701,2	71,50	540,80	55,15	588,98	60,06
25	354,15	308,1	694,1	70,78	765,0	78,00	590,02	60,16	642,57	65,52
26	379,31	330,0	743,4	75,81	819,3	83,55	631,92	64,44	688,21	70,18
27	413,81	360,0	811,1	82,71	893,8	91,14	689,40	70,30	750,81	76,56
28	448,16	389,9	878,4	89,57	968,0	98,71	746,64	76,14	813,14	82,92
29	475,58	413,8	932,1	95,05	1027,3	104,75	792,32	80,79	862,89	87,99
30	505,02	439,4	989,8	100,94	1090,8	111,24	841,36	85,80	916,31	93,44
32	583,07	507,3	1142,8	116,53	1259,4	128,43	971,39	99,05	1057,92	107,88
34	659,96	574,2	1293,5	131,90	1425,5	145,36	1099,49	112,12	1197,42	122,10
36	736,77	641,0	1444,1	147,25	1591,4	162,28	1227,46	125,17	1336,80	136,32
38	813,79	708,0	1595,0	162,65	1757,8	179,24	1355,77	138,25	1476,53	150,56
40	909,05	790,9	1781,7	181,69	1963,6	200,23	1514,48	154,43	1649,39	168,19
42	996,51	867,0	1953,2	199,17	2152,5	219,49	1660,18	169,29	1808,06	184,37
44	1101,83	958,6	2159,6	220,22	2380,0	242,69	1835,66	187,18	1999,17	203,86
46	1192,12	1037,1	2336,6	238,26	2575,0	262,57	1986,07	202,52	2162,98	220,56
48	1312,75	1142,1	2573,0	262,37	2835,5	289,15	2187,05	223,02	2381,86	242,88
50	1414,86	1230,9	2773,1	282,78	3056,1	311,64	2357,16	240,36	2567,12	261,77

Further diameters upon request !

CASAR®

STARFIT



regular lay or
langs lay

CASAR®

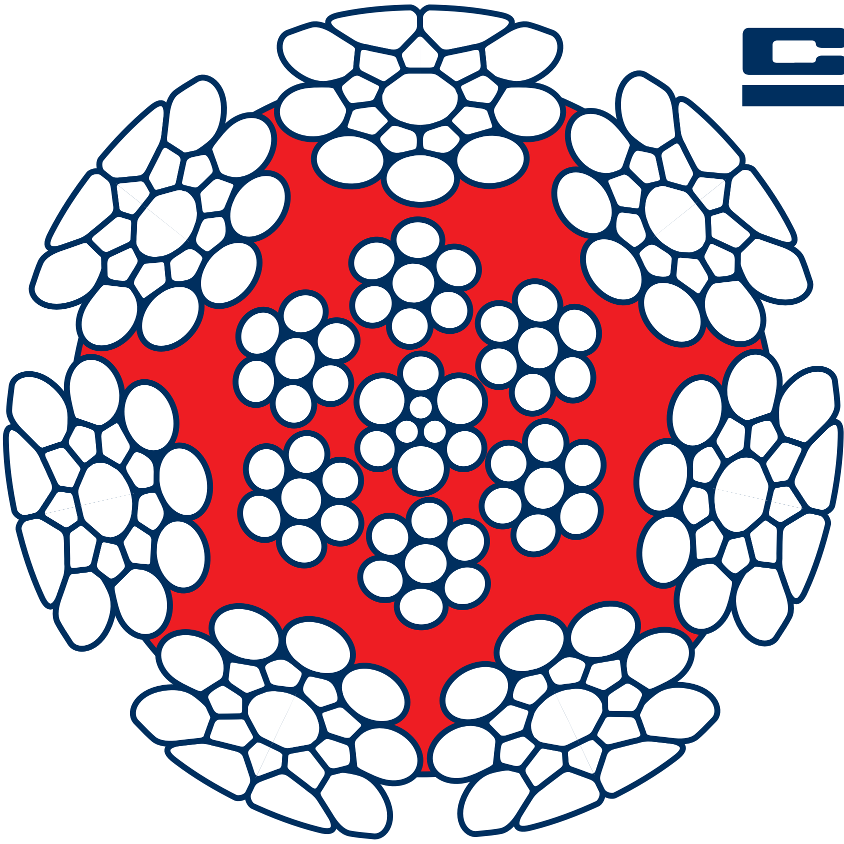
STARFIT

- is a 14-strand rotation resistant, hammered rope.
- is fully lubricated.
- has a plastic layer between the steel core and the outer strands.
- has a very high breaking strength
- has a very smooth surface and is therefore especially suited for multi layer spooling.

CASAR® ULTRAFIT

Nominal diameter	Metallic area	Weight	Calculated aggregate breaking load				Minimum breaking load			
			with tensile strength of wire							
			1960 N/mm² (200kp/mm²)		2160 N/mm² (220kp/mm²)		1960 N/mm² (200kp/mm²)		2160 N/mm² (220kp/mm²)	
mm	mm²	kg/%m	kN	t	kN	t	kN	t	kN	t
8	34,22	30,1	67,1	6,84	73,9	7,54	57,0	5,81	62,1	6,33
9	45,82	40,3	89,8	9,16	99,0	10,09	76,3	7,78	83,1	8,48
10	56,71	49,9	111,1	11,33	122,5	12,49	94,5	9,63	102,9	10,49
11	65,31	57,5	128,0	13,05	141,1	14,39	108,8	11,10	118,5	12,08
12	77,79	68,5	152,5	15,55	168,0	17,13	129,6	13,22	141,1	14,39
13	93,47	82,3	183,2	18,68	201,9	20,59	155,7	15,88	169,6	17,29
14	107,61	94,7	210,9	21,51	232,4	23,70	179,3	18,28	195,2	19,91
15	124,22	109,3	243,5	24,83	268,3	27,36	207,0	21,10	225,4	22,98
16	145,06	127,7	284,3	28,99	313,3	31,95	241,7	24,64	263,2	26,84
17	160,01	140,8	313,6	31,98	345,6	35,24	266,6	27,18	290,3	29,60
18	179,95	158,4	352,7	35,97	388,7	39,64	299,8	30,57	326,5	33,29
19	197,06	173,4	386,2	39,38	425,6	43,40	328,3	33,48	357,5	36,46
20	224,27	197,4	439,6	44,82	484,4	49,40	373,6	38,10	406,9	41,49
21	237,91	209,4	466,3	47,55	513,9	52,40	396,4	40,42	431,7	44,02
22	265,14	233,3	519,7	52,99	572,7	58,40	441,7	45,04	481,1	49,05
23	286,37	252,0	561,3	57,24	618,6	63,08	477,1	48,65	519,6	52,98
24	317,51	279,4	622,3	63,46	685,8	69,93	529,0	53,94	576,1	58,74
25	349,43	307,5	684,9	69,84	754,8	76,96	582,1	59,36	634,0	64,65
26	369,79	325,4	724,8	73,91	798,8	81,45	616,1	62,82	671,0	68,42
27	395,19	347,8	774,6	78,98	853,6	87,04	658,4	67,14	717,0	73,12
28	425,38	374,3	833,7	85,02	918,8	93,69	708,7	72,27	771,8	78,70
29	451,24	397,1	884,4	90,19	974,7	99,39	751,8	76,66	818,7	83,49
30	490,53	431,7	961,4	98,04	1059,5	108,04	817,2	83,33	890,0	90,76
32	561,22	493,9	1100,0	112,17	1212,2	123,61	935,0	95,34	1018,3	103,84
34	648,83	571,0	1271,7	129,68	1401,5	142,91	1081,0	110,23	1177,2	120,04
36	700,97	616,9	1373,9	140,10	1514,1	154,40	1167,8	119,08	1271,8	129,69
38	784,99	690,8	1538,6	156,89	1695,6	172,90	1307,8	133,36	1424,3	145,24
40	870,87	766,4	1706,9	174,06	1881,1	191,82	1450,9	147,95	1580,1	161,13
42	951,04	836,9	1864,0	190,08	2054,3	209,48	1584,4	161,57	1725,6	175,96
44	1046,62	921,0	2051,4	209,18	2260,7	230,53	1743,7	177,81	1899,0	193,64
46	1146,74	1009,1	2247,6	229,19	2476,9	252,58	1910,5	194,81	2080,6	212,17
48	1252,19	1101,9	2454,3	250,27	2704,7	275,81	2086,1	212,73	2272,0	231,68
50	1351,47	1189,3	2648,9	270,11	2919,2	297.67	2251,6	229,59	2452,1	250,05

Further diameters upon request !



CASAR®
ULTRAFIT

regular lay

CASAR®
ULTRAFIT

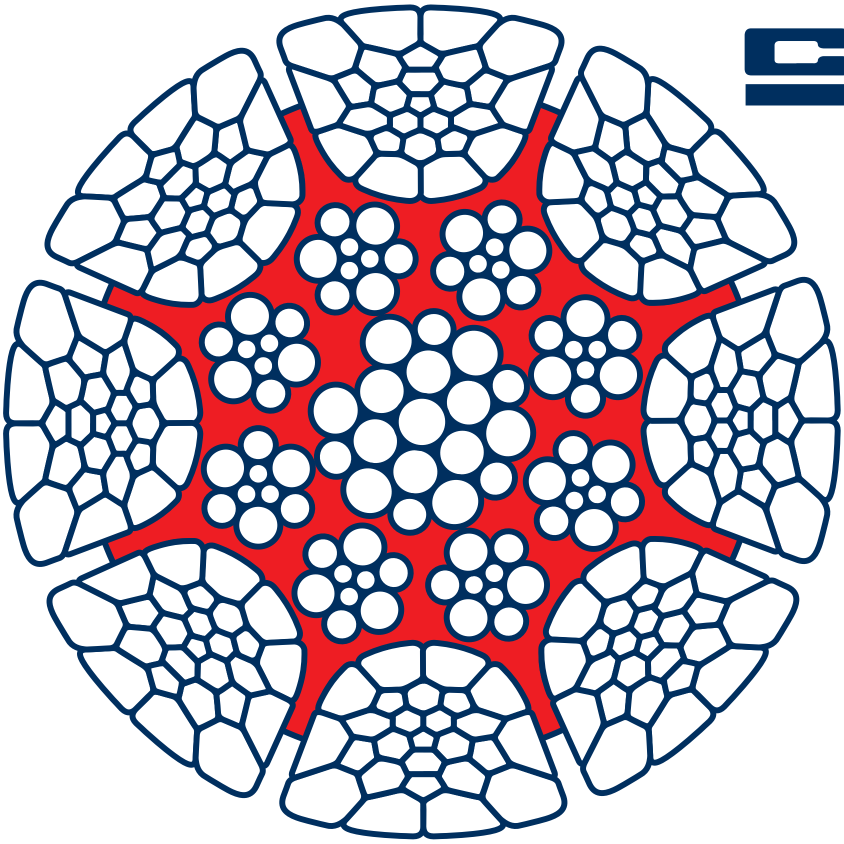
- is an 7-strand hammered rope.
- is fully lubricated.
- has a plastic layer between the steel core and the outer strands.
- has a very high breaking strength
- has a very smooth surface and is therefore especially suited for multi layer spooling.

CASAR® ULTRAFIT may not be used with a swivel.

CASAR® PARAFIT

Nominal diameter	Metallic area	Weight	Calculated aggregate breaking load with tensile strength of wire 1960 N/mm² (200kp/mm²)		Calculated aggregate breaking load with tensile strength of wire 2160 N/mm² (220kp/mm²)		Minimum breaking load with tensile strength of wire 1960 N/mm² (200kp/mm²)		Minimum breaking load with tensile strength of wire 2160 N/mm² (220kp/mm²)	
mm	mm²	kg/%m	kN	t	kN	t	kN	t	kN	t
8	36,97	31,4	72,5	7,39	79,9	8,14	63,05	6,43	68,68	7,00
9	46,56	39,6	91,3	9,31	100,6	10,26	79,40	8,10	86,49	8,82
10	57,09	48,5	111,9	11,41	123,3	12,57	97,34	9,93	106,04	10,81
11	71,25	60,6	139,6	14,24	153,9	15,69	121,49	12,39	132,35	13,50
12	82,66	70,3	162,0	16,52	178,6	18,21	140,96	14,37	153,55	15,66
13	97,89	83,2	191,9	19,56	211,4	21,56	166,91	17,02	181,83	18,54
14	114,85	97,6	225,1	22,95	248,1	25,30	195,84	19,97	213,35	21,76
15	130,87	111,2	256,5	26,16	282,7	28,83	223,16	22,76	243,10	24,79
16	149,58	127,1	293,2	29,89	323,1	32,95	255,06	26,01	277,85	28,33
17	171,09	145,4	335,3	34,20	369,6	37,68	291,75	29,75	317,82	32,41
18	189,23	160,8	370,9	37,82	408,7	41,68	322,68	32,90	351,51	35,84
19	213,70	181,6	418,9	42,71	461,6	47,07	364,41	37,16	396,97	40,48
20	233,67	198,6	458,0	46,70	504,7	51,47	398,45	40,63	434,06	44,26
21	256,54	218,1	502,8	51,27	554,1	56,50	437,45	44,61	476,54	48,59
22	284.51	241,8	557,6	56,86	614,5	62,67	485,15	49,47	528,51	53,89
23	309,81	263,3	607,2	61,92	669,2	68,24	528,29	53,87	575,51	58,69
24	337,86	287,2	662,2	67,53	729,8	74,42	576,12	58,75	627,61	64,00
25	366,17	311,2	717,7	73,19	790,9	80,65	624,40	63,67	680,21	69,36
26	393,92	334,8	772,1	78,73	850,9	86,76	671,71	68,50	731,74	74,62
27	426,46	362,5	835,9	85,24	921,2	93,93	727,21	74,15	792,20	80,78
28	459,06	390,2	899,8	91,75	991,6	101,11	782,78	79,82	852,74	86,96
29	491,46	417,7	963,3	98,23	1061,6	108,25	838,04	85,46	912,94	93,09
30	529,11	449,7	1037,1	105.75	1142,9	116,54	902,24	92,00	982,88	100,23
32	597,54	507,9	1171,2	119,43	1290,7	131,61	1018,93	103,90	1109,99	113,19
34	678,69	576,9	1330,2	135,65	1466,0	149,49	1157,31	118,01	1260,74	128,56
36	757,45	643,8	1484,6	151,39	1636,1	166,84	1291,61	131,71	1407,04	143,48
38	848,20	721,0	1662,5	169,52	1832,1	186,82	1446,35	147,49	1575,62	160,67
40	934,70	794,5	1832,0	186,81	2018,9	205,87	1593,84	162,53	1736,29	177,05
42	1030,49	875,9	2019,8	205,96	2225,9	226,97	1757,19	179,18	1914,24	195,20
44	1137,59	967,0	2229,7	227,36	2457,2	250,56	1939,82	197,81	2113,19	215,49
46	1240,77	1054,7	2431,9	247,99	2680,1	273,29	2115,76	215,75	2304,85	235,03
48	1351,25	1148,6	2648,5	270,07	2918,7	297,63	2304,16	234,96	2510,09	255,96
50	1454,55	1236,4	2850,9	290,71	3141,8	320,38	2480,29	252,92	2701,97	275,52

Further diameters upon request !



CASAR® PARAFIT

regular lay

CASAR® PARAFIT

- is an 8-strand hammered rope.
- is fully lubricated.
- has a double parallel lay steel core, avoiding internal cross-overs.
- has a plastic infill.
- has an extremely high breaking strength.
- has a very smooth surface and is therefore especially suited for multi layer spooling.

CASAR® PARAFIT may not be used with a swivel.

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........copies of the brochure	*Which rope for my crane?*
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.... copies of the brochure	*Wire rope end connections*
.... copies of the brochure	*Wire rope inspection*
.... copies of the brochure	*Calculating the service life of running steel wire ropes*
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