PDF E HB-07-02	**Handbook Steel Wire Ropes** **Paul Gerd Voigt**	c:\ Handbook
08	**Technical Information, Rope Properties, Rope Behaviour,**	**08-Tecin**
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8.4.3.5	**Fleet Angles, Rope Rotation, Rope Torque by Rope Guiding, Diagonal Pull**	Page 1 of 9
8.4.3.5.3	**Rope Damage by Diagonal Pull (Fleet Angle) in field Operation**	2005-03-03

		See
8.4.3.5.3.1	**- Diagonal Pull (Fleet Angle) at Crane Ropes, Draglines**	
8.4.3.5.3.2	**- Diagonal Pull (Fleet Angle) at Friction Hoist Ropes (Underground Mining)**	
-1	**In field application diagonal pull (fleet angle) can not only reduce the service life of the rope it can also create severe rope damage.**	
-2	In Bulletin 88 OIPEEC Mr H. M. Huber reports „Extreme Rope Rotation “related to diagonal rope pull. At the Conference of IFT University Stuttgart Nov. 2005 Dr. Dipl. Ing. Silke Schönherr reported above the „Reduction of Fatigue Life of wire ropes because of diagonal pull between rope sheaves“. Also D. Fuchs. has mentioned that already at fleet angles above 1° at friction hoist ropes with 6-strand Lang lay ropes and also with regular lay ropes problems appear in rope structure, especially at great depth. Using adequate Rope Constructions e. g. more stable constructions, three Layer oval strand ropes (rotation resistant) mostly the problem can be solved. See § 7	
-3	**Factors influencing Rope Life & rope damage.** **Rope related:** Rope diameter, Rope diameter tolerance. Rope construction, stiffness of rope structure, strand- wire-clearances, grade of performing (Helix-height & helix length), rope rotational behaviour without tension (rope loop turn test). **Equipment and handling, operating related:** Fleet angle (diagonal pull), load range of stresses & tension, total unloading, rope length, hoisting height, forced rope rotation, acceleration & deceleration, combination of rope rotation and rope tension.	
-4	**Some experiences of rope damage in the field at rope diagonal pull (fleet angle):**	
-4.1	Ropes were installed on an overhead crane in a steel mill. Figure 4.1.1 and 4.1.2. Rope diameter 40 mm ∅, 6x36WS IWRC zZ. After a short time wires in the rope became loose in Zone A-B continually increasing. A little bit later also wires became loose (lifted wires 5.1) also in Zone CD. One rope system (Figure 4.1.2) Fleet angle at highest hook position 6°. Groove ope ning angle 40°. Groove radius 21 mm. The rope had to be removed because of loose wires in these zones. In all the other rope zones the rope was completely intact... At the entrance on the drum and analogous in zone CD the rope was	

forced to rotate (opening the rope structure) because of the diagonal pull (fleet angle).
Rope length, multiple shearing, load range and loading - unloading up to slack rope condition are relevant compared with only bending fatigue test.

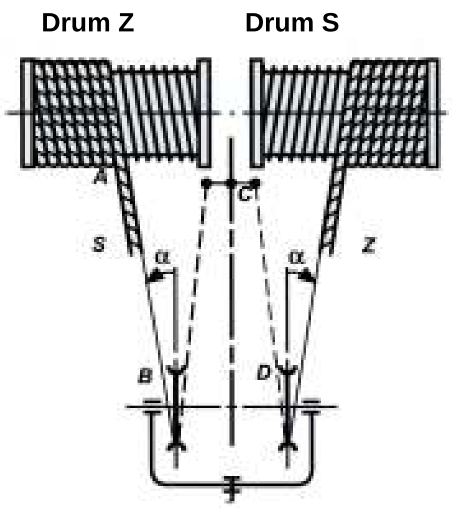


Fig: 4.1.1 two rope system

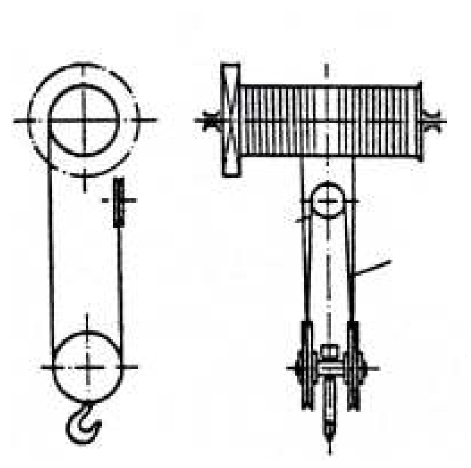


Fig 4.1.2 One rope system

-4.2 Corkscrew (Figure 5.8)
The rope became a corkscrew (5.7) when operating on an overhead-crane (Figure 4.1.1) in Zone AB and in the other rope in Zone CD (between fixed end and sheave, both ropes in right lay. When using right and left lay ropes, correctly installed, the corkscrew would be at the same location on both drums). The earlier ropes had run without any complaints. The measured rope diameter of the former ropes was 41 mm (+ 2,5 %). The diameter of this rope was 42,00 mm. The larger rope (same nominal rope diameter but other design rope diameter). The rope was delivered by mistake. It was a special design for a Lebus groove system with a requested actual rope diameter of 42 mm and nominal rope diameter of 40 mm. Groove radius 21,5 mm. The rope was replaced with the earlier smaller design diameter and a tolerance of 2,5 %. This rope was running without problems again.
Four years later, the problem was forgotten and again the larger rope was delivered and the same rope damage had occurred.

-4.3 **Service Life of Dragline Hoist ropes.**
The Draglines from different Dragline Manufacturers have different rope guiding systems; as well for the hoist and drag ropes.

-4.3.1 **Hoist Rope**
The Boom Point Sheaves of one type has tilting bearings in each sheave (Fig. 4.3.1.2). Having 2 or more ropes the Sheaves are tilting quite often in different direction as shown. At the other system the sheaves are mounted on a shaft in a cage (Fig. 4.3.1.1. & 4.3.1.3)
The complete cage is tilting. In both systems the fleet angle of the ropes when running into the groove of the point sheave can be quite different. The service life of the ropes operating in the “cage system” is 30 to 50 % higher.

Fig. 4.3.0
Boom Point Sheave

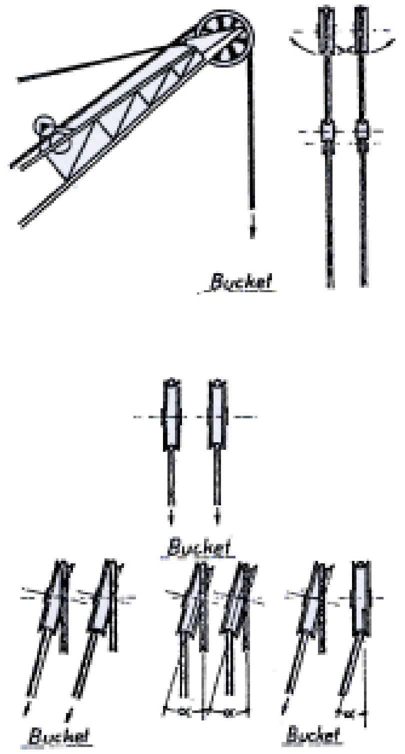


Fig. 4.3.1

Sheaves are tilting with the diagonal pull	Sheaves are tilting differently

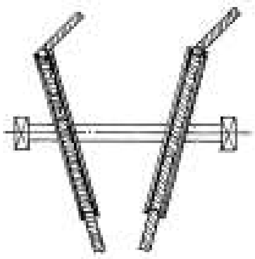


Fig 4.3.1.2

Sheaves with tilting bearings

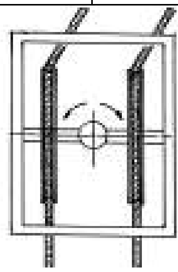


Fig 4.3.1.1

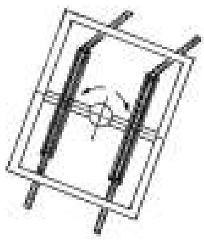


Fig 4.3.1.3

Sheaves on a shaft within tilting cage

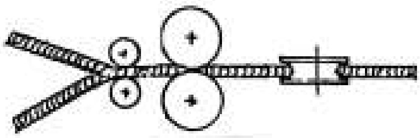
-4.3.2 **Dragrope)**

Different rope guiding systems exist also for the drag-ropes.
One system (horizontal guiding) guides the ropes through horizontal and vertical sheaves and guide bars (Fig. 4.3.2.1). Guide bares over which the ropes are also bend (Fig. 4.3.2.1.2)
having small D/d relations.
The other system guides the ropes above sheaves under reverse bending over another sheave below. Both sheaves are moving together into the defection angle. There is no bending around the bars as in the horizontal system. Despite the reverse bending, these ropes achieve a higher service life (30-50%) than the horizontal guiding system without reverse bending Fig. 4.3.2.1 & 4.3.2.2

Figure 4.3.2.1 Horizontal rope guiding

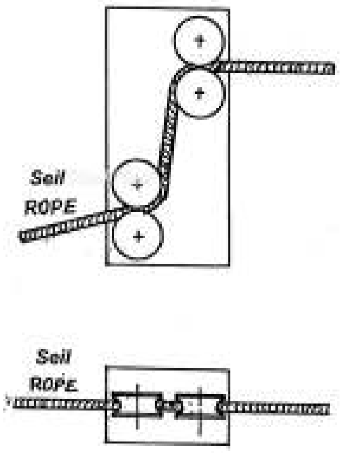
Fig: 4.3.2.1.1

Fig: 4.3.2.1.2

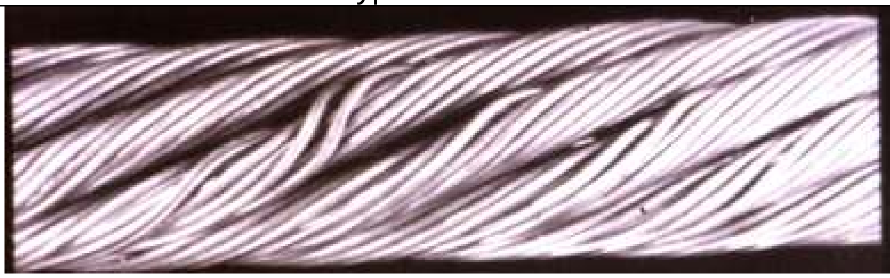
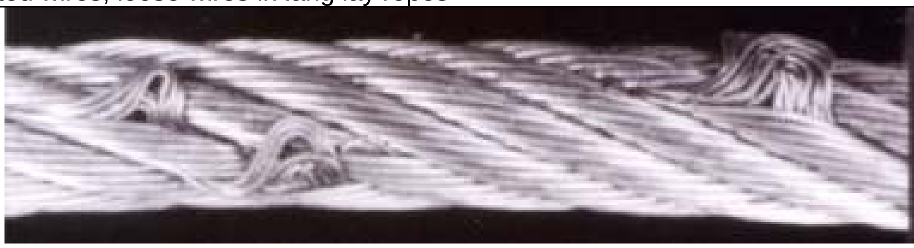
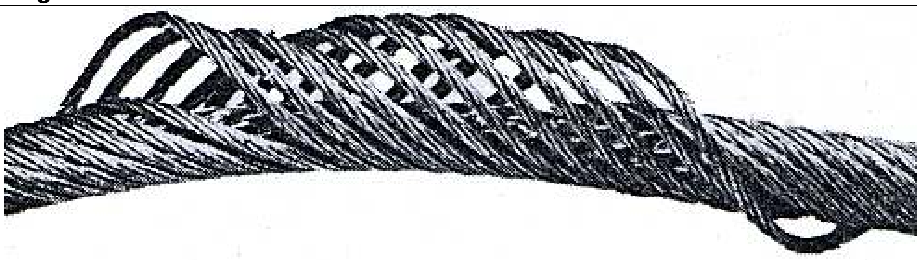


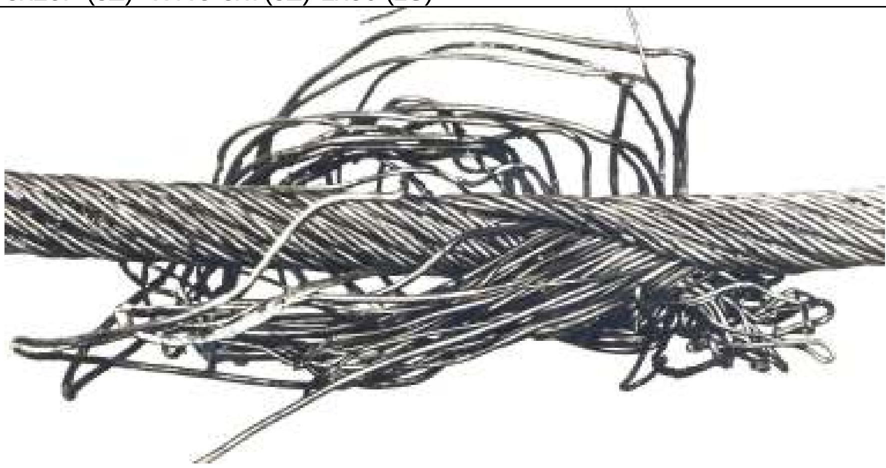
Horizontal Rope guiding
Fig: 4.3.2.1.3

Fig 4.3.2.2.0 Rope Guiding



Rope guiding with reverse bending
Fig: 4.3.2.2.1

-5	**Rope damage at diagonal pull (Fleet angle)** = Lifted wires (in Lang Lay ropes) = Liftend Strands = Wire Looping (Hairneedles) = Corkscrew type deformation	
-5.1	 Fig: 5.1 (7.7.5.5.3.4.5) Lifted wires, loose wires in lang lay ropes	
-5.2	 **Fig: 5.2 (7.7.5.5.3.4.4)** **Hairneedles in ordinary lay ropes**	
-5.3	 **Fig. 5.3** **These are no hairneedles or lifted wires)** **Broken wires at contact point of core-wires and outer-strand-wires**	
-5.4	 **Fig: 5.4 Single layer round strand rope. Diagonal pull. Also sheave grooves might be too small.**	
-5.4.1	 **Fig: 5.4.1 Multi-Layer Strand Rope (Rotation resistant, low rotation)** **Lifted strands. This is not bird caging (Bird caging see Costello 6) & Voigt, Steel Wire Rope Lifted strands 3).**	

-5.5	 **Fig 5.5: Protrusion of steel core**	
-5.6	 Fig: 5.6 (7.7.5.3.1.10) Protrusion of Wires because of wrong lay direction of core centre strand. The centre strand is closed in the opposite lay direction on the rope and the steel core. In combination with rope rotation wires will be massaged to one position and the wires will protrude to the outside. 8x25F (sZ) IWRC 8x7(sZ)-1x36 (zS)	
-5.6.1	 **Fig: 5.6.1 (7.7.5.3.1.10.1)** **The 8 outer strands have been removed. The steel core of Fig. 5.6 is shown. The protruded wires are coming alone from the centre strand**	
-5.7	Corkscrew	
		
	 **Fig: 5.8. Corkscrew type deformation.** **Reason:** **Rope related: wrong dimensioning of core , wrong density of fibre core, rotational stresses from manufacturing** **Equipment and handling, operating related: e. g. diagonal pull (fleet angle)**	

-6	Dr. D. Fuchs (formerly DMT) point of view to the fleet angle problem:	
	Ropes, running under a fleet angle diagonal into the groove of a sheave or drum undergo a force attack on its surface in circumference direction. The effect of this in circumference operating force on the stability of the rope structure depend on different factors: - fleet angle - rope construction lay direction - rope diameter - rope length - grade of preforming - related rope tension An increasing angle has the consequence of an increase of the working circumference force. The effect of the circumference force is increasing with the rope diameter because of the growing lever. The stability of the rope structure against this attack, which causes to loosen the rope structure or the creation of bird caging, determines the resistance. Determining are therefore the selection of the rope construction and lay direction. A rope closing rotation supports the resistance of the selected rope construction. 1) Further influences are the rope length and the working tensile forces. Whereby the rope tension is having a special significance... Above a certain height, the rope tension forces are able to stabilize the rope structure against the attacking circumference forces successfully. If the working tensile forces are below the limit, which enables the support of the rope construction, the disturbance of the rope structure will occur. The critical condition for the relevant rope construction appears, if the working tensile forces are going towards zero. Taking in account the condition of the rope drive and the working condition a targeted selection of a rope construction can work against the problems. This means that for friction mine hoist installations with large rope diameters and very long ropes, already at rope deflection angles of > 1 degree, the selection of rope constructions is limited. 1) Remark: There is a difference between single layer and multiple layer (rotation resistant) rope constructions.	
-7	**Literature:** **1) H. M. Huber, Bulletin 88 OIPEEC „Extreme Rope Rotation“** **2) Schönherr, S. Dr. „Reduzierung der Lebensdauer von Drahtseilen durch Schrägzug bei Seilscheiben“. IFT Universität Stuttgart Feb. 2005** **3) Voigt, P.G. Handbook Steel Wire Ropes, Section. 7 Rope Damage, & 8.4.3.5.3 Rope damage because of diagonal pull (Fleet Angle)** **4) Fuchs, D. Sicherheit & Lebensdauer von Förderseilen, Glückauf 122 (1986)** **5) G. Rebel, Torsional behaviour of triangular strand ropes for drum winders. OIPEEC Bulletin 74, 1997** **6) Costello, G. A. Theory of Wire Rope. §7. Birdcaging in Wire Rope, §8. Rope Rotation**	