DISCARD CRITERIA FOR WIRE ROPES

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1 BACKGROUND

The life of wire ropes running over sheaves is always limited by wear and by the alternating stresses in the wires. In most cases, external visible defects are used to discard the rope and replace it. This is also true for elevator ropes. The wire ropes are inspected by magnetic testing methods only in special cases.

Most of the external visible defects listed in ISO 4309 (DIN 15 020) are very seldom found on elevator ropes. In a few cases, as the result of surface wear and extensive core shrinkage, there is a decrease of the wire rope diameter of more than 10 %, this being specified as a discard criterion for the wire rope. Extensive corrosion is a more frequent criterion for the replacement of the wire ropes. However, in most cases the wire ropes will be discarded because of the external visible wire breaks.

The number of visible wire breaks was the most important discarding criterion since the start of wire rope usage. Woernle (1924,1929) was one of the first to observe the increase of the number of wire breaks systematically /1, 2/. The main intention of his investigations was to determine the relationship between the number of wire breaks and the residual breaking load.

More recently Rossetti (1973) /3/ conducted investigations with the same aim. Müller (1961) /4/ carried out a great number of bend-over-sheave-tests with different wire ropes by counting the wire breaks after each test sequence. From the test results, he developed the discard numbers of wire breaks which have been listed in the DIN 15 020 and later in ISO 4309.

In West Germany over the last 15 years one of the wire ropes has broken on two elevators out of about 200 000. Obviously the discard number of visible wire breaks according to ISO 4309, DIN 15 020 etc., is a very safe discard criterion.

This experience is related only to wire ropes, traction sheaves and pulleys currently used in elevators. Recently, new constructional solutions have been seen. Instead of ordinary lay wire ropes there are cases of the use of Langs lay, and instead of traction sheaves and pulleys constructed of cast iron or steel use has been made of plastic. The use of Langs lay ropes and plastic sheaves indicates that a higher endurance of the wire ropes can be expected.

2 TESTS

The question is: how safe are elevators with Langs lay ropes and plastic sheaves. This question can be answered by the results of the bend-over-sheave-tests carried out in the last years /5, 6, 7/. These tests have been run with Filler, Seale and Warrington parallel lay wire ropes 8 x 19 with different cores. In most cases, steel pulleys with round grooves have been used. A number of bending tests have been carried out with ordinary lay wire ropes running over sheaves with V-grooves of steel construction and with round grooves of plastic construction.

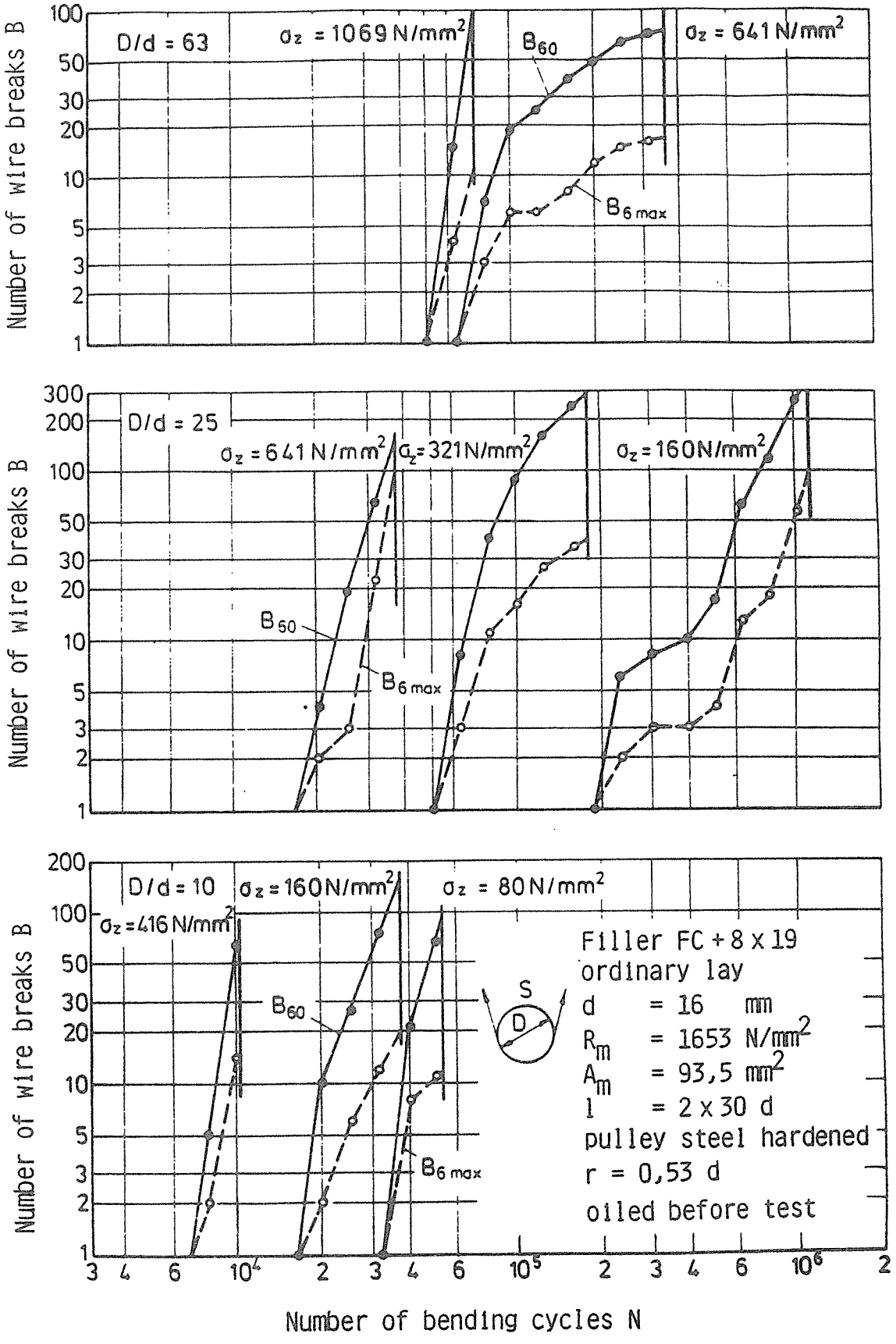

FIGURE 1: Wire break sequence of a Filler rope

During the bending tests, the wire breaks have been counted at sampling times over specified distances. For one rope, the counted numbers of wire breaks of some bending tests with different load and D/d-ratio are shown in Figure 1 /7/. The numbers of wire breaks at 80 % of the wire rope life time can be determined from Figure 1 and similar diagrams. The numbers of wire breaks $B_{80\%}$ are strongly dependent on the specific tensile load S/d^2 and on the diameter ratio D/d. There are also wide variations even for one single wire rope construction. It is useful to summarize the numbers of wire breaks $B_{80\%}$ by a linear regression calculation /5/. The discard number of wire breaks B_A is then determined by suitable statistically determined limits. The safety level then depends on the chosen limitation.

3 RESULTS

The discard number of wire breaks on a reference length of 30 times the wire rope diameter is for the chosen safety level conditions /5/:

$$B_{A30} = g_0 + g_1 \cdot \left(\frac{Sd_0^2}{S_0 d^2}\right)^2 + g_2 \left(\frac{d}{D}\right)^2 + g_3 \cdot \left(\frac{d}{D}\right)^2 \cdot \left(\frac{Sd_0^2}{S_0 d^2}\right)^2 \qquad (1)$$

and the discarding number of wire breaks on a reference length of 6 times the wire rope diameter is

$$B_{A6} = 0{,}5\, B_{A30} \qquad (2)$$

where
- S = the tensile load
- d = the wire rope diameter
- D = the pulley diameter
- S_o = 1 N
- d_o = 1 mm .

The factors g_i are listed in Table 1. Figure 2 shows the discard number of wire breaks B_{A30} for the Filler and Warrington ropes FC + 8 x 19, ordinary lay, according to equation (1).

Wire ropes		g_o	g_1	g_2	g_3
Filler Warr.	FC + 8 x 19 ordinary lay	27	-0,000261	-2330	-0,0389
Seale		23,7			
Filler Warr.	IWR + 8 x 19 ordinary lay	50	-0,000249	-2470	-0,0603
Seale		45,5			
Filler Warr.	IWRP + 8 x 19 ordinary lay	50	-0,000215	-2470	-0,0520
Seale		45,5			
Filler Warr.	IWRC + 8 x 19 ordinary lay	50	-0,000331	-2470	-0,0802
Seale		45,5			

TABLE 1: Discarding number of visible wire breaks

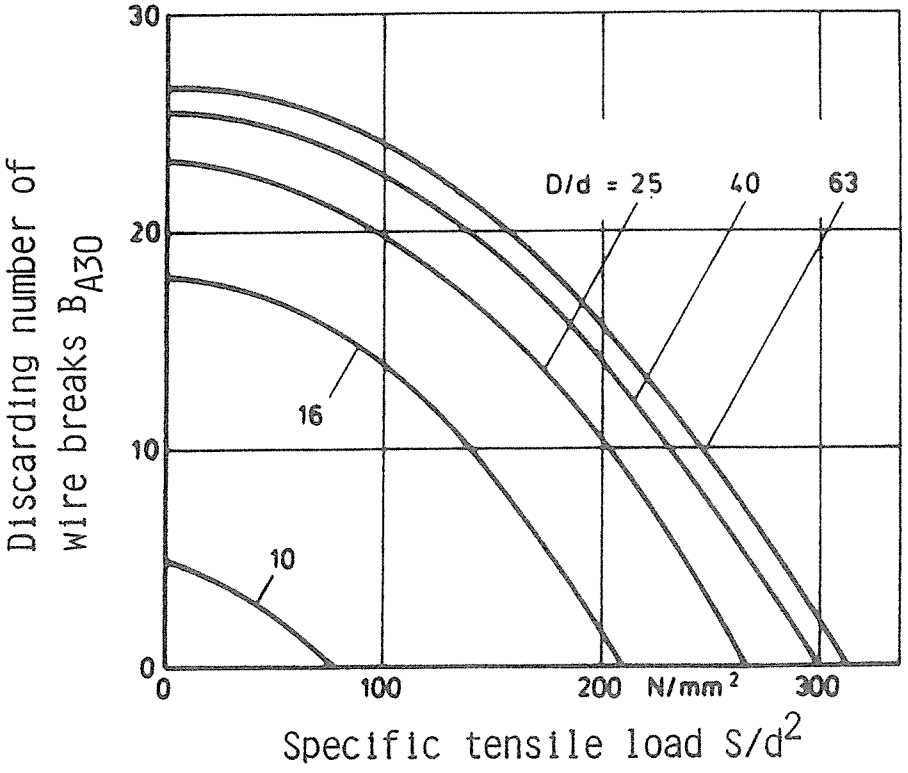

FIGURE 2: Discarding number of wire breaks B_{A30} of wire ropes Filler and Warrington FC + 8 x 19 ordinary lay

Further results of the bending tests for the same safety level are:

- Not one of all Langs lay wire rope constructions tested in steel grooves has any safe visible discard criterion. The discarding number of visible wire breaks is $B_{A30} = 0$.

- Not one of all wire rope constructions tested in plastic grooves shows a safe visible discard criterion. The discarding number of visible wire breaks is $B_{A30} = 0$.

- For ordinary lay wire ropes being bent over pulleys in hardened V-grooves, the discarding number of visible wire breaks is at least as high as in round grooves.

The discard numbers of wire breaks B_{A6} and B_{A30} are listed in Table 2 for the specific tensile load S/d^2 and the diameter ratio D/d valid for elevators. These discard numbers of wire breaks have been derived from the test results defined by equation (1) and those according to the technical rules given in ISO 4309 and DIN 15 020.

For ordinary lay wire ropes with a fibre core: The discard numbers of wire breaks derived from the test results are nearly the same as those from the technical rules. There have never been any safety problems with elevators using wire ropes of this construction, thus the limitation of the test results seems to have been chosen correctly.

For ordinary lay wire ropes with a steel core: The test results indicate that for the same safety level conditions it is acceptable to permit twice as many visible wire breaks to occur before discarding the rope, than would be allowed for an ordinary lay rope with a fibre core.

For Langs lay wire ropes in steel grooves: The discard number of wire breaks is zero (as mentioned before).

TABLE 2: Discarding number of wire breaks for elevator ropes

wire ropes		Discarding number of wire breaks according to DIN 15020 and ISO 4309		out of test results grooves out of steel		grooves out of plastic	
		B_{A6}	B_{A30}	B_{A6}	B_{A30}	B_{A6}	B_{A30}
Warrington and Filler	ordinary lay 8 x 19 + FC	13	26	13	26	0	0
	6 x 19 + FC	10	19	10	20	0	0
	8 x 19 + WR	13	26	24	47		
	6 x 19 + WR	10	19	18	35		
	Langs lay 8 x 19 + FC	6	13	0	0	0	0
	6 x 19 + FC	5	10	0	0	0	0
	8 x 19 + WR	6	13	0	0		
	6 x 19 + WR	5	10	0	0		
Seale	ordinary lay 8 x 19 + FC	10	19	11	22	0	0
	6 x 19 + FC	6	12	8	16	0	0
	8 x 19 + WR	10	19	21	43		
	6 x 19 + WR	6	12	16	32		
	Langs lay 8 x 19 + FC	5	10	0	0	0	0
	6 x 19 + FC	3	6	0	0	0	0
	8 x 19 + WR	5	10	0	0		
	6 x 19 + WR	3	6	0	0		

4 RECOMMENDATION

It is recommended that a wire rope should be replaced when the smaller of the two discarding numbers of wire breaks of Table 2 has ocurred. Wire ropes of Langs lay should not be used in elevators, unless there is magnetic inspection. Pulleys with plastic grooves should be only employed with the restrictions given by the Sicherheitsrichtlinie SR Kunststoffrollen /8/.

5 REFERENCES

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/7/ Feyrer, K.: Die Drahtbruchentwicklung von laufenden Seilen. DRAHT 34 (1983) 5, p. 245 - 249.

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