STEEL ROPES TESTING

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ABSTRACT
At the Department of the Building- and Materials Handling Machinery of the Technical University Budapest we dealt with testing of the elevator steel ropes. We established the stochastic - funkcion between the diameter and legth of rops with sampling and continuos measurings; determined the longitudinal and transversal static- and dynamic elasticity modulus of the ropes, than the damping of the oscillation, the hysteresis and relaxation of the longitudinal deformation. The paper presents some interesting results and new measuring instruments.

1 INTRODUCTION

At the Department of the Building- and Materials Handling Machinery of the Technical University Budapest we are dealing with measurements of many kinds of steel ropes for appr. 20 years. The object of the tests has been the checking of the ropes and the determination of the dynamic characteristics. Our orderer were alwais factoris and design bueros, that produce or design rope winches and winding machines for lifts or kranes.

2 STATISTICALY CHARACTERISTICS OF THE DIAMETER

For the lifts with traction drive sheaves the most important demand is the constant diameter of the ropes. We have built a test bank, wich can be used for testing the cross sections of a rope quantity of a whole cable drum, with given pre-stressing without any demoges of the ropes. On the test bank we can measure the rope-stress and the extension, so we can determine the rope's static modulus of elasticity. The resultes of the measurements has been elaborated statictically. The first step is the determination of the statistic distribution of the rope's diameter:

$$\hat{F}(d_k) = \frac{k}{n}$$

and the empiric density funktion:

$$\hat{f}(d_k) = \frac{\hat{F}(d_k) - \hat{F}(d_{k-1})}{d_k - d_{k-1}} ,$$

where $d_1 \leqslant d_2 \leqslant \; .. \; d_k \leqslant \; .. \; d_n$ are the orderly set of the measurement data.

Some of these distribution- and density funktions you can see in fig. 1., 2.

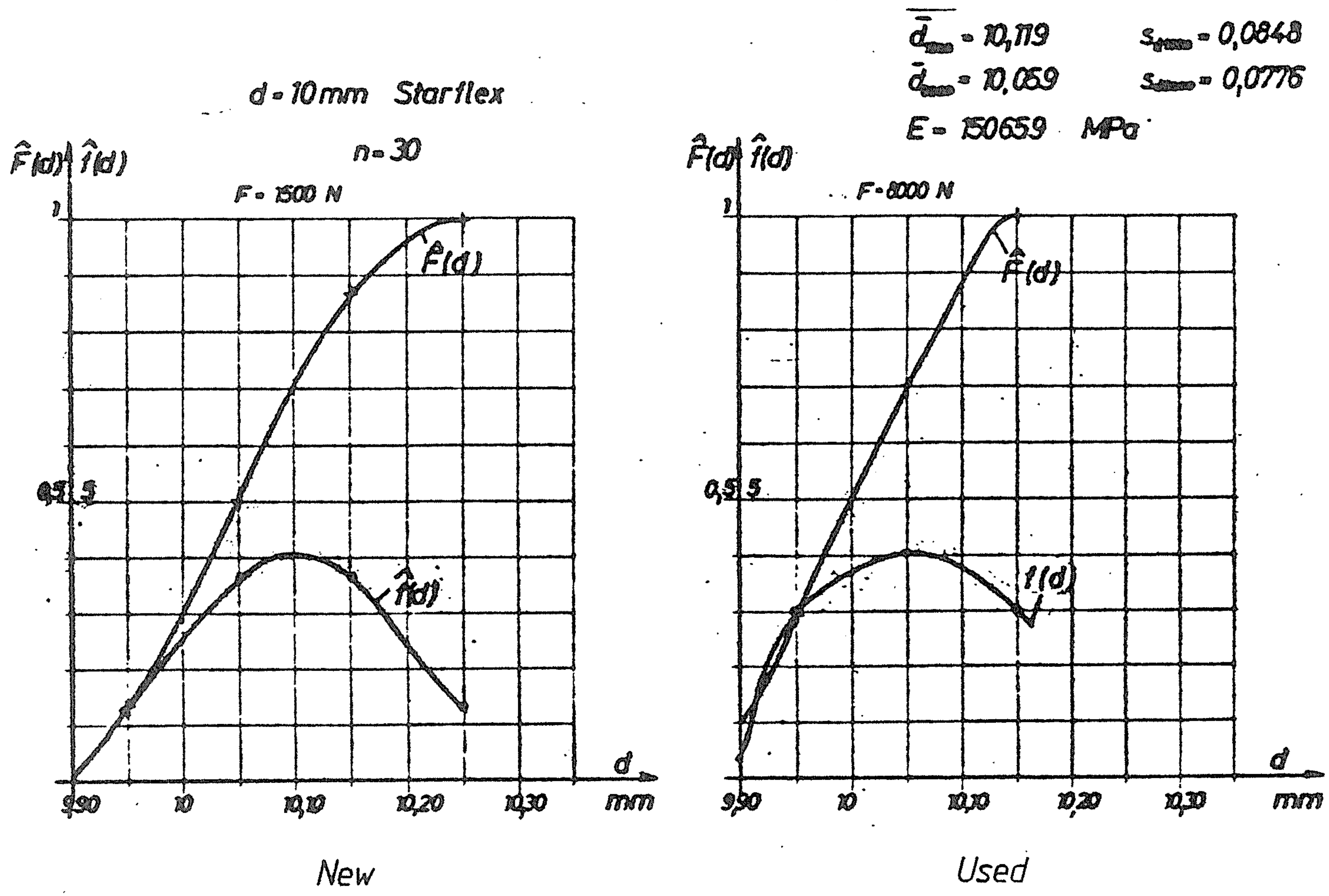
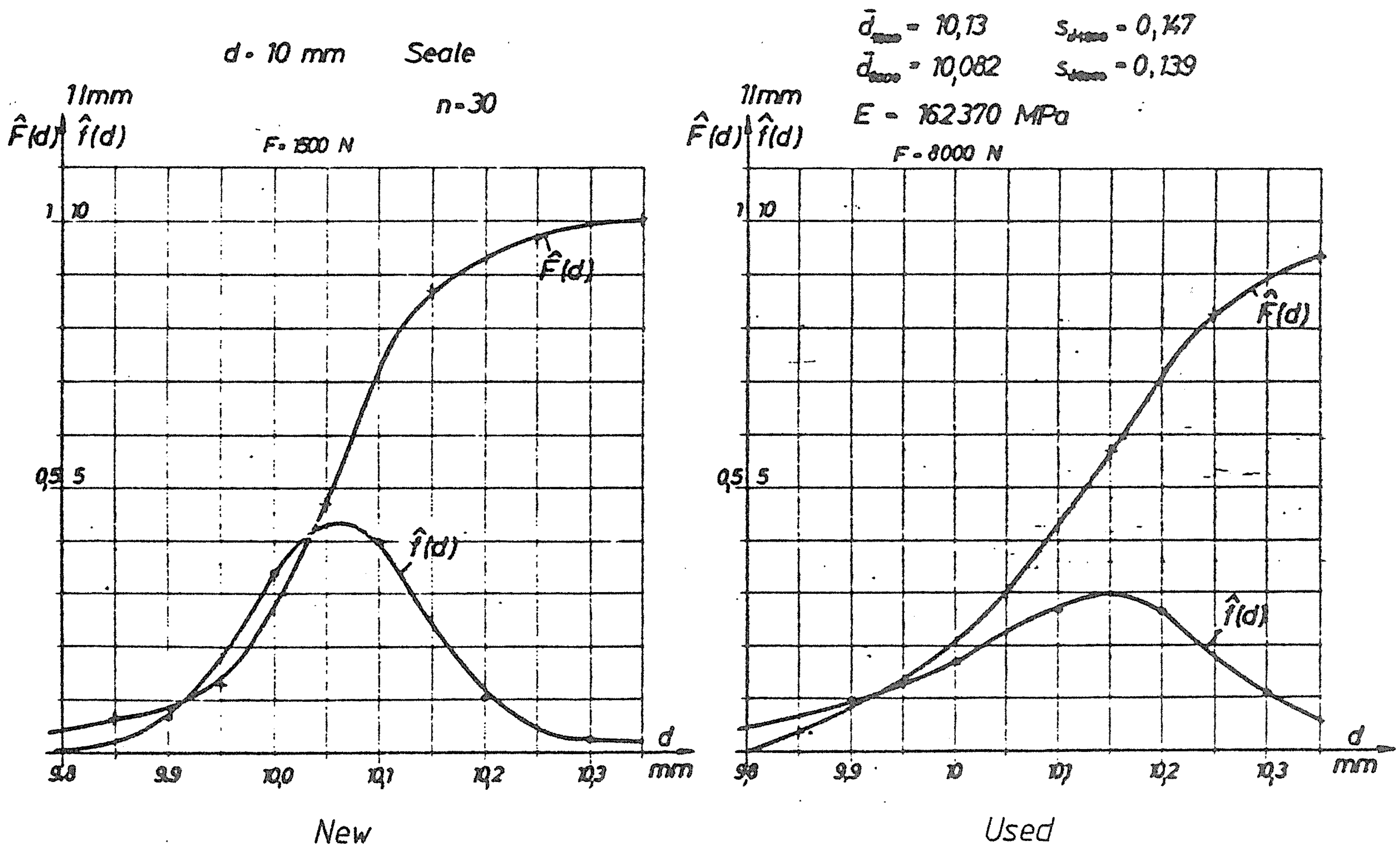

d = 10mm Starflex
n = 30
F = 1500 N
F = 8000 N
$\hat{F}(d)$ $\hat{f}(d)$
1
0,5
9,90
10
10,10
10,20
10,30
d
mm
New
Used
E = 150659 MPa
0,0848
0,0776
10,119
10,059

Figure 1



d = 10 mm
Seale
n = 30
F = 1500 N
1/mm
F̂(d) f̂(d)
1 10
0,5 5
9,8 9,9 10,0 10,1 10,2 10,3 mm
d
F̂(d)
f̂(d)
New
d̄ = 10,13
s = 0,147
d̄ = 10,082
s = 0,139
E = 162370 MPa
F = 8000 N
9,8 9,9 10 10,1 10,2 10,3 mm
Used

Figure 2

3 MODULUS OF ELASTICITY AND DAMPING COEFFICIENT

The static modulus of elasticity

$$E_{st} = \frac{(F_2 - F_1)\ \ell_o}{(\ell_2 - \ell_1)\ A_s} ,$$

where F_1, F_2 are the rope forces, ℓ_o, ℓ_1, ℓ_2 are the measured rope length and A_s is the sum of the cross section area of the wires in the rope.

There was a need for determing of the dinamic modulus of elasticity and damping coefficient. Thaat we have determined from the longitudinal swing-Radian frequency

$$\omega = \sqrt{\frac{1}{mc} - (\frac{k}{2m})^2} ,$$

and the logaritmical decrement:

$$\ln \frac{J_i}{J_{i+1}} = \frac{k}{2m} T .$$

In the formulas we used m, as the swinging mass, k as the damping coefficient, J_i, J_{i+1} as the swing amplitudes, T as the swing period and

$$c = \frac{\ell}{A_s\ E_s}$$

as the spring constant.

From these formulas E_s and k can be calculated. For ëxample we have determined

$$E_s = 73.000 \text{ MPa and } k = 5.700 \text{ Ns/m}$$

for a Seale-rope.

4 THE DIAMETER-LENGTH FUNKTION

6 years ago there was a question how the rope forces of a lift with springed hanging-up change, during the using period. To solve this problem we have to know how the rope diameter changed along the length of the rope. Mr.Sümegi, one of our students has got the taste in his diploma-work. He designed and built a measuring device, wich one can use - by an inductive distance sensor - for continuous measuring and recording of the diameter changes. In the 3. you can see the dewice. The diameter changes of the four parallel ropes can be observed in 4. The hoisting hight was 34 m, the type of the rope $S6x19+A_t$, dia. 11 mm, the spead of the rope during the measuring v = 0,2 m/s. For the measurement data processing we used a digital computer. The results are assumed in the annexed table. As you can see, the changes

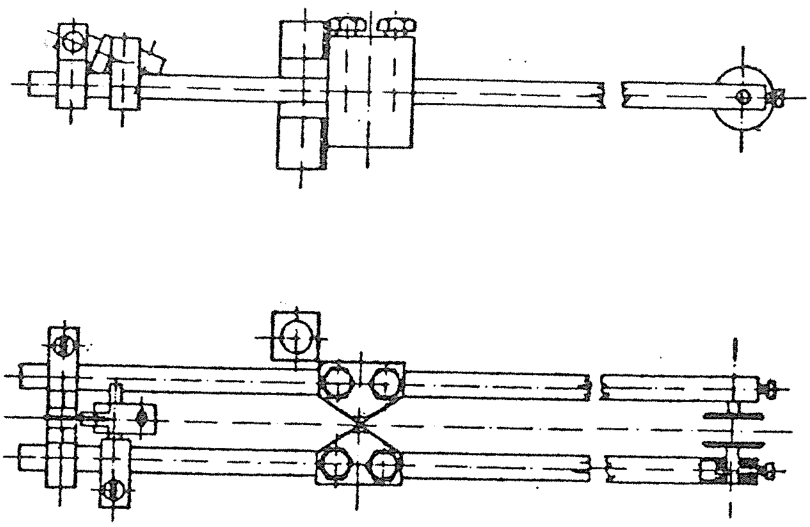


FIGURE 3 Testing stand.

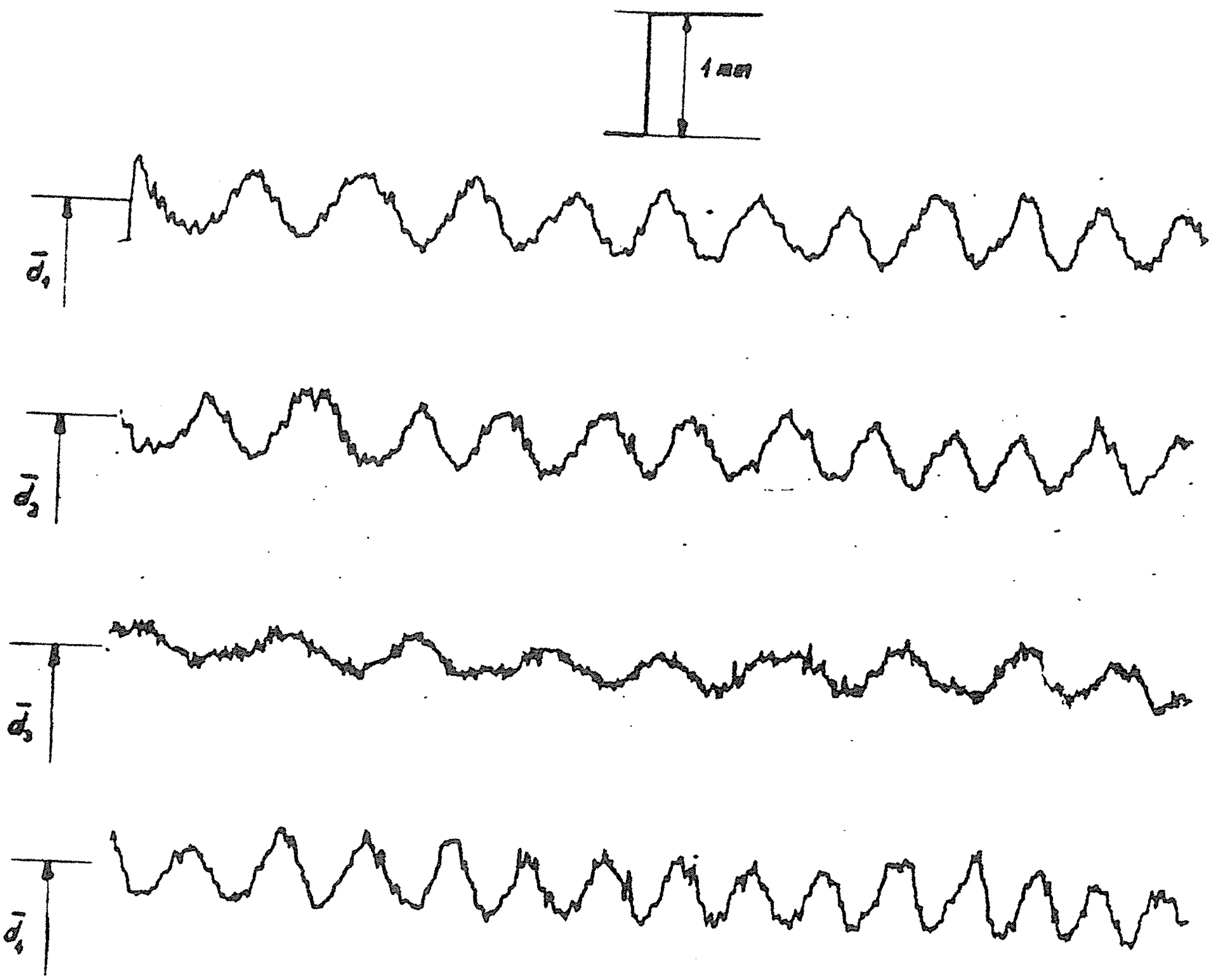


FIGURE 4 Diameter changes in four parallel ropes

of diameter are periodical, however the length of periods and amplitudes are unequal.

5 THE HYSTERESIS OF THE ROPES

Two years ago wie built a new measuring bank, wich we can use under periodically changing rope forces. The changes of force and length can be measured and registrated. It's essential construction you can see in 5 and four varions measurement results in picture 6. The aim of these studies is the search of the hysteresis-curve and the rope fatigues. Now we have only the starting results. The studies are continuing.

6 REFERENCES

SVÁB J.:
Untersuchung der elastischen Eigenschaften von Aufzug-Drahtseilen, Wissenschaftliche Zeitschrift der Hochschule für Verkehrswesen "Friedrich List" in Dresden. 17. (1970, H.3)

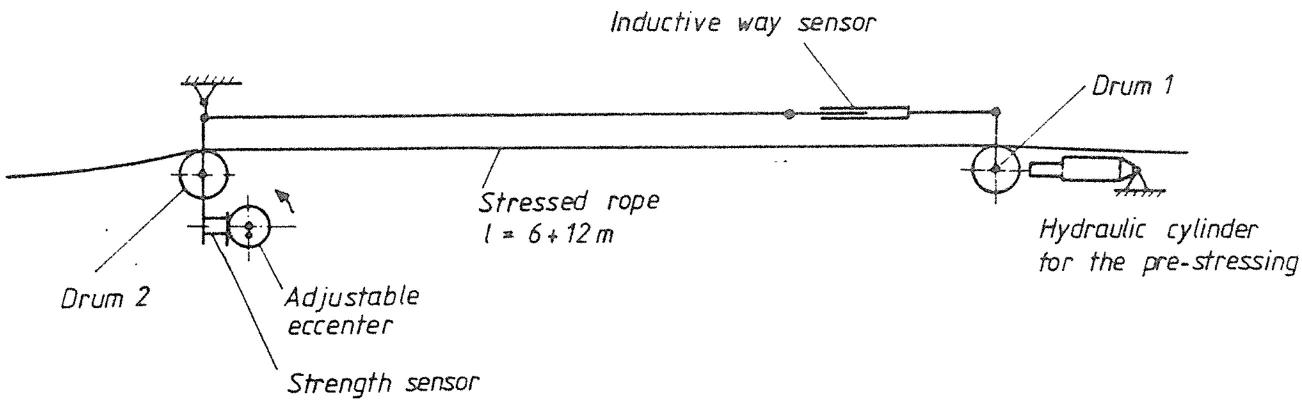


FIGURE 5 The schematic of the new testing stand

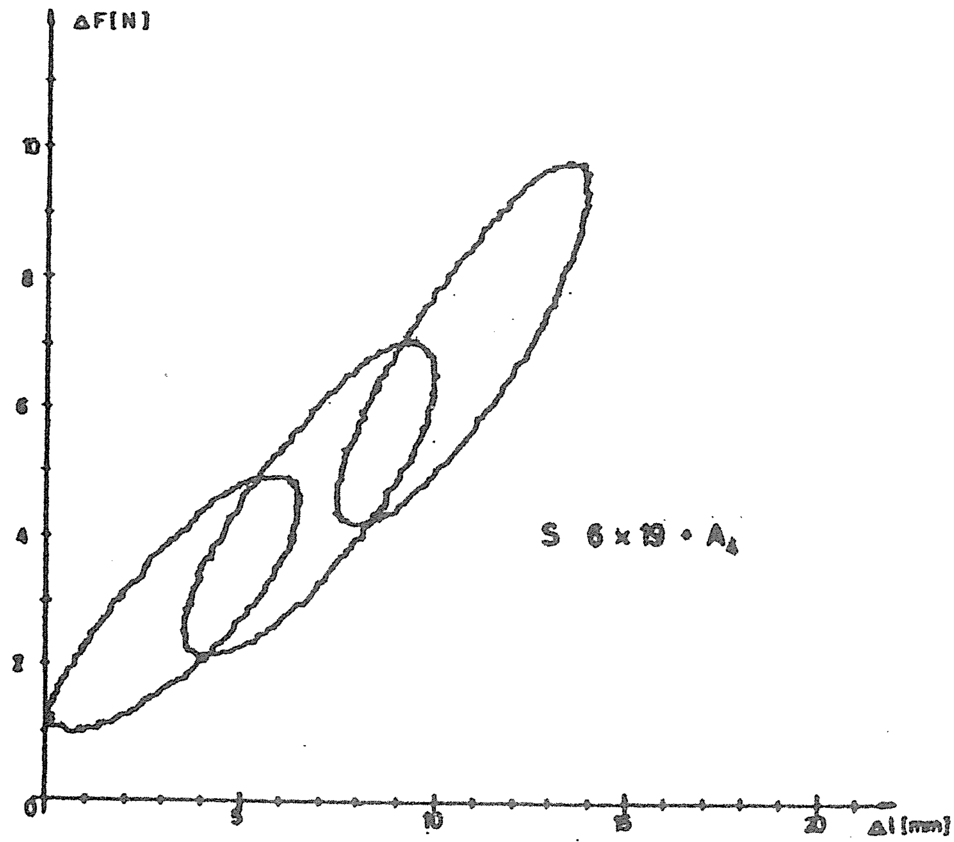


FIGURE 6 Measurement results

Number of the rope:			1	2	3	4
d	max	mm	11,15	11,11	11,25	11,26
	min	mm	10,51	10,47	10,74	10,56
	mean	mm	10,81	10,77	10,90	10,89
Characteristic of the waves						
	φ_0	m	0,912	2,111	1,500	1,270
A	λ	m	2,390	2,590	4,019	2,470
	A	mm	0,26 -0,23	0,24 -0,23	0,17 -0,20	0,19 -0,23
B	λ	m	3,651	3,627	3,912	2,527
	A	mm	0,26 -0,30	0,30 -0,26	0,16 -0,17	0,33 -0,25
C	λ	m	3,006	2,320	3,004	2,609
	A	mm	0,27 -0,27	0,24 -0,26	0,20 -0,19	0,34 -0,23
D	λ	m	2,735	2,977	3,401	2,366
	A	mm	0,10 -0,27	0,19 -0,30	0,10 -0,23	0,30 -0,31
E	λ	m	2,730	2,595	3,304	2,097
	A	mm	0,23 -0,20	0,23 -0,26	0,19 -0,19	0,25 -0,27
F	λ	m	2,791	2,761	3,697	2,257
	A	mm	0,23 -0,25	0,22 -0,25	0,26 -0,20	0,27 -0,20
G	λ	m	2,25	2,761	3,375	2,205
	A	mm	0,17 -0,30	0,30 -0,21	0,27 -0,21	0,24 -0,27
H	λ	m	3,006	2,320	3,476	2.250
	A	mm	0,20 -0,26	0,23 -0,26	0,21 -0,10	0,24 -0,26
I	λ	m	2,147	2,165		1,902
	A	mm	0,31 -0,26	0,19 -0,25		0,10 -0,26
J	λ	m	2,415	2,165		2,250
	A	mm	0,23 -0,23	0,17 -0,25		0,29 -0,25
K	λ	m		2,590		1,900
	A	mm		0,33 -0,23		0,37 -0,29
L	λ	m				2,043
	A	mm				0,23 -0,29
M	λ	m				1,020
	A	mm				0,14 -0,33
Mean values	λ	m	2,764	2,610	3,696	2,229
	A	mm	0,24 -0,26	0,24 -0,25	0,20 -0,20	0,26 -0,27

TABLE 1 Test Results