THE SPRING RESEARCH AND MANUFACTURERS' ASSOCIATION

CONSISTENCY OF INITIAL TENSION IN EXTENSION SPRINGS

by

Ing. P.A.M. Korzilius

Report No. 322

January 1980

THE SPRING RESEARCH AND MANUFACTURERS' ASSOCIATION

Report No. 322

CONSISTENCY OF INITIAL TENSION IN EXTENSION SPRINGS

SUMMARY

Previous studies concerning initial tension indicated that high and very low values of initial tension can only be achieved with a loss in accuracy.

In this work a large number of extension springs obtained from production runs, and covering different coiling methods, materials and spring designs, were accurately measured in order to determine the value and range of the initial tension. The optimum initial tension, expressed as a stress which gave the best tolerances was found to be in the range of 8-18% of the tensile strength. This is a general observation only, and applies to normal production conditions.

A critical note is made as regards the method of measuring initial tension. When an accurate value is required it is not sufficient to take two load-length readings and calculate the initial tension. Information also needs to be obtained of the initial part of the load deflection curve.

January 1980

CONTENTS

CONSISTENCY OF INITIAL TENSION IN EXTENSION SPRINGS

by

Ing. P.A.M. Korzilius

1. INTRODUCTION

Initial tension in extension springs offers the advantage of increased energy storage in the same design volume. The higher the amount of initial tension, the more the design benefits. Recent work (1,2), however, on initial tension in springs has indicated that the maximum possible initial tension in a spring can only be achieved at the expense of the accuracy with which the springs can be produced. Similarly, it is very difficult to produce a close coiled spring on an automatic coiling machine without any initial tension.

To complement previous work, a study was undertaken to determine if there is an optimum level of initial tension for producing precision springs, and if the method of coiling has any effect on this consistency. In order to produce information which is of practical value and is representative for springs made by the industry, the majority of batches of test springs used for this work were taken from normal production runs, and covered a range of materials, coiling methods and spring specifications.

2. PROCEDURE

The work involved the measurement of a large number of extension springs, and a statistical analysis to determine the consistency of initial tension. It appears to be normal practice in industry to determine the initial tension in extension springs by measuring two load-length values and projecting a straight line through the two points obtained; the intial tension (load) is then determined from the intersection of this straight line with the load axis.

In theory the initial tension is the maximum load that can be applied to an extension spring without extending the spring, thereby assuming a theoretical load-deflecting curve as is shown in fig. 4a. In practice a small deflection occurs immediately after applying a small load. The deflection is mainly due to end hook extension, and must be disregarded in initial tension measurement. The end loops can cause further "deformations" to the theoretical curve when they do not transmit the load through the centre of the spring body. In this case the coils open on one side of the body earlier than on the other, and the load-deflection curve will be as in fig. 4b. Initial tension may not be constant throughout all coils in the spring body so that some deviation can be expected at the beginning of the theoretically straight characteristic. The correct method of determining the amount of initial tension is shown in fig. 4c, and it is clear that a two load-length test along with the working part of the curve will not indicate the true amount. It will in fact show too low an amount, and the deviation based on the experience from this investigation, can be quite considerable. In order to measure the correct amount of initial tension, the load-length characteristic of the spring has to be established. A consistent and quick method was found for measuring spring load and length using electronic transducers and recording the entire load-deflection curve on a x-y plotter.

Batches of 25 springs (details in Table 1) to a particular design were measured and the level of "initial" load determined from the characteristics. The load consistency was found via statistical analysis of load measurements.

RESULTS AND DISCUSSION

The results of the tests are given in fig. 1 where the amount of initial tension, as a percentage of the tensile strength is presented against the tolerance of the initial load. The tolerance of the initial load shown, is based on twice the standard deviation (aaprox. 95% confidence) for the spring design in question. Clearly the trend of the consistency to question. Clearly the trend of the consistency to worsen near the level of zero initial tension and towards the higher levels, can be identified.

According to these measurements the most consistent initial tension is obtained for springs having an initial tension in the range 8 - 18% of the U.T.S. of the material. The majority of the springs measured appeared to offer a tolerance of between ± 5 and ± 10% (fig.2). This figure may seem rather high, but it must be borne in mind that it is not the level of inital tension alone that determines the spring performance and quality. Most applications of extension springs will not require the spring to be used in the coil bound condition, but will specify a spring rate or one or more load-length values. In practical terms this means that both the spring rate and the level of initial tension need to be accurately controlled. Effects of both these parameter have been illustrated in fig.3. Since the measurement of the initial tension was affected via load deflection curves of each spring individually, a value for the spring rate was available. The distribution of tolerances as measured on spring rate have also been entered in fig.2, the majority in this case being in the range of 0-10%.

The wire quality and the spring index, two factors that generally have an effect on the coiling performance, have little influence on thetolerance obtained. The coiling method did not seem to matter, and this is probably due to the fact that extension spring manufacture still relies to a great extent on the skill of machine operators.

4. CONCLUSIONS

1. The best tolerance of initial tension under normal production conditions can be expected when the critical tension is in the range of 10-15% of the tensile strength.

2. Accurate measurment of initial tension cannot be done with a two load-length test, but should be obtained from a large number of load-length measurements to determine the initial slope of the curve.

5. REFERENCES

1. M.R.Southward. "An investigation into initial tension in extension springs". SRAMA Report No. 260, May 1976.

2. M.S.Bayliss. "Initial tension in carbon and stainless steel springs coiled in automatic coiling machines". SRAMA Report No. 296, December 1978.

TABLE I DETAILS OF SPRINGS USED

No.	Material	Coiling Method	Spring Index	Initial Load N	Initial Tension N/mm^2	Tolerance ±N
1	BS 1408B-R1	T	8.9	0.45	46.2	0.20
2	"	T	9.6	1.94	78.6	0.38
3	BS 1408B-R2	DP	6.9	1.56	152.7	0.23
4	"	T	6.2	37.48	209.9	2.46
5	"	H	6.8	17.79	298.8	1.26
6	"	DP	7.5	3.18	131.6	0.32
7	"	DP	6.9	1.96	59.7	0.99
8	BS 1408B-R3	SP	9.8	0.58	77.9	0.25
9	"	SP	7.5	3.32	108.5	0.70
10	"	T	8.8	4.36	132.0	0.41
11	"	SP	11.1	21.52	606.7	1.84
12	"	DP	9.8	1.55	254.5	0.16
13	"	DP	8.3	2.97	340.7	0.44
14	"	SP	8.9	1.40	80.3	0.08
15	"	T	9.2	5.59	80.5	4.47
16	"	SP	7.2	43.50	435.0	11.60
17	BS 1408C-R3	DP	8.7	1.83	274.1	0.20
18	"	DP	8.3	0.27	63.2	0.11
19	"	DP	10.6	0.28	162.8	0.05
20	"	DP	5.1	27.17	14.7	2.55
21	"	DP	10.4	4.83	353.0	0.29
22	"	DP	5.6	9.67	42.7	1.89
23	"	DP	7.1	5.26	256.0	2.49
24	BS 1408 M1	H	6.1	4.48	122.9	1.21
25	BS 1408 M2	T	6.6	16.32	269.3	1.05
26	BS 2803 G2	SP	8.3	6.02	389.2	0.71
27	En 58A	DP	6.3	0	0	-
28	"	T	3.6	15.72	273.6	1.99
29	"	H	10.8	2.16	78.9	0.47
30	"	DP	5.9	35.90	251.3	4.06
31	"	DP	8.9	31.03	307.2	2.14
32	"	DP	3.9	79.16	47.8	18.05

SP = Single Point Machine

DP = Double Point Machine

T = Torsion Spring Coiling Machine

H = Hand Coiling

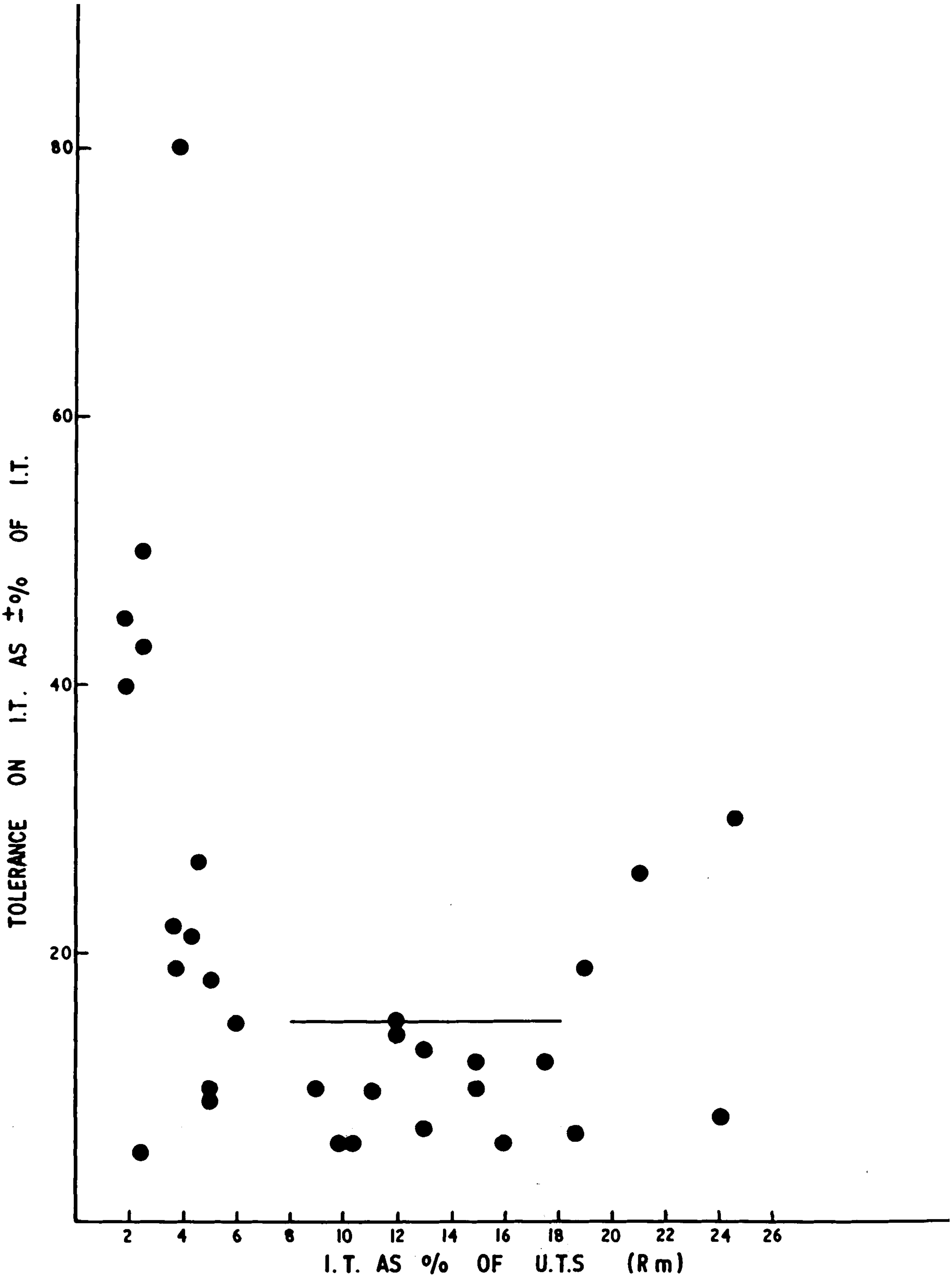


FIG. 1.
TOLERANCE ON I.T. OBSERVED ON CURRENT PRODUCTION WITHIN THE INDUSTRY.

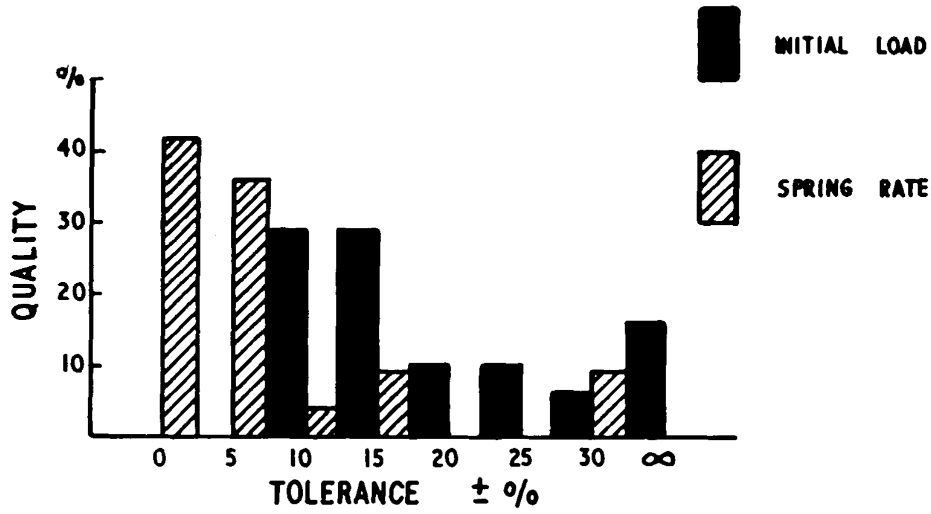


FIG. 2 DISTRIBUTION OF TEST SPRING TOLERANCES.

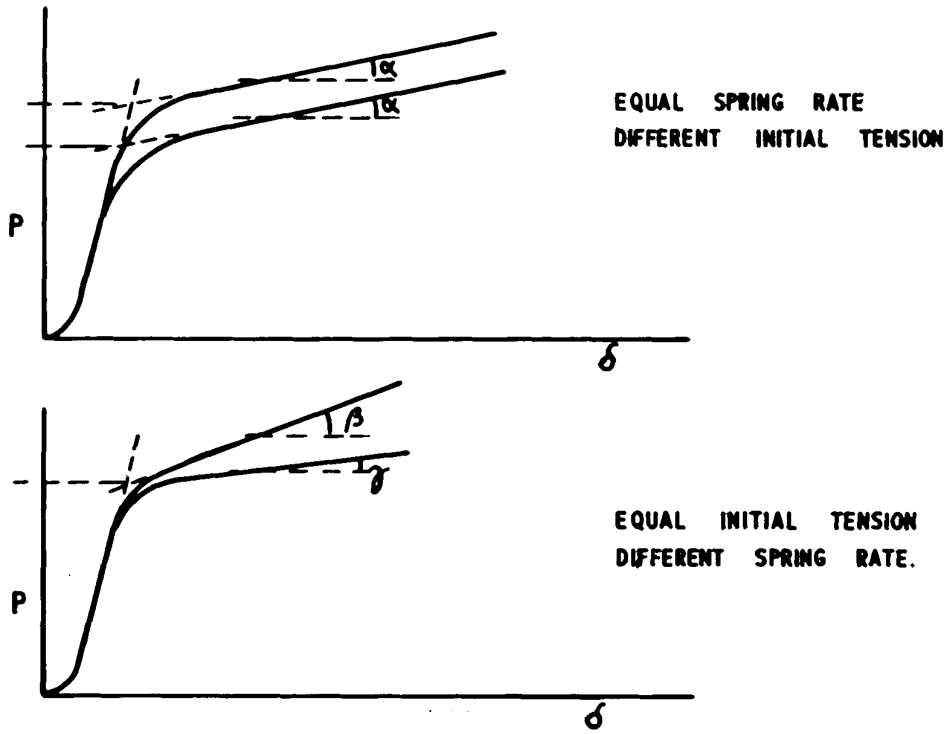
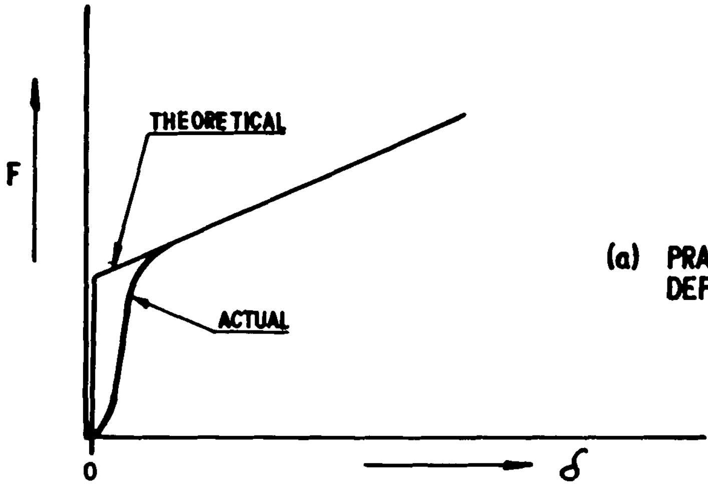
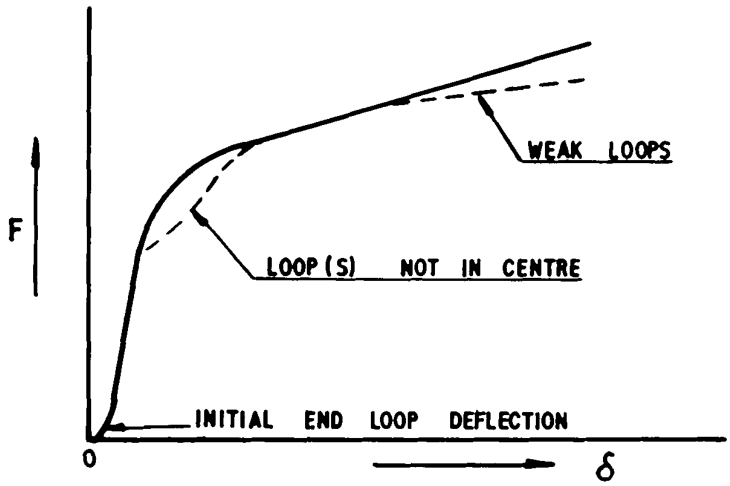


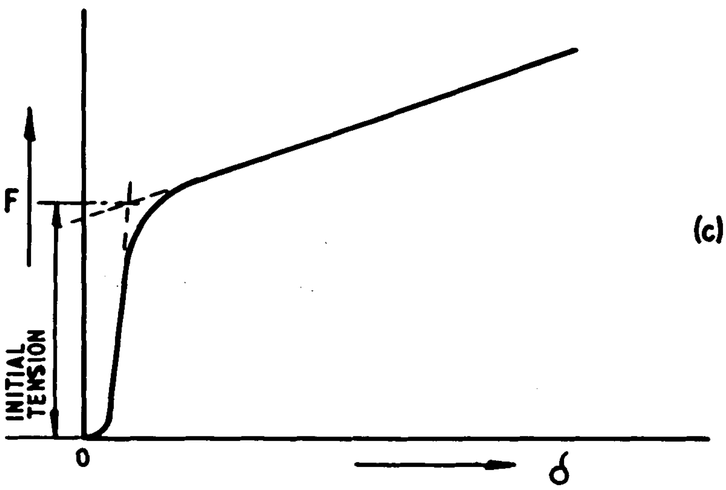
FIG. 3. EFFECT OF SPRING RATE.



(a) PRACTICAL LOAD DEFLECTION CURVES.



(b) EFFECTS OF END LOOPS.



(c) INITIAL TENSION AS DETERMINED IN MEASUREMENTS.

FIG. 4. LOAD / DEFLECTION CHARACTERISTICS AND INITIAL TENSION.