



**International Institute For Cotton**  
**Technical Research Division**  
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**Research Record No.163**

**The Accuracy Of Current Test Methods**  
**For Knitted Fabrics**

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## Introduction

The last analysis of results produced in our laboratory testing was reported in 1977 (*Research Record No. 60*), when estimates were made, on a range of then current test methods, of the degrees of accuracy being achieved, and recommendations on the amount of sampling were given.

Since then we have entered the computer age, and facilities now exist for the storage and retrieval of large quantities of data, enabling such analyses to be carried out very much more easily.

Computer storage of the raw laboratory data is now carried out on a routine basis for all our larger knitgoods projects; this report describes methods for the retrieval and analysis of data from some of these projects and for calculating the reliability of test figures, and sample sizes required for given degrees of accuracy.

The computer programme for storage and analysis of the raw data from the knitgoods projects has been named LABSTATS.

## Method Of Analysis

### a. Use of Root-Mean-Square % CV

In *Research Record No. 60*, results from a large number of test swatches (from 48 to 237, depending on the test method) were collected and the percentage Coefficient of Variation (% CV) calculated for each test swatch.

A mean (arithmetic) % CV (V) was then calculated for each test, and the % accuracy (P) at the 95% confidence level derived from the equation.

$$P = 1.96 \cdot V / \sqrt{n}$$

where n was the number of observations in the test sample.

The number of observations ( $n^1$ ) required to achieve a given accuracy target, A%, was then calculated using another form of the same equation

$$n^1 = (1.96 \cdot V / P)^2$$

It was subsequently realised that the use of the arithmetic mean of % CV is not quite correct according to statistical theory, and the value of V used in the LABSTATS calculations is the *Root-Mean-Square % CV*. The differences produced by this change are, in most cases, slight.

### b. Special Treatments of Shrinkage and Spirality Results

Analysis of shrinkage and spirality results by the standard method presented problems, and the technique was clearly unsuitable without modifications.

These properties share the same qualification in that they possess direction as well as magnitude, that is to say they can be either positive or negative. They can also be zero, which gives an obviously meaningless result when an attempt is made to calculate % CV.

Special techniques have therefore been incorporated into the computer routine to deal with shrinkage and spirality. These have had to be invented, as no evidence has been unearthed from the literature of any previous attempt to tackle this type of problem.

In the case of shrinkage, the statistical calculations are based, not on the shrinkage results

themselves, but on the variations in the final length measurements, expressed as fractions of the initial length measurements. Thus, zero shrinkage has a value of 1, 10% shrinkage a value of 0.9 etc. and it is these values which have been used to calculate the statistical data.

A consideration of the variations in an angular measurement, such as spirality, led to the conclusion that any meaningful measure of these variations should be independent of the mean value, that is, the direction.

An arbitrary mean, of 100 degrees, was therefore selected, which gives a "% CV" numerically equal to the standard deviation.

## **Accuracy Targets**

Following the survey reported in *Research Record No. 60*, an accuracy target of 4% was set for all test methods; that is, the laboratory estimate of the mean value should be within 4% of the true mean 19 times out of 20.

During the course of the extensive knitting test programme which was subsequently undertaken, it was decided that this was not sufficiently tight for fabric weight measurement, and for this parameter the accuracy target was reset to 3%.

It was also decided that a target of 4% would result in too much testing being required in the case of yarn strength measurement, and the corresponding target was therefore reset to 6%.

From a study of the results, and in the knowledge of the significance of the data in our knitgoods programmes, it is suggested that a target of 4% in the case of stitch length measurements is much too high, and should be reset to 1%.

No previous target was set for spirality testing, but it is suggested that a suitable figure would be 1%, which is perhaps better described as 1 degree.

## **Results**

The results obtained from the data produced in some of our current knitgoods projects are given in *Tables 1 to 4*.

*Tables 1 & 2* show the data from two of the crosslinked series of Central Project (interlock and rib) fabrics.

*Table 3* gives figures from the fine gauge interlock study (grey fabrics), and *Table 4* gives a complete analysis of the results produced in the Sandoz SM Project.

The figures in the first column of each table show the normal sample size for each test. The second column gives the Root-Mean-Square % CV over all the fabrics tested. The level of accuracy attained is calculated from this value of % CV and shown in the next column. The target for accuracy is given in the fourth column, and the final column shows the sample size that would be required to attain that degree of accuracy with a 95% level of confidence.

## **Conclusions**

The results confirm that, in general, the present accuracy targets are being met without difficulty. In most cases, the testing level could be reduced or, probably preferably, accuracy targets could be tightened up.

Possible exceptions are bursting strength, yarn extension, and spirality.

An interesting feature of this study has been the good agreement between data taken from different projects, and even between grey and finished fabric testing.

**Table 1**

Crosslinkine - Finish 3 - STATISTICS		13-JAN-83 09:15:26			
Property	Sample size	Mean % C. V.	Accuracy %	Required accuracy	Minimum sample
Length shrinkage, % *	5	0.78	0.68	4.00	1
Width shrinkage, % *	5	1.29	1.13	4.00	1
Weight, g/sq. m., BW	5	1.63	1.43	3.00	2
Weight, g/sq. m., AW	5	1.57	1.38	3.00	2
Courses Per 3cm., BW	10	1.45	0.90	4.00	1
Courses Per 3cm., AW	10	1.49	0.92	4.00	1
Wales Per 3cm., BW	10	1.96	1.22	4.00	1
Wales Per 3cm., AW	10	1.74	1.08	4.00	1
Stitch length, BW (mm.)	10	0.42	0.26	1.00	1
Stitch length, AW (mm.)	10	0.44	0.27	1.00	1
Burst strength, BW (kN/sm)	10	7.18	4.45	4.00	13
Burst strength, AW (kN/sm)	10	7.20	4.46	4.00	13
Distension at burst, BW %	10	4.87	3.02	4.00	6
Distension at burst, AW %	10	3.70	2.30	4.00	4
Angle of spirality, BW (deg) **25		2.19	0.86	1.00	19
Angle of spirality, AW (deg) **25		2.89	1.13	1.00	33
Width, BW (cm.)	NO DATA ENTERED				
Yarn strength, AW (s)	15	10.31	5.22	6.00	12
Yarn extension at break, AW %	15	11.28	5.71	4.00	31
Yarn Tex, AW	2	1.27	1.76	4.00	1
Fabric thickness, AW (mm/1000)	10	1.45	0.90	4.00	1
Yarn strength, BW (s)	15	10.22	5.17	6.00	12
Yarn extension at break, BW %	15	9.94	5.03	4.00	24
Yarn Tex, BW	NO DATA ENTERED				
Fabric thickness, BW (mm/1000)	10	1.34	0.83	4.00	1

\* % C. V. calculated from scatter in measurements.

\*\* % C. V. calculated using mean of 100 (degrees).

**Table 2**

Crosslinking - Finish 3E - STATISTICS

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Property	Sample size	Mean % C. V.	Accuracy %	Required accuracy	Minimum sample
Length shrinkage, % *	5	0.87	0.77	4.00	1
Width shrinkage, % *	5	1.51	1.32	4.00	1
Weight, g/sq.m., BW	5	1.98	1.73	3.00	2
Weight, g/sq.m., AW	5	1.59	1.40	3.00	2
Courses Per 3cm., BW	10	1.49	0.92	4.00	1
Courses Per 3cm., AW	10	1.43	0.89	4.00	1
Wales Per 3cm., BW	10	1.98	1.23	4.00	1
Wales Per 3cm., AW	10	1.74	1.08	4.00	1
Stitch length, BW (mm.)	10	0.47	0.29	1.00	1
Stitch length, AW (mm.)	10	0.45	0.28	1.00	1
Burst strength, BW (kN/sm)	10	7.80	4.83	4.00	15
Burst strength, AW (kN/sm)	10	6.76	4.19	4.00	11
Distension at burst, BW %	10	8.65	5.36	4.00	18
Distension at burst, AW %	10	6.77	4.19	4.00	11
Angle of spirality, BW (deg) **25		2.52	0.99	1.00	25
Angle of spirality, AW (deg) **25		2.10	0.82	1.00	17
Width, BW (cm.)	NO DATA ENTERED				
Yarn strength, AW (g)	15	10.47	5.30	6.00	12
Yarn extension at break, AW %	15	11.32	5.73	4.00	31
Yarn Tex, AW	2	1.07	1.49	4.00	1
Fabric thickness, AW (mm/1000)	10	2.47	1.53	4.00	2
Yarn strength, BW (g)	15	9.26	4.68	6.00	10
Yarn extension at break, BW %	15	8.73	4.42	4.00	19
Yarn Tex, BW	NO DATA ENTERED				
Fabric thickness, BW (mm/1000)	10	2.25	1.39	4.00	2

\* % C. V. calculated from scatter in measurements.

\*\* % C. V. calculated using mean of 100 (degrees).

**Table 3**

FINE GAUGE INTERLOCK - STATISTICS

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Property	Sample size	Mean % C. V.	Accuracy %	Required accuracy	Minimum sample
Length shrinkage, % *	5	0.79	0.69	4.00	1
Width shrinkage, % *	5	1.29	1.13	4.00	1
Weight, g/sq.m., BW	5	1.39	1.22	3.00	1
Weight, g/sq.m., AW	5	1.14	1.00	3.00	1
Courses Per 3cm., BW	10	1.33	0.82	4.00	1
Courses Per 3cm., AW	10	1.58	0.98	4.00	1
Wales per 3cm., BW	10	1.45	0.90	4.00	1
Wales per 3cm., AW	10	1.70	1.05	4.00	1
Stitch length, BW (mm.)	10	0.47	0.29	1.00	1
Stitch length, AW (mm.)	10	0.51	0.32	1.00	1
Burst strength, BW (kN/sm)	10	7.81	4.84	4.00	15
Burst strength, AW (kN/sm)	10	7.00	4.34	4.00	12
Distension at burst, BW %	10	5.29	3.28	4.00	7
Distension at burst, AW %	10	2.64	1.64	4.00	2
Angle of spirality, BW (deg) **25		1.92	0.75	1.00	15
Angle of spirality, AW (deg) **25		1.30	0.51	1.00	7
Width, BW (cm.)	3	0.94	1.06	4.00	1
Yarn strength, AW (g)	15	10.74	5.43	6.00	13
Yarn extension at break, AW %	15	8.45	4.28	4.00	18
Yarn Tex, AW	2	1.21	1.68	4.00	1
Fabric thickness, AW (mm/1000)	10	1.67	1.03	4.00	1
Yarn strength, BW (g)	15	9.26	4.69	6.00	10
Yarn extension at break, BW %	15	7.63	3.86	4.00	14
Yarn Tex, BW	2	1.92	2.67	4.00	1
Fabric thickness, BW (mm/1000)	10	1.86	1.15	4.00	1

\* % C. V. calculated from scatter in measurements.

\*\* % C. V. calculated using mean of 100 (degrees).

Table 4

STENTER MERCERISING - STATISTICS

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Property	Sample size	Mean % C. V.	Accuracy %	Required accuracy	Minimum sample
Length shrinkage, % *	5	1.35	1.18	4.00	1
Width shrinkage, % *	5	1.43	1.25	4.00	1
Weight, g/sq.m., BW	5	2.06	1.81	3.00	2
Weight, g/sq.m., AW	5	1.71	1.50	3.00	2
Courses Per 3cm., BW	10	1.45	0.90	4.00	1
Courses Per 3cm., AW	10	1.47	0.91	4.00	1
Wales Per 3cm., BW	10	1.78	1.10	4.00	1
Wales Per 3cm., AW	10	1.61	1.00	4.00	1
Stitch length, BW (mm.)	10	0.55	0.34	1.00	2
Stitch length, AW (mm.)	10	0.43	0.26	1.00	1
Burst strength, BW (kN/sm)	10	6.61	4.10	4.00	11
Burst strength, AW (kN/sm)	10	7.54	4.67	4.00	14
Distension at burst, BW %	10	7.37	4.57	4.00	14
Distension at burst, AW %	10	6.50	4.03	4.00	11
Angle of spirality, BW (deg) **25		2.85	1.12	1.00	32
Angle of spirality, AW (deg) **25		2.54	1.00	1.00	25
Width, BW (cm.)	3	0.85	0.96	4.00	1
Yarn strength, BW (g)	15	8.66	4.38	6.00	8
Yarn strength, AW (g)	15	9.39	4.75	6.00	10
Yarn extension at break, BW %	15	8.91	4.51	4.00	20
Yarn extension at break, AW %	15	11.22	5.68	4.00	31
Yarn count, tex, BW	2	1.37	1.91	4.00	1
Yarn count, tex, AW	2	0.71	0.98	4.00	1
Fabric thickness, BW (mm/1000)	10	2.19	1.36	4.00	2
Fabric thickness, AW (mm/1000)	10	2.42	1.50	4.00	2

\* % C. V. calculated from scatter in measurements.

\*\* % C. V. calculated using mean of 100 (degrees).