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Fabric Production For Projects K1 And K2

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Contents

1. Introduction

The information recorded in this report relates specifically to the production of the fabrics for the projects Kl and K2. In addition, details of the yarns and a comparison between course length measurements on the machines and grey stitch length as determined in the laboratory have been included. However, analysis of any other test data relating to the properties of the fabrics has been deliberately omitted as this will be reported separately.

2. Machinery And Instrumentation

Three single jersey sinker-top weft knitting machines were used to produce the fabric.

a) An 18 gauge Camber Velnit; 26" diameter, 36 feeders, 1500 needles, fitted with triptape positive feed and side creels.

b) A 24 gauge Monarch XL-JS; 26" diameter, 60 feeders, 1920 needles, fitted with triptape positive feed and side creels.

c) A 28 gauge Camber Twinit; 24" diameter, 68 feeders, 2112 needles, fitted with triptape positive feed and side creels.

Course length (run-in) was measured using a Welmstar electronic course length / yarn speed meter.

Yarn input tension was measured using the Schmidt yarn tension meter.

3. Knitting Plan

The basic knitting plan proposed in the document ‘Project Planning K1 and K2 - Knitting’ was adhered to with the following two exceptions.

1. When knitting on the 24 gauge machine began it was found that the proposed tightest construction, i.e. Piece No. 24/2-48/291/1 with tightness factor K = 17.04, was in fact just on the extreme physical/knittable limit of the machine. Therefore, although it would have probably just been possible to produce the fabric, the fault rate would have been high and the fabric would have been too tight to be considered commercially viable.

Consequently, it was decided to amend the entire 24 gauge knitting plan. This was achieved by increasing each stitch length by 5%. The revised plan is shown in *Table 1*, together with the 18 and 28 gauge plans which were unchanged.

2. Towards the end of the planned fabric production it became apparent that after all the fabrics had been completed and an allowance had been made for further yarn testing, there would be a small residue remaining of the four yarn counts, Ne 1-28, 2-56, 1-36, 2-72, which are utilised in both projects. This being the case, it was felt desirable to have an extra piece of each K2 construction in reserve, therefore the remaining yarn was utilised to produce an extra 20 pieces of approximately 70 metres length, one of each K2 variable on the 28 and 24 gauge machines. All these pieces are numbered 15. The revised knitting plans for all three gauges are shown in *Tables 2-4*.

4. Yarn

The yarn was ordered from Courtaulds Northern Spinning Division, and delivered in the quantities proposed in the preliminary plan.

For the basic plans Kl and K2

Machine Gauge, npi	Nominal Yarn Count, Ne	
18	1-16	2-32
	1-20	2-40
	1-24	2-48
24	1-24	2-48
	1-28	2-56
	1-32	2-64
28	1-32	2-64
	1-36	2-72
	1-40	2-80

All singles yarns were Courtaulds Combed KCW quality having a twist factor of 3.5 and standard Z direction of twist. Twofold yarns were Courtaulds Super Combed Sudan quality.

For the supplementary trials (spirality) in Kl

Gauge, npi	Count, Ne	Twist direction	Twist Factor
18	1-20	S	3.5
24	1-28	S	3.5
		Z	3.0
		Z	4.0
28	1-36	S	3.5

After the yarn had been delivered and before any knitting began all the yarn was checked in IIC's laboratories for count, twist factor, coefficient of friction against steel, and twist liveliness. *Table 5* summarises the results obtained and the IIC methods of test used are contained in *Appendix 1*.

4.1. Preliminary Yarn Testing

The preliminary yarn testing carried out by IIC was intended primarily as a quality control check to try and identify any serious discrepancies in the yarn delivered from the specifications, before knitting commenced. Full yarn testing including Uster strength and evenness measurements and Classimat readings are being carried out by Courtaulds now that knitting is completed. These results will be reported separately.

The results obtained from the preliminary testing indicated that, on average, the characteristics of the yarn delivered were within acceptable tolerances.

- **Yarn Count**: Resultant yarn count tested was in the main within 1 unit of Ne.
- **Twist Factor**: Yarn twist factor was on average within 0.1 twist factor unit.
- **Twist Liveliness**: Twist liveliness readings obtained using IIC's experimental test method are reported in *Table 5*, but will be discussed in detail in a separate report.
- **Coefficient of Friction (μ)**: It is generally accepted by the knitting industry that a yarn with a coefficient of friction reading against steel of 0.20 or below will perform adequately during knitting. As can be seen from the table of results, all the singles yarns fell well within this general guideline; in fact, they all had readings of 0.1 or below. However, it can also be seen that all the twofold yarns had a coefficient of friction reading of 0.2 and above. Examples of typical traces obtained on the yarns using the 'Shirley' yarn friction recorder are shown in *Figure 1*.

  On examination of these traces it is immediately noticeable that not only is the trace for twofold yarn much larger in diameter (indicating the higher friction) but also that the normal smooth line has become very irregular and variable. To establish whether or not this was a typical result to obtain for twofold yarn, other twofold yarns from stock were tested, and similar results obtained. The test instrument manufacturers were contacted and also several twofold yarn suppliers to obtain their opinion. However, no clear consensus of opinion emerged. Apparently twofold yarns are not generally tested for coefficient of friction and therefore knowledge of typical results was limited. As yet, therefore, it has not been possible to establish whether or not the readings obtained are typical. However, suffice is to say all the twofold yarns performed well in knitting with no discernable practical effect that could be directly related to a high friction coefficient.

  It may be that, in fact, there should be two pass/fail levels for friction coefficients for cotton yarns; one for singles and one for twofold. However, the work necessary to establish whether or not this is true would need to be the subject of a separate investigation - outside the scope of these projects.

4.2. Yarn Replacement

Although the initial limited yarn testing carried out prior to knitting did not indicate any serious discrepancies or variations in the yarns, unfortunately, once knitting began, several problems became apparent.

4.2a. Ne 1-40

Almost immediately knitting of the Ne 1-40 yarn began on the 28 gauge machine, excessive stripiness in the fabric was apparent. Courtaulds were contacted and on examination of the problem, which appeared to be caused by count variation within and between cones, they agreed to re-spin the order. Fortunately, they were able to do so from the same fibre blend used for the original deliveries.

Subsequent testing of the returned yarn, by Courtaulds, discovered count variation within the 1-40's delivery between 1-27 and 1-40 Ne.

4.2b. Ne 1-16

Shortly after knitting of the Ne 1-16's yarn began, a very high incidence of faults in the fabric was noticed. The faults - mainly holes of various sizes - appeared to be caused by a high frequency of periodic large impurities, neps and slubs in the yarn. Courtaulds were again consulted and after investigation agreed to replace the order, although they were not able to do so from the original fibre blend. As one of the main considerations when planning the projects was to keep the fibre blend constant, thus eliminating any additional possible variation due to changes in the fibre blend, it was decided that although the yarn would commercially be unacceptable, because of the high number of impurities etc., it would be possible in the context of these projects to persevere with the yarn in the interests of overall continuity.

4.2c. Ne 1-32

Unfortunately, some time after knitting of the 1-32's yarn on both 24 and 28 gauge machines was well underway without significant problems, the 1-32's suddenly started causing excessive striping in the fabric, again caused by count variation within and between cones. Courtaulds were again consulted and agreed to replace the complete order. Again a decision had to be made whether to replace the yarn with a yarn spun from a different fibre blend or persevere with the faulty lot. In this case however so much of the programme on two gauges of machine depended on consistent 1-32's yarn, and also it was felt count variation could possibly affect the determination of the physical structure etc., therefore, it was decided to replace the whole delivery.

All the constructions were therefore re-knitted from the replacement yarn and identified by the suffix 'A' after the piece code number on both the pieces and piece tickets. To enable a comparison to be made between the fabrics knitted from both deliveries, the pieces knitted from the first delivery are also included in the finishing plan for Kl. This has increased the total number of pieces to be finished in K1 by 8; 6 of 24G and 2 of 28G.

4.3. Fault Rate

To obtain a general idea of the performance of each yarn count during knitting and also to test for an effect of tightness factor or machine gauge on the performance of the yarn, a fault rate analysis was carried out. Every time a fault appeared in the fabric which could be specifically related to the yarn as opposed to the machine or operative, a record was kept and the totals for each piece are included on the production data charts.

The detailed analysis of fault rate, averaged to faults per 100,000 metres of yarn, for each yarn count, stitch length and machine gauge can be found in *Appendix 2*. A summary of the average total faults for each yarn count/gauge is shown in *Table 6*.

Generally speaking more fabric faults were found to be caused by the singles yarn than the twofold yarn and, on the evidence of the figures, the Ne 1-16's yarn would not appear to be of a very high quality. However, on the average there is no conclusive evidence to suggest that for the yarns used in this project at the stitch lengths knitted there is any consistent or systematic effect of stitch length/tightness factor or machine gauge on the incidence of yarn related fabric faults.

It would however be dangerous to deduce too much from the figures presented here because, although a substantial amount of yarn has been knitted, to arrive at reliable or meaningful conclusions significantly larger quantities of yarn for each variable would need to have been tested.

4.4. Yarn Faults

During the course of the fabric production certain types of yarn faults regularly occurred. As illustration, a typical selection of the faults were collected and are shown in *Appendix 3*.

Generally speaking, the types of faults occurring differed between the singles and twofold yarn. The common faults experienced in the singles yarns are usually caused by slubs and loose fibres and less frequently by loose yarn. The common faults in the twofold yarns however are mainly caused by loose wrappings being caught up in the yarn.

4.5. General Yarn Performance & Quality

The general impression remaining after completing the knitting is that the overall quality and performance of the singles yarn could have been better. Perhaps the fact that some of the yarn counts were non standard for the mill, and consequently frequent quality changes were required, could have contributed to the higher than average incidence of yarn faults.

In the main however, the twofold yarn gave little trouble during knitting and the general quality was good, although some of the doubling faults illustrated in *Appendix 3* would not normally be expected.

5. Fabric Production

The pieces were produced according to the production plans in *Tables 2-4*.

5.1. Production Data/Quality Control

All quality control and production measurements recorded during the course of the knitting are listed on the production data charts, *Appendix 4*, which are arranged in machine gauge, yarn count order.

5.1a. Course Length

The course length target figure for each piece was calculated from the nominal stitch length multiplied by the number of needles in the machine.

The course length figures quoted for the start and end of each piece are mean results from several readings taken over at least five feeders, selected at random around the machine.

The accuracy of the Welmstar course length counter is quoted by the manufacturers as being ±1% and therefore the production tolerance on course length measurements was also set at ±1%, i.e. adjustments to the run-in would only be made, after a quality was initially set up, if the mean course length measurement deviated from the target figure by ±1% In fact, it was not found necessary to make any such adjustments, and an inspection of the figures will show that in all cases the measurements were very much better than ±1% . *Figure 2*, which shows the linear regression analysis, confirms this point.

5.1b. Courses/3cm off Machine

This measurement was intended only as a quick ready reckoner to enable the number of machine revolutions required to produce a length of 75 metres to be calculated. After each quality/yarn change, a piece of the fabric was taken from the machine and allowed to relax free of tension for several minutes. Courses/3cm were measured and converted to Courses/cm, from which the required number of machine revolutions could be calculated. Thus, for a 75 metre piece,

$$Revs = C/cm \times 100 \times 75 / F$$

where F is the number of feeders.

5.1c. Courses/3Cm

As an additional production/quality control measurement, the courses/3cm were measured at the beginning and end of each piece, centrally above the take-down rollers.

5.1d. Yarn Tension

At the beginning of each piece yarn input tension was checked, adjusted where necessary and maintained throughout the total production at between 3-5 gms.

5.1e. Additional Information

- Each piece includes a cutting line to facilitate fabric processing and handling during finishing.
- At the end of each piece, the machines were thoroughly blown down to clear fly and contamination from the guides and feeder holes.
- Samples for fabric testing were removed from each piece 1 and from the specials 11-14.

5.2. Piece Identification

Each piece was marked at the beginning and end with a piece identification number.

e.g.

Code: 18/1-24/311/1

Decode: 18 gauge / Ne 1-24 / Stitch length 0.311cm / Piece No. 1

The piece number represents the project, i.e. K1 or K2 and the finishing route through which the piece will be processed.

For example, all pieces numbered 1 are project Kl, tubular finish.

In addition to the code which is written on each piece, each piece also has a piece ticket attached to it. On these are written the project number K1 or K2, the piece identification code, the weight of the piece and any knitting comments. For example, any faults in the fabric which need to be noted by the finishers.

The piece tickets are also colour coded according to gauge, for ease of identification.

All 18 gauge Pink tickets

All 24 gauge Blue tickets

All 28 gauge Green tickets

Pieces made from twofold yarn are further identified by a stripe through the ticket.

18G Ne 1-20 Pink ticket

18G Ne 2-40 Pink ticket + stripe

The ‘special’ pieces for Kl are further identified by a black 'X' on the back of the piece ticket.

5.3. Fabric Faults

Any holes created in the fabric during knitting were mended to avoid processing problems during finishing. The faults are recorded on the piece tickets.

5.4. General Comments

Apart from routine maintenance and general wear and tear repairs, all the machines performed well throughout the knitting. However, one or two general points were noticed which may deserve consideration.

1. The effectiveness of the stop motions on all three machines was generally good.

However, the particular type of bottom stop incorporated on the Monarch machine was prone to sticking and therefore did not act as efficiently or effectively as the type of the bottom stop motion incorporated on the Camber machines.

2. The speed of the machine can sometimes have an effect on the efficiency of the stop motions. For example, the 28 gauge machine has an average operating speed higher than the other two machines, and consequently the length of the yarn path from the bottom stop motion to the feeder is more critical if there is to be sufficient time for the stop motion to actually stop the machine before a broken end reaches the feeder and casts off.

   One of the main reasons for yarn breakages however is slubs and impurities on the yarn collecting in guide and feeder holes. If the break happens before the bottom stop motion, then path length is critical. If the break happens at the feeder however, there is little that can be done.

   Two possible ways of alleviating this problem could be to either build slub catchers in the machines early in the yarn path to allow the bottom stop motions the maximum time possible to activate, and/or changing the size of guide holes earlier in the yarn path to a size nearer that of the feeder, thereby catching the clubs etc. before they reach the feeder.

   Recent discussions with Camber suggest that this is an area of machine design which they are investigating.

6. Comparison Of Stitch Length Measured On Machine And Measured In The Fabric In The Laboratory.

As one of the main objectives of these projects is to examine and identify physical changes in the fabric brought about as a result of various different finishing routes and machinery, it is essential that stitch length, probably the most important single physical parameter of any knitted structure, can be accurately determined. It is also important that the method of measuring gives a consistent and reliable estimate of the stitch length from which the fabric is known to have been knitted.

The results in *Figure 2* confirm that the stitch length measured going into the fabric corresponds with the target with a very high degree of correlation, therefore to test that the laboratory is also predicting accurately the fabric stitch length, the two sets of data have been compared. Initially the course length measurements were converted to stitch length in mm and the mean for each variant calculated. Mean stitch length in mm is quoted by the laboratory.

Tables 7-9 contain the individual data for each machine gauge plus the confidence limits, although excluding measurements made on the 'special' fabrics.

Figure 3 shows the linear regression analysis of the data. The R^2 figure of 0.99 reflects the high degree of correlation between the two sets of measurements and confirms that stitch length measurements made in the laboratory can be accepted as reliably predicting actual fabric stitch length, within any practical discernable limits.

The IIC method of test for stitch length is included in *Appendix 5*.

Table 1

FABRIC CONSTRUCTION AND TIGHTNESS FACTORS

18 GAUGE CAMBER VELNIT; 26" Diameter, 36 Feeders, 1500 Needles

YARN COUNT	STITCH LENGTH CM.						
	.311	.327	.344	.362	.380	.399	.419
NE 1/16 2/32 K			17.66	16.78	15.99	15.22	14.50
NE 1/20 2/40 K		16.61	15.79	15.00	14.29	13.61	
NE 1/24 2/48 K	15.95	15.17	14.42	13.70	13.05		

24 GAUGE MONARCH XL-JS; 26" Diameter, 60 Feeders, 1920 Needles

YARN COUNT	STITCH LENGTH CM.							
	.262	.276	.291	.306	.321	.337	.354	.372
NE 1/24 2/48 K				16.21	15.45	15.17	14.01	13.33
NE 1/28 2/56 K			15.79	15.01	14.31	13.63	12.98	
NE 1/32 2/64 K		15.58	14.78	14.06	13.40	12.76		

28 GAUGE CAMBER TWINIT; 24" Diameter, 68 Feeders, 2112 Needles

YARN COUNT	STITCH LENGTH CM.						
	.246	.259	.273	.287	.301	.316	.332
NE 1/32 2/64 K			15.76	14.99	14.29	13.61	12.96
NE 1/36 2/72 K		15.64	14.83	14.11	13.45	12.82	
NE 1/40 2/80 K	15.64	14.85	14.09	13.40	12.78		

K = Tightness Factor $\frac{\sqrt{tex}}{l}$ calculated from nominal tex count.

Table 2

18 GAUGE KNITTING PLAN

Piece Identification Code

			K 1		K 2 MERCERISING & DYEING								K1 Spirality Trials			
G	NE	SL cm	TUB	OW									S+Z			
18	2-48	.311	1	2												
18	1-24	.311	1	2												
18	1-24	.327	1	2												
18	1-20	.327	1	2									11			
18	2-40	.327	1	2												
18	2-48	.327	1	2												
18	2-48	.344	1	2												
18	2-40	.344	1	2												
18	2-32	.344	1	2												
18	1-16	.344	1	2												
18	1-20	.344	1	2									11			
18	1-24	.344	1	2												
18	1-24	.362	1	2												
18	1-20	.362	1	2									11			
18	1-16	.362	1	2												
18	2-32	.362	1	2												
18	2-40	.362	1	2												
18	2-48	.362	1	2												
18	2-48	.380	1	2												
18	2-40	.380	1	2												
18	2-32	.380	1	2												
18	1-16	.380	1	2												
18	1-20	.380	1	2									11			
18	1-24	.380	1	2												
18	1-16	.399	1	2												
18	1-20	.399	1	2									11			
18	2-40	.399	1	2												
18	2-32	.399	1	2												
18	2-32	.419	1	2												
18	1-16	.419	1	2												

Table 3

24 GAUGE KNITTING PLAN

Piece Identification Code

			K 1		K 2 MERCERISING & DYEING								K1 Spirality Trials				K 2
G	NE	SL cm	TUB	CW									S+Z	S	T.F. 3.0	T.F. 4.0	
24	2-64	.276	1	2													
24	1-32	.276	1	2													
24	1-32	.291	1	2													
24	1-28	.291	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
24	2-56	.291	1	2	3	4	5	6	7	8	9	10					15
24	2-64	.291	1	2													
24	2-64	.306	1	2													
24	2-56	.306	1	2	3	4	5	6	7	8	9	10					15
24	2-48	.306	1	2													
24	1-24	.306	1	2													
24	1-28	.306	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
24	1-32	.306	1	2													
24	1-32	.321	1	2													
24	1-28	.321	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
24	1-24	.321	1	2													
24	2-48	.321	1	2													
24	2-56	.321	1	2	3	4	5	6	7	8	9	10					15
24	2-64	.321	1	2													
24	2-64	.337	1	2													
24	2-56	.337	1	2	3	4	5	6	7	8	9	10					15
24	2-48	.337	1	2													
24	1-24	.337	1	2													
24	1-28	.337	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
24	1-32	.337	1	2													
24	1-24	.354	1	2													
24	1-28	.354	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
24	2-56	.354	1	2	3	4	5	6	7	8	9	10					
24	2-48	.354	1	2													
24	2-48	.372	1	2													
24	1-24	.372	1	2													

Table 4

28 GAUGE KNITTING PLAN

Piece Identification Code

			K 1		K 2 MERCERISING & DYEING								K1 Spirality Trials			K 2
G	NE	SL cm	TUB	DW									S + Z			
28	2-80	.246	1	2												
28	1-40	.246	1	2												
28	1-40	.259	1	2												
28	1-36	.259	1	2	3	4	5	6	7	8	9	10	11			15
28	2-72	.259	1	2	3	4	5	6	7	8	9	10				15
28	2-80	.259	1	2												
28	2-80	.273	1	2												
28	2-72	.273	1	2	3	4	5	6	7	8	9	10				15
28	2-64	.273	1	2												
28	1-32	.273	1	2												
28	1-36	.273	1	2	3	4	5	6	7	8	9	10	11			15
28	1-40	.273	1	2												
28	1-40	.287	1	2												
28	1-36	.287	1	2	3	4	5	6	7	8	9	10	11			15
28	1-32	.287	1	2												
28	2-64	.287	1	2												
28	2-72	.287	1	2	3	4	5	6	7	8	9	10				15
28	2-80	.287	1	2												
28	2-80	.301	1	2												
28	2-72	.301	1	2	3	4	5	6	7	8	9	10				15
28	2-64	.301	1	2												
28	1-32	.301	1	2												
28	1-36	.301	1	2	3	4	5	6	7	8	9	10	11			15
28	1-40	.301	1	2												
28	1-32	.316	1	2												
28	1-36	.316	1	2	3	4	5	6	7	8	9	10	11			15
28	2-72	.316	1	2	3	4	5	6	7	8	9	10				15
28	2-64	.316	1	2												
28	2-64	.332	1	2												
28	1-32	.332	1	2												

Table 5

PRELIMINARY YARN TESTING K1 AND K2 YARNS

YARN COUNT NE	FRICTION μ	YARN COUNT RESULTANT cc	TURNS/INCH SINGLE	TURNS/INCH FOLDED	TWIST FACTOR TPI/√cc SINGLE	TWIST FACTOR TPI/√cc FOLDED	TWIST LIVELINESS TURNS	TWIST LIVELINESS TW
1-16	0.08	16.46	14.16		3.49		22.93	0.36
1-20	0.08	20.24	15.73		3.50		26.85	0.42
1-24	0.08	25.21	16.77		3.38		26.03	0.41
1-28	0.08	28.17	18.10		3.41		31.95	0.50
1-32 Replacement	0.10	32.58	20.76		3.64			0.49
1-36	0.08	37.06	21.77		3.54		46.75	0.71
1-40 Replacement	0.08	40.90	22.20		3.47		34.00	0.53
2-32	0.20	15.97	20.10	10.82	3.56	2.70	6.75	0.11
2-40	0.21	20.45	22.45	12.80	3.51	2.83	7.07	0.11
2-48	0.20	23.58	24.93	13.18	3.63	2.71	5.65	0.09
2-56 1st Delivery	0.23	27.60	28.40	14.80	3.82	2.81	9.70	0.13
2nd Delivery	0.24	27.50	24.71	12.67	3.33	2.42	6.72	0.11
2-64	0.24	31.91	29.42	13.66	3.68	2.42	8.13	0.13
2-72	0.21	36.27	27.40	15.50	3.21	2.57	9.80	0.15
2-80	0.21	39.65	30.50	15.80	3.43	2.51	9.30	0.15
1-20 S	0.09	20.85	16.23		3.55		28.38	0.44
1-28 S	0.08	28.11	18.78		3.54		32.80	0.51
1-36 S	0.09	35.96	20.83		3.48		38.23	0.60
1-28 Z 3.0	0.097	28.48	15.54		2.92		26.87	0.42
1-28 Z 4.0	0.085	27.64	21.12		4.02		36.90	0.58

Table 6

SUMMARY – YARN FAULT RATES

M/C GAUGE	YARN COUNT NE	TOTAL LENGTH YARN KNITTED M.	AVERAGE FAULTS PER 100,000 M.
18 GAUGE	1-16	5,995,394.64	4.50
	2-32	5,994,360.36	0.22
	1-20	5,949,571.68	0.50
	2-40	5,787,025.92	0.10
	1-24	5,899,427.64	0.20
	2-48	5,894,918.64	0.22
24 GAUGE	1-24	6,664,706.40	0.33
	2-48	6,755,566.80	0.31
	1-28	38,710,091.00	0.25
	2-56	37,539,080.10	0.07
	1-32	6,995,948.40	0.43
	2-64	6,988,092.60	0.09
28 GAUGE	1-32	7,014,187.08	0.10
	2-64	7,141,395.36	0.13
	1-36	38,679,643.72	0.11
	2-72	39,259,658.56	0.09
	1-40	7,286,674.64	0.18
	2-80	7,286,674.64	0.10
18 GAUGE	1-20S+Z	2,974,785.84	0.94
28 GAUGE	1-36S+Z	3,547,171.04	0.20
24 GAUGE	1-28S+Z	3,471,444.00	0.32
	1-28S	3,471,444.00	1.07
	1-28 3.0	3,471,444.00	0.20
	1-28 4.0	3,471,444.00	0.14

Table 7

18 GAUGE

TARGET	S.L. ON M/C		S.L. LAB BW		TARGET	S.L. ON M/C		S.L. LAB BW	
	$\bar{x}$	95%CL	$\bar{x}$	95%CL		$\bar{x}$	95%CL	$\bar{x}$	95%CL
1-16/3.44	3.4434	.034 -	3.476	.01	2-32/3.44	3.44	.021 -	3.442	.01
3.62	3.62	.0	3.612	.014	3.62	3.6167	.034 -	3.594	.013
3.80	3.8034	.037 -	3.837	.018	3.80	3.795	.013	3.801	.01
3.99	4.0050	.025	4.104	.009	3.99	3.9834	.037 -	3.975	.01
4.19	4.1933	0	4.209	.01	4.19	4.1884	.036 -	4.175	.01
1-20/3.27	3.2725	.026 -	3.289	.02	2-40/3.27	3.2717	.032 -	3.213	.01
3.44	3.44	.0	3.497	.01	3.44	3.4408	.025	3.432	.02
3.62	3.6183	.025	3.664	.01	3.62	3.6217	.034 -	3.607	.014
3.80	3.7917	.025 -	3.785	.01	3.80	3.7983	.025	3.771	.007
3.99	4.00	.0	4.052	.014	3.99	3.99	0	3.996	.004
1-24/3.11	3.117	0	3.127	.01	2-48/3.11	3.11	.023 -	3.079	.01
3.27	3.27	0	3.257	.01	3.27	3.2725	.026 -	3.306	.01
3.44	3.4467	0	3.550	.02	3.44	3.44	0	3.444	.02
3.62	3.6217	.023 -	3.620	.01	3.62	3.6250	.029	3.611	.014
3.80	3.7983	.025	3.822	.01	3.80	3.7983	.025	3.768	.011

Table 8

24 GAUGE

TARGET	S.L. ON M/C		S.L. LAB BW		TARGET	S.L. ON M/C		S.L. LAB BW	
	$\bar{x}$	95%CL	$\bar{x}$	95%CL		$\bar{x}$	95%CL	$\bar{x}$	95%CL
1-24/306	3.0593	.032 -	3.086	.01	2-48/306	3.0623	.03 -	3.066	.01
321	3.2153	.034 -	3.209	.01	321	3.2138	.031 -	3.189	.01
337	3.3763	.034 -	3.444	.02	337	3.3725	.013 -	3.225	.01
354	3.542	.0	3.565	.01	354	3.5433	.034 -	3.576	.02
372	3.7125	.009 -	3.751	.02	372	3.7178	.032 -	3.728	.01
1-28/291	2.9085	.002 -	2.936	.02	2-56/291	2.911	.003	2.910	.01
306	3.0624	.007 -	3.071	.013	306	3.0597	.005	3.105	.02
321	3.2118	.006 -	3.216	.006	321	3.209	.008	3.225	.007
337	3.370	.0	3.397	.01	337	3.3745	.007	3.373	.008
354	3.545	.008-	3.573	.01	354	3.5417	.003 -	3.538	.01
1-32/276 A	2.760	.0	2.820	.02	2-64/276	2.7703	.033 -	2.745	.01
291 A	2.911	.0	2.958	.01	291	2.9118	.033 -	2.938	.01
306 A	3.063	.0	3.09	.02	306	3.056	0	3.079	.01
321 A	3.208	.0	3.228	.02	321	3.214	0	3.212	.01
337 A	3.370	.0	3.389	.01	337	3.377	.009	3.395	.01

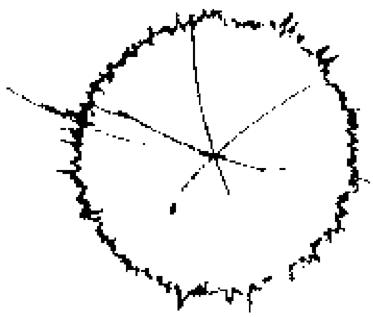
Table 9

28 GAUGE

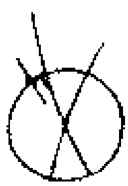
TARGET	S.L. ON M/C $\bar{x}$	95%CL	S.L. LAB BW $\bar{x}$	95%CL	TARGET	S.L. ON M/C $\bar{x}$	95%CL	S.L. LAB BW $\bar{x}$	95%CL
1-32/273 A	2.7261	.01	2.758	.01	2-64/273	2.7285	.029 –	2.72	.01
287 A	2.8717	0	2.918	.01	287	2.8658	.029 –	2.834	.012
301 A	3.0138	.032 –	3.045	.01	301	3.0102	.023 –	3.026	.005
316 A	3.1593	.009 –	3.192	.01	316	3.1581	.023	3.171	.005
332 A	3.3132	.02	3.35	.008	332	3.3156	.026	3.344	.015
1-36/259	2.5902	.002	2.610	.01	2-72/259	2.5871	.007 –	2.550	.01
273	2.7317	.006–	2.770	.01	273	2.7272	.006 –	2.734	.01
287	2.873	.003	2.871	.005	287	2.8719	.005	2.844	.009
301	3.0146	.002	3.046	.01	301	3.0093	.005	3.020	.01
316	3.165	.007	3.188	.01	316	3.1601	.006 –	3.192	.01
1-40/246	2.4704	.021	2.488	.01	2-80/246	2.4615	.016	2.439	.01
259	2.5888	0	2.610	.01	259	2.584	.021	2.593	.01
273	2.7332	.025–	2.719	.013	273	2.7326	.009 –	2.740	.01
287	2.8717	0	2.877	.013	287	2.8741	0	2.859	.01
301	3.0161	0	3.049	.02	301	3.0149	.026	3.00	.01

Figure 1

YARN FRICTION TESTING



TYPICAL TRACE FOR
2-FOLD YARN



TYPICAL TRACE FOR
SINGLES YARN

Figure 2

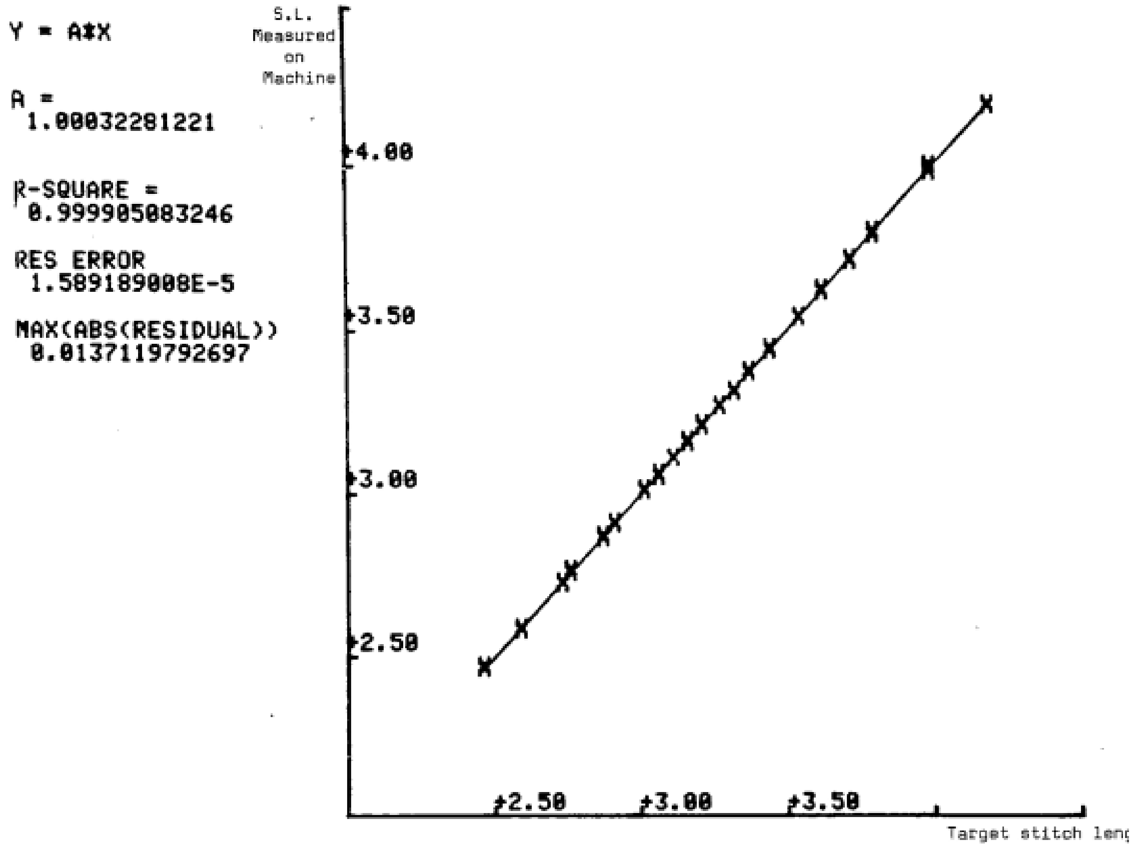


Figure 3