

JBS - CASE STUDY

14 Gauge 1 x 1 Rib Winch Bleach

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C O N T E N T S

1. INTRODUCTION
2. SUMMARY OF RESULTS
3. SAMPLING AND TESTING
4. VARIATION IN YARN AND STITCH LENGTH AS KNITTED (GREY FABRIC)
 - 4.1. Yarn
 - 4.1.1. count
 - 4.1.2. twist factor/turns per metre
 - 4.2. Stitch Length
5. RESULTS AND ANALYSIS
6. VARIATION IN FABRIC DIMENSIONS
 - 6.1. Influence of Different Yarn Sources
 - 6.2. Overall Variation
7. COMPARISON WITH STARFISH
 - 7.1. Development of a New Quality
8. SHRINKAGE

TABLES 1 - 23
FIGURES 1 - 37

1. INTRODUCTION

Over the last eight/nine years the IIC has been following a programme of research and development which has had one main overall objective; to assist cotton knitgoods manufacturers to overcome the problem of excessive shrinkage. During this period an extensive amount of data has been collected on interlock, rib and plain jersey fabrics all of which have been produced in commercial quantities and finished through full-scale processing. The analysis of this data has resulted in the development of a computer model - codename, STARFISH, - which enables the finished dimensions and properties of certain knitted fabrics to be predicted from a knowledge of the main knitting and finishing variables, e.g. yarn count, stitch length, knitting machine, dyeing and finishing route.

In order that the cotton knitgoods industry as a whole can take advantage of this work, the IIC has begun to develop a network of centres throughout the world who can use STARFISH to service their local industry.

In 1984 the Danish Clothing and Textile Institute signed an agreement with IIC to become the STARFISH user-centre for Denmark. Since then, DBTI has been evaluating the potential and applicability of the STARFISH system to the Danish industry. As part of this process of evaluation the DBTI entered into an agreement with the knitting company JBS which enabled samples of their 1 x 1 rib production to be taken at intervals, subject to production availability. This has been proceeding for about 18 months.

The objectives of this sampling exercise were threefold:-

1. To provide JBS with quantitative information about their fabric production, e.g. the range and sources of variation in their products, which could then be used by the company to assist them in improving the quality of their products.
2. To develop information on locally knitted and finished fabrics to enable the STARFISH model to be correlated to the conditions prevailing in the Danish industry.
3. To generate additional data on fabrics currently outside the existing data base in order to broaden the scope and applicability of the STARFISH model.

Sampling of commercial production can be time consuming and expensive but in the long term provides valuable information about the unavoidable variations in raw materials, production and process control which have to be accepted by manufacturers, retailers and consumers of cotton knitgoods. On the other hand, it also allows avoidable sources of variation to be identified, which enables action to be taken to reduce overall variation and improve product quality.

The agreement between DBTI and JBS has so far enabled samples to be collected of 14 and 22 gauge 1 x 1 rib fabric knitted from two nominal yarn counts, Ne 1/24 and Ne 1/60, processed through several different bleaching/dyeing and finishing routes, e.g. winch bleach, winch dye, overflow jet dye ATYC and jet dye Gaston County. The sampling procedure is still continuing at JBS but sufficient samples have now been gathered from one quality to allow a preliminary analysis and report to be prepared.

The quality which has been examined in this report is a 14 gauge 1 x 1 rib fabric, design no. 300, knitted from combed ring spun yarn of nominal count Ne 1/24 (24.6tex), winch bleached and finished by Martensens Fabrik.

2. SUMMARY OF RESULTS

1. Most of the grey fabrics sampled in this study were apparently produced to a reasonable level of quality control, although some additional variation has been introduced by the fact that the yarn used was from two different sources. In two cases the knitting machines appear to have been improperly adjusted for stitch length.
2. Both yarns were delivered with average counts very close to the nominal or specified count, and with commercially acceptable/realistic variability. However, the turns per metre or twist in the two yarns was found to be dissimilar which has contributed to the overall variation in finished fabric shrinkage.
3. The variation in stitch length was found to be within acceptable/realistic commercial tolerances with the exception of two samples. These have increased the overall variation in finished fabric shrinkage.
4. The finisher has apparently done a good job in containing variations in finishing. Fabric widths have obviously been carefully monitored and therefore variation in the fabric has been channelled into higher variations in courses and weight.
5. Variations in length and width shrinkage observed in these fabrics are a direct reflection of variation in knitted stitch length and apparently also of differences in the two yarns. This is presumably related to the differences in twist observed between the two yarns but may also be associated with intrinsic differences in the fibres from which the yarns were spun.
6. Average shrinkage levels to 5 wash and tumble cycles are not unreasonably high for 1 x 1 rib fabric and if they could be maintained consistently, should not cause serious problems to the consumer. However, the fabrics produced from the Greek yarn have on average higher shrinkage in both length and width directions, by 2.0% and 1.6% respectively, than those observed in the fabrics produced from the Egyptian yarn. If these were to be taken into account, different

finishing targets would need to be set for both fabrics to achieve the same average levels of shrinkage in the finished fabrics, as delivered.

7. The STARFISH model has been shown to predict average values for courses, wales and weight in the finished reference state with reasonable precision, although at the present time it is unable to take account of differences in twist levels in the yarn. By using the average measured values for length and width shrinkage the STARFISH model is also predicting average finished fabric dimensions as received.
8. An example of how the STARFISH model can be used to develop a new quality with improved shrinkage levels has been illustrated. Using the information obtained from the fabrics in this study, it was found that average shrinkage levels could be improved, while maintaining similar average weights and finished widths for each machine diameter, by increasing the stitch length from 0.307 to 0.33 cm. The original count of yarn could be maintained.
9. Shrinkage measured by the single cycle tumble dry test compared to the 5 cycle test, overestimates width shrinkage by 1% and underestimates length shrinkage by 2.25%, for the fabrics examined in this study.

3. SAMPLING AND TESTING

The fabrics included in this study were knitted by JBS and processed at Martensens Fabrik using a winch bleaching process. In all, thirty two fabrics were sampled, 16 grey state and the corresponding 16 bleached and finished. The first eight samples were produced during October-November 1984, the second eight were produced during the period June-September 1985.

The fabrics were knitted on 14 and 15 gauge 1 x 1 rib machines of various diameters to the same nominal quality, No. 300, using combed ring spun yarn, nominal count Ne 1/24 (24.6Tex) from two different sources. Details of the knitting machinery are given in Table 1.

The samples and details of the knitting and finishing were collected by DBTI and sent to IIC. On receipt the samples were tested according to standard IIC testing procedures both "as received" and after relaxation to the reference state. The complete test data for all the samples are included in Tables 2-5.

At the bottom of each table the ratio of calculated/observed weight, courses and wales are given. These provide an automatic internal check on the self-consistency of the test data for the laboratory to ensure that inconsistent results are quickly identified. To be acceptable, the ratio must fall within the range 0.95 - 1.05. Fabrics giving results outside this range are retested until better self consistency is achieved. Results which fall near the limits of the acceptable range are often the result of inherent variability in the specimens under test and/or a feature of the construction or finish which creates handling problems in the laboratory. For example, difficulty in removing yarn for the measurement of yarn count or stitch length.

Similar checks for self-consistency of the test data can be made by using the following two equations to calculate weight and shrinkage for each fabric, which can then be compared directly to the measured values.

Weight calculation

$$\text{Weight gsm} = [\text{courses/cm} * \text{wales/cm} * \text{Tex} * \text{stitch length cm} * 0.1] * 2$$

Shrinkage calculation

$$\begin{aligned} \% \text{ shrinkage (length)} &= [\text{courses (AW)} - \text{courses (BW)}] / \text{courses (AW)} * 100 \\ \% \text{ shrinkage (width)} &= [\text{wales (AW)} - \text{wales (BW)}] / \text{wales (AW)} * 100 \end{aligned}$$

Individual data obtained from the above 3 equations are given in Tables 6-9 and are summarised below. BW refers to the "as received" (before wash) state and AW refers to the relaxed reference state (after 5 cycles of washing/rinsing and tumble drying).

Grey fabric 16 samples

	<u>Measured</u>		<u>Calculated</u>		<u>Mean diff</u>	<u>% Mean diff</u>
	<u>Mean</u>	<u>S.D.</u>	<u>Mean</u>	<u>S.D.</u>		
Weight BW	185.14	6.89	185.84	5.65	-0.7	-0.43
(gsm) AW	255.27	7.37	265.34	7.32	-10.07	-3.95
<u>%shrinkage</u>						
Length	18.9	2.31	18.6	1.58	0.3	
Width	16.38	3.92	16.11	3.67	0.27	

Finished fabric 16 samples

Weight BW	187.17	6.46	193.14	5.61	-5.97	-3.22
(gsm) AW	236.65	6.28	244.39	7.28	-7.75	-4.15
<u>%shrinkage</u>						
Length	12.24	0.56	11.67	1.43	0.56	
Width	12.49	2.32	11.39	2.42	1.1	

These results indicate a reasonable level of agreement between the measured and calculated values. There is no significant difference between measured and calculated values for shrinkage and although on average calculated weight is overestimating measured weight by 2.9%, agreement is well within the limits $\pm 5\%$ imposed on the laboratory through the data checking procedure.

4. VARIATION IN YARN AND STITCH LENGTH AS KNITTED (grey fabric)

Most often the major source of variations in the final performance and properties of similarly dyed and finished knitted fabrics can be traced to variations in the yarn and stitch length from which the fabrics were manufactured. Variation in these two parameters leads to differences in the relaxed reference dimensions of similar fabrics which, when finished to the same weight and width, will exhibit differences in shrinkage. A certain level of variation in raw material and production control is, of course, inevitable and has to be accepted as the product of normal random fluctuations in materials, processing and testing. However to avoid unacceptably high levels of variation in the final product performance, strict quality control must be maintained over these two parameters during the knitting operation.

4.1. Yarn

The sixteen fabrics included in this study were produced using yarn from two different sources. These were identified as 1) Greek yarn and 2) Egyptian yarn. The first eight samples collected were knitted from the Greek yarn, the second eight samples from the Egyptian yarn.

Samples of yarn on cone were not available for testing and therefore yarn was extracted from the grey fabrics, as received, and measured for count (Tex), single end strength and % extension, and turns per metre. From the measurements of tex and turns per metre the alpha tex twist factors and corresponding English twist factors were calculated. The results are given in Table 10.

4.1.1. Count - Figure 1

A common commercial tolerance applied to yarn count in the UK is $\pm 2.5\%$ on nominal or specified count, which is approximately equivalent to a coefficient of variation of $CV = 1.25\%$. It is however not unusual for this tolerance to be exceeded, especially when yarn is obtained from more than one supplier. Therefore a more commercially achievable tolerance would probably be $\pm 3\%$ on nominal or specified count or a coefficient of variation of $CV = 1.5\%$.

For the fabrics examined in this study, the overall average yarn count was found to be 24.68 Tex with a standard deviation of 0.3 and a coefficient of variation of $CV = 1.2\%$. The Greek yarn had an average count of 24.75 Tex with a standard deviation of 0.24, $CV = 0.97\%$ and the Egyptian yarn had an average count of 24.61 Tex with a standard deviation of 0.34, $CV = 1.38\%$.

From these results we can therefore deduce that both yarns have on average been delivered very close to specification (nominal count Ne 1/24, 24.6 Tex) and with low variability. The average difference in yarn count between the two sources is neither practically nor statistically significant, although there is an indication that the Egyptian yarn may have been more variable.

4.1.2. Twist factor/Turns per metre - Figure 2

When yarns for knitting are specified the twist factor to which they are spun is often overlooked or it is specified as "normal hosiery twist". In the UK normal hosiery twist would be taken to imply an English twist factor of 3.5/3.6 but this will vary depending on the yarn count (finer yarn usually higher twist) and the fibre from which it is spun, and the spinner. Twist factor, in addition is seldom, if ever, measured on a routine quality control basis by knitters. There is however some evidence to suggest that the amount of twist in a given yarn will influence the dimensions of the reference state, i.e. that the number of courses and wales in the relaxed fabric will vary between fabrics knitted to the same average stitch length from yarns of the same average count but with different twist factors (turns per metre).

The two yarns sampled in this study were found to have statistically significant differences in the levels of twist or turns per metre. The average twist factor recorded for all the samples is alpha tex = 37.5 with a standard deviation of 1.8. However, the Greek yarn had an average twist factor of alpha tex = 39.1 with a standard deviation of 0.9, and the Egyptian yarn had an average twist factor of alpha tex = 35.9 with a

standard deviation of 0.7. The Greek yarn is therefore, on average, more highly twisted than the Egyptian yarn.

Differences can also be seen between the two yarns in terms of strength and % extension. The Egyptian yarn is stronger than the Greek yarn but the Greek yarn is more extensible. These differences are presumably related to the fibre from which the yarns are spun - Egyptian fibre is longer, finer and stronger, - and to the amount of twist in the yarn; more twist, higher extensibility.

4.2. Stitch length - Figure 3

A common commercial tolerance applied to stitch length in the UK is $\pm 2.5\%$ on specified stitch length which is approximately equivalent to a coefficient of variation of $CV = 1.25\%$. This has been found to be well within the commercial capability of knitters who operate standard quality control procedures using modern instrumentation and in fact is more often than not improved upon. ($\pm 1.5\%$, $CV = 0.75\%$ is not uncommon).

The overall average stitch length in the grey as received fabric was found to be 0.313cm with a standard deviation of 0.008 and a coefficient of variation of $CV = 2.41\%$.

The average stitch length in the fabric produced from the Greek yarn was 0.314cm with a standard deviation of 0.004 and a coefficient of variation of $CV = 1.19\%$ and the average stitch length in the fabric produced from the Egyptian yarn was 0.312 with a standard deviation of 0.01 and a coefficient of variation of $CV = 3.3\%$. Therefore the major source of the high overall level of variation is to be found in the second batch of fabrics and in particular from two samples, one produced on machine no. 23 (12" diameter) and one produced on machine no. 36 (18" diameter). These discrepancies are in opposite directions - machine 23 longer than average, machine 36 shorter than average. Therefore the average stitch length for the fabrics produced from Egyptian yarn is similar to that found in the fabric produced from Greek yarn.

With the exception of these two fabrics the variation in stitch length is within the commercial tolerance limits previously stated of $\pm 2.5\%$ on specified stitch length. In the absence of a stitch length specification, this can be taken to mean for this quality average stitch length 0.313cm $\pm 2.5\%$ or $CV = 1.25\%$.

5. RESULTS AND ANALYSIS

Individual measurements for tex, stitch length, courses, wales, weight and shrinkage are given in Tables 11-14 for grey fabric, 15-18 for finished fabric. The fabrics from different yarn sources are tabulated separately. The mean, standard deviation, and coefficient of variation for each property has been calculated, and is also included in the tables.

Figures 4-15 illustrate the results graphically for grey fabric, Figures 16-27 for finished fabric. The data is plotted indicating the yarn source and knitting machine/diameter on which the fabric was produced. The plots also include bars indicating the overall average values ± 2 standard deviations.

6. VARIATION IN FABRIC DIMENSIONS

An indication of the levels of variation which have to be expected in the dimensions of similarly finished fabrics can be obtained by an examination of the dimensions of the reference state.

The variation in dimensions found in the grey fabric are a direct result of variations in knitted stitch length and yarn. Variation in dimensions found in the finished relaxed fabric reflect both the variation in knitting and any additional variation introduced by the finishing procedure.

6.1. Influence of Different Yarn Sources

Differences in yarn and stitch length between the fabrics produced from the two yarn sources have already been noted and therefore, to examine this point further, the data from the two sets of fabric were analysed separately to try to isolate the influence, if any, of the different yarn sources. In order to compare the two yarns directly, it is necessary to allow for the variations in stitch length which are not the same in both cases - the Egyptian yarn was knitted with a much wider range of stitch lengths than the Greek.

When comparing the reference state dimensions the effect of stitch length can be removed (approximately) by multiplying the courses per cm or the wales per cm by the stitch length, and by multiplying the weight per unit area by the stitch length divided by the tex.

Tables 11-18 give the individual results for each fabric set both as received and after relaxation to the reference state, both grey and finished. Summaries are given in Tables 19 and 20 but the most important factors (the factors for courses, wales and weight corrected for stitch length) are shown below for the reference state fabrics.

Grey Reference

<u>Factor</u>	<u>Greek</u>	<u>Egyptian</u>	<u>E/G%</u>
courses	5.27	5.23	99.2
wales	3.17	3.22	101.6
weight	3.23	3.23	100.0

Finished Reference

<u>Factor</u>	<u>Greek</u>	<u>Egyptian</u>	<u>E/G%</u>
courses	5.07	4.93	97.2
wales、	3.10	3.18	102.6
weight	3.05	3.03	99.3

These factors may look very similar but they indicate that, in the finished reference state, fabric made from the Egyptian yarn will have approximately 2.5% fewer courses/cm and 2.5% more wales/cm than that made from the Greek yarn. The weight will be about the same. In fact, we found almost exactly these differences in the average levels of courses and wales. It should also be noted that the differences between the two yarn sources are greater in the finished fabric than in the grey.

The practical meaning of this is that if fabrics are made with exactly the same stitch length and are delivered with exactly the same width (wales/cm) and weight, then there will be differences in the length and width shrinkages of about the same amounts, i.e. fabric made from the Egyptian yarn will shrink about 2.5% less in the length and about 2.5% more in the width.

In practice of course these potential differences become obscured because different fabrics are not knitted to exactly the same stitch length nor finished to exactly the same dimensions.

Examination of the actual shrinkage values obtained from these two sets of fabrics do however confirm differences between the two yarn sources. After finishing, the fabrics produced from Egyptian yarn have, on average, 2% less length shrinkage than those produced from the Greek yarn. In the width direction however, the variation in width shrinkage measurements are such that the potentially greater level of shrinkage in the Egyptian fabrics has been obscured and an average 1.6% less width shrinkage has in fact been recorded.

Tables 21 and 22 summarise the results of a more detailed statistical analysis, using the Student's t-test, which confirms that courses, wales and length shrinkage, in particular, are statistically significantly different between the two sets of finished fabric. Width shrinkage does not show a statistically significant difference because of the general level of variation between the two data sets.

In addition to the differences in average shrinkage found between the two fabric sets, the effect of the large overall variations in stitch length, (and in consequence the variation in reference courses and wales) on shrinkage can be seen in Figures 28 and 29. In these figures the length and width shrinkages recorded in the finished fabrics are plotted against stitch length. The yarn source is also identified. The measured data are summarised below:

	<u>Average</u>	<u>Range</u>
Greek Yarn		
% Length shrinkage	13.3	12.3 - 13.9
% Width shrinkage	13.3	10.4 - 15.6
Egyptian Yarn		
% Length shrinkage	11.2	9.8 - 13.9
% Width shrinkage	11.7	7.4 - 15.3
All fabrics		
% Length shrinkage	12.2	9.8 - 13.9
% Width shrinkage	12.5	7.4 - 15.6

6.2. Overall Variation

Having considered the fabrics from the Greek and Egyptian yarns separately, the question of the overall variation remains.

The total variation in the reference state dimensions of the finished fabrics was as follows, expressed as the coefficients of variation.

	<u>CV%</u>
courses	3.38
wales	2.67
weight	2.65

If these results are typical of normal production it means that most of the time the dimensions (and therefore the shrinkage) will vary by at least $\pm 2.5\%$ from the intended values, and that some of the time the discrepancy will be in the region of $\pm 5\%$ or more.

A part of this variation was certainly caused by the use of the two different yarn types but inadequate control over the stitch length during knitting was also partly to blame, since this was the main reason for the wide variation in the Egyptian yarn set. This point is illustrated by Figures 16 - 27 which show that the overall variation is very similar to that of the fabrics made from the Egyptian yarn.

The variation coefficients can also be used to judge how well the finisher has coped with the fabric that he has been given. Obviously he can not be expected to deliver the fabric with much less variation than is present in the reference state, but a poor finisher can cause much greater variation if his processing is not under good control.

The variability of the dimensions of the fabrics as delivered by the finisher were:

	<u>CV%</u>
courses	3.66
wales`	1.63
weight	3.45

It is apparent that the finisher has endeavoured to keep tight control over fabric width, which is usually a high priority for finishers. Therefore, the variation coefficient for the wales is only 1.6%. However, the inevitable consequence of this has been that the inherent variation in the fabric (as shown by the reference state values) has been channelled into increases in the variation of courses and especially of the weight. These increases are by no means excessive, however, and so the finisher appears to be doing a good job of keeping the variation down to approximately the level which was already built into the fabric at the knitting stage.

Finally, it should be pointed out that the overall levels of variation found in the finished reference state also give an indication of the accuracy with which the STARFISH predictive model can be used to predict the test results for any given sample or group of samples taken from production.

The STARFISH prediction is a calculation of the mean value of a large number of samples, so an individual test may return values anywhere within two standard deviations of the predicted values.

The average of tests on 5 or more different pieces will be expected to lie within one standard deviation of the prediction. This assumes of course that the particular yarn and processing route used in the STARFISH model is appropriate for the production being sampled. The applicability of the current STARFISH model to the fabrics in this study is illustrated in the next section.

7. COMPARISON WITH STARFISH

The STARFISH model allows the average dimensions of the finished reference state to be predicted from a knowledge of the average yarn count (tex) and average stitch length used in its manufacture, plus information about the bleaching or dyeing route through which the fabric is to be processed. If the dimensions of the reference state can be predicted with reasonable accuracy, then the dimensions of the finished, as delivered, fabric with a certain level of shrinkage can also be calculated.

In Figures 30-32 the results obtained from these fabrics, measured in the reference state, are shown compared to those which would have been predicted using the STARFISH model for winch bleached fabric. Although the fit is not perfect (at present the model is unable to take account of differences in yarn twist factor) the curve passes on average through the centre of the

data and illustrates how the influence of stitch length can be predicted in reference state dimensions.

If the model is run, using average measured values for yarn count and stitch length the following values are obtained.

As knitted - average measured values all fabrics

Tex 24.68
stitch length 0.313

Finished Reference

	<u>Average Measured</u>		<u>STARFISH Predicted</u>	
	<u>Mean</u>	<u>SD</u>		
Tex	23.89	0.39	23.9	23.8
Stitch length	0.307	0.007	0.307	0.307
Courses/cm	16.32	0.55	16.4	16.6
Wales/cm	10.24	0.27	10.3	10.3
Weight gsm	236.6 (245)	6.28	236	250
Calc wt	244.4	7.3	248	

Finished as Delivered

	<u>Average Measured</u>		<u>Predicted from Measured Shrinkages</u>		
	<u>Mean</u>	<u>SD</u>			
%Length Shrinkage	12.24	1.44	-		13.2
%Width Shrinkage	12.5	2.32	-		12.0
Courses/cm	14.41	0.53	14.4	14.6	(14.4)
Wales/cm	9.07	0.15	9.0	9.0	(9.1)
Weight gsm	187.2 (191.7)	6.46	182.0		
Calc wt GSM	193.1	5.61	190	192	191

In all cases the predicted values are within ± 1 standard deviation of the average measured values obtained from all fabrics.

7.1. Development of a new quality

One of the uses to which STARFISH can be put is to assist in the development of a new fabric quality or in the modification of an existing quality to, for example, improve the average level of shrinkage. Often a manufacturer will be asked by his customer to deliver a fabric with improved stability while maintaining the same fabric weight (cost) and fabric width (cutting efficiency in making-up or sizing limitations in garments).

On the surface this appears to be an impossible combination. If width shrinkage is to be improved then the fabric has to be finished narrower (more wales); if length shrinkage is to be improved then the fabric must be finished with more courses. More courses and wales in the finished fabric means a heavier fabric. Normally the manufacturer will not want to change

the yarn count and therefore the only option available is to knit the fabric to a different stitch length. Unless this problem has been faced in the past and a successful solution developed, the decision by how much or how little and in which direction, shorter or longer to make the change can be very much a hit and miss operation. In any case, several trial pieces will have to be knitted and finished, fabric tested, and more fabric produced if the first trials were unsuccessful. By using STARFISH the manufacturer can obtain a good first estimate of the quality which has been knitted to achieve the specification laid down by his customer, and at the same time obtain finishing targets for his finisher. The results obtained from the fabrics included in this report can be used as an example.

Original finishing specifications were not available at the time of writing but one can deduce what they might have been by taking the average results obtained from the as received finished fabrics (although ideally some allowance should be made for partial relaxation of the fabric during transportation).

Average finished dimensions

Courses/cm	14.41	0.53	
Wales/cm	9.07	0.15	
Weight gsm	187.2	6.46	191.7
%Length shrinkage	12.24	1.44	
%Width shrinkage	12.5	2.32	

From the average wales per centimetre a table of finished fabric widths can be constructed for each machine diameter/needles.

<u>Gauge</u>	<u>Diameter</u>	<u>Needles</u>	<u>Finished Width cm Tubular</u>
15	12	564	31.1
14	14/15	660	36.4
14	16	696	38.4
14	18	792	43.7
14	20	876	48.3
14	22	972	53.6

If these fabrics were knitted to the same average yarn count and stitch length, but finished to deliver, for example, average shrinkage values of 8 x 8, then the average finished dimensions would have to be:

Courses/cm	15.0	14.9
Wales/cm	9.4	9.3
Weight gsm	200	203
%Length shrinkage	8	10
%Width shrinkage	8	10

which would result in finished fabric widths for the above 6 machines of:

<u>Diameter</u>	<u>Needles</u>	<u>New Finished Width cm Tubular</u>
12	564	29.9 30.3
14/15	660	34.9 35.5
16	696	36.8 37.4
18	792	41.9 42.6
20	876	46.4 47.1
22	972	51.5 52.3

A decrease in fabric width of up to 2 cm and an increase in fabric weight of 13 gsm or 7% on the original fabric has resulted.

By spending a short period examining this problem using STARFISH the following potential solution was discovered. By increasing the knitted stitch length from 0.307 cm to 0.330 cm and finishing the fabric with 9 wales/cm and 14 courses/cm, fabric weight and width can be maintained and shrinkage will be reduced to 8 x 8% on average.

e.g. Average knitted

Tex	24.7
Stitch length	0.330

Predicted Finished Reference Dimensions

courses/cm	15.3
wales/cm	9.8
weight gsm	222 232

Predicted Finished As Delivered Dimensions for 8 x 8% Shrinkage

courses/cm	14.1
wales/cm	9.0
weight gsm	188 196.5

At this stage obviously actual knitting and finishing trials would need to be carried out to establish that the new finishing targets for courses can be met by the finisher. It would also be necessary to evaluate the appearance, hand etc. of the new fabric as changes in these properties cannot be taken into account by the model.

It is also important to remember that the STARFISH model can only predict the average dimensions and performance of a fabric. If the actual yarn count or stitch length as knitted is allowed to vary or if there are variations in finished dimensions, fabric weight and shrinkage will also vary. Thus maximum benefit can only be obtained if strict quality control is maintained at all stages of production and processing.

Printouts from the STARFISH model for the previous examples are included as Figures 33 - 35.

8. SHRINKAGE

Comparisons were made of the shrinkage values returned after 1 wash and tumble drying cycle, and after the standard reference relaxation procedure (5 cycles including tumble drying).

The individual data are contained in Table 23 and illustrated in Figures 36 and 37.

On average the single cycle tumble dry test underestimates total length shrinkage by 2.25% and overestimates width shrinkage by 1%.

Although there are small differences between the two fabric sets the general conclusions are the same.

Previous work which has compared line drying with tumble drying suggests that if these fabrics had been line dried, length shrinkage would have been underestimated compared to the 5 cycle test by approximately 3% and width shrinkage by approximately 8%.

With rib fabrics in particular, there is always a danger that comparatively low levels of width shrinkage to tumble drying will translate to an extension or growth if other methods of drying are used.

This point should be kept in mind when issuing shrinkage specifications for rib fabrics, and also in the choice of test method used for quality control purposes.

JBS : CASE STUDY : 1x1 RIB 14 GAUGE

Nominal Yarn Ne 1/24 (24.6 Tex)

Machinery / Processing Details

Sample Ref No	Machine No	Gauge	Diam.	Needles *2	Design No	Process / Colour
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Greek yarn

D6052	34	14	14	* 660	300	Winch Bleach/White
D2396	32	14	15	660	300	Winch Bleach/White
C8106	32	14	15	660	300	Winch Bleach/White
D2417	33	14	16	696	300	Winch Bleach/White
C8138	36	14	18	792	300	Winch Bleach/White
D2453	36	14	18	792	300	Winch Bleach/White
D2350	1	14	20	876	300	Winch Bleach/White
D2342	1	14	20	876	300	Winch Bleach/White

Egyptian yarn

P4903	23	15	12	564	300	Winch Bleach/White
P4899	34	14	14	* 660	300	Winch Bleach/White
D1532	32	14	15	660	300	Winch Bleach/White
D1298	22	14	16	696	300	Winch Bleach/White
D1285	33	14	16	696	300	Winch Bleach/White
P4976	36	14	18	792	300	Winch Bleach/White
D2535	1	14	20	876	300	Winch Bleach/White
D2226	26	14	22	972	300	Winch Bleach/White

* Denotes non standard number of needles

Project Name - Greige 14g - Controls for winch bleaching

GREIGE 14G (Winch bleach)

	D6052	D2396	C8106	D2417	C8138	D2453	D2358	D2342
Length shrinkage, TD	18.65	18.82	19.66	18.99	18.28	19.29	18.47	18.73
Width shrinkage, TD	21.76	16.49	15.52	16.62	14.86	15.43	15.66	15.99
Length shrinkage, 5x	20.67	20.84	21.76	21.86	20.38	21.31	20.23	20.58
Width shrinkage, 5x	22.58	16.83	15.84	16.83	14.96	15.85	15.82	15.97
Weight (gsm)BW	174.84	187.87	181.35	186.86	193.49	192.20	178.48	179.31
Weight (gsm)AW	258.54	256.81	259.82	255.86	263.75	253.18	256.38	258.94
Courses per 3cm BW	41.98	41.58	48.58	41.78	41.88	48.98	41.88	48.88
Courses per 3cm TD	51.78	51.88	58.18	51.58	51.28	58.88	58.98	58.28
Courses per 3cm AW	51.75	52.18	58.88	51.38	52.88	51.58	51.18	58.68
Wales per 3cm BW	25.36	26.28	26.38	26.28	26.48	26.28	25.95	25.88
Wales per 3cm TD	31.28	31.88	38.98	31.48	31.88	38.78	38.38	38.78
Wales per 3cm AW	31.85	38.78	38.98	31.88	38.98	38.98	31.88	38.58
Stitch length (mm) BW	3.11	3.89	3.16	3.89	3.15	3.16	3.18	3.17
Stitch length (mm) AW	3.87	3.83	3.18	3.83	3.87	3.18	3.11	3.13
Burst strength, BW	715.98	788.58	745.88	724.38	748.48	747.18	798.28	698.88
Burst strength, AW	681.78	783.48	714.78	789.88	731.38	713.18	713.28	784.18
Distension at burst, BW	17.62	18.85	17.66	17.19	18.26	17.42	18.33	17.38
Distension at burst, AW	23.82	23.41	23.54	23.26	23.84	23.57	23.55	23.75
Angle of spirality, BW	8.45	-8.76	-8.26	-8.63	-8.95	-8.89	-8.68	-2.17
Angle of spirality, AW	-8.12	8.87	1.75	8.94	8.89	-8.38	-8.28	-8.78
Width, BW	36.28	37.18	36.98	38.63	43.63	44.17	58.63	48.77
Yarn strength, BW	343.84	325.81	326.45	354.99	345.51	345.45	339.84	348.77
Yarn strength, AW	336.63	339.28	335.21	341.99	341.12	344.17	332.24	348.63
Yarn extension at break, BW	7.55	7.16	7.67	7.76	7.79	8.17	7.83	7.79
Yarn extension at break, AW	9.12	8.84	9.88	8.81	9.14	9.13	8.97	8.79
Yarn count (tex), BW	24.78	24.76	24.91	24.66	25.24	24.58	24.69	24.48
Yarn count (tex), AW	24.66	24.16	24.44	24.84	25.81	24.13	24.46	24.27
Thickness, BW	858.48	868.98	889.58	862.58	986.58	894.18	987.48	988.58
Thickness, AW	1233.88	1219.18	1235.78	1221.38	1224.88	1224.88	1238.68	1231.98
Turns per metre	818.88	783.58	782.88	777.58	887.58	775.58	767.58	782.58

DATA CHECKS

Calc/Obs Wt BW	1.84	8.99	1.83	8.99	1.81	8.96	1.84	1.81
Calc/Obs Wt AW	1.85	1.82	1.82	1.84	1.84	1.84	1.85	1.84
Calc/Obs Courses/3cm AW	1.82	1.81	1.82	1.83	1.81	1.81	1.81	1.81
Calc/Obs Wales/3cm AW	1.85	1.83	1.81	1.82	1.88	1.81	8.99	1.81

Project Name - 14g, winch bleached

WINCH BLEACHED 14G

	D6052	D2396	C8106	D2417	C8138	D2453	D2350	D2342
Length shrinkage, TD	10.72	11.56	11.32	10.21	9.96	10.61	10.49	11.51
Width shrinkage, TD	15.36	16.83	13.20	16.94	13.41	13.10	13.92	14.05
Length shrinkage, 5x	13.47	13.77	13.62	13.41	12.31	12.82	13.15	13.86
Width shrinkage, 5x	14.70	15.64	10.41	15.20	12.16	12.47	13.07	12.58
Weight (gsm)BW	190.18	183.70	193.34	193.35	190.12	189.74	188.01	182.22
Weight (gsm)AW	247.12	237.17	238.24	240.89	238.21	237.25	234.75	232.68
Courses per 3cm BW	43.40	44.00	42.50	44.10	43.60	44.20	43.30	42.70
Courses per 3cm TD	49.10	48.70	47.60	48.30	49.00	48.90	48.90	49.30
Courses per 3cm AW	50.20	50.30	49.10	49.00	49.95	50.00	48.85	48.85
Wales per 3cm BW	27.00	26.80	27.90	27.20	26.00	26.92	27.20	26.60
Wales per 3cm TD	31.60	31.40	31.20	31.90	30.90	30.00	30.20	30.20
Wales per 3cm AW	30.00	30.30	30.60	31.40	29.85	29.00	30.15	29.74
Stitch length (mm) BW	3.08	3.04	3.10	3.04	3.08	3.08	3.11	3.12
Stitch length (mm) AW	3.05	3.03	3.10	3.01	3.06	3.07	3.09	3.10
Burst strength, BW	693.20	687.00	686.20	731.90	707.00	686.30	679.00	688.10
Burst strength, AW	661.00	720.40	689.20	727.70	686.30	690.90	664.70	643.50
Distension at burst, BW	19.10	18.55	19.17	19.18	19.51	19.12	19.57	19.34
Distension at burst, AW	21.32	20.84	21.09	21.78	21.33	20.81	21.44	20.87
Angle of spirality, BW	-3.06	2.33	2.58	-0.31	1.42	-1.75	0.08	-2.86
Angle of spirality, AW	0.26	2.33	1.32	2.50	-1.57	0.00	1.40	-0.13
Width, BW	33.85	37.35	36.02	38.93	43.67	44.73	49.43	49.57
Yarn strength, BW	331.12	373.75	349.13	330.92	326.68	320.76	334.93	317.60
Yarn strength, AW	340.64	377.78	380.55	383.65	387.35	402.39	385.59	380.69
Yarn extension at break, BW	7.24	7.42	7.31	6.58	6.68	6.46	7.03	6.82
Yarn extension at break, AW	7.05	6.82	6.81	7.21	7.54	7.56	7.55	7.20
Yarn count (tex), BW	24.15	23.98	23.65	24.17	24.51	23.95	24.03	24.02
Yarn count (tex), AW	24.02	23.81	23.49	24.25	24.36	23.86	24.10	23.89
Thickness, BW	024.50	021.30	059.60	029.30	054.00	043.10	037.70	027.30
Thickness, AW	1100.00	1090.40	1100.40	1092.30	1102.10	1093.70	1097.90	1089.10
Colour - R value	87.78	87.00	87.46	85.95	87.52	87.49	86.80	85.60
Colour - G value	89.23	88.50	88.75	87.12	88.92	88.99	88.16	86.87
Colour - B value	100.75	99.59	99.90	97.06	100.18	100.22	98.77	96.91

DATA CHECKS

Calc/Obs Wt BW	1.02	1.04	1.00	1.01	1.03	1.03	1.04	1.04
Calc/Obs Wt AW	1.02	1.03	1.02	1.05	1.04	1.02	1.04	1.03
Calc/Obs Courses/3cm AW	1.00	1.01	1.00	1.02	1.00	1.01	1.02	1.01
Calc/Obs Wales/3cm AW	1.03	1.05	1.02	1.02	1.02	1.03	1.04	1.02

Project Name - 14g, winch bleached

WINCH BLEACHED 14G

	D1285	P4976	D1532	P4903	D2535	D2226	P4899	D1298
Length shrinkage, TD \	8.62	8.34	8.20	11.79	8.72	8.40	9.20	10.15
Width shrinkage, TD \	11.95	15.65	15.48	11.13	8.84	12.12	12.83	10.40
Length shrinkage, Sx	11.20	10.23	9.84	13.87	11.05	10.37	10.94	11.06
Width shrinkage, Sx	11.31	15.10	15.28	10.13	7.41	11.52	12.81	10.13
Weight (gsm)BW	187.90	182.12	186.12	171.60	196.00	194.32	177.70	180.12
Weight (gsm)AW	236.75	242.05	241.31	219.98	238.96	239.01	226.77	235.18
Courses per 3cm BW	43.30	46.00	44.20	38.40	42.00	44.10	43.25	42.05
Courses per 3cm TD	49.00	51.50	48.70	43.10	47.00	48.18	46.70	46.60
Courses per 3cm AW	48.00	52.00	49.20	44.60	48.60	48.50	47.90	46.70
Wales per 3cm BW	27.40	27.40	26.50	27.00	28.00	27.00	27.15	27.45
Wales per 3cm TD	31.40	32.60	31.50	31.10	31.40	31.50	31.20	30.50
Wales per 3cm AW	31.20	32.70	31.70	30.50	31.30	30.70	30.90	29.70
Stitch length (mm) BW	3.06	2.94	3.05	3.26	3.08	3.06	3.09	3.14
Stitch length (mm) AW	3.04	2.92	3.03	3.23	3.07	3.03	3.08	3.13
Burst strength, BW	862.90	860.30	831.40	825.70	820.00	851.00	846.50	831.70
Burst strength, AW	816.30	852.70	803.10	777.00	778.50	809.20	797.80	804.30
Distension at burst, BW	19.14	18.55	18.32	18.84	19.44	20.28	19.56	20.39
Distension at burst, AW	22.44	21.35	20.82	21.33	21.92	21.57	20.81	22.05
Angle of spirality, BW	-2.41	1.09	-2.68	-2.09	-4.43	-3.61	-4.32	-1.32
Angle of spirality, AW	0.01	-0.80	-0.83	-0.70	-1.49	-0.22	-1.00	-0.24
Width, BW	37.27	44.07	36.27	30.90	45.63	52.17	34.40	37.97
Yarn strength, BW	415.71	381.99	416.89	375.13	387.43	385.96	357.03	384.36
Yarn strength, AW	450.45	434.75	428.41	453.59	447.44	427.24	442.61	482.19
Yarn extension at break, BW	7.21	6.91	7.35	7.41	6.71	7.04	7.15	5.79
Yarn extension at break, AW	7.44	7.00	6.72	7.05	6.79	6.57	6.57	6.45
Yarn count (tex), BW	24.06	23.35	24.19	23.26	24.17	23.87	23.76	24.50
Yarn count (tex), AW	24.02	23.01	24.06	23.39	24.03	24.25	23.33	24.30
Thickness, BW	836.00	820.00	813.70	819.00	873.40	847.20	831.00	857.00
Thickness, AW	1039.10	1048.60	1056.00	1050.60	1096.10	1061.30	1059.20	1080.20
Colour - R value	76.55	75.12	75.68	74.72	77.65	78.86	75.59	77.96
Colour - G value	77.56	76.27	76.57	75.81	78.85	80.10	76.66	79.20
Colour - B value	87.86	86.59	86.81	85.88	89.87	91.12	86.48	90.25

DATA CHECKS

Calc/Obs Wt BW	1.03	1.06	1.03	1.02	1.01	1.03	1.00	1.05
Calc/Obs Wt AW	1.04	1.05	1.05	1.04	1.04	1.02	1.04	1.00
Calc/Obs Courses/3cm AW	1.00	0.99	1.00	1.00	0.99	1.01	1.01	1.02
Calc/Obs Wales/3cm AW	0.99	0.99	0.99	0.99	0.97	1.02	1.01	1.03

JBS : CASE STUDY

TABLE C

1x1 RIB : 14 GAUGE : NOMINAL YARN Ne 1/24 (24.6 Tex)
 GREY Fabric controls for WINCH BLEACH

MEASURED Vs CALCULATED WEIGHT gsm

Sample Ref.No.	Wt BW Calc	Wt BW Meas	Diff c-m	%Diff c-m/m	Wt AW Calc	Wt AW Meas	Diff c-m	%Diff c-m/m
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Greek yarn

D6052	182.04	174.84	-7.2	-4.12	270.48	258.54	-11.94	-4.62
D2396	184.83	187.07	2.24	1.2	260.29	256.01	-4.27	-1.67
C8106	186.12	181.35	-4.77	-2.63	264.04	259.02	-5.02	-1.94
D2417	184.76	186.86	2.1	1.12	265.62	255.05	-10.56	-4.14
C8138	195.19	193.49	-1.7	-0.88	273.82	263.74	-10.07	-3.82
D2453	184.17	192.2	8.03	4.18	264.24	253.18	-11.05	-4.37
D2350	185.73	178.48	-7.25	-4.06	268.01	256.37	-11.64	-4.54
D2342	181.62	179.31	-2.31	-1.29	260.47	250.94	-9.53	-3.8
mean	185.56	184.2	-1.36	-0.81	265.87	256.61	-9.26	-3.61
sd	4.21	6.74	5.27	2.87	4.71	3.91	2.96	1.16

Egyptian yarn

F4903	194.57	189.34	-5.23	-2.76	247.81	234.67	-13.14	-5.6
F4899	179.45	175.45	-3.99	-2.28	261.64	249.31	-12.33	-4.94
D1532	190.83	195.8	4.97	2.54	270.72	262.18	-8.54	-3.26
D1298	179.64	181.55	1.91	1.05	256.38	248.05	-8.34	-3.36
D1285	187.27	186.5	-0.76	-0.41	263.19	252.82	-10.37	-4.1
F4976	175.1	177.02	1.92	1.08	272.84	262.02	-10.82	-4.13
D2535	190.23	191.75	1.52	0.79	268.45	258.85	-9.6	-3.71
D2226	191.91	191.23	-0.69	-0.36	277.42	263.6	-13.83	-5.25
mean	186.13	186.08	-0.04	-0.04	264.81	253.94	-10.87	-4.29
sd	7.1	7.36	3.35	1.79	9.6	9.85	2.06	0.88
mean	185.84	185.14	-0.7	-0.43	265.34	255.27	-10.07	-3.95
sd	5.65	6.89	4.32	2.35	7.32	7.37	2.6	1.05

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JBS : CASE STUDY

1x1 RIB : 14 GAUGE : NOMINAL YARN Ne 1/24 (24.6 Tex)
 GREY Fabric controls for WINCH BLEACH Finish

MEASURED Vs CALCULATED SHRINKAGE

Sample Ref.No.	Calc LS%	Meas LS%	Diff c-m	Calc WS%	Meas WS%	Diff c-m
Greek yarn						
D6052	19.03	20.67	1.64	18.33	22.58	4.25
D2396	20.35	20.84	0.49	14.66	16.83	2.17
C8106	20.28	21.76	1.49	14.89	15.84	0.95
D2417	18.71	21.06	2.35	15.48	16.83	1.35
C8138	19.62	20.38	0.76	14.56	14.96	0.4
D2453	20.58	21.31	0.73	15.21	15.85	0.64
D2350	19.77	20.23	0.47	16.29	15.82	-0.47
D2342	19.37	20.5	1.13	15.41	15.97	0.56
mean	19.71	20.85	1.13	15.6	16.84	1.23
sd	0.66	0.51	0.66	1.23	2.4	1.44
Egyptian yarn						
P4903	20.43	20.14	-0.29	4.59	3.94	-0.65
P4899	16.58	16.96	0.38	19.16	18.17	-0.99
D1532	16.47	15.94	-0.53	16.88	16	-0.88
D1298	17.47	16.26	-1.21	18.3	18.04	-0.26
D1285	17.93	16.75	-1.18	16.4	15.62	-0.78
P4976	18.44	18.4	-0.03	22.09	21.43	-0.65
D2535	16.24	15.57	-0.67	17.36	16.56	-0.8
D2226	16.28	15.54	-0.74	18.15	17.71	-0.44
mean	17.48	16.95	-0.53	16.62	15.93	-0.68
sd	1.44	1.59	0.55	5.17	5.17	0.24
mean	18.6	18.9	0.3	16.11	16.38	0.27
sd	1.58	2.31	1.04	3.67	3.92	1.4

JBS : CASE STUDY

TABLE 8

1x1 RIB : 14 GAUGE : NOMINAL YARN Ne 1/24 (24.6 Tex)
 FINISHED Fabric WINCH BLEACH

MEASURED Vs CALCULATED WEIGHT gsm

Sample Ref.No.	Wt BW Calc	Wt BW Meas	Diff c-m	%Diff c-m/m	Wt AW Calc	Wt AW Meas	Diff c-m	%Diff c-m/m
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Greek yarn

D6052	193.6	190.18	-3.42	-1.8	251.8	247.12	-4.69	-2.46
D2396	191.2	183.7	-7.5	-4.00	244.08	237.17	-6.91	-3.76
C8106	193.05	193.34	0.28	0.15	243.21	238.24	-4.97	-2.57
D2417	195.67	193.35	-2.32	-1.2	253.83	240.89	-12.93	-6.69
C8138	196.14	190.12	-6.02	-3.17	247.32	238.2	-9.12	-4.8
D2453	195.2	189.74	-5.46	-2.88	242.41	237.25	-5.16	-2.72
D2350	195.91	188.01	-7.9	-4.2	243.55	234.75	-8.8	-4.68
D2342	189.22	182.22	-6.99	-3.84	238.69	232.68	-6.01	-3.3
mean	193.75	188.83	-4.92	-2.63	245.61	238.29	-7.32	-3.87
sd	2.5	4.06	2.86	1.55	5.06	4.33	2.83	1.45

Egyptian yarn

P4903	174.85	171.6	-3.25	-1.89	228.26	219.98	-8.28	-4.82
P4899	191.48	177.78	-13.7	-7.7	236.51	226.77	-9.74	-5.48
D1532	192.11	186.12	-5.99	-3.22	252.37	241.31	-10.99	-5.91
D1298	197.62	188.11	-9.51	-5.05	234.62	235.18	0.57	0.3
D1285	194.26	187.98	-6.28	-3.34	247.11	236.75	-10.36	-5.51
P4976	192.23	182.12	-10.12	-5.55	253.72	242.05	-11.67	-6.41
D2535	198.41	196	-2.42	-1.23	249.71	238.96	-10.75	-5.48
D2226	199.21	194.32	-4.89	-2.51	243.18	239.01	-4.17	-2.15
mean	192.52	185.5	-7.02	-3.81	243.18	235	-8.17	-4.43
sd	7.76	8.16	3.82	2.15	9.2	7.72	4.25	2.31
mean	193.14	187.17	-5.97	-3.22	244.39	236.65	-7.75	-4.15
sd	5.61	6.46	3.43	1.91	7.28	6.28	3.51	1.88

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JBS : CASE STUDY

1x1 RIB : 14 GAUGE : NOMINAL YARN Ne 1/24 (24.6 Tex)
FINISHED Fabric WINCH BLEACH

MEASURED Vs CALCULATED SHRINKAGE

Sample Ref.No.	Calc LS%	Meas LS%	Diff c-m	Calc WS%	Meas WS%	Diff c-m
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Greek yarn

D6052	13.55	13.47	-0.08	12.34	14.7	2.36
D2396	12.52	13.77	1.25	11.55	15.64	4.08
C8106	13.44	13.62	0.18	8.82	10.41	1.59
D2417	11.45	13.41	1.96	13.38	15.2	1.83
C8138	12.71	12.31	-0.4	10.22	12.16	1.94
D2453	11.6	12.82	1.22	9.66	12.47	2.81
D2350	11.36	13.15	1.79	9.78	13.07	3.28
D2342	12.59	13.86	1.27	10.56	12.58	2.03
mean	12.4	13.3	0.9	10.79	13.28	2.49
sd	0.86	0.52	0.86	1.52	1.77	0.85

Egyptian yarn

F4903	13.9	13.87	-0.04	11.48	10.13	-1.35
F4899	9.71	10.94	1.23	12.14	12.81	0.68
D1532	10.16	9.84	-0.32	16.4	15.28	-1.13
D1298	9.96	11.86	1.91	7.58	10.13	2.55
D1285	11.27	11.2	-0.07	12.18	11.31	-0.87
F4976	11.54	10.23	-1.31	16.21	15.1	-1.11
D2535	11.93	11.05	-0.89	10.54	7.41	-3.13
D2226	9.07	10.37	1.3	9.45	11.52	2.07
mean	10.94	11.17	0.23	12	11.71	-0.28
sd	1.55	1.26	1.14	3.06	2.65	1.91
mean	11.67	12.24	0.56	11.39	12.49	1.1
sd	1.43	1.44	1.04	2.42	2.32	2.02

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JBS : CASE STUDY

1x1 RIB : 14 GAUGE : FOR WINCH BLEACH FINISH

IIC TEST DATA : YARN TAKEN FROM GREY FABRIC AS RECEIVED

Sample Reference	Tex	%Ext	SES	Tpm	aTex	TFe
Greek Yarn						
D6052	24.78	7.55	343.04	810	40.32	4.21
D2396	24.76	7.16	325.01	783.5	38.99	4.08
C8106	24.91	7.67	326.45	782	39.03	4.08
D2417	24.66	7.76	354.99	777.5	38.61	4.04
C8138	25.24	7.79	345.51	807.5	40.57	4.24
D2453	24.5	8.17	345.45	775.5	38.38	4.01
D2350	24.69	7.83	339.04	767.5	38.14	3.99
D2342	24.48	7.79	340.77	782.5	38.71	4.05
mean	24.75	7.71	340.03	785.75	39.09	4.09
sd	0.24	0.28	10.03	15.1	0.89	0.09

Egyptian Yarn

P4903	24.38	6.75	379.98	726.5	35.87	3.75
P4899	24.59	7.23	398.67	711	35.26	3.69
D1532	24.73	6.48	402.18	744	37	3.87
D1298	24.6	6.73	420.65	727	36.05	3.77
D1285	24.4	7.07	414.27	733.5	36.23	3.79
P4976	24.1	6.88	420.35	704.5	34.58	3.61
D2535	24.91	7.01	420.12	730	36.43	3.81
D2226	25.21	7.38	455.51	713	35.8	3.74
mean	24.61	6.94	413.96	723.69	35.9	3.75
sd	0.34	0.29	21.96	13.15	0.74	0.08

1) aTex = alpha Tex Twist Factor ($Tpm/100*\sqrt{Tex}$)2) TFe = English Twist Factor ($aTex/9.5673$)

*** COLUMN STATISTICS ***

		N	Mean	SD	CV%
1.	Tex	16	24.6836	0.2963	1.20
2.	%Ext	16	7.3273	0.4854	6.63
3.	SES	16	376.9989	41.5884	11.03
4.	Tpm	16	754.7188	34.8473	4.62
5.	aTex	16	37.4992	1.8256	4.87
6.	TFe	16	3.9195	0.1908	4.87

JBS : CASE STUDY

TABLE 11

14 GAUGE 1x1 RIB : NOMINAL YARN No 1/24 (24.6 TEX)

Grey Fabric As Received : Greek yarn

Sample Reference	Tex	SLcm	C/cm	C*SL	W/cm	W*SL	Mt gsm	Mt*SL Tex
D6852	24.78	0.311	13.97	4.35	0.45	2.63	174.04	2.19
D2394	24.76	0.309	13.83	4.27	0.73	2.7	187.07	2.33
C8186	24.91	0.316	13.5	4.26	0.77	2.77	181.35	2.3
D2417	24.66	0.309	13.9	4.29	0.73	2.7	186.86	2.34
C8138	25.24	0.315	13.93	4.39	0.8	2.78	193.49	2.42
D2453	24.5	0.316	13.63	4.3	0.73	2.76	192.2	2.48
D2358	24.69	0.318	13.67	4.35	0.65	2.75	178.48	2.3
D2342	24.48	0.317	13.6	4.31	0.6	2.73	179.31	2.32

*** COLUMN STATISTICS ***

		N	Mean	SD	CVI
1.	Tex	8	24.7527	0.2446	0.99
2.	SLcm	8	0.3138	0.0037	1.19
3.	C/cm	8	13.7542	0.1754	1.28
4.	C*SL	8	4.3161	0.0442	1.02
5.	W/cm	8	0.6837	0.1128	1.38
6.	W*SL	8	2.7252	0.0488	1.79
7.	Mt gsm	8	184.1988	6.7394	3.66
8.	Mt*SL Tex	8	2.3353	0.0841	3.68

JBS : CASE STUDY

TABLE 12

14 GAUGE 1x1 RIB : NOMINAL YARN No 1/24 (24.6 TEX)

Grey Fabric As Received : Egyptian yarn

Sample Reference	Tex	SLcm	C/cm	C*SL	W/cm	W*SL	Mt gsm	Mt*SL Tex
P4983	24.38	0.33	12.47	4.11	9.7	3.2	189.34	2.56
P4899	24.59	0.311	14	4.36	8.37	2.61	175.45	2.22
D1532	24.73	0.309	14.37	4.43	8.7	2.69	195.8	2.44
D1298	24.6	0.32	13.7	4.38	8.33	2.67	181.55	2.36
D1285	24.4	0.31	14.03	4.34	8.83	2.73	186.5	2.37
P4976	24.1	0.294	14.6	4.29	8.47	2.49	177.82	2.16
D2535	24.91	0.312	14.27	4.46	8.57	2.68	191.75	2.41
D2226	25.21	0.309	14.4	4.44	8.57	2.64	191.23	2.34

*** COLUMN STATISTICS ***

		N	Mean	SD	CVI
1.	Tex	8	24.6145	0.3426	1.39
2.	SLcm	8	0.3118	0.0183	3.38
3.	C/cm	8	13.9792	0.6723	4.81
4.	C*SL	8	4.3534	0.1119	2.57
5.	W/cm	8	8.6917	0.4396	5.06
6.	W*SL	8	2.7126	0.2183	7.75
7.	Mt gsm	8	186.8888	7.3632	3.96
8.	Mt*SL Tex	8	2.3576	0.1254	5.32

JBS : CASE STUDY

TABLE 13

14 GAUGE 1x1 RIB : NOMINAL YARN No 1/24 (24.6 TEX)

Grey Fabric Reference State : Greek yarn

Sample Reference								Mt*SL		
	Tex	SLcm	C/cm	C*SL	W/cm	W*SL	Mt gsm	Tex	LSX	WSX
D6052	24.66	0.307	17.25	5.3	10.35	3.18	258.54	3.22	20.67	22.58
D2396	24.16	0.303	17.37	5.26	10.23	3.1	256.01	3.21	20.84	16.83
C8106	24.44	0.31	16.93	5.25	10.3	3.19	259.02	3.28	21.76	15.04
D2417	24.84	0.303	17.1	5.17	10.33	3.13	255.05	3.11	21.06	16.83
C8138	25.01	0.307	17.33	5.31	10.3	3.16	263.74	3.23	20.30	14.96
D2453	24.13	0.31	17.17	5.31	10.3	3.19	253.18	3.25	21.31	15.85
D2350	24.46	0.311	17.03	5.3	10.33	3.22	256.37	3.26	20.23	15.02
D2342	24.27	0.313	16.87	5.28	10.17	3.18	250.94	3.24	20.5	15.97

*** COLUMN STATISTICS ***

		N	Mean	SD	CV%
1.	Tex	8	24.4965	0.3189	1.30
2.	SLcm	8	0.3079	0.0037	1.20
3.	C/cm	8	17.1313	0.1818	1.06
4.	C*SL	8	5.2739	0.0470	0.89
5.	W/cm	8	10.2896	0.0610	0.59
6.	W*SL	8	3.1679	0.0371	1.17
7.	Mt gsm	8	256.6086	3.9126	1.52
8.	Mt*SL Tex	8	3.2252	0.0527	1.63
9.	LSX	8	20.8455	0.5137	2.46
10.	WSX	8	16.0353	2.3965	14.24

JBS : CASE STUDY

14 GAUGE 1x1 RIB : NOMINAL YARN No 1/24 (24.6 TEX)

Grey Fabric Reference State : Egyptian yarn

Sample Reference								Mt*SL		
	Tex	SLcm	C/cm	C*SL	W/cm	W*SL	Mt gsm	Tex	LSX	WSX
P4903	23.94	0.325	15.67	5.09	10.17	3.3	234.67	3.18	20.14	3.94
P4899	24.25	0.311	16.78	5.21	10.35	3.21	249.31	3.19	16.96	18.17
D1532	24.68	0.305	17.2	5.24	10.47	3.19	262.18	3.24	15.94	16
D1298	23.92	0.317	16.6	5.25	10.2	3.23	248.05	3.28	16.26	18.04
D1285	23.85	0.305	17.1	5.22	10.57	3.23	252.02	3.24	16.75	15.62
P4976	23.84	0.294	17.9	5.27	10.07	3.2	262.02	3.23	18.4	21.43
D2535	24.51	0.31	17.03	5.28	10.37	3.22	258.05	3.28	15.57	16.56
D2226	25.21	0.306	17.2	5.26	10.47	3.2	263.6	3.2	15.54	17.71

*** COLUMN STATISTICS ***

		N	Mean	SD	CV%
1.	Tex	8	24.2755	0.4920	2.03
2.	SLcm	8	0.3090	0.0091	2.94
3.	C/cm	8	16.9354	0.6384	3.77
4.	C*SL	8	5.2280	0.0604	1.15
5.	W/cm	8	10.4313	0.2219	2.13
6.	W*SL	8	3.2215	0.0359	1.11
7.	Mt gsm	8	253.9384	9.0521	3.88
8.	Mt*SL Tex	8	3.2297	0.0371	1.15
9.	LSX	8	16.9460	1.5907	9.39
10.	WSX	8	15.9348	5.1728	32.46

TABLE 14

JBS : CASE STUDY

14 GAUGE 1x1 RIB : NOMINAL YARN Ne 1/24 (24.6 TEX)

Finished Fabric WINCH BLEACH As Received : Greek yarn

TABLE 15

Sample Reference	Tex	SLcm	C/cm	C*SL	W/cm	W*SL	Wt gsm	Wt*SL Tex
D6052	24.15	0.308	14.47	4.45	9	2.77	190.18	2.42
D2396	23.98	0.304	14.67	4.46	8.93	2.72	183.7	2.33
C8106	23.65	0.31	14.17	4.39	9.3	2.88	193.34	2.53
D2417	24.17	0.304	14.7	4.46	9.07	2.75	193.35	2.43
C8138	24.51	0.308	14.53	4.48	8.93	2.75	190.12	2.39
D2453	23.95	0.308	14.73	4.54	8.97	2.77	189.74	2.44
D2350	24.03	0.311	14.43	4.5	9.07	2.82	188.01	2.44
D2342	24.02	0.312	14.23	4.44	8.87	2.77	182.22	2.37

*** COLUMN STATISTICS ***

		N	Mean	SD	CV%
1.	Tex	8	24.0578	0.2438	1.01
2.	SLcm	8	0.3082	0.0038	0.98
3.	C/cm	8	14.4917	0.2106	1.45
4.	C*SL	8	4.4668	0.0448	0.99
5.	W/cm	8	9.0175	0.1338	1.47
6.	W*SL	8	2.7792	0.0585	1.82
7.	Wt gsm	8	188.8319	4.8645	2.15
8.	Wt*SL Tex	8	2.4193	0.0688	2.48

JBS : CASE STUDY

14 GAUGE 1x1 RIB : NOMINAL YARN Ne 1/24 (24.6 TEX)

Finished Fabric WINCH BLEACH As Received : Egyptian yarn

TABLE 16

Sample Reference	Tex	SLcm	C/cm	C*SL	W/cm	W*SL	Wt gsm	Wt*SL Tex
P4903	23.26	0.326	12.8	4.18	9	2.94	171.6	2.41
P4899	23.76	0.309	14.42	4.45	9.05	2.79	177.78	2.31
D1532	24.19	0.305	14.73	4.49	8.83	2.69	186.12	2.35
D1298	24.5	0.314	14.82	4.41	9.15	2.88	188.11	2.41
D1285	24.06	0.306	14.43	4.42	9.13	2.8	187.98	2.39
P4976	23.35	0.294	15.33	4.51	9.13	2.68	182.12	2.29
D2535	24.17	0.308	14.27	4.4	9.33	2.88	196	2.5
D2226	23.87	0.306	14.7	4.5	9.27	2.84	194.32	2.49

*** COLUMN STATISTICS ***

		N	Mean	SD	CV%
1.	Tex	8	23.8956	0.4271	1.79
2.	SLcm	8	0.3087	0.0092	2.97
3.	C/cm	8	14.3375	0.7336	5.12
4.	C*SL	8	4.4198	0.1874	2.43
5.	W/cm	8	9.1125	0.1555	1.71
6.	W*SL	8	2.8126	0.0898	3.17
7.	Wt gsm	8	185.5838	8.1552	4.40
8.	Wt*SL Tex	8	2.3947	0.0772	3.22

JBS : CASE STUDY

TABLE 17

14 GAUGE 1x1 RIB : NOMINAL YARN No 1/24 (24.6 TEX)

Finished Fabric MINCH BLEACH Reference State : Greek yarn

Sample Reference	Tex	SLcm	C/cm	C*SL	W/cm	W*SL	Mt gsm	Wt*SL		
								Tex	LSZ	WSZ
D6052	24.02	0.305	16.73	5.11	10.27	3.13	247.12	3.14	13.47	14.7
D2396	23.01	0.303	16.77	5.00	10.1	3.06	237.17	3.02	13.77	15.64
C8106	23.49	0.31	16.37	5.00	10.2	3.16	238.24	3.15	13.62	10.41
D2417	24.25	0.301	16.6	5	10.47	3.15	240.89	2.99	13.41	15.2
C8138	24.36	0.306	16.65	5.1	9.95	3.05	238.2	3	12.31	12.16
D2453	23.06	0.307	16.67	5.11	9.93	3.05	237.25	3.05	12.02	12.47
D2350	24.1	0.309	16.28	5.03	10.05	3.1	234.75	3.01	13.15	13.07
D2342	23.89	0.31	16.28	5.04	9.91	3.07	232.68	3.02	13.06	12.50

*** COLUMN STATISTICS ***

		N	Mean	SD	CVZ
1.	Tex	8	23.9711	0.2755	1.15
2.	SLcm	8	0.3063	0.0032	1.04
3.	C/cm	8	16.5438	0.2000	1.21
4.	C*SL	8	5.0676	0.0410	0.81
5.	W/cm	8	10.1100	0.1924	1.90
6.	W*SL	8	3.0968	0.0478	1.54
7.	Mt gsm	8	238.2884	4.3267	1.82
8.	Wt*SL Tex	8	3.0454	0.0627	2.06
9.	LSZ	8	13.3008	0.5215	3.92
10.	WSZ	8	13.2790	1.7699	13.33

JBS : CASE STUDY

TABLE 18

14 GAUGE 1x1 RIB : NOMINAL YARN No 1/24 (24.6 TEX)

Finished Fabric MINCH BLEACH Reference State : Egyptian yarn

Sample Reference	Tex	SLcm	C/cm	C*SL	W/cm	W*SL	Mt gsm	Wt*SL		
								Tex	LSZ	WSZ
P4903	23.39	0.323	14.07	4.8	10.17	3.20	219.98	3.04	13.07	10.13
P4899	23.33	0.308	15.97	4.92	10.3	3.17	226.77	3	10.94	12.81
D1532	24.06	0.303	16.4	4.96	10.57	3.2	241.31	3.03	9.84	15.28
D1298	24.3	0.313	15.57	4.88	9.9	3.1	235.18	3.03	11.06	10.13
D1285	24.02	0.304	16.27	4.95	10.4	3.16	236.75	3	11.2	11.31
P4976	23.01	0.292	17.33	5.06	10.9	3.18	242.05	3.07	10.23	15.1
D2535	24.03	0.307	16.2	4.98	10.43	3.21	238.96	3.06	11.05	7.41
D2226	24.25	0.303	16.17	4.9	10.23	3.1	239.01	2.99	10.37	11.52

*** COLUMN STATISTICS ***

		N	Mean	SD	CVZ
1.	Tex	8	23.7997	0.4830	2.03
2.	SLcm	8	0.3066	0.0090	2.93
3.	C/cm	8	16.0958	0.7047	4.38
4.	C*SL	8	4.9301	0.0763	1.55
5.	W/cm	8	10.3625	0.2952	2.85
6.	W*SL	8	3.1757	0.0506	1.85
7.	Mt gsm	8	235.0023	7.7238	3.29
8.	Wt*SL Tex	8	3.0259	0.0295	0.97
9.	LSZ	8	11.1703	1.2594	11.27
10.	WSZ	8	11.7110	2.6492	22.62

JBS : CASE STUDY : 1x1 RIB 14 GAUGE

TABLE 19

Nominal Yarn Ne 1/24 (24.6 Tex)

Averages

	Greek			Egyptian			All		
	\bar{x}	s.d.	ICV	\bar{x}	s.d.	ICV	\bar{x}	s.d.	ICV
Grey fabric as received									
Tex	24.75	0.24	0.99	24.61	0.34	1.39	24.68	0.3	1.2
S.L.cm	0.314	0.004	1.19	0.312	0.01	3.3	0.313	0.008	2.41
C/cm	13.75	0.18	1.28	13.98	0.67	4.81	13.87	0.49	3.52
W/cm	0.68	0.11	1.3	0.69	0.44	5.06	0.69	0.31	3.57
Mtqsm	184.2	6.74	3.66	186.1	7.36	3.96	185.1	6.89	3.72
Grey fabric Reference State									
Tex	24.5	0.32	1.3	24.28	0.49	2.83	24.39	0.42	1.71
S.L.cm	0.308	0.004	1.2	0.309	0.009	2.94	0.308	0.007	2.18
C/cm	17.13	0.18	1.06	16.94	0.64	3.77	17.03	0.46	2.73
C+SL	5.27	0.05	0.89	5.23	0.06	1.15	n.a.	n.a.	n.a.
W/cm	10.29	0.06	0.59	10.43	0.22	2.13	10.36	0.17	1.67
W*SL	3.17	0.04	1.17	3.22	0.04	1.11	n.a.	n.a.	n.a.
Mtqsm	256.6	3.91	1.52	253.9	9.85	3.88	255.3	7.37	2.89
Mt*SL/Tex	3.23	0.05	1.65	3.23	0.04	1.15	n.a.	n.a.	n.a.
LSX	20.85	0.51	2.46	16.95	1.59	9.39	18.9	2.32	12.25
MSX	16.84	2.4	14.24	15.93	5.17	32.46	16.39	3.92	23.94

JBS : CASE STUDY : 1x1 RIB 14 GAUGE

TABLE 20

Nominal Yarn Ne 1/24 (24.6 Tex)

Averages

	Greek			Egyptian			All		
	\bar{x}	s.d.	ICV	\bar{x}	s.d.	ICV	\bar{x}	s.d.	ICV
Finished fabric as received									
Tex	24.86	0.24	1.01	25.9	0.43	1.79	23.98	0.35	1.44
S.L.cm	0.308	0.003	0.98	0.309	0.009	2.97	0.308	0.007	2.14
C/cm	14.49	0.21	1.45	14.34	0.73	5.12	14.41	0.53	3.66
W/cm	9.02	0.13	1.47	9.11	0.16	1.71	9.07	0.15	1.63
Mtqsm	188.8	4.06	2.15	185.5	8.16	4.4	187.2	6.46	3.45
Finished fabric Reference State									
Tex	23.97	0.28	1.15	23.8	0.48	2.83	23.89	0.39	1.63
S.L.cm	0.306	0.003	1.04	0.307	0.009	2.95	0.307	0.007	2.15
C/cm	16.54	0.2	1.21	16.1	0.7	4.38	16.32	0.55	3.58
C+SL	5.07	0.04	0.81	4.93	0.08	1.55	n.a.	n.a.	n.a.
W/cm	10.11	0.19	1.9	10.36	0.3	2.85	10.24	0.27	2.67
W*SL	3.1	0.05	1.54	3.18	0.06	1.85	n.a.	n.a.	n.a.
Mtqsm	238.3	4.33	1.82	235	7.72	3.29	236.6	6.28	2.65
Mt*SL/Tex	3.05	0.06	2.86	3.03	0.03	0.97	n.a.	n.a.	n.a.
LSX	13.3	0.52	3.92	11.17	1.26	11.27	12.24	1.44	11.78
MSX	13.28	1.77	13.33	11.71	2.65	22.62	12.5	2.32	18.58

JBS : CASE STUDY : 1x1 RIB 14GAUGE

TABLE 21

STUDENTS T STATISTIC FOR 7 DEGREES OF FREEDOM (N=8)

95% = 2.365 *
 99% = 3.499 **
 99.9% = 5.408 ***

Greek yarn vs Egyptian yarn

	Mean Difference	t	r sq
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Grey fabric as received

Tex	-0.14	0.87	0.05
S.L.cm	-0.002	0.49	0.27

Grey fabric Reference State

Tex	-0.22	1	0.19
S.L.cm	1.0E-3	0.3	0.18
C/cm	-0.2	0.78	0.09
C*SL	-0.05	1.59	0.03
W/cm	0.14	1.63	0.06
W*SL	0.05	2.75 *	0.01
Wtgsa	-2.67	0.67	0.13
Wt*SL/Tex	1.0E-3	0.18	0.08
LSX	-3.9	6.17 ***	0.01
WSX	-0.9	0.42	0.77

JBS : CASE STUDY : 1x1 RIB 14GAUGE

TABLE 22

STUDENTS T STATISTIC FOR 7 DEGREES OF FREEDOM (N=8)

95% = 2.365 *
 99% = 3.499 **
 99.9% = 5.408 ***

Greek yarn vs Egyptian yarn

	Mean Difference	t	r sq
--	--------------------	---	------

Finished fabric as received

Tex	-0.16	0.87	0.002
S.L.cm	1.0E-3	0.13	0.07
C/cm	-0.15	0.53	0
W/cm	0.1	1.23	0.34
Wtgsa	-3.33	0.97	0.02

Finished fabric Reference State

Tex	-0.17	0.82	0.06
S.L.cm	3.0E-4	0.08	0.21
C/cm	-0.45	1.62	0.05
C*SL	-0.14	4.2 **	0.04
W/cm	0.25	1.9	0.42
W*SL	0.08	2.76 *	0.04
Wtgsa	-3.29	0.98	0.51
Wt*SL/Tex	-0.02	0.75	0.1
LSX	-2.13	4.14 **	0
WSX	-1.57	1.3	0.19

JBS : CASE STUDY

1x1 RIB : 14 GAUGE : NOMINAL YARN Ne 1/24 (24.6 Tex)

SHRINKAGE AFTER 1(W+T)CYCLE and 5(W+T)CYCLES

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-----
Sample      1*W+T  5*W+T      1*W+T  5*W+T
Reference   LSX    LSX    Diff   WSX    WSX    Diff
-----

```

Greek Yarn

D6052	10.72	13.47	2.75	15.36	14.7	-0.66
D2396	11.56	13.77	2.22	16.83	15.64	-1.19
C8106	11.32	13.62	2.3	13.2	10.41	-2.79
D2417	10.21	13.41	3.2	16.94	15.2	-1.74
C8138	9.96	12.31	2.35	13.41	12.16	-1.25
D2453	10.61	12.82	2.21	13.1	12.47	-0.63
D2350	10.49	13.15	2.66	13.92	13.07	-0.85
D2342	11.51	13.86	2.34	14.05	12.58	-1.47
mean	10.8	13.3	2.5	14.6	13.28	-1.32
sd	0.6	0.52	0.35	1.58	1.77	0.71

Egyptian Yarn

P4903	11.79	13.87	2.08	11.13	10.13	-1
P4899	9.2	10.94	1.74	12.83	12.81	-0.02
D1532	8.2	9.84	1.65	15.48	15.28	-0.2
D1298	10.15	11.86	1.71	10.4	10.13	-0.27
D1285	8.62	11.2	2.58	11.95	11.31	-0.64
P4976	8.34	10.23	1.89	15.65	15.1	-0.55
D2535	8.72	11.05	2.33	8.84	7.41	-1.43
D2226	8.4	10.37	1.97	12.12	11.52	-0.6
mean	9.18	11.17	1.99	12.3	11.71	-0.59
sd	1.23	1.26	0.32	2.35	2.65	0.46
mean	9.99	12.24	2.25	13.45	12.49	-0.96
sd	1.25	1.44	0.42	2.27	2.32	0.69

=====

JBS : 14G 1x1 RIB : GREY FABRIC AS RECEIVED

Nominal Yarn Ne 1/24 (24.6 Tex)

FIGURE 1

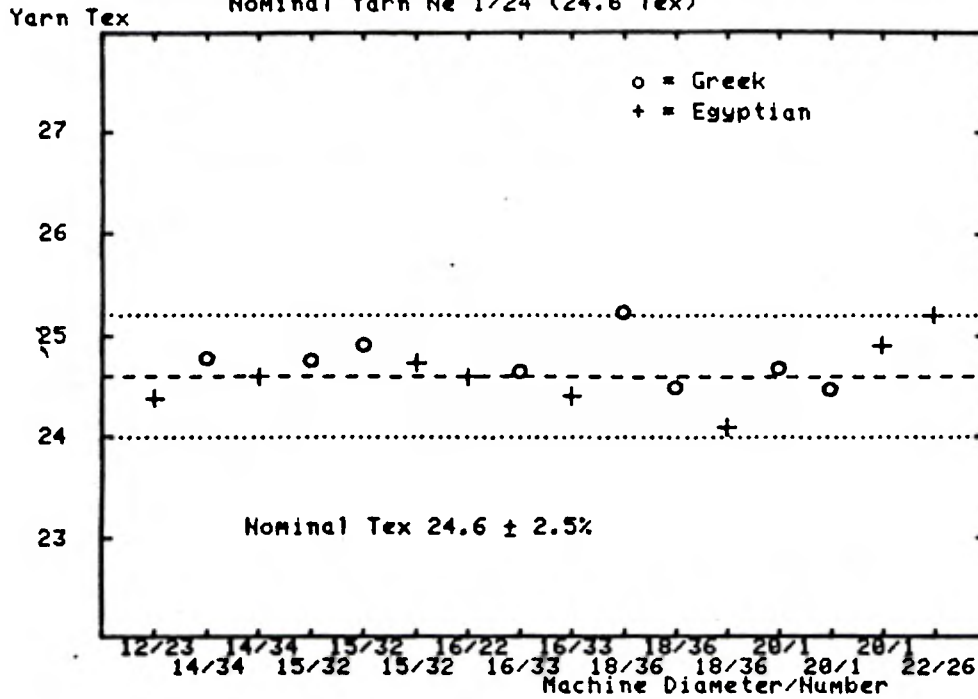
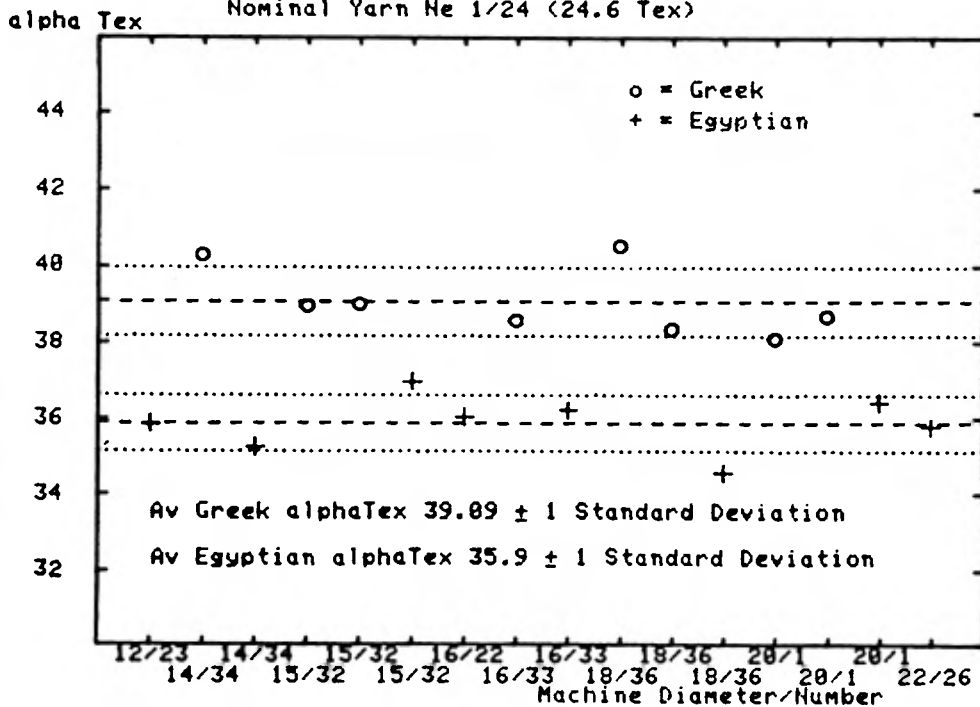


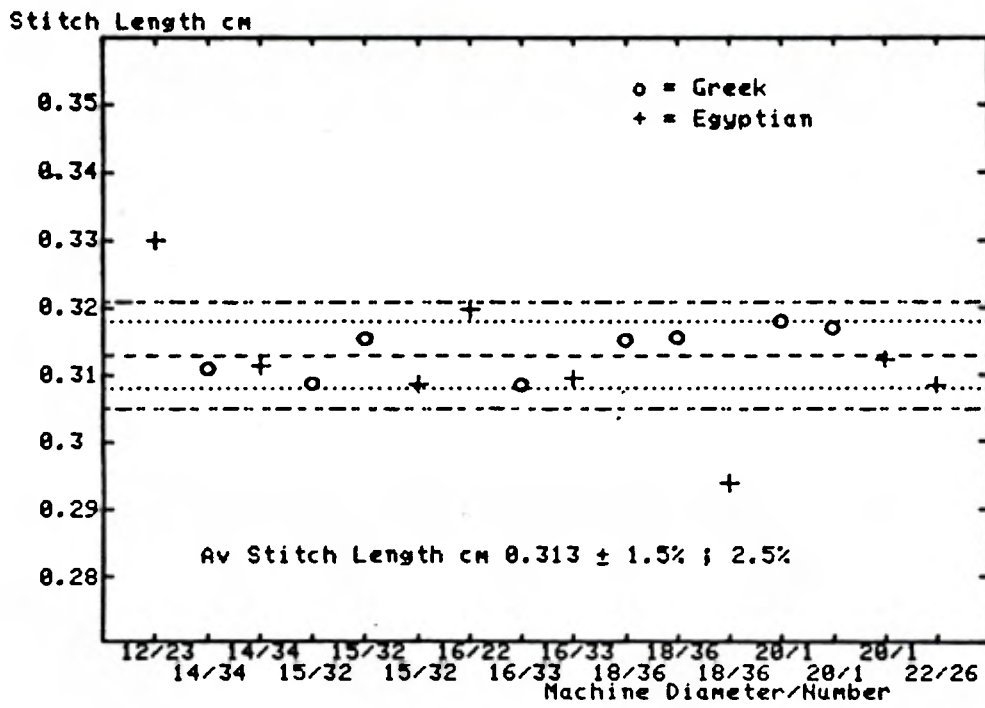
FIGURE 2

JBS : 14G 1x1 RIB : GREY FABRIC AS RECEIVED

Nominal Yarn Ne 1/24 (24.6 Tex)



JBS : 14G 1x1 RIB : GREY FABRIC AS RECEIVED



JBS : 14G 1x1 RIB : GREY FABRIC AS RECEIVED

FIGURE 4

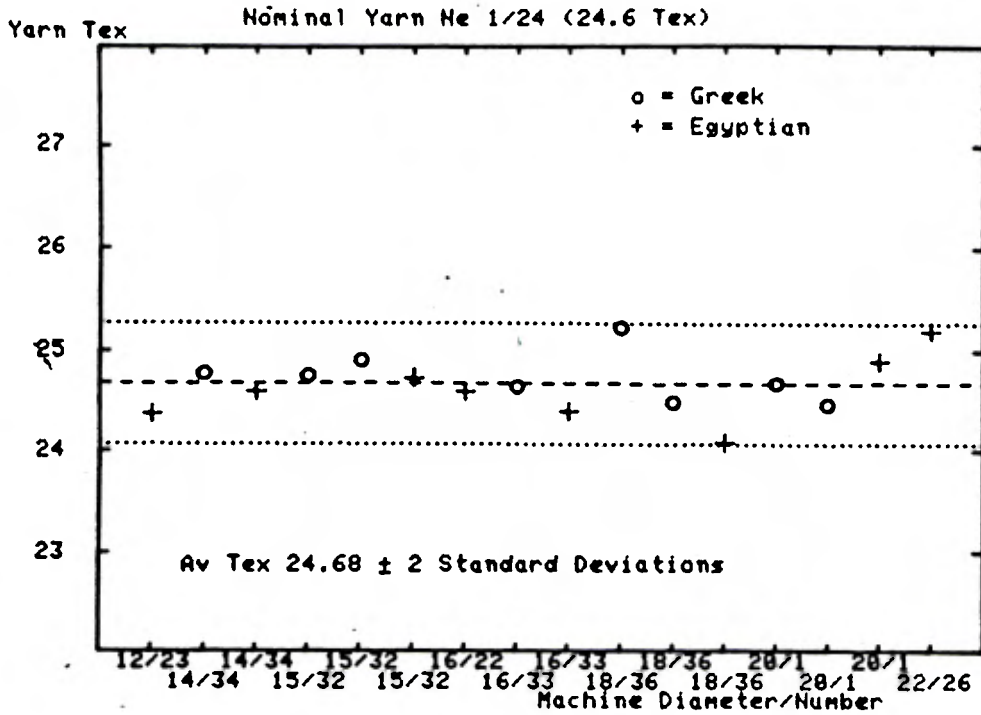
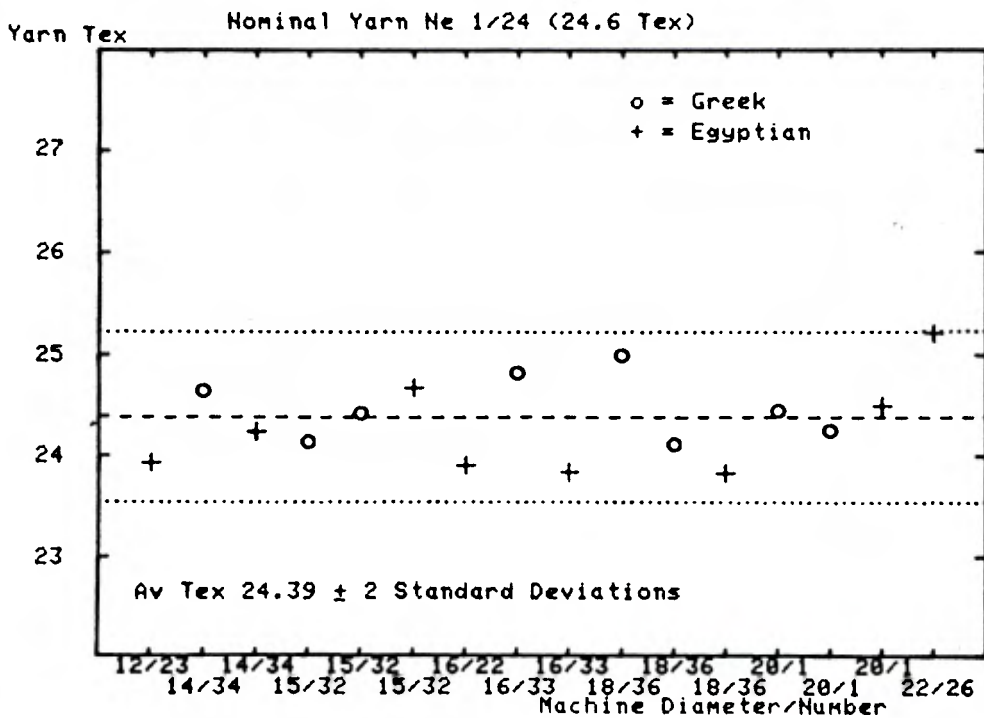


FIGURE 5

JBS : 14G 1x1 RIB : GREY FABRIC REFERENCE STATE



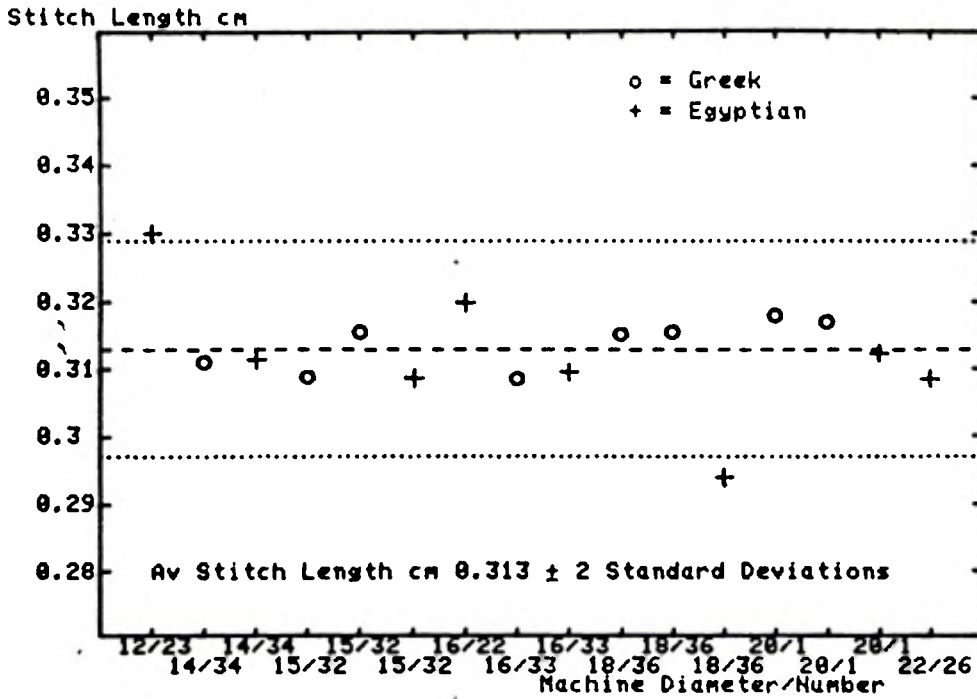
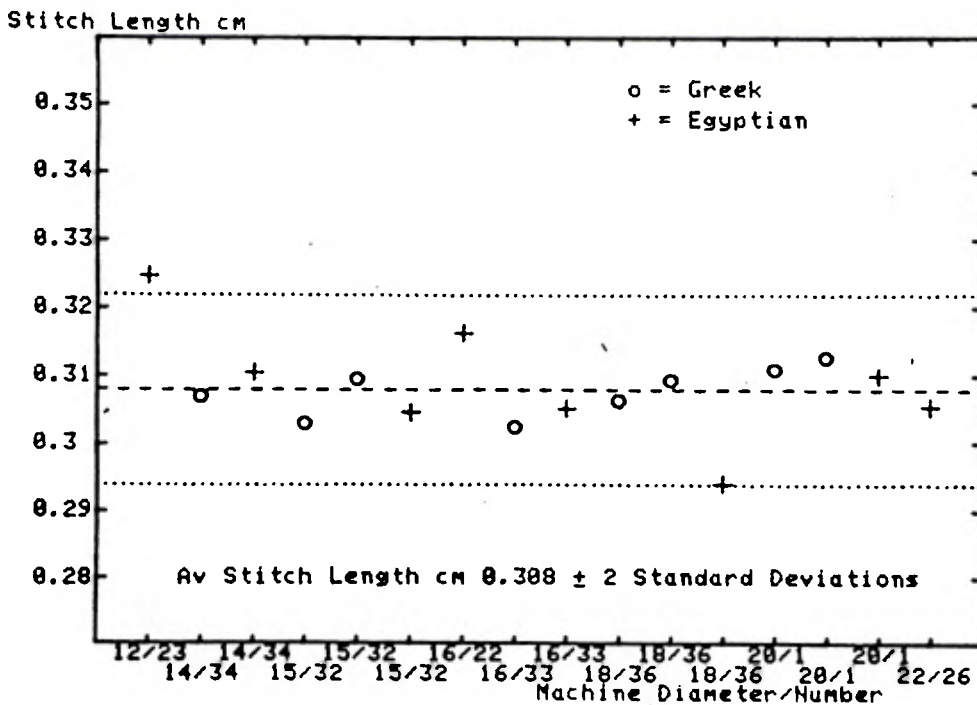
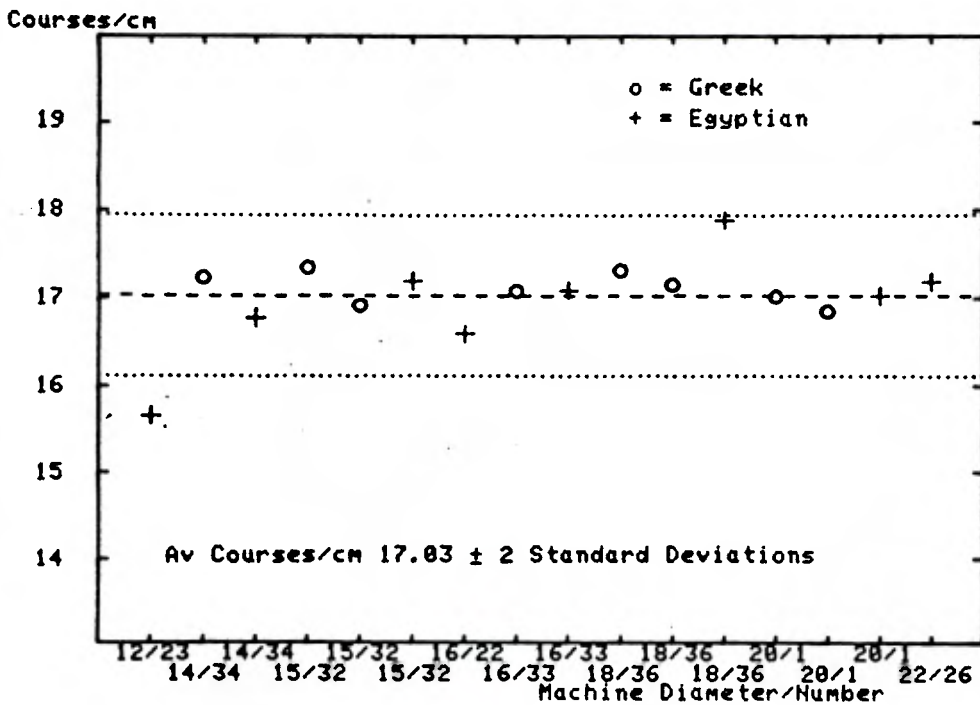
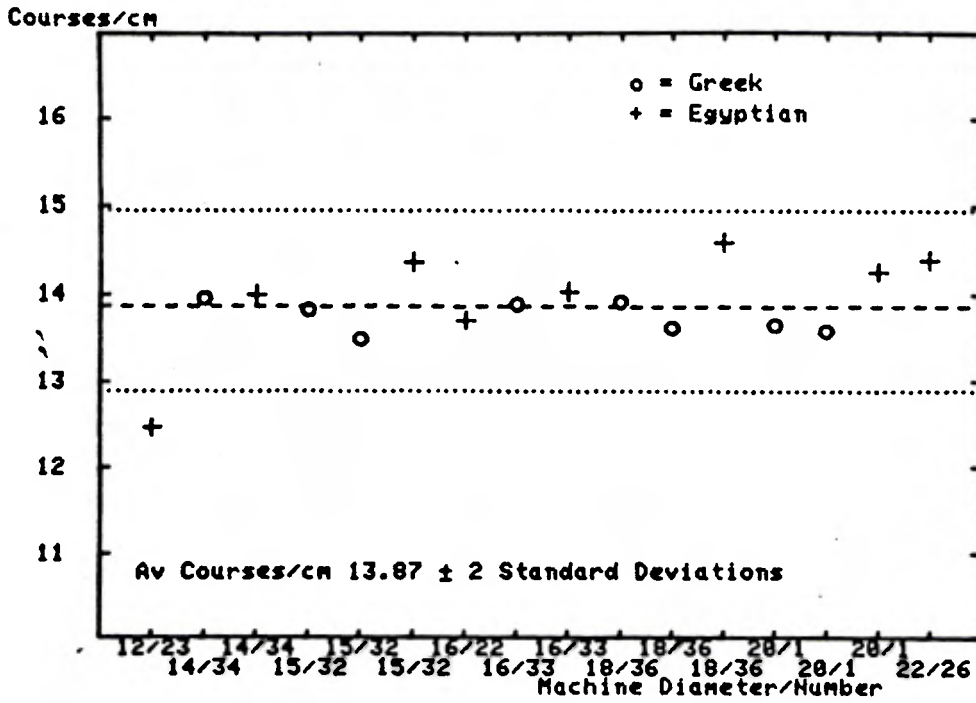


FIGURE 7





JBS : 14G 1x1 RIB : GREY FABRIC AS RECEIVED

FIGURE 10

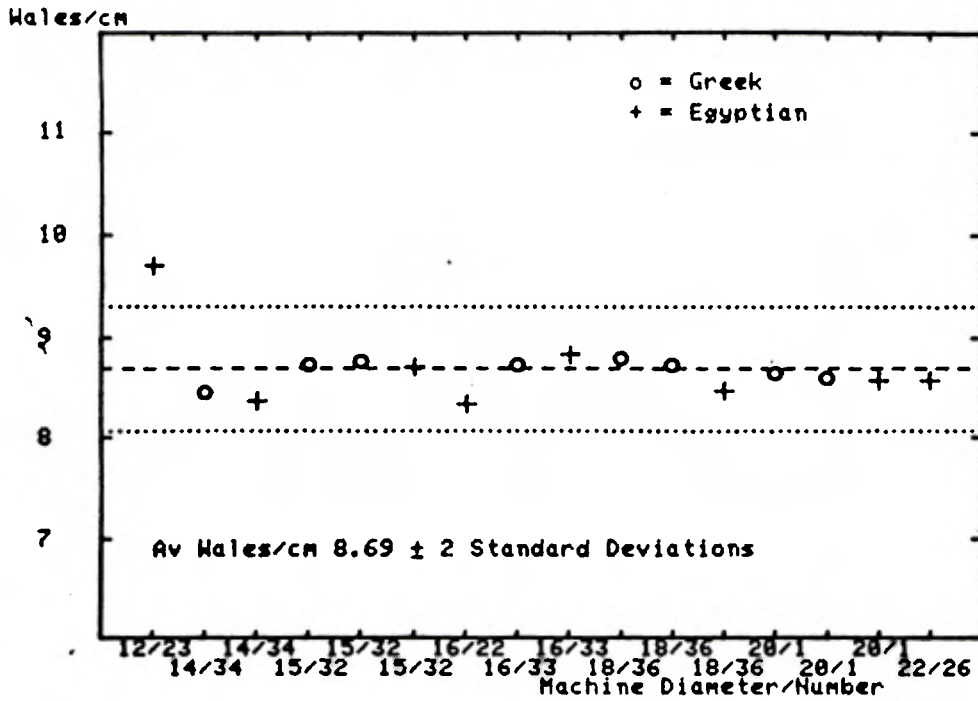
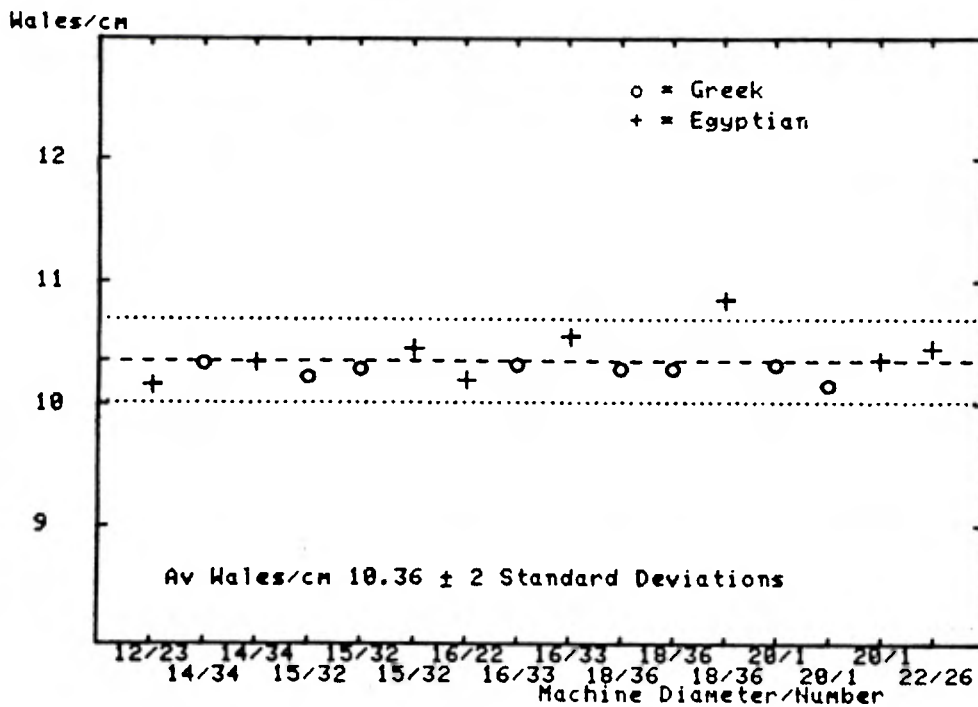


FIGURE 11

JBS : 14G 1x1 RIB : GREY FABRIC REFERENCE STATE



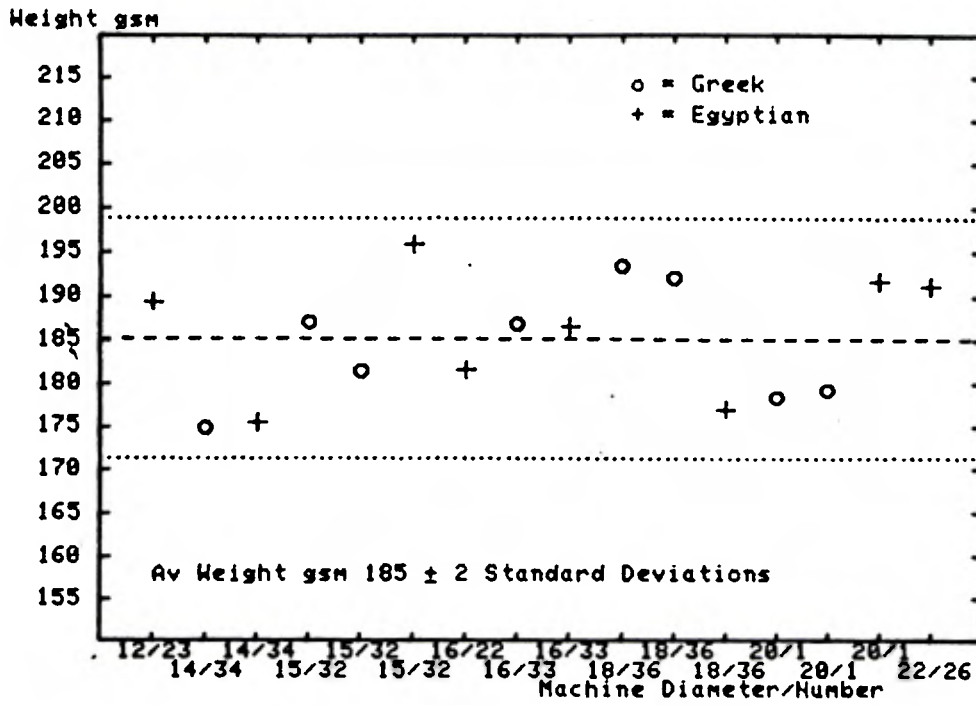
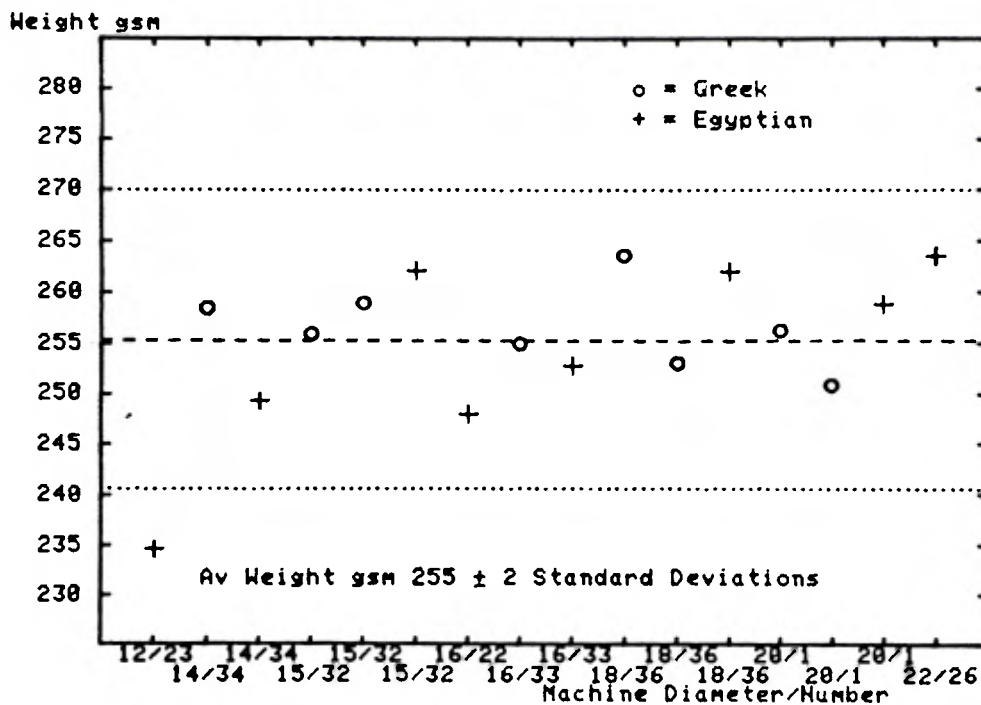
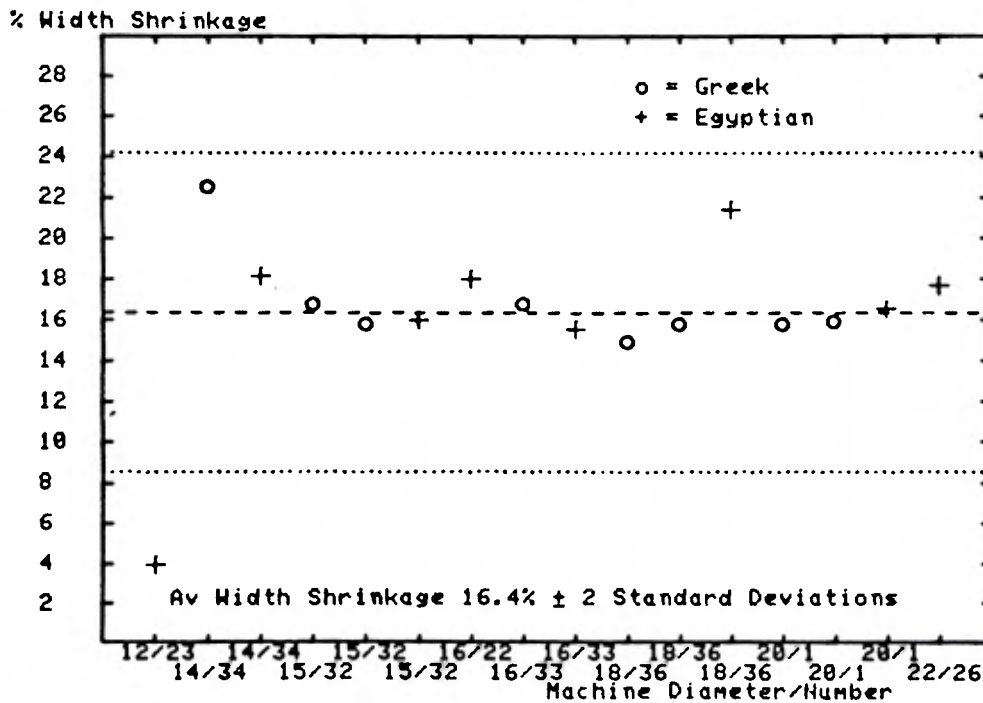
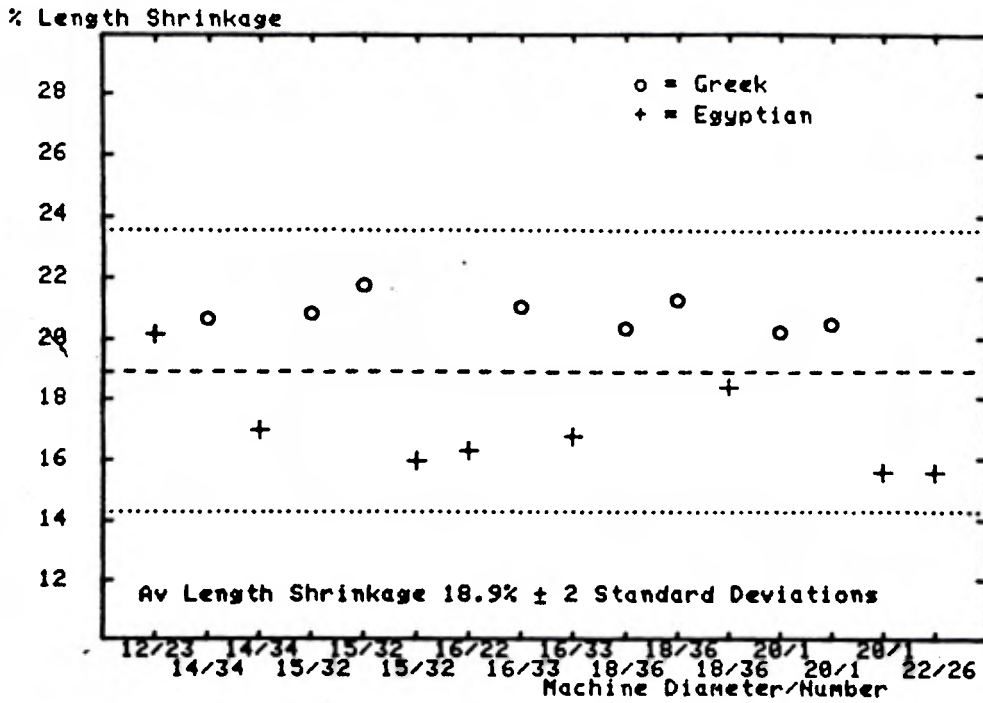


FIGURE 13





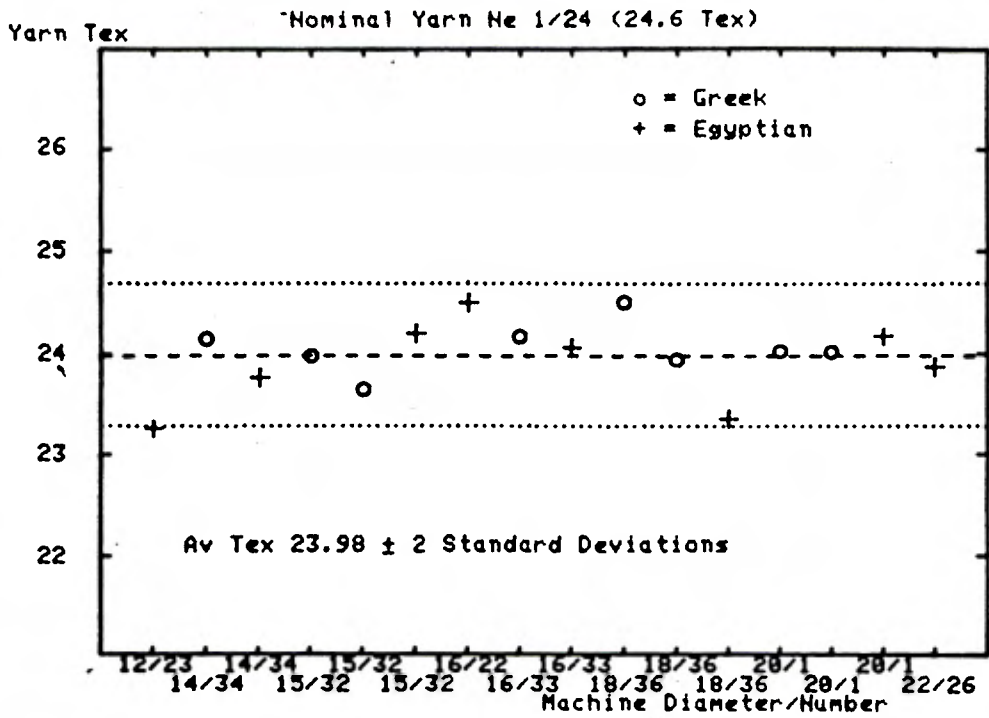
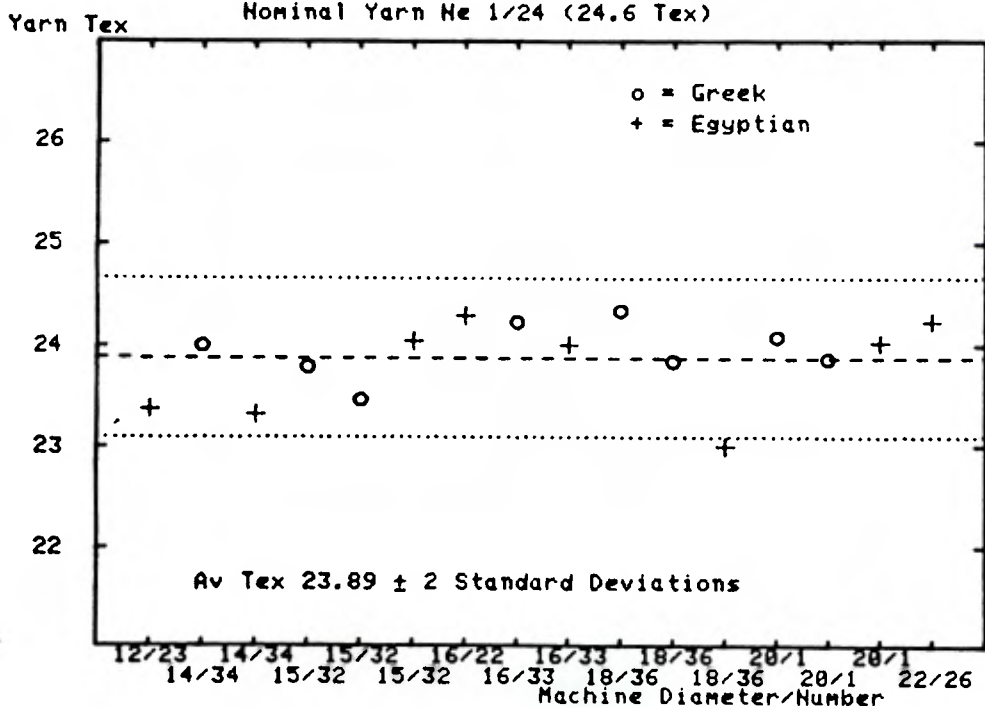


FIGURE 17



JBS: 14G 1x1 RIB : FINISHED FABRIC (WINCH BLEACH) AS RECEIVED

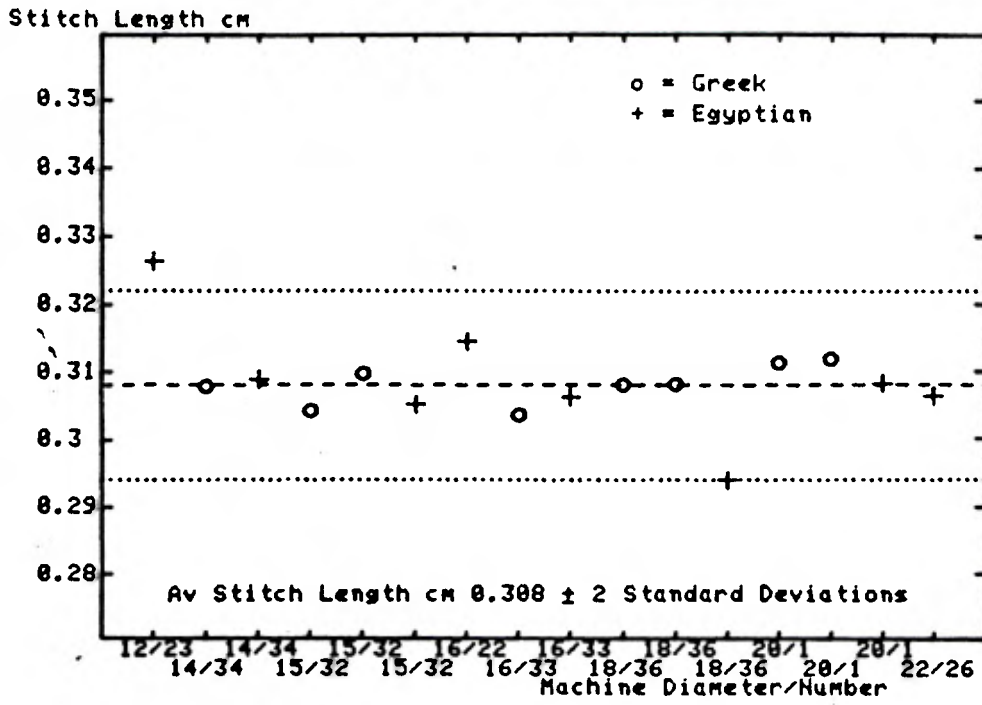
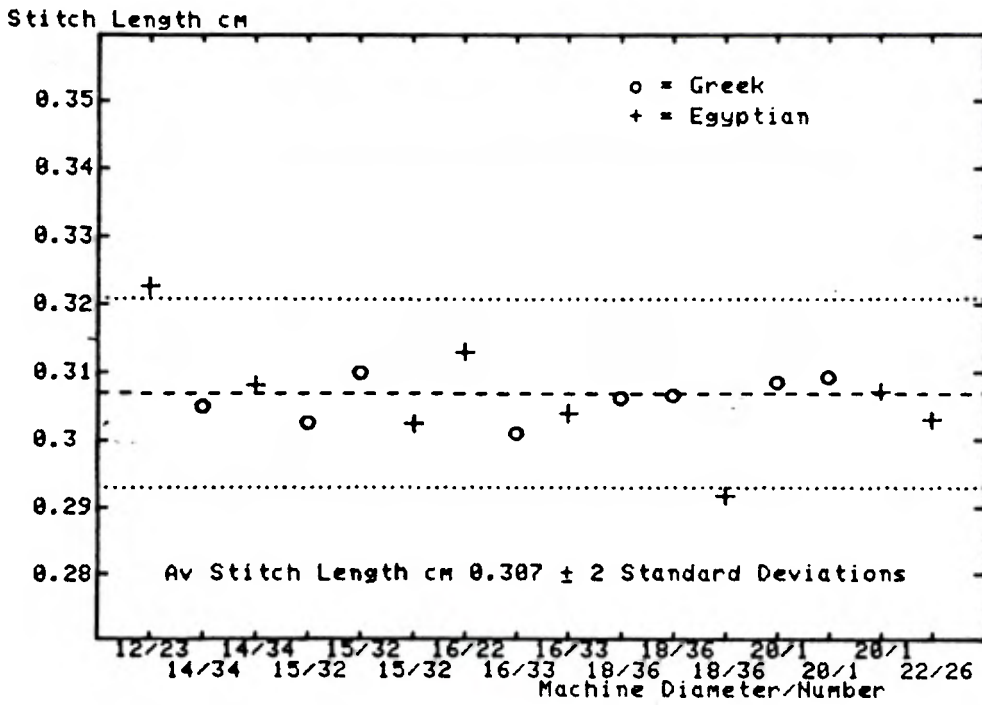


FIGURE 19

JBS: 14G 1x1 RIB : FINISHED FABRIC (WINCH BLEACH) REFERENCE STATE



JBS: 14G 1x1 RIB : FINISHED FABRIC (WINCH BLEACH) AS RECEIVED

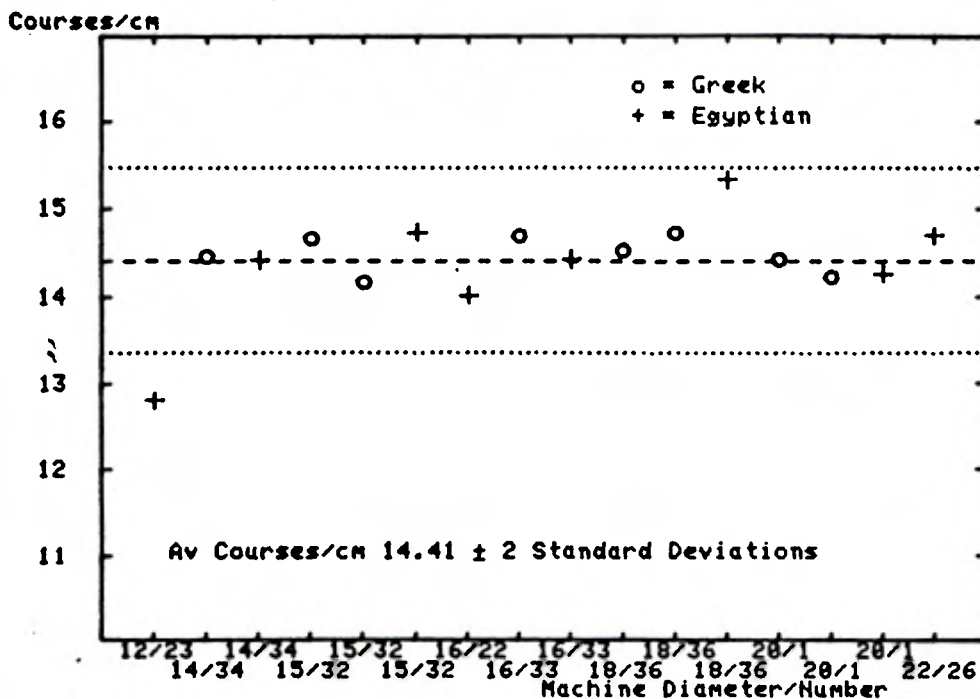
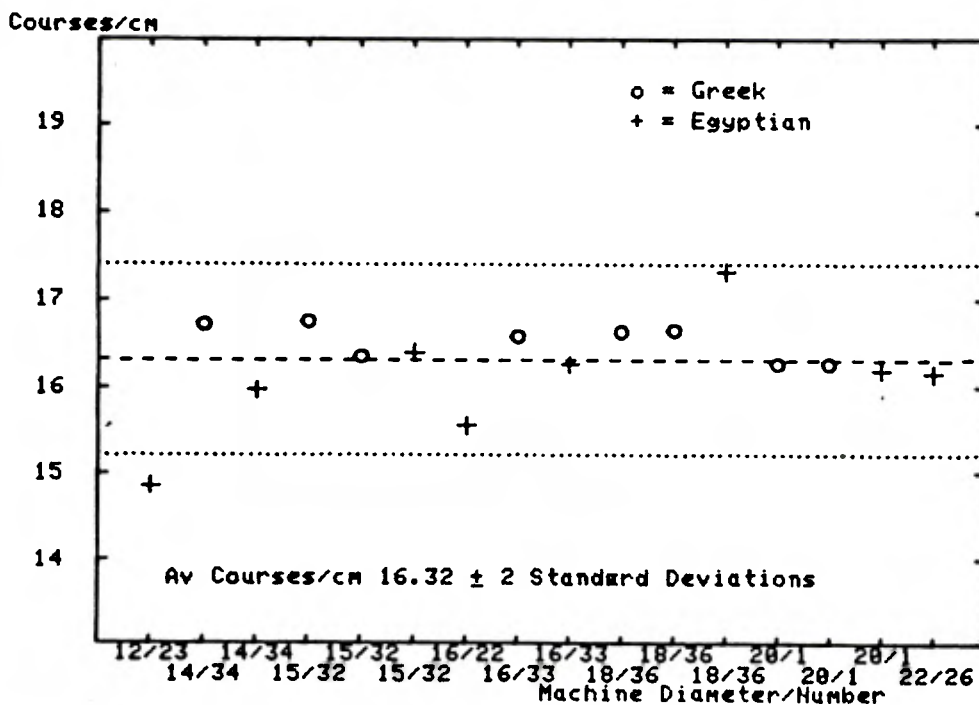
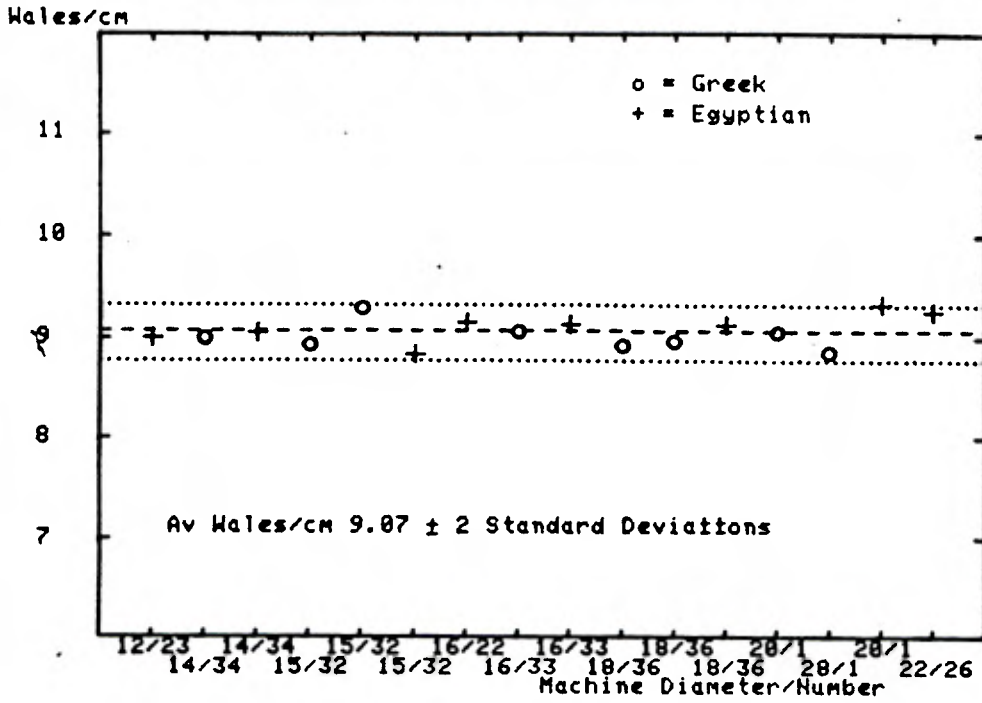


FIGURE 21

JBS: 14G 1x1 RIB : FINISHED FABRIC (WINCH BLEACH) REFERENCE STATE

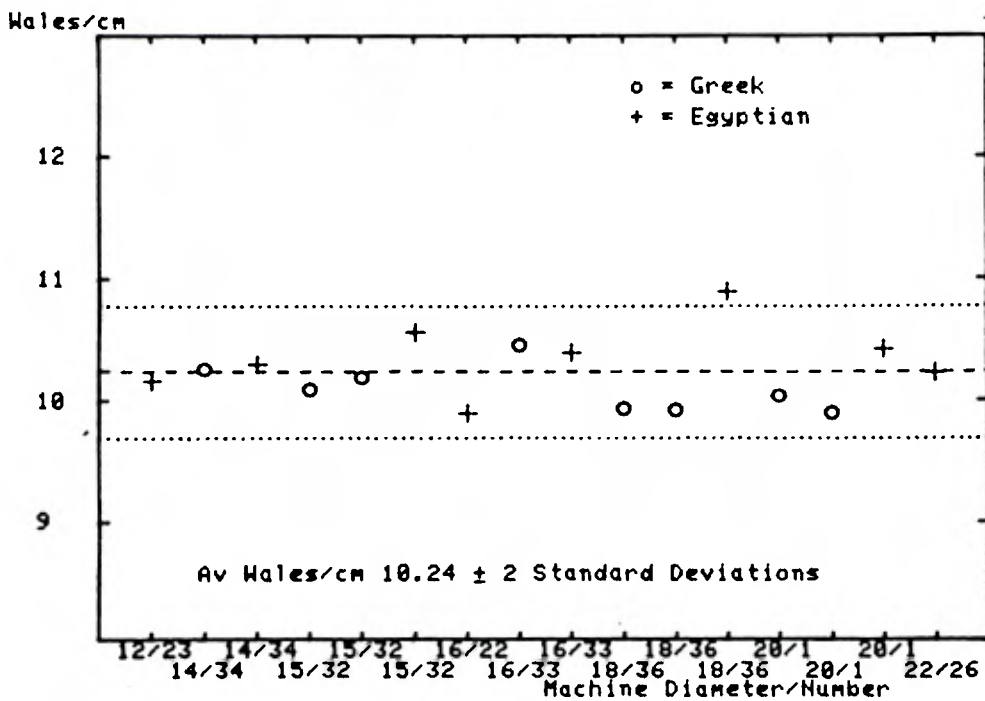


JBS: 14G 1x1 RIB : FINISHED FABRIC (WINCH BLEACH) AS RECEIVED FIGURE 22



JBS: 14G 1x1 RIB : FINISHED FABRIC (WINCH BLEACH) REFERENCE STATE

FIGURE 23



JBS: 14G 1x1 RIB : FINISHED FABRIC (WINCH BLEACH) AS RECEIVED

FIGURE 24

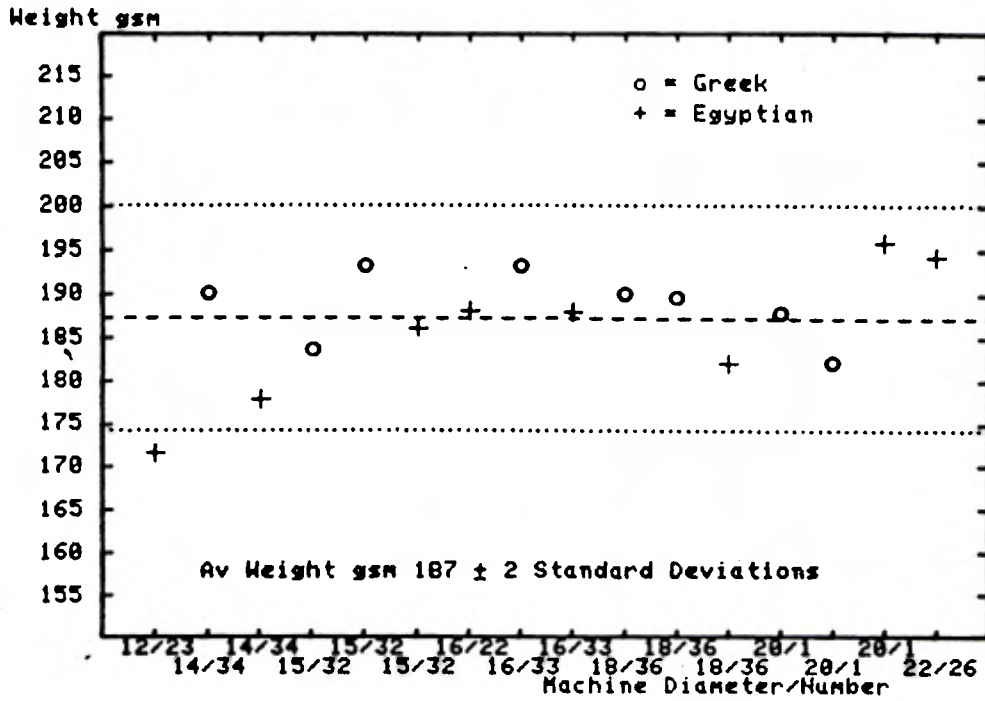
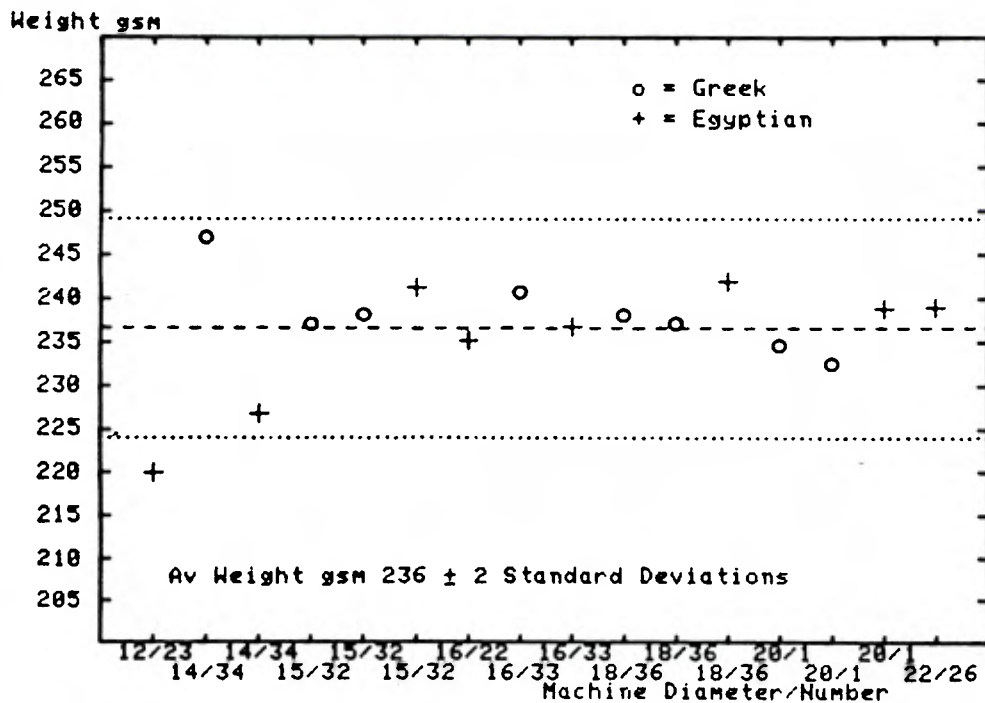


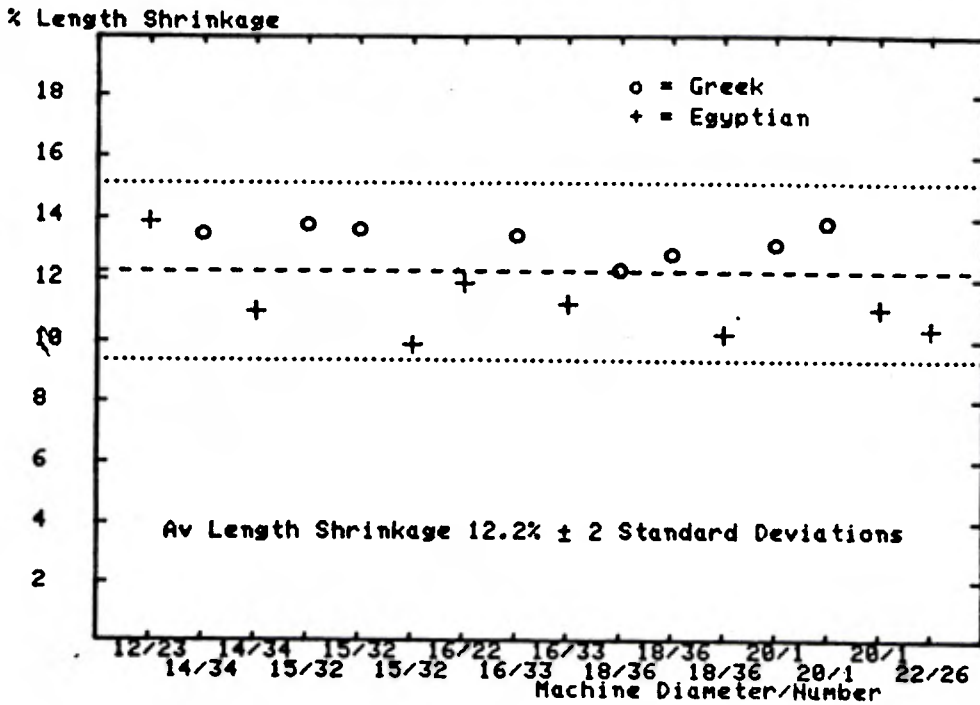
FIGURE 25

JBS: 14G 1x1 RIB : FINISHED FABRIC (WINCH BLEACH) REFERENCE STATE



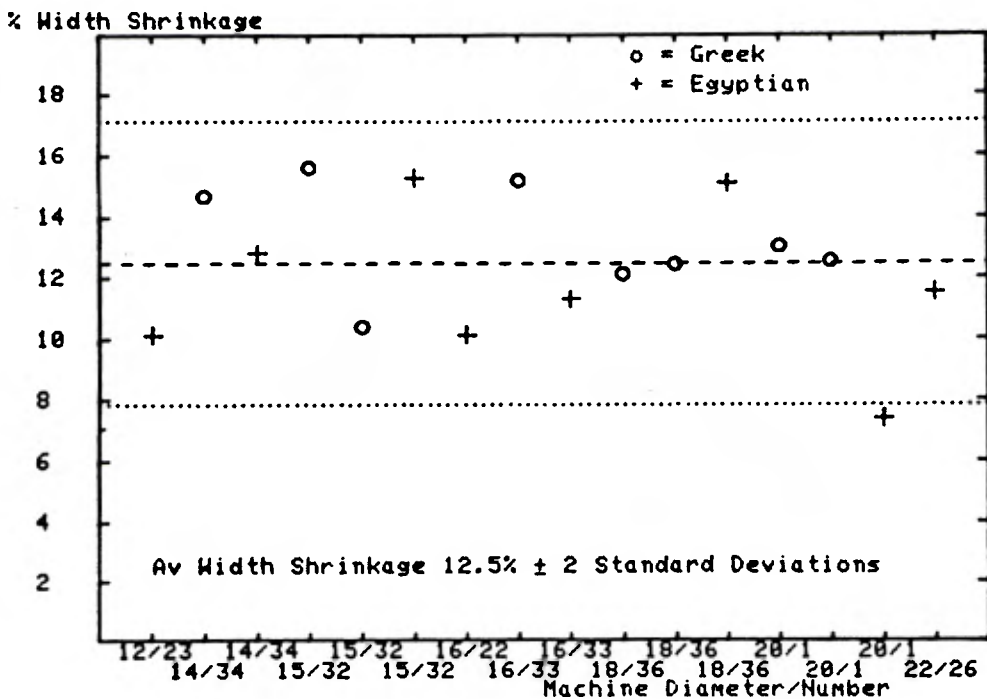
JBS: 14G 1x1 RIB : FINISHED FABRIC (WINCH BLEACH)

FIGURE 26



JBS: 14G 1x1 RIB : FINISHED FABRIC (WINCH BLEACH)

FIGURE 27

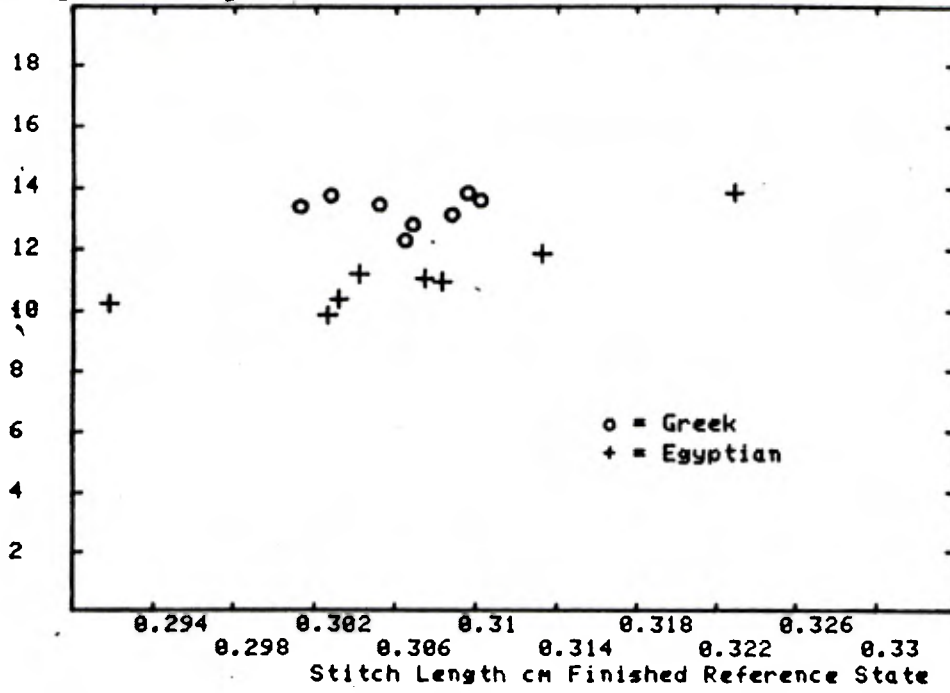


JBS: 14G 1x1 RIB : FINISHED FABRIC (WINCH BLEACH)

FIGURE 28

% Length Shrinkage

Nominal Yarn Ne 1/24 (24.6 Tex)

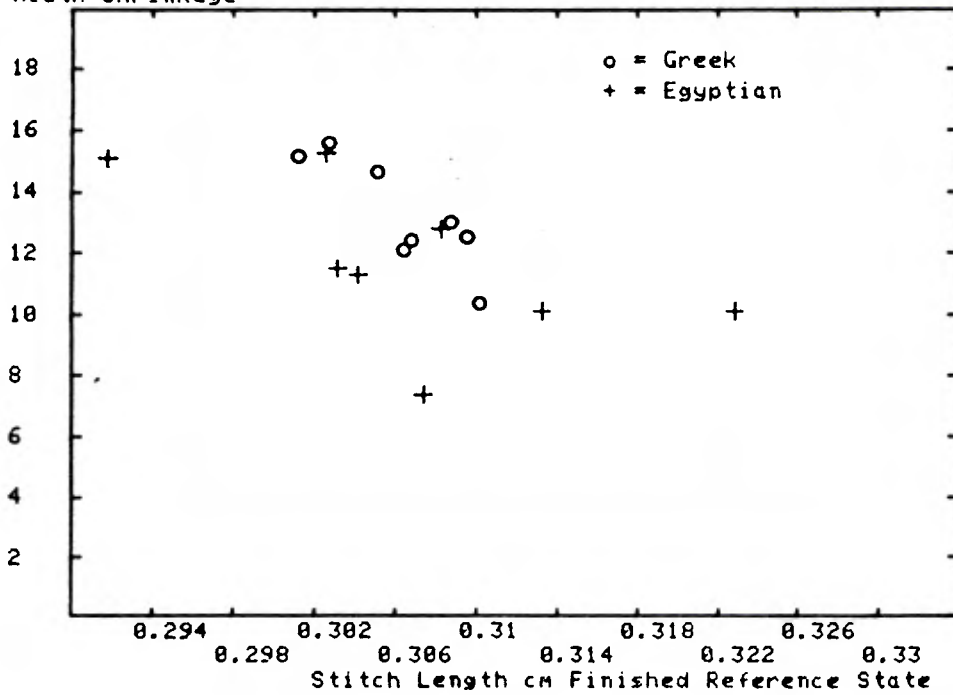


JBS: 14G 1x1 RIB : FINISHED FABRIC (WINCH BLEACH)

FIGURE 29

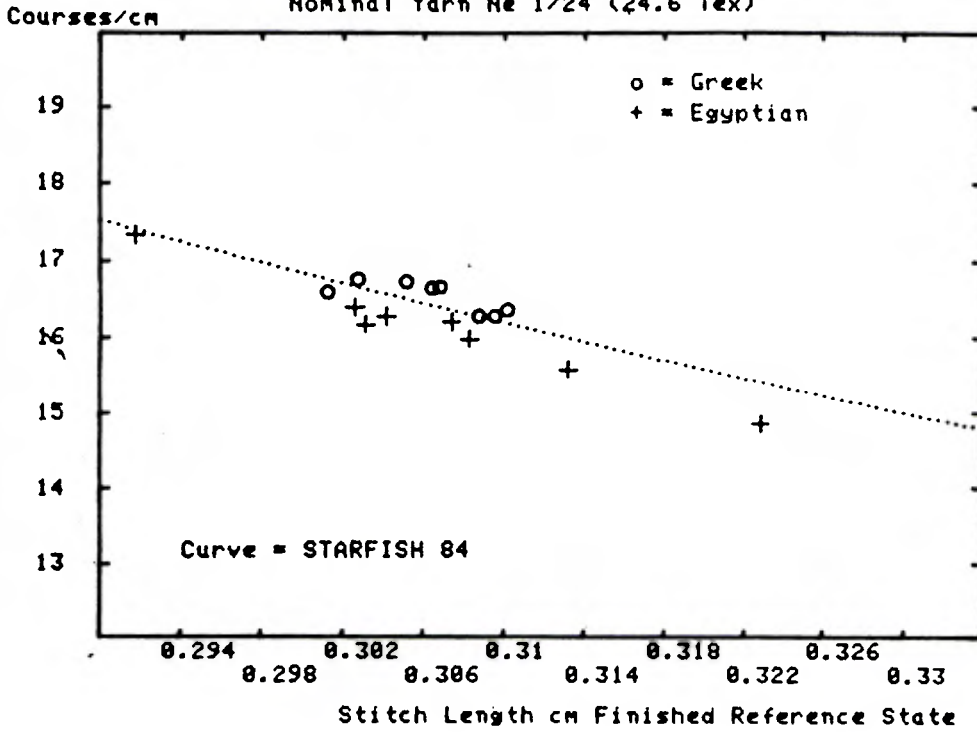
% Width Shrinkage

Nominal Yarn Ne 1/24 (24.6 Tex)



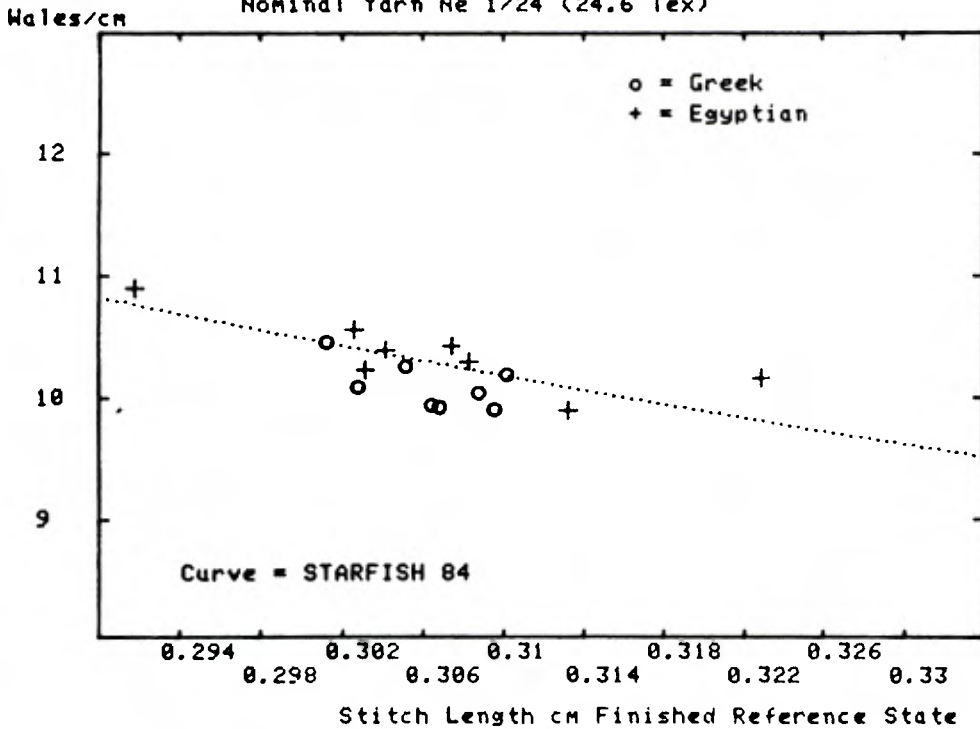
JBS: 14G 1x1-RIB : FINISHED FABRIC (WINCH BLEACH) REFERENCE STATE
Nominal Yarn Ne 1/24 (24.6 Tex)

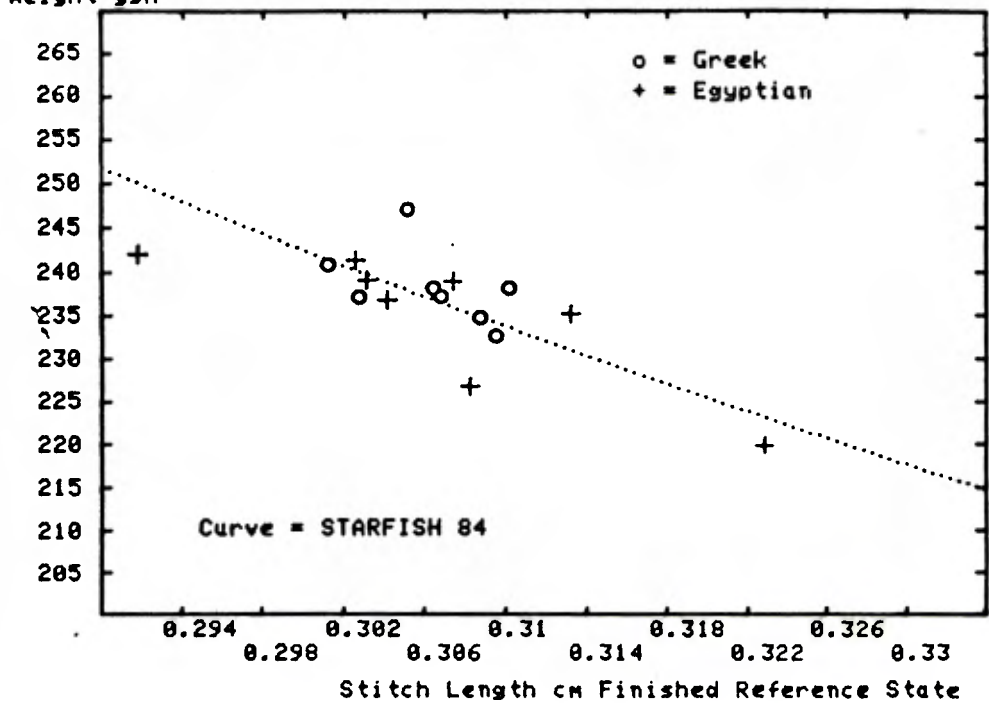
FIGURE 30



JBS: 14G 1x1 RIB : FINISHED FABRIC (WINCH BLEACH) REFERENCE STATE
Nominal Yarn Ne 1/24 (24.6 Tex)

FIGURE 31





I.I.C. - STARFISH 84 -				MODEL PREDICTIONS				SEP-22-1986			
FABRIC : 1x1 RIB - SINGLES, combed ring yarns PROCESS : WINCH DYE (WHITE) MACHINE : 15 gauge 12 inch 564 needles TARGETS : Finished Reference State Dimensions											
Average as knitted				Average reference dimensions							
Yarn Tex	StLen cm	C.Len cm	Tness Fctr	Yarn Tex	StLen cm	Tness Fctr	courses /cm	wales /cm	weight g/sm	width cm(T)	
24.7	0.313	353.1	15.9	23.9	0.307	15.9	16.4	10.3	236	27.5*	
Shrinkage convention is + for growth, - for contraction Qualities marked with a * have unreasonable finishing targets Estimates are given in good faith but without liability Yarn counts are given as Resultant for folded yarns Tightness factor is $\sqrt{\text{Tex}}/\text{St.len}$ in cm											

I.I.C. - STARFISH 84 -				MODEL PREDICTIONS				SEP-22-1986			
FABRIC : 1x1 RIB - SINGLES, combed ring yarns PROCESS : WINCH DYE (WHITE) MACHINE : 15 gauge 12 inch 564 needles TARGETS : Targets are Finished Length & Width Shrinkages											
Average as knitted				Average as delivered				Shrinkage (SW&T)			
Yarn Tex	StLen cm	C.Len cm	Tness Fctr	courses /cm	wales /cm	weight g/sm	width cm(T)	Length %	Width %		
24.7	0.313	353.1	15.9	14.4	9.0	182	31.4	-12.2	-12.5		
Shrinkage convention is + for growth, - for contraction Qualities marked with a * have unreasonable finishing targets Estimates are given in good faith but without liability Yarn counts are given as Resultant for folded yarns Tightness factor is $\sqrt{\text{Tex}}/\text{St.len}$ in cm											

I.I.C. - STARFISH 84 -				MODEL PREDICTIONS				SEP-22-1986			
FABRIC : 1x1 RIB - SINGLES, combed ring yarns PROCESS : WINCH DYE (WHITE) MACHINE : 15 gauge 12 inch 564 needles TARGETS : Finished Reference State Dimensions											
Average as knitted				Average reference dimensions							
Yarn	StLen	C.Len	Tness	Yarn	StLen	Tness	courses	wales	weight	width	
Tex	cm	cm	Fctr	Tex	cm	Fctr	/cm	/cm	g/sm	cm(T)	
24.7	0.313	353.1	15.9	23.9	0.307	15.9	16.4	10.3	236	27.5*	
Shrinkage convention is + for growth, - for contraction Qualities marked with a * have unreasonable finishing targets Estimates are given in good faith but without liability Yarn counts are given as Resultant for folded yarns Tightness factor is $\text{Root}(\text{Tex})/\text{St.len}$ in cm											

I.I.C. - STARFISH 84 -				MODEL PREDICTIONS				SEP-22-1986			
FABRIC : 1x1 RIB - SINGLES, combed ring yarns PROCESS : WINCH DYE (WHITE) MACHINE : 15 gauge 12 inch 564 needles TARGETS : Targets are Finished Length & Width Shrinkages											
Average as knitted				Average as delivered				Shrinkage (5W&T)			
Yarn	StLen	C.Len	Tness	courses	wales	weight	width	Length	Width		
Tex	cm	cm	Fctr	/cm	/cm	g/sm	cm(T)	%	%		
24.7	0.313	353.1	15.9	15.0	9.4	200	29.9	-8.0	-8.0		
Shrinkage convention is + for growth, - for contraction Qualities marked with a * have unreasonable finishing targets Estimates are given in good faith but without liability Yarn counts are given as Resultant for folded yarns Tightness factor is $\text{Root}(\text{Tex})/\text{St.len}$ in cm											

I.I.C. - STARFISH 84 -				MODEL PREDICTIONS				SEP-22-1986			
FABRIC : 1x1 RIB - SINGLES, combed ring yarns PROCESS : WINCH DYE (WHITE) MACHINE : 15 gauge 12 inch 564 needles TARGETS : Finished Reference State Dimensions											
Average as knitted				Average reference dimensions							
Yarn Tex	StLen cm	C.Len cm	Tness Fctr	Yarn Tex	StLen cm	Tness Fctr	courses /cm	wales /cm	weight g/sm	width cm(T)	
24.7	0.325	366.6	15.3	23.9	0.319	15.3	15.6	9.9	227	28.4*	
24.7	0.330	372.2	15.1	23.9	0.324	15.1	15.3	9.8	223	28.8*	
24.7	0.335	377.9	14.8	23.9	0.329	14.9	15.1	9.6	219	29.2*	
Shrinkage convention is + for growth, - for contraction Qualities marked with a * have unreasonable finishing targets Estimates are given in good faith but without liability Yarn counts are given as Resultant for folded yarns Tightness factor is $\sqrt{\text{Tex}/\text{St.len}}$ in cm											

I.I.C. - STARFISH 84 -				MODEL PREDICTIONS				SEP-22-1986			
FABRIC : 1x1 RIB - SINGLES, combed ring yarns PROCESS : WINCH DYE (WHITE) MACHINE : 15 gauge 12 inch 564 needles TARGETS : Targets are Finished Length & Width Shrinkages											
Average as knitted				Average as delivered				Shrinkage (5W&T)			
Yarn Tex	StLen cm	C.Len cm	Tness Fctr	courses /cm	wales /cm	weight g/sm	width cm(T)	Length %	Width %		
24.7	0.325	366.6	15.3	14.4	9.1	192	30.9	-8.0	-8.0		
24.7	0.330	372.2	15.1	14.1	9.0	188	31.3	-8.0	-8.0		
24.7	0.335	377.9	14.8	13.9	8.9	185	31.8	-8.0	-8.0		
Shrinkage convention is + for growth, - for contraction Qualities marked with a * have unreasonable finishing targets Estimates are given in good faith but without liability Yarn counts are given as Resultant for folded yarns Tightness factor is $\sqrt{\text{Tex}/\text{St.len}}$ in cm											

JBS : 1x1 RIB 14 GAUGE : FINISHED FABRIC (WINCH BLEACH)

% Length Shrinkage (1*W+T)

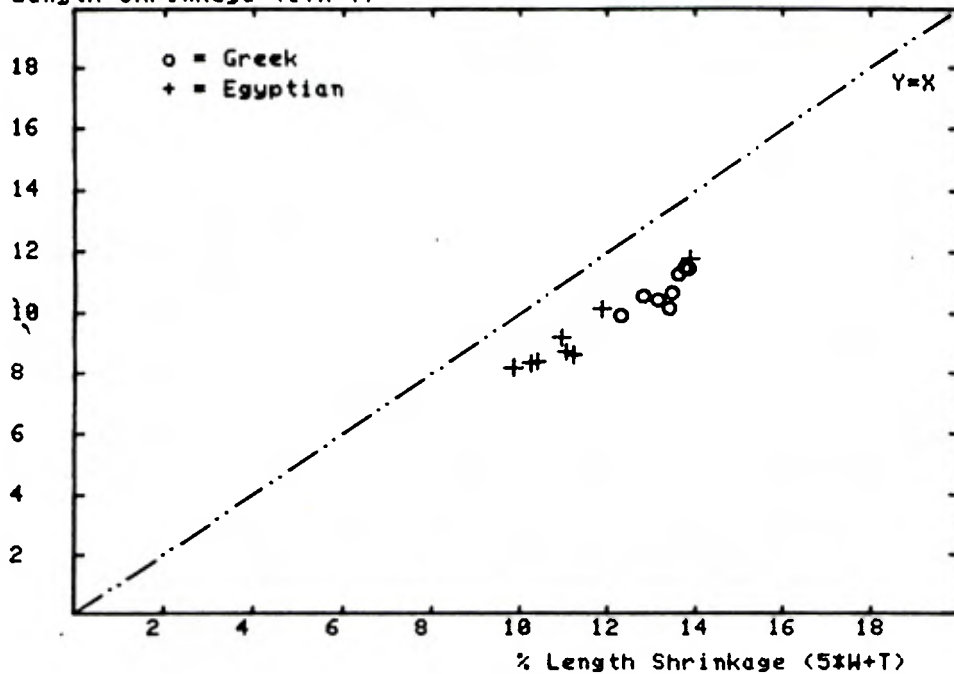


FIGURE 37

JBS : 1x1 RIB 14 GAUGE : FINISHED FABRIC (WINCH BLEACH)

% Width Shrinkage (1*W+T)

