International Institute for Cotton

Research Record No. 64

Project 761

Effect of Yarn Count and Stitch Length on the Physical and Dimensional Properties of 24 Gauge Plain Single Jersey Fabrics

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Key Words: Single Jersey, 24 gauge, Yarn count, Stitch length, Tightness factor, Weight, Extensibility, Bursting strength, Shrinkage

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I GENERAL INTRODUCTION

Background To The Project And Progress To Date.

In 1974, IIC agreed to sponsor a research project entitled "Knitting Performance of Cotton Yarns and the Effect of Fabric Structure and Finishing upon the Dimensional Properties of Cotton Outerwear", at Leeds University, under the supervision of Dr. J.J.F. Knapton. The agreed term of sponsorship was three years, and the areas to be investigated covered the whole spectrum of cotton in knitted outerwear; from the technical aspects of knitting the yarn on double and single jersey machinery, through various methods of finishing to eventual making-up and wearer trial evaluations. However, due to the fact that a suitable research student could not be found, it was later decided to split the programme into smaller, more manageable units which could be carried out separately.

As a result of this decision, the first part - an investigation of "the relationship between yarn count and gauge on single-jersey machinery" - was carried out by a student working for his B.Sc. Hons. Degree, and was completed in 1975.

For this investigation a series of some forty-five different fabrics was knitted on two gauges of single-jersey machine; a Camber Zoomnit 28 gauge, sited at Leeds, and a Camber Velnit 18 gauge sited at TRD.

The fabrics were made using nine different counts of ring spun yarn, at five different tightness factors for each yarn. The report on the 'knitability' of the various yarns and the yarn and machinery limitations was written up in thesis form and presented for the student's Hons. Degree examinations. A copy of this thesis is on file in the knitting department.

The main conclusions reported from this study are that, unlike wool, knitting conditions for cotton yarns are less critical and they possibly have a far greater scope in the knitting field than was previously recognised. This was concluded because, of the nine yarns tried, all appeared to knit equally well over a similar range of loop lengths and, although the two machines were of completely different gauges, the knitable range was found to be very similar, which made it impossible to define a count/gauge relationship purely from knitting performance.

It must be pointed out, however, that the conclusions drawn from this study were made with relation to the actual knitting only, and on a subjective assessment of the fabrics. Insufficient fabric was produced to realistically assess fault rates and no fabric testing of any sort was carried out.

The next stage of the project would have been for another student to continue the appraisal of knitting performance by making a similar series of fabrics on a 24 gauge single-jersey machine. After this, a full-scale testing programme, to assess the physical and dimensional properties of all the fabrics from all three gauges of machine, would have been carried out before a few qualities were selected for re-knitting and finishing trials. Unfortunately, in mid 1975, Dr. J.J.F. Knapton left Leeds to take up a post at North Carolina State University. This left the problem of finding adequate supervision for the project at Leeds. After several months of discussions, both with the University and within TRD, the decision was eventually made to bring the project back to TRD for continuation and to end the sponsorship at Leeds for the time being. By the end of 1975, therefore, we had in our possession at TRD, forty-five rolls of fabric, being those which had been knitted on the 18 gauge and 28 gauge machines, and the residue of all the yarn.

As originally planned, therefore, to complete the initial investigation into knitting performance, the first step was to produce a similar series of fabrics on our 24 gauge Monarch single jersey machine. Five of the original nine counts of yarn were chosen, in the range Ne 1/20 - 1/30. These covered the finer counts of yarn knitted on the 18 gauge machine and the coarser counts knitted on the 28 gauge. Having produced the fabric, a full-scale systematic test laboratory investigation of the physical and dimensional properties of all the fabrics from all the machines was planned.

To begin with, it was decided to concentrate on testing the 24 gauge samples, using them to establish the method of working. This was primarily for ease of handling and for analysing the results and also because the 24 gauge machine was readily available at TRD for additional knitting, if required. In addition, another project concerned with the physical and dimensional properties of single-jersey structures was already in progress on the 24 gauge machine, which would benefit from detailed information about the plain knit structure.

Consequently, systematic testing began on the 24 gauge samples and included tests to determine

Dimensional stability (shrinkage),

Courses per inch and wales per inch,

Weight per unit area,

Stitch length,

Burst strength,

Directional extension on the Instron,

in both the greige state fabric and the fabric after laundering.

As testing progressed, it became apparent that, similarly to the samples knitted on the 18 and 28 gauge machines, the two 24 gauge samples knitted with the longest loop lengths could not be considered as commercially viable fabrics, and usually only the two samples knitted at the tightest stitch lengths were acceptable. Consequently, to enable more information to be gathered about the top end of the knittable range, it was decided that some additional fabrics should be produced. Three more fabrics for the Ne 1/28 and 1/30 yarns were knitted using tightness factors which fell between and around those originally used to produce the two tightest fabrics, i.e. two were set at approximately equal intervals between samples 1 and 2 and the third at a similar distance after 2, - thus giving a total of 8 fabrics for these yarn counts, with at least four and possibly five falling within the commercially significant area.

To enable the production of the extra fabrics for the Ne 1/20, 1/24, 1/26 yarn counts, it was necessary to purchase additional yarn as the original lots had been used up. The main problem this caused was ensuring that the new yarns would match the specs of the original. However, it was possible to obtain the extra quantities from the same yarn spinner, and yarn testing carried out on the new batches showed that within the commercial limitations of the spinner the new yarns were comparable (*Table 1*).

Whilst awaiting delivery of the new lots of yarn, testing was continued on the additional 1/28 and 1/30 fabrics. However, during this stage, a growing concern was beginning to be felt with regard to testing procedures and the accuracy and reliability of test results.

The two tests which were giving the most cause for anxiety were those concerned with determining dimensional stability (shrinkage), and fabric burst strength. Some of the discrepancies experienced in the burst strength results could have been attributed to the test instrument which was giving considerable problems at the time, but discussions were also taking place regarding the most appropriate diaphragm size for testing knits. Additionally, certain other tests were becoming suspect due to unexpected irregularities in the results, which, it was felt, could not be wholly attributed to the fabrics themselves. Consequently, it was decided that until such time as the various knitted fabric test methods could be investigated and their reliability and accuracy confirmed to everyone's satisfaction, knitting of the extra fabrics for the 1/20, 1/24 and 1/26 yarn counts should not be carried out and testing of the 18 gauge and 28 gauge samples should be postponed.

The project is now at the stage where, for the most part, an analysis of all the results so far obtained has been completed and, consequently, it seems appropriate to collect all the available information together so that an appraisal of the situation can be made, i.e. correlating the results to enable the identification of possible trends so that decisions can be made with regard to re-knitting and re-testing on the 24 gauge, testing and additional knitting on 18 and 28 gauge, and whether or not the whole project needs rethinking and restructuring in the light of recent developments, requirements etc.

The time is also right for this discussion as, since systematic work on the project was halted, several test method evaluation trials have been carried out and a statistical analysis of each test from past results, to establish existing accuracy and reliability standards, by PFG is nearing completion.

II KNITTING ON 24 GAUGE MONARCH XL-JS

For the knitting trials on the 28 gauge and 18 gauge machines the knitting extremes of each machine for each yarn were found, i.e. the slackest and tightest fabrics possible were knitted, and then three others made at equal intervals in between. To maintain continuity this method was also used to produce the samples on the 24 gauge machine. For each yarn, on the mid-range sample, a tension test was carried out to ascertain the ability of the yarns to continue knitting at very high input tensions.

Originally, five fabrics for each of the five yarns chosen were produced. These were later supplemented by three additional fabrics knitted from the Ne 1/28 and 1/30 yarns. In the case of the Ne 1/20, 1/24 and 1/26 yarns, additional yarn was ordered and tested on receipt but as yet has not been knitted.

In all cases, for convenience of knitting, the number of operative feeds on the Monarch XL-JS was reduced by half, from 60 to 30. This was achieved by putting every alternate feeder out of action by setting the needle selection mechanism for those feeders to all miss, and raising the stitch cams to a zero setting. Run-in, by means of the trip-tape positive feed mechanism, was measured over two revolutions of the machine using the HATRA yarn length counter and, from this, stitch length and tightness factor were calculated.

Input tensions were adjusted to 3 - 5 g at each feeder by altering the stitch cam settings, using the Schmidt Yarn Tension Meter (type 2), which has a range of 3 - 30 g. Greater accuracy in measuring input tensions was not possible due to the fluctuations of the needle on the meter which is caused by the irregularities in diameter, common to spun cotton yarns. Tensions lower than 3 g cannot be detected by this meter.

Before knitting of the fabrics commenced, all the stitch cams on the machine were equalled by first putting the machine on positive feed and setting each feeder to the same tension. The calibration dials on the cams were then put to read '0'. To zero the inoperative feeders, the indicator dials were turned anti-clockwise to 5 and then given one complete turn. The zero setting was confirmed by removing the cams and checking their position by eye. It is essential that inoperative cams are put at their minimum setting to insure against fabric or yarn distortion at non-knitting feeders during fabric production.

For fabric knitting specs, see *Table 2*.

NB: Similarly to the knitting on the 28 and 18 gauge machines, when the tightest possible fabric was achieved, the stitch length was increased slightly before knitting the piece. This was because, at the absolute minimum knitting limits of the machine, the chances of continually getting fabric faults and needle distortion are very great and in a commercial situation at no time would a machine be expected to produce at its knitting limit.

Likewise, the slackest fabrics produced were not always the slackest possible. In some cases, the limit of the positive feed mechanism was reached but, usually, before attaining this point the fabric had become so slack it was no longer commercially viable and to go slacker still seemed pointless.

III TEST METHODS

After knitting on the 24 gauge machines was completed, all the fabrics were submitted to the laboratory for systematic physical testing. The tests which were carried out on the greige fabric from the machine, and on samples which had received one wash and line dry or one wash and tumble dry were

Dimensional stability (Shrinkage),

Courses per inch; wales per inch,

Weight/unit area,

Stitch length,

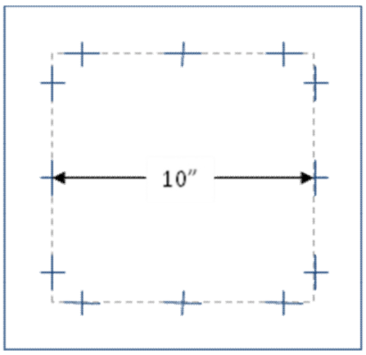
Burst strength,

Directional extension on the Instron.

The test methods used were, unless indicated, the standard methods used in the laboratory at that time, and were as follows.

Dimensional Stability (Shrinkage)

From the swatch, two test samples were cut and a test area of approximately 10" square marked on them in indelible ink. The test area was marked from a wale line using a ruler, and three marks were made along each side of the area from which measurements were taken.



After conditioning in a standard atmosphere for a minimum of two hours, the distances between the marks, 3 for length and 3 for width, were re-measured and recorded.

Both samples were then washed in the Hoover Automatic washing machine at wash setting 5, using a domestic detergent. After washing, one sample was dried in the tumble drier, the other pegged on a line to dry.

When both samples were dry, they were again placed in a standard atmosphere for conditioning before the distances between the marks were re-measured. From the average of the three readings taken for length and width in both the greige and washed states, the percentage shrinkage was calculated.

After measuring, both samples were then pressed using a hand steam iron and after conditioning re-measured.

Thus results were obtained for percent shrinkage before and after press for both wash and line-dry and wash and tumble-dry.

Courses per inch; Wales per inch

Using the cloth counting glass, the number of courses per inch and wales per inch were counted. One reading per sample in the greige, after one wash and line-dry, and after one wash and tumble-dry.

Weight/Unit Area

From the greige swatch, a 5¼" square test sample was cut using the cutting die. After conditioning, the sample was weighed on the balance. This was repeated for both washed and line-dried and washed and tumble-dried samples.

Knowing the weight and the area of the small test sample, the oz/sq. yd. or gm/sq. m. of the fabric can be calculated. One sample only was weighed for each fabric.

Stitch Length

Usually, stitch length was calculated by measuring the unravelled length of yarn in one hundred wales. A wale line was marked on the fabric and then, using the cloth counting glass, one hundred wales were counted and marked. Cuts were then made along the marked lines, one hundred wales apart, and five courses unravelled and measured under a fixed tension. The average length of the five courses divided by one hundred gives the length of yarn in one stitch. This was repeated on greige, line-dried and tumble-dried samples.

In some cases, measurements were made over fifty wales and only four courses unravelled.

Burst Strength

Using either the small- or large-diameter rings, depending on instructions, five tests were made on each sample. The fabric burst pressure is read directly from the dials on the machine in lbs per sq. inch (psi).

The average of the readings was then taken and the results converted to Kn/m^2. When the small-diameter ring was used, a diaphragm correction factor was included in the calculations. There is not a correction factor for the large-diameter ring.

Directional Extension on the Instron

This was not a standard test for knitted fabrics but, to try and extract more information about the samples, a method similar to the standard test for evaluating tear strength on woven fabrics was used.

The test samples were cut from the swatch using the 6" x 4" die on the cutting machine. Five replications were made in the length and five in the width directions.

The test samples were clamped between the jaws of the machine as centrally as possible at a test length of 5", i.e. 1" of the fabric was in the jaws at either end.

Readings for extension percent and load were read from the chart recorder after each test. Averages were calculated from these readings to give percent extension in length or width directions and the average load required to tear the samples.

The test was repeated on greige, line-dried and tumble-dried samples.

IV RESULTS

The results of all the tests carried out on the 24G samples have, for convenience of analysis, been regrouped onto comparison charts. Where possible, either standard deviation and % CV or 95% confidence limits and accuracy have been calculated and graphs drawn.

During the course of testing, minor modifications to the test methods detailed above were made and in some cases, retests were carried out. These instances are indicated where appropriate on the graphs and tables. Presentation of results in this report has been mainly confined to graphs. Detailed tables of test results are available in the project file.

V DISCUSSION

Although purely from the knitting performance of the yarns it has proved impossible to establish a knitting count/gauge relationship, it might eventually be possible to do so from an assessment of the effect of count on the physical and dimensional properties of the resultant fabrics.

If fabrics made from one particular yarn count have a better overall performance than fabrics from other counts then, obviously, the most appropriate yarn count for 24G gauge single jersey has been established.

Stitch Length/Weight

As might have been expected, the results have shown that, for each yarn count, as stitch length is decreased, the fabric weight increases: *Figures 1-6*.

This is due to the fact that when the knitted loop length is decreased, more courses and wales are formed in a given area of the fabric. Thus more yarn is held in the area which consequently will cause the fabric to weigh heavier. Obviously, the coarser the yarn count for a given stitch density, the heavier the resultant fabric, but in all cases, the results seem to indicate that the rate of increase is approximately the same. The results also indicate that after relaxation of the fabric by one wash and tumble-dry, the percentage weight increase from greige to relaxed is very similar for all yarn counts and stitch lengths. Thus for a given stitch length from a given count of yarn, it should be possible to predict the fabric greige weight and the amount by which it will increase after relaxation or, conversely, if a fabric weight is specified (which is more usual in a commercial situation) and if these results are representative, it becomes possible to identify the various combinations of yarn counts and stitch lengths which will produce the required weight of fabric.

Resultant fabric weight however, is not the only criterion for choosing a particular count of yarn or stitch length. Altering either or both of these parameters directly affects the other physical properties of the fabric, i.e. dimensional stability, burst strength, extensibility.

Shrinkage

The dimensional stability or potential shrinkage in a fabric is probably its most important physical characteristic from a commercial point of view. The results from this series of fabrics have indicated certain trends in shrinkage behaviour which relate the effect of yarn count, stitch length and weight.

From the graphs, *Figures 7-24*, one can see that, in all cases, as stitch length is increased, the potential length shrinkage in the fabric also increases, while the width, after a certain point, no longer shrinks, but extends.

If shrinkage against weight is considered, the same trend can be seen.

As weight decreases, (i.e. stitch length is increased), the length shrinkage increases and the width moves to extension. In both cases, the effects are more severe with the 1/30 yarn count than the 1/20s.

A similar trend is also apparent when shrinkage is plotted against tightness factor - a common knitting parameter which is a function of the square root of yarn count and the reciprocal of the loop length. In each case, however, there is a crossover point where the potential shrinkage in both length and width directions is similar. This could be important, because at this point it seems likely that the forces acting in both length and width directions are about equal, thus producing a more stable and balanced fabric. This could, maybe, have some effect on edge curl?

Extensibility

The effect of stitch length and count on the extensibility of a fabric has also shown a quite consistent trend, *Figures 25-28*. As stitch length increases, so does the extensibility of the fabric in both length and width directions, although there is more extensibility in the width than in the length at a given load. The reason for this would seem to lie in the nature of knitted fabrics as, due to the method of construction, there is always more movement possible in the width than the length. Extension plotted against tightness factor also shows a similar trend. As tightness factor decreases (i.e. loop length increases), percentage extension in both the length and width increases.

The results also prove that the amount of possible extension is directly related to load. The more load applied, the more the fabric extends until it reaches breaking point. However, although in all cases the general trends are apparent for all yarn counts, the Ne 1/20 and 1/30 appear to be behaving slightly differently in the width direction. Whereas the Ne 1/24, 1/26 and 1/28 continue to extend to breaking point, the Ne 1/20 and 1/30 tend to level off at a given extension, regardless of tightness factor, stitch length or load. This may be due to an irregularity in the test or perhaps something inherent in these particular yarns; either way, more experimental data are needed before drawing any definite conclusions.

The other important point to notice is that, on the whole, the majority of the inherent extension in a fabric is removed by relatively low loads. An effect which tends to be more noticeable as tightness factor decreases (i.e. loop length increases). This can be illustrated by reference to the graphs. If the tightest fabric knitted from the 1/20 yarn is considered, it extends approximately 15% in length and 29% in width at 1 Kg; 34% in length and 59% in width at 5 Kg and 68% in length at break (52 Kg) and 93% in width at break (35 Kg).

The 1/20 fabric knitted at the lowest tightness factor, however, extends approximately 28% in length and 59% in width at 1 Kg; 44% in length and 90% in width at 5 Kg and 65% in length at break (26 Kg) and 112% in width at break (14.6 Kg).

This also explains why, when the results were recalculated to assume a pretension of 1 Kg (*Figures 30-31*) and the extension at 5 Kg or the total extension were re-plotted against tightness factor, an opposite trend seemed to appear. This, in fact, is not the case - what the graphs are saying is, that once the big changes in extension at low loads have been compensated for there is little difference in fabric extensibility at a 5 Kg load and the apparent increase in fabric extensibility at break at increased tightness factors is primarily because there is an increase in fabric strength, due to a combination of increased yarn strength and decreased loop length.

With regard to *Figure 29* which shows total load at break against tightness factor, the interesting feature is not that fabric strength increases as yarn strength, count and tightness factor increases, but that in all cases the fabrics are always stronger in the length direction than the width direction. This could possibly be due to the fact that in the length direction - due to the plain knit construction - the wales form interlocking chains while the courses do not and can be pulled almost straight under load. Thus, in the length direction, the fabric strength is a function of the strength of the chains, whereas in the width, the fabric strength is related almost totally to the single-end strength of the yarn.

Burst Strength

The burst strength of the fabrics appears to be directly affected by the yarn strength and the count and stitch length once again. If burst strength is plotted against weight - which has already been shown to be directly related to the count and stitch length - there is a clear progression, especially in the greige. As weight increases (stitch length decreases) the fabrics become stronger. However, the interesting fact to note is that although fabric strength is related directly to stitch length and therefore stitch density, fabric strength does not appear to be increased by the increase in stitch density which has been brought about by shrinkage, i.e. when the fabric has been shrunk, and therefore the stitch density and weight has increased, these results indicate that burst strength is unaffected. It appears therefore that fabric strength is fixed by the specifications at the time of knitting and cannot be increased by any shrinkage treatment.

The explanation for this could be that, although the weight and extensibility of the fabric may be increased due to compaction, ultimately fabric strength is determined by the loop length at the time of bursting and, since loop length does not change significantly in laundering, the fabric strength will remain the same.

This fact was also noticed in the results of the tests on the Instron. Although fabric extensibility increased by large amounts after laundering, total breaking load for a given fabric remained almost constant.

However, both the tests for extension and burst strength were not entirely satisfactory from the point of view of reproducibility and, therefore, further experimental work should be carried out to confirm this trend.

VI CONCLUSIONS

Although only major trends have been identified in the above discussion and there is much that still needs to be carefully considered before the next stage can be properly planned, the value of this preliminary systematic investigation is obvious.

Ultimately, when additional work has been done on the 24G, and testing on the 28G and 18G fabrics has been carried out, together with organised finishing trials, it should be possible to make quantitative predictions about the performance of knitted fabrics from a knowledge of knitting specifications. Such predictions should be of significant value to industry.

Table 1

Original Yarn Order for Leeds (Tested at Leeds)

COTTON COUNT	TWIST FACTOR	TEX COUNT	MEAN BREAK LOAD	MEAN EXT. AT BREAK	FRICTION AGAINST STEEL
1/20	3.5	29.5 (29.2)	371 gm	7.9%	0.10
1/24	3.5	24.6	274 gm	6.3%	0.10
1/26	3.5	22.7 (23.3)	287 gm	6.9%	0.12
1/28	3.5	21.1 (21.7)	264 gm	7.7%	0.11
1/30	3.3	19.7	238 gm	7.5%	0.11

Re-order: New Yarn for Additional Knitting

1/20	3.56	30.43	422.6 gm	8.9%	0.125
1/24	3.3	25.67	329.5 gm	8.3%	0.134
1/26	3.5	23.5	311.4 gm	9.2%	0.125

Of the second batch of yarns, count and twist factor were tested at TRD. Breaking load, extension at break and friction against stainless steel at the Shirley Institute.

All yarn supplied by Pear New Mill, Stockport - part of the Carrington Viyella Group.

Table 2

Knitting Specifications for 24G samples

Yarn: Ne 1/20 29.2 tex

SAMPLE	1	2	3	4	5
Run-in (2 revs)	37.5 ft	45 ft	52 ft	60 ft	67 ft.
Stitch Length in	.117	.141	.163	.188	.209
cm	.298	.357	.413	.476	.532
Tightness Factor	18.16	15.13	13.09	11.34	10.16
CPI+WPI on m/c	46,28	32,28	24,28	19,28	15.5,28
Width at in	35	35	35	35	35
Rollers cm	88.9	88.9	88.9	88.9	88.9
TENSION TEST ON 4 UP TO 50 GMS, SHOWED NO PROBLEMS IN KNITTING					

Yarn: Ne 1/24 24.6 tex

SAMPLE	1	2	3	4	5
Run-in (2 revs)	36 ft	44.5 ft	52.5 ft	61 ft	67 ft
Stitch Length in	.113	.139	.164	.191	.209
cm	.286	.353	.417	.484	.532
Tightness Factor	17.36	14.04	11.91	10.24	9.33
CPI+WPI on m/c	48,28	31,28	22,28	17.5,28.5	14.5,29
Width at in	35	34	35	34.5	34.5
Rollers cm	88.9	86.4	88.9	87.6	87.6
TENSION TEST ON 3 UP TO 70 GMS, SHOWED NO PROBLEMS IN KNITTING					

Yarn: Ne 1/26 23.3 tex

SAMPLE	1	2	3	4	5
Run-in (2 revs)	36 ft	44.5 ft	53 ft	61.5 ft	70 ft
Stitch Length in	.113	.139	.166	.192	.219
cm	.286	.353	.421	.489	.556
Tightness Factor	16.89	13.66	11.48	9.89	8.69
CPI+WPI on m/c	47,28	30,28	22,28	16.5,28	14,28
Width at in	34.5	34.5	34.5	34.5	35
Rollers cm	87.6	87.6	87.6	87.6	88.9
TENSION TEST ON 3 UP TO 80+ GMS, STILL KNITTING NO PROBLEMS					

Yarn: Ne 1/28 21.1 tex

SAMPLE	1	2	3	4	5	6	7	8
Run-in (2 revs)	35 ft	45 ft	55 ft	65 ft	75 ft	38.3 ft	41.7 ft	48.4 ft
Stitch Length in	.109	.141	.172	.203	.234	.120	.130	.151
cm	.278	.357	.437	.516	.595	.305	.330	.384
Tightness Factor	16.77	13.04	10.67	9.03	7.83	15.27	14.12	12.13
CPI+WPI on m/c	50,28	28,28	19.5,28	15,28	12,28	41,28	33,28	25,28
Width at in	34.5	34.5	34.5	34.5	34.5	34.5	34.5	34.5
Rollers cm	87.6	87.6	87.6	87.6	87.6	87.6	87.6	87.6
	TENSION TEST ON 3 KNITTED OK UP TO 60 GMS - YARN BROKE							

Yarn: Ne 1/30 19.7 tex

SAMPLE	1	2	3	4	5	6	7	8
Run-in (2 revs)	34.5 ft	44 ft	53 ft	62 ft	71.5 ft	38.8 ft	43 ft	50.75 ft
Stitch Length in	.108	.138	.166	.194	.223	.121	.134	.159
cm	.274	.349	.421	.492	.567	.308	.340	.404
Tightness Factor	16.21	12.71	10.55	9.02	7.82	14.49	13.05	10.99
CPI+WPI on m/c	48,28	29,28	21,28	16,28	13,28	38,28	31,28	23,28
Width at in Rollers	34.5	34.5	34.5	34.5	34.5	34.5	34.5	34.5
	TENSION TEST ON 3 KNITTED OK UP TO 65 GMS - YARN BROKE							

Figure 1

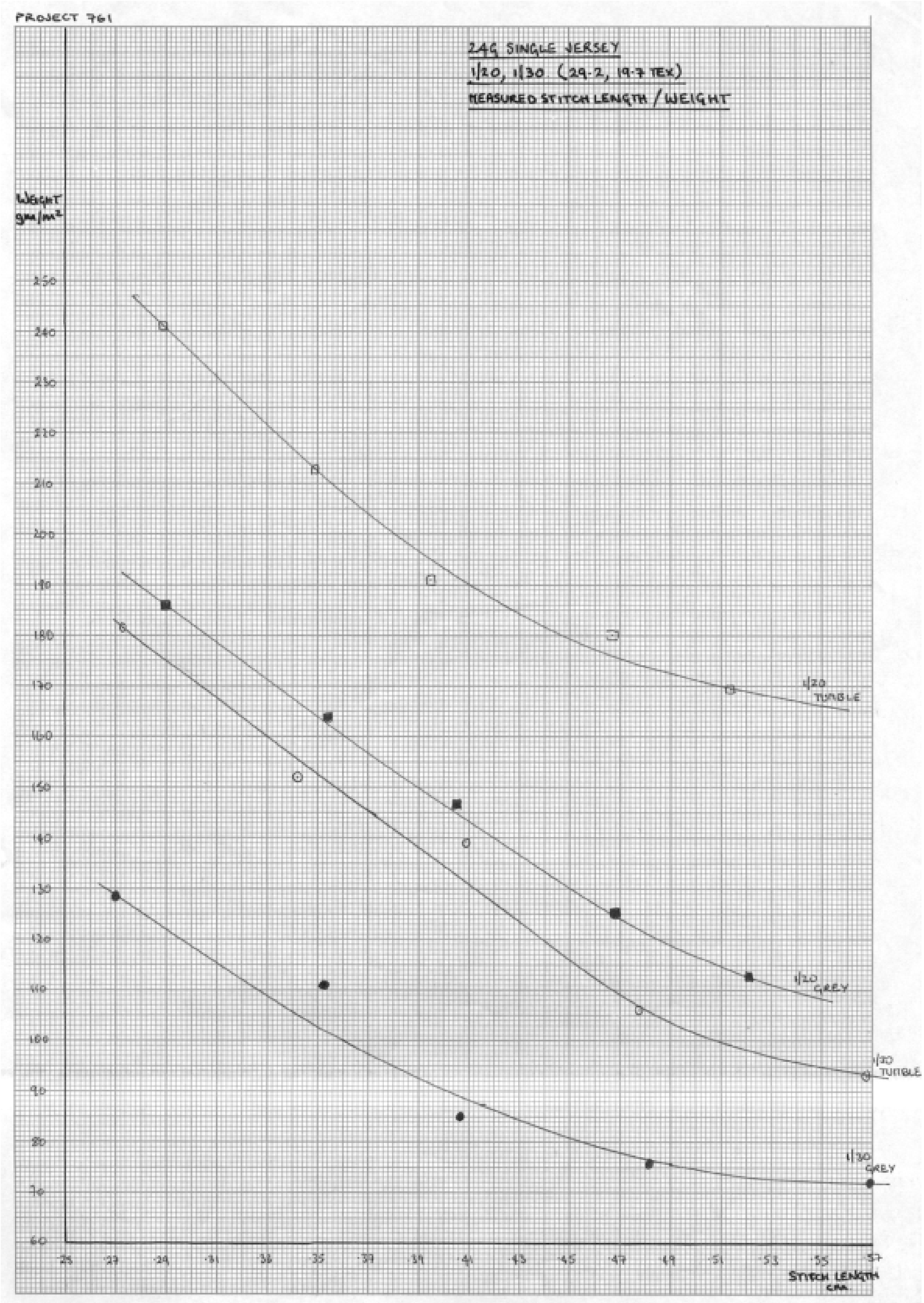

PROJECT 761
24G SINGLE JERSEY
1/20, 1/30 (29.2, 19.7 TEX)
MEASURED STITCH LENGTH / WEIGHT
WEIGHT gm/m²
1/20 TUMBLE
1/20 GREY
1/20 TUMBLE
1/30 GREY
STITCH LENGTH cm.

Figure 2

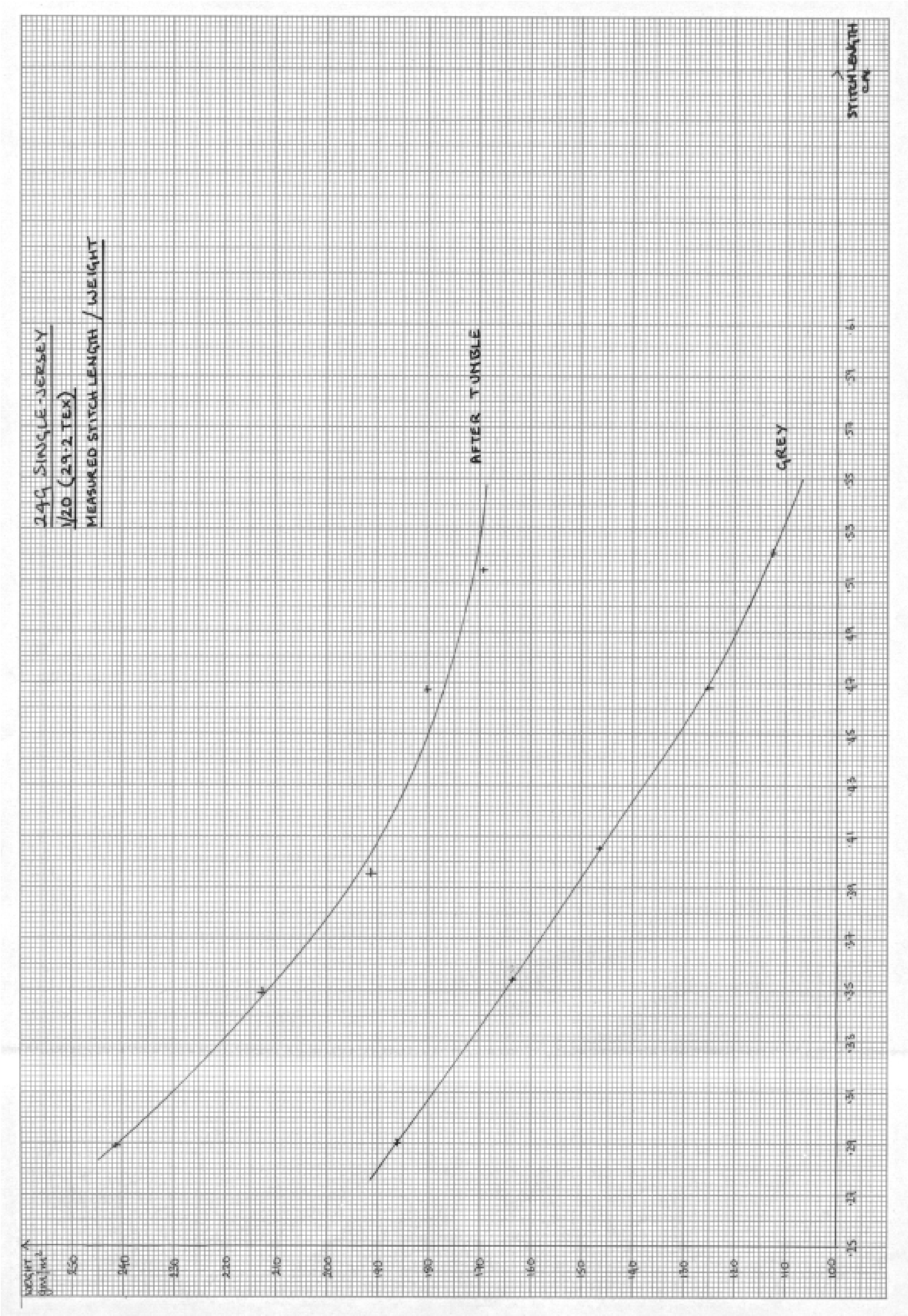
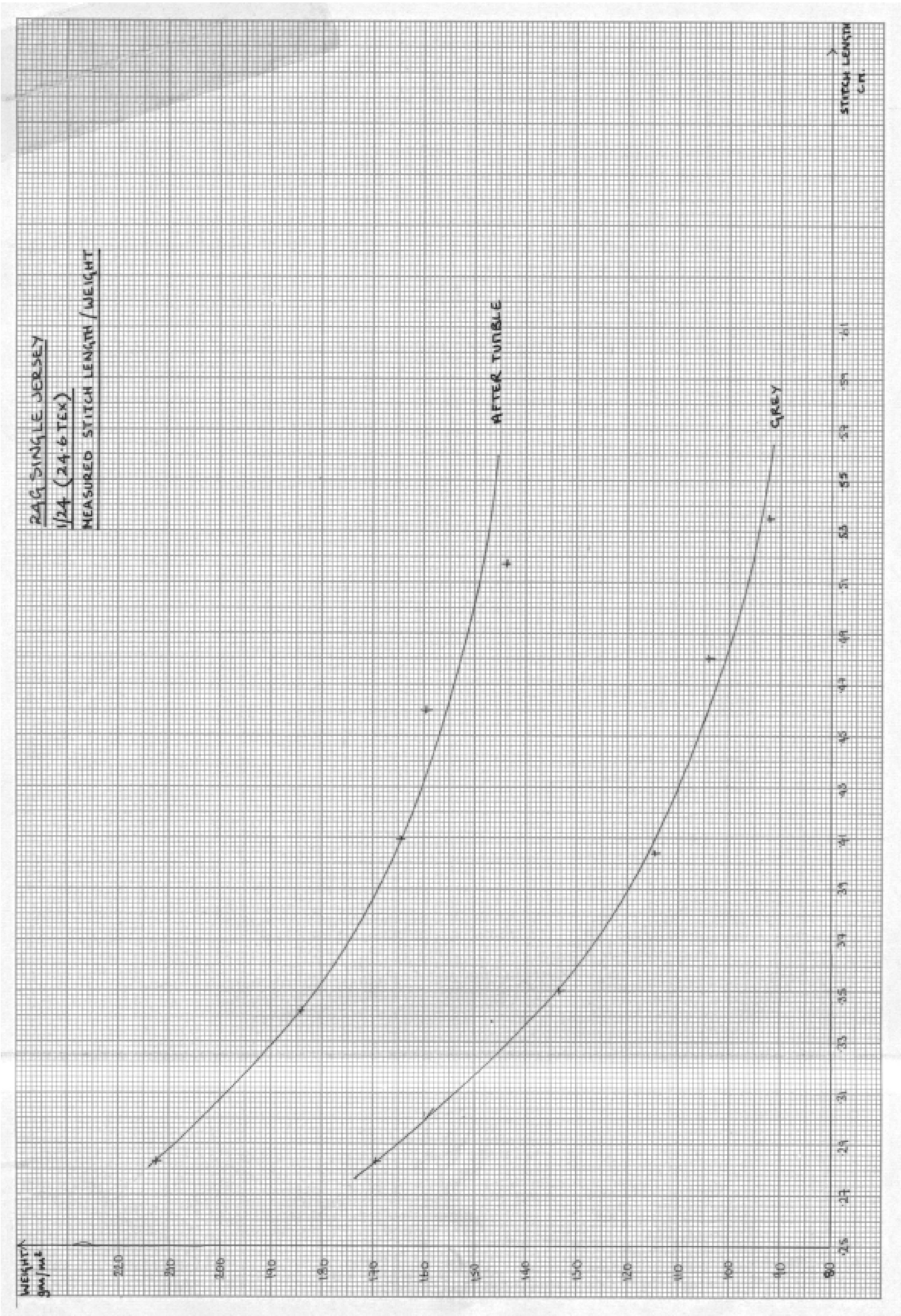

24G SINGLE-JERSEY
1/20 (29.2 TEX)
MEASURED STITCH LENGTH / WEIGHT
AFTER TUMBLE
GREY
STITCH LENGTH

Figure 3


24G SINGLE JERSEY
1/24 (24.6 TEX)
MEASURED STITCH LENGTH / WEIGHT
AFTER TUMBLE
GREY
WEIGHT gm/m²
STITCH LENGTH cm
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
.25
.27
.29
.31
.33
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.57
.59
.61

Figure 4

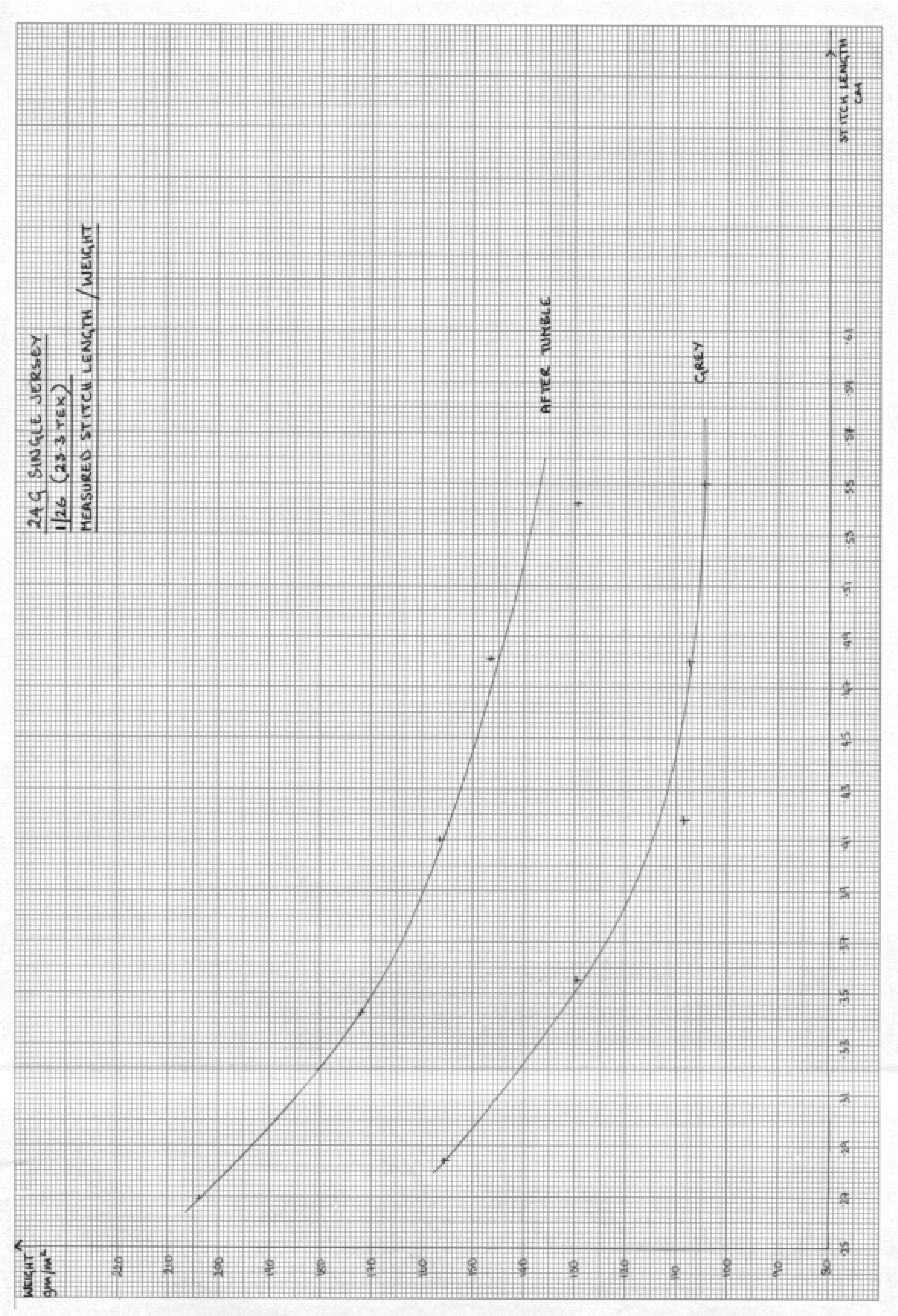

24G SINGLE JERSEY
1/26 (23.3 TEX)
MEASURED STITCH LENGTH / WEIGHT
AFTER TUMBLE
GREY
STITCH LENGTH CM
WEIGHT gm/m²

Figure 5

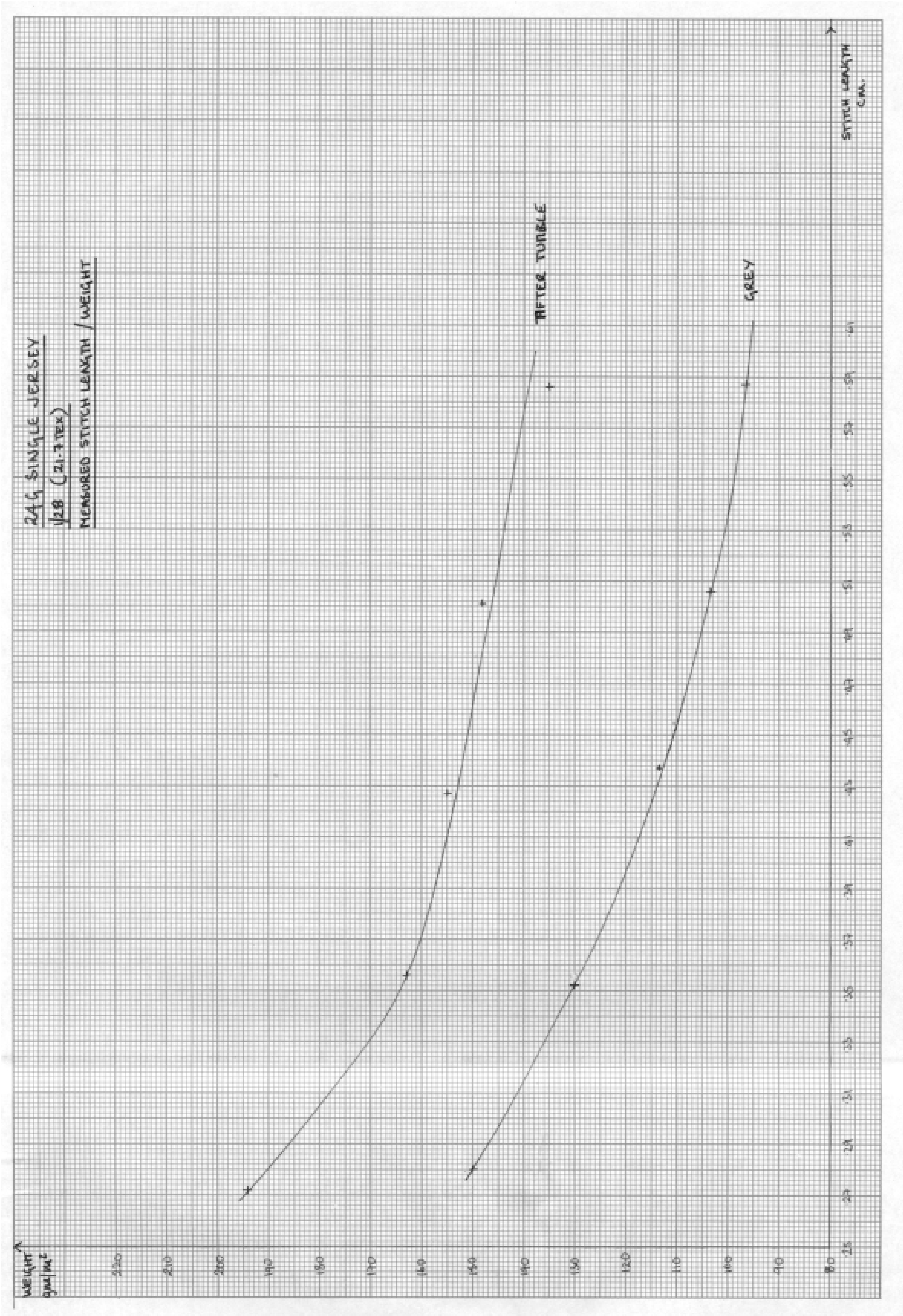

24 G SINGLE JERSEY
1/28 (21.7 TEX)
MEASURED STITCH LENGTH / WEIGHT
AFTER TUMBLE
GREY
STITCH LENGTH CM.
WEIGHT gm/M²

Figure 6

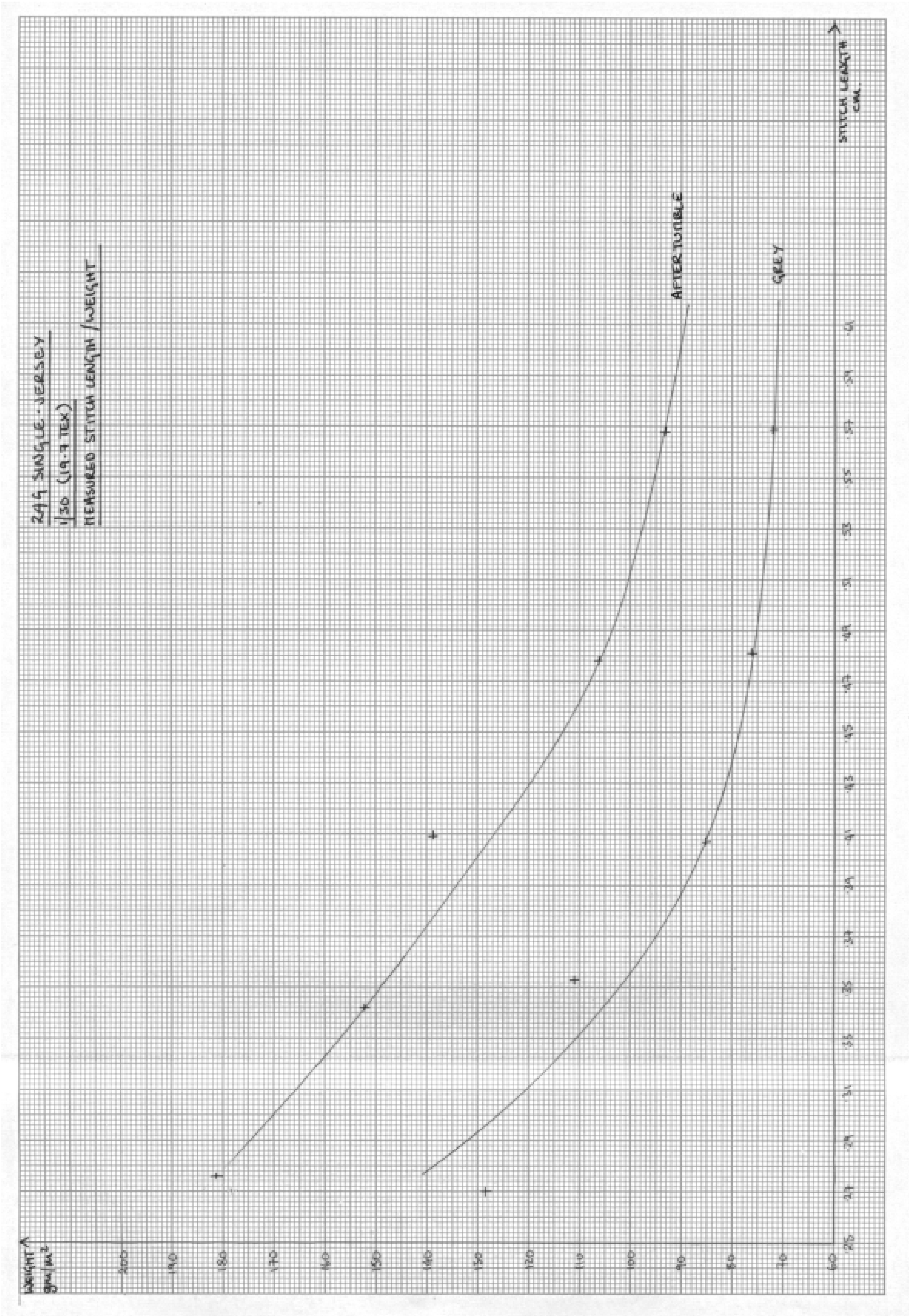

24G SINGLE · JERSEY
1/30 (19.7 TEX)
MEASURED STITCH LENGTH / WEIGHT
AFTER TUMBLE
GREY
STITCH LENGTH cm
WEIGHT gm/m²

Figure 7

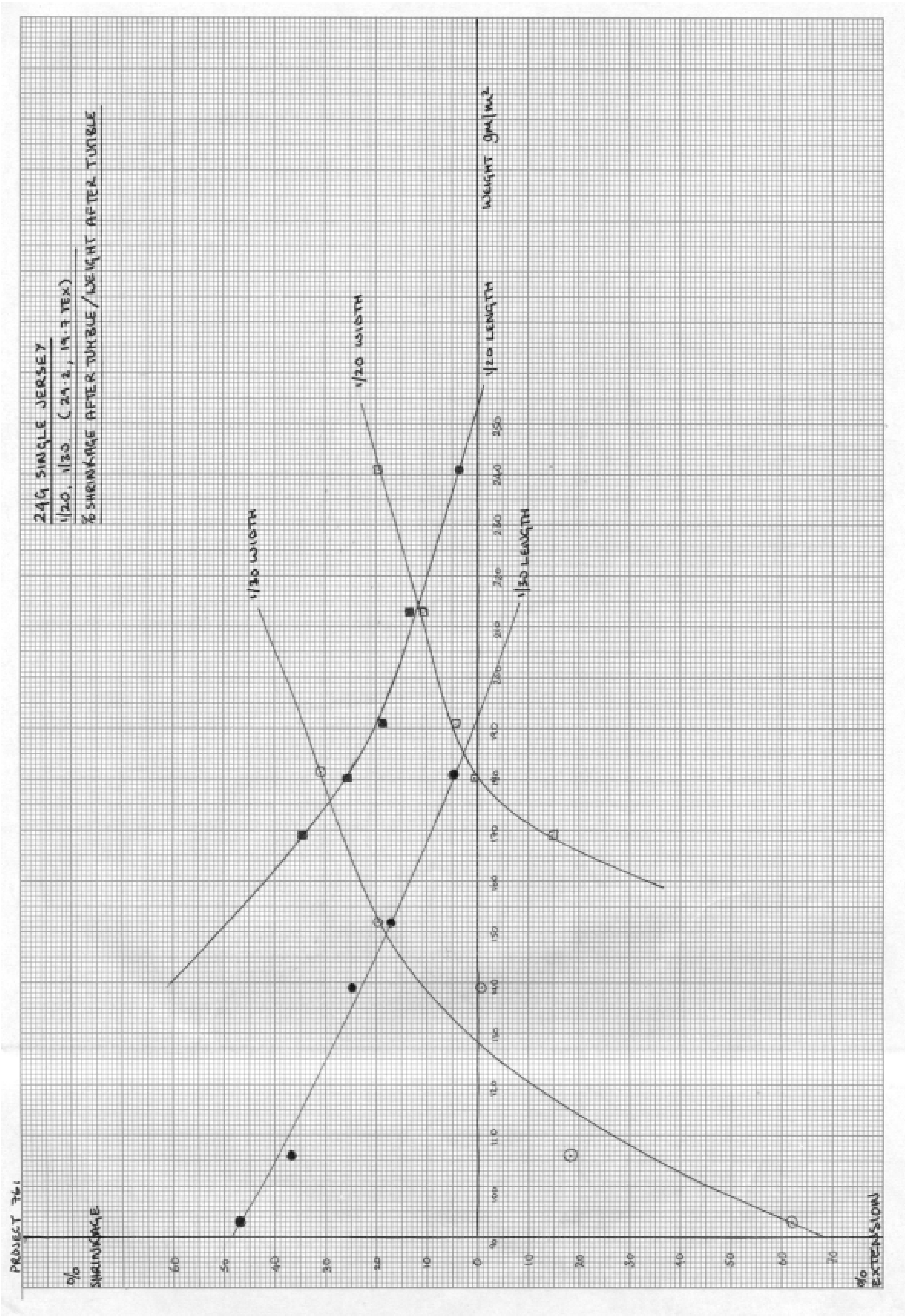

24G SINGLE JERSEY
1/20, 1/30, (29.2, 19.7 TEX)
% SHRINKAGE AFTER TUMBLE/WEIGHT AFTER TUMBLE
1/30 WIDTH
1/20 WIDTH
1/20 LENGTH
1/30 LENGTH
WEIGHT gm/m²
PROJECT 761
% SHRINKAGE
% EXTENSION

Figure 8

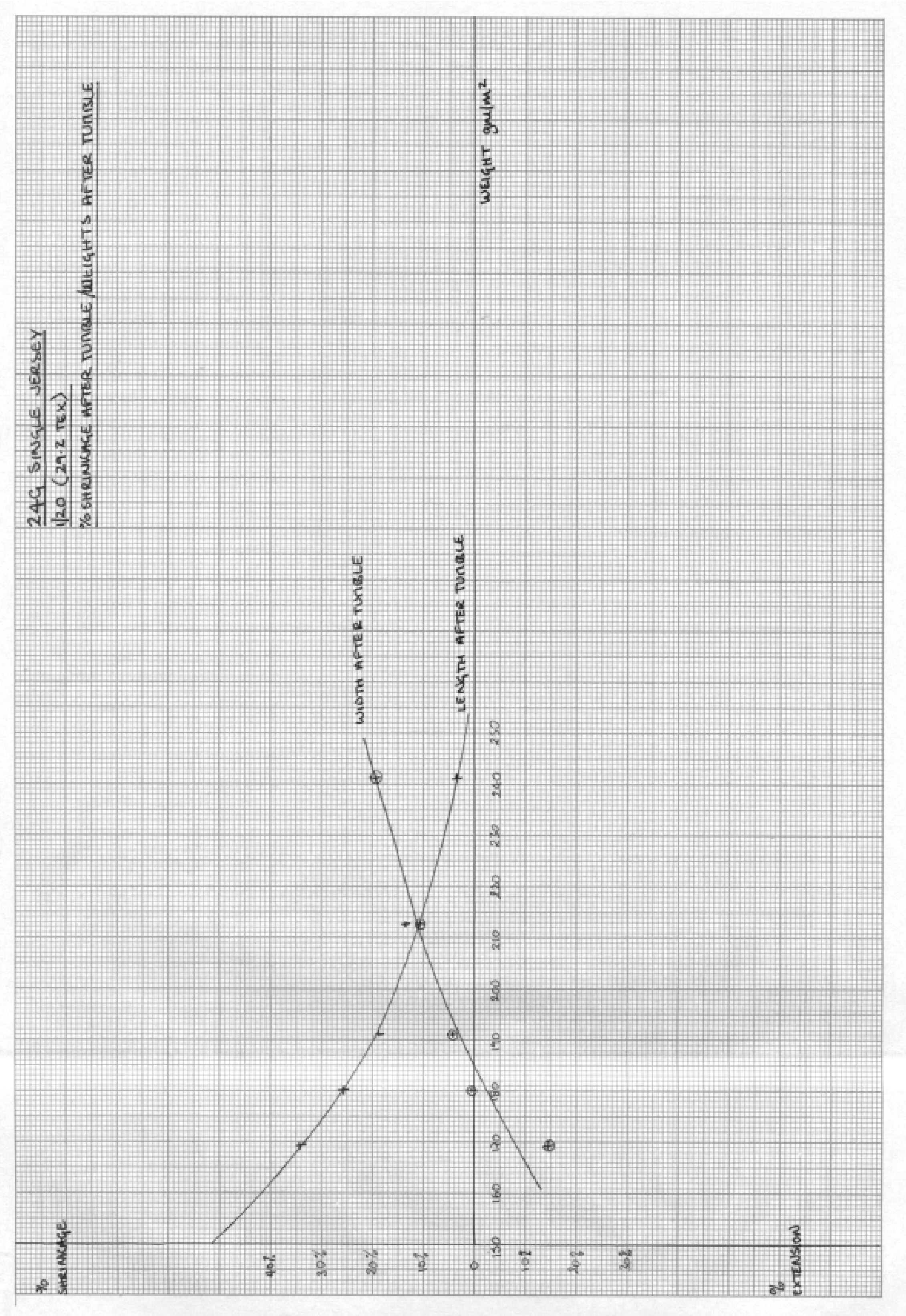
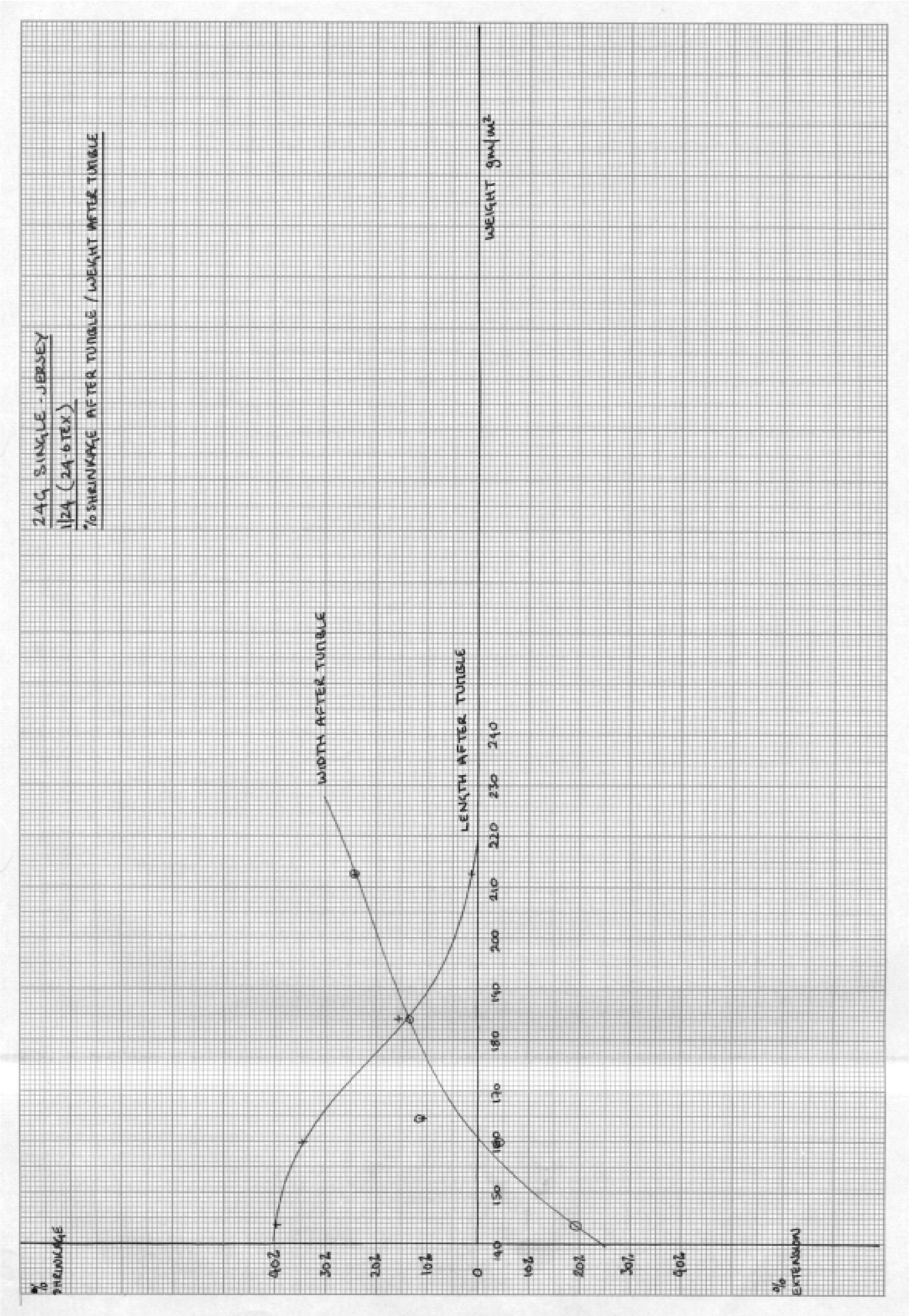
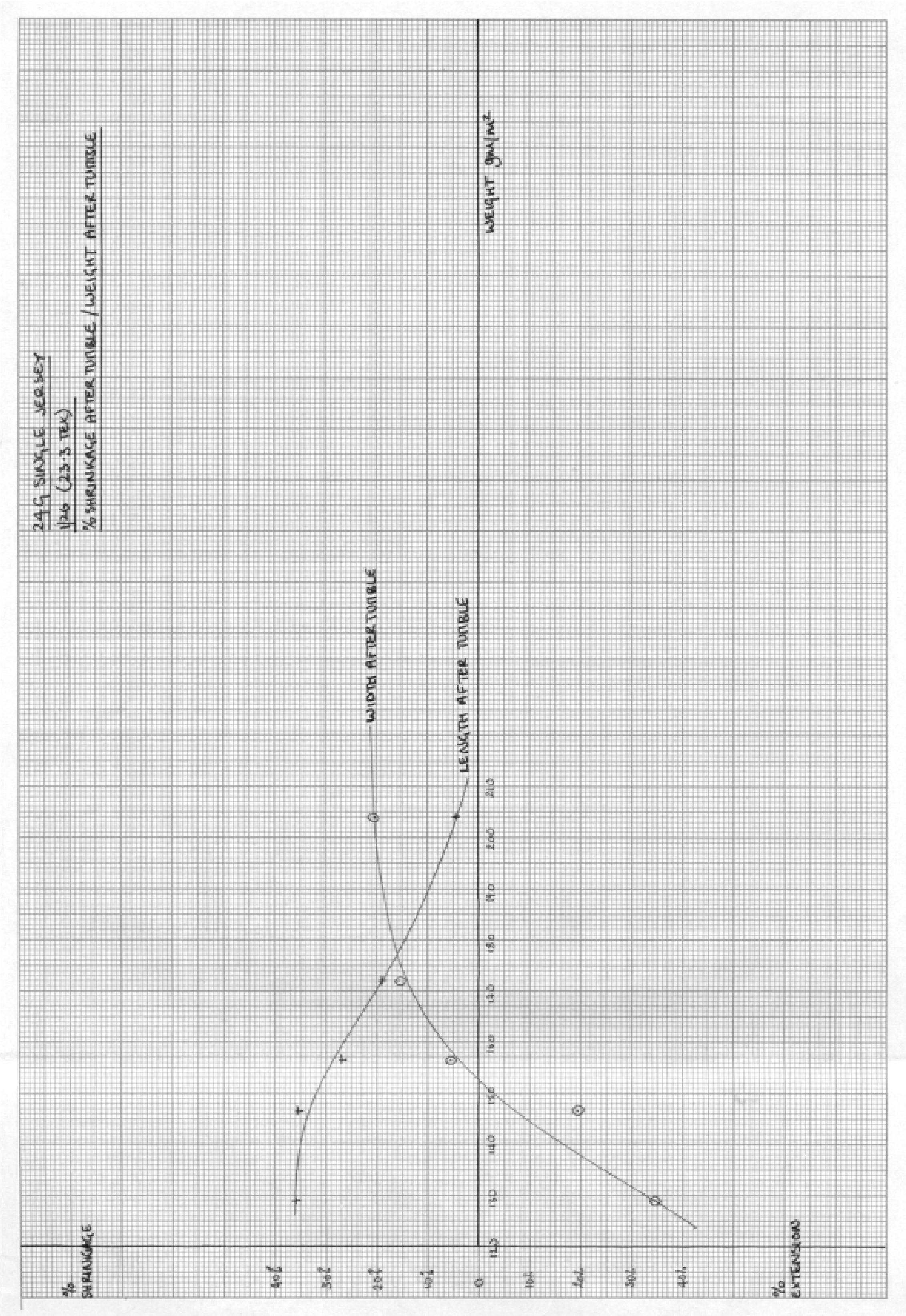

24G SINGLE JERSEY
1/20 (29.2 TEX)
% SHRINKAGE AFTER TUMBLE/WEIGHTS AFTER TUMBLE
WEIGHT gm/m²
WIDTH AFTER TUMBLE
LENGTH AFTER TUMBLE
% SHRINKAGE
% EXTENSION

Figure 9



24G SINGLE - JERSEY
1/24 (24.6TEX)
% SHRINKAGE AFTER TUMBLE / WEIGHT AFTER TUMBLE
WIDTH AFTER TUMBLE
LENGTH AFTER TUMBLE
WEIGHT gm/m²
% SHRINKAGE
% EXTENSION
40%
30%
20%
10%
0
10%
20%
30%
40%
140
150
160
170
180
190
200
210
220
230
240

Figure 10



24G SINGLE JERSEY
1/26 (23.3 TEX)
% SHRINKAGE AFTER TUMBLE / WEIGHT AFTER TUMBLE
WIDTH AFTER TUMBLE
LENGTH AFTER TUMBLE
WEIGHT gm/m²
% SHRINKAGE
% EXTENSION

Figure 11

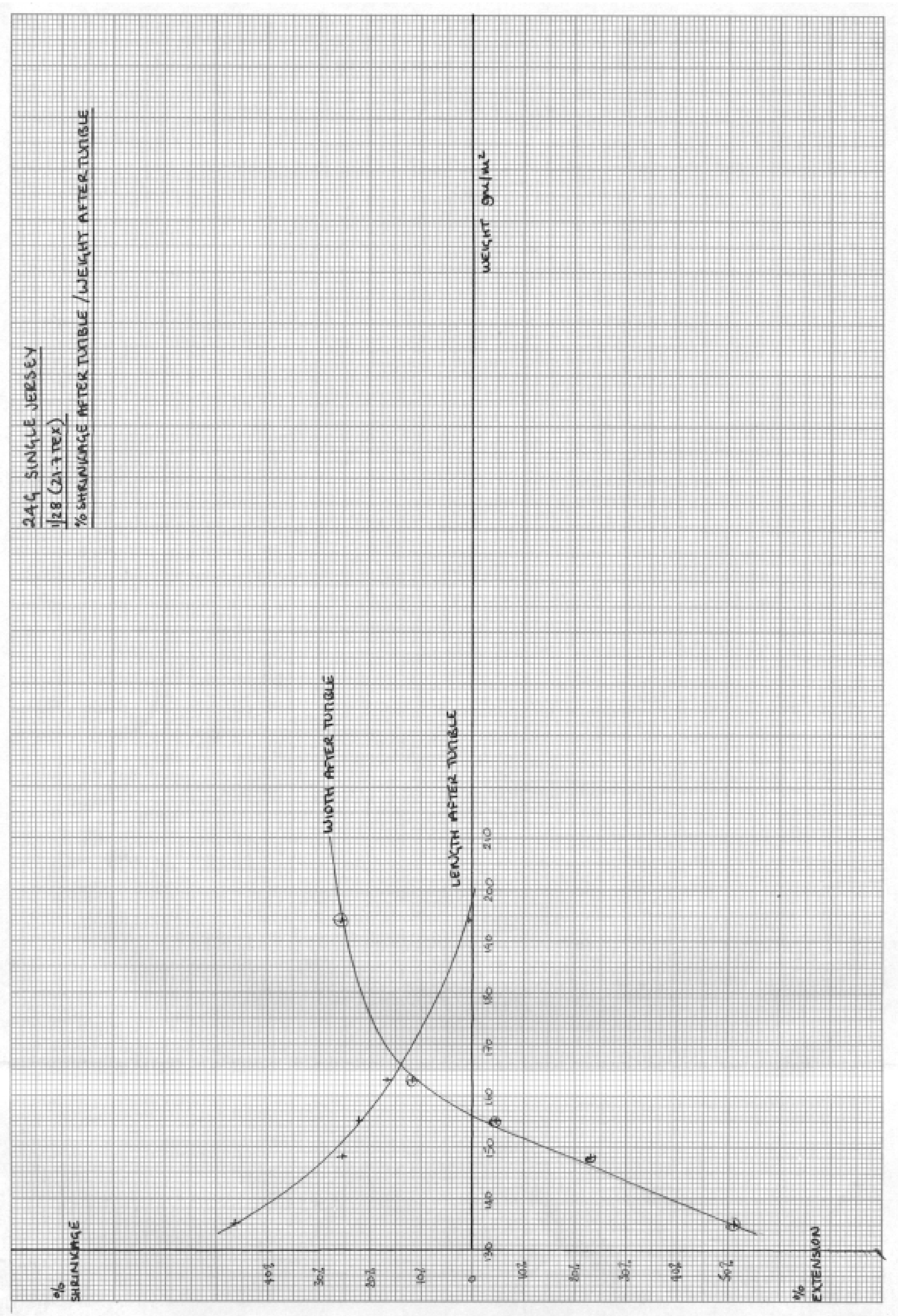

24G SINGLE JERSEY
1/28 (21.7 TEX)
% SHRINKAGE AFTER TUMBLE / WEIGHT AFTER TUMBLE
WIDTH AFTER TUMBLE
LENGTH AFTER TUMBLE
WEIGHT gm/m²
% SHRINKAGE
% EXTENSION
130
140
150
160
170
180
190
200
210
40%
30%
20%
10%
0
10%
20%
30%
40%
50%

Figure 12

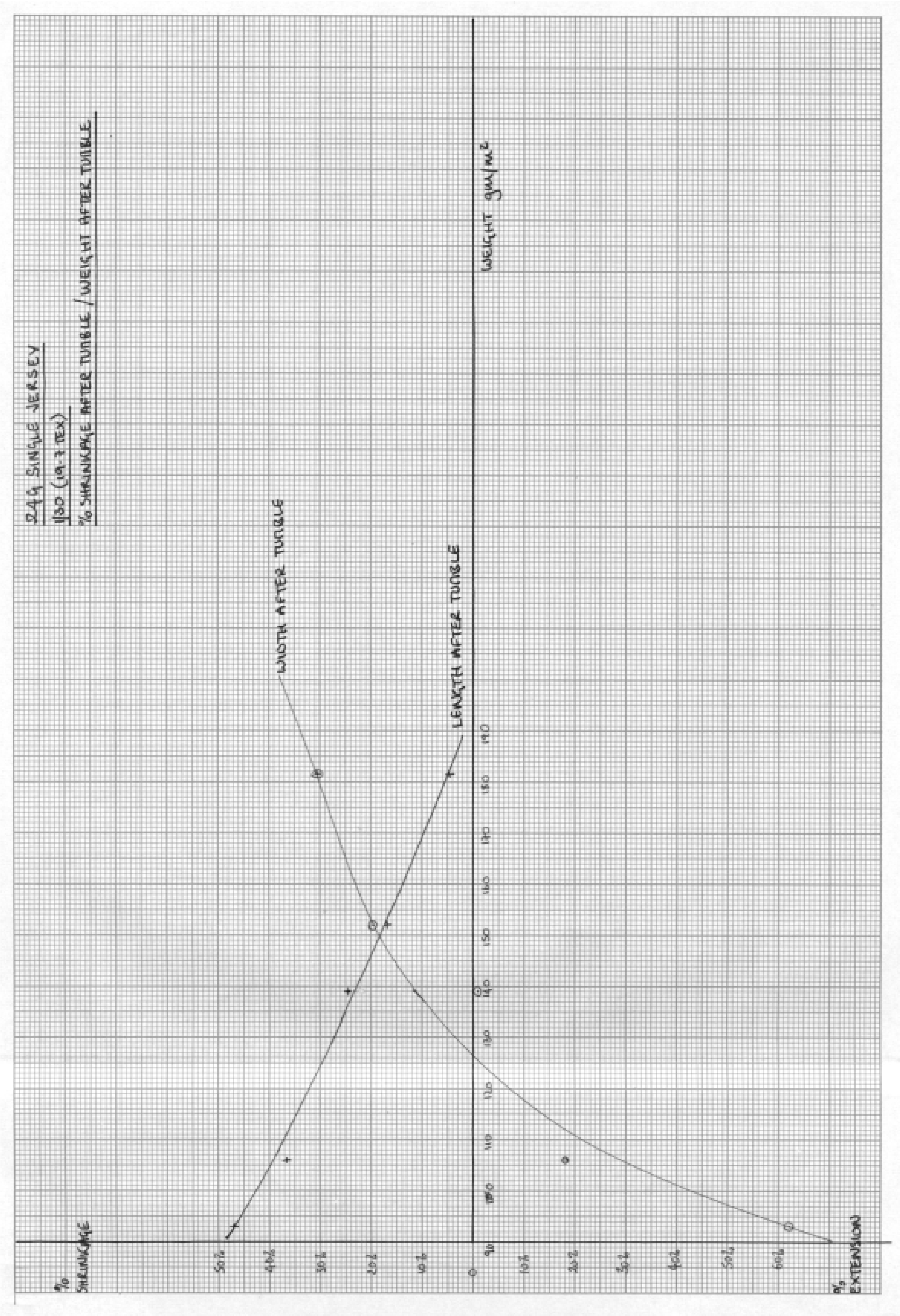
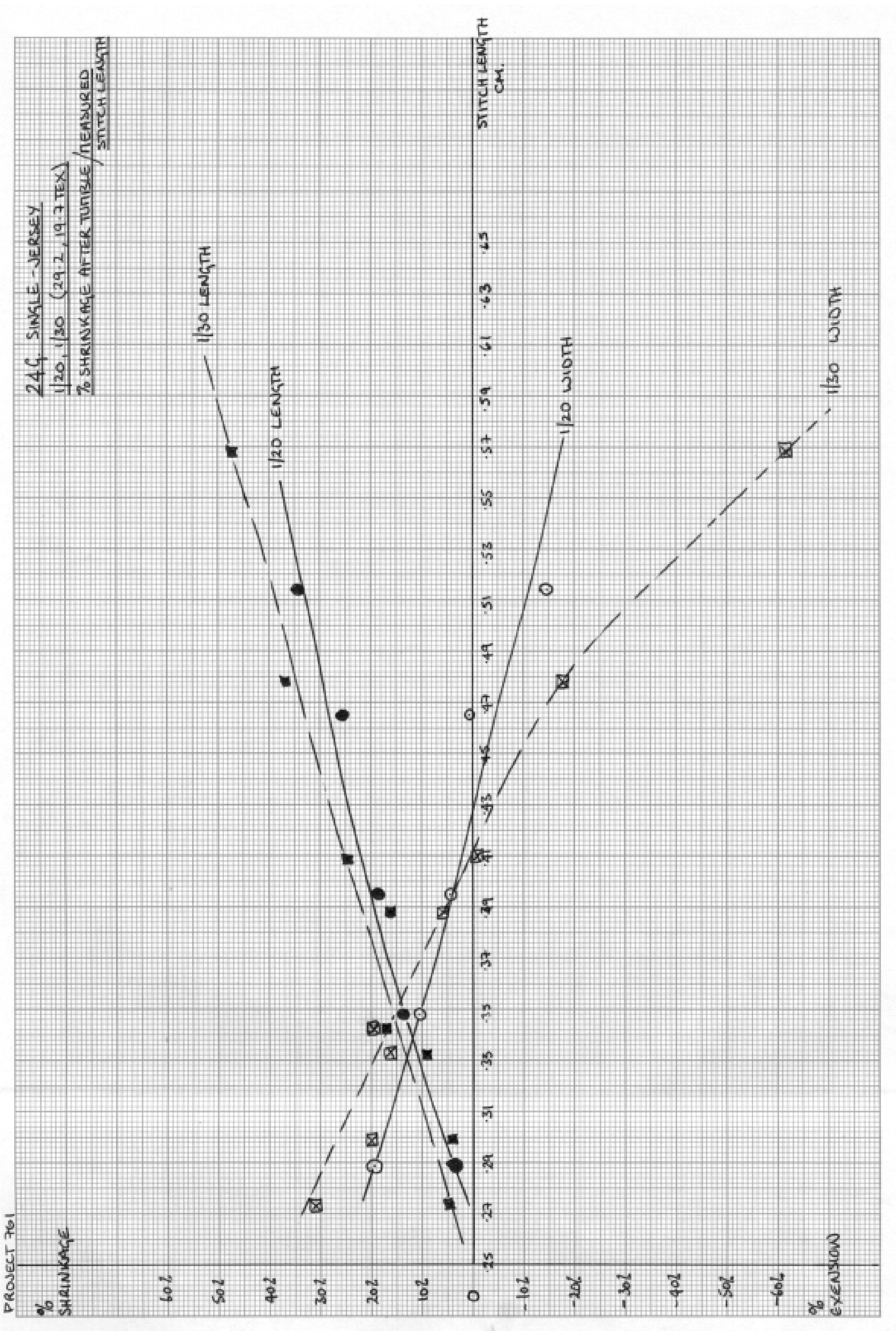

24g SINGLE JERSEY
1/30 (19.7 TEX)
% SHRINKAGE AFTER TUMBLE / WEIGHT AFTER TUMBLE
WIDTH AFTER TUMBLE
LENGTH AFTER TUMBLE
WEIGHT gm/m2
% SHRINKAGE
% EXTENSION

Figure 13



PROJECT 761
% SHRINKAGE
246 SINGLE-JERSEY
1/20, 1/30 (29.2, 19.7 TEX)
% SHRINKAGE AFTER TUMBLE / MEASURED STITCH LENGTH
1/30 LENGTH
1/20 LENGTH
1/20 WIDTH
1/30 WIDTH
STITCH LENGTH CM.
% EXTENSION

Figure 14

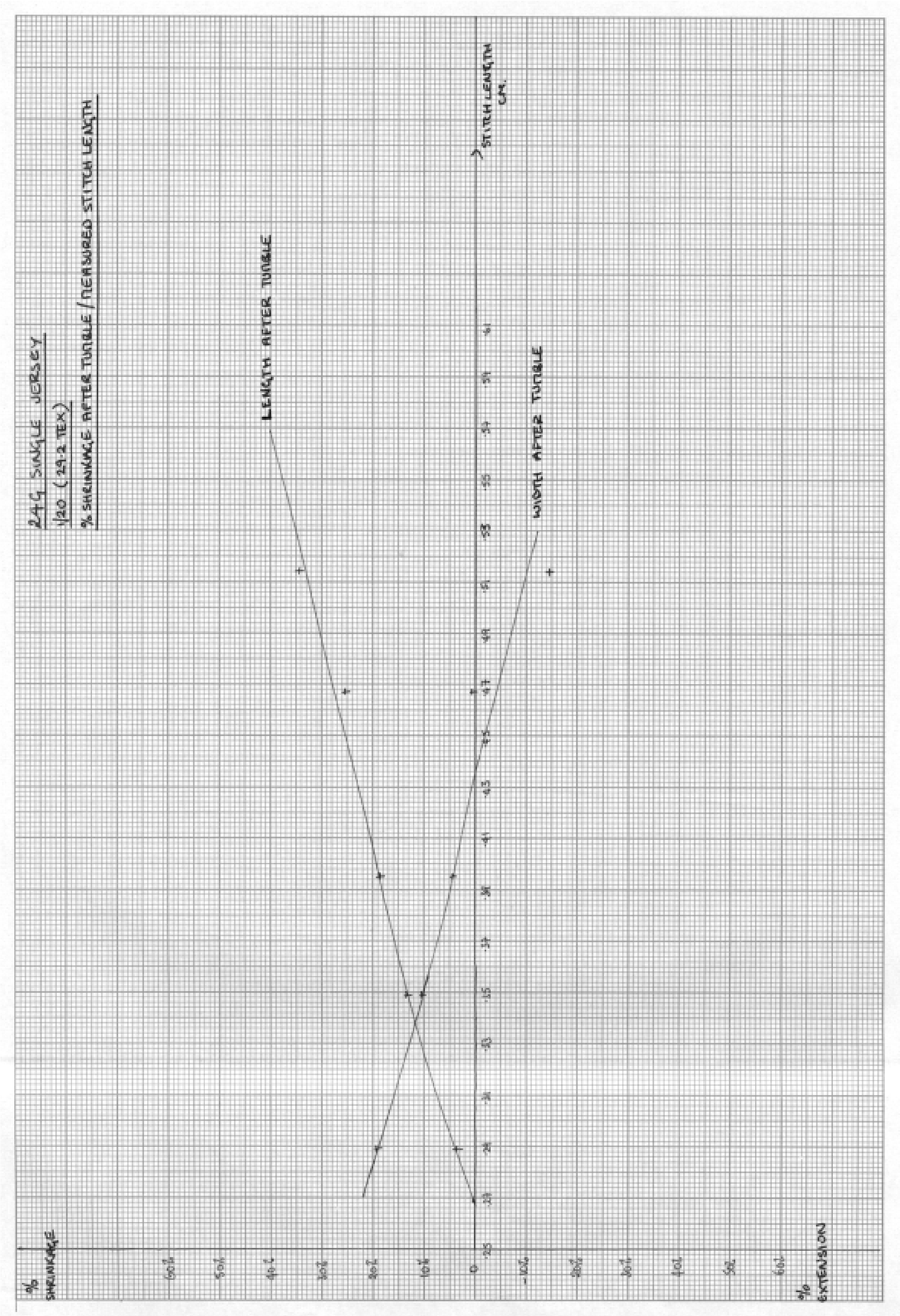

24G SINGLE JERSEY
1/20 (29.2 TEX)
% SHRINKAGE AFTER TUMBLE / MEASURED STITCH LENGTH
LENGTH AFTER TUMBLE
WIDTH AFTER TUMBLE
STITCH LENGTH CM.
% SHRINKAGE
% EXTENSION

Figure 15

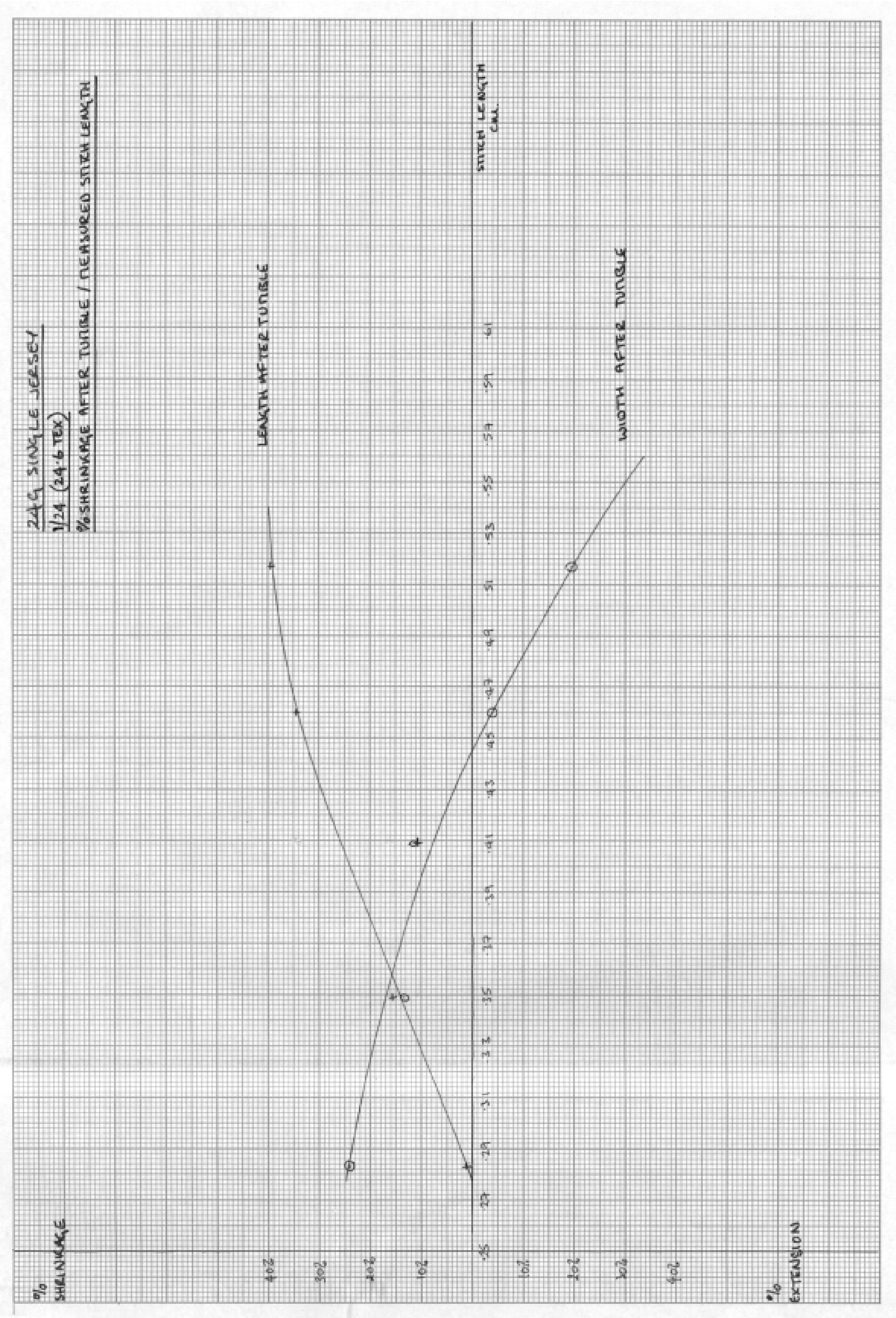
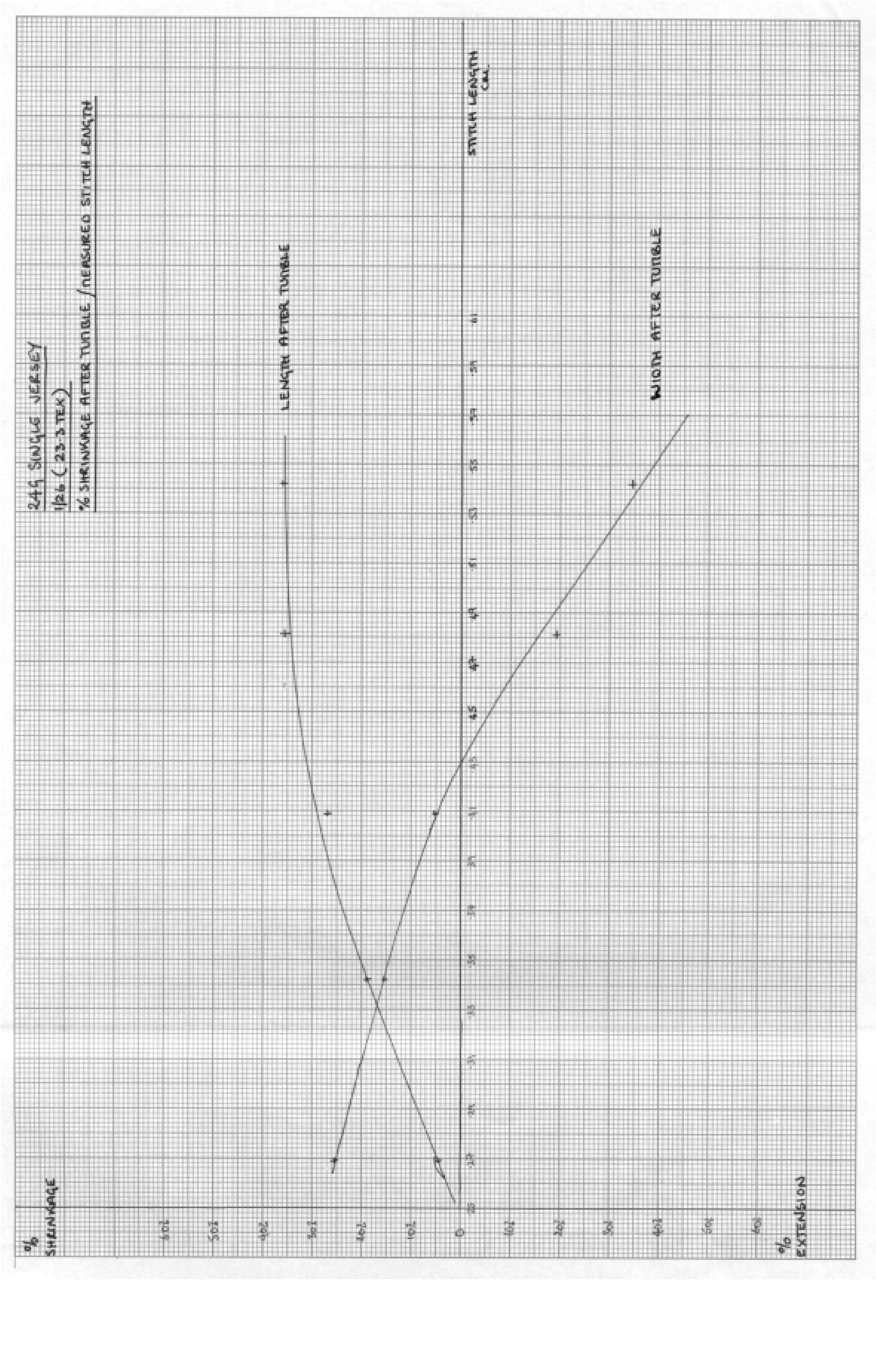

24G SINGLE JERSEY
1/24 (24.6 TEX)
% SHRINKAGE AFTER TUMBLE / MEASURED STITCH LENGTH
LENGTH AFTER TUMBLE
WIDTH AFTER TUMBLE
STITCH LENGTH CM.
% SHRINKAGE
% EXTENSION

Figure 16



24G SINGLE JERSEY
1/26 (23.3 TEX)
% SHRINKAGE AFTER TUMBLE / MEASURED STITCH LENGTH
LENGTH AFTER TUMBLE
WIDTH AFTER TUMBLE
STITCH LENGTH CM.
% SHRINKAGE
% EXTENSION

Figure 17

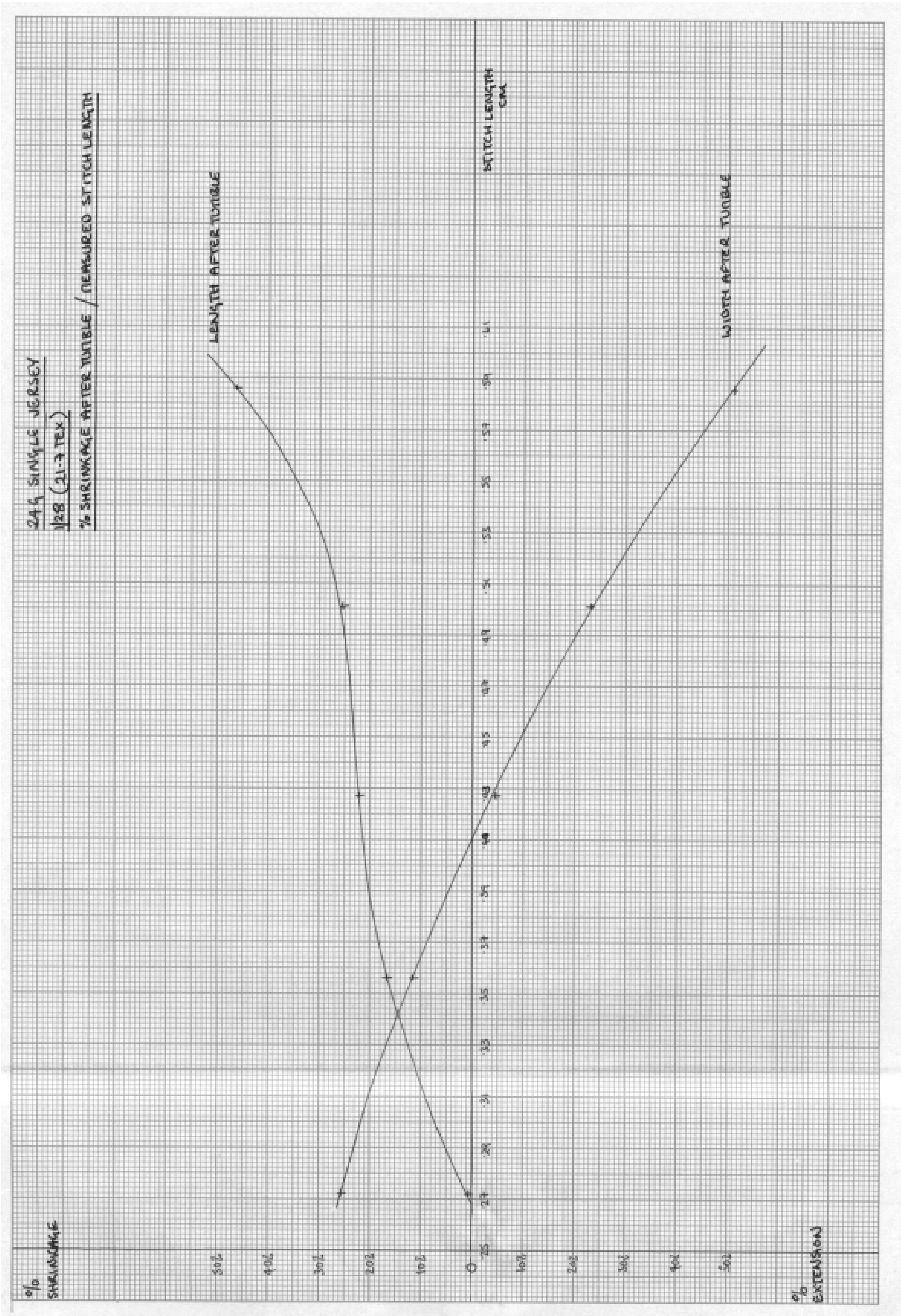

24G SINGLE JERSEY
1/28 (21.7 TEX)
% SHRINKAGE AFTER TUMBLE / MEASURED STITCH LENGTH
LENGTH AFTER TUMBLE
WIDTH AFTER TUMBLE
STITCH LENGTH CM
% SHRINKAGE
% EXTENSION

Figure 18

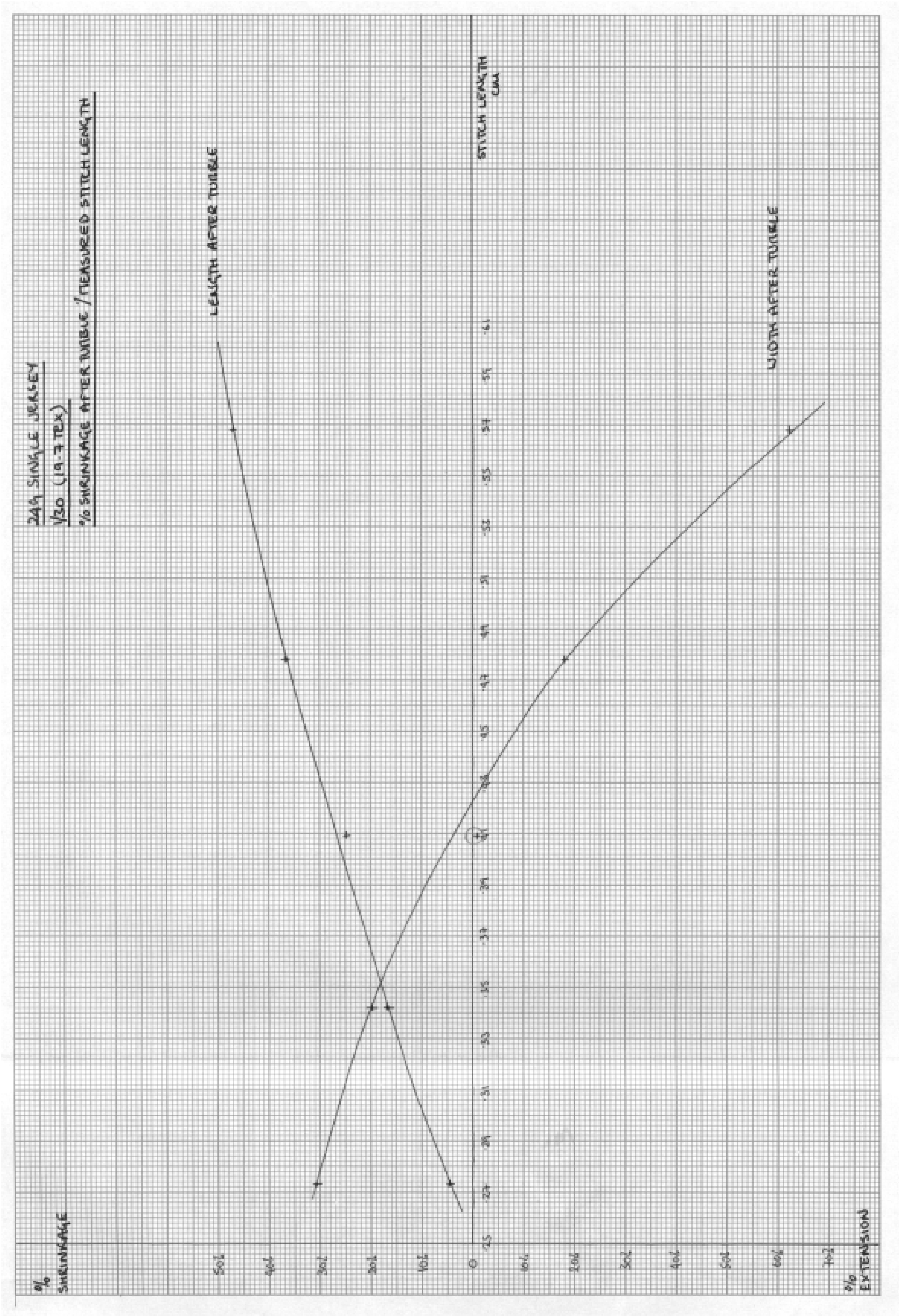

24G SINGLE JERSEY
1/30 (19.7 TEX)
% SHRINKAGE AFTER TUMBLE / MEASURED STITCH LENGTH
LENGTH AFTER TUMBLE
WIDTH AFTER TUMBLE
STITCH LENGTH CM
% SHRINKAGE
% EXTENSION

Figure 19

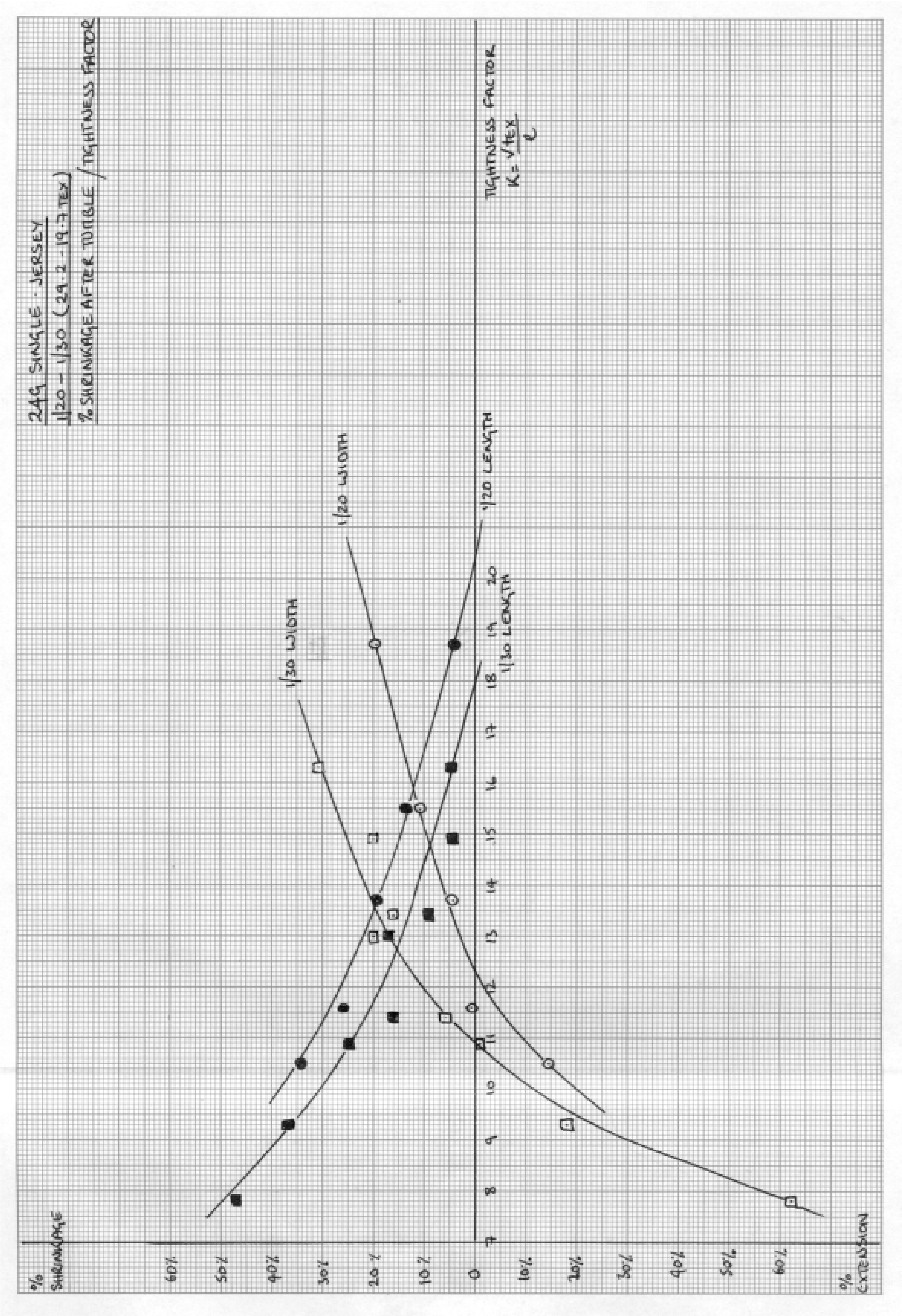

249 SINGLE · JERSEY
1/20 – 1/30 (29.2 – 19.7 TEX)
% SHRINKAGE AFTER TUMBLE / TIGHTNESS FACTOR
1/20 WIDTH
1/30 WIDTH
1/20 LENGTH
1/30 LENGTH
TIGHTNESS FACTOR
K = √TEX / ℓ
% SHRINKAGE
% EXTENSION
60%
50%
40%
30%
20%
10%
0
10%
20%
30%
40%
50%
60%
7
8
9
10
11
12
13
14
15
16
17
18
19
20

Figure 20

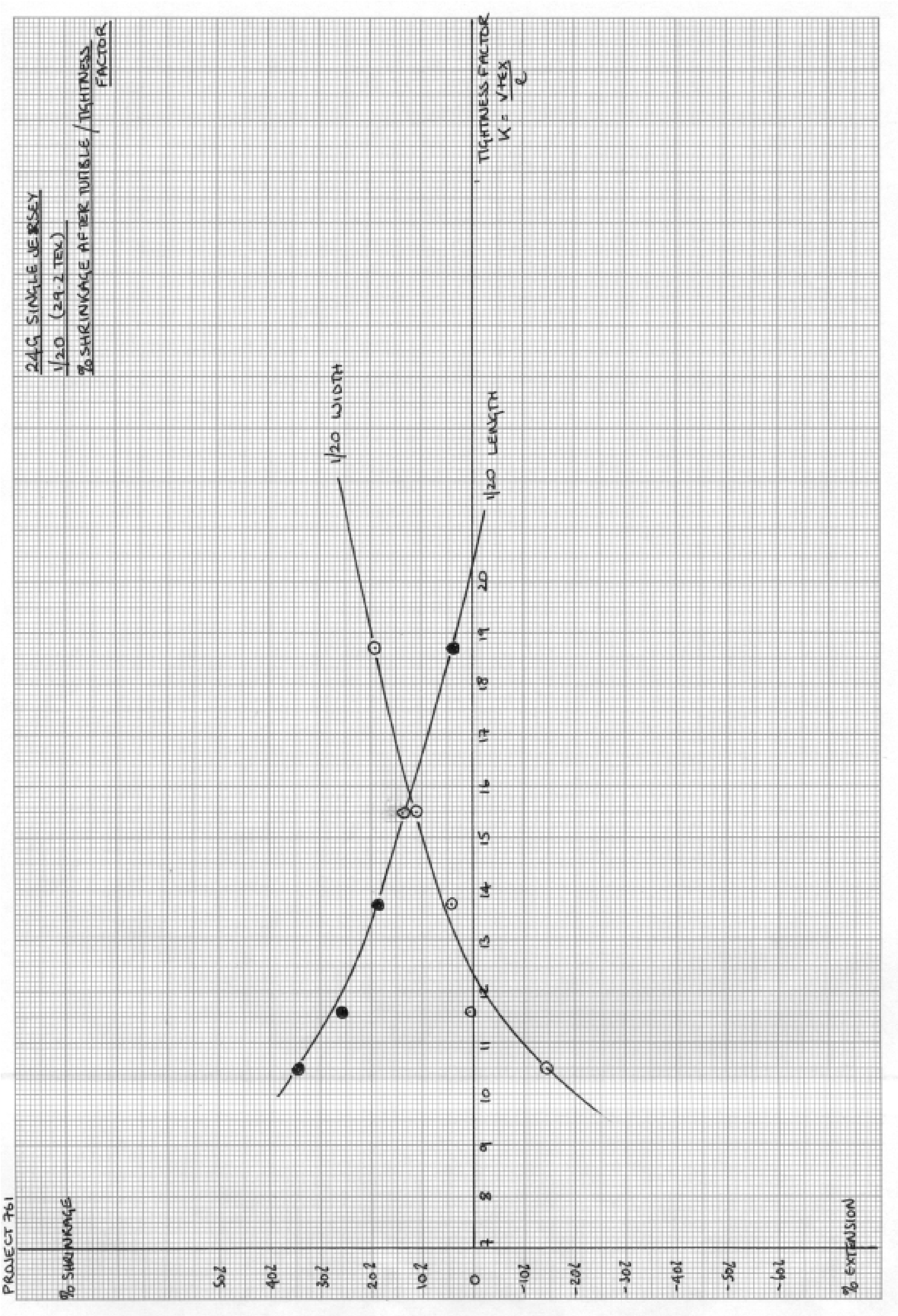
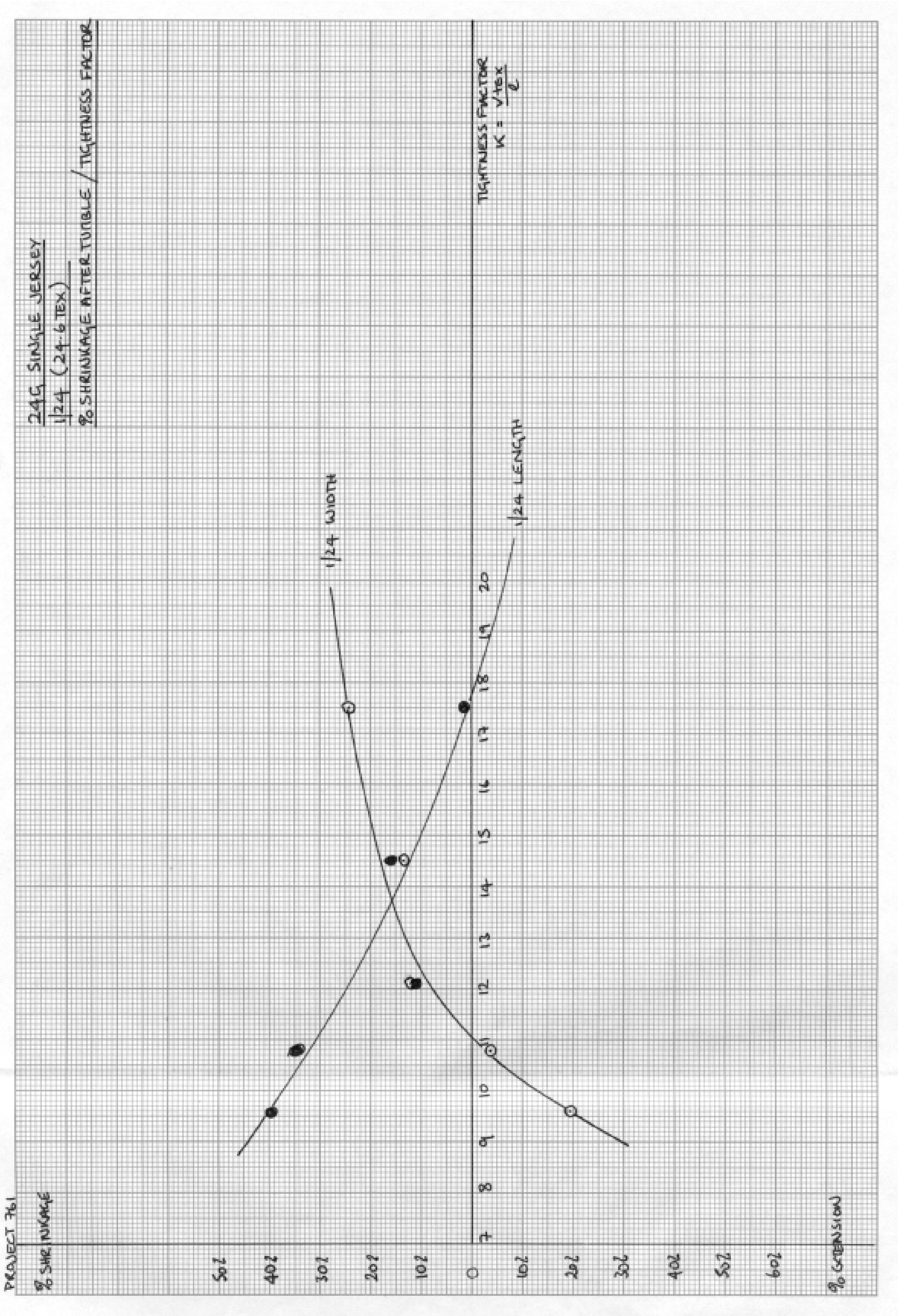

PROJECT 761
% SHRINKAGE
24G SINGLE JERSEY
1/20 (29.2 TEX)
% SHRINKAGE AFTER TUMBLE / TIGHTNESS FACTOR
1/20 WIDTH
1/20 LENGTH
TIGHTNESS FACTOR
K = √TEX / ℓ
% EXTENSION

Figure 21



PROJECT 761
24G SINGLE JERSEY
1/24 (24·6 TEX)
% SHRINKAGE AFTER TUMBLE / TIGHTNESS FACTOR
% SHRINKAGE
% EXTENSION
TIGHTNESS FACTOR K = √tex / l
1/24 WIDTH
1/24 LENGTH

Figure 22

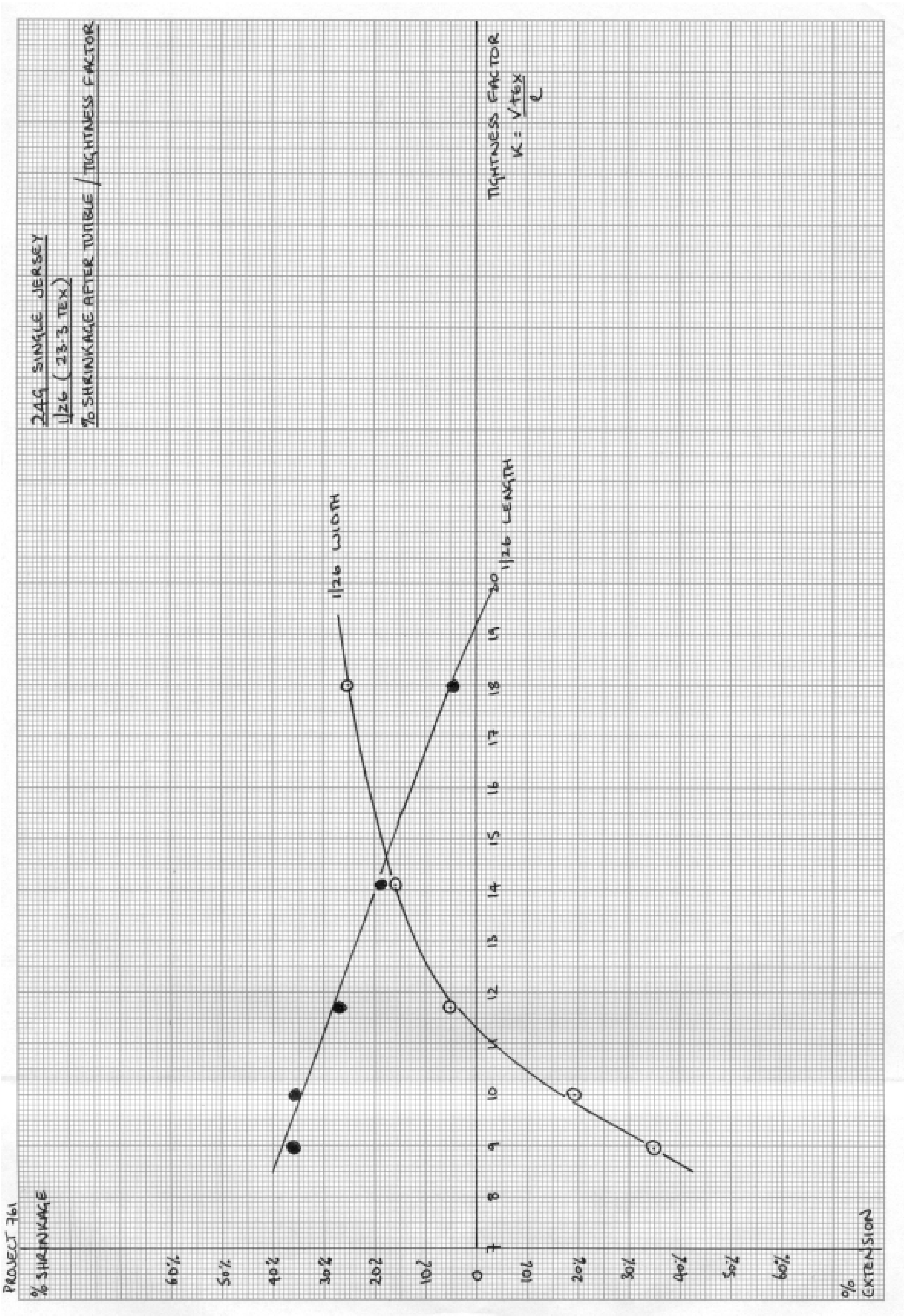

PROJECT 761
% SHRINKAGE
24G SINGLE JERSEY
1/26 (23.3 TEX)
% SHRINKAGE AFTER TUMBLE / TIGHTNESS FACTOR
1/26 WIDTH
1/26 LENGTH
TIGHTNESS FACTOR
K = √tex / ℓ
% EXTENSION

Figure 23

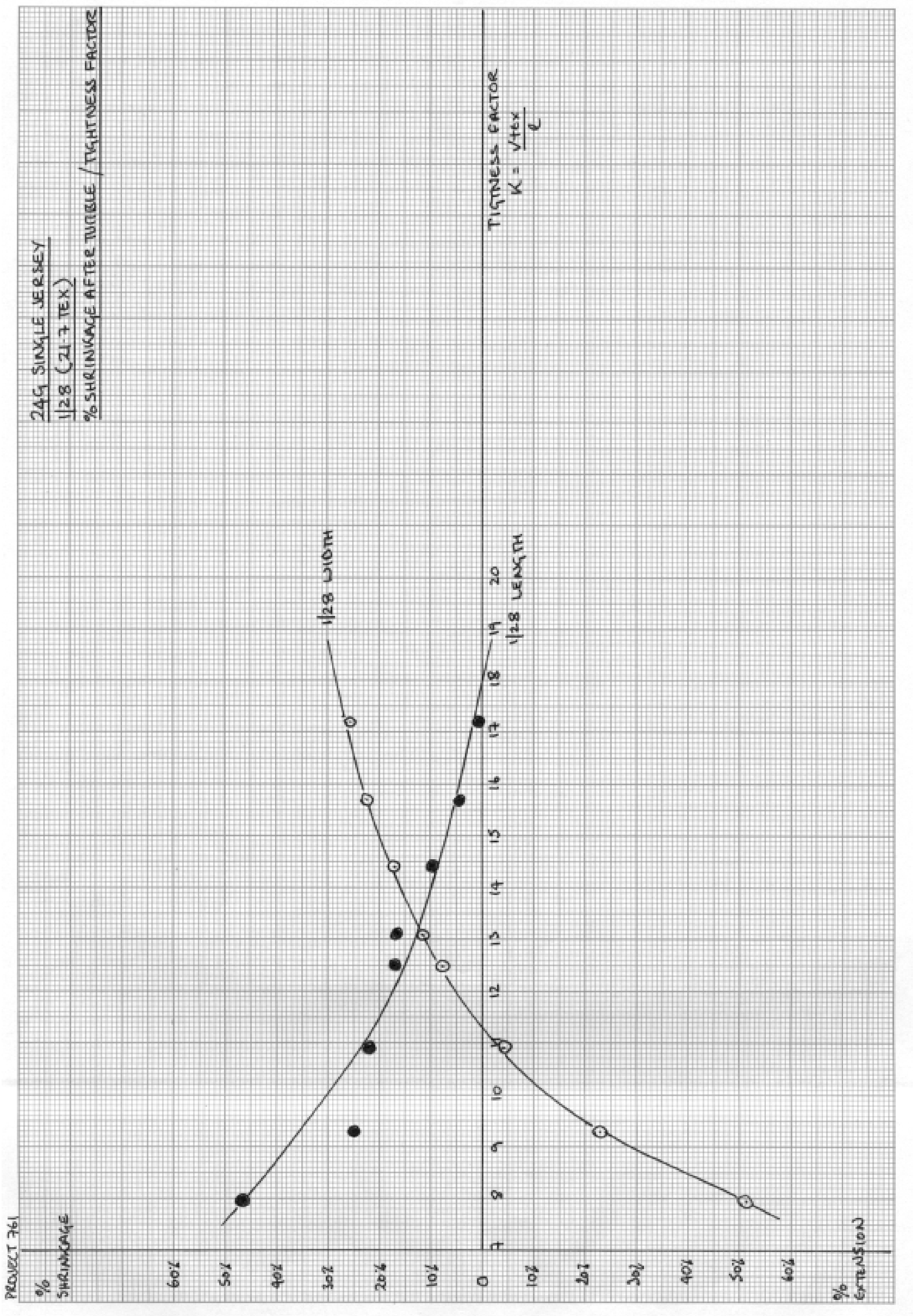
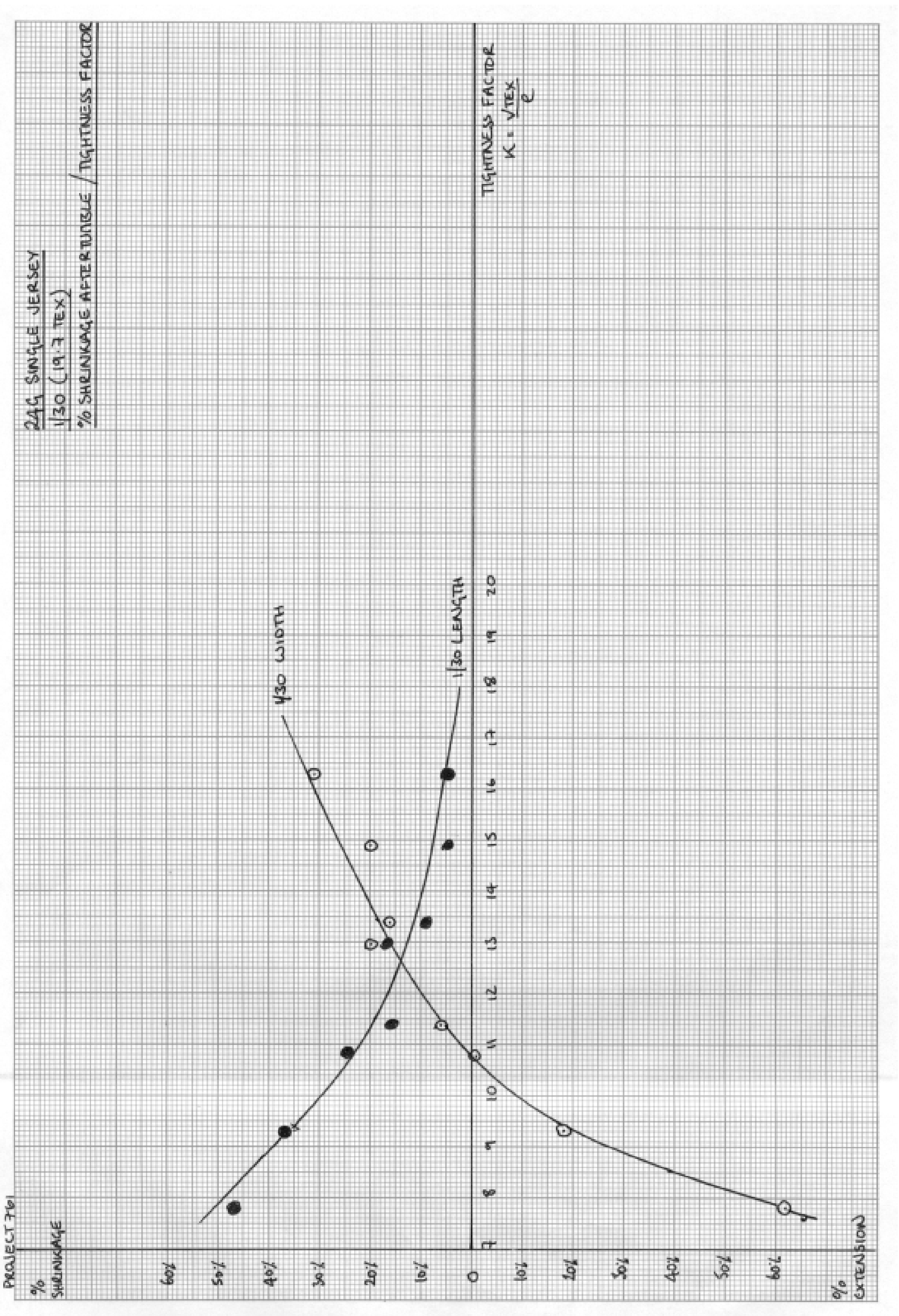
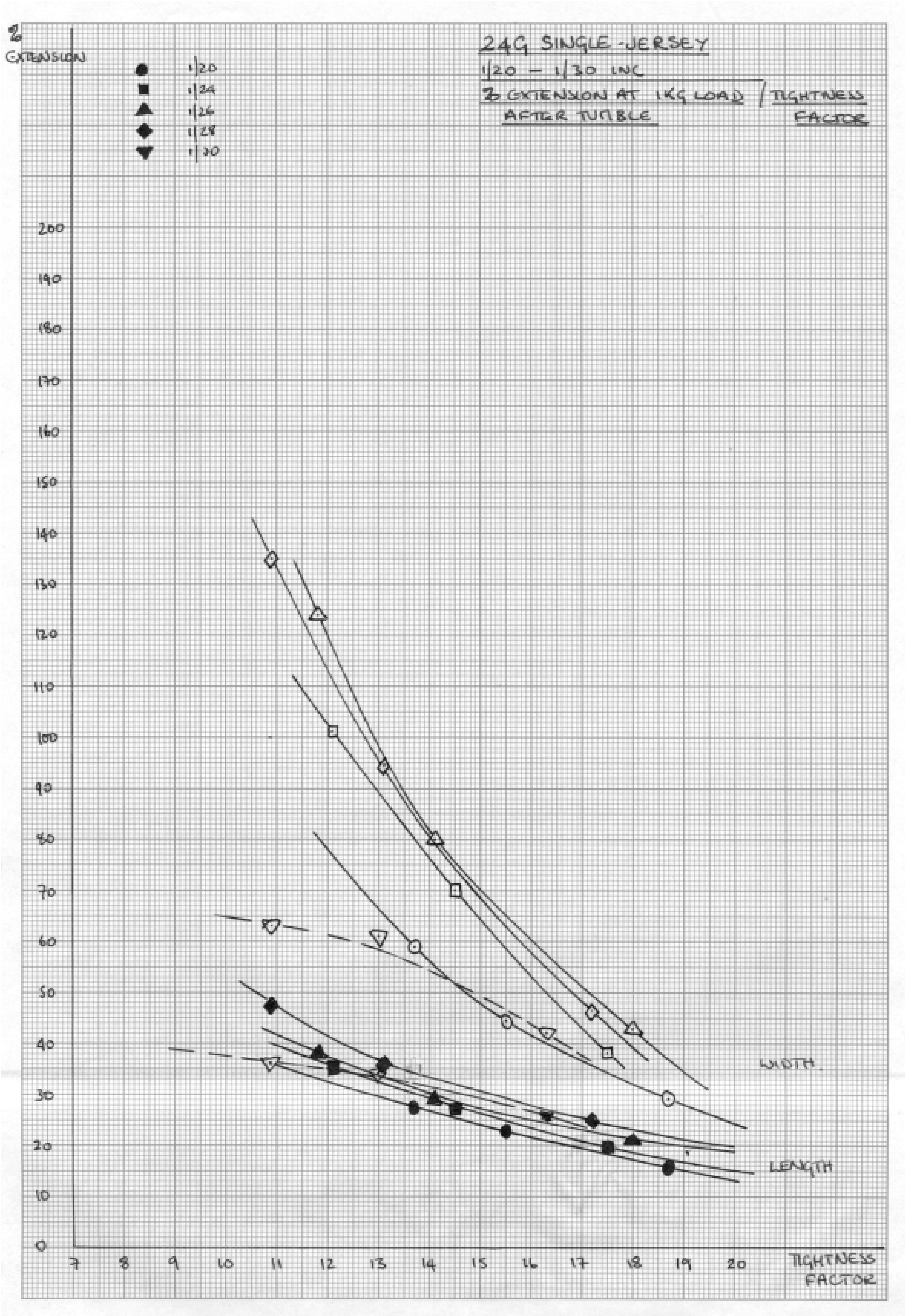

24G SINGLE JERSEY
1/28 (21.7 TEX)
% SHRINKAGE AFTER TUMBLE / TIGHTNESS FACTOR
TIGHTNESS FACTOR
K = √tex / ℓ
1/28 WIDTH
1/28 LENGTH
PROJECT 761
% SHRINKAGE
% EXTENSION

Figure 24



24G SINGLE JERSEY
1/30 (19.7 TEX)
% SHRINKAGE AFTER TUMBLE / TIGHTNESS FACTOR
TIGHTNESS FACTOR
K = √TEX / ℓ
1/30 WIDTH
1/30 LENGTH
PROJECT 761
% SHRINKAGE
% EXTENSION

Figure 25



%
EXTENSION
1/20
1/24
1/26
1/28
1/30
24G SINGLE-JERSEY
1/20 – 1/30 INC
% EXTENSION AT 1KG LOAD / TIGHTNESS FACTOR
AFTER TUMBLE
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
7
8
9
10
11
12
13
14
15
16
17
18
19
20
TIGHTNESS FACTOR
WIDTH
LENGTH

Figure 26

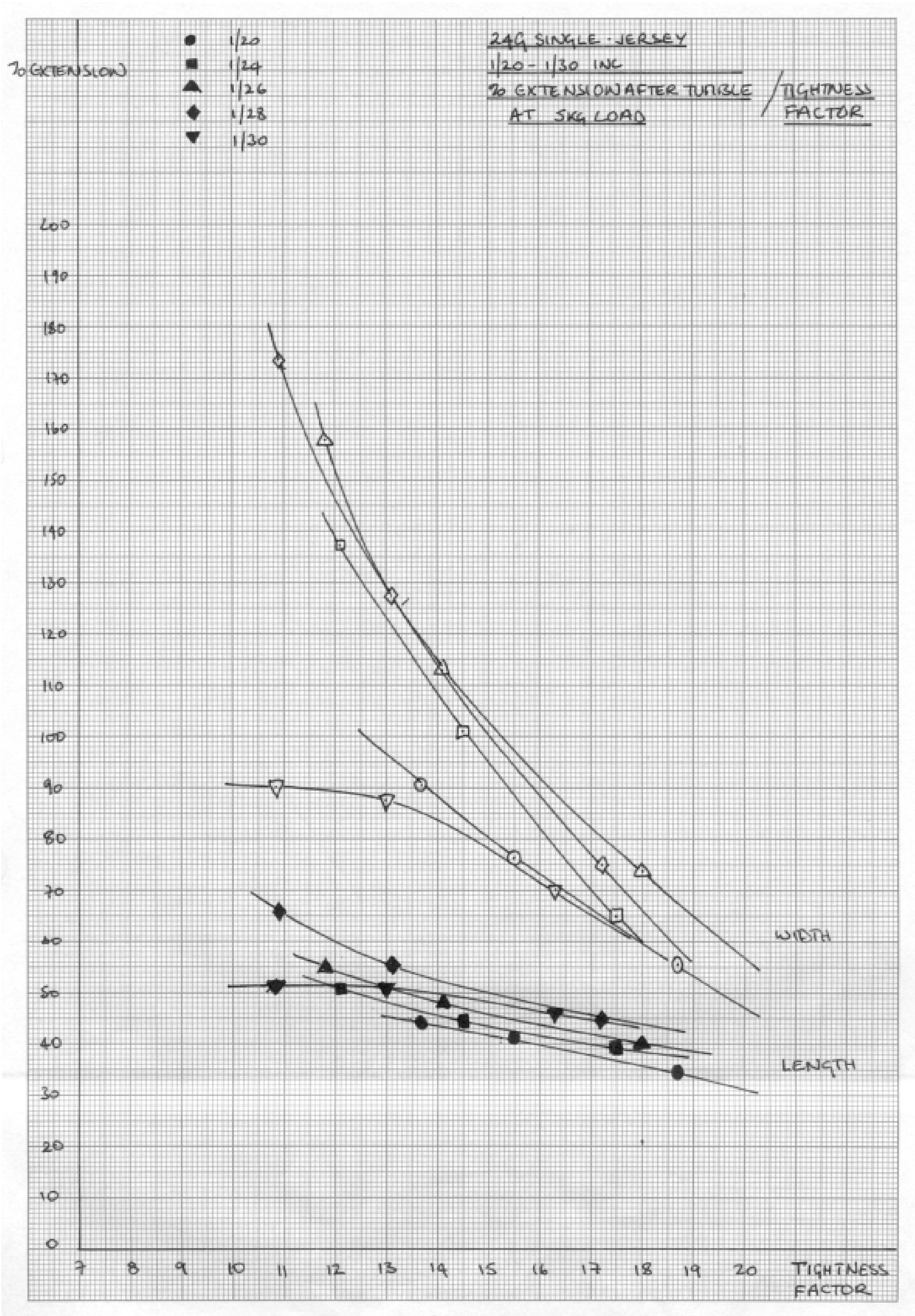
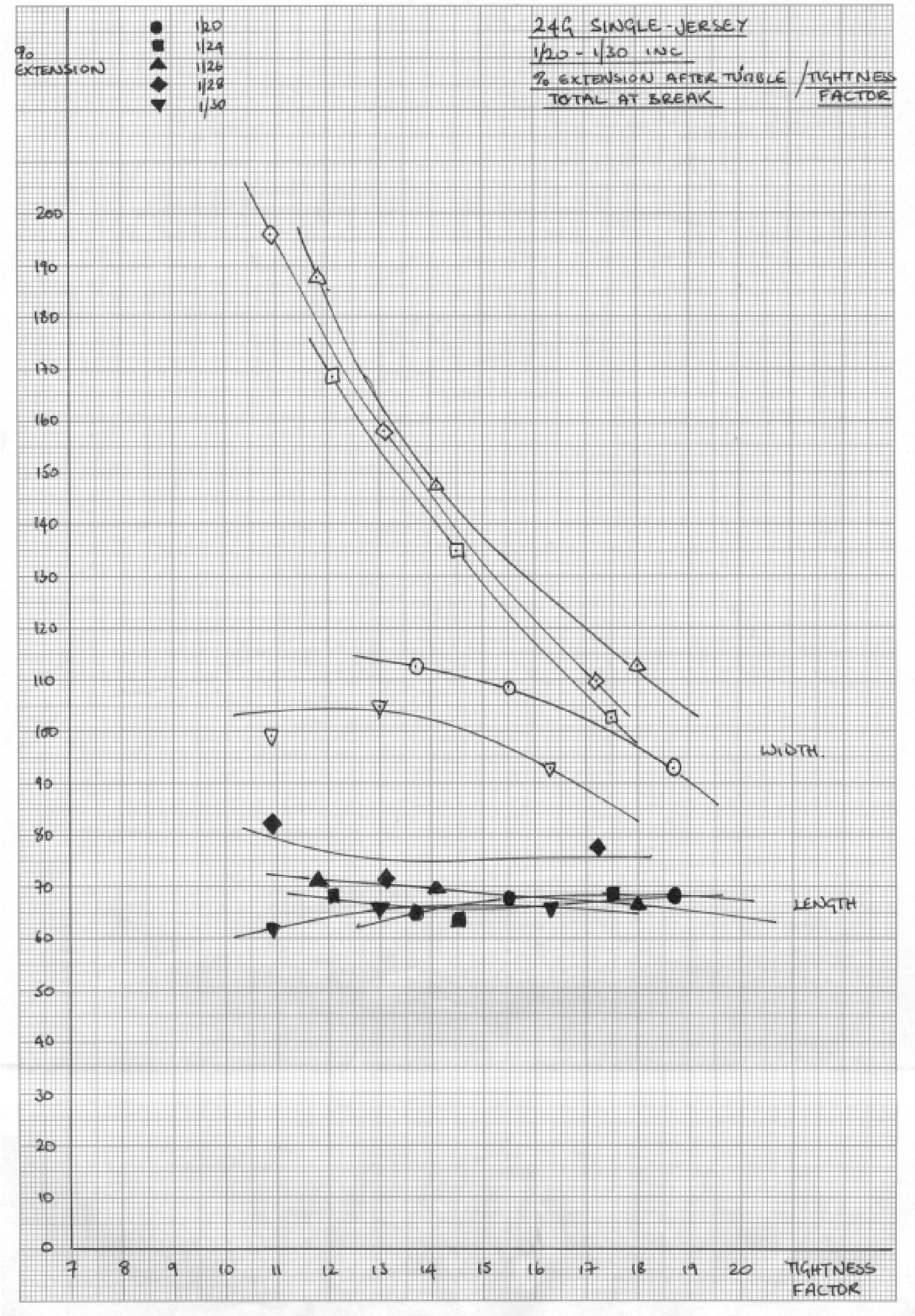
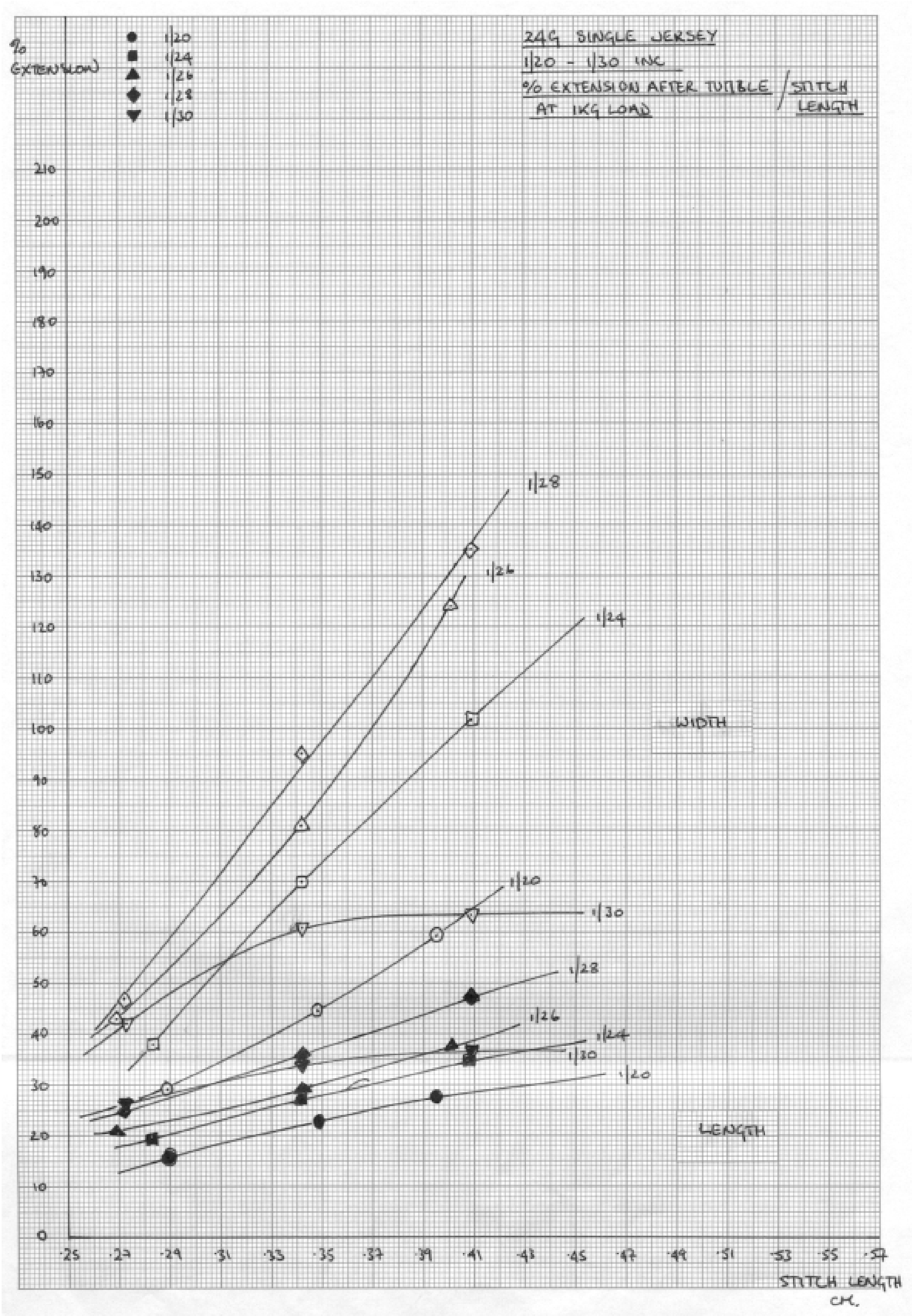

% EXTENSION
1/20
1/24
1/26
1/28
1/30
24G SINGLE - JERSEY
1/20 - 1/30 INC
% EXTENSION AFTER TUMBLE AT 5KG LOAD
/ TIGHTNESS FACTOR
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
7
8
9
10
11
12
13
14
15
16
17
18
19
20
TIGHTNESS FACTOR
WIDTH
LENGTH

Figure 27



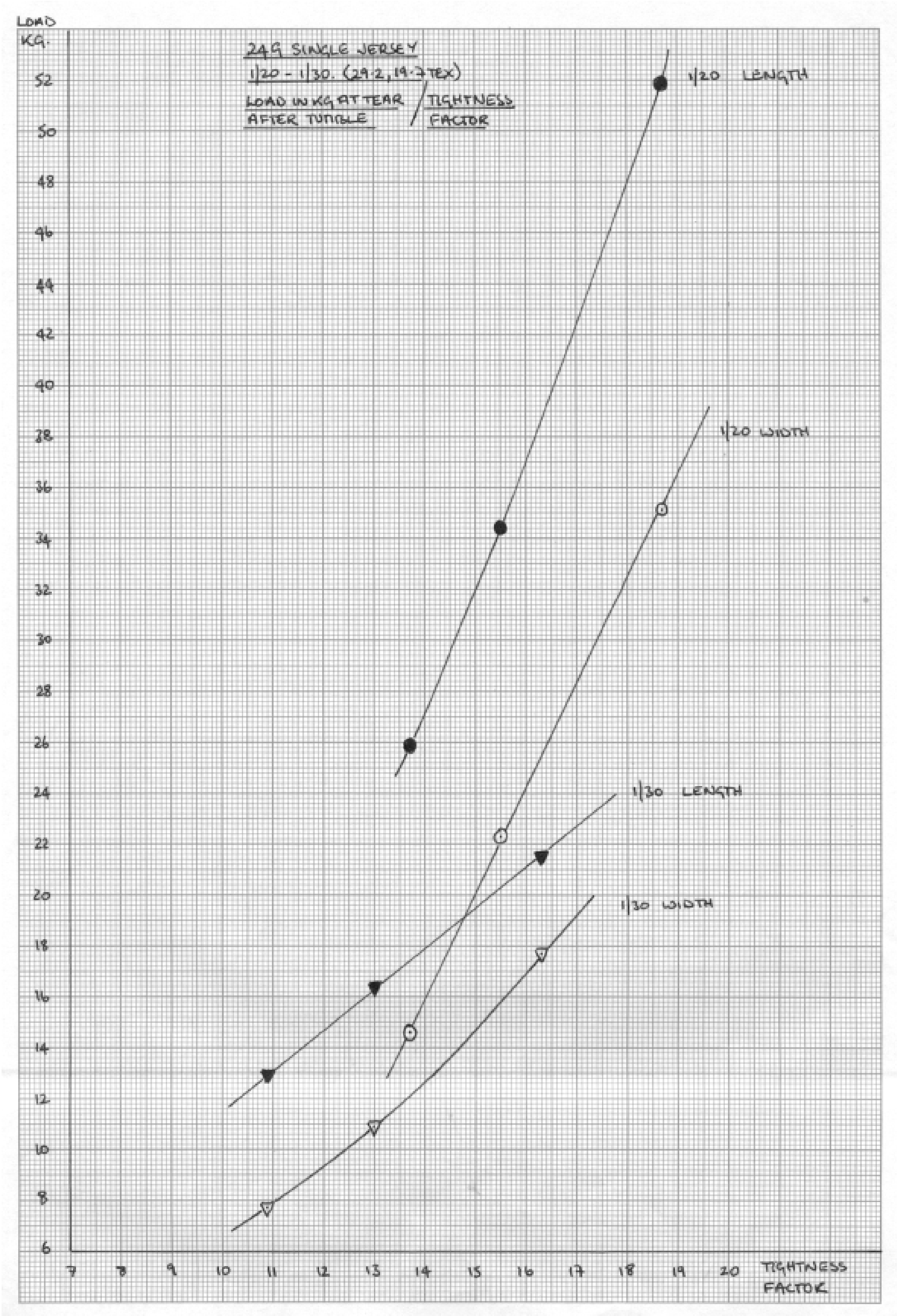
24G SINGLE-JERSEY
1/20 - 1/30 INC
% EXTENSION AFTER TUMBLE / TOTAL AT BREAK / TIGHTNESS FACTOR
% EXTENSION
1/20
1/24
1/26
1/28
1/30
WIDTH.
LENGTH
TIGHTNESS FACTOR

Figure 28



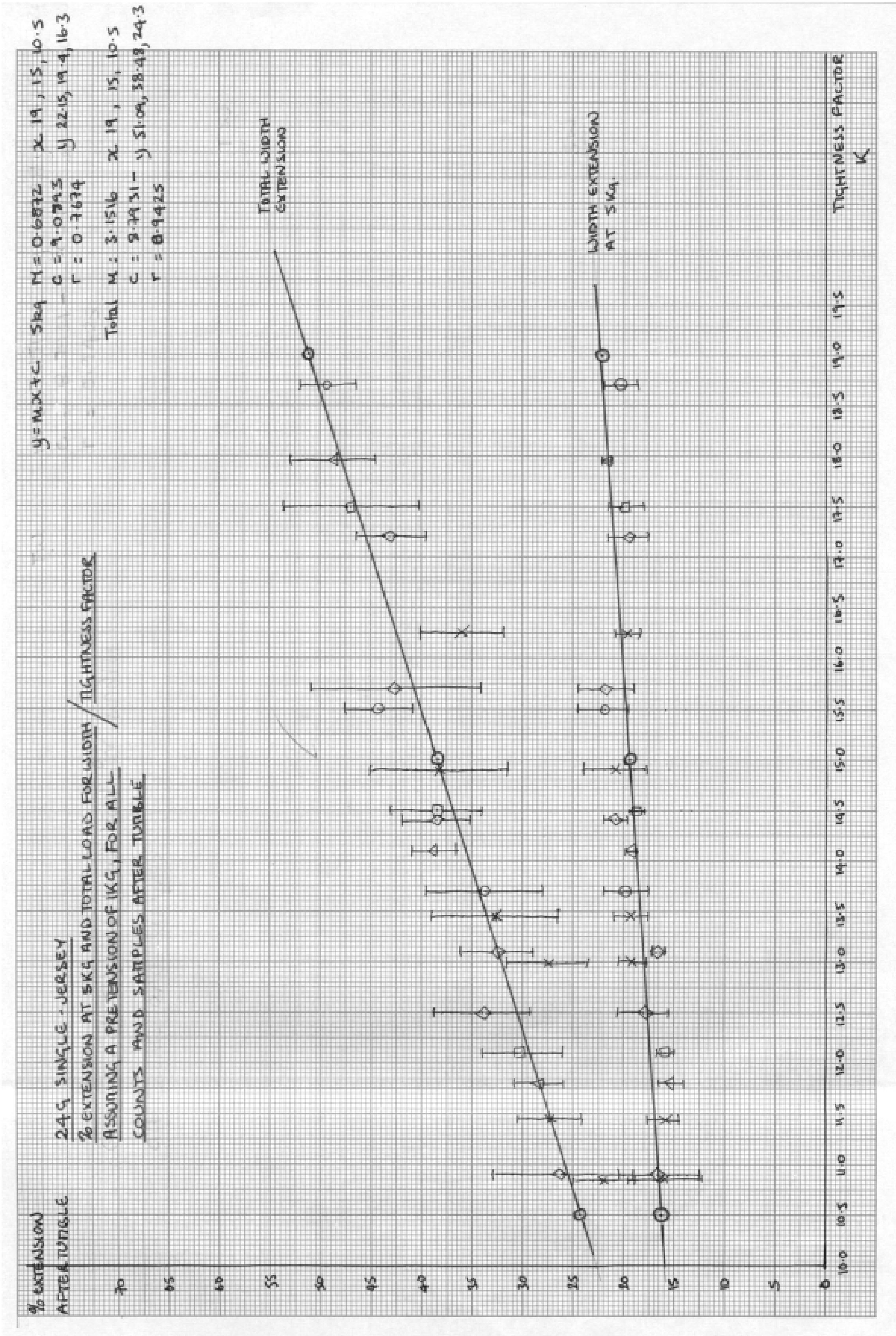
24G SINGLE JERSEY
1/20 - 1/30 INC
% EXTENSION AFTER TUMBLE / STITCH LENGTH
AT 1KG LOAD
% EXTENSION
1/20
1/24
1/26
1/28
1/30
WIDTH
LENGTH
STITCH LENGTH CM.

Figure 29



LOAD
KG.
24G SINGLE JERSEY
1/20 - 1/30. (29.2, 19.7 TEX)
LOAD IN KG AT TEAR AFTER TUMBLE / TIGHTNESS FACTOR
1/20 LENGTH
1/20 WIDTH
1/30 LENGTH
1/30 WIDTH
TIGHTNESS FACTOR

Figure 30



24g SINGLE - JERSEY
% EXTENSION AT 5KG AND TOTAL LOAD FOR WIDTH / TIGHTNESS FACTOR
ASSUMING A PRETENSION OF 1KG, FOR ALL
COUNTS AND SAMPLES AFTER TUMBLE
% EXTENSION AFTER TUMBLE
TOTAL WIDTH EXTENSION
WIDTH EXTENSION AT 5kg
TIGHTNESS FACTOR K

Figure 31

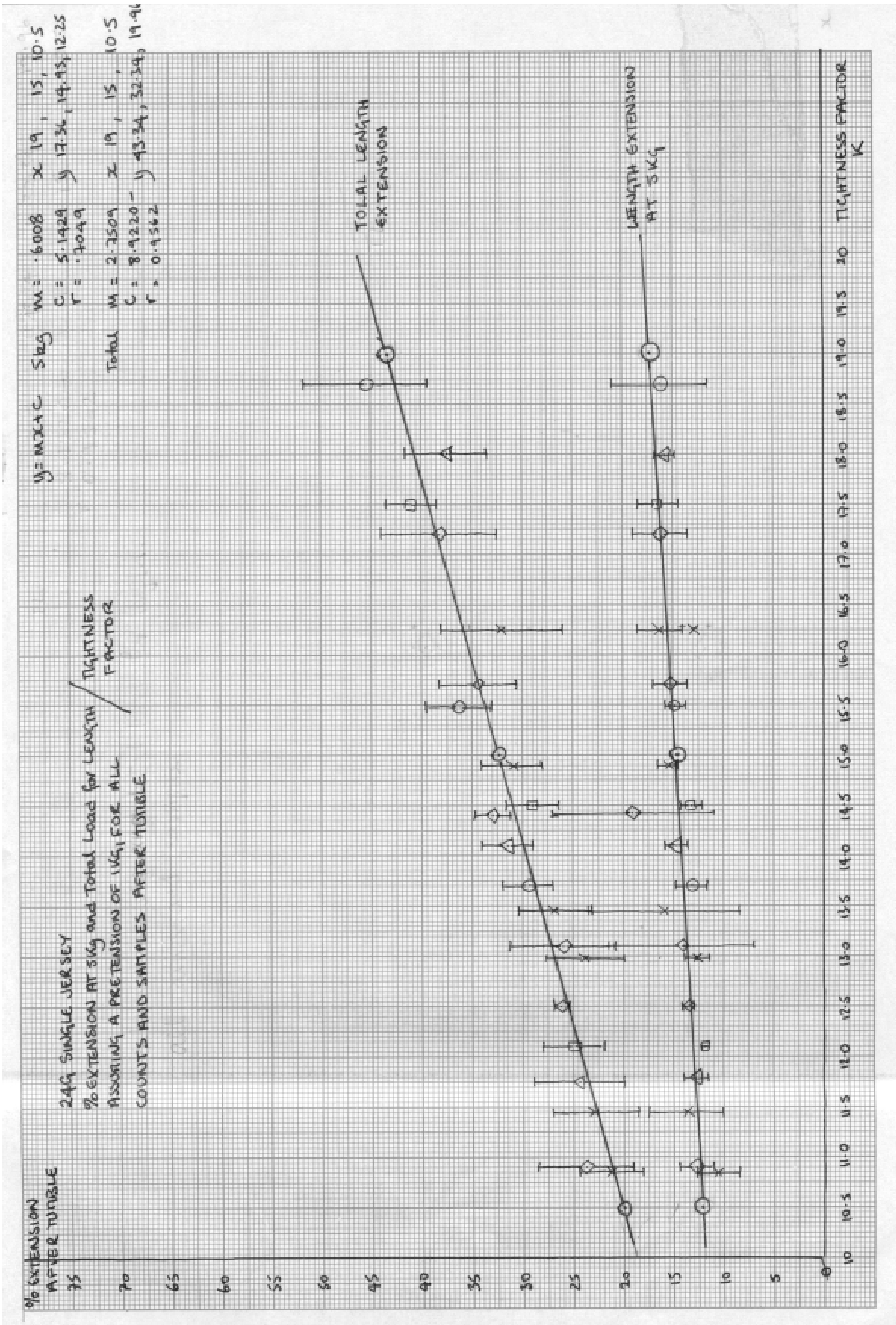
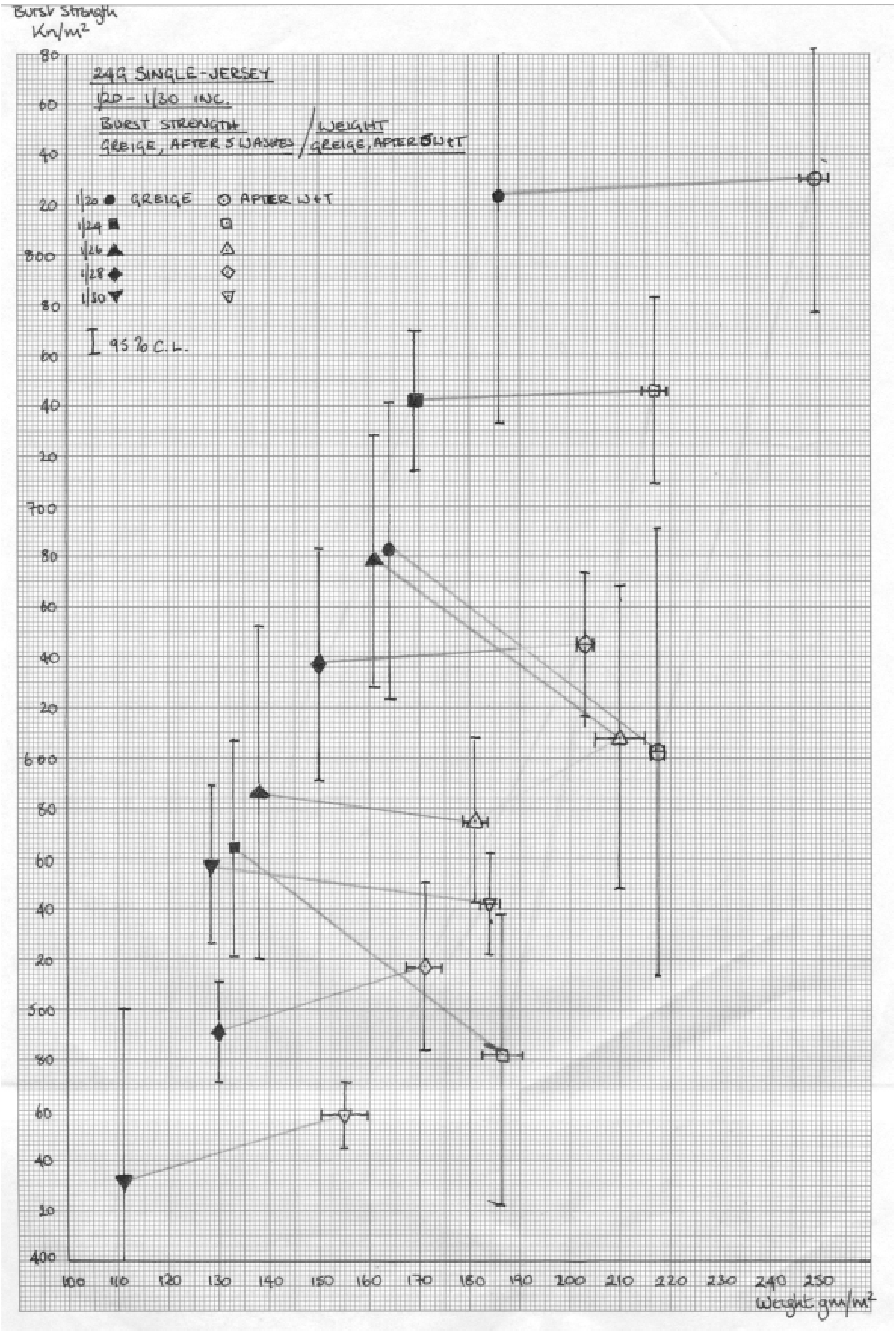

% EXTENSION AFTER TUMBLE
24G SINGLE JERSEY
% EXTENSION AT 5KG and Total Load for LENGTH / TIGHTNESS FACTOR
ASSUMING A PRETENSION OF 1KG, FOR ALL COUNTS AND SAMPLES AFTER TUMBLE
y = mx + c
TOTAL LENGTH EXTENSION
LENGTH EXTENSION AT 5KG
TIGHTNESS FACTOR K

Figure 32



Burst Strength Kn/m²
24G SINGLE-JERSEY
1/20 - 1/30 INC.
BURST STRENGTH GREIGE, AFTER 5 WASHES / WEIGHT GREIGE, AFTER 5 W+T
1/20 ● GREIGE ⊙ AFTER W+T
1/24 ■
1/26 ▲
1/28 ◆
1/30 ▼
95% C.L.
80
60
40
20
800
80
60
40
20
700
80
60
40
20
600
80
60
40
20
500
80
60
40
20
400
100 110 120 130 140 150 160 170 180 190 200 210 220 230 240 250
Weight gm/m²

Figure 33

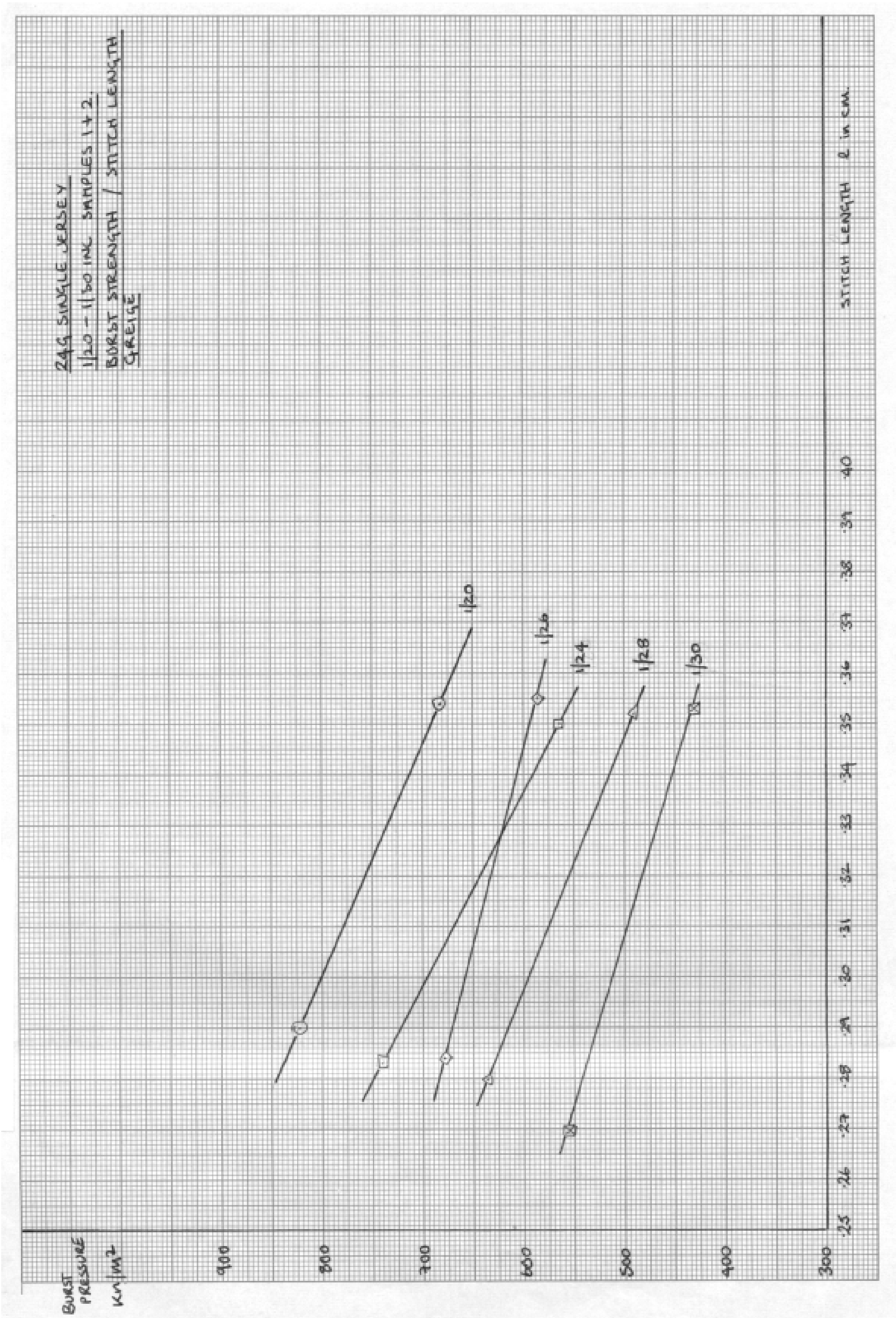
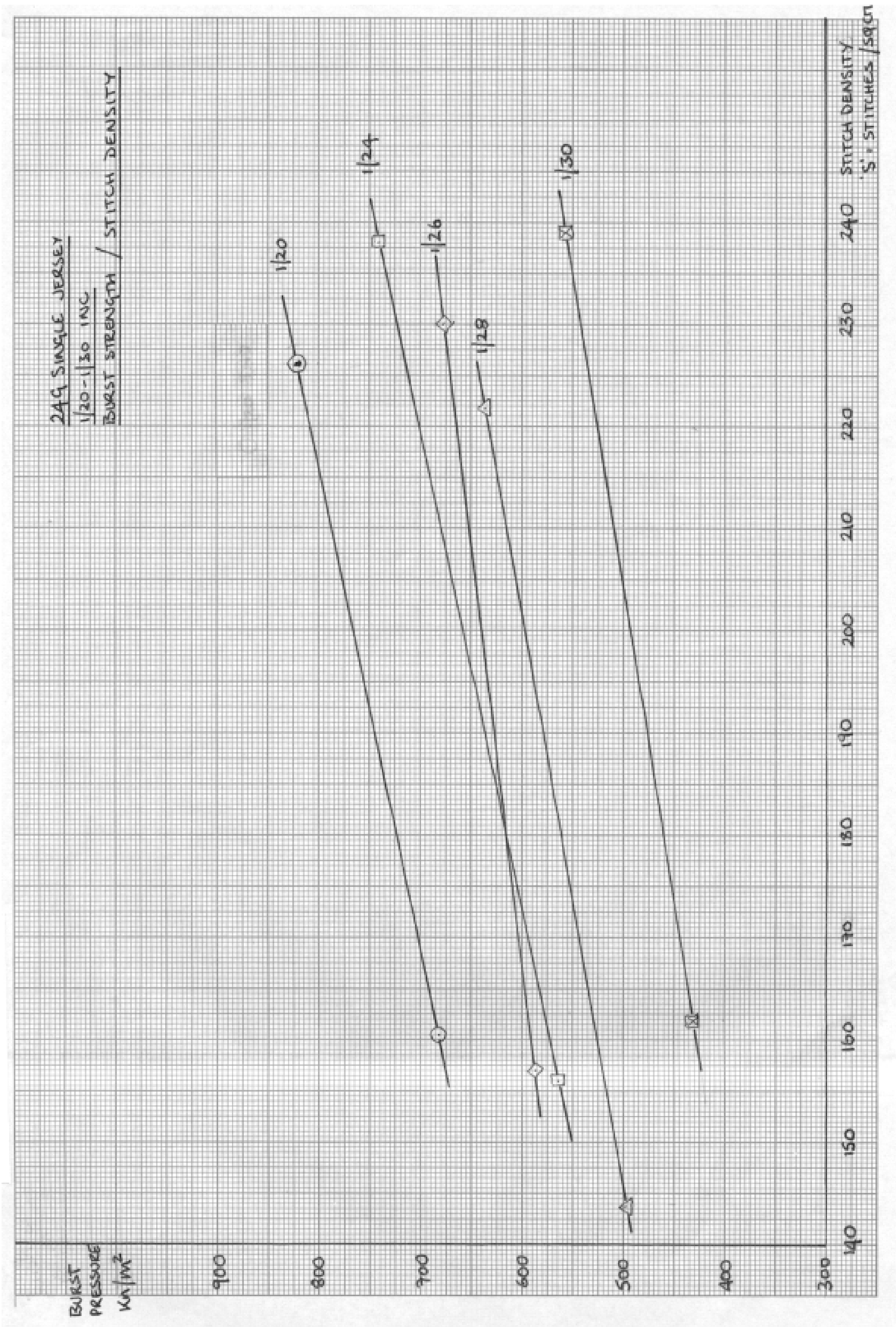

24G SINGLE JERSEY
1/20 – 1/30 INC SAMPLES 1+2
BURST STRENGTH / STITCH LENGTH
GREIGE
BURST PRESSURE
KN/M²
900
800
700
600
500
400
300
STITCH LENGTH l in CM.
·25
·26
·27
·28
·29
·30
·31
·32
·33
·34
·35
·36
·37
·38
·39
·40
1/20
1/26
1/24
1/28
1/30

Figure 34



24G SINGLE JERSEY
1/20-1/30 INC
BURST STRENGTH / STITCH DENSITY
BURST PRESSURE Kn/M²
STITCH DENSITY 'S' = STITCHES/SQCM
1/20
1/24
1/26
1/28
1/30
300
400
500
600
700
800
900
140
150
160
170
180
190
200
210
220
230
240