Relative Short Fibre Content

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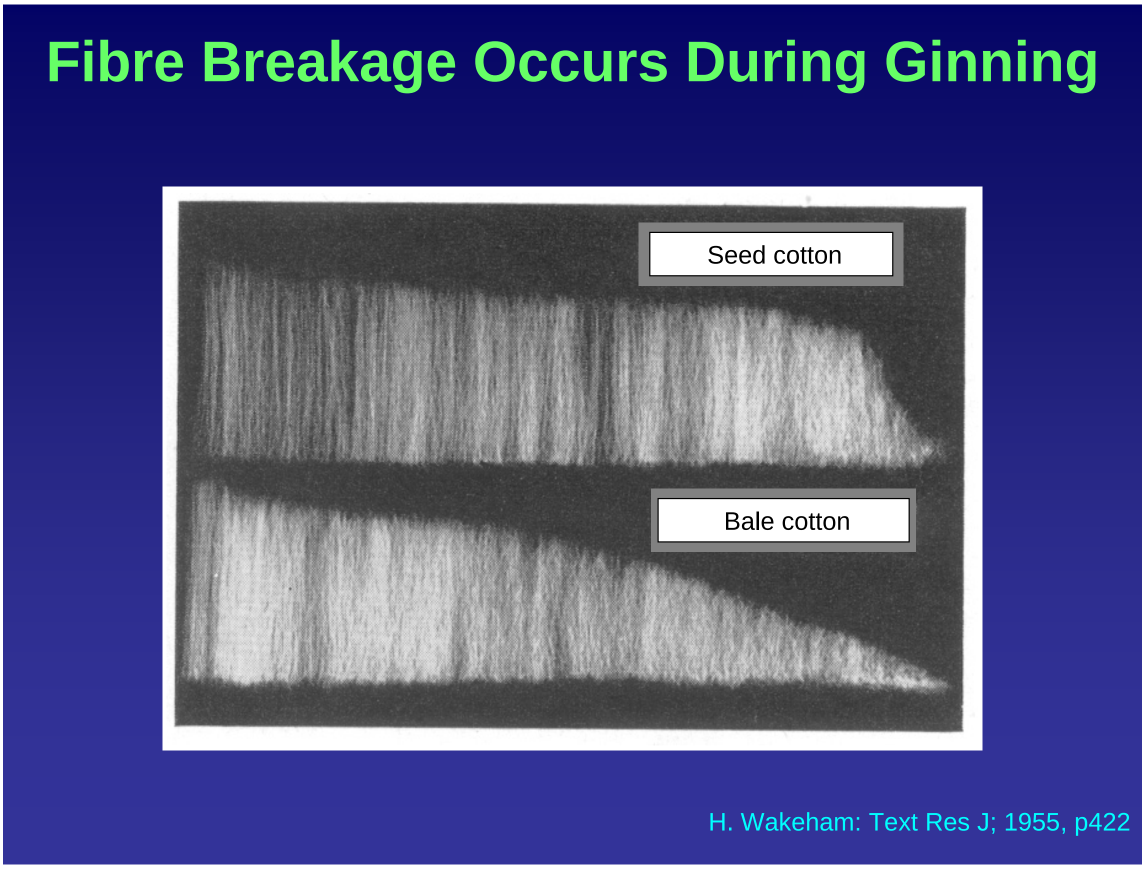
Introduction

The short fibre content (SFC) is an important property of raw cotton. High levels of SFC result in large amounts of waste in processing, high concentrations of fly in the working atmosphere, high end-breakage rates in spinning, lower yarn strength, and inferior yarn regularity [1-24]. The SFC of carefully hand-ginned cotton is very low [1,3,12,35] but it is increased by fibre breakage that occurs during the mechanical handling and cleaning involved in the ginning process [8,27-36] (***Figure 1***).

Figure 1



The commercial staple length is primarily a measure of the longer fibres so it is only slightly affected by even quite large amounts of fibre breakage [1,3,9]. Cotton producers are rewarded for delivering clean, long cotton but are not penalised directly for the presence of large numbers of short fibres. Therefore, the purchasers of raw cotton have been demanding for many years that a way be found to allow for SFC in the price that they pay [9,10,21,24,60].

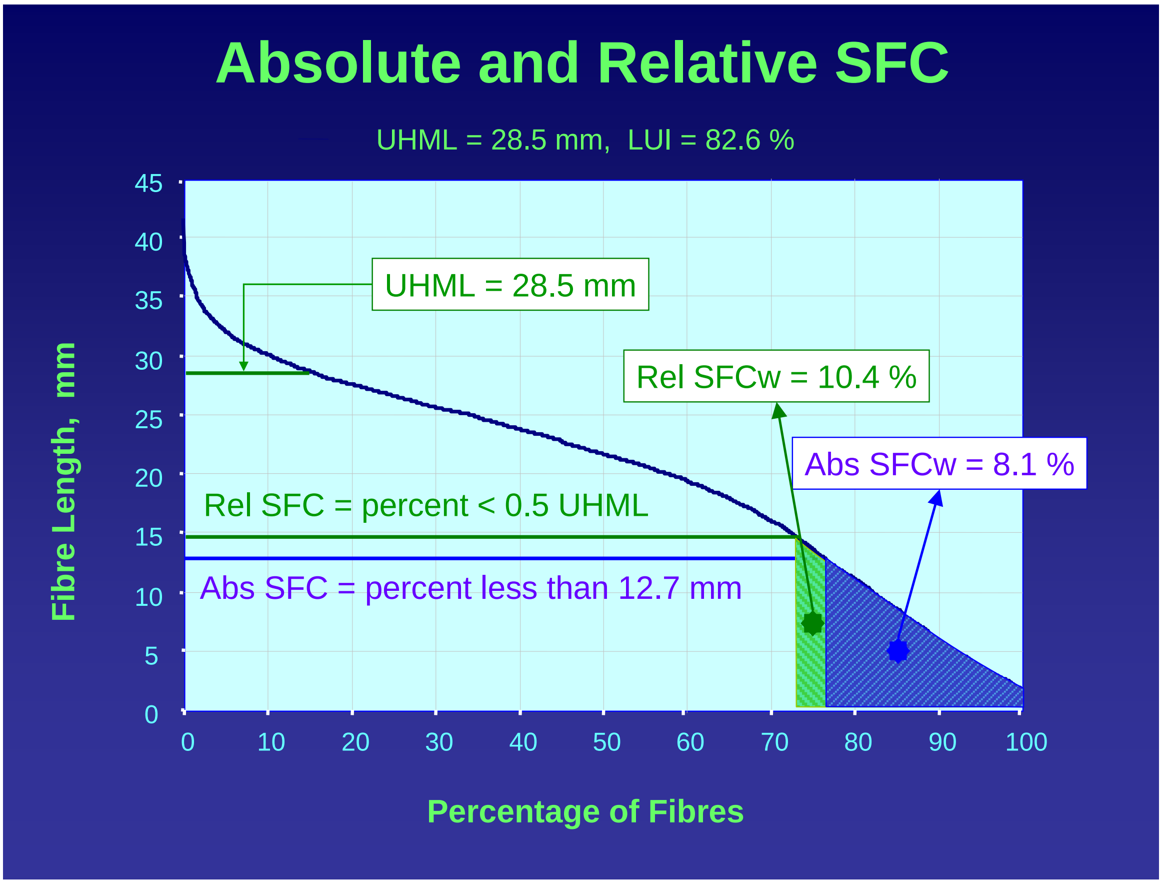
There are two main reasons why objective measurement of SFC has not yet been included in cotton classification.

The first problem is that the standard measure of SFC, namely the percentage by weight of fibres shorter than 12.7 mm, is strongly affected by the cotton type [21, 61]. For a given amount of fibre damage, a short-staple cotton will naturally show a higher percentage of fibres shorter than 12.7 mm than a long-staple type. Therefore, simple inspection of the staple length and the SFC will not reveal whether the cotton is a short-staple type that has been very carefully handled, or a longer type that has been badly mistreated.

The second problem is that objective measurements of SFC are not sufficiently reliable [21,25,26,59] to fit comfortably into the high-speed testing systems that are used for cotton classification: to obtain a reliable test result a large number of specimens has to be tested, for which there is insufficient time.

A possible answer to the first problem is to change the definition of SFC to one based on the Relative Short Fibre Content (Rel.SFC). An example of a Rel.SFC parameter would be the percentage of fibres, by weight or by number, that are shorter than one half of the Staple Length (***Figure 2***).

Figure 2



Rel.SFC parameters have been advocated in the past [1,11,60,61] and there is at least one standard test method [BS 4044] that delivers a Rel.SFC by definition. Intuitively, such a parameter should be influenced only little, if at all, by the cotton staple type, but this has not been shown unambiguously. Advocates of relative measures of SFC have suggested that they are more useful when it comes to predicting the performance of a sliver in drafting and the consequent strength and regularity of yarns, especially ring-spun but also OE-rotor-spun.

A simple computer-based statistical model of fibre breakage has been constructed which shows that, indeed, a Rel.SFC parameter seems capable of giving an unbiased estimate of fibre damage. It can also show how the variation of length in the original seed cotton, presumably a heritable trait, affects all length parameters as well as the intrinsic degree of variability that can be expected of SFC testing.

A Simple Statistical Model of Fibre Breakage

Several authors have built theoretical models of fibre breakage with varying degrees of complexity [37-50]. The work of Robert is particularly relevant [45-50]. For a basic, simple model, as attempted here, only a few starting assumptions have to be made.

- The variation of fibre length in the seed cotton (before ginning) conforms to a normal distribution.
- Fibre breakage during ginning is a random process, not correlated with the fibre length.
- A fibre that breaks during processing may do so at any random point along its length.

The first assumption, of a normal distribution, is reasonably well supported in the literature [45-54].

The second and third assumptions are more debatable. Several authors claim that breakage is related to the individual fibre strength, which probably is related to the individual fibre maturity – or at least the wall thickness [30,31,55-57]. Since there is a good chance that length, strength and wall thickness are inter-related, it is possible that the random breakage assumption is not strictly valid. However, it will do as a first approximation. It has also been argued that there should be an "end-gripping" effect [44,49]. This would mean that broken fibre fragments of less than a certain minimum gripping length should not appear, or appear less frequently than longer fragments. However, it is known that fibre fragments do appear in great numbers in very small lengths, for example in fibre fly [6,7], so a random point of breakage may not be so far from the truth.

The original mean fibre length by number and its coefficient of variation, are given the symbols MLn(0) and CVn(0). Some published values for the mean and CV of length in carefully hand-ginned cotton are given in ***Table 1***.

An important finding from these authors [51, 52] was that the CV of fibre length within seeds is much greater than that between seeds. Therefore, we should expect that the variation between samples of the same stock should be little more than that within the samples.

Table 1

Mean and CV of Seed Cotton

Cotton	Mean Length, mm	CV of Length, %	Reference
Reba B50	24.8	23.6	12
1021	27.5	26.0	12
Acala SJ	27.4	18.7	12
Laxmi	22.4	24.8	52
320 F	22.4	22.7	52
Buri 0394	23.6	19.0	52
MCU 2	24.9	22.4	52
LSS	21.6	19.2	52
Jarila	22.6	21.6	52
Virnar	21.8	21.5	52
Gaorani 6	21.3	18.7	52
Karunganni 5	22.9	20.0	52
Jayadhar	23.4	20.0	52
Vijalpa	24.4	21.9	52
Westerns 1	20.8	19.5	52
Vijay	22.6	17.4	52
Sind Sudhar	24.4	19.8	51
Jayawant	23.4	18.4	51
Surat 1027	24.4	19.0	51
PA 4F	19.3	22.3	51

NB: Reference 12 values are probably number-based, others are weight-based

Operation of the Model

The model works as follows.

1. Values for MLn(0) and CVn(0) are specified.
2. Values for the probability of fibre breakage, P(b)1 to P(b)4, are specified for up to four stages of processing. The probability is given as a percentage.
3. The required total number of fibres, Nf, is specified.
4. A series of Nf random numbers is generated, having a normal distribution with mean and CV as specified in step 1, representing individual fibre lengths in the seed cotton, before any processing.
5. Each fibre is taken in turn and subjected to a two-step random breakage process. The first step is a break/no break decision, based on probability P(b)1. If the fibre is selected for a break, then a random point along its length is selected as the break point. The total number of fibres is increased by one for each break, though the total mass is preserved.

6. The output from this first process is fed as input to the second process, which is identical except that the probability of a break is given by P(b)2. Once again, the total number of fibres is increased by one for each fibre break.
7. The output of the second process serves as input to the third.
8. The output of the third process serves as input to the fourth.
9. Length distribution statistics are computed on the final population of processed fibres.

Note:

- The concept of a fibre break during ginning is somewhat special. Of course all fibres are broken when they are removed from the seed. In this context, an "unbroken" fibre is one that is detached from the seed at a point close to the seed surface; a broken fibre is one that is detached from the seed in two pieces, one of which is the result of a break that occurs a significant distance away from the surface. See the discussion of Lord [28]. Of course, more than two breaks are possible in a given fibre but these are (arbitrarily) neglected: in this model, each fibre may produce a maximum of only two fragments per process. All of the fibres and all of the fibre fragments are retained in the fibre population – none are lost in the machinery.
- P(b) can be set to zero for any process. If all probabilities are set to zero, then the (notional) length distribution of the seed cotton is computed. If all probabilities are greater than zero, then it can be imagined that the four processes represent the harvesting and ginning operation plus three stages of lint cleaning.
- A number of replications, R, can be specified. The whole model is run R times, with each set of length distribution statistics being saved. At the end, the means and CVs of all of the length distribution statistics are calculated and displayed. For example, if the number of fibres is set at 3000 and the number of replications is set to 10, then this models the recommended test conditions for measuring length distribution parameters by the AFIS device.
- A minimum fibre-fragment length can be specified to qualify for inclusion in the calculation of length distribution statistics. For example, the AFIS device is said to exclude all fragments of less than 1.5 mm from its calculations, and the various hand-stapling devices also exclude fibre fragments below a certain length. Devices like the Uster HVI, Premier ART, and Premier aQura also can not detect fibre fragments below a certain length but they estimate such very short fibres by back-projection.
- Both number-based and weight-based length distribution statistics are calculated. The conversion from number-based mean and CV to weight-based statistics is made using the method of Morton & Hearle [52], which is essentially the same as that specified by ASTM D1440. Effective length is as defined by BS 4044. UHM Length is as defined by ASTM D123, namely *the mean length by number of the longer half of the fibres by weight*. Uniformity Ratio (UR) is the mean length by number as a percentage of the Effective length. Length Uniformity Index (LUI) is the mean length by weight as a percentage of the UHM length.
- Six short fibre content measures are calculated – three by number and three by weight. The Absolute SFC (Abs.SFC) is the percentage of fibres, by number or

by weight shorter than 12.7 mm. The Relative SFC (Rel.SFC) is the percentage of fibres by number shorter than half the Effective length, or the percentage by weight shorter than half the UHM length. Finally, SFC as defined by BS 4044 is calculated by number and by weight but these two are not discussed further in this paper. Provision is made for calculation of the Floating Fibre Index [11,60] (also not discussed here).

Results

Figure 3 shows a typical screen display.

Figure 3

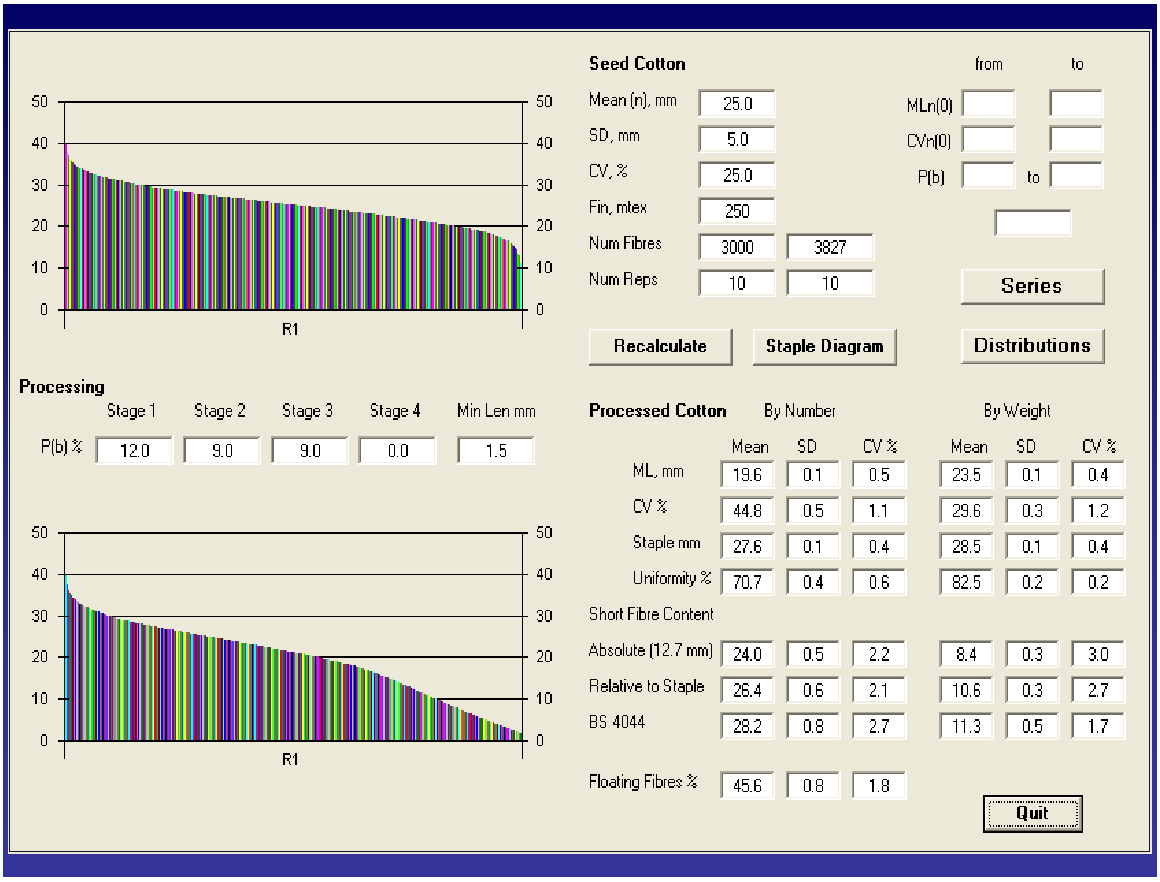


Figure 4 shows the effect of the number of fibres, passed through a single process, on the CV of the estimates of UHM length for a very low (10%) and a very high (50%) level of fibre breakage. Five separate runs were made, each of 30 replications. All five data points are shown, to illustrate the scatter, and the power-law regressions illustrate how the CV declines with increasing numbers of fibres. As expected, the rate of decline is according to the square root of the number of fibres.

Figure 5 shows the same treatment for the CV of estimating the Abs.SFC by weight. Note that the curves are levelling off after about 3000 fibres.

Figure 4

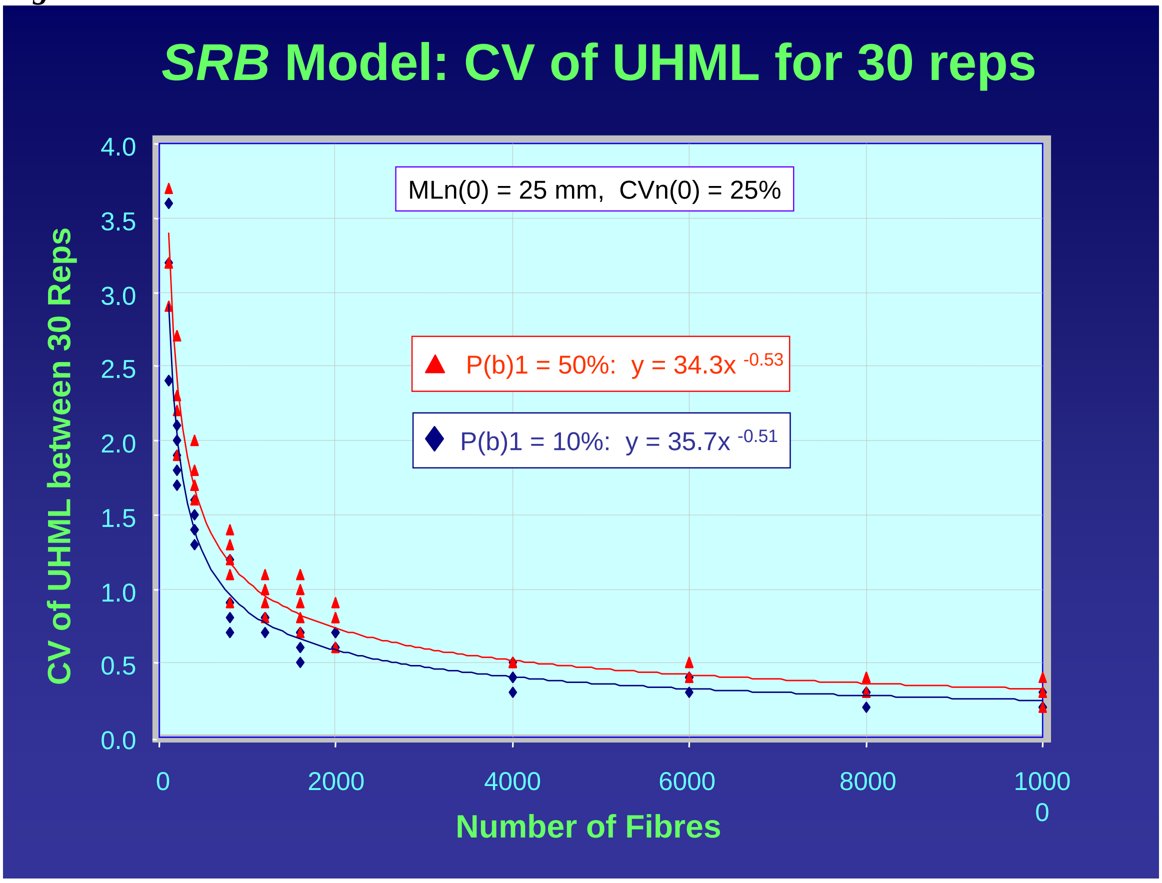


Figure 5

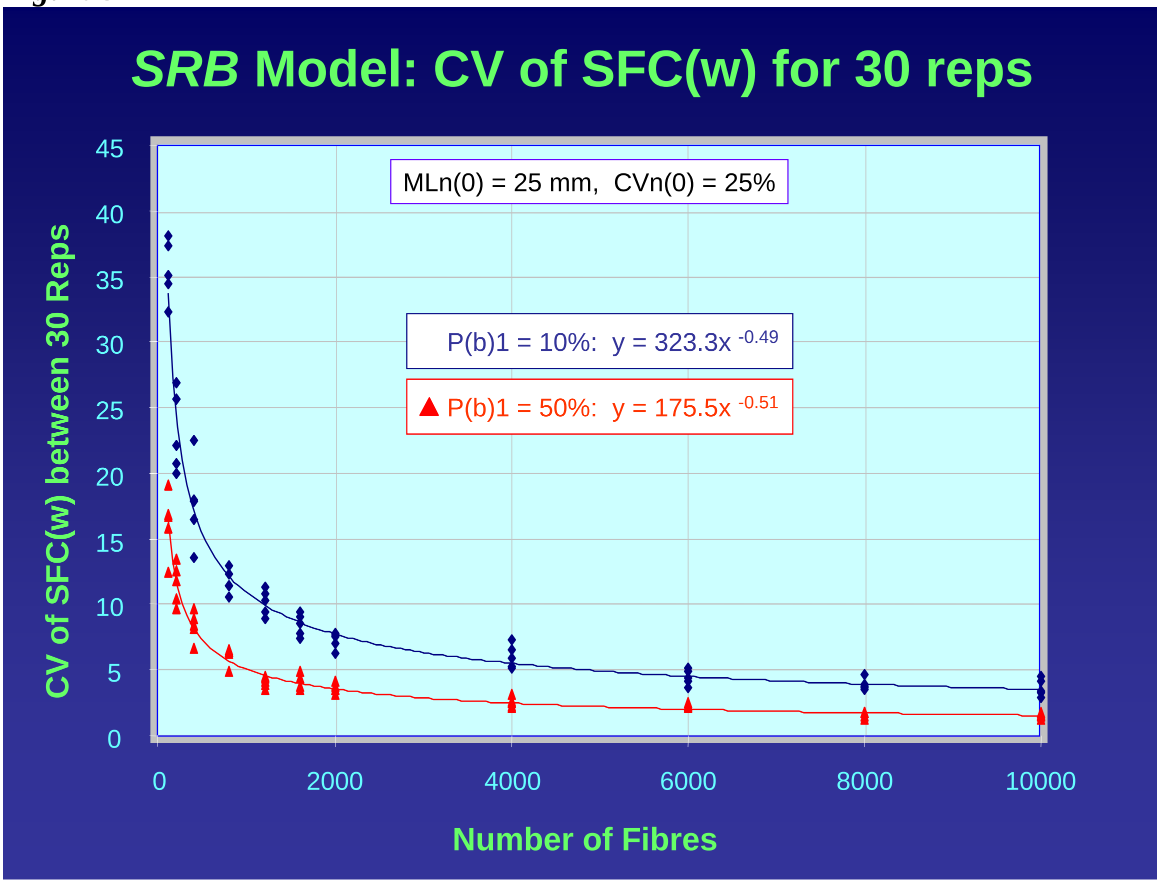


Table 2 shows the results of a series of 200 individual runs, each with 3000 fibres and a minimum length requirement of 1.5 mm. The mean and CV for the 200 replications give some idea of the intrinsic variation to be expected in fibre length statistics, based on certain assumptions about the variation in the original seed cotton and the amount of random fibre breakage suffered.

Table 2

Coefficients of Variation for SRB* Model Predictions

MLn(0) = 25 mm, 3000 fibres, 200 Replications, three-stage processing
(P(b) is allocated to the three stages in the proportions 0.4:0.3:0.3)

	P(b) = 20%		**P(b) = 40%**	
CVn(0), %	**25**	**35**	**25**	**35**
UHM Length	0.5	0.7	0.6	0.8
Abs. SFC (w)	5.5	4.4	3.6	3.4
Rel. SFC (w)	4.9	3.5	3.3	2.5

* *SRB = Simple Random Breakage*

The results show that the intrinsic variation of SFC is expected to be in the region of about 2.5 to 5.5 %CV, and that Rel.SFC has a lower CV than Abs.SFC. What is perhaps equally interesting is to compare the variability of SFC with that of staple length. The ratio CV of SFC to CV of UHM is in the range 3.4 to 12.3. Therefore, those who have argued that SFC is inherently more variable than UHM length find some support here. The implication of these results is that, in order to have the same confidence level from SFC measurements as from UHM length, it will be necessary to test at least ten times as many specimens.

Some results of multiple measurements on a new device for measuring length distributions, the Premier aQura instrument, have been kindly provided by the manufacturers along with Premier ART measurements on the same group of cottons. Data from round tests on AFIS instruments were published at this conference in 1992 [62]. ***Table 3*** and ***Table 4*** show that the ratio of CVs for these devices is within about the same range as that for the *SRB* model.

Table 3

Coefficients of Variation for a Prototype aQura Instrument

(50 replications, Premier 2003)

Cotton ID	**CA 1**	**CA 2**	**CA 3**	**CA 4**
Effective Length	3.3	2.8	2.7	3.2
Abs. SFC (w)	9.8	12.6	12.2	15.9

Table 4

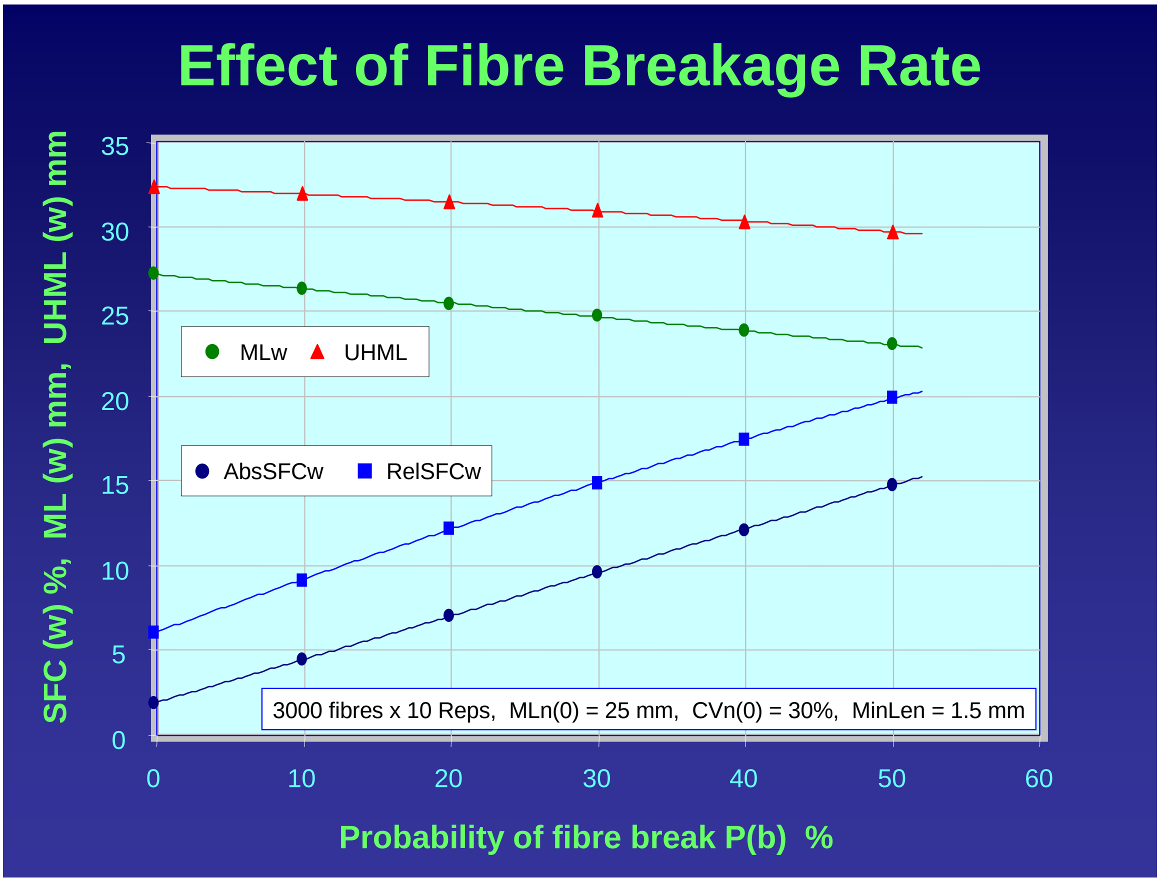
Coefficients of Variation for AFIS Instruments

(Round test between 18 laboratories, USA 1991)

	Within labs	**Between labs**
UQ Length	1.2	1.8
Abs. SFC (w)	12.8	15.7

Figure 6 shows the effect of fibre breakage on the mean and UHM length, as well as the absolute and relative short-fibre contents. If these predictions are anywhere close to real life, then it would seem that typical values for fibre breakage lie between about 20 and 40%.

Figure 6



Testing the Model

The model is a simple one with certain arguable assumptions. Therefore, it is important to check that it delivers results that are at least consistent with observed measurements. Several sources of data exist that can be used for checking. Probably the most important and useful are the results of the Bremen Round Tests for the AFIS device [59]. These data include the Mean length, CV of length and SFC by number and by weight for a series of cottons, each tested in about forty different laboratories. Some results from recent round tests are given in ***Table 5***.

Table 5

Bremen Round Test Data for AFIS : 2000-2 to 2003-1

Cotton	**By Number**			**By Weight**		
	MLn	**CVn**	**SFCn**	**MLw**	**CVw**	**SFCw**
CIS Pervyi	20.7	46.6	22.9	25.3	33.7	8.3
US Pima	23.5	49.5	20.9	29.3	33.1	5.8
China	21.0	44.8	21.5	25.3	31.2	7.3
CIS	21.2	40.2	17.8	24.7	28.8	5.9
Aust. Sicala	19.6	51.4	27.9	24.8	35.7	9.9
Greece	20.3	48.5	24.9	25.1	34.8	9.0
US – MOT	19.0	54.1	30.4	24.5	36.8	10.8
El Paso	20.0	46.0	23.0	24.4	32.7	8.0
Chad	20.0	47.9	24.3	24.6	34.5	8.8
Zimbabwe	20.8	44.7	20.8	24.9	32.3	7.3
Mex. Juarez	19.3	49.9	26.3	24.0	35.1	9.6
Turkey	19.2	48.6	26.1	23.7	35.5	9.9

The attempt to model these data proceeds in three stages.

1. For each Round Test, the data are extracted for those laboratories that measured all three of the required parameters, either by weight or by number. Grand means are calculated for all six parameters and separate plots are made of mean length and CV of length by number against SFC by number. It is found that decent straight lines can be fitted with coefficients of determination that lie between about 0.7 and 0.95

Two examples are given in ***Figure 7*** and ***Figure 8***. The regression lines are extrapolated back to zero SFC to obtain preliminary estimates for MLn(0) and CVn(0).

Figure 7

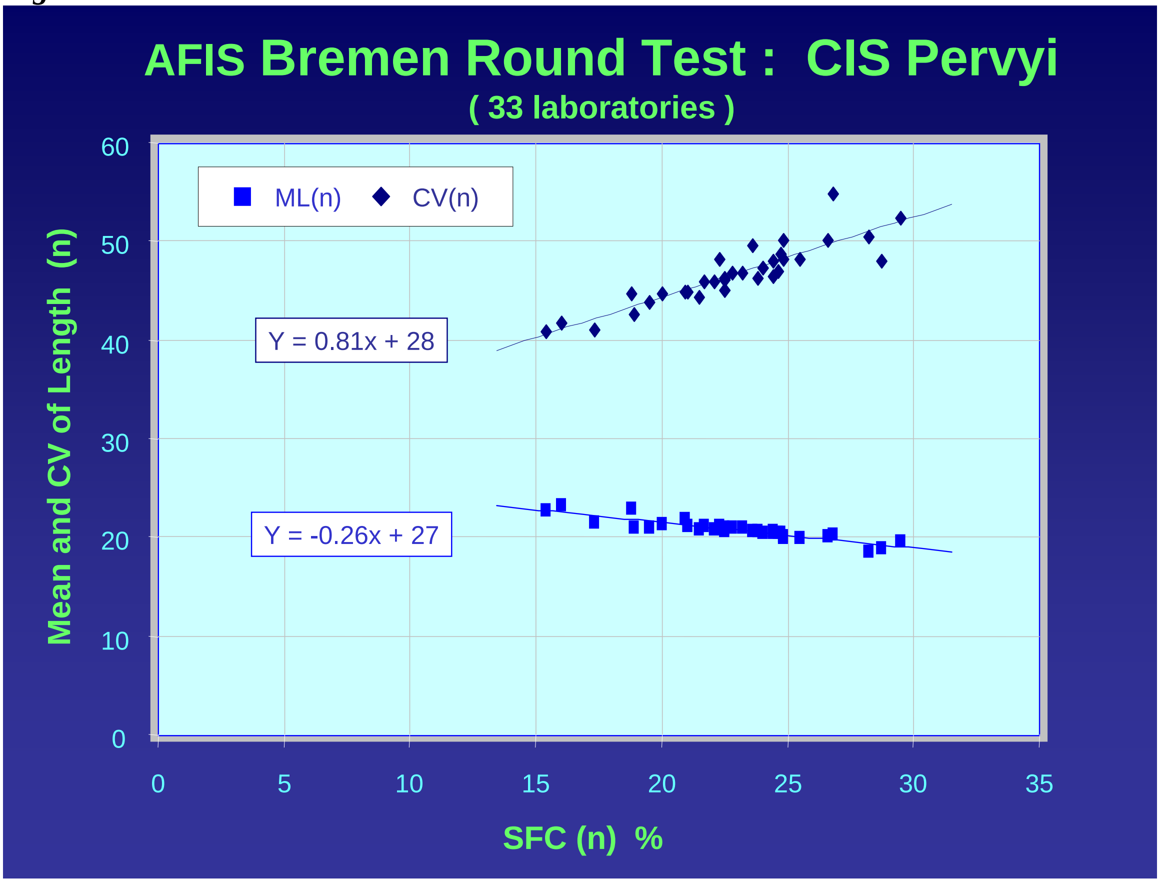
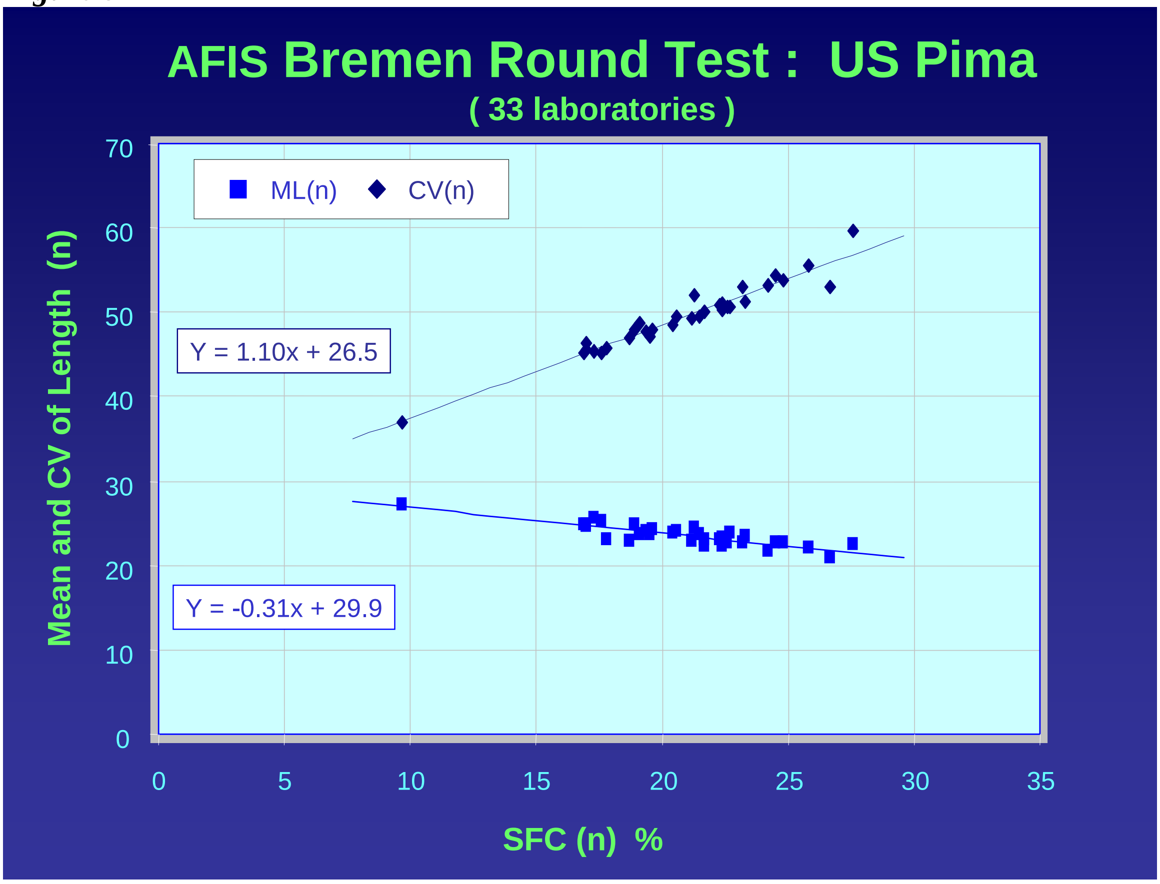


Figure 8



2. These values are rounded to integers and used as starting inputs for the fibre breakage model, which is set up for its simplest case – where there is only one breakage process. The model is run, with 3000 fibres and 10 replications, for six different values of P(b), namely 0, 10, 20, 30, 40 and 50% and separate plots are produced of mean length, CV of length, and SFC, by number and by weight as a function of the breaking probability, P(b). These plots are used to generate arbitrary (though well-fitting, second order polynomial) regression equations and the equations are used to calculate the six values of P(b) that correspond to the six measured AFIS results. The goodness of fit is judged by calculating the variation coefficient of these six separate estimates for P(b). The values of MLn(0) and CVn(0) are varied (as integers) by trial and error to improve the goodness of fit. After several cycles, the CV of the estimates of P(b) can be brought to below about 5%. Integer values for MLn(0) and CVn(0), and a single-stage process were used simply to save time. No doubt better fits could have been obtained by automating this procedure, by using non-integer values for the inputs, and by utilising a three-stage process.

3. Having established reasonable values for MLn(0) and CVn(0) for a given cotton, the six resulting values for P(b) are averaged and are used as input to the model, using 3000 fibres and 30 replications, to calculate average estimates for the six length distribution statistics.

Results for the last twelve cottons of the Bremen Round Tests are shown in ***Table 6*** and ***Figure 9***.

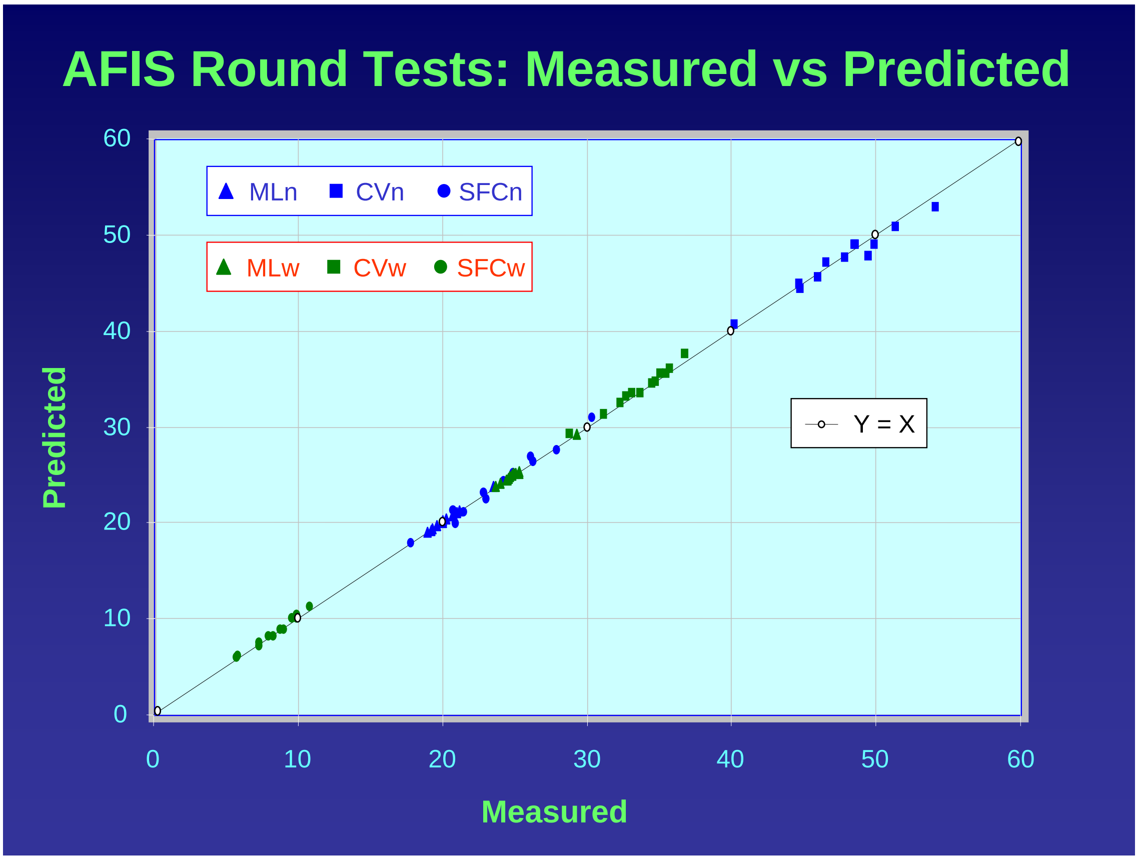
Table 6

Testing the Model – Predictions for Bremen Round Test Cottons

(3000 fibres x 30 Replications, min length = 1.5 mm - single process)

	Required Inputs			**By Number**			**By Weight**		
Cotton	**MLn(0)**	**CVn(0)**	**P(b)**	**MLn**	**CVn**	**SFCn**	**MLw**	**CVw**	**SFCw**
CIS Pervyi	26	28	28.7	20.7	47.1	23.2	25.3	33.4	8.1
US Pima	30	28	29.1	23.8	47.8	19.9	29.2	33.5	6.0
China	26	25	26.8	21.0	44.3	21.0	25.2	31.2	7.2
CIS	25	25	19.7	21.3	40.6	17.8	24.8	29.3	6.1
Aust. Sicala	26	30	35.6	19.8	50.9	27.5	25.0	36.0	10.0
Greece	26	29	31.4	20.4	49.0	25.2	25.2	34.6	8.9
US – MOT	25	33	35.6	19.1	52.8	30.0	24.4	37.5	11.3
El Paso	24	31	21.7	20.2	45.5	22.5	24.4	33.1	8.2
Chad	24	33	23.1	20.1	47.6	24.3	24.6	34.5	8.9
Zimbabwe	25	29	22.9	20.9	44.8	21.2	25.1	32.4	7.5
Mex. Juarez	23	36	21.8	19.4	49.0	26.3	24.1	35.6	10.0
Turkey	23	35	23.3	19.2	48.9	26.9	23.8	35.5	10.3

Figure 9



A similar procedure was used to fit the by-number measurements of Mean length, Effective length and SFC for the Premier aQura measurements mentioned earlier. In this case, a three-stage processing was used, with the total fibre breakage being arbitrarily allocated to the three stages in the proportions 0.4 : 0.3 : 0.3. For example, if the total amount of fibre breakage is specified as 30%, then 12% was allocated to the first process, and 9% each to the second and the third.

Results are shown in ***Table 7, Figure 10,*** and ***Figure 11***. Note that *Figure 11* includes data points for the SFC by weight, even though fitting was done using only the by-number measurements.

Table 7

Testing the Model – Predictions for Premier aQura Measurements

(3000 fibres x 30 Replications, min length = 1.5 mm, 3-stage process)

	Model Inputs			**Predicted Values**			**Measured Values**		
Cotton	**MLn(0) mm**	**CVn(0) %**	**P(b) %**	**MLn mm**	**EL mm**	**SFCn %**	**MLn mm**	**EL mm**	**SFCn %**
Australia (med)	25	34	40.8	18.3	31.2	34.5	18.3	31.1	34.4
USA (med)	25	32	40.5	18.3	30.4	33.3	18.1	30.3	34.6
USA (med)	26	29	43.7	18.5	30.7	33.2	18.4	30.6	33.9
Giza 88 (ELS)	33	33	42.9	23.4	39.6	27.4	23.3	39.6	27.4

Figure 10

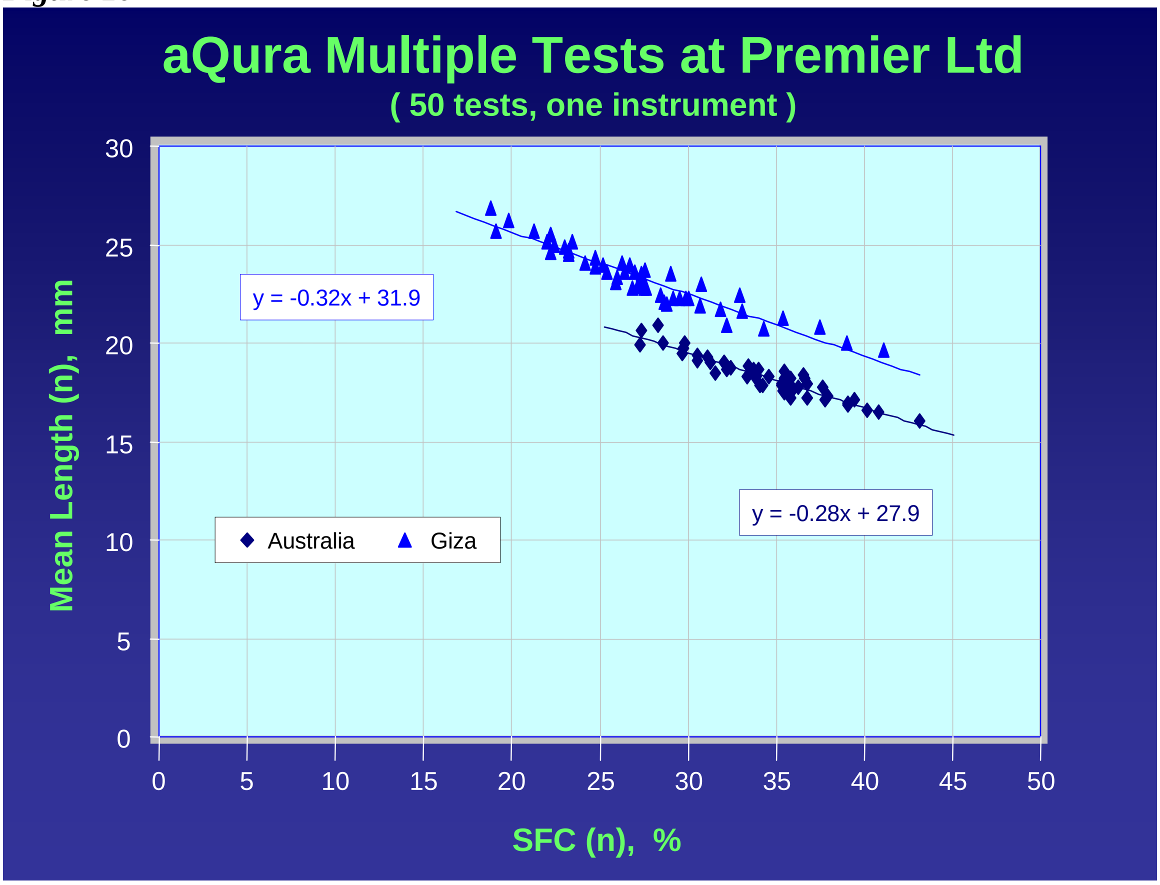
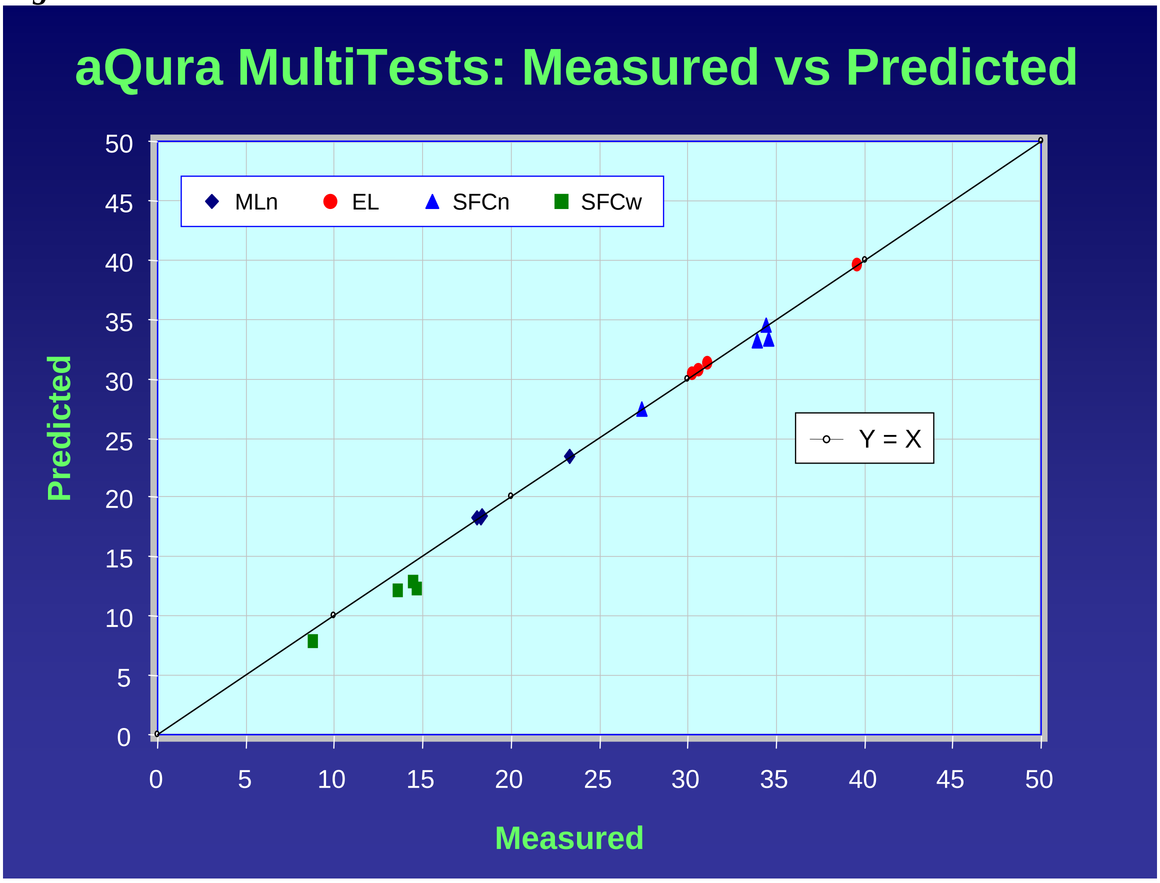


Figure 11



It seems clear from these two sets of predictions, based upon measurements made by two completely different technologies, that the model is capable of producing output that conforms to measured values found in the real world.

In passing, it might be noted that the relationships discovered in *Figures 7 and 8* (variation between instruments) and in *Figure 10* (variation within an instrument) are deserving of much closer investigation and analysis but this is outside the scope of the present paper.

Effect of the Original Coefficient of Variation, CVn(0)

Figures 12, 13, and 14 show the general effect of the original CV of length in the seed cotton, CVn(0), on the length distribution statistics for a cotton with an original mean length, MLn(0) of 25 mm. These are the results of runs with 10 replications of 3000 fibres each and a minimum length of 1.5 mm.

Figure 12

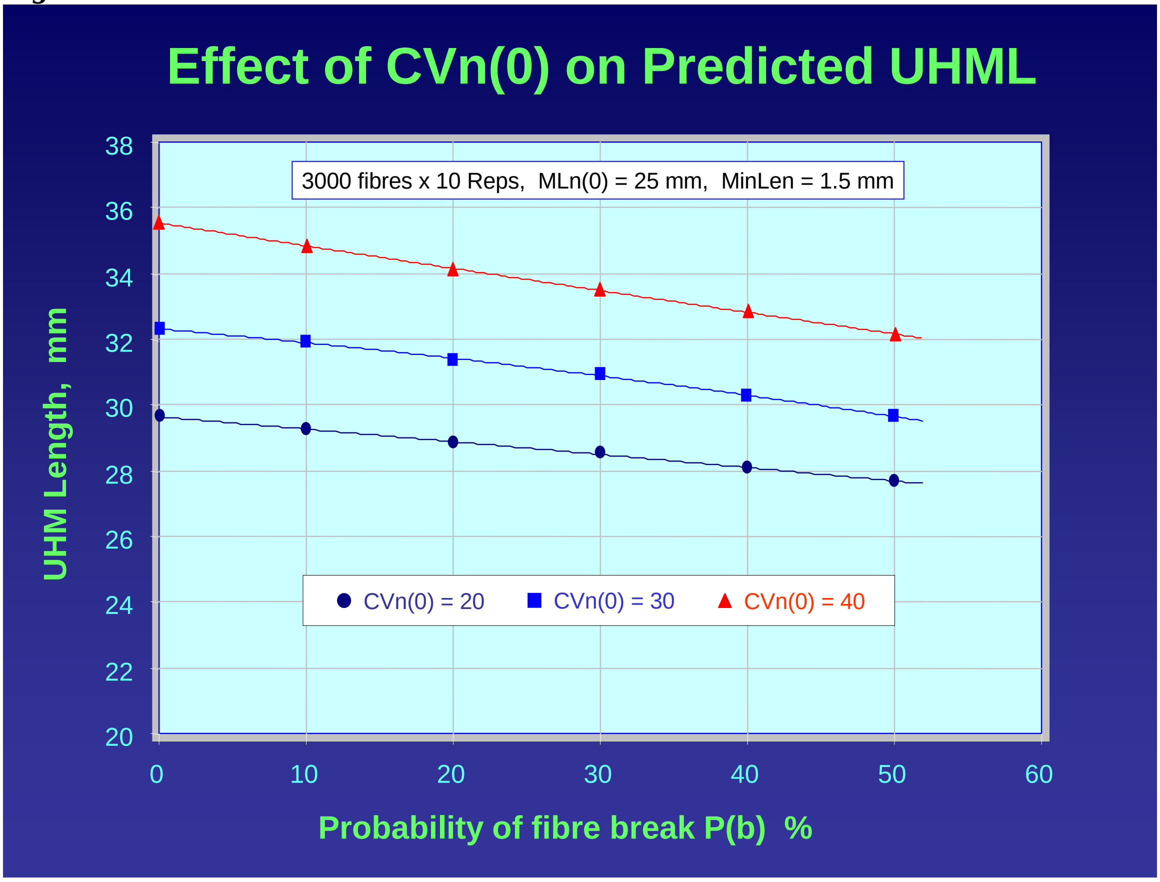


Figure 13

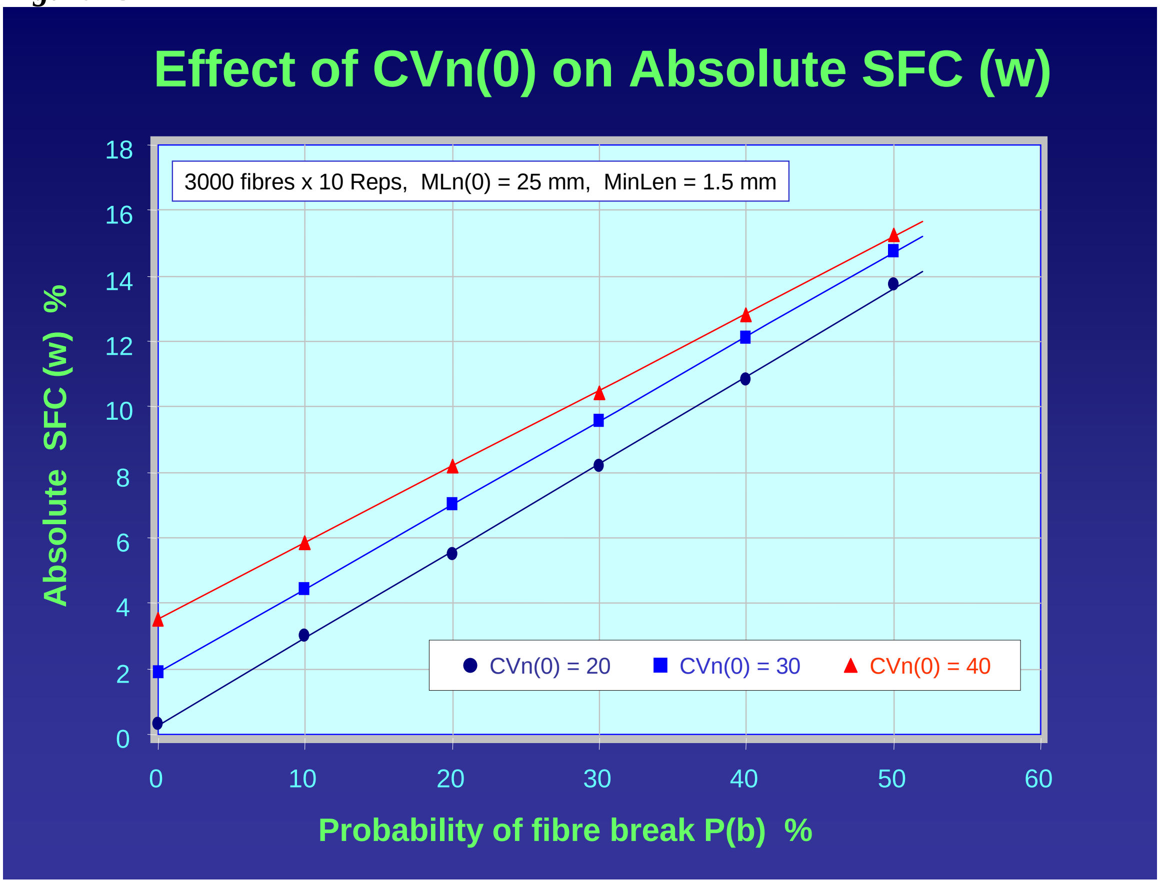
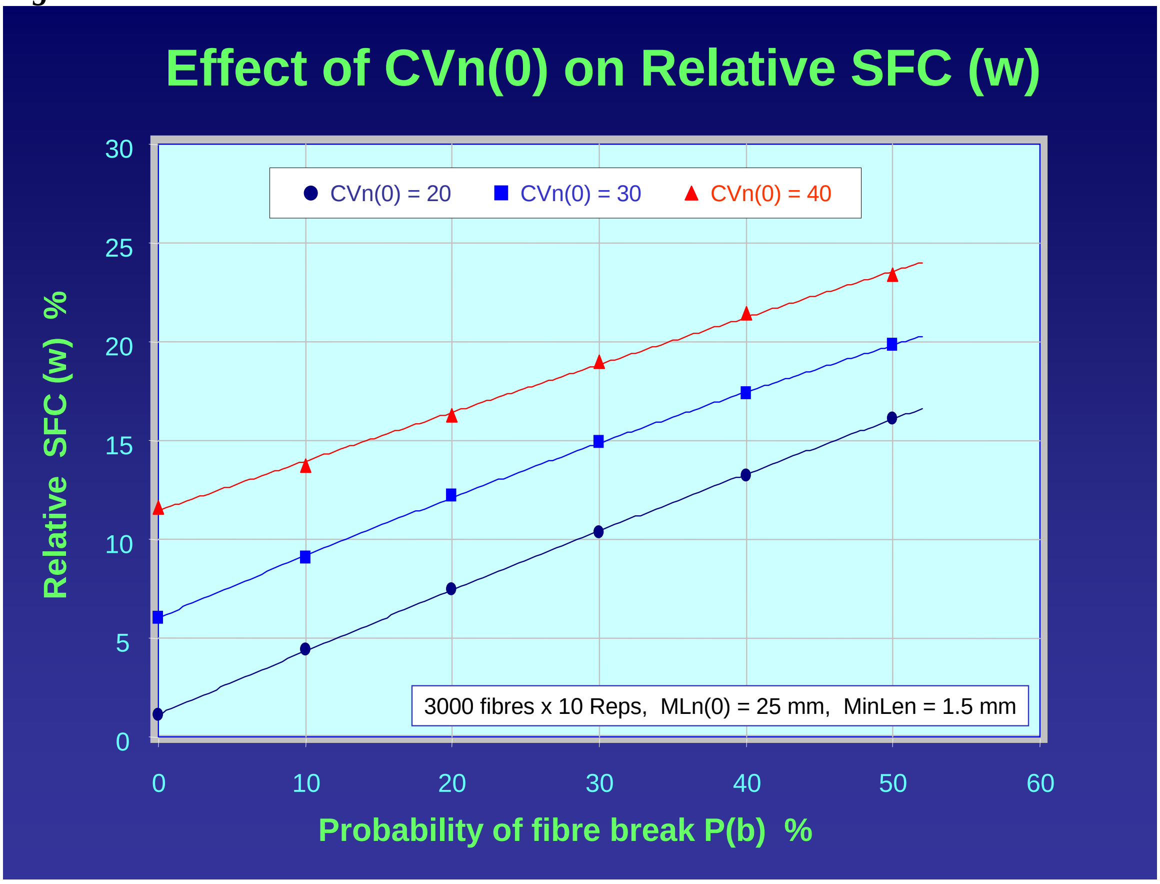


Figure 14



Three interesting points arise.

- The mean length by number (not shown), is quite unaffected by CVn(0), even at quite high levels of fibre breakage.
- The mean length by weight (not shown) and the staple length (Effective length or UHM length) are improved by increasing CVn(0), whilst SFC of any description is worsened.
- The decline in mean length and staple length with increasing degree of fibre breakage is rather slow compared to the rather rapid increase in SFC.

Consideration of these findings leads to a somewhat disturbing possibility. If a cotton breeder is selecting for longer staple length and is evaluating his experimental fibre after a relatively gentle, small-scale ginning process (or, like the commercial classification process, is paying little or no regard to SFC) then he can achieve his objective by selecting (perhaps un-knowingly) for a high CVn(0) with consequently higher SFC. The increase in staple length will be rewarded by the marketing system but the increase in SFC will probably go un-noticed; at least until someone takes the trouble to look at the trends over an extended period [9]. Presumably (and hopefully) the more alert breeders are also selecting their cottons on the basis of the CV of length, or the length uniformity index, as well as the staple length.

Figure 15

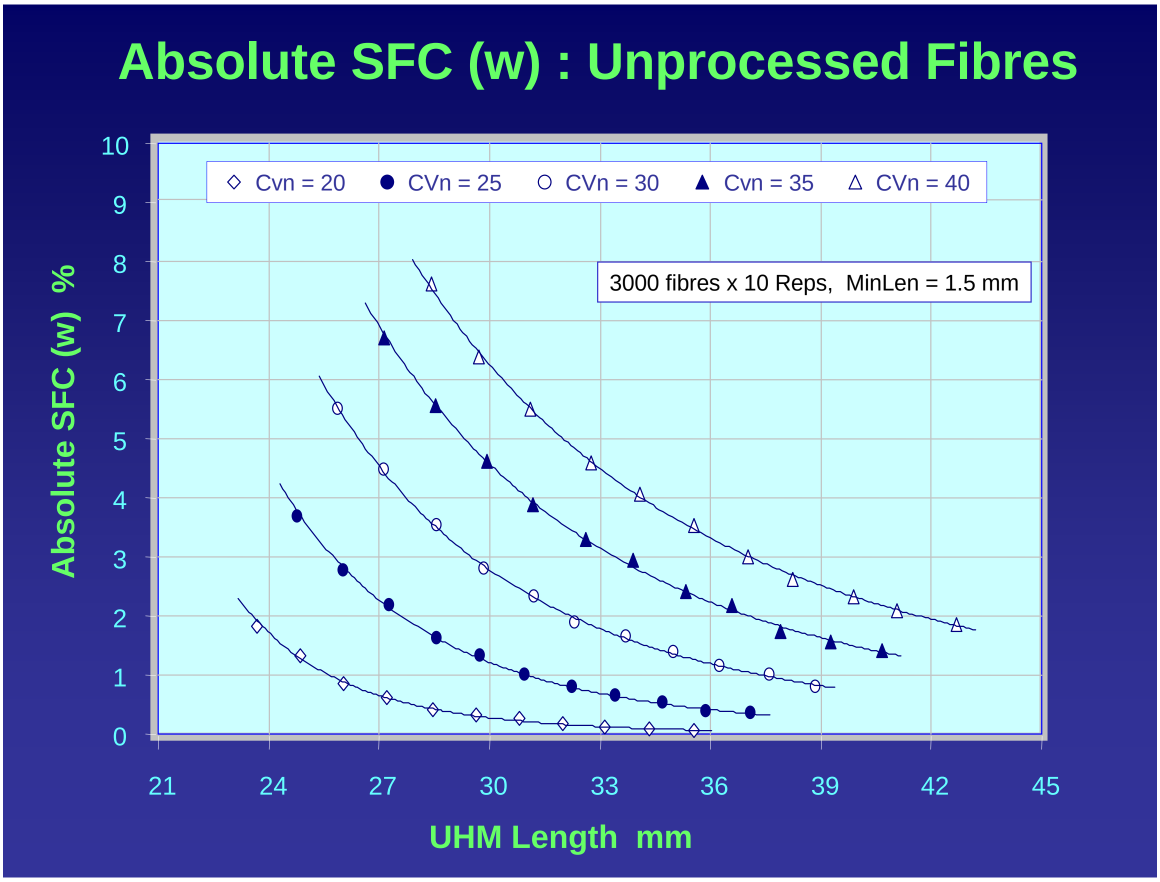


Figure 15 shows the influence of CVn(0) on the Absolute SFC by weight for unprocessed cotton of different staple lengths. This emphasises the importance of the CV of length in the seed cotton and, at the same time, the reason why the Absolute SFC can not be part of a classification system. It is quite clear from these curves that, even with no fibre breakage at all, short staple cottons are at a significant disadvantage.

Relative Short Fibre Content

Figure 16 shows the same series as in *Figure 15*, but with Relative SFC by weight on the ordinate. These lines are scarcely different from horizontals. When the effect of fibre breakage is introduced, the lines are displaced upwards but they are still almost horizontal. The same behaviour is shown by the Length Uniformity Index (***Figure 17***) so that, when Rel.SFCw is plotted as a function of LUI, a nice coherent relation is obtained (***Figure 18***). The relationship changes somewhat for different degrees of fibre breakage (***Figure 19***) but it is clear that a much better basis for cotton classification might be found somewhere among these relationships.

Figure 16

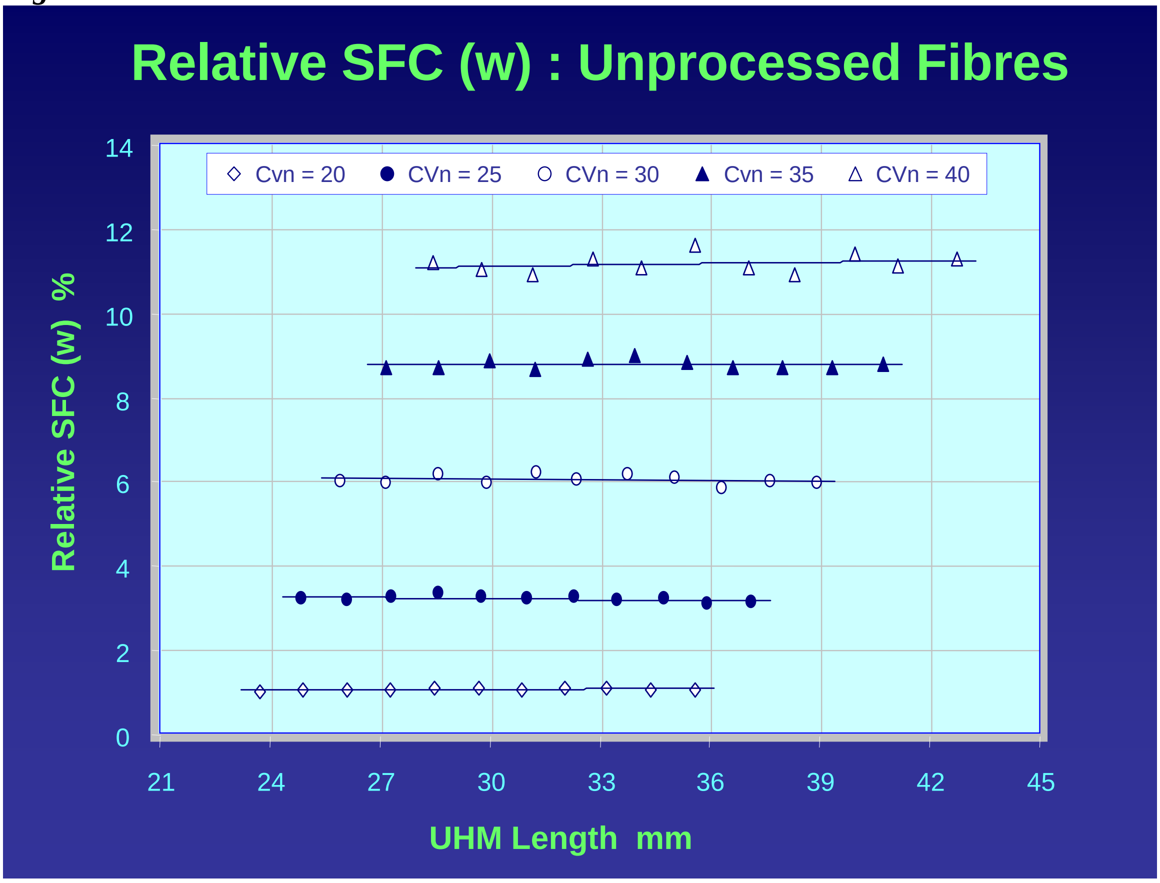


Figure 17

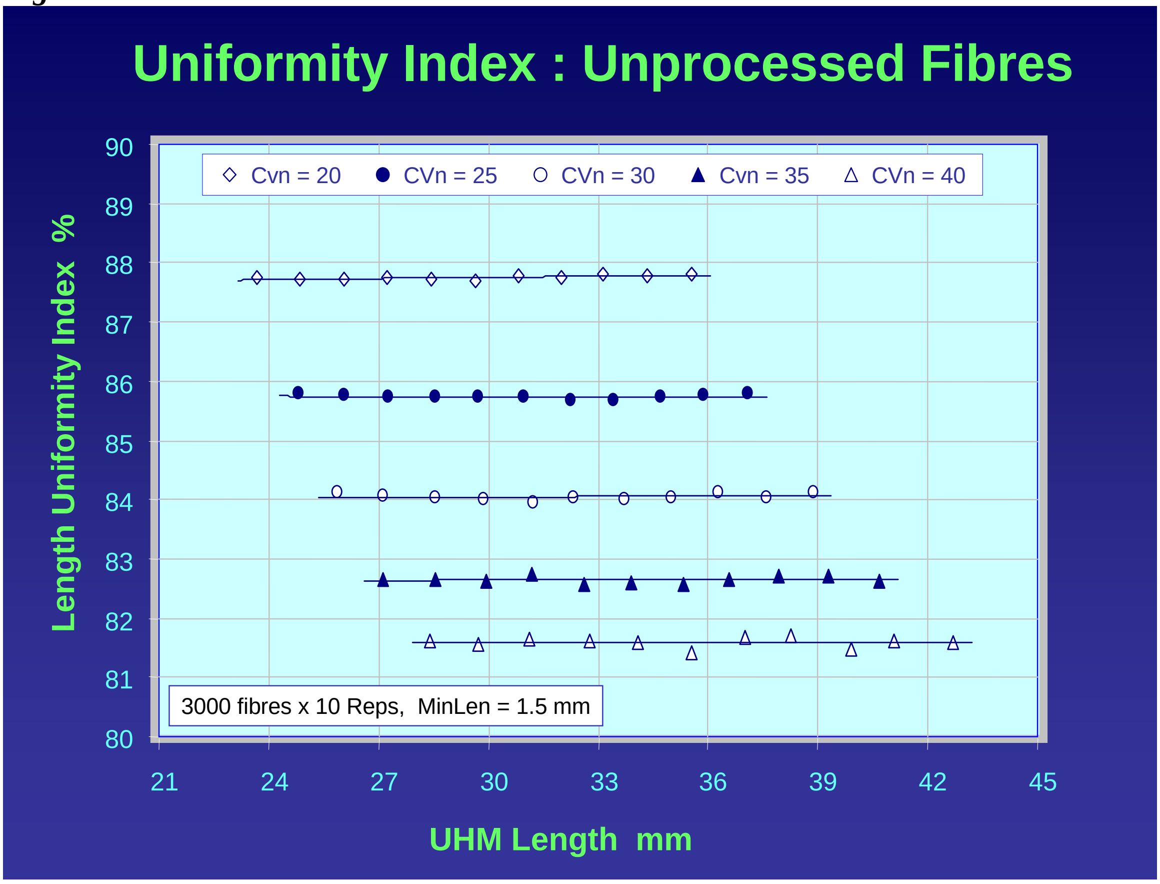


Figure 18

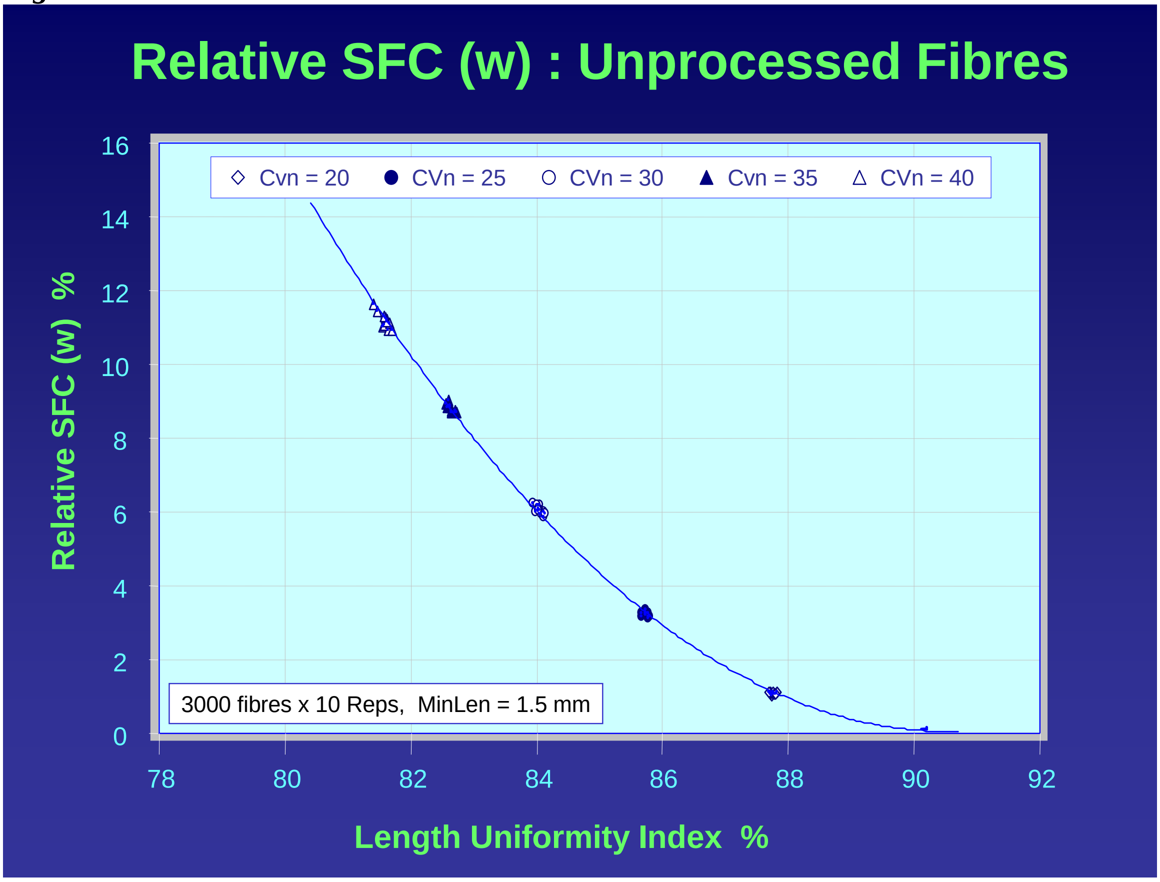
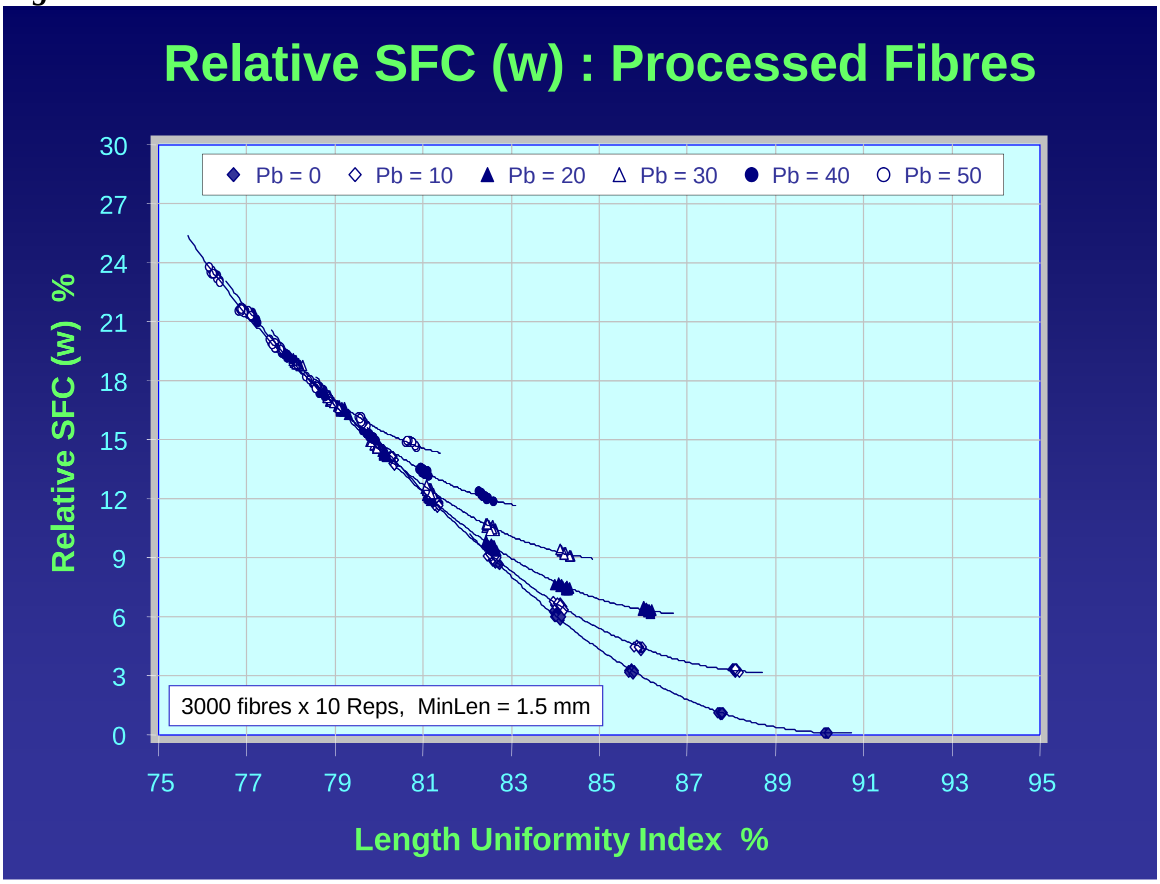


Figure 19



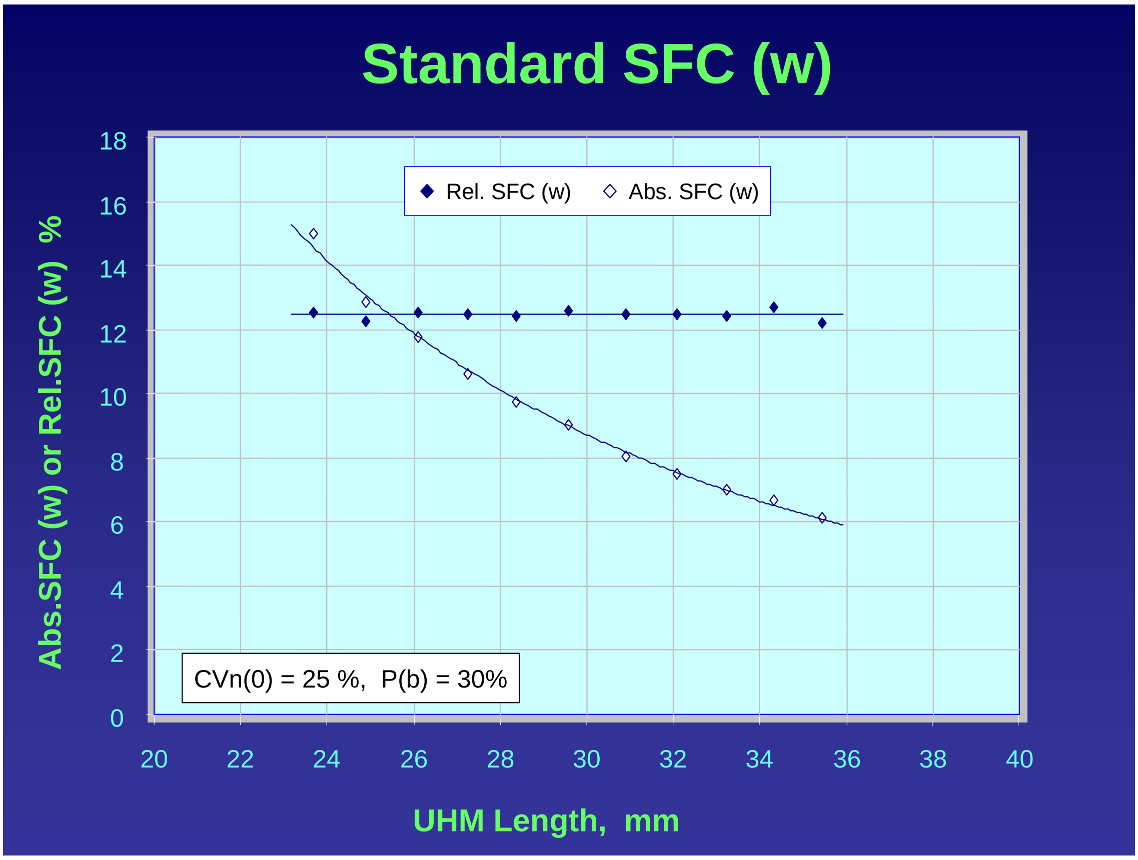
These results lend some support to those who have argued that, in cotton classification the LUI can serve as a proxy for SFC, by suitable manipulation of the data based upon regression analysis of large sets of classification data [21,25,26,60]. It is both a strength and a drawback of such approaches that they depend on the practical determination of what is termed the "*normal SFC*" for a given staple length, for a given group of cottons, in a given growing area, for a given growing season.

On the other hand, the clear suggestion from the present results is that the concept of a "*practical-normal SFC*" might find even more success if the SFC parameter in question were to be a Relative one rather than the present Absolute (12.7mm) standard, and perhaps also if the population of "classification data" were generated from a statistical model such as the one exposed here.

For example, if we define a standard seed cotton as one with MLn(0) = 25 mm and CVn(0) = 25%, and if we further specify a standard degree of fibre breakage as 30%, then it turns out that the corresponding "*standard-normal Relative SFC*" (*Std.SFC*) is about 12.5% by weight, *independent of the staple length*.

The equivalent "standard-normal Absolute SFC" depends on the UHM length. It varies from about 14% for UHM = 24 mm to about 7% for UHM = 33 mm (***Figure 20***).

Figure 20



Premiums and discounts based on a "standard-normal" Rel.SFC level would be impartial between cotton staple types and would exert market pressure towards lower fibre breakage *and* more uniform seed cotton. Alternatively, a system for moderating the measured staple length, such as that advocated by Bragg [21], should also be relatively easy to devise using the "standard-normal" values that could be calculated for Length Uniformity Index. To test the practical validity of this approach, it would be necessary for HVI software to be modified so that Rel.SFC can be calculated and displayed.

Advocates for retaining the Absolute SFC will note that a "standard-normal Absolute SFC" for any measured value of staple length can easily be determined by simple regression analysis (e.g. Figure 20), once the standard model has been decided.

Use of a theoretical, model-based standard fibre length distribution is, of course, open to the criticism that it departs from real life. However, it has the major advantages that it needs to be determined only once and, once fixed, it is applicable to any cotton grown and processed at any time, anywhere in the world, whereas the practical "normal SFC" has to be re-determined every new season for every different growing area (since it is dependent upon the current mix of cotton varieties and ginning practices).

There is still the small reservation that a universally acceptable theoretical model has yet to be perfected. The simple model exposed here is designed only to demonstrate the probable usefulness of the Rel.SFC concept. An acceptable, practical theoretical model would have to be firmly based on extensive empirical test data, and might require a slightly more sophisticated set of starting assumptions.

Of course, the second big problem, that of the relative unreliability of SFC testing, remains. A part of this problem is now shown to be intrinsic to the parameter: SFC really is much more variable than, say, UHML. The only solution for that is to make more tests, for example by module averaging, as suggested by Knowlton [26]. The fact that the CV of fibre length within seeds is apparently greater than that between samples [51,52] weighs heavily in favour of module averaging as a reasonable approach.

Even so, it seems likely that improvements in the within- and between-laboratory reproducibility of SFC testing instruments are still possible and would be desirable. *Figures 7, 8, and 10* may have something to say in this context.

Conclusions

- A simple random breakage (*SRB*) model predicts fibre length distributions that are similar to measured ones.
- The intrinsic variability of SFC is more than three times greater than for UHM length. Therefore it will always be necessary to test at least ten times as many specimens to have the same reliability.
- The percentage of fibres shorter than 12.7 mm is unsuitable as a cotton classification criterion because it is unfair to growers of short-staple cottons.
- The percentage of fibres shorter than one half the UHM length is unaffected by cotton staple type.
- A "standard-normal" SFC (*Std.SFC*) can be defined by reference to a *SRB* model with defined (standard) inputs. This *Std.SFC* parameter should be suitable as a yardstick for cotton classing provided that sufficient specimens can be tested within the available time – e.g. by the use of module averaging.

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