INTERNATIONAL WOOL TEXTILE ORGANISATION

TECHNOLOGY & STANDARDS COMMITTEE **BUENOS AIRES MEETING**

Commercial Technology Forum **May 2003**

Chairman: A.G.DE BOOS (Australia) **Report No: CTF 04**

TEAM-3 Processing Trial - May 2003 Update

By

TEAM-3 Steering Committee

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SUMMARY

This report provides an update on the progress of the TEAM-3 trial. It shows that processing performance has improved since the late 1980's and that mills are producing tops with Hauteur values, on average, 4.9 mm longer than is predicted by the TEAM-2 general formula. Larger differences occur as the Hauteur increases above 75 mm. In addition, mills are producing tops which have, on average, CV of Hauteur values 2.3 % less than predicted by the TEAM-2 formula and Romaine values that are, on average, 2.0 % greater than predicted. With regards to core/comb relationships, the mean fibre diameter of the top is, on average, 0.24 μm coarser than the mean fibre diameter of the greasy wool.

A statistical analysis was conducted on 453 consignments that were submitted by 29 mills as part of the TEAM-3 trial. The analysis shows that the effects of Staple Length and Staple Strength on Hauteur are similar for both the TEAM-2 and the TEAM-3 databases. Using the current TEAM-3 data, the inclusion of CV of Diameter and CV of Length in the regression model results in a small improvement in the prediction of Hauteur. However, based on the data available, fibre curvature does not have a determinable influence on the processing prediction of these 453 consignments.

INTRODUCTION

In March 2001, at the Shanghai meeting of the International Wool Textile Organisation (IWTO), AWTA Ltd announced the commencement of the TEAM-3 trial. The commencement of TEAM-3 was in response to an industry request for an update to the existing processing prediction formulae (TEAM). These formulae, which utilise measurements of Staple Length & Staple Strength, have been the industry benchmark for the prediction of Hauteur (average fibre length in the top), Coefficient of Variation of Hauteur and Romaine (fibre wastage). Although there have been a number of attempts to provide improved prediction of processing performance, a survey conducted in 1997 (Douglas & Couchman) clearly showed that the TEAM formulae remain the generally recognised world benchmarks. While this survey showed general satisfaction with the current TEAM formulae, it did indicate that there are specific wool types that do not predict accurately.

Due to the shortage of industry funds, research to improve prediction for these difficult types and for a wider range of wools has been left to individual topmakers and their customers. However, AWTA Ltd's introduction of Laserscan as its standard for all Presale Fibre Diameter tests in Australia and the availability of Staple Length & Staple Strength data on most combing lots in catalogues provided both a catalyst and an opportunity to develop improved predictive formulae at minimal cost. It has been suggested that the new measurements provided by Laserscan, such as Coefficient of Variation (CV) of

Diameter and Mean Fibre Curvature, may influence top making performance. If so, their inclusion in the TEAM formulae may improve the accuracy of predicting such performance.

This is the third successive paper presented to IWTO which provides an update on the progress of the TEAM-3 trial. The first report (Lindsay *et al*, 2002a) summarised the data from 163 commercial processing consignments whilst the second report (Lindsay *et al*, 2002b) was based on 313 consignments. The TEAM-3 database has continued to expand and this third report examines the data from 453 commercial consignments.

At the time of writing, 34 mills had signed an agreement to participate in the TEAM-3 trial and a total of 29 mills have submitted 459 commercial consignments. The global distribution of the processing mills participating in TEAM-3 is illustrated in Table 1. This report provides a snapshot of current processing practice by examining the results of 453 of these consignments. It was not possible to provide a report on the entire database as further analysis of submitted top samples is required before the data can be included in any report.

Table 1. TEAM-3 Participating Mills (as at March 2003)

Country	Mills	Country	Mills
Australia	7	Japan	1
China	9	Korea	1
Czech Republic	1	Singapore	1
France	2	Slovak Republic	1
Germany	1	Taiwan	1
India	5	Thailand	1
Italy	3		

CONSIGNMENT DETAILS

A summary of the major raw wool and processing characteristics of the TEAM-2 and TEAM-3 databases (as at March 2003) is presented in Tables 2 and 3. The TEAM-3 data reported in Table 2 and Table 3 is derived from 453 consignments totalling 103,134 bales of greasy wool. In contrast, the TEAM-2 database totalled 603 consignments.

Table 2. Range and Mean of the Raw Wool Characteristics of Consignments

	TEAM-1 & TEAM-2 Total Database			TEAM-3 Database (March 2003)		
	Avg	Max	Min	Avg	Max	Min
Schlumberger Yield (%)	--	--	--	69.40	78.05	57.44
Mean Fibre Diameter (μm)	22.0	31.0	17.0	20.3	24.9	16.4
Staple Length (mm)	86	123	59	86	104	71
CV Length (%)	19	30	12	18	28	14
Staple Strength (N/ktex)	39	60	23	38	49	24
Tip Breaks (%)	--	--	--	22	54	5
Mid Breaks (%)	--	--	--	53	86	28
Base Breaks (%)	--	--	--	26	58	6
Vegetable Matter Base (%)	2.1	10.0	0.1	1.2	5.3	0.3
CV of Diameter (%)	--	--	--	21.7	25.2	19.1
Mean Fibre Curvature (deg/mm)	--	--	--	93	124	74
Comfort Factor (%)	--	--	--	97.1	99.5	85.4

Table 3. Range and Mean of the Processing Characteristics of Consignments

	TEAM-1 & TEAM-2 Total Database			TEAM-3 Database (March 2003)		
	Avg	Max	Min	Avg	Max	Min
Hauteur (mm)	67	97	48	73	91	58
CV of Hauteur (%)	49	61	31	45	58	33
Romaine (%)	8	21	1	9.0	18.1	2.3
Top & Noil Yield (%)	64	77	46	70.5	79.6	59.0
Mean Fibre Diameter (μm)	22.1	31	17	20.6	25.4	16.5
CV of Diameter (%)	--	--	--	21.1	25.1	17.3
Comfort Factor (%)	--	--	--	96.9	99.8	82.8

The range data depicted in Tables 1 and 2 is shown graphically in Figures 1 to 14.

Figure 1: TEAM-3 SDRY Histogram

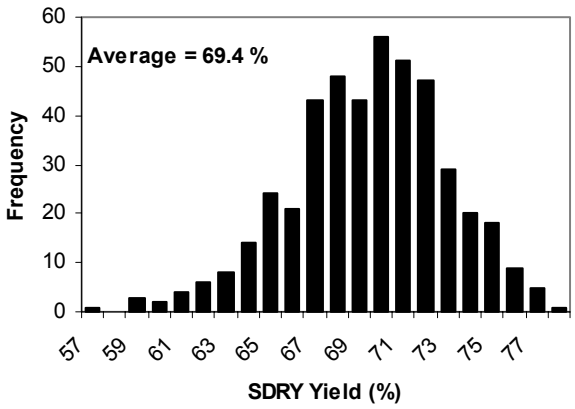


Figure 2: Team-3 VMB Histogram

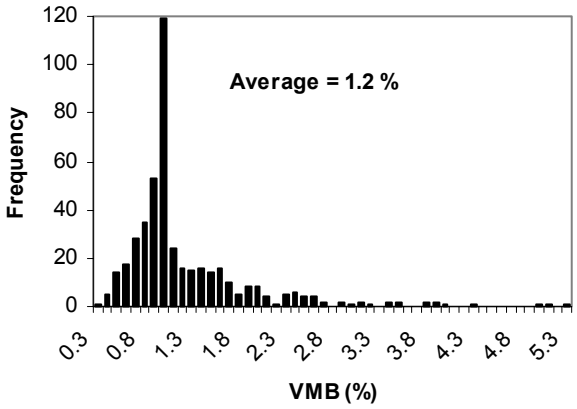


Figure 3 : TEAM-3 Mean Fibre Diameter Histogram

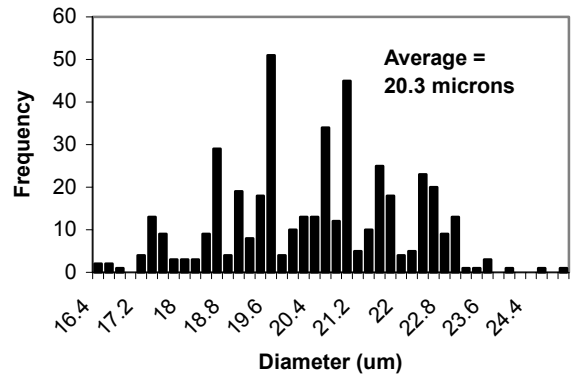


Figure 4: TEAM-3 CV of Diameter Histogram

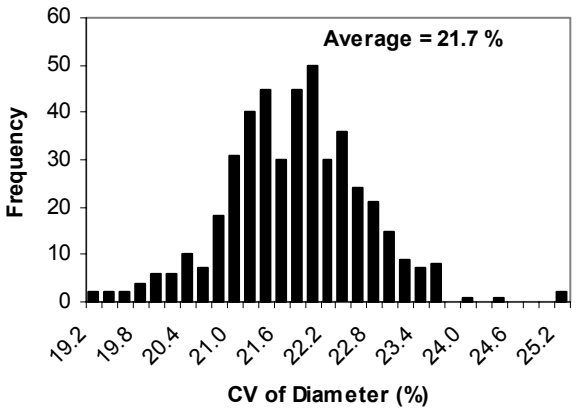


Figure 5: TEAM-3 Fibre Curvature Histogram

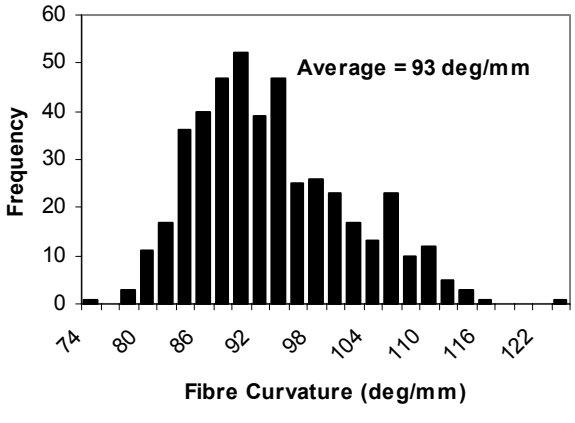


Figure 6: TEAM-3 Staple Length Histogram

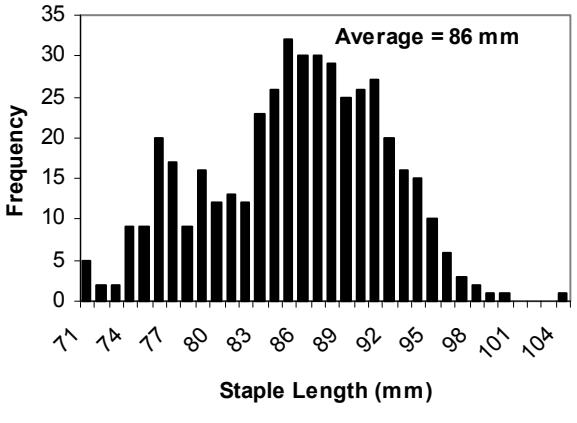


Figure 7: TEAM-3 CV Staple Length Histogram

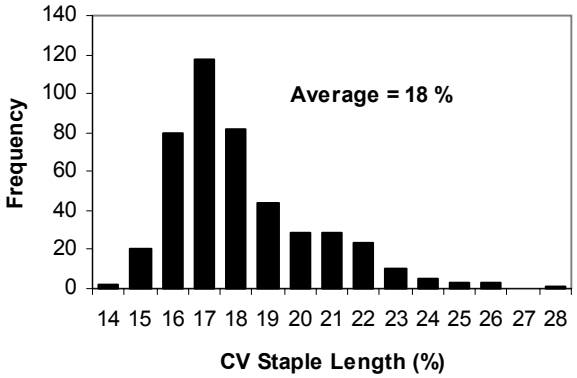


Figure 8: TEAM-3 Staple Strength Histogram

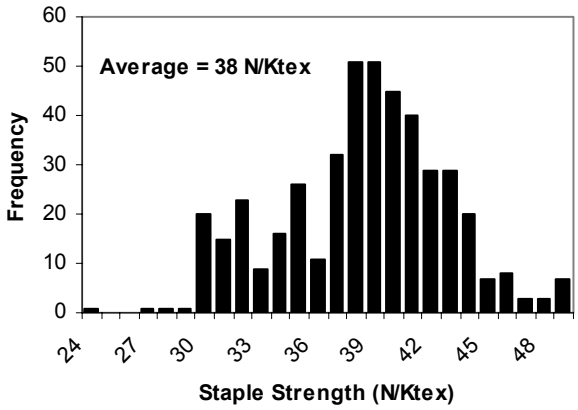


Figure 9: TEAM-3 Tip Break Histogram

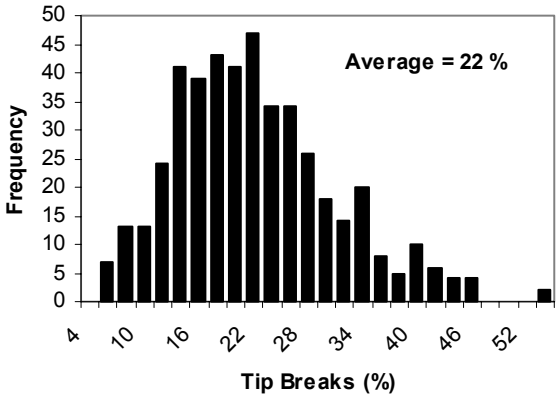


Figure 10: TEAM-3 Mid Break Histogram

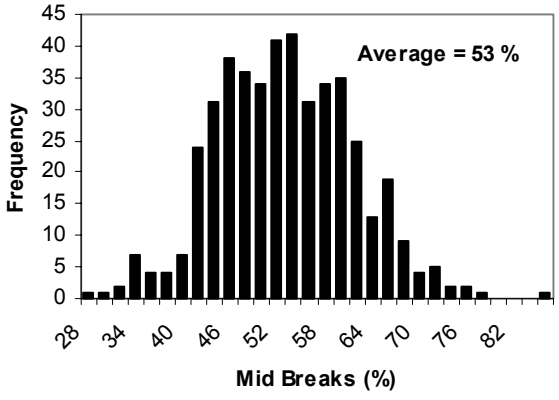


Figure 11: TEAM-3 Base Break Histogram

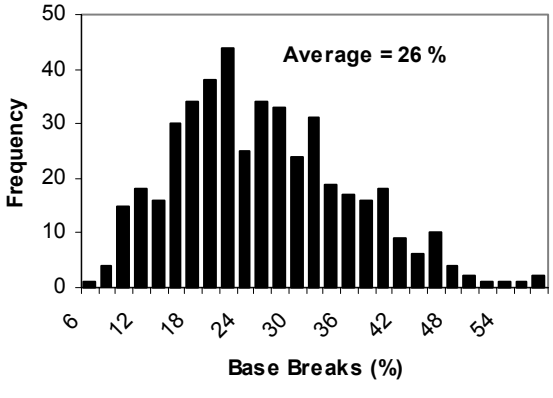


Figure 12: TEAM-3 Hauteur Histogram

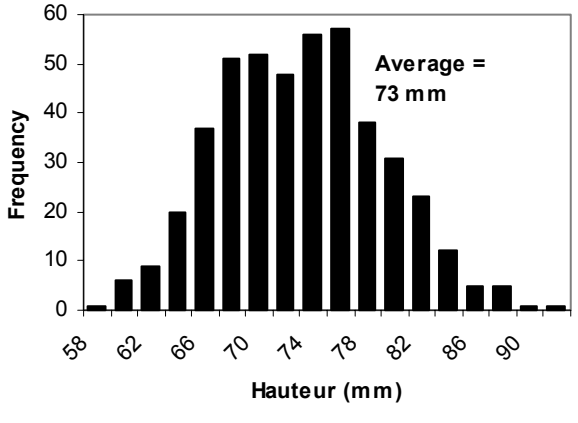


Figure 13: TEAM-3 CV Hauteur Histogram

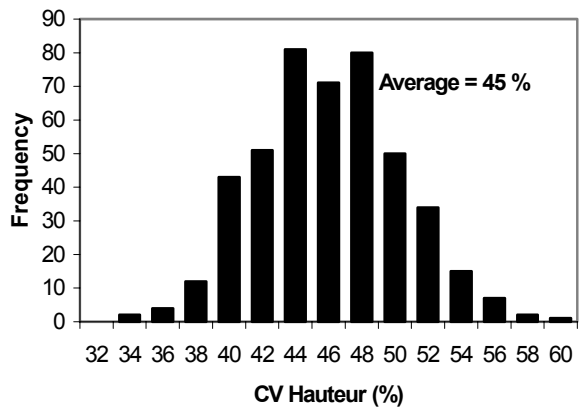
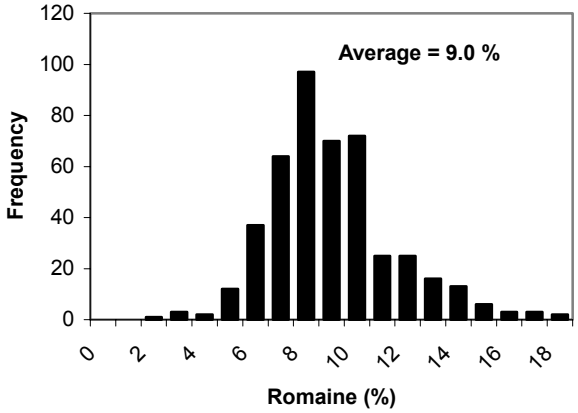


Figure 14: TEAM-3 Romaine Histogram



There are some interesting differences between the ranges of the TEAM-2 and TEAM-3 data sets. The TEAM equations are based on multiple regression statistical techniques and, in order to increase the applicability of such methods, it is important to have as wide a range of inputs (raw wool measurements) as possible. In the development of the TEAM-2 prediction equations, considerable effort was made to increase the ranges of the raw wool values of blends to improve the equations' robustness. As a general comment, the further one moves away from the mean values, the less accurate a prediction is likely to be. For the TEAM-3 trial, commercial processing consignments have been accepted and, unlike TEAM-2, there has been no effort to increase the ranges of the raw wool values.

In the original TEAM trials, combing batches were submitted for inclusion in the TEAM project and farm lots that had not been pre-sale tested were sampled and tested post-sale. In effect, this meant that the range of raw wool measurements was unknown at the time of blend construction and therefore restrictions could not be placed on inclusion or exclusion of lots from the blend on the basis of the raw wool attributes. As such, it was always likely that the ranges of the raw wool attributes from the TEAM-3 database would be smaller than TEAM-2.

In addition, the knowledge of acceptable ranges and specification limits was not as well understood in the 1980's as it is today with the hindsight of experiences obtained with raw wool measurements and prediction over the past 20 years. These trade experiences have resulted in application of greasy wool specifications for blend engineering, based on measurement. Today, for example, typical specifications require mean and range component values for diameter and staple length, mean and minimum component values for staple strength and mean and maximum component values for vegetable matter. These, along with a TEAM-2 predicted Hauteur, form a common base for raw wool specification. With this in mind, restrictions in the ranges of raw wool attributes observed in the TEAM-3 data set are only to be expected. The basis for inclusion of combing batches into the TEAM-3 program is on the basis of current commercial practice and a requirement for 95% of the blend components to be pre-sale measured for Length & Strength.

Specific comments on the raw wool characteristics depicted above are as follows:

- *Diameter*: The upper range in fibre diameter is lower in the TEAM-3 database, which is likely to be a reflection of the overall reduction in these types of wool being available due to the fining up of the Australian clip over the past 10 to 15 years.
- *Staple Length*: Whilst the mean value is similar in both data sets, the maximum and minimum values have contracted significantly in the TEAM-3 data set. The reduction in the maximum value is partly due to the lower range of diameter and also due to specification restrictions. The higher minimum value is primarily due to industry experience that suggests shorter wools do not predict as well with

the TEAM-2 formulae as they are close to the extremes of the data set used to generate the equations. Some combers use specific mill based formulae for short wool blends.

- *Staple Strength*: Under the appraisal system used during the TEAM-2 project it was difficult for subjective appraisal to differentiate the actual staple strength when it was greater than approximately 30 N/Ktex. Experience, and the use of prediction with TEAM-2, has resulted in topmakers having a better understanding of the available trade-offs between raw wool attributes as well as the cost of high or low strength as a measurement.
- *Vegetable Matter:* During the TEAM-2 project special effort was made to increase the range of vegetable matter blends in order to improve the robustness of the prediction formulae. Commercial decisions being made today clearly indicate that restrictions are placed on maximum vegetable matter levels.
- *Other Measurements*: The TEAM-3 trials are designed to determine if improvements to the prediction equations currently in use (TEAM-2) can be achieved with the addition of measurements that have been introduced since the TEAM-2 equations were published. There have been changes in specification and combing practices and industry now has a better understanding of available measurements, all of which may be impacting on differences observed today. The TEAM-3 data set therefore identified a number of raw wool measurements and their ranges that were not available or published in the original TEAM Report.

PROCESSING PERFORMANCE AND COMPARISON TO TEAM-2

Based on the data from 453 commercial consignments, the average difference between actual Hauteur and TEAM-2 predicted Hauteur is 4.9 mm (Table 4). The 140 consignments added to the TEAM-3 database since the Nice meeting have had an impact on the difference between actual and predicted Hauteur. The difference between actual and predicted Hauteur reported at Nice was 4.1 mm.

In terms of CV of Hauteur, actual values are, on average, 2.3% less than predicted by TEAM-2. This result has changed from the 1.6% difference reported in the Nice report. For Romaine, actual values are 2.0% greater than predicted which has changed from the 1.8% difference reported previously.

Table 4. Comparison between Actual and Predicted Hauteur, CV of Hauteur and Romaine (Derived from 453 TEAM-3 processing consignments).

	HAUTEUR (mm)			**CV of HAUTEUR (%)**			**ROMAINE (%)**		
	Predicted*	Actual	Diff.	Predicted*	Actual	Diff.	Predicted*	Actual	Diff.
Mean:	67.7	72.6	4.9	47.4	45.1	-2.3	7.0	9.0	2.0
St Dev:	5.1	6.1	3.9	3.0	4.3	3.2	1.0	2.5	1.7

* Note: Predicted using TEAM-2 general formulae (1988)

Figures 15-17 show graphically the differences between actual and predicted Hauteur, CV of Hauteur and Romaine. The slopes on these three graphs confirm that processing performance has changed significantly over the past 15 years. The slope effects suggest that simple mill adjustments will not adequately compensate for these differences. However, individual mill effects must be investigated before new prediction formulae can be recommended for each of these parameters.

Although the average difference between actual Hauteur and TEAM-2 predicted Hauteur is 4.9 mm, Figure 15 shows that the differences are larger for Hauteur values in excess of 75 mm. The average difference between actual and predicted Hauteur is 7.4 mm for all those consignments with an actual Hauteur of 75 mm or greater. Approximately 35% of the 453 consignments submitted have Hauteur values in excess of 75 mm.

Figure 15. Hauteur Differences (Actual - TEAM2)

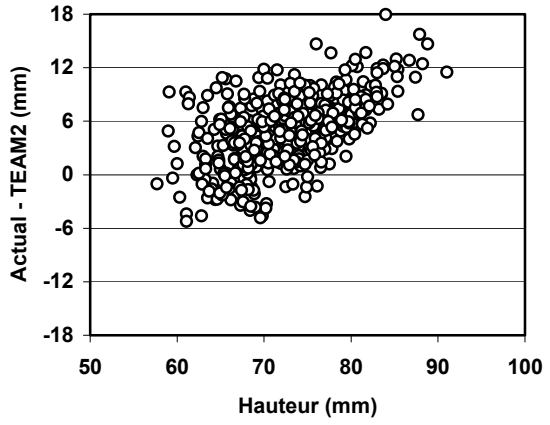


Figure 16. CV Hauteur Differences (Actual - TEAM2)

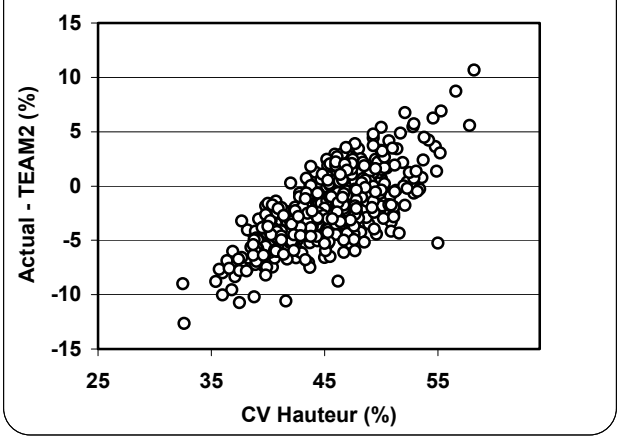
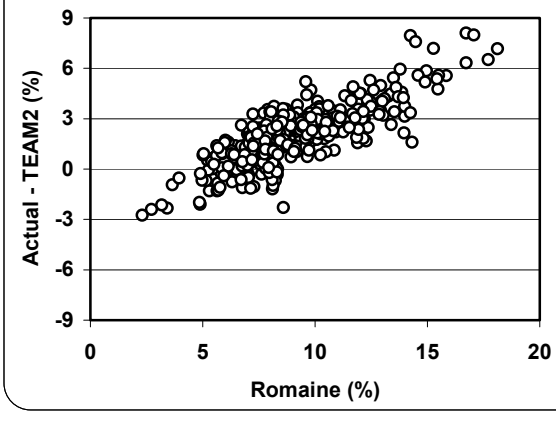


Figure 17. Romaine Differences (Actual - TEAM2)



CORE/COMB RELATIONSHIPS

Figure 18 shows the relationship between the core mean fibre diameter and the top mean fibre diameter for the 453 commercial processing consignments. For each processing consignment submitted as part of the TEAM-3 trial, a minimum of five samples of top are provided to AWTA Ltd for analysis. The diameter of the top that is used in this analysis is that measured by AWTA Ltd, using Laserscan. As such, Figure 18 shows a direct comparison between the Laserscan core result and the Laserscan top result. On average, the mean fibre diameter of the top is 0.24 μm coarser than the mean fibre diameter of the greasy wool. The core/comb comparison reported at the Nice conference (Lindsay *et al*, 2002b) was 0.3μm.

Figure 18. Core/Comb Fibre Diameter Comparison

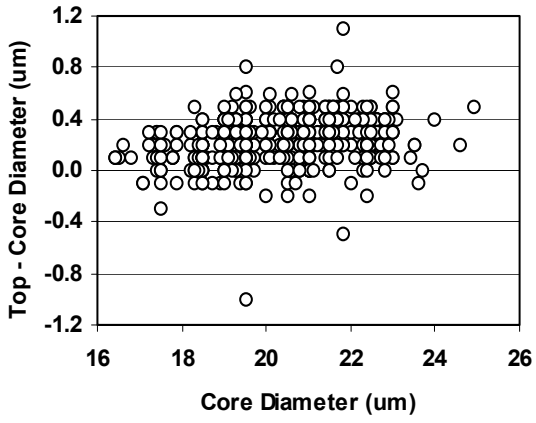
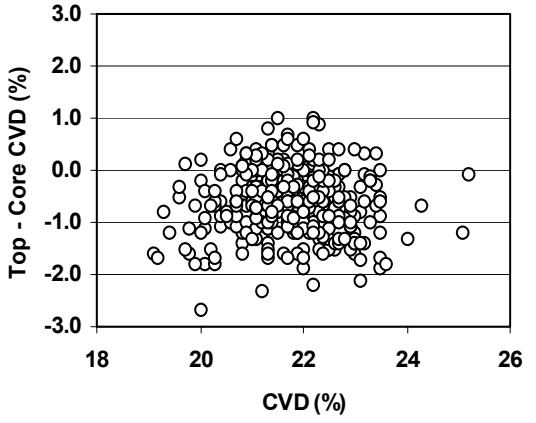


Figure 19 compares the CV of Diameter of the greasy wool and the top. It shows that the CV of Diameter is, on average, 0.6% lower in the top than it is in the core. This is an expected result as processing is understood to remove proportionally more fine fibres than coarse fibres as noil. This has the effect of increasing the fibre diameter in the top (Figure 18) and decreasing the fibre diameter variation in the top. This result is similar to that reported at the 2002 Nice conference where the difference was 0.5%.

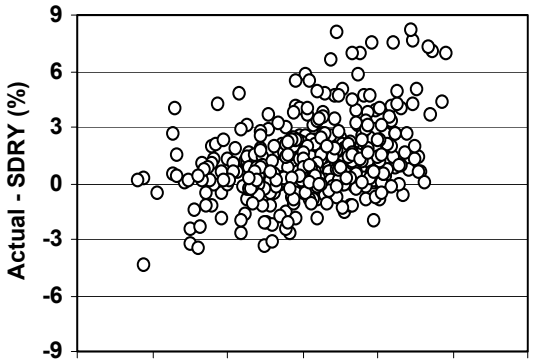
Figure 19. Core/Comb CV of Diameter Comparison



YIELD COMPARISON

A comparison between the actual Top and Noil yield achieved by the processing mills and the predicted yield using the Schlumberger Dry Top and Noil Yield (SDRY) formula is shown in Figure 20. On average, the actual yield is 1.2% higher than the yield predicted by the SDRY formula. The difference reported in Nice was 1.1%.

Figure 20. Yield Comparison



STATISTICAL ANALYSIS OF TEAM-3 DATA

The data from the consignments submitted for the TEAM-3 trial was analysed using the S Plus statistical package. As with the reports presented to IWTO in May and December 2002, the analysis included re-determining the coefficients for the current TEAM formula for Hauteur and then adding either one, two or three new variables to the model. The variables added were Mean Fibre Curvature (MFC), CV of Diameter (CVD), and CV of Length (CVL). Eight different multiple regression analyses were conducted which plotted Hauteur against the factors shown in Table 5.

For reference, the TEAM-2 general equation, as published in 1988, is as follows:

$$H = 0.52L + 0.47S + 0.95D - 0.19M^* - 0.45V - 3.5 + [MA1]$$

Where: H = Hauteur (mm); D = Mean Fibre Diameter (μm); L = Staple Length (mm); S = Staple Strength (N/ktex); V = Vegetable Matter Base (%); M* = Adjusted percentage of middle breaks; MA1 = Mill Adjustment Factor

Table 5 is of identical format to the table presented in earlier TEAM-3 reports (Lindsay *et al*, 2002a , Lindsay *et al*, 2002b). Regression 1 is an analysis of the TEAM-3 database using Staple Length (SL), Staple Strength (SS), Fibre Diameter (D), Adjusted Mid Breaks (M*) and Vegetable Matter Base (V) as a function of Hauteur. These are the same coefficients that formed the basis of the TEAM-2 equation. It is noticeable that the regression analysis on the TEAM-3 database gives a lower Standard Error (SE) than was reported for TEAM-2, suggesting improved repeatability.

Although the coefficients for SS and SL are similar between TEAM-2 and Regression 1, the effect of Fibre Diameter continues to be more significant in the TEAM-3 analysis (1.31 compared to 0.95).

In the December 2002 report to IWTO (Lindsay *et al*, 2002b) the statistical analysis showed that VMB had a positive effect on Hauteur i.e. as VMB increases so too does Hauteur. Although this effect was not statistically significant, it was an unusual result and most likely a reflection of the small range of VMB in the TEAM-3 database. Although the absolute range in VMB has not changed in the current database, the

average VMB has increased slightly (1.2% compared to 1.1%). In the December 2002 report, 94% of the consignments had a VMB of 2.0% or less. The current database has 90% of all consignments with a VMB of 2% or less. Although the VMB term is still not statistically significant, it's coefficient is now negative (-0.31), which is a more logical outcome.

Table 5. Statistical Analysis using Additional Factors of CVD, MFC and CVL.

Regression		SL	SS	D	M*	V	CVD	MFC	CVL	SE (mm)	R^2
	TEAM-2	0.52	0.47	0.95	- 0.19	- 0.45				3.4	84%
1	TEAM-3	0.54	0.44	1.31	-0.17	***-0.31***				2.85	79%
2	TEAM-3 +CVD	0.44	0.30	1.69	-0.18	***-0.42***	-1.05			2.81	80%
3	TEAM-3 + MFC	0.54	0.45	1.26	-0.16	***-0.31***		***-0.01***		2.86	79%
4	TEAM-3 + CVL	0.40	0.40	1.59	-0.16	***0.003***			-0.53	2.76	81%
5	TEAM-3 + CVD + MFC	0.43	0.30	1.49	-0.18	***-0.41***	-1.11	***-0.05***		2.81	80%
6	TEAM-3 + CVD + CVL	0.34	0.30	1.84	-0.17	***-0.11***	-0.78		-0.47	2.74	81%
7	TEAM-3 + MFC + CVL	0.40	0.41	1.48	-0.16	***0.01***		***-0.02***	-0.53	2.77	81%
8	TEAM-3 + CVD + MFC + CVL	0.34	0.30	1.63	-0.17	***-0.10***	-0.85	***-0.05***	-0.47	2.74	81%

Note: All coefficients that are not statistically significant are in Italics and Bold.

THE ADDITION OF NEW VARIABLES TO THE TEAM MODEL

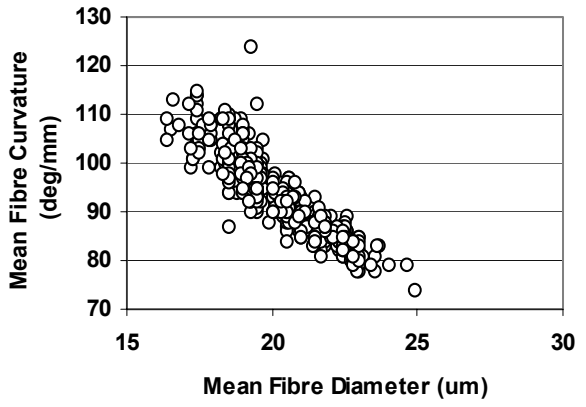
As with the December 2002 report, the addition of CVD (Regression 2) and CVL (Regression 4) improve the processing prediction model with the SE and the R^2 improving slightly over Regression 1. It is also worth noting that when CVD is added to the model together with the TEAM-3 variables (Regression 2) that the coefficients for both SS and CVD are significant. There has been some opinion that CVD could replace SS as a predictor of processing performance. This analysis suggests that SS is still important for processing prediction.

The addition of Fibre Curvature (MFC) to the model (Regression 3) did not result in any improvement to the prediction of Hauteur. This is similar to the results presented in the previous TEAM-3 reports. A plot of MFD against MFC for the TEAM-3 database is shown in Figure 21. The relationship shown is as expected, i.e. as MFD increases, MFC decreases. The range of MFC for each micron level is approximately 10 to 15 degrees/mm.

Based on work presented by Peterson (2002) and Haigh (2002), it is expected that, at a given diameter, wool of lower fibre curvature will produce tops of longer Hauteur. Peterson compared the processing results of fleeces which differed in fibre curvature by more than 15 degrees/mm (compared fleeces MFC values of less than 85 degrees/mm with those greater than 100 degrees/mm). Haigh (2002) compared sale lots of low, medium and high curvature at four different micron levels. The range between the low and high curvature sale lots was approximately 15 to 20 degrees/mm (although the range was 29 degrees/mm for one wool type). Both these studies concluded that, for a given fibre diameter, lower curvature wools produce tops of longer Hauteur.

The work reported here looks at the processing results of consignments rather than fleeces or sale lots. Despite the fact that the range in curvature at a given micron level is slightly less than the range reported by Peterson and Haigh, the use of MFC does not improve processing prediction on the TEAM-3 data set.

Figure 21. Fibre Diameter and Fibre Curvature Relationships



THE USE OF M* IN THE TEAM MODEL

As in the December 2002 report to IWTO, M* was compared to the use of the actual mid break percentage (M). Table 6 shows that using M instead of M* did not change the SE and R^2 values of Regression 1 (as reproduced from Table 5).

Table 6. Statistical Analysis using M instead of M*.

Regression		SL	SS	D	M*	M	V	CVD	MFC	CVL	SE (mm)	R^2
1	TEAM-3	0.54	0.44	1.31	-0.17		***-0.31***				2.85	79%
2	M* replaced by M	0.55	0.45	1.31		-0.14	***-.27***				2.85	79%

Note: All coefficients that are not statistically significant are in Italics and Bold.

MEASUREMENT AND PREDICTION OF CHARACTERISTICS OF FIBRE ENDS IN TOP

In addition to measuring the fibre diameter and Hauteur characteristics of top samples submitted as part of the TEAM-3 trial, the tops are also being used to estimate the diameter of the Fibre Ends. Research by CSIRO (Garnsworthy *et al*, 1985) has highlighted the importance of the diameter of wool Fibre Ends in determining the comfort of wool fabrics worn close to the skin. In November 2001, the IWTO Congress accepted a new Draft Test Method, 'Measurement of Fibre End Characteristics in Wool Slivers as a Guide to Fabric Skin Comfort' (IWTO-DTM-60-01), which describes a technique for the measurement of the diameter of fibre ends in top and defines a Fibre Ends Fineness Index (FEFI).

A report to IWTO in June 2002 (Mahar *et al*, 2002) demonstrated that raw wool measurements could be used to predict Fibre Ends characteristics of tops. This analysis is now extended to include 310

consignments from the TEAM-3 database; nearly double the number from the earlier report. Results for the 310 consignments are summarised in Table 7. The fibre diameter and comfort factor of the raw wool and of the Fibre Ends are measured results. The FEFI is a predicted result (IWTO-DTM-60-01).

Table 7. Raw Wool and Fibre Ends Characteristics of 310 consignments from TEAM3

	Average Values			Prediction Parameters	
	Raw Wool	Fibre Ends	Difference	R*	SE
MFD (µm)	20.4	20.1	0.3	0.96	0.43µm
Comfort Factor (%)	97.2	97.6	- 0.4	0.94	0.54%
FEFI		- 0.4			

*The Multiple Linear Regression Coefficients for relationships between MFD, and CF, and statistically significant (5% level) Raw Wool parameters.

The Fibre Ends in a top are generally finer than the greasy wool mean fibre diameter, and based on the results from the 310 TEAM-3 consignments, the average difference is 0.3µm. Similarly, the comfort factor of the Fibre Ends is, on average, 0.4% higher than the greasy wool comfort factor. The Fibre Ends characteristics of the tops remain predictable from raw wool measurements, though the Standard Errors are slightly higher than those reported earlier. The mean fibre diameter and comfort factor of the greasy wool are the major determinants of the prediction.

CONCLUSIONS

This report has provided an update on the progress of the TEAM-3 trial. It has been shown that processing performance has improved since the late 1980's and that mills are producing tops with Hauteur values, on average, 4.9 mm longer than is predicted using the TEAM-2 general formula. Larger differences occur as the Hauteur increases above 75 mm. In addition, mills are producing tops with CV of Hauteur values, on average, 2.3% less than predicted by TEAM-2 and Romaine values 2.0% greater than predicted. The level dependencies identified in the TEAM-3 database would indicate that there is likely to be potential for an improvement in processing prediction.

The core/comb comparison for the data set shows that the diameter of the top is, on average, 0.24 µm coarser than the diameter of the core. In addition, the CV of diameter decreases by 0.6% in the top.

Using the current TEAM-3 data, the inclusion of CV of Diameter and CV of Length in the regression model results in a small improvement in the prediction of Hauteur. However, based on the data available, fibre curvature does not have a determinable influence on the processing prediction of these 453 consignments.

It is expected that the TEAM-3 trial will conclude towards the end of 2003 or early 2004. This will be dependent on sufficient data being received during this time. The TEAM-2 report was based on 603 consignments and it is hoped that this number will be obtained in time for a further update at the Shanghai conference in December 2003. It is likely that a final report on this industry project will be presented to the Evian conference of IWTO in 2004. In this report, all data will be presented together with any recommendations with regards to amendments to the existing TEAM formulae.

ACKNOWLDEGEMENTS

The TEAM-3 Steering Committee would like to acknowledge David Crowe (AWTA Ltd) for his assistance with the statistical analysis.

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