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Predicting Processing Results of Sale Lots. Part 1: Performance of TEAM Hauteur Equations.

By

V.E. Fish, J.W. Marler & T.J. Mahar

Australian Wool Testing Authority Ltd PO Box 190, Guildford NSW 2161, Australia

SUMMARY

This paper investigates comments by some wool buyers and processors, that the processing performance of some wool types does not match the performance predicted by the TEAM general formulae. The TEAM-2 and proposed TEAM-3 processing prediction equations were applied to the 311 sale lots under investigation, however this paper deals with 14 wool categories, the difficult-to-predict wool types, processed in a research facility's mini-mill.

Stretchy Bellies and Bellies sale lots were found to consistently process longer than predicted using both the TEAM-2 and proposed TEAM-3 equations. This was also true for the SRS®-type and Elite-type sale lots. In contrast, the Short-and-Strong sale lots processed shorter than predicted by the Hauteur prediction equations, indicating a limitation of the processing prediction equations investigated when used on sale lots at the extremes of the datasets used to develop consignment equations.

Whilst these wool types represent extremes in the range of available wool and are thus unlikely to be combed in isolation as 100% consignments, it is felt that further work is required to determine which parameters could potentially be used to improve the processing prediction of these hard-to-predict sale lots.

This paper concentrates on Hauteur prediction because that is the stated area of concern. However, it is emphasised that whilst there may be differences in Hauteur results, these may be out-weighed by different Romaine and CVH prediction results and thus industry participants are advised to consider all three results when making any commercial decisions.

INTRODUCTION

Since the introduction of TEAM-2 (TEAM Management Committee, 1988) predicted Hauteur in Sale Catalogues, there has been ongoing comment that some specific wool types (for example, belly wool, some pieces types, cotted wool types) produced predicted Hauteur values that did not agree with wool buyers' expectations, even though these wool types constitute a very small percentage of the total annual clip.

The application of a prediction formula based on consignments to individual sale lots, and vice versa, is only justified if it can be demonstrated that the processing outcome is the sum of the individual components. This additivity has been demonstrated in earlier research (Rottenbury et al., 1987) but it has also been noted that prediction accuracy is likely to drop as one moves to the extremes of the population (Brown et al, 1985).

The aim of this report is to assess which, if any, of the nominated wool types have been inadequately predicted for Hauteur by the TEAM-2 formula.

In commercial practice, it is not normal to process batches of the nominated wool types, let alone single sale lots on their own. To quantify the processing potential of single sale lots, individual display samples were processed to top in the CSIRO mini-mill. The wool buying trade across Australia assisted in the selection of the lots that were considered problematic. A range of wool types that were considered, to process according to the TEAM-2 formula, supplemented the selection.

The wool types of particular interest in this trial, to be compared with the control pieces lots, were:

- Bellies and Stretchy Bellies sale lots; and
- Variable Length Pieces (With or without Locks).

In addition, due to comments from some exporters, the following types were also included, and are compared with the control fleece sale lots:

- High and Low Mean Fibre Curvature fleece sale lots;
- Elite and SRS®-type fleece sale lots;
- Cotted fleece sale lots;
- Short-and-strong fleeces;
- High Strength & High Midbreak Percentage fleeces.

In total, 21 different wool types were included in the full trial; however, this paper will concentrate on the 14 wool types mentioned above.

The major areas selected for investigation, determined after consultation with wool exporters, are:

- **Variable Length Pieces (VLP) and Variable Length Pieces with Locks (LKS) are not adequately predicted by the measurement systems in use.**

Some industry members maintain these wool types contain some very short pieces, which may not be selected during Length & Strength Testing. An alternative argument is that the inclusion of these very short pieces within the measurement may bias the predicted result by including very short staples in the measurement that have a high probability of being removed during processing anyway. This may show up in the Romaine prediction, however this is yet to be investigated;

- **Stretchy Bellies (SBL), and to a lesser extent Control Bellies (BLS), process longer than predicted.**

It is believed that the Staple Length of these wool types is inadequately measured due to the physical structure of the staples. Bellies-wool staples are characterised by a helical shaped crimp structure, which acts like a spring. They are typically unextended during staple measurement (Fish et al 2003) and hence the staple length of this wool type is significantly shorter than it would be if they were extended. This has implications for the Staple Strength calculation, which is derived using the Staple Length of the unextended staple through the calculation of the linear density of each staple (IWTO-30-98);

- **The processing behaviour of Cotted fleece (COT) sale lots cannot be adequately predicted by the available techniques.**

This wool type is considered hard to sample tufts and then draw staples for measurement without breakage. The effort required to remove a staple from the fleece is not measured during Length & Strength testing, thus entanglement is not taken into account during prediction. Consequently, Cotted fleece sale lots may be expected to be difficult to predict due to the level of fibre entanglement. This may show up in the Romaine prediction, however this is yet to be investigated;

- **High Strength & High Midbreak Percentage (HSM) wool types.**

These were included to address perceptions that the TEAM-2 prediction model unfairly penalised sale lots with high Midbreak percentage, even when sale lots exhibit high Staple Strength values. If this perception is correct, then this wool type should process longer than predicted;

- **Short-and-strong fleeces**

These were included because it has been noted that in some cases, the predicted Hauteur is longer than the original staple length, this is perceived by some buyers to be an illogical outcome;

- **The benefit, or otherwise, of Low Mean Fibre Curvature (LFC) sale lots.**

Previous reports (Haigh, 2002) have suggested that LFC wool produces longer top than predicted, when compared with High Mean Fibre Curvature (HFC) wool. No benefits for consignments were reported and discussed in the TEAM-3 final report (TEAM-3 Steering Committee, 2004). While it might be argued that the benefits of LFC sale lots may be reduced by combining sale lots into consignments based primarily on MFD and expected Hauteur values, the processing of single sale lots in a non-commercial environment should highlight any effects likely to be present, and

- **SRS®-type (SRS) and Elite-type (ELT) wool processes longer than predicted (Crowe, pers. Comm., 2004; Pike, 2004).**

This view is based on the breeding aims of these two wool types. Particular breeding aims (Watts, 2004; Watts, date unknown) of these wool types is to produce long, even fleeces with bold crimp, which it is claimed should translate into long, even top, providing the wool production objectives are met.

TEAM-2 was the most recognised processing prediction equation in use at the time of assembling the current sale lots dataset under investigation and it was thus used in this study.

However, it is important to recognise one fundamental difference between the use of TEAM-2 as the predictor in this trial, and the generation of the TEAM-2 equation. The TEAM-2 equation was generated using the Hauteur of consignments processed under normal commercial conditions. In contrast, samples in this trial were processed as single sale lots in controlled conditions. No commercial pressure (for example, changing the machine settings if the Romaine was considered too high) was placed on the processing of the sale lots. Whilst this may not be considered normal commercial practice, it must be remembered that it is also not normal commercial practice to process batches prepared from 100% of the nominated wool types being studied. They are usually incorporated into blends, in differing proportions, with other wool types.

For the purposes of the current trial, the advantages of using sale lots rather than consignments were:

- Processing individual wool types as sale lots allowed the full processing behaviour of each wool type to be expressed (Mooy et al., 1988); and
- Within a consignment, the effects of individual wool types are masked, thus making it difficult to quantify the effect of an individual wool type.

METHODOLOGY

Three hundred and eleven (311) sale-lot display samples were sampled and tested at AWTA Ltd, and subsequently processed at the CSIRO, Textile and Fibre Technology Mini-mill (Smith & Hoschke, 1982). The display samples were sampled from commercial sale-lots in compliance with IWTO-38-91 and were a minimum greasy wool weight of 4kg.

SELECTION OF SALE-LOTS

Nominated and control wool types were selected to provide contrast for the interpretation of results. The control types were of similar MFD to the nominated types and were representative of standard sale lines, for example Fleece or Pieces lines

The selection and measurement of the sale-lots has previously been reported (Fish et al, 2003). However, a brief account will also be provided here.

Throughout this report, the wool types will be identified using the 3-letter codes listed in Table 1.

Table 1: List of the wool types included in the trial, and their associated 3-letter code.

Code	Wool Type	Code	Wool Type
FLC	'Control' Fleece	SRS	SRS®-type Fleece
FFC	Fine Fleece	ELT	Elite-type Fleece
HFC	High MFC Fleece	COT	Cotted Fleece
LFC	Low MFC Fleece	PCS	'Control' Pieces
HSM	High SS, High Midbreak %	VLP	Variable Length Pieces
LST	Long & Strong Fleece	LKS	Variable Length Pieces with Locks
SAS	Short & Strong Fleece	BLS	Control Bellies
		SBL	Stretchy Bellies

MEASUREMENT OF RAW WOOL PROPERTIES

Most sale-lots were purchased and assigned to the trial based on their certified presale results (Test Methods IWTO-19, 12, 7 and 30). Presale Yield and Micron, and Length & Strength testing was conducted on 311 sale-lots in accordance with the IWTO methods and regulations (Core Test Reg, 1994; IWTO-38).

PROCESSING OF SALE-LOTS

Sale-lots were processed into top at the CSIRO Mini-mill in Geelong (Smith & Hoschke, 1982). The integrity of each sale-lot was maintained throughout the top-making process. Changes were not made to the machine settings during the processing of sale lots, and there were no requirements to balance Noil/Top yields, or Hauteur/CVHauteur for commercial purposes.

Tops were measured for Hauteur, CVH, MFD and CVD in accordance with IWTO-17-85 (Hauteur), IWTO-12-01 (MFD) and IWTO-34-85 (Regain) by AWTA Ltd Textile Testing.

RESULTS AND DISCUSSION

The TEAM-2 Hauteur prediction equation was the processing prediction equation in use at the time the sale lot processing trial commenced. The TEAM-2 equation plus the CSIRO mini-mill correction factor (Equation 1) was used to predict the Hauteur of tops produced from the 311 sale lots under investigation, using certified presale raw wool measurements. The TEAM-2 general equation was applied to the control fleece sale lots. The residual values (Actual Hauteur – Predicted Hauteur) were calculated for the control fleeces (5.6mm), and this value became the mill correction factor for the CSIRO mini-mill, for this trial.

$$\hat{H} = 0.52L + 0.47S + 0.95D – 0.19M^* - 0.45V – 3.5 + MA \quad (1)$$

The single mill repeatability estimate reported by Mooy et al (1988) was ±3mm, which was used as a guide to determine which of the wool types were not well predicted. A mean residual greater than ±3mm indicated that a wool type did not process as it was predicted by TEAM-2. Table 2 shows the mean residual for TEAM-2 (T2) and 95% confidence interval for the sale lots processed during this trial. The final dataset consisted of 14 identified wool types, however this report focuses on the selected wool types identified previously in the introduction. Included in the lots selected for investigation were samples that were queried because they were perceived as being different to their predicted Hauteur (Appendix 1).

Table 2: The Mean Residual (T2), SD and Confidence Interval of the Residual Hauteur for the 14 wool types under investigation.

Wool Category	No Lots	Mean (TEAM-2) Residual (mm)	Signif.	SD Residual (mm)	95% Confidence Interval ±(mm)
All Sale Lots	311	1.5	***	6.6	0.7
'Control' Pieces	22	0.7	ns	5.5	2.3
Control Bellies	26	6.1	***	4.6	1.8
Stretchy Bellies	32	9.8	***	4.5	1.6
Variable Length Pieces	18	-2.2	*	3.8	1.8
Variable Length Pieces with Locks	14	0.4	ns	4.3	2.3
'Control' Fleece	33	0.0	ns	5.7	1.9
Cotted	7	0.5	ns	4.9	3.6
Short & Strong	14	-5.8	*	7.7	4.0
Long & Strong	7	3.1	ns	3.6	2.7
High SS, High Midbreak %	8	1.7	ns	6.0	4.2
High MFC	15	1.7	ns	6.2	3.1
Low MFC	16	0.6	ns	5.7	2.8
SRS®-type	6	4.4	ns	9.2	7.4
Elite-type	6	5.9	*	4.3	3.4

ns= not significant, * = significant at the 95% confidence level, ** = significant at the 99% confidence level, *** = significant at the 99.9% confidence level

Bellies and Stretchy Bellies

Control Bellies and Stretchy Bellies wool types both processed significantly longer than predicted. While the Control Bellies processed 6.1mm longer than predicted, the Stretchy Bellies processed 9.8mm longer, well beyond the 3mm range found by Mooy et al (1988). The confidence limit for these two wool types was very low; ±1.8mm for the Control Bellies and ±1.6mm for the Stretchy Bellies, indicating they consistently processed longer than predicted. This is supported by the results shown in Figure 1.

Variable Length Pieces

The Variable Length Pieces and Variable Length Pieces with Locks wool types processed as predicted by TEAM-2, even if they were compared with the Control Pieces group. This result indicates that the staples measured for Length and Strength adequately described the processing behaviour of the sale lots during processing.

Wool Types of High and Low MFC, SRS® and Elite

Table 2 shows that the High MFC and Low MFC wool types processed as predicted by the TEAM-2 equation. The mean residuals of 1.7mm and 0.6mm respectively were well within the 3mm guide imposed to determine the accuracy of the prediction.

In contrast, the Elite-type and SRS®-type wool sale lots did not process as predicted. These wool types processed 5.9mm and 4.4mm longer than predicted by the TEAM-2 equation, respectively. The 95% confidence interval for Elite-type wool (±3.4mm) was smaller than that of the SRS®-type wool (±7.4mm), indicating that there was more variation in the prediction of Hauteur for the SRS®-type sale lots than the Elite-type sale lots. Unexpectedly, the SRS®-type confidence interval was the largest across the wool types investigated

Cotted Wool Types

The seven (7) Cotted fleece sale-lots processed as predicted by the TEAM-2 equation. The mean residual of 0.5mm indicated the matted appearance of the fleece did not adversely affect the testing or processing behaviour of the sale lots when their performance was predicted using the TEAM-2 Hauteur equation.

Short & Strong, and High Strength with High Midbreaks

The fourteen (14) Short & Strong fleece sale lots processed much shorter than was predicted by the TEAM-2 equation. These sale lots processed 5.8mm shorter than predicted, the largest value of over-prediction for any of the wool types investigated. The confidence interval for the Short & Strong wool type was large (±4.0mm) when directly compared with the control fleeces (±1.9mm).

However, while the confidence interval value for the High Strength and High Midbreak wool type was very close to that of the Short & Strong sale lots (±4.2mm), it was found that the High Strength & High Midbreak group processed as predicted by the TEAM-2 Hauteur equation.

Figure 1 can be used to compare the Residual (difference between the Actual Hauteur and TEAM-2 Predicted Hauteur) range by wool types. The SD around the mean of each wool type is indicated with a bar. The results in Figure 1 are a visual representation of the data in Table 2.

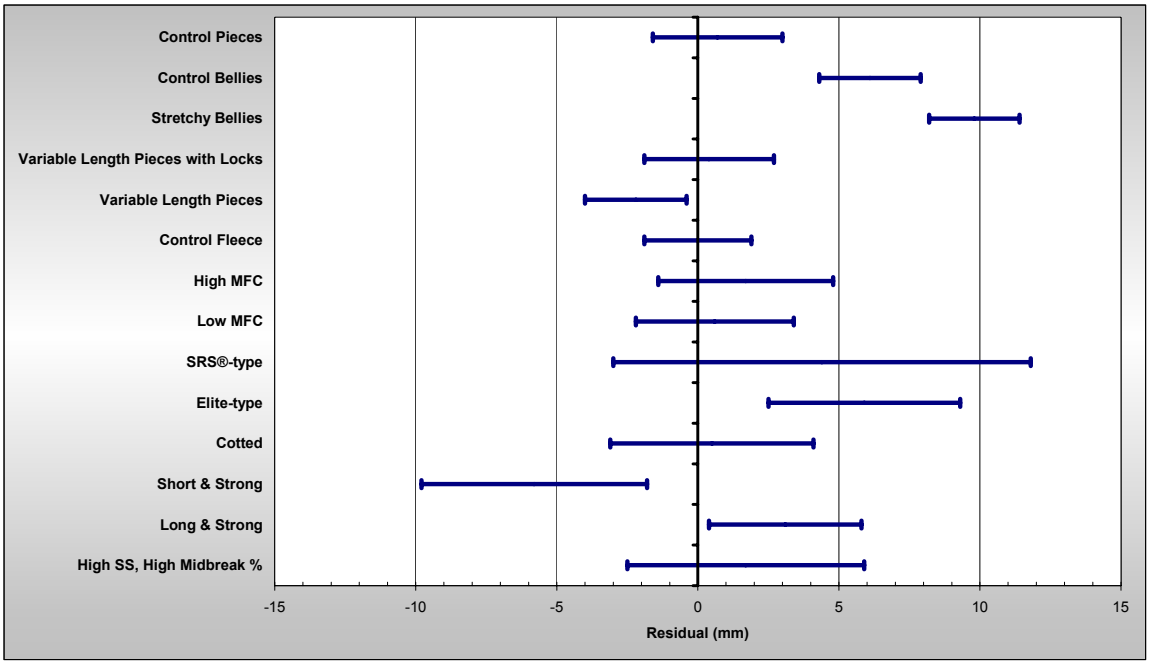

Figure 1: The range of Residual Hauteur values for the 14 Wool Types under Investigation.

HAUTEUR PREDICTION USING PROPOSED TEAM-3 FORMULA

Since the commencement of this trial, a review of the TEAM formulae was undertaken (TEAM-3 Steering Committee, 2004). New estimates of processing prediction was developed, and recommended for industry adoption. The recommended TEAM-3 Hauteur equation was applied to the sale lot data set in the same way as the TEAM-2 equation, in order to gauge any differences in the relationships. Table 3 shows the results for wool type when the recommended TEAM-3 equation is applied.

$$\hat{H} = 0.43L + 0.35S + 1.38D - 0.45V - 0.15M - 0.59CVD - 0.32CVL + 21.8 - MA \quad (2)$$

Table 3: The Mean, SD and Confidence Interval of the TEAM-3 Residual (T3) Hauteur for the 14 wool categories under investigation.

Wool Categories	No Lots	Mean (TEAM-3) Residual (mm)	Signif.	Difference (T3-T2) (mm)	SD Residual (mm)	Confidence Limit ±(mm)
All Sale Lots	311	1.7	***	0.2	6.5	0.7
'Control' Pieces	22	1.9	ns	1.2	6.2	2.6
Control Bellies	26	5.3	***	-0.8	4.7	1.8
Stretchy Bellies	32	8.5	***	-1.3	4.6	1.6
Variable Length Pieces	18	-0.3	ns	1.9	3.5	1.6
Variable Length Pieces with Locks	14	3.8	*	3.4	5.8	3.0
'Control' Fleece	33	0.0	ns	0.0	5.4	1.8
Cotted	7	3.1	ns	2.6	6.4	4.7
Short & Strong	14	-6.5	*	-0.7	8.2	4.3
Long & Strong	7	4.0	*	0.9	3.3	2.4
High SS, High Midbreak %	8	0.9	ns	-0.8	5.8	4.0
High MFC	15	1.3	ns	-0.4	5.9	3.0
Low MFC	16	1.1	ns	0.5	5.3	2.6
SRS®-type	6	4.4	ns	0.0	9.2	7.4
Elite-type	6	6.5	*	0.6	4.5	3.7

ns= not significant, * = significant at the 95% confidence level, ** = significant at the 99% confidence level, *** = significant at the 99.9% confidence level.

In most cases, the predicted TEAM-3 equation was found to predict Hauteur in sale lots in much the same way as the TEAM-2 equation. The exceptions were the Cotted fleece, and Variable Length Pieces with Locks sale lots.

Variable Length Pieces

The Variable Length Pieces (VLP) type wool processed as predicted by TEAM-3. However, the Variable Length Pieces with Locks (LKS) sale lots processed longer than predicted when compared to the Control Fleece (FLC) group. However, the LKS should be compared directly with the Control Pieces (PCS) sale lots. The mean LKS sale lots residual was 1.9mm greater (3.8 – 1.9 = 1.9mm) than the mean residual for the PCS. With respect to the PCS, the LKS processed as predicted.

Cotted Wool Types

The Cotted fleece sale lots appear to have processed longer than predicted by TEAM-3; their mean residual was just longer (3.1mm) than the ±3mm guide set previously. This result is still not overly convincing, since only seven (7) sale lots were included and the 95% confidence interval was ±4.7mm, indicating this group is highly variable.

CONCLUDING REMARKS

The data presented supports claims that, when processed on their own, some wool types do not process as predicted by the TEAM-2 Hauteur Equation. It was found that Stretchy Bellies and Bellies processed +9.8mm and +6.1mm longer than predicted, when using the TEAM-2 equation and +8.5mm and +5.3mm respectively when the TEAM-3 equation was used. It would be useful to devise a method to better predict these wool types. Research to address this will be reported in a subsequent paper. To put these differences into commercial perspective a combing blend containing 80% fleece and 20% Stretchy Bellies would result in an under-prediction of approximately 2mm and 1mm respectively.

There was no apparent difference between the processing predictability of Low Fibre Curvature and High Fibre Curvature sale lots. Both wool types processes as predicted when compared with the Control Fleece sale lots

SRS®-type and Elite-type sale lots were found to process longer than predicted. This result supports the view of some sectors of the industry, which believe that these wool types do produce a longer top than predicted by the TEAM-2.

The Cotted sale lots process as predicted when the TEAM-2 equation is used. This result was unexpected. Comparison of the TEAM-3 residual with the Control Fleece sale lots residual showed that the Cotted sale lots processed longer than predicted, however this result was questioned because of the high confidence interval (±4.7mm), and small sample size (7 sale lots).

High Strength & High Midbreak Percentage sale lots were also found to process as predicted.

Short-and-strong pieces processed shorter than predicted using both TEAM-2 and TEAM-3 Hauteur prediction equations. This shows that further research is required to improve the predictability of short staple length wool types.

In summary, with respect to Hauteur, the results support the views that some wool types process longer than the TEAM formulae would predict (for example, Bellies and Stretchy Bellies). In contrast, there were other wool types (for example Variable Length Pieces, Variable Length Pieces with Locks, Cotted Fleece) that processed as TEAM predicted despite the occasional comment form the trade to the contrary.

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APPENDIX 1

COMPARISON OF INDIVIDUAL SALE LOTS

Table A1 lists the sale lots that were included in the trial because they were perceived to differ visually from the presale measurements. The specific comments are included in the table.

Table A1: Comments made about specific lots, the SL and Hauteur values of each lot.

Wool Type	Lot	Comment	SL (mm)	TEAM-2 Predicted (mm)	Hauteur (mm)	Residual (mm)
Control Pieces	1	Expected SL of 58mm	78	57.4	54.7	-2.7
	2	Expected SL of 80mm	73	64.5	66.7	2.2
	3	Expected shorter SL	64	52.2	51.0	-1.2
	4	Expected longer SL than 71mm	71	55.3	56.8	1.5
	5	Expected SL of 90mm	82	63.6	67.8	**4.2**
Variable Length Pieces	6	Expected to process shorter	77	66.4	58.3	**-8.1**
	7	Expected shorter SL	74	58.6	59.4	0.8
	8	Expected SL of 65mm	73	62.0	62.1	0.1
	9	Expected SL less than 72mm	72	57.2	55.9	-1.3
	10	Expected SL to be shorter	71	57.9	59.3	1.4
	11	Expected SL of 64mm	68	59.7	59.4	-0.3
	12	Expected shorter SL	85	68.1	63.7	**-4.4**
	13	Unexpected SL and SS result.	65	52.2	54.5	2.3
	14	Expected SL of 85mm	77	63.3	62.3	-1.0
Variable Length Pieces with Locks	15	Expected shorter SL	68	54.8	54.1	-0.7
	16	Expected SL of 61mm	61	49.4	47.6	-1.8
	17	Expected SL less than 70mm.	70	60.8	51.3	**-9.5**
	18	Expected to process shorter	82	59.1	51.4	**-7.7**

Using the guide of 3mm, 13 of the 18 sale lots were found to be consistent with the TEAM-2 predicted Hauteur. Of the other five sale lots, lot 5 processed longer than predicted (4.2mm), indicating the sale lot was perhaps slightly longer than measured. In contrast, sale lots 6, 12, 17 and 18 all processed shorter than was predicted.