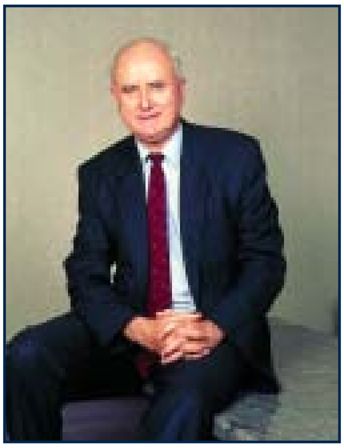
TEAM

Final Report – January 1985



This reprint of the TEAM 1 and TEAM 2 reports has been prepared to commemorate the retirement in March 2001 of the Deputy Managing Director of AWTA Ltd, Mr Sas Douglas, after more than 30 years service. Sas is widely recognised in the wool industry all over the world, having developed a significant profile through his activities within Australia and overseas, and his regular participation at IWTO Congresses.

Sas graduated with a Bachelor of Science (Honours II) in Wool Technology from the University of New South Wales in 1964. He was the Officer in Charge of the University's Wool Testing Laboratory from January 1961 to July 1962. Subsequently he worked as a Technical Officer for Agserv Industries Pty Ltd for 3 years, and followed that with a 3-year stint as Technical Manager for one of AWTA Ltd's early competitors, Auscore Testing Pty Ltd, Sydney. He then worked for the Bureau of Agricultural Economics (BAE) in Canberra in the capacity of Principal Research Officer, Wool Marketing Section for 2 years. In September 1970 he joined the then Statutory AWTA in the capacity of Assistant Director. He subsequently served as Deputy Director from 1972 to 1982. When the Statutory Authority was privatised in 1982 he became General Manager - Operations. In 1986 he became Deputy Managing Director.

Sas's Masters Thesis was on the subject of Sale by Objective Measurement, providing an early indication of his special interest in the modernisation of wool selling and marketing systems. While employed by the BAE he was a member of the Australian Objective Measurement Project Technical Committee.

Although Sas's career includes many significant milestones, he will undoubtedly be remembered for his major role in the early development of the IWTO Specification for Staple Length & Strength. Sas was a member of the TEAM 1 Project Management Committee and was the Chairman of the TEAM 2 Project Management Committee. Apart from this important work he also managed AWTA Ltd's internal research effort to develop more efficient sampling systems for staple measurement.

Leaders are remembered for their achievements. Sas has always been a team player and modest in acknowledging his own achievements. To him the TEAM Project was indeed a team effort, and succeeded because of the commitment of the industry organisations, the various companies and individuals who participated in the project. However, while this has to be recognised, Sas's personal contribution must not be understated. Not only within the TEAM Project Management Committee, but also within AWTA Ltd, Sas directed his intellectual capacity, his commercial acumen and his enormous energy and capacity for hard work towards a successful outcome to the project.

The measure of this success is the current uptake of Staple Measurements within Australia. It is now approaching 80% of all bales tested, and has grown continually despite early hiccups in 1986 and 1987. Of all the milestones Sas has achieved, perhaps the most significant is his contribution to the success of TEAM.

TRIALS EVALUATING ADDITIONAL MEASUREMENTS

FINAL REPORT

1985

Report to the Raw Wool Measurement
Research Advisory Committee
of the Australian Wool Corporation.

January 1985

First Printed by
Australian Wool Corporation
Melbourne, January, 1985

ISBN 0-643-03838-8

Reprinted by

Australian Wool Testing Authority Ltd
March, 2001

IWTO CONFERENCE, PARIS, JANUARY, 1985

This is the fifth report on progress of the TEAM Project given to the Wool Committee of IWTO.

The Project is now complete and this Report summarises the major findings as they relate to industry.

It has been submitted as a Final Report to the Wool Measurement Research Advisory Committee of the Australian Wool Corporation. This latter Committee supervised the financing of the Project by the Australian Wool Research Trust Fund.

PREFACE

The last decade has seen rapid change in the way wool is marketed in an industry previously steeped heavily in tradition. Much of this change has been made possible by the introduction of innovative procedures, and this continues. Research into additional measurements of staple length, staple strength, etc., and their relevance to industry follows the success of coretesting for specification of value-determining characteristics of wool and the establishment of sale by sample as the preferred marketing method.

By 1980, research instruments for measuring staple length and staple strength separately had been adapted by CSIRO Division of Textile Physics for use by AWTA. Recently, prototypes of automated instrumentation for measuring these characteristics were developed; commercial production of the CSIRO instrument is now underway. Meanwhile, a mechanical-tuft-sampling machine to draw tufts of staples automatically from grab samples was developed by AWTA Ltd. Australian standards for all these instruments and procedures are nearly complete.

For three years the TEAM Project has provided industry with an opportunity for participation and debate, while developing an understanding of the potential application of additional measurements of greasy wool to wool processing and wool trading. Both conceptually and in practice, the TEAM Project has been an industry project. Many organisations and industry sectors have cooperated to permit the research to be planned, procedures to be designed and implemented, and data to be collected and analysed.

The involvement of the industry throughout this period reflects the awareness of the industry for the need to experiment, to refine strategies in trading and processing of wool, and to examine new technology and concepts which have the potential to improve efficiency in the industry.

In particular, the Australian Wool Corporation became committed to study the feasibility of Sale by Description, leading to its involvement in detailed planning and promotion for the introduction of Sale with Additional Measurement and, ultimately, Sale by Description into the industry.

The aim of the TEAM Project was to enable processors of Australian combing wools to evaluate the new measurements of staple length, staple strength, position of weakness and clean colour. In so doing, considerations included:

- the confirmation of the importance of raw wool characteristics on processing performance and fibre length characteristics of top;
- the development of formulae to predict processing performance and fibre length characteristics of top;
- the establishment of a database of greasy wool and processed wool characteristics which can expand the technical knowledge concerning factors influencing processing;
- the comparison of processing performance both within mills and between mills;
- an economic evaluation of benefits from raw wool specification; and
- the communication of TEAM research findings as they developed, which has given industry experience in the use of the new measurements.

The TEAM Project has been planned and executed jointly by Australian Wool Testing Authority Ltd and CSIRO Division of Textile Physics, maintaining close association with the Raw Wool Services Department of the Australian Wool Corporation. Officers from each of these groups formed a Management Committee.

Communication with the industry has been a feature of the work. Throughout the Project, frank and detailed discussions were held with the major participants, the combing mills. In January, 1984, an Interim report was released which summarised preliminary findings and trends. Over the three-year period of the Project, four progress reports were presented to the Wool and Technical Committees of the International Wool Textile Organisation, and several reports have appeared in industry journals. Committee members have presented papers to trade seminars in Australia and at international forums.

The operations of the TEAM Project are now complete. After 36 months, we have data on 232 consignments for analysis. This report is a summary of the principal findings relevant to industry; a more detailed technical report is in preparation. It will be a compilation of scientific papers dealing in detail with all aspects of the Project.

The Management Committee takes this opportunity to thank all participants and industry groups for their cooperation.

M. W. Andrews

S. A. S. Douglas

A. H. M. Ireland

R. J. Quirk

R. A. Rottenbury

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1. SUMMARY OF THE REPORT - CONCLUSIONS & RECOMMENDATIONS

As a result of the Project a considerable improvement has been made in the understanding of the interaction between measurements of raw wool and subsequent processing behaviour. Prediction formulae for the fibre-length characteristics of the top and for noil were derived for a wide range of combing plants. Sufficient information is now available on comparative processing performance to enable the generalisation of these formulae. However, a considerable expansion of the total database will be required before the industry can be confident in the stability of the prediction process.

Conclusions

The principal conclusions of the TEAM Project are:

- In general, diameter, staple length, staple strength, and vegetable matter base are the most significant raw wool characteristics affecting fibre length in the top, and noil. The relative importance of each raw wool characteristic, or group of characteristics, is different for individual mills, and appears dependent upon the range and type of wools processed.

- It has been specifically demonstrated that the classification of wool soundness is significantly improved by using measured staple strength. Measurement overcomes the limitations associated with subjective assessment and enables wools of different processing potential to be detected.

- A general basis for the calculation of a theoretical Hauteur has been established. The formulae are based on the influence of important measured raw wool characteristics. *While the formulae developed in TEAM and presented in this report can be seen as establishing the principle of theoretical values they can by no means be regarded as representing the ultimate relationship. Results from more mills and consignments should be included before any status is granted to such formulae. Meanwhile, the ones published here serve for guidance.*

- In order to achieve a satisfactory general relationship across mills, it has been found preferable to group wools according to wool category (fleece or skirtings) and provide a separate formula for each category.

- The general formula to predict the Hauteur of consignments of fleece wool is:

$$H = 0.70D + 0.45L + 0.41S - 5.7$$

where H = Hauteur (mm)
D = Mean Fibre Diameter by Coretest (um)
L = Mean Staple Length (mm)
S = Mean Staple Strength (Newtons/kilotex)

- The general formula to predict the Hauteur of consignments of skirtings is:

$$H = 1.53D + 0.40L + 0.32S - 20.1$$

- Formulae can be established for individual mills, based on the measured raw wool characteristics of consignments combed at that mill. These formulae may generally provide a more accurate prediction for each mill than the general formula. They also provide the means for an overall comparison of a mill's performance with the general theoretical formula.

- The Hauteur predicted by the formula derived for a mill is generally more accurate and precise than the mill expectations. A parallel economic study has clearly identified substantial gains to processors, from using additional measurements, through increased predictability.

- Clean colour of Australian greasy wool has an indirect influence on the worsted processing performance through its association with wool type, but our work on its influence on top colour was inconclusive.

- Whilst topmakers may feel they are achieving optimum results with their present method of building processing batches, advances have been prevented by the lack of relevant specifications of the raw material. With the ability to use additional measurements, there is increased flexibility for the selection and manipulation of input material to provide best solutions for the end use.

- Understanding of the concepts and enthusiasm for their adoption have increased substantially as a result of the Project.

Recommendations

1. Using the formulae provided in the Report as a guide, industry should work towards the establishment of an internationally recognised general formula or set of general formulae to predict theoretical values for Hauteur from objectively measured raw wool characteristics. It is suggested that the International Wool Textile Organisation (IWTO) should accredit such formula or formulae and review regularly, as appropriate.

2. The possibility of accrediting similar general formulae to estimate noil should be investigated.

3. It is necessary to establish a database mill by mill in order to relate individual mill performance to the general formulae. Also the general formulae need to be expanded and refined. Every assistance should be given to industry to enable databases to be established, and/or enlarged to achieve these aims.

4. Constant attention must be paid to existing measurement methods used for raw wool and top, particularly in regard to standardisation, calibration, operating procedures, and harmonisation between mills and laboratories.

5. The logical outcome of improved estimation of processing performance using general predictive formulae is more efficient blending. The potential for least-cost solutions to blending of wools for topmaking should be appreciated. The use of computers enables inventories to be effectively allocated for topmaking. Where necessary, assistance should be provided to mills, topmakers, and woolbuyers, to enable them to adapt such concepts to their wool trading and processing roles.

6. The availability of presale measurements enables wool buyers to prepare consignments progressively to meet their client's needs without having to wait for post-sale testing and the potential risk of adjustment to consignments when measurements do not confirm subjective appraisal. Presale measurement of staple length and staple strength should be introduced as quickly as possible.

7. It is recommended that the implementation of colour measurement of raw wool receive lower priority for the present than that of staple length and strength of raw wool. On the other hand, a high priority should be given to both the refinement of measurement techniques and research into the factors relating the colour characteristics of wool measured at each stage of the processing chain.

8. The momentum of research and development on raw wool measurement processing consequences should be maintained, giving consideration to characteristics that require specification to improve the robustness of the predictive formulae, for example, the method of reporting the position of staple weakness.

2. THE TEAM PROJECT: SCOPE AND OPERATION

Background

The TEAM Project (Trials Evaluating Additional Measurements) provided raw wool measurements of staple length, staple strength, position of staple weakness and clean colour to supplement coretest information of yield, vegetable fault content and mean fibre diameter on nominated commercial consignments of Australian wool combed at 14 mills in 9 countries. In exchange, the mills and/or topmakers cooperating in the Project provided processing results and top measurements. The Project commenced sampling and testing in October, 1981.

The aim of the Project was to enable processors to evaluate the potential of these measurements for greasy wool. Once sufficient data had been accumulated, the relationships between processing performance and the raw wool characteristics were analysed. The information gained from the Project will assist industry to evaluate economic and commercial benefits of additional measurements.

The TEAM Project has been designed and controlled by the TEAM Project Management Committee comprising:

Dr. M. W. Andrews (Chairman)	Assistant Chief CSIRO Division of Textile Physics
Mr. S. A. S. Douglas	General Manager – Operations AWTA Ltd
Mr. A. H. M. Ireland	Research Officer AWTA Ltd
Mr. R. J. Quirk	Manager - Raw Wool Services Australian Wool Corporation
Mr. R. A. Rottenbury	Senior Research Scientist CSIRO Division of Textile Physics

The Project has been supported by a special grant from the Wool Research Trust Fund administered by the Australian Wool Corporation to the extent of approximately A$300,000, principally to cover sampling and testing costs.

Industry Participation

A significant feature of the Project has been the involvement of a wide range of commercial interests within the world wool industry - combing mills, topmakers, wool buying firms and wool broking/private treaty merchanting companies. The list of firms cooperating in the Project is:

(a) Combing Mills

14 combing mills in nine countries participated in the Project. These mills are estimated to comb at least 50% of all wool top produced in the countries involved:

Bremer Woll-Kammerei	Germany
Burlington Industries Wool Co	United States of America
Canobolas Wool Topmaking Pty Ltd	Australia
Cheil Wool Textile Co Ltd	Korea
F. W. Hughes Pty Ltd	Australia
Nippon Keori Kaisha Ltd	Japan
Peignage Amedee	France
Pettinatura Italiana	Italy
Port Phillip Mills Pty Ltd	Australia
Raymond Woollen Mills Ltd	India
Riverina Wool Combing Pty Ltd	Australia
Sir James Hill & Sons Topmakers Ltd	United Kingdom
Toa Boshoku Co Ltd	Japan
W. & J. Whitehead Ltd	United Kingdom

Unfortunately, for commercial reasons, two of the original 12 mills were unable to meet commitments to process 20 consignments in the Project, and a further two mills were invited to participate.

(b) Topmakers

10 topmakers commission combed at five of the mills in the Project:

Australian Wool Corporation	Australia
Bloch & Behrens Pty Ltd	Denmark
Cargill Pty Ltd	Australia
Antoine Segard & Co	France
W. A. Fritze & Co	Germany
C. Itoh & Co	Japan
Kulenkampff & Konitzky	Germany
Lohmann & Co	Germany
Prouvost Lefebvre & Co	France
Simptra Dewavrin Pty Ltd	France

(c) Suppliers

26 Australian wool buying firms purchased TEAM Project consignments on behalf of topmakers and combers:

Australian Wool Corporation
Booth Hill & New Pty Ltd
Black & Baer Pty Ltd
Bloch & Behrens Pty Ltd
Cargill Pty Ltd
K. V. Chapman & Co
Compagnie D'Importation De Laines
Dalgety Australia Ltd
A. Dewavrin Segard Pty Ltd
W. A. Fritze & Co. (Aust) Pty Ltd
Hart (Aust) Pty Ltd
F. W. Hughes Pty Ltd
C. Itoh & Co. (Aust) Ltd
Kanematsu-Gosho (Aust) Pty Ltd
Lempriere (Aust) Pty Ltd
Lohmann & Co Pty Ltd
Marubeni (Aust) Pty Ltd
A. McGregor & Co
Mitsui & Co (Aust) Ltd
P. J. Morris Pty Ltd
Nissho Iwai (Aust) Ltd
Port Phillip Mills Pty Ltd
Prouvost Lefebvre & Co
J. Sanderson & Co (Aust) Pty Ltd
Simptra Dewavrin (Aust) Pty Ltd
Wesfarmers Europe

(d) Broker and Private Treaty Merchants

55 Australian companies assisted by providing samples for the measurement of the additional characteristics:

Adelaide Wool Co
Albany Wool Stores Pty Ltd
Australian Estates Co Ltd
Australian Mercantile Land and Finance Co Ltd
Bennetts Farmers Ltd
Burns Wool Pty Ltd
Central Classing Pty Ltd
R. E. Chadwick Pty Ltd
Colyer Wilcox
Crompton & Son Pty Ltd
Dalgety-Winchcombe
Dennys Strachan Mercantile
A. C. & K. Dibb
Economic Wool Producers
Elders IXL Ltd
Farmers Grazcos Pty Ltd
Fermil Wool Facility Pty Ltd
Glenelg Warehousers
G. K. Heffernan
Henty Wool Services Pty Ltd
Hume Warehousers
Jemalong Wools
Lohmann & Co (Aust) Pty Ltd
G. H. Michell & Son Pty Ltd
Newcastle Warehousers
New Zealand Traders
Pitt Son & Badgery Ltd
I. L. Pinniger & Co Pty Ltd
Plimex Pty Ltd
Port Adelaide Wool Co Pty Ltd
Primac
Primaries of W.A. Pty Ltd
Queensland Wool Centre
Roberts, Stewart & Co Ltd
E.P. Robinson
Schute Bell Badgery Lumby Ltd
V. H. Smythe Pty Ltd
Starlotters & Wool Auctions of Australia
Sydney Wool Brokers Ltd
Tourwool Pty Ltd
Victorian Producers Co-Op Pty Ltd
Watswool Pty Ltd
WAVCOP
Western Wool Traders
Westralian Farmers Co-Op Pty Ltd
Websters Wool Growers Pty Ltd
Western Livestock Pty Ltd
Westwools
Wool Agency Co
Wool Lot Builders
Wool Marketing Service
Wool Handling Centre
Woolcombers W.A. Pty Ltd
Wool Warehousers Geelong
Yennora Warehouse

Procedures

All procedures in the Project were commissioned by the Management Committee. AWTA Ltd were delegated to conduct the operations related to the sampling and testing and supervision of quality control procedures devised by the Management Committee. CSIRO Division of Textile Physics was required to develop procedures for data management and to develop and apply appropriate analytical techniques.

Detailed procedures used in the conduct of the Project were:

- the mill or topmaker nominated a consignment for the Project to their Australian supplier and to AWTA Ltd acting for the Project;

- the supplier advised AWTA Ltd of sale lots purchased for that consignment;

- AWTA Ltd officers collected the display grab sample and forwarded it to one of five regional centres, Brisbane, Sydney, Melbourne, Adelaide or Fremantle, for staple subsampling. If the sample had been discarded or the lot had not been sold by sample, arrangements were made to grab sample the lot;

- the staples were forwarded to AWTA Ltd Sydney for staple length and strength testing on each lot. Broken staples for each lot in a consignment were blended, scoured, carded and measured for colour;
- after quality control checks on the sampling and testing procedures, display samples were returned to the broker or private treaty merchant. Regular round trials were conducted to monitor sampling performance;
- a Customer Report on the consignment was prepared for distribution to the mill, topmaker, and supplier after combing data had been received. The report summarised the coretest and additional measurement data for each sale lot in the consignment and the combined values for the consignment. Data analysis was conducted by CSIRO Division of Textile Physics;
- the mill combed the consignment in the normal way but wastes were collected and top samples taken at specified intervals. Quality control records for each stage of processing were maintained. A Processing Report forwarded to AWTA Ltd specified quantities of top, noil and wastes and relevant measured top characteristics. Samples of top were also forwarded;
- on receipt of the Processor Report, AWTA Ltd distributed the Customer Report to the mill, topmaker and supplier;
- the top samples received were measured for top-length characteristics and colour. Checks were made on any anomalous results. Provision has been made for further testing;
- from time to time, confidential progress reports were prepared for each mill; and
- at least every year, each participant was visited by members of the Management Committee. Initially, this was on an *ad hoc* basis but in the last two years special visits were organised.

Description of Wool in the Project

The selection of wool types for the Project was entirely dependent upon the comber or topmaker concerned. For reasons of economics and logistics, it was necessary to confine consignment sizes to approximately 300 bales or less, and to ensure consignments consisted entirely of Australian wool and were either sold by sample or were able to be sampled prior to shipment. Consequently, a comprehensive range of types was not always possible. As part of their normal practice, some mills specialise in particular types; others comb a wider range of wools. However, the TEAM Project Management Committee encouraged participants to select a wide range of types with a range of raw wool characteristics.

Based on the measurements of 232 consignments, a general description of the range of wool in the Project is as follows:

* **Wool Type**

Fleece types only:	70%
Skirtings types only:	20%
Fleece/Skirtings blends:	10%

* **Diameter**

Finer than 20.0 μm:	20%
Fineness between 20.0 - 23.0 μm:	58%
Fineness between 23.1 - 25.0 μm:	8%
Coarser than 25.0 μm:	14%

* **Vegetable Matter**

Less than 1.0% VM base:	38%
VM base between 1.1 - 3.0%:	36%
More than 3.0% VM base:	26%

* Average consignment size in the Project (bales):	155
* Average number of lots per consignment:	17
* Total bales included in the Project:	36,000

In almost all cases, deliveries were on the basis of coretest for yield, mean fibre diameter and vegetable matter base. Other characteristics considered important to achieve a specific top length were subjectively appraised by the commercial interests. Staple length, staple strength, position of staple weakness, coefficent of variation of staple length of each sale lot, and colour of each consignment were measured as part of the Project. These results were not made available to the commercial interests until after combing.

It can be seen that in terms of wool type, diameter and vegetable matter base, the wools used in the Project are fairly representative of the Australian clip.

In respect of those additional measurements which were not available at sale or at the time the consignment was assembled, Figure 1 shows the distribution of mean staple length and mean staple strength of all consignments in the TEAM Project.

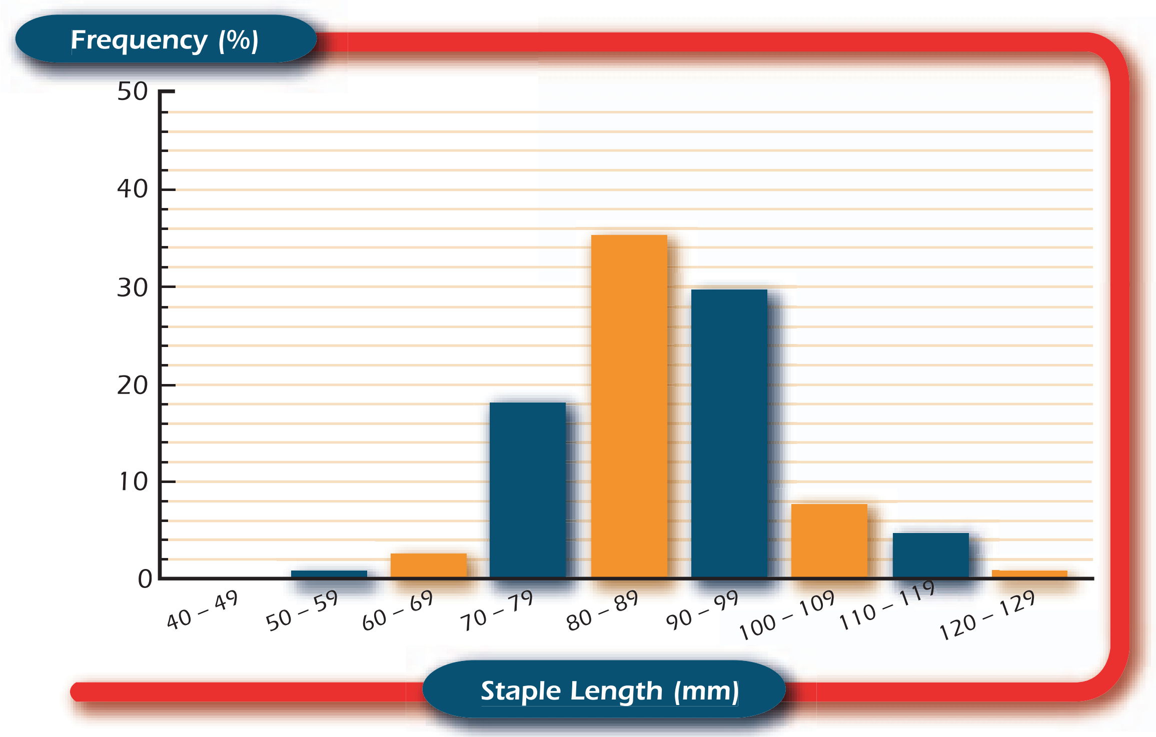
Between-Consignment Comparisons

Figure 2 compares the mean and range of the mean values for each raw wool characteristic of the consignments processed by each mill.

As a general observation, the distribution of mean staple length between consignments within a mill probably reflects a decision to purchase types of specific length, or particular types which might achieve a specific Hauteur in the top. However, the distribution of staple strength between consignments within mills is wide in all mills and reflects the low reliability of the subjective appraisal of staple strength. It is clear that some mills in the Project (e.g., Mills E and G), specialise in particular types which, with the exception of staple strength, appear well controlled in deliveries of wools to the required specification.

Figure 3 compares the mean and range of the mean values for Hauteur and noil for the consignments processed by each mill. The ranges for Hauteur and noil vary considerably from mill to mill.

Figure 1
Distribution of Mean Staple Length
and Mean Staple Strength of
232 TEAM Consignments



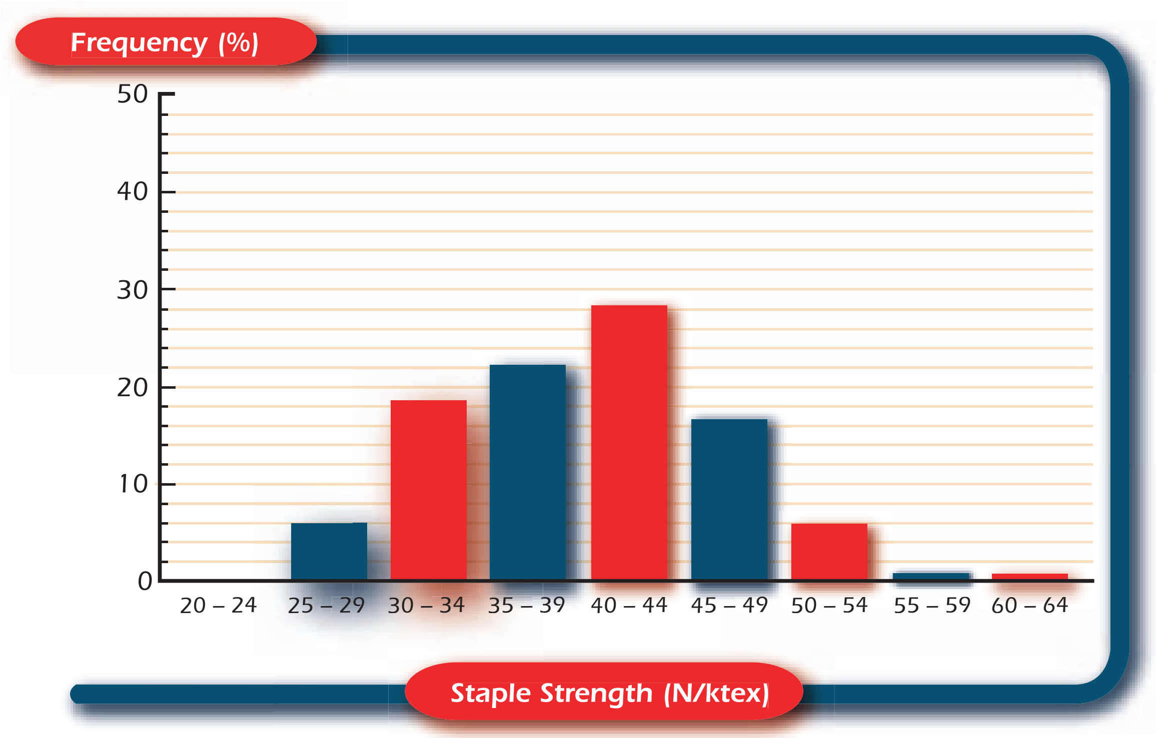


Figure 2
Range of the Mean Values of the Raw Wool Characteristics of Consignments

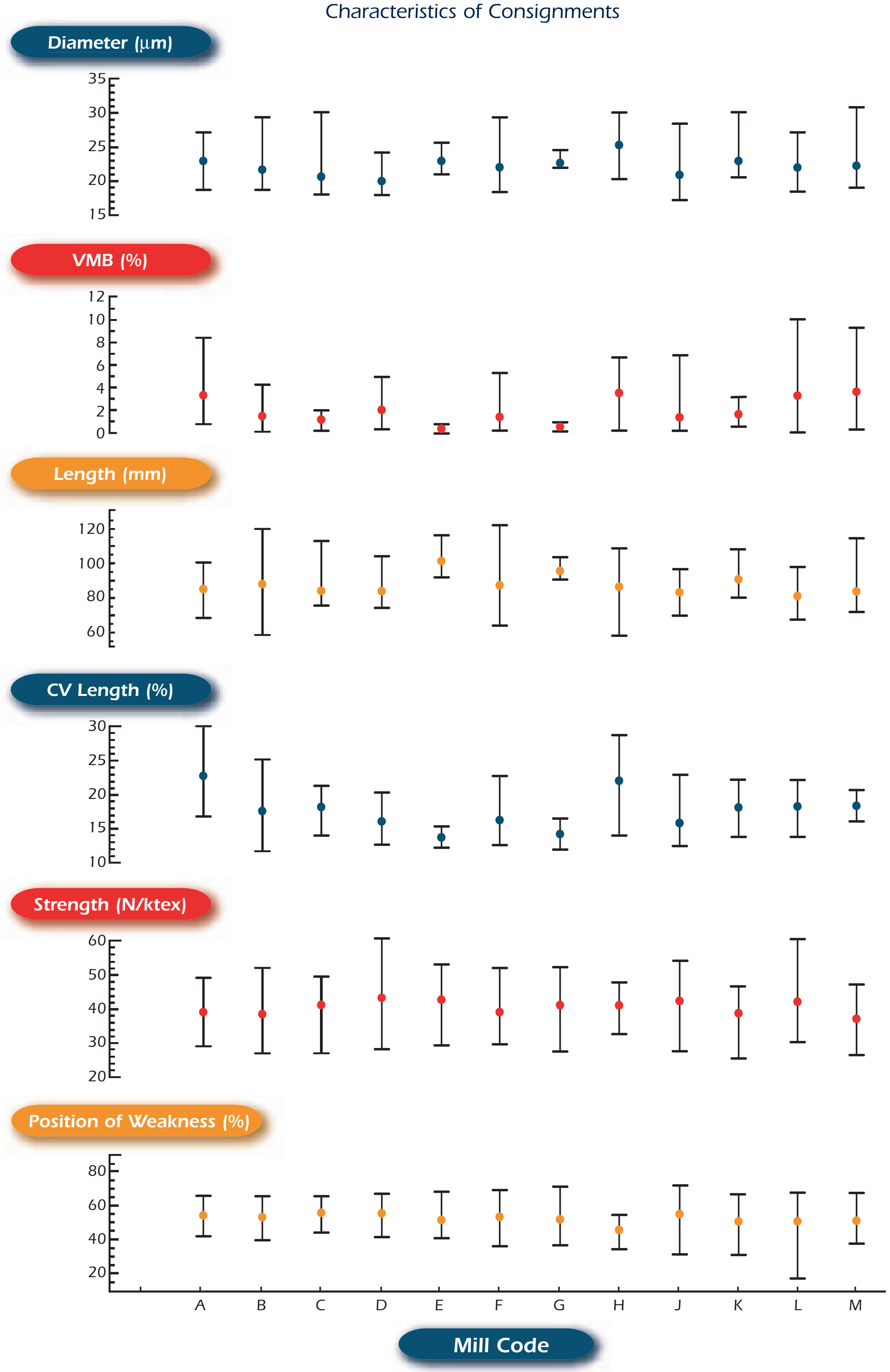
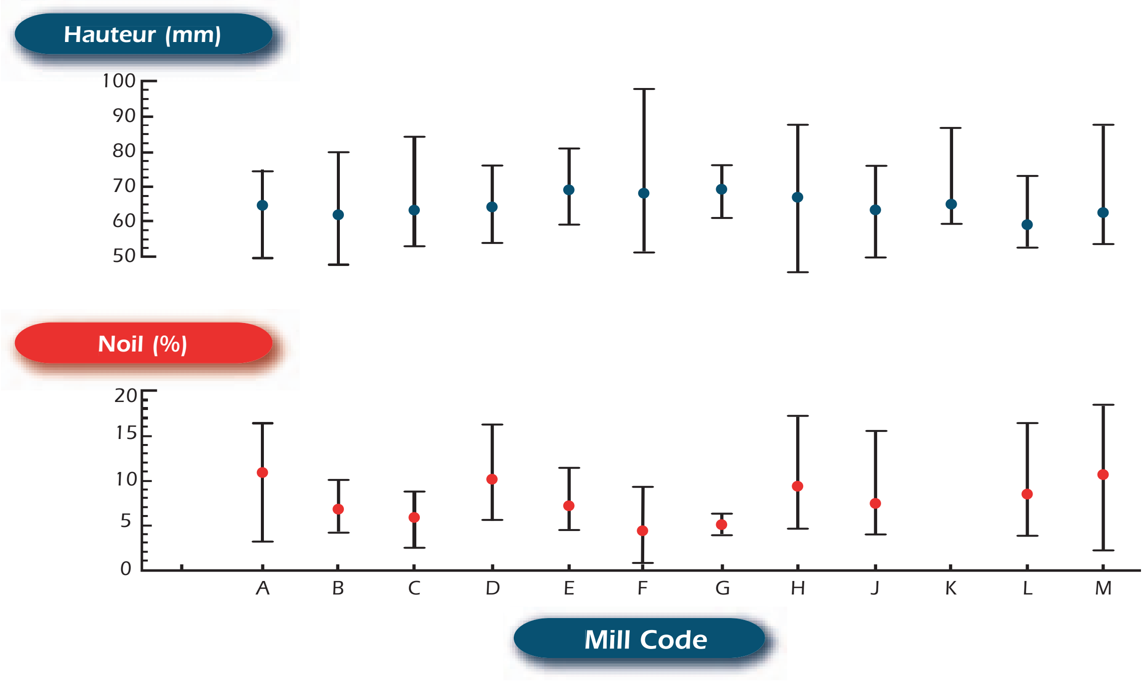


Figure 3
Range of the Mean Values of Hauteur and Noil*
of Consignments



* Noil data not available for Mill K

Within-Consignment Variability

Each consignment comprised a number of sale lots which were purchased at auction or privately and then grouped for shipment to the combing mill. A few consignments consisted of pre-blended batches.

Examination of the test data for the component lots of individual consignments generally shows a wide spread of mean staple length and strength measurements from lot to lot. Table 1 summarises the mean, maximum and minimum ranges of the characteristics observed within consignments comprising auction sale lots.

The average range of staple length and staple strength between sale lots in a consignment is 27 mm and 30 Newtons/kilotex, respectively. These values of staple length and strength are the result of subjective matching of lots for each consignment. It is likely the range of values within consignments could be controlled if measurements for these characteristics were available at the time of assembling the consignment.

TABLE 1. WITHIN-CONSIGNMENT VARIABILITY

A. CORE TEST DATA

Range of Sale Lot Measurements Within Consignments	Mean Fibre Diameter (μm)	Vegetable Matter Base (%)	Schlumberger Dry Top and Noil Yield (%)
Average Range	1.5	2.6	12.3
Maximum Range	5.8	12.0	31.9
Minimum Range	0.3	0.3	1.4

B. ADDITIONAL MEASUREMENTS

Range of Sale Lot Measurements Within Consignments	Staple Length (mm)	Staple Strength (N/ktex)
Average Range	27	30
Maximum Range	76	55
Minimum Range	3	4

3. PREDICTION OF PROCESSING PERFORMANCE

Introduction

Processing experiments ([1,2,3,4]) have confirmed the significance of certain greasy wool characteristics, such as staple length and staple strength, on top length and processing, and determined the level of their influence under controlled conditions. In some of these trials, held prior to 1980, wools were selected which had all the raw wool characteristics similar except one, which was varied among processing batches. As would be expected, if all other characteristics are similar, a longer staple length produces a longer fibre length in the top. Similarly, a higher staple strength will give a longer fibre length in the top.

Perhaps the most significant contribution ([5]) was the measurement and analysis of 39 consignments at one Australian mill during 1980, which established a high level of association between a processing factor and a selection of the characteristics of greasy wool. This work provided strong evidence that Hauteur could be predicted from a formula dependent upon only a few raw wool characteristics. More recently (6), statistical techniques for the development of predictive formulae have been examined.

It became evident that the potential to estimate Hauteur and other top characteristics from objective specification should be evaluated in other mills and on an international level. Further, as most of the greasy wool produced in Australia is exported, the involvement of a selection of Australia's wool customers seemed desirable to enable them to assess the usefulness of the new specifications. Consequently, the TEAM Project was initiated in 1981.

Previous progress reports on the TEAM Project have provided some insight into the following:

- the data being obtained;
- the methods of analysis;
- the variability within and between consignments;
- the suitability of using raw wool measurements to predict processing performance;
- the potential commercial implications; and
- the effect of staple strength.

The concept of a general formula to predict Hauteur of wool tops was introduced in earlier reports (7) but it was too early to comment with certainty on the suitability of this approach. With data now complete, and analyses updated, progress in this area has been substantial. In fact, the highlight of this report is the confirmation of the considerable generality that exists among mills with respect to the influence of raw wool characteristics on early-stage worsted processing.

The development of the analysis of results proceeded in three stages. In the first stage, with only limited numbers of consignments processed by each mill, preliminary analyses were conducted in order to gain some idea of the level of consistency of the relationships between the raw wool characteristics and the parameters of processing and the characteristics of the top.

The next stage was to develop formulae to enable the processor to predict the level of noil and the fibre-length characteristics of the top from the measurements available on the raw wool, a different formula for each processing factor for each processor, for ranges of wool types, and, in the case of commission combers, for each topmaker's wool. Such formulae were progressively updated, using results from further consignments, a process which should be continued to the point where the database is large enough for the formulae to be reliable and robust.

It is important to bear in mind the distinction between the objectives of the first two stages ([6]):

(i) Explanation: the screening of the raw wool measurements to determine those which have a significant effect on the processing factor, and

(ii) Prediction: arriving at the most effective formula for predicting future results.

There are, of course, factors limiting prediction. Other characteristics of wool that have a certain level of importance are not taken into account, for example, crimp and style; batch composition may influence processing; and machine settings and mill procedures need to be reproducible.

In the third and ultimate stage of the Project, with the total number of consignments exceeding 200, it became possible to commence the testing of hypotheses with respect to the generality of the relationships across mills between the raw wool and the processing. Once again there was a clear distinction between the explanation of the processing behaviour in terms of the characteristics of the raw wool, and the development of methods of prediction.

1-16 The work will be reported as follows:

- General formulae for Hauteur: general formulae are submitted as initial estimates which will be subject to refinement as the database is expanded; validation procedures are outlined.

- Analyses of the individual mills for all processing factors: emphasis is placed on the essential requirements for robust predictive formulae for individual mills. In these analyses we are better placed to deal with the effects of range and interrelationships of characteristics, local factors, wool types, etc.

- Applicability of formulae: this includes an assessment of the performance of mill formulae for Hauteur in comparison with the subjective estimates provided by topmakers/combers.

Development of a General Formula for Hauteur

Formulae were given in Chapter 1 to predict Hauteur of a consignment, for fleece types and for skirtings types. These were:

Fleece: $H = 0.70D + 0.45L + 0.41S - 5.7$

(based on results for 9 mills and 130 consignments)

Skirtings: $H = 1.53D + 0.40L + 0.32S - 20.1$

(based on results for 4 mills and 50 consignments)

where H = Predicted Hauteur (mm)

D = Mean Fibre Diameter (µm)

L = Mean Staple Length (mm)

S = Mean Staple Strength (N/ktex)

The methods that were used to obtain these formulae, the stability of the relationships found, their application to future consignments, and their usefulness to processors are discussed below.

Essentially, by analysing actual data for each consignment and each mill, a mathematical formula can be derived which expresses the relationship between the raw wool measurements and top characteristics, such as Hauteur. This formula then enables the substitution of actual raw wool measurements of subsequent consignments, so that the predicted Hauteur can be calculated. The usefulness of this formula to the mill, topmaker, or wool buyer, will depend on how close the values of predicted Hauteur are to the actual values of Hauteur.

A general formula can only be considered reliable if it reflects similar behaviour for all the mills used in the analysis. Analysis of 10 mills, involving 180 consignments has shown that in order to achieve a satisfactory general relationship across these mills, the database has had to be grouped according to wool category (fleece or skirtings). That is, a formula has been developed for each of these categories separately. When a consignment consisted of both fleece and skirtings types, it was included in the skirtings category.

The reduction in the numbers of mills and consignments used in the general analysis from 12 and 232, respectively, requires an explanation. The analytical method for the general analysis can only include data from mills, which have combed a sufficient number of consignments of fleece or skirtings. In addition, two mills were excluded from the general analysis because their data were inappropriate for pooling with the remaining data. In one case, consignments had been processed on different machinery lines within the mill. Significant differences between lines were apparent and insufficient consignments existed for each line. In the second case, some data were missing, and only subjective estimates for noil were provided.

The best formula to predict Hauteur was obtained using multiple linear regression procedures ([8]). Measurements made on the CSIRO Almeter were used. An exhaustive search ([9]) was made of combinations of raw wool characteristics to find the subset which produced the best relationship with Hauteur. The subset of raw wool characteristics so found for Hauteur was diameter, staple length, and staple strength.

After a relationship between raw wool measurements and Hauteur has been established, the usefulness of the formula in predicting processing performance of future consignments must then be confirmed. The process of making this confirmation is called cross validation ([6]). Two methods were used to validate the formulae for Hauteur. Firstly, one mill was excluded from the analysis, and a formula was produced using the data for the remaining mills. This formula was then applied to the data for the mill which had been excluded, and the Hauteur of each consignment was calculated individually. The procedure was repeated leaving out each of the mills in turn. Secondly, all mills were included in the analysis, but one consignment was excluded at random from each mill. As in the first method, a formula was found without these consignments and predicted values for Hauteur were calculated for them. The excluded consignments were then replaced and the procedure repeated 10 times.

For each validation for each method, the difference between the measured value for Hauteur and the value found using the formula was calculated. A formula that performs well in prediction should have a low residual error, and in validation should not produce differences that are consistently positive or negative; these differences should be scattered about zero and their average, or mean bias, should be near to zero. Both of the methods described showed no significant bias in prediction for the general formulae for fleece and skirtings given above.

Raw Wool Characteristics

From the general formulae, it will be evident that diameter, staple length, and staple strength, are the dominant raw wool characteristics influencing Hauteur. These have not been selected in any subjective way, but have been determined by complex statistical analyses, which have also evaluated the importance of other raw wool characteristics measured on the consignments. The other measurements considered in the analyses were:

WB	=	Wool Base by coretest (%)
VM	=	Vegetable Matter Base by coretest (%)
POB	=	Position of Staple Weakness (%)
CV(L)	=	Coefficient of Variation of Staple Length (%)
L*	=	Colour - lightness (CIE units)
b*	=	Colour - yellowness (CIE units)

Whilst these other measurements may be important in formulae developed for individual mills, they do not appear as significant in the analyses to determine general formulae for the prediction of Hauteur.

It is a source of satisfaction to note that the characteristics dominant in the general relationship are the factors which, together with vegetable matter content, would be expected, *a priori*, to have most influence. Viewed from the behaviour of fibres in a textile system the most important fibre characteristics for influencing fibre length after processing are fibre length and strength in the raw material. The factors directly related to these in raw wool are staple length, staple strength, and fibre diameter. Vegetable matter content will also have an influence, but it has most likely been accommodated in our analysis by the separation into two categories, fleece and skirtings.
With respect to the fact that two formulae are necessary to explain the relationships between raw wool and top length, it is possible that further stratification of the data will be necessary as the database is expanded, i.e., different types, origins, etc. On the other hand, it is possible that inclusion of other characteristics utilised as additional measurements may remove this requirement for stratification.

Predictive Capability

The strength of a regression relationship may be measured by two statistics. The coefficient of multiple determination (R^2) indicates the fraction of the variation in Hauteur between the consignments which is explained by the raw wool data used in the formula; it reflects the level of association between the raw wool variables and Hauteur and is often called the degree of association and expressed as a percentage ($100R^2$). The mean square error (MSE) is a measure of the reliability of the raw wool data as a predictor of Hauteur; a large MSE indicates a formula is less reliable.

The values of these statistics found in analyses for the general formulae for Hauteur were:

Fleece:	$100R^2 = 81\%$	MSE = 9.76 mm^2
Skirtings:	$100R^2 = 94\%$	MSE = 3.66 mm^2

Although it would seem that the formula for skirtings is more reliable than that for fleece wools, it should be noted that only four mills and 50 consignments were available for the analysis of skirtings types and in this sense it is less representative. The results for fleece types are more typical of the level of reliability that we expect to occur in a general formula for Hauteur. Expansion of the database for skirtings with inclusions of a greater range of wool types and more mills will result in changes, certainly in the magnitude of the coefficients in the formula and its mean square error, and perhaps in a different subset of raw wool characteristics.

Another important aspect to be emphasised in using the formula is the simplicity of the adjustment to the predicted value of Hauteur to allow for mill differences. Individual mills can comb consistently longer or shorter tops than the values for Hauteur predicted by the general formula. In the case of the general formula for predicting Hauteur for fleece wools, a range of 6 mm would be found across the nine mills if each was given identical fleece wool to process. Accordingly, a mill that has accumulated its own database would be in a position to estimate the adjustment appropriate to its own situation. The adjustment is in effect an additional constant factor to be added to the general formula.

An individual mill adjustment is determined in the following way. Raw wool measurements for a number of consignments which represent adequately the range of these characteristics for that mill are accumulated and the average values for diameter, staple length and staple strength and Hauteur are found. For fleece consignments the mill adjustment is calculated as follows:

$$A = \bar{H} - 0.70\bar{D} + 0.45\bar{L} + 0.41\bar{S} - 5.7 + A$$

and therefore,

$$A = \bar{H} - 0.70\bar{D} - 0.45\bar{L} - 0.41\bar{S} + 5.7$$

Where

$\bar{H}$	=	average value for Hauteur for the mill's fleece consignments
$\bar{D}$	=	average value for diameter for the mill's fleece consignments
$\bar{L}$	=	average value for staple length for the mill's fleece consignments
$\bar{S}$	=	average value for staple strength for the mill's fleece consignments
A	=	mill adjustment (mm)

The predicted value for a new consignment H′ will then be given by:

$$H' = H + A$$

where H = Hauteur predicted by the general formula.

There are advantages for a mill in developing a formula based on its own data. The general formulae provide predictions that are based on data for a number of mills and are therefore not necessarily the best for a particular mill. Results for analysis of individual mills are discussed in the next section.

It is appropriate to re-emphasise that the formulae developed in the TEAM Project and presented in the report can be seen as establishing the principle of general formulae for Hauteur, but they can by no means be regarded as representing the ultimate relationships. Results from more mills and consignments should be included before any status is granted to such formulae. Preliminary analyses have also investigated the development of general formulae for other processing characteristics, particularly noil, but as will be seen later in this chapter the reliability of formulae to predict noil for individual mills is not as promising as for Hauteur. This is due to the stronger influence of other factors on this characteristic, particularly mill practice.

Analyses for Individual Mills

Results from preliminary analyses of the data obtained for 11 mill participants were summarised in the Interim Report ([7]). The evidence presented confirmed earlier research ([5]), which demonstrated that within a particular commercial environment there can be a high level of association of raw wool characteristics with processing factors, particularly with the fibre length properties of the top. However, it was clear that the degree of association and the relative importance of particular raw wool characteristics depended on the population of wools and the range of each characteristic. This work has now been extended to include further consignments and analyses.

Here we are faced with the same problems that arise in the development of the general formulae in respect to the choice of variables, their method of selection and estimation of coefficients of a prediction formula. The process is not simply a question of feeding all measurable characteristics into an equation and estimating the coefficients from a limited set of data ([6]).

Top characteristics and processing variables, which have been examined in the analyses are:

Noil (%) (Romaine)

Hauteur (mm)

Coefficient of Variation of Hauteur (%)

Barbe (mm)

Short Fibre Content (%)

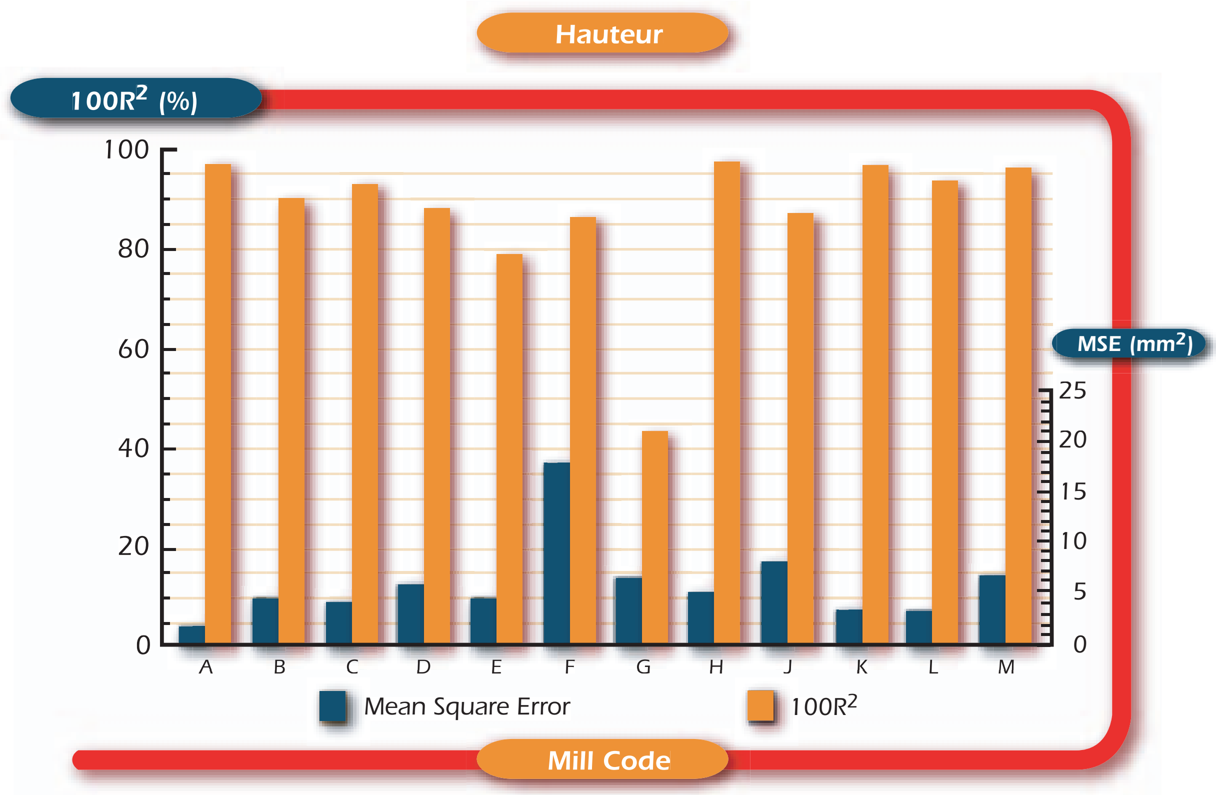
Long Fibre Length (mm)

The raw wool data, which have been examined to establish the best relationship are:

	Symbol
Fibre Diameter (µm)	D
Staple Length (mm)	L
Staple Strength (N/ktex)	S
Vegetable Matter Base (%)	VM
Position of Staple Weakness (%)	POB
Coefficient of Variation of Staple Length (%)	CV(L)
Wool Base (%)	WB
Colour - Lightness (CIE Units)	L*
Colour - Yellowness (CIE Units)	b*
Category Factors	
- for mills with fleece and skirtings consignments only, one factor is sufficient	F
- for mills with fleece, skirtings, and fleece/skirtings blends, two factors are required	F1 & F2

The methods used for the subset selection have been outlined [5]. The degree to which the best subset of raw wool variables is able to account for the consignment differences for Hauteur and other processing factors was measured by the mean square error (MSE) and the values for the degree of association ($100R^2$). The values for MSE and $100R^2$ for each mill are plotted in Figure 4 for Hauteur and noil to illustrate the trends observed across mills.

The best relationships are summarised in Table 2 and 3 for Hauteur and noil respectively and in Tables 4, 5, 6 and 7 for the other fibre-length factors. In each table the best subsets of raw wool variables are listed together with the corresponding values for MSE and $100R^2$. For Hauteur and noil the subset (D, L, S, VM) is included for each mill for comparison. Although the analyses sometimes involved significant higher-order terms (5), this aspect of the work is not presented here. For some mills with sufficient consignments of fleece, skirtings, or fleece/skirtings blends, a category factor F or as necessary F1 and F2 was included in the analyses to divide the population of consignments into two or three categories, respectively.



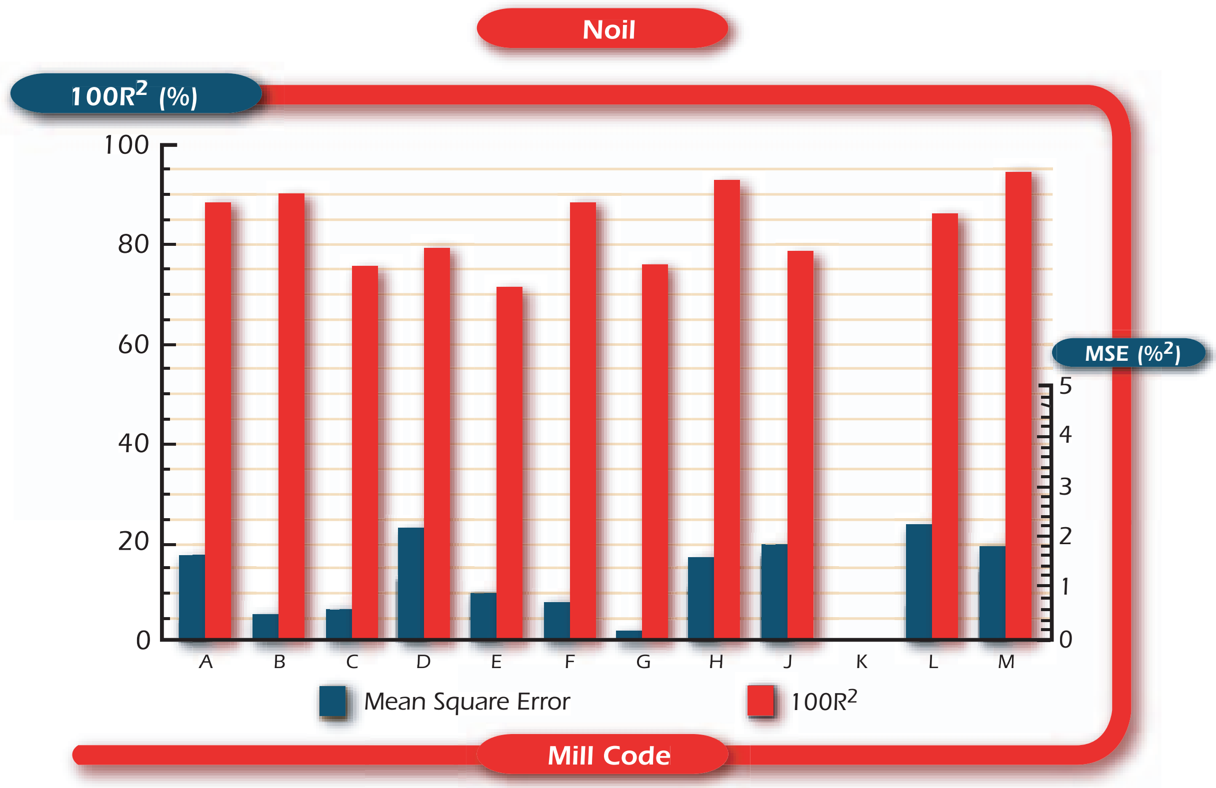


Figure 4
Plot Values for Mean Square Error and
$100R^2$ for Individual Mills

Figure 4 shows that for individual mills the subsets of raw wool characteristics are highly associated with Hauteur as adjudged by the low values for MSE and high values of $100R^2$. These MSE and $100R^2$ values are relatively constant from mill to mill with one exception in each case, Mill F has a markedly higher MSE than the other mills and Mill G has a low value for $100R^2$. The low value for $100R^2$ for Mill G arises because of the limited range of Hauteur found in the consignments; its MSE value, however, is comparable to other mills. For Mill F more scouring and processing lines were employed than in other mills and therefore the mill may have lacked some control in comparison.

Mill A achieved the best result for Hauteur; the MSE is only 2.4 mm^2 (which corresponds to a standard error* of just 1.5 mm) compared to the value of 18.5 mm^2 for Mill F. For Mill A, $100R^2$ is 97, i.e., 97% of the variation in Hauteur was explained by the raw wool measurements. The size of the standard error is approximately 2% of the mean Hauteur, which shows that predictive potential for Mill A is high.

Compared with Hauteur, the values for MSE and $100R^2$ for noil are not as good. There remains considerable error not accounted for and further work is required to determine the residual factors and how much the present limitations are due to inherent mill practice, sampling variability, and the effect of other characteristics not measured in the Project ([5]).

Table 2 gives the important raw wool characteristics influencing Hauteur for each mill. With regard to the best subset of raw wool characteristics it should be noted:

– the subset selected as the best subset is different from mill to mill;

– our selection criteria allowed the number of variables to vary from one to the maximum of five, the most common being four;

– with one exception there are always at least two of the characteristics, diameter, staple length, and staple strength, in the best subset for each mill;

– the subset (D, L, S, VM) was similar in performance, only slightly inferior in most cases, to the best subset;

– in some instances, a variable identifying the wool as fleece or skirtings types is included in the subset; and

– quite often there are other subsets which give similar values of MSE and $100R^2$ to those reported as the best subset. For example, for Mill C other equivalent subsets were (D, L, S, CVL, b*), (D, VM, WB, L*, b*), and (D, S, VM, WB, L*).

Standard error is the square root of the MSE and hence is an expression of the error in the units of the characteristic.

SUMMARY OF THE BEST MULTIPLE REGRESSION SUBSETS##
FOR HAUTEUR

TABLE 2

MILL CODE	RAW WOOL VARIABLES	MSE (mm^2)	($100R^2$) (%)
A	D, S, VM, WB, F (D ,L, S, VM)	2.4 5.4	97 92
B	D, L, L* (D, L, S, VM)	5.1 7.8	90 86
C	D, L, S, L*, b* (D, L, S, VM)	4.6 7.9	93 87
D	L, S, POB, CV(L) (D, L, S, VM)	6.3 9.6	88 82
E	L, S (D, L, S, VM)	5.0 5.6	79 79
F	D, L, WB (D, L, S, VM)	18.4 18.2	86 87
G	S (D, L, S, VM)	6.8 6.5	43 56
H	D, L, S, F1, F2 (D, L, S, VM)	5.4 8.4	97 95
J	L, S, POB, WB (D, L, S, VM)	8.4 11.9	87 82
K++	D, L, WB (D, L, S, VM)	3.4 3.2	96 97
L	D, L, S, F (D, L, S, VM)	3.4 4.9	93 90
M	D, S, VM, b* (D, L, S, VM)	6.9 8.6	95 93

The subset (D, L, S, VM) is also reported for each mill.
++ *Based on a low number of observations; reported only for Hauteur.*

The selection of particular subsets by the analyses can be explained by a number of factors, particularly the type of wool being combed at the mill and therefore the range of the raw wool characteristics. For example, a mill, which consistently purchases wools within the 21 to 23 micron range, might not expect to find diameter as one of the important characteristics in a formula for the prediction of fibre length, since in this case the contribution of diameter to fibre length is fairly constant.

Conversely, a mill which regularly processes both free wools and wools with considerable vegetable fault is likely to find that vegetable matter base is an important characteristic in the subset used to predict fibre length.

The interrelationships or correlations between the raw wool characteristics of the consignments, which are combed at each mill, are also important. Examples of such correlations are vegetable matter base with wool base, and yellowness with diameter (particularly where both merino and crossbred wools are involved). Sometimes in these cases, only one of the correlated characteristics will appear as significant in the relationships with a processing factor. As an extension of this principle, the influence of yield and colour on processing probably arises indirectly through their connections with wool type and style ([5]).

A similar situation occurs for noil (Table 3). The subset selected as the best subset is different from mill to mill, with diameter the most predominant raw wool characteristic. The subset (D, L, S, VM) performs well for most mills.

The important raw wool characteristics appearing in the best subsets for other fibre length properties of the top are as follows:

- Coefficient of Variation of Hauteur (%) (Table 4)

  The best subset is different from mill to mill. However, staple strength, staple length, and vegetable matter base, appear most frequently.

- Barbe (mm) (Table 5)

  Staple length appears in all subsets predicting Barbe. Less important characteristics are staple strength and diameter.

- Short Fibre Content (% less than 25 mm) (Table 6)

  There is no dominant characteristic influencing short fibre content. Diameter, staple strength, yellowness, staple length and position of weakness each appear in several subsets.

- Long Fibre Length (Length at 1%) (Table 7)

  As might be expected, staple length is dominant, appearing in all subsets related to this top characteristic. Secondary characteristics include position of weakness and coefficient of variation of staple length.

SUMMARY OF THE BEST MULTIPLE REGRESSION SUBSETS##
FOR NOIL

TABLE 3

MILL CODE	RAW WOOL VARIABLES	MSE (%^{2})	$100R^2$ (%)
A	D, WB, F (D ,L, S, VM)	1.8 3.3	88 79
B	L, WB, L* (D, L, S, VM)	0.6 1.0	81 67
C	D, VM, L*, b* (D, L, S, VM)	0.7 1.2	75 57
D	D, WB (D, L, S, VM)	2.3 3.7	79 70
E	D, S (D, L, S, VM)	1.1 1.1	71 74
F	L, VM, POB (D, L, S, VM)	0.8 1.1	88 84
G	D, L, VM, L* (D, L, S, VM)	0.1 0.1	75 67
H	L, F2 (D, L, S, VM)	1.7 3.0	92 87
J	D, VM, POB, b* (D, L, S, VM)	1.9 2.4	78 73
L	D, L*, F (D, L, S, VM)	2.4 3.5	84 77
M	D, VM (D, L, S, VM)	1.9 2.1	93 93

The subset (D, L, S, VM) is also reported for each mill.

SUMMARY OF THE BEST MULTIPLE REGRESSION SUBSETS
FOR CV OF HAUTEUR

TABLE 4

MILL CODE	RAW WOOL VARIABLES	MSE (%^{2})	100R^2 (%)
A	D, L, S, CV(L), F	0.7	93
B	L, WB	17.3	55
C	VM, L*, b*	5.8	72
D	L, S, VM, POB, WB	2.0	89
E	S, VM	5.8	48
F	D, L, S, VM	7.6	74
G	VM, POB	4.9	81
H	D, L, S, VM, POB	3.2	85
J	S, POB, WB	8.0	74
L	D, L, S, L*, F	6.4	82
M	S, CV(L), WB	3.9	64

SUMMARY OF THE BEST MULTIPLE REGRESSION SUBSETS
FOR BARBE

TABLE 5

MILL CODE	RAW WOOL VARIABLES	MSE (mm^2)	100R^2 (%)
A	D, L, S, WB, L*	2.7	98
B	D, L, L*	8.6	94
C	D, L, S, CV(L), b*	7.3	94
D	L, S, CV(L)	7.3	87
E	L, S, b*	3.8	89
F	D, L, b*	10.2	95
G	L	9.2	14
H	L, VM, WB	10.8	96
J	L, S, POB, WB	5.9	90
L	L, S, F	4.0	93
M	L	11.0	94

SUMMARY OF THE BEST MULTIPLE REGRESSION SUBSETS
FOR SHORT FIBRE CONTENT (% less than 25mm)

TABLE 6

MILL CODE	RAW WOOL VARIABLES	MSE ($\%^2$)	$100R^2$ (%)
A	D, L, S, F	0.8	92
B	D, CV(L), b*	2.1	65
C	D, VM, L*, b*	3.5	70
D	S, POB, WB	3.1	78
E	S, b*	1.6	61
F	D, POB, WB	8.2	66
G	L, VM, POB	3.7	82
H	D, L, L*, b*, F2	0.7	94
J	L, S, POB, WB	5.9	77
L	S, CV(L), b*, F	4.2	73
M	VM, CV(L), WB	2.6	76

SUMMARY OF THE BEST MULTIPLE REGRESSION SUBSETS
FOR LONG FIBRE LENGTH (L @ 1%)

TABLE 7

MILL CODE	RAW WOOL VARIABLES	MSE (mm^2)	$100R^2$ (%)
A	D, L, POB, CV(L), F	6.0	98
B	D, L, S, VM, WB	20.6	96
C	D, L, CV(L), b*	7.1	98
D	L, CV(L), WB	13.5	84
E	L, CV(L), b*	7.8	93
F	L, CV(L)	16.8	96
G	L, POB	17.3	54
H	L, VM, L*	17.2	97
J	L, VM, POB, L*	8.3	91
L	L, POB, CV(L), WB	12.1	91
M	D, L, POB, L*	6.7	99

In terms of the relative errors involved, the reliability of the relationships for Hauteur, Barbe and long fibre length were superior to the reliability of the relationships for coefficient of variation of Hauteur, short fibre content, and noil.

There still remains the question of verification of the predictive models obtained (6), since cross validation or verification of the relationships developed for individual mills have not yet been conducted. Further work by each mill is needed to establish the robustness of the relationships developed.

Factors Affecting Mill Performance

The effectiveness of a relationship between raw wool characteristics and top characteristics is mill dependent. In particular, whilst the worsted combing process is basically similar for all mills, various makes and models of machinery are used, and factory layout and production parameters differ. Furthermore, aspects of quality control and mill management can affect performance.

In comparing mills in terms of the measured characteristics of tops produced by each mill, it is not sufficient to say that one mill consistently produces shorter or longer tops than another. These differences may be qualified by considerations of the management of card waste i.e., whether they are re-incorporated or not, and the degree of cleanliness in the top. Thus, the interrelationship between Hauteur, noil, and top and noil yield, needs to be considered both in technical specification of the top and the economic consequences.

Several examples of mill influence on processing performance have been observed in the Project.

(i) Scouring and Processing Lines.

Most mills have more than one scour train, often of different makes and ages. Similarly, different sets of cards or combs may be used. In one mill, the allocation of TEAM Project consignments to different lines introduced too much variation into the analysis and the influence of raw wool variables on processing performance was masked. Within the Project, it was not possible to prevent the confounding of the influence of comb settings with that of other processing effects. It would seem possible at least to develop a database specifically for each processing line.

(ii) The Influence of Time.

Data were collected for the Project over a three year period. In some cases, processing of most consignments was completed in a much shorter period; in other cases it extended over the full time span. Thus, mill variation due to peaks and troughs of workload, delays in maintenance, changes in equipment or settings, must be considered. We believe the progressive feedback from the Project assisted some mill management in processing subsequent consignments. One mill adjusted its machinery during the Project after reviewing the progress data.

(iii) Measurement of Fibre Length of Top.

The results presented here for individual mills refer to those obtained using the Almeter method. As discussed in detail in chapter 6, some mills participating in the TEAM Project used methods other than the Almeter to determine mean fibre length in the top. In these cases, measurements used in this report were made at CSIRO with an Almeter AL-100 and Fibroliner. Often there were significant changes in the analyses of a mill's performance when its own results were substituted, particularly where the Almeter method was not employed. Predictions for Hauteur or Barbe can be made to within a few millimetres but good control over length measurements is required to achieve such results.

Application of the Formulae

The predicted values for new consignments should be compared with actual processing results. This is the ultimate test of the reliability of prediction from the regression equation. Such an equation can on average be expected to be reliable in use if wool types being assessed are within the range of types which were used to establish it. In any mill the database would be updated continually as each consignment is completed. The mill could then refine the subsets and the formula progressively to check the predictive power. In addition, as the database expands, the value of introducing other raw wool characteristics to improve predictability can be tested.

At this stage the best subsets of the raw wool characteristics which could be used to predict top characteristics are different for each mill, and for each top characteristic within a mill. Whether these subsets continue as the most relevant remains to be seen as more results are accumulated, but it would seem realistic to expect the most influential characteristics in predicting processing performance to fluctuate until a large database is established for each mill.

Preliminary data indicate a topmaker can obtain a more reliable relationship from his own consignments than is obtained from the complete database of the combing mill. The question also arises as to whether the topmaker can simply predict processing performance at a number of mills or whether separate formulae are necessary.

Mills and some topmakers who build up a database and establish their own formulae, will probably use their own formulae to assist in the prediction of processing performance. Consequently, the actual raw wool measurements are more useful to them than a theoretical Hauteur calculated from a general industry formula.

On the other hand, Australian suppliers and other topmakers who comb at a number of mills, could find it difficult to use individual mill formulae as they value or purchase each sale lot. In these cases, initial use of a general formula could enable a comparative set of data to be established by suppliers/topmakers. By comparing actual values obtained, with those predicted by the general formula, it should be possible to develop consistent relationships for each mill. This is similar to the use of IWTO test results for top and noil combing yields and mean fibre diameter by coretest.

In the same way that IWTO recognises the formulae and average processing allowances for the calculation of Estimated Commercial Top and Noil Yields by coretest, it is recommended that IWTO consider encouragement of the development of theoretical Hauteur formulae. As well as the additional measurements appearing on Test Certificates and in sale catalogues, a theoretical Hauteur calculated from recognised formulae could appear on these documents.

Comparison of Mills' Expectations with Predictions

It has never been claimed that the Project would provide a simple solution to the commercial application of additional measurements, but rather that it would provide the basis for processors and topmakers to interpret and analyse the new measurements, and furnish guidelines on how the resultant data may be used to improve efficiency in wool processing and commerce ([7]). Hopefully, in this way commercial implications associated with the introduction of additional measurements will become well understood by the topmaker and comber.

Neither the formulae for the individual mills nor the general formulae for fleece and skirtings types can be expected to predict the processed result exactly. The formulae are useful if they can be applied to estimate the processing result within acceptable tolerances, and in particular, if they can detect abnormal situations in advance. What is acceptable as a tolerance can differ from mill to mill, but to be useful, a prediction formula must be more reliable than the subjective expectations of the mill or topmaker.

Where it was possible, the values for the mill expectations were obtained. Table 8 compares predicted Hauteur and expected Hauteur with the actual Hauteur. The figures shown are the percentage of consignments which actually combed within 1, 2 or 3 mm etc., of the predicted and expected Hauteur. Revised codes were allocated to prevent identification of this information with the processing information.

The values of the mills' expectations were provided to us after the additional measurements were made available to the mill and after processing occurred.

The expectations of the mills/topmakers deviated by a greater margin from the actual Hauteur than results predicted by the mills' formulae. In terms of the mean deviation from the actual Hauteur, the mill/topmaker expectation tends to be an underestimate.

The data reported in Table 8 allow for both positive and negative deviations i.e., no particular distinction has been made between tops, which combed shorter than expected or predicted and those that have combed longer. We appreciate that the cost penalties of the two situations may be different but we are not in a position to adjust for them. While greater concern is expressed when tops comb shorter than expected, nevertheless improved predictions can reduce the conservatism often evident in estimating the expected length and thus will also have economic ramifications. This is discussed in the next chapter.

THE RELATIONSHIP OF EXPECTED HAUTEUR (MILL) AND PREDICTED HAUTEUR (FORMULA) TO ACTUAL HAUTEUR

Percentage of each mill's consignments which actually combed within 1,2, …, 9 mm of predicted and expected Hauteur.

TABLE 8

Deviation from Actual Hauteur	MILL 1		MILL 2		MILL 3		MILL 4		MILL 5		MILL 6		MILL 7		MILL 8		MILL 9	
	Exp (%)	Pred (%)	Exp (%)	Pred (%)	Exp (%)	Pred (%)	Exp (%)	Pred (%)	Exp (%)	Pred (%)	Exp (%)	Pred (%)	Exp (%)	Pred (%)	Exp (%)	Pred (%)	Exp (%)	Pred (%)
0 - 1 mm	-	53	19	42	-	37	35	35	22	55	55	70	29	62	29	41	38	54
1 - 2 mm	6	23	19	23	16	42	10	20	28	17	10	25	38	24	12	24	30	38
2 - 3 mm	6	6	4	19	16	21	-	10	11	17	25	-	-	9	23	23	-	-
3 - 4 mm	12	18	15	8	5	-	10	15	11	11	10	5	5	5	6	-	8	-
4 - 5 mm	6	-	12	-	-	-	5	5	-	-	-	-	9	-	12	12	8	-
5 - 6 mm	17	-	8	4	21	-	10	10	16	-	-	-	14	-	6	-	8	8
6 - 7 mm	6	-	8	4	11	-	10	-	6	-	-	-	-	-	6	-	8	-
7 - 8 mm	6	-	-	-	10	-	-	-	6	-	-	-	-	-	6	-	-	-
8 - 9 mm	12	-	-	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-
> 9 mm	29	-	15	-	21	-	20	5	-	-	-	-	-	-	-	-	-	-

Exp = Expected Hauteur advised by mill/topmaker

Pred = Predicted Hauteur from formula based on the best subset of raw wool variables for that mill

NOTE: Mill identities have been re-coded for this table

References

1. Andrews, M.W., Proc. Seminar - Staple Length and Staple Strength of Greasy Wool, CSIRO Div. Text. Physics, Ryde, Paper 5, (1979).

2. Turpie, D.W.F., and Gee, E., Proc, 6th Int. Wool Research Conf., Pretoria, 3, 293, (1980).

3. Hunter, L., and Gee, E., Proc. 6th Int. Wool Research Conf., Pretoria, 3, 327, (1980).

4. Andrews, M.W., and Rottenbury, R.A., J. Text. Inst., 66, 200, (1975).

5. Rottenbury, R.A., Andrews, M.A., and Brown, G.H., Text. Res. J., 53, 29, (1983).

6. Brown, G.H., Rottenbury, R.A., and Kavanagh, W.J., Text. Res. J., in press.

7. TEAM Project Interim Report, Australian Wool Corporation, Melbourne (1984).

8. Draper, N.R., and Smith, H., "Applied Regression Analysis", John Wiley & Sons, New York, (1968).

9. Miller, A.J., "Selecting Subsets of Regression Variables", Proc. Symp - Regression Analyses, Statistical Soc. of Australia, (1979) .

4. ECONOMIC IMPLICATIONS

The adoption of additional measurement will have both technical and economic consequences for wool processors. Economic considerations arise in three main areas:

- improved accuracy and reliability of the prediction of top characteristics, processing performance and in the estimation, prior to combing, of the likely cost of a top;
- the potential for improvements in processing productivity; and
- improved control procedures for batching and blending wools to meet a given top specification at least cost.

Within the early-stage processing sector the potential benefits of additional measurement to individual firms will vary depending on their type of operation. Some companies produce tops against specific orders and attempt to minimise cost in purchasing greasy wool to meet the spinner's technical specification. Similarly, other mills produce standard tops but their commercial decisions relate more to selection of blends either at the time of purchase, or at the mill, to ensure costs are minimised. For the commission comber, improved processing efficiency and control are probably the main sources of benefit. For integrated mills, predictability, blending, and productivity, will play an interrelated role in profitability.

Economic Analysis of Prediction*

To be complete an economic analysis would consider overall benefits in terms of all the above factors. The TEAM Project data comparing the reliability of the prediction of Hauteur with a mill's subjective expectations provide information on one aspect of the economic benefits to be derived from additional measurement. Table 8 in Chapter 3 of this report shows the relationship of actual, predicted, and expected values of Hauteur for nine mills; the predicted values were based on the best formula derived for each mill at the completion of the Project.

Prior to the completion of this work, an economic analysis was conducted on data for five of the mills. Mills' Hauteur estimations, made without additional measurement, were compared with a Hauteur predicted, in each case, from a formula derived for each mill and comprising four raw wool variables - diameter, staple length, staple strength and vegetable matter base.

Using price relationships developed to represent average premiums/discounts applying to Hauteur ranges ([1]), the benefits, if any, of prediction over subjective expectation can be estimated. The serious consequences of outright rejection of a top failing to meet specification was not considered in this approach. This analysis detected favourable revenue effects using prediction from the raw wool measurements for four of the mills; however, one mill estimated Hauteur more accurately than the predicted results.

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* *The analyses summarised in this section were provided by M.L. Spinks and C. Monty, Economics Department, Australian Wool Corporation.*

The economic analysis for Hauteur concluded that:

– on average, additional measurement would have increased gross revenue per consignment by about $760. However, this varied between an average cost of $24 for one mill to an average benefit of $1,256 for another;

– the results for individual mills and all mills are highly variable. In other words, the benefits (costs) of additional measurement ranged from a cost of $2,911 to a benefit of $4,432 on individual consignments; and

– after adjusting the results for the quantity in each consignment, the benefit to the mills from using a formula to predict Hauteur is about 6 cents/kg clean or 4 cents/kg greasy.

The analysis showed that processors have a better chance of producing top to specifications and consequent financial benefit if they use additional measurement.

In all the wider aspects of topmaking and combing, benefits exist and these will be quantified in future economic evaluations.

Potential for Productivity Improvements

With increasing acceptance of additional measurement, and establishment of databases by topmakers and combers, many innovative concepts can be expected to emerge. Provision of detailed raw material specifications to the combing mill, will enhance its ability to adapt processing procedures to optimise processing results. For example, the effects of changes of procedures designed to reduce fibre breakage will be better identified. A comber on long runs of a standard top type may be able to increase carding speeds and other machine settings for higher staple strength wools, whilst compensatory action could be taken for weaker or more variable length wools.

Flexibility in Blending

It can be expected that additional measurement will assist description of wool for computerised optimisation techniques, which will enable a variety of blends to be proposed to meet a desired top specification. This benefit will flow from the increased ability to predict processing performance of components of a blend.

Perhaps the greatest commercial potential for additional measurement exists in the application of techniques to enable topmakers to prepare blends of wool from a greater range of types and at least cost ([2, 3]). It can be expected that major topmakers in the worsted industry will follow examples already evident, e.g., in blend preparation for carpet yarns in New Zealand ([4]).

References

1. Bell, P.J.M., Proc. Seminar on Additional Measurement for Wool, Ichinomiya, Japan, (1984).

2. Dent, W.T., J. Text. Inst., 67 286-291, (1976).

3. Bell, P.J.M., Wool Technol. Sheep Breeding, 26, Nov. 4, 29-37, (1978).

4. Carnaby, G.A., Computer Blends - I. Principles, WRONZ Communication No. C81, (1983).

5. THE SIGNIFICANCE OF STAPLE STRENGTH

The influence of staple strength on top length and other processing characteristics has already become evident from earlier sections of the report. Staple strength appears in the general formulae derived for the prediction of Hauteur and in almost all of the individual mill formulae relating raw wool measurements to Hauteur.

This is of particular significance because it has been shown that subjective appraisal of staple strength is unreliable in "sound" wools. Whilst most appraisers can make a clear distinction between "tender" and "sound" wools, they will have difficulty in ranking "sound" wools or in estimating the Newtons/kilotex value of particular lots. In addition, the superiority of the test across the whole range of strength is due in large part to the level of sampling (approx. 60 staples) and the fact that it is random.

The vast majority of consignments in the TEAM Project comprised wools subjectively appraised as sound. As Table 1 and Figure 2 showed, the range of measured staple strength within and between consignments was large. Further evidence of the impact of staple strength measurement is detailed below.

The Effect of Staple Strength on Processing

At the request of one mill, before processing, four consignments were split in two parts by the TEAM Management Committee by re-allocating component lots according to raw wool measurements. Three consignments were split solely on the basis of staple strength of the component lots and one consignment was split on the basis of the values of staple strength and staple length. The raw wool measurements and the Hauteur and noil produced after combing are summarised in Table 9.

Whilst all consignments were ordered and delivered as sound wool, simple grouping of component lots on the basis of objective measurement clearly illustrated the influence of staple strength on processing. In general, an increase of 10-15 N/ktex between consignments produced tops 5-6 mm longer. These results are comparable in magnitude to those found in pilot-scale processing studies ([1]).

There were associated changes in the noil produced for each consignment comparison. Lower values for noil were found with higher staple strength.

It should be made clear that the purpose of this exercise was to establish the value of knowing the average staple strength and length of a consignment before processing in order to predict Hauteur more accurately. It offers little information on the value or otherwise of separating sale lots for the purpose of controlling variability.

SUMMARY OF SPLIT-CONSIGNMENT PROCESSING TRIALS

TABLE 9

	PART A	PART B
CONSIGNMENT 1		
Diameter (µm)	23.6	23.4
VM Base (%)	0.5	0.5
Staple Length (mm)	112	112
Staple Strength (N/ktex)	38	50 (+12 N/ktex)
Position of Weakness (%)	62	69
Hauteur (mm)	76	82 (+6 mm)
Noil (%)	5.9	5.0 (-0.9%)
CONSIGNMENT 2		
Diameter (µm)	25.1	25.1
VM Base (%)	0.5	0.4
Staple Length (mm)	111	110
Staple Strength (N/ktex)	37	47 (+10 N/ktex)
Position of Weakness (%)	60	56
Hauteur (mm)	67	74 (+7 mm)
Noil (%)	5.4	4.5 (-0.9%)
CONSIGNMENT 3		
Diameter (µm)	21.9	21.9
VM Base (%)	0.8	0.7
Staple Length (mm)	95	95
Staple Strength (N/ktex)	32	47 (+15 N/ktex)
Position of Weakness (%)	44	45
Hauteur (mm)	63	69 (+6 mm)
Noil (%)	8.6	7.2 (-1.4%)
CONSIGNMENT 4		
Diameter (µm)	21.2	21.3
VM Base (%)	0.7	0.7
Staple Length (mm)	93	100 (+7 mm)
Staple Strength (N/ktex)	29	40 (+11 N/ktex)
Position of Weakness (%)	42	55
Hauteur (mm)	61	66 (+5 mm)
Noil (%)	11.3	9.0 (-2.3%)

Seasonal Variation in Staple Strength

Data for staple strength measurements can be analysed for seasonal trends and regional differences (2). Sufficient data from sale lots of TEAM consignments were available to enable comparison of fleece wools of 20-23 micrometres sold in Sydney, Melbourne, Newcastle and Goulburn throughout each quarter of each season from 1981/82 up to the end of March 1984. The trend over the three seasons is shown in Figure 5. The staple strength of the fleece lots selected in TEAM Project consignments from these eastern Australian centres averaged approximately 45 N/ktex during the 1981/82 and 1982/83 seasons. The drought during 1982/83 was reflected in the strength measurement of wool sold in the first half of the 1983/84 selling season. Fleece lots in the TEAM Project from these same centres averaged less than 30 N/ktex during this period.

This marked decrease in strength within the 1983/84 season should be viewed in the context of reports from commercial delegates at the IWTO Conference in Paris, January 1984, that Australian wools purchased during September-November, 1983 were processing much shorter than expected yet, subjectively, appeared to be sound.

Suppliers and processors are already aware of many of the effects of staple strength due to seasons, regions and countries of origin. The example presented here illustrates how these effects can be quantified in objective terms.

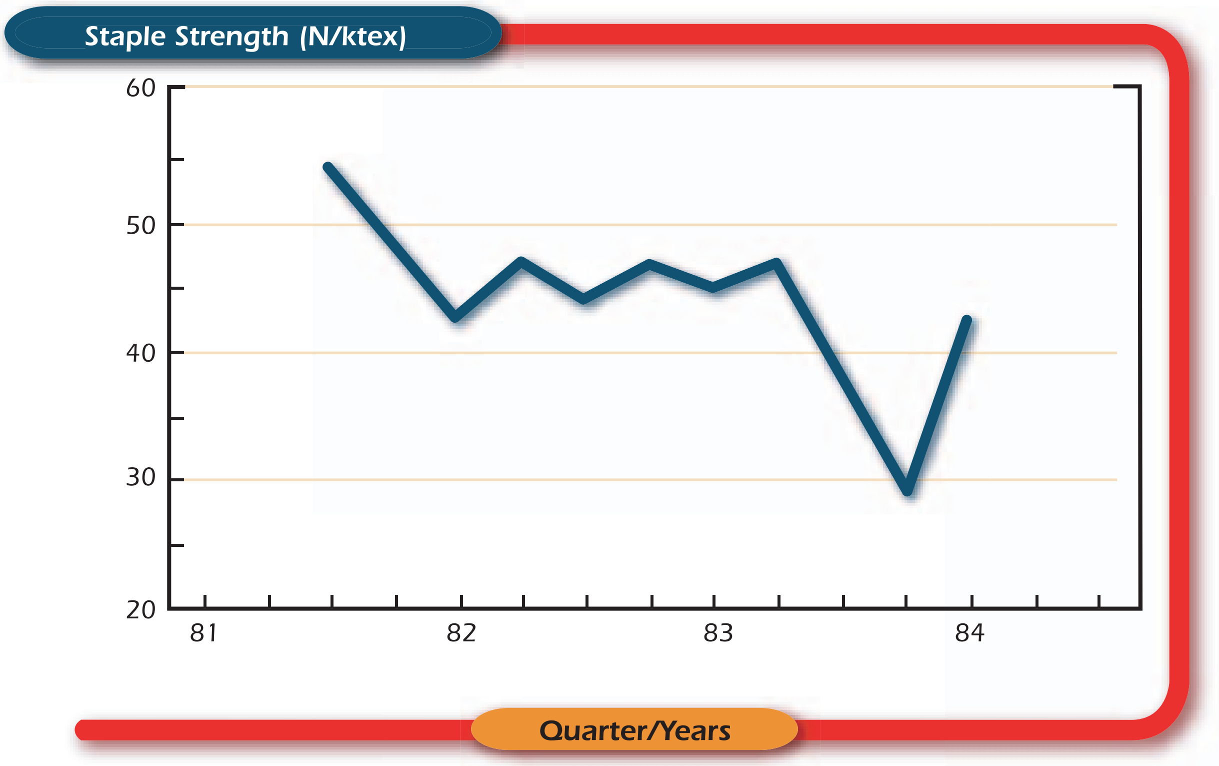

Figure 5

Seasonal Variation of Staple Strength
Combined Data for Sydney, Melbourne,
Newcastle and Goulburn.

Position of Staple Weakness

Although pilot-trial research ([3]) has shown that position of staple weakness can influence Hauteur when other raw wool characteristics are controlled, in practice its influence is overshadowed by the influence of the level of staple strength. While position of weakness has appeared in the best subset of variables for Hauteur for some mills in the TEAM Project, the effect of commercial blending of wools of different staple lengths with a range of positions of weakness masks the direct influence position of weakness might have on the top characteristics.

On the other hand, position of weakness can influence the fibre length distribution of the top, even at high levels of staple strength ([3]). Accordingly, position of weakness appears in the best subsets for the characteristics of fibre length distribution and noil in the TEAM Project (see Tables 2-7).

References

1. Rottenbury, R.A., Andrews, M.W., Bell, P.J.M., and Bownass, R., Proc. IWTO Tech. Cttee, Paris, (1985).

2. Rottenbury, R.A., Proc. Seminar-Staple Length and Staple Strength of Greasy Wool, CSIRO, Div. Text. Physics, Ryde, Paper 2 (1979).

3. Rottenbury, R.A., Kavanagh, W.J., Eley, J.R., and Andrews, M.W., Proc. IWTO Tech. Cttee, Paris, (1985).

6. RAW WOOL AND TOP MEASUREMENTS

Colour Measurement in Raw Wool and Top

Colour measurement of raw wool is normally conducted on core samples. Because of logistical problems, this was not possible for TEAM Project wools. However, a colour measurement was determined for each consignment by conducting a colour test on the accumulated broken staples remaining after the strength tests. Preliminary comparison tests showed a satisfactory correlation between this technique and colour measured from core samples in terms of the lightness (L*) and yellowness (b*) parameters.

As will have been noted in Chapter 3, either L*, b*, or both have appeared in some of the groups of raw wool characteristics influencing Hauteur or noil. In one instance (Mill M), we note b* is correlated with staple length, which does not appear in the best group of characteristics to predict Hauteur. In other instances, the presence of the colour component probably provides an indication of wool style.

Analyses of the data for TEAM consignments ([1]) indicate that the spread of values for colour is quite narrow; 79% of the consignments having L* values which lie within the range of two units (from 88 to 90), and 68% of the consignments having b* values within the range of two units (from 12 to 14). Consignments of skirtings types had colour values inferior to those obtained on the fleece types.

Of interest are the equivalent measurements for wool top produced from these consignments. The range for top values reflected this low variation for greasy wool. L* and b* results for 3 mills, re-coded 1, 2 and 3 are plotted in Figure 6. Simple regression analyses were conducted for each mill to examine the relationship between the raw wool and top measurements. The regression of the L* values of tops against raw wool indicated that the degree of association between the two measurements was not high. For Mill 1, only 30% of the variation in the L* values for top was accounted for by changes in the L* values of the greasy wool. It was slightly improved for Mill 2 but worse for Mill 3. In the case of b* values, the degree of association between the measurements was improved, the highest degree of association being that found for Mill 2 where 62% of the variation in the b* values of the tops was accounted for by the greasy wool differences.

The poor relationship between the top measurements and those on greasy wool is not unexpected. It arises principally because of:

- the narrowness of the range for clean colour observed between mill batches;
- the limitations of the precision of the test methods employed, particularly for those on the greasy wool; and
- the variation arising from processing conditions.

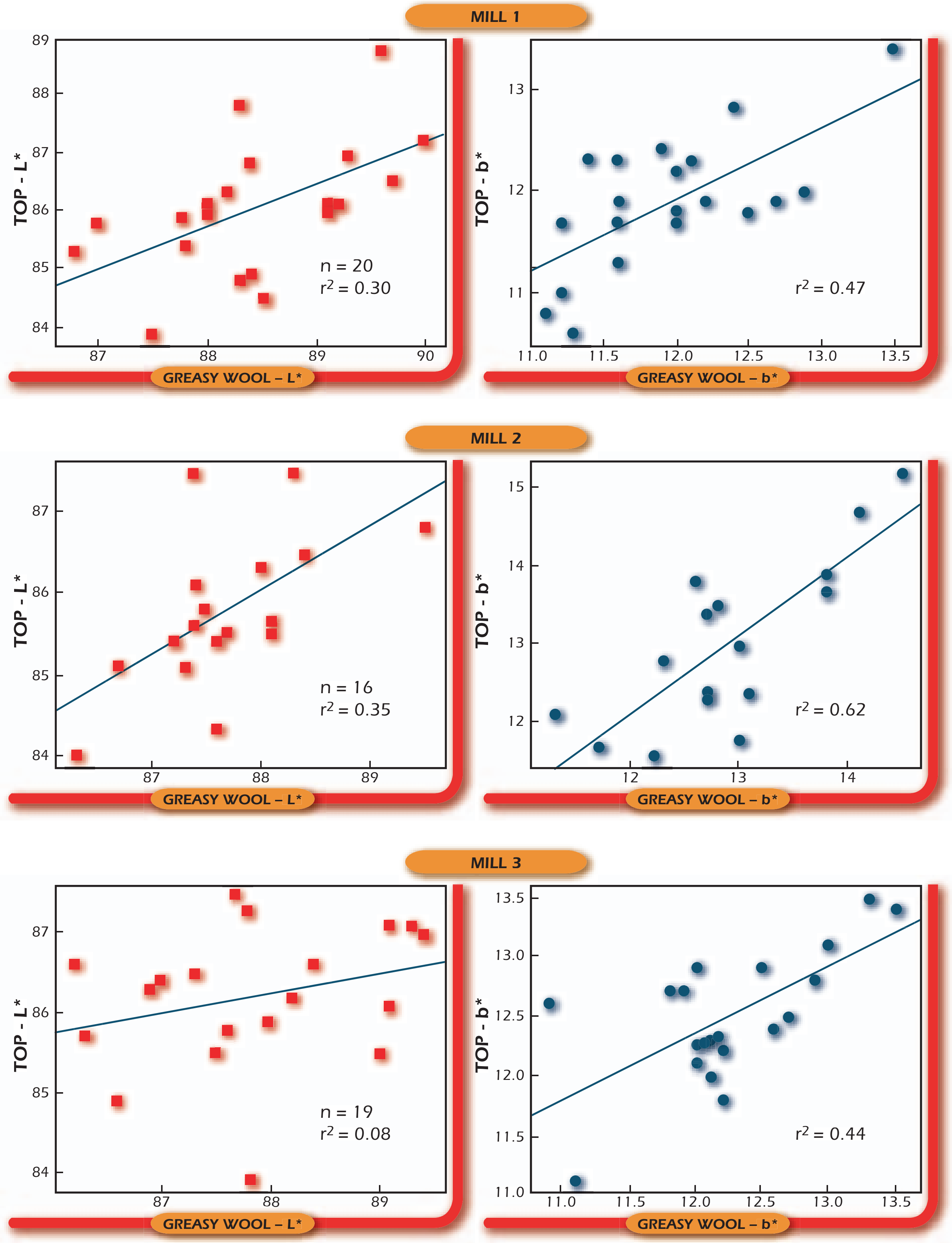

Figure 6

(extract from ref. 1)

L* and b* relationships between measurements

on top and greasy wool for three mills

The results tend to cast some doubts on the usefulness of the raw wool measurements for the processors if they are to be used for predicting closely the resultant colour of the wool after processing. However, they do not preclude their use for other purposes, such as their more general use for batching of wools to meet the colour requirements demanded for special end uses.

Relationship Between Airflow Measurements of Diameter in Top and Raw Wool

The TEAM Project has provided a database for study of the relationship between mean fibre diameter of greasy wool determined by coretest and the resultant top measured by the individual mill. In the Interim Report ([2]), data based on 11 mills and 149 consignments showed, overall, there was no significant difference between core and top (+0.01 µm).

The final data are based on 12 mills and 211 consignments, and are shown in Table 10. There is little change to the data presented in the Interim Report. Whilst the differences between top and core for individual mills range from +0.25 um to -0.44 µm, the combined difference is -0.03 µm, i.e., on average the top is 0.03 um finer than the core.

When core testing for fineness was introduced in the mid 1960's, a 0.5 um difference between top and core tests was generally expected. It was suggested that the noils removed in combing were finer than the resultant top, which was in turn coarser than the raw wool measurement. Data published in 1976 ([3]) comparing core/comb results on 122 consignments of Australian wool collected from 45 combing mills over the period 1964 - 1973 showed the difference between top and core was then 0.3 µm (the top being coarser). Now the latest TEAM data on 211 consignments show the difference to be non-significant statistically.

The reasons for differences between mills, different diameter groups and changes in the relationship over time are not clear, but it is our opinion that several factors which may have varied simultaneously are involved. These include:

- changes in processing machinery and speed of operation which can affect the amount and fineness of combing noil; and
- standardisation and calibration in airflow measurement of diameter of tops and greasy wool.

Relationship Between Dry Combed Top and Noil Yield and Estimated Yield by Coretest

The estimation of top and noil yield by coretest was the first application of coretesting to greasy wool trading. Although the IWTO method of test is confined to the determination of wool base and vegetable matter base, the information is only useful in trading when it is converted, using IWTO recognised formulae, to an estimated commercial yield.

COMPARISON OF MEAN FIBRE DIAMETER IN TOP AND RAW WOOL
FOR 12 MILLS, 211 CONSIGNMENTS*

TABLE 10

MILL CODE	MEAN FIBRE DIAMETER (AIRFLOW) CORE (µm)	TOP (µm)	DIFFERENCE (µm) (Top-Core)
1	22.41	22.38	-0.03
2	22.88	23.00	+0.12
3	21.64	21.58	-0.06
4	20.33	20.30	-0.03
5	20.06	20.01	-0.05
6	22.19	22.36	+0.17
7	22.14	22.02	-0.12
8	22.69	22.25	-0.44
9	25.43	25.68	+0.25
10	21.12	21.04	-0.08
11	23.10	22.89	-0.21
12	22.17	22.32	+0.15
Mean Results	**22.18**	**22.15**	**-0.03**

** Mill identities have been re-coded.*

COMPARISON OF DRY COMBED TOP AND NOIL YIELD WITH THE
ESTIMATED YIELD BY CORETEST FOR 12 MILLS, 227 CONSIGNMENTS**

TABLE 11

MILL CODE	TOP AND NOIL YIELD CORE (µm)	COMB (µm)	DIFFERENCE (%) (Comb-Core)
1	60.51	59.55	-0.96
2	57.18	59.00	+1.82
3	58.97	58.64	-0.33
4	62.66	62.34	-0.32
5	64.92	65.47	+0.55
6	63.84	63.97	+0.13
7	72.83	72.04	-0.79
8	64.40	63.58	-0.82
9	68.28	68.97	+0.69
10	63.32	63.72	+0.40
11	62.73	62.22	-0.51
12	62.20	62.65	+0.45
Mean Results	**64.44**	**64.42**	**-0.02**

*** Mill identities have been re-coded.*

The estimated commercial top and noil yield calculations include standard allowances for regain, residual fatty matter and ash, and tear (romaine). In addition, processing allowances based on vegetable matter base and its composition, are deducted during the calculation. The processing allowances are based on an original survey of 289 combing yields prior to 1964. Their relevance was confirmed in 1976 by a further survey of 397 consignments on Australian wools, which found that, on average, the estimated commercial top and noil yield, calculated in accordance with the IWTO formulae, accurately predicts the actual combing yield. That survey (3) also showed large differences in the relationship of core/comb yields between mills and variation in the relationship within mills.

The findings of that early survey are confirmed by the TEAM Project data summarised in Table 11. On average, the dry combing yield is 0.02% lower than the coretest yield. The mean difference between the core/comb yields for individual mills varies from +1.82 (combing yield greater than core) to -0.96% (combing yield less than core).

More detailed analysis of core/comb results from the Project will appear in the subsequent Technical Report.

Measurement of Fibre Length of Tops

Mills participating in the TEAM Project measured length routinely by either the Almeter, Almeter AL-100, WIRA Fibre Diagram Machine, and Suter Comb Sorter. Whilst raw wool characteristics for individual mills can be related to the top measurements obtained from each mill's instrument, values shown in the report have all been based on Almeter or Almeter AL-100 measurements. Where the mill did not have its own Almeter, top samples were measured in Australia at CSIRO using an Almeter AL-100.

In addition, top samples from mills who provided Almeter top length results for the Project were re-measured at CSIRO. This enabled a comparison of the CSIRO instrument and eight industry Almeters. Whilst differences between length measurement methods are well known, Table 12 shows the degree to which differences occur with the Almeter method. To maintain confidentiality, the mills have been re-coded. The difference between five of the mills and the CSIRO instrument is small but biases of -1.3 mm, -3.1 mm and -4.5 mm occur for three of the mills. The differences are reported in terms of the CSIRO instrument because it is the instrument common to all the comparisons.

COMPARISON OF MILL AND CSIRO ALMETER MEASUREMENTS
FOR 8 MILLS, 159 CONSIGNMENTS

TABLE 12

MILL CODE	HAUTEUR (mm)	AVERAGE DIFFERENCE (CSIRO-Mill) CV HAUTEUR (%)	BARBE (mm)	% <25mm (%)	L @ 1% (mm)
1	-0.6	+0.8	-0.3	+0.5	+0.6
2	-0.5	-2.3	-2.0	-0.2	+2.7
3	-1.3	0.0	-1.6	n.a.	n.a.
4	+0.2	0.0	+0.2	n.a.	n.a.
5	-0.2	-1.3	-1.3	n.a.	n.a.
6	-3.1	+2.0	-2.6	+1.8	-3.0
7	-4.5	+6.3	-1.8	n.a.	n.a.
8	-0.9	-3.3	-3.5	+0.3	-0.3
Mean Result	**-1.4**	**+0.3**	**-1.4**	**+0.6**	**0.0**

Standardisation and Harmonisation

The variation in the relationships between raw wool and top measurements, or measurements of the same characteristic by different mills or laboratories, highlights the importance of standardisation of instrumentation and procedures, and the harmonisation of testing organisations and mill laboratories.

In the comparison of raw wool and top measurements for similar characteristics, it is quite clear that processing procedures used to convert raw wool to top will influence any comparison. Nevertheless, even with recognised testing procedures, constant vigilance is required to ensure that Standards are well defined, unambiguous, and repeatable. In this regard the responsibility given to Interwoollabs and other organisations conducting round trials of test methods cannot be underestimated.

References

1. Rottenbury, R.A., Wool Tech. and Sheep Breeding, in press.
2. TEAM Project Interim Report, Australian Wool Corporation, Melbourne, (1984).
3. Ward, D.J., and Douglas, S.A.S., Proc. IWTO Tech. Cttee., Paris (1976).

7. ACKNOWLEDGEMENTS

This is not the end of TEAM. To the Management Committee and their colleagues this report is the beginning of the task they face in properly documenting all of the results and analyses and the detail and conclusion leading from them.

It will take a year or more to draw together a technical compilation embodying a proper account of the Project and its immediate consequences. Valuable data have been put aside in order to follow the main thread of the Project. Important questions, secondary to the direct determination of the influence of raw wool characteristics on Hauteur and noil, remain to be answered.

Nevertheless, this is the appropriate time to mention the individual contributions of those who have guided and assisted the Management Committee to this point. We have already noted the wave of industry interest in the Project; the participants are listed and thanked elsewhere in the Report. As for our colleagues, it is an invidious task to mention some to the exclusion of others, because the technical environment prospers with the comments and criticisms of all colleagues. We shall do our best to be fair.

Mr. Peter Bell, Director-Europe, Australian Wool Corporation, has been a consultant to the Project from its inception and has been kept informed of all the deliberations of the Management Committee to enable him to operate efficiently in that role. Needless to say his advice was of great value and his direct assistance in maintaining contact with participants must also be mentioned.

The Committee was advised on all statistical matters by Dr. George Brown, CSIRO Division of Mathematics and Statistics, and by Mrs. Wilma Kavanagh of the CSIRO Division of Textile Physics. Under their guidance, systems of analysis were explored and the appropriate methods for our particular needs were worked out within the Project. In the later stages of the Project this task magnified in intensity and depth and they were supported by Mrs. Teresa Murphy, CSIRO Division of Textile Physics.

Right from its origin the Project was seen to have impact directly upon the questions that always affect change in industry - what will be the cost of introducing new methods, and particularly, what will be the economic benefits flowing to the whole industry as a result?

Because of the role of the Australian Wool Corporation in the industry and its particular concern to assess the economic balance of new procedures, the machinery was set in place for using the data and technical conclusions of the Project for examination of the costs and benefits of procedures arising from the Project. Mr. Murray Spinks and Ms. Corola Monty worked alongside the Project and some of their conclusions are summarised in Chapter 4. As with the technical material, much remains to be done, and we thank them for joining in this report with an indication of their progress.

Within the organisations that have fostered this Project there are many others who have gone much further than mere duty to assist the logistics and reporting of the Project. Without naming individuals, we thank you all for your help.

To the Chairman and members of the Australian Wool Corporation's Wool Measurement Research Advisory Committee, our report to you comes with our thanks for your confidence in us and in the concepts of the Project.