# INTERNATIONAL WOOL TEXTILE ORGANISATION

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## PREDICTION OF WOOL PREPARATION CATEGORY FOR CLASSED FLEECE LINES USING A UNIFORMITY INDEX


**by**

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### SUMMARY

*AWTA Ltd has developed a measure of the uniformity of wool characteristics in a lot viz. the Uniformity Index (UI). The Index was obtained using Multiple Regression Analysis and is based on measures of Coefficient of Variation of Staple Length (CVL), Coefficient of Variation of Diameter (CVD), Coefficient of Variation of Strength (CVS), and variation in Position of Break (Uniformity of POB). The Index has been shown to differentiate between the majority of Bulk Classed and Classed Grower Lots in validation trials over a twelve month period. It is anticipated that, with the assistance of various sectors of the Australian wool industry, the UI can be shown to indicate differing levels of variation within sale lots in addition to predicting preparation category.*


### INTRODUCTION

The International Wool Textile Organisation (IWTO) Core Test Regulations[1] define different classes of wool lots based on wool preparation category. These definitions appear in Section 1.3 of the Regulations. Test Houses are required to identify the category on IWTO Certificates, and AWTA Ltd achieves this by attaching a suffix to the Test Number and by printing the category name on the Certificate.

These wool preparation categories are currently used in many trading contracts to specify "Classed Grower Lots Only", or exclude particular wool types such as Bulk Classed Lots. These exclusions are an attempt by processors to reduce the variation in parameters within lots of wool included in the delivery.

Difficulties can arise for the Test House in clearly identifying any category of wool preparation based on an external examination of the bales during the sampling and weighing process. Comments have previously been made to AWTA Ltd that bales purchased as Classed Grower Lots appeared to be wool blended from various sources (Bulk Classed Lot) when opened up for processing.

The price differentials that are evident between Bulk Classed Lots and Classed Grower Lots indicate the industry's belief that Bulk Classed Lots are inferior due to their variability and are therefore not permitted in some consignments.

The definition of Bulk Classed lots i.e. "bales containing wool blended from various sources"[1] gives the impression of variability within the lot of wool. Conversely, Classed Grower Lots i.e. "wool from an individual grower comprising bales classed from one clip"[1] would suggest a high degree of uniformity. These assumptions are generally correct however there are exceptions to the rule. Those Bulk Class operations dealing with significant volumes of wool, such as the larger Australian Brokers, have numerous bin types which help improve the matching of wool types within Bulk Classed Lots. Equally, the degree of variability in Classed Grower Lots is influenced by the uniformity of the flock of sheep and the standard of classing.

A recent trend in wool specification is to provide measurements of variation in addition to the mean for various wool parameters. Coefficient of Variation in Diameter and Coefficient of Variation in Length are two characteristics that provide useful information on the variability that is evident within wool lots. To assist the industry to evaluate the uniformity of a particular Lot, and hence predict preparation category, AWTA Ltd have endeavored to combine available test information into a Uniformity Index (UI)

This paper reports on the development of the Uniformity Index, and summarises the observations on the Index over the twelve month period from February 1997 to January 1998.

**DEVELOPMENT OF THE UNIFORMITY INDEX (UI)**

The initial step in the development of the Uniformity Index was to determine the wool characteristics that were most significant in the differentiation between Bulk Classed Lots and Classed Grower Lots.

The assessment involved each of the three AWTA Ltd laboratories selecting 50 Bulk Classed Lots and 50 Classed Grower Lots that were similar in micron and were described as fleece types. Test data for Clean Colour; Laserscan MFD and Coefficient of Variation of MFD; ATLAS Staple Strength, Coefficient of Variation of Strength, Staple Length, Coefficient of Variation of Staple Length, and variation in Position of Break; Wool Base; and Vegetable Matter Base were then assessed for each of these lots using Multiple Regression Analysis. This analysis identified variation in Position of Break (Uniformity of POB), Coefficient of Variation of Length (CVL), and Coefficient of Variation of MFD (CVD) as the characteristics that had a significant influence on the differentiation between Bulk Classed Lots and Classed Grower Lots.

The equation developed from this initial analysis was then validated using a new set of data from the three AWTA Ltd laboratories. Again, data for 50 Classed Grower Lots and 50 Bulk Classed Lots was obtained from each laboratory. The validation confirmed the importance of Uniformity of POB, CVL, and CVD in the Uniformity Index equation.

A enhanced version of the Uniformity Index (UI) was then developed by combining both the original and validation data sets and performing a Multiple Regression Analysis. The equation obtained from that analysis was as follows:

$$UI = 325.4 - (10.3 \times CVD) - (5.5 \times CVL) + (1.8 \times \text{Uniformity of POB})$$

The equation attempts to distinguish Bulk Classed Lots from Classed Grower Lots by calculating an estimate of the uniformity within the lot. Improved uniformity is indicated by a higher Uniformity Index value. It should be remembered that the ultimate purpose of the equation is to predict Bulk Classed or Classed Grower Lots. Further work may indicate that the UI can be used as a system which can replace these categories as the method of specifying uniformity within lots of wool.

An additional investigation was initiated for non-fleece wools in which 50 Classed Grower Lots and 50 Bulk Classed Lots were analysed using Multiple Regression Analysis. This investigation indicated that a different equation was required. Based on the limited availability of Bulk Classed Lots with the necessary test information, the investigation into developing an equation for non-fleece wool was deferred.

**VALIDATION OF THE MODEL**

To confirm the stability of the Uniformity Index equation over a twelve month period, AWTA Ltd commenced data collection from each of the three laboratories on a monthly basis. Each laboratory collected information for 50 Bulk Classed Lots and 50 Classed Grower Lots that were similar in MFD each month. All of the lots selected were fleece wools that had Staple Test data available. The CVD data was obtained by subsequent measurement of each of the selected lots on Laserscan.

The validation of the model over the twelve months indicated a distinct separation of the Uniformity Index for Bulk Classed Lots and Classed Grower Lots. Analysis on a month by month basis indicated that the separation of classing types was maintained throughout the year. Based on the success of the validation, a new regression analysis was undertaken using all of the test data collected over the twelve months. The equation obtained from this final analysis confirmed the importance of CVD, CVL, and Uniformity of POB and in addition, identified CVS as an influencing factor. The equation was as follows:

**UI = 236.0 - (5.5 x CVD) - (4.9 x CVL) - (0.7 x CVS) + (1.6 x Uniformity of POB)**

An estimation of the importance of the terms appearing in the UI equation are presented in Table 1. The most significant variable, based on the statistical significance of the regression terms, is Uniformity of POB followed by CVL, CVD, and CVS.

Table 1: Importance of Selected Terms in the UI Equation

| CHARACTERISTIC | RELATIVE IMPORTANCE |
|---|---|
| Uniformity of POB | 100 |
| Coefficient of Variation in Length (CVL) | 92 |
| Coefficient of Variation in Diameter (CVD) | 55 |
| Coefficient of Variation in Strength (CVS) | 37 |

Appendix 1 presents a histogram of the Uniformity Index values obtained over the twelve month period using the new equation. The range of UI values, when initially calculated, ranged from -70 for Bulk Classed Lots to 170 for Classed Grower Lots. Using a simple scaling technique, the values were adjusted to fall within a range of 0 to 100. The distributions for the two preparation types are both normal. Bulk Classed Lots have a mean Uniformity Index value of 41, and Classed Grower Lots a mean of 59. Table 2 separates the UI distribution into four groups showing the proportion of preparation type in each group.

Table 2: UI Distributions for Bulk Classed and Grower Classed Lots

| | **Proportion of Lots (%)** | |
|---|---|---|
| **Uniformity Index** | **Bulk Classed** | **Grower Classed** |
| **Group 1 (0-25)** | 5.7 | 0.2 |
| **Group 2 (26-50)** | 75.8 | 18.5 |
| **Group 3 (51-75)** | 18.5 | 74.9 |
| **Group 4 (75-100)** | 0.1 | 6.4 |

To test the robustness of the Uniformity Index equation, a number of multiple regressions were performed on random selections of data from the overall data set. Each analysis involved randomly selecting half of the data to generate a UI equation and then validating this equation with the remaining data. In all occasions, CVD, CVL, Uniformity of POB, and CVS were identified as important factors in predicting Bulk Class lots from Classed Grower lots. There was also very little change in the magnitude of the regression terms indicating the final equation as being suitable for all data sets.

## FUTURE DIRECTIONS

While Appendix 1 and Table 2 show a distinct separation of the Uniformity Index of Bulk Classed lots and Classed Grower lots, the data reveals a degree of overlap between the two categories. Some of this overlap will be due to the uncertainty of the measurements and the algorithm. The remaining overlap however, potentially supports the view that some Bulk Classed Lots may be better classed than others, and conversely, some Classed Grower Lots exhibit more variation than others. To verify this assumption, the assistance of the Australian wool trade will be sought. It is proposed that comparisons of uniformity will be made between the objective calculation of UI and the subjective appraisal by industry experts. If assistance can be gained, it is also proposed that processing trials be implemented.

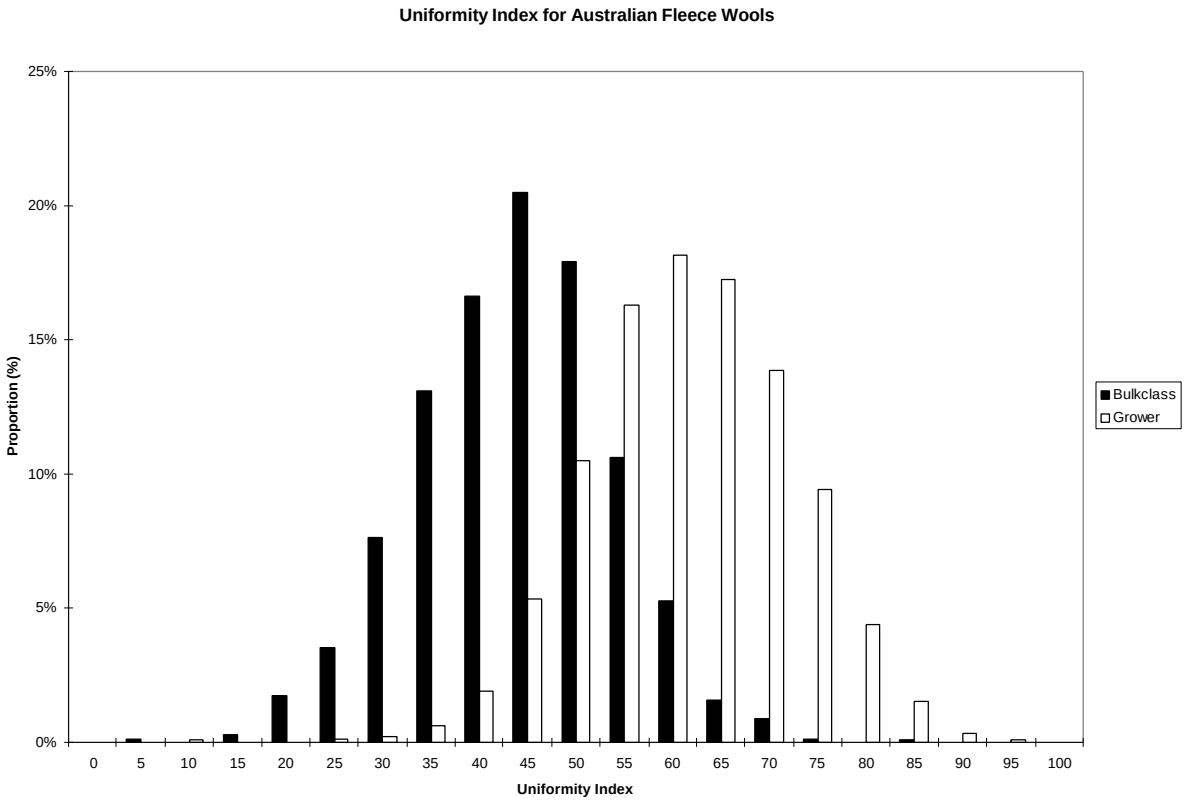
Depending on the correlation that exists and the support of industry sectors, it may be possible for processors of Australian wool to include the Uniformity Index value as a means of specifying an acceptable level of variation within the lot, instead of using the wool preparation category.

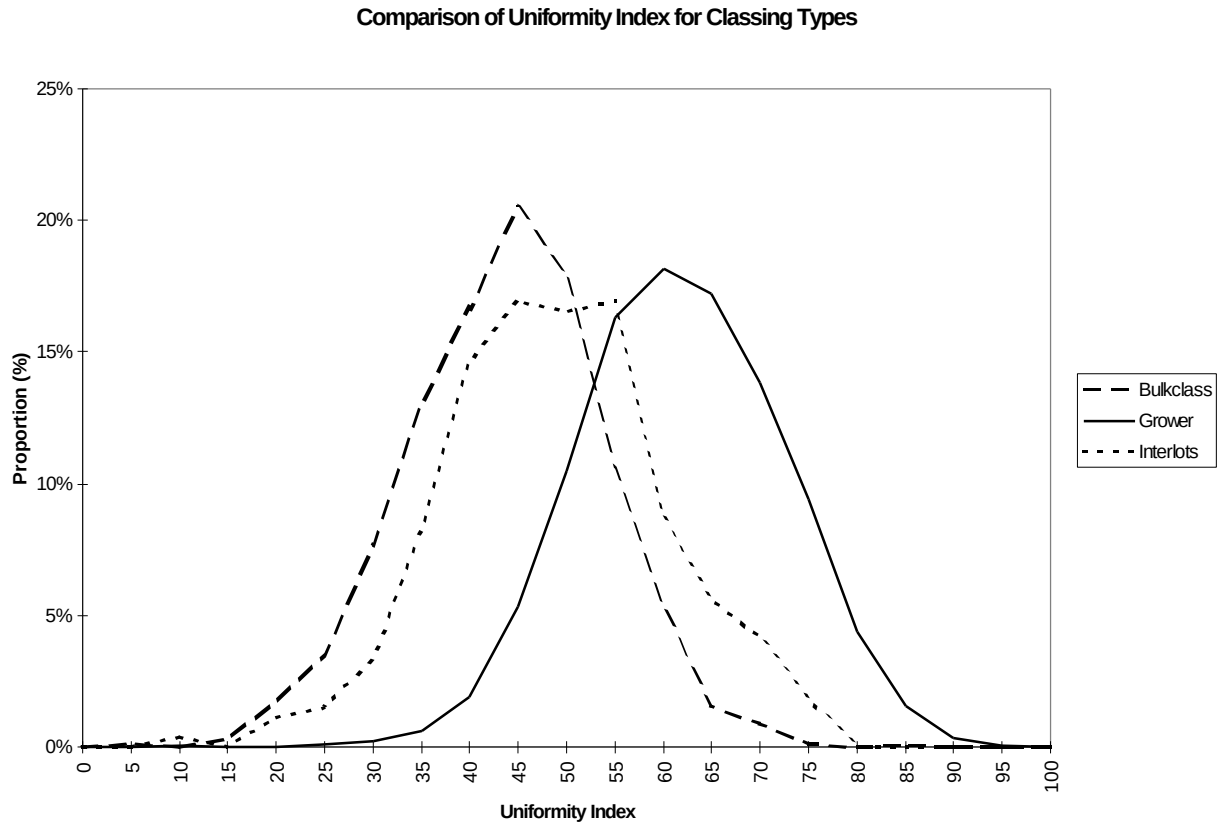
Further areas of investigation will include assessing the Uniformity Index of Interlot wools. Some preliminary information has already been obtained with the calculation of UI values for 400 Interlots from South Australia. The distribution of these values, in comparison to those obtained for Classed Grower lots and Bulk Classed lots, are displayed in Appendix 2. The distribution falls between the two alternative classing types; however, it is closer to that of Bulk Classed lots. The average UI for Interlots is 46.

## REFERENCE

1. IWTO Core Test Regulations.

Appendix 1


Uniformity Index for Australian Fleece Wools
25%
20%
15%
10%
5%
0%
Proportion (%)
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Uniformity Index
Bulkclass
Grower


Comparison of Uniformity Index for Classing Types
25%
20%
15%
10%
5%
0%
Proportion (%)
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Uniformity Index
Bulkclass
Grower
Interlots