IWTO TECHNOLOGY & STANDARDS COMMITTEE NICE MEETING

RAW WOOL GROUP **December 1998**

A Review Of The Range Checks Used When Testing For Wool Base In Accordance With IWTO-19

by

P D Morgan

Australian Wool Testing Authority Ltd, PO Box 240, North Melbourne, Victoria 3051, Australia

INTRODUCTION

The testing of multiple sub-samples for Wool Base and applying a statistically determined acceptable Outlier Test to the between-subsample range of Wool Base values is a fundamental part of Raw Wool testing. The current Range Checks, which are recorded in Table H1 in IWTO-19, were developed by an Australia/New Zealand Working Group comprising representatives from the then Australian Wool Measurement Standards Authority, AWTA Ltd, and Wool Research Organisation of New Zealand. The Working Group's report was presented to the IWTO meeting held in Copenhagen in June 1983.

The values were determined primarily from analysis of 260 trials in the International Laboratory Round Trials (ILRT), and were set at values which were expected to result in approximately 5% of tests requiring that extra sub-samples be tested before issuing a result. The details of this work are described in IWTO-19[(1)].

It is appropriate to review these values because:

* it is 15 years since they were established;

* practical experience indicates that 8-10% of tests (not 5%) regularly require extra sub-samples to be tested; and

* general quality assurance philosophies, today, are more attuned to looking for gross errors, rather than applying additional testing to a relatively high number of tests, most of which are not in error. A 1% level of rejection is more relevant to this situation, rather than the 5% level currently applied in IWTO-19. Range Check values used in IWTO-28 are now set at the 1% level.

Note, an improvement in precision is obviously achieved on the tests for which additional sub-samples are tested. But, this has very little impact as a whole because:

* virtually all test results today are conducted on Presale lots, which are invariably combined with other Presale results to produce very precise overall answers; and

* if tested in large parcels, there is a limit of 12,000 kg Greasy or 7,000 kg Scoured & Carbonised wool which can be tested as a single test, which ensures that an acceptable level of precision is maintained at all times.

The aim of this paper is to:

* review current ILRT data with the view to updating the precision values in Table G1 and the Range Check values in Table H1 in IWTO-19;

* consider the use of 1% level, rather than the 5% level of rejection, in line with current thinking; and

* examine why the actual proportion of tests which require additional sub-samples tested does not

match the theoretical expectation.

MATERIALS and METHODS

Data Source

Results from the most recent 664 International Laboratory Round Trials (ILRT) conducted between 1992 and 1998 were used in the analyses. The participating ILRT laboratories were:

* Australian Wool Testing Authority Ltd, (AWTA Ltd) (Sydney, Melbourne and Fremantle);
* New Zealand Wool Testing Authority Ltd, (NZWTA Ltd), Napier;
* Wool Testing Bureau S.A., (WTB), Port Elizabeth, South Africa; and
* Laboratorio de Fibras Textiles INTA Bariloche, Argentina.

Wools used in these trials came from Australia, New Zealand and South Africa, and covered a wide range of Wool Base, Vegetable Matter Base and Mean Fibre Diameter.

Data Analysis

Precision Data and Range Checks

The within-laboratories and between-laboratories components of variance were calculated on a trial-by-trial basis and transformed to standard deviation values. The standard deviation data were plotted against Wool Base in 2 ways, one where the 664 individual results were plotted, and secondly where the standard deviation values were averaged with ranges of 1% of Wool Base (e.g. 50.1% to 51.0%) and the average values plotted. (The average standard deviation values were obtained by calculating the average variance values and transforming them to standard deviation).

The standard deviation data were regressed against Wool Base in the second case above and the regression formulae were used to determine standard deviation values for the mid points of Wool Base ranges in steps of 5%. The Wool Base ranges were from 40.1% to 65.0%, with mid-point values of 42.5%, 47.5% etc. Wool Base Range Check were obtained by multiplying the standard deviation values obtained from the regression analyses by the relevant upper 1% values from the 'Studentised Range' table[(2)]. A table similar to H1 in IWTO-19 was constructed from this data.

As in the existing Table H1, the Range Checks used when comparing the results from the first set of subsamples tested (either 2 or 3 subsamples) were based on the between-subsample data. The Range Checks used when comparing the results of the initial subsamples and the additional subsamples are based on the pooled between-subsample data plus the between-laboratory information, as in the current Range Checks. The between-subsample plus between-laboratory values were obtained by adding the respective variance values and transforming the sum to the standard deviation.

Comparison of Actual and Expected Number of Outliers

As most Presale tests are commenced with 2 subsamples, the range of differences in Wool Base between the first 2 subsamples of each test conducted at each laboratory was plotted within intervals of 5% of Wool Base to observe the nature of their distribution. The proportion of outliers under the revised Range Checks was determined and compared with the expected value of 1%.

RESULTS and DISCUSSION

Distribution of Wool Base Results

The number of the individual trials within ranges of Wool Base was as follows:

TABLE 1

NUMBER OF TRIALS WITHIN VARIOUS WOOL BASE RANGES

WOOL BASE RANGE (%)	NUMBER OF TRIALS
< 40.1	1
40.1 – 45.0	12
45.1 – 50.0	68
50.1 – 55.0	106
55.1 – 60.0	229
60.1 – 65.0	197
>65.0	51
TOTAL	664

Precision Data

The between-subsample and between-laboratory components of variance for Wool Base calculated from these analyses and the values currently listed in IWTO-19 are reported in Table 2.

TABLE 2

BETWEEN-SUBSAMPLE and BETWEEN-LABORATORY COMPONENTS OF VARIANCE

WOOL BASE RANGE (%)	DATA FROM THIS ANALYSIS (σ^2)		CURRENT DATA IN IWTO-19 (σ^2)	
	SUBSAMPLES	LABORATORIES	SUBSAMPLES	LABORATORIES
< 40.1	0.778	0.518	0.92	0.61
40.1 – 45.0	0.556	0.374	0.56	0.50
45.1 – 50.0	0.389	0.266	0.36	0.40
50.1 – 55.0	0.265	0.184	0.25	0.31
55.1 – 60.0	0.172	0.123	0.18	0.23
60.1 – 65.0	0.105	0.078	0.12	0.17
>65.0	0.079	0.060	0.09	0.11

The lower values for the between-laboratories data is indicative of an improvement in laboratory harmonisation since 1983. The between-subsamples data are similar to the previous data. The new data for Wool Base levels less than 40.1% should be viewed with caution, as it is based on results from only 1 trial.

Range Check Values

The between-subsample and the between-laboratory data demonstrated the expected negative relationship with Wool Base (Appendix 1). Also as expected, the data, although following mostly a linear trend did have a non-linear component. When a curve of the form:

$$\text{Standard Deviation} = a + b*\log(\text{Wool Base})$$

was fitted, it accounted for 70%, or more, of the variation (Table 3). Fitting a quadratic term did not improve the goodness of fit.

TABLE 3

REGRESSION STATISTICS

PARAMETER	WITHIN-LABS	BETWEEN-LABS
A	4.8432	3.8483
B	-2.5165	-1.987
MSE	0.01	0.01
R^2	0.84	0.70

Wool Base Range Checks calculated at the mid-point of 5% ranges of Wool Base, based on standard deviation data derived from the regression formulae reported above and the upper 1% value from the 'Studentised Range' are reported in Table 4.

TABLE 4

REVISED RANGE CHECKS

WOOL BASE RANGE (%)	NUMBER OF SUBSAMPLES TESTED						
	INITIAL TESTING		INITIAL plus ADDITIONAL TESTING				
	2	3	3	4	5	6	7
< 40.1	3.2	3.6	4.7	5.0	5.2	5.4	5.6
40.1 – 45.0	2.7	3.1	4.0	4.2	4.4	4.6	4.7
45.1 – 50.0	2.3	2.6	3.3	3.6	3.7	3.9	4.0
50.1 – 55.0	1.9	2.1	2.8	2.9	3.1	3.2	3.3
55.1 – 60.0	1.5	1.7	2.2	2.4	2.5	2.6	2.7
60.1 – 65.0	1.2	1.3	1.8	1.9	2.0	2.0	2.1
>65.0	1.0	1.2	1.5	1.6	1.7	1.8	1.8

Comparison of Actual and Expected Outliers

Examination of the pooled frequency distributions of the Wool Base range between the first 2 subsamples tested in each laboratory in each trial in the ILRT indicates a non-normal distribution of the data at all levels of Wool Base (Appendix 2). In all cases, the data demonstrates a skewness towards the high side. Such a distribution suggests that the actual number of results which exceed the Wool Base Range Check will be greater than expected. Calculation of the actual number of outliers when the revised Range Checks were applied to the results from the ILRT data used in these analyses confirms that this does occur (Table 5).

TABLE 5

PROPORTION OF OUTLIERS IN ALL LABORATORIES ARISING FROM REVISED RANGES CHECKS

WOOL BASE RANGE (%)	NUMBER OF COMPARISONS	OUTLIERS	
		NUMBER	PROPORTION (%)
< 40.1	4	1	25.0
40.1 – 45.0	63	3	4.8
45.1 – 50.0	379	6	1.6
50.1 – 55.0	586	12	2.0
55.1 – 60.0	1267	10	0.8
60.1 – 65.0	1066	16	1.5
> 65.0	282	5	1.8
TOTALS	**3647**	**53**	**1.5**

RECOMMENDATIONS

It is recommended that the following changes be made to IWTO-19:

1. The precision values in Table G1 be amended to take account of the more recent variance data reported in Table 2 in this paper. A copy of such a table follows;

2. The Range Check values in Table H1 be replaced by the values reported in Table 3 in this paper. A copy of such a table is included the following redraft of Appendix H, IWTO-19;

If these recommendations are accepted, Appendix H needs to be rewritten as follows:

"In the testing of greasy wool samples for yield it is necessary to carry out the full test procedure on more than one subsample in order to ensure that gross errors do not go undetected. To detect gross errors in the subsample results, a suitable form of Outlier Test must be applied to the subsample Wool Base values. The requirements to be met by the Outlier Test are that it is efficient (i.e. capable of detecting true outliers) and can be readily incorporated into the routine test procedures of IWTO-19.

There are a number of different tests available for detecting outliers results[(1)] and each one has a particular type of situation for which it is best suited. It has been accepted that the most appropriate test for use in IWTO-19 is a Range Test based on the 'Studentised Range'. In this test, the range (i.e. the difference between the highest and lowest values) of the measured values of the variable is divided by the appropriate value of the population standard deviation of the variable, to give a value called the 'Studentised Range'. Critical values of this ratio have been calculated for different levels of probability and are available in the form of published tables[(2)].

The obvious pre-requisite for the use of this test in IWTO-19 is to have suitable independent estimates of the population between-subsamples standard deviation. Some estimates had been obtained in earlier work by David and Brown[(3)] from analysis of interlaboratory trial data available at that time, and from analyses of the first 260 trials in the Interlaboratory Round Trials (ILRT) covering the period from 1978 to 1984. The ILRT are conducted between independent laboratories from various parts of the world. Data from that analysis of ILRT results provided estimates of population variation, which were used together with critical 'Studentised Range' values to determine limit values to the between-subsample differences in Wool Base in use prior to 1999.

Subsequent analysis of ILRT data[(4)], covering 664 trials conducted between 1992 and 1998, has been used to update the estimates of between-subsamples and between-laboratories standard deviation. This data has been used to update the precision table (G1) and the Range Checks (H1).

Between-subsample data were used to calculate the Range Checks for the initial set of subsamples tested, while the between-laboratory data was added to the between-subsample data in determining the Range Checks after additional subsamples have been tested. The between-subsample and between-laboratory

variances are added and transformed to the standard deviation when calculating the Range Checks after additional subsamples have been tested. In each case the standard deviation is multiplied by the relevant of the upper 1% point of the 'Studentised Range' from published tables. The between-laboratory data is added to the within-laboratories data when additional subsamples are tested to account for the greater variance which may arise when independent tests are conducted on a sample at different times

REFERENCES

1. ASTM E178-80. Standard Practice for Dealing with Outlier Observations'

2. May, J.M. Biometrica 39, 192-193, 1952. 'Extended and Corrected Tables of the Upper Percentage Points of the Studentised Range'.

3. David, H.G. & Brown, G.H. J. Text. Inst. 66, 275-281, 1975. 'The Precision of Yield Testing of Greasy

4. Morgan, P.D. 'A Review of the Range Checks Used when Testing for Wool Base in Accordance with IWTO-19'. Submission to IWTO Technical Committee, Raw Wool Group, Nice, 1998

TABLE H1

RANGE CHECKS

WOOL BASE RANGE (%)	NUMBER OF SUBSAMPLES TESTED						
	INITIAL TESTING		INITIAL plus ADDITIONAL TESTING				
	2	3	3	4	5	6	7
< 40.1	3.2	3.6	4.7	5.0	5.2	5.4	5.6
40.1 – 45.0	2.7	3.1	4.0	4.2	4.4	4.6	4.7
45.1 – 50.0	2.3	2.6	3.3	3.6	3.7	3.9	4.0
50.1 – 55.0	1.9	2.1	2.8	2.9	3.1	3.2	3.3
55.1 – 60.0	1.5	1.7	2.2	2.4	2.5	2.6	2.7
60.1 – 65.0	1.2	1.3	1.8	1.9	2.0	2.0	2.1
>65.0	1.0	1.2	1.5	1.6	1.7	1.8	1.8

BIBLIOGRAPHY

1. IWTO Test Method, IWTO-19. Determination of Wool Base and Vegetable Matter Base of Core samples of Raw Wool.

2. May, JM (1952). Biometrica 39, 192-193. Extended and Corrected Tables of the Upper Percentage Points of the Studentised Range.

Table G1

Estimates of the components of variance and 95% Confidence Limits for a Single Test for Wool Base

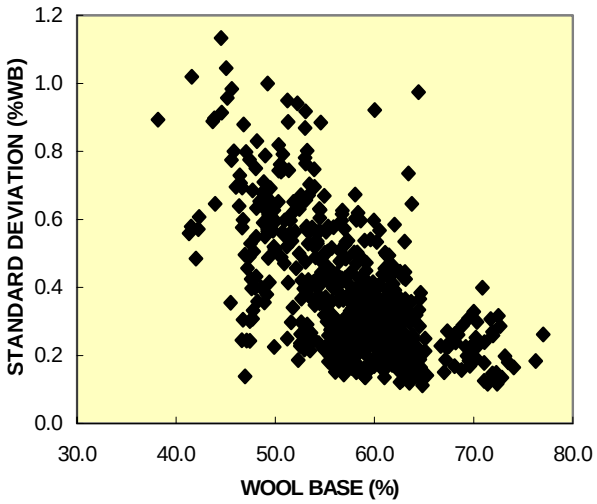
Mean Wool Base (%)	σ_S^2	σ_L^2	Cores / Lot	Country of Origin									
				Australia & South Africa				New Zealand				South America	
				Machine Coring		Manual Coring		Machine Coring		Manual Coring		Manual Coring	
				2 Subs	3 Subs	2 Subs	3 Subs	2 Subs	3 Subs	2 Subs	3 Subs	2 Subs	3 Subs
Up to 40.0	0.778	0.518	20	2.0	1.8			1.9	1.8				
			30	1.9	1.8	2.0	1.8	1.9	1.8	2.0	1.9	2.3	2.1
			50	1.9	1.8	1.9	1.8	1.9	1.8	2.0	1.8	2.1	2.0
			100	1.9	1.8	1.9	1.8	1.9	1.7	1.9	1.8	2.0	1.9
40.1 - 45.0	0.556	0.374	20	1.7	1.6			1.7	1.6				
			30	1.7	1.6	1.7	1.6	1.6	1.5	1.8	1.7	2.0	1.9
			50	1.6	1.5	1.7	1.5	1.6	1.5	1.7	1.6	1.9	1.8
			100	1.6	1.5	1.6	1.5	1.6	1.5	1.6	1.5	1.7	1.6
45.1 - 50.0	0.389	0.226	20	1.5	1.4			1.4	1.3				
			30	1.4	1.3	1.5	1.4	1.4	1.3	1.5	1.5	1.8	1.8
			50	1.4	1.3	1.4	1.3	1.4	1.3	1.5	1.4	1.7	1.6
			100	1.4	1.3	1.4	1.3	1.4	1.3	1.4	1.3	1.5	1.4
50.1 - 55.0	0.265	0.184	20	1.3	1.2			1.2	1.2				
			30	1.2	1.1	1.3	1.2	1.2	1.1	1.3	1.3	1.7	1.6
			50	1.2	1.1	1.2	1.1	1.2	1.1	1.3	1.2	1.5	1.4
			100	1.1	1.1	1.2	1.1	1.1	1.1	1.2	1.1	1.3	1.2
55.1 - 60.0	0.172	0.123	20	1.1	1.0			1.0	1.0				
			30	1.0	1.0	1.1	1.0	1.0	0.9	1.2	1.1	1.6	1.5
			50	1.0	0.9	1.0	1.0	1.0	0.9	1.1	1.0	1.3	1.3
			100	0.9	0.9	1.0	0.9	0.9	0.9	1.0	0.9	1.1	1.1
60.1 - 65.0	0.105	0.078	20	0.9	0.9			0.9	0.8				
			30	0.9	0.8	1.0	0.9	0.8	0.8	1.0	1.0	1.5	1.4
			50	0.8	0.8	0.9	0.8	0.8	0.7	0.9	0.9	1.2	1.2
			100	0.8	0.7	0.8	0.7	0.7	0.7	0.8	0.8	1.0	1.0
65.1 and above	0.079	0.060	20	0.9	0.9			0.8	0.8				
			30	0.8	0.8	0.9	0.9	0.8	0.7	1.0	1.0	1.4	1.4
			50	0.7	0.7	0.8	0.8	0.7	0.7	0.9	0.8	1.2	1.1
			100	0.7	0.6	0.7	0.7	0.7	0.6	0.7	0.7	0.9	0.9

`

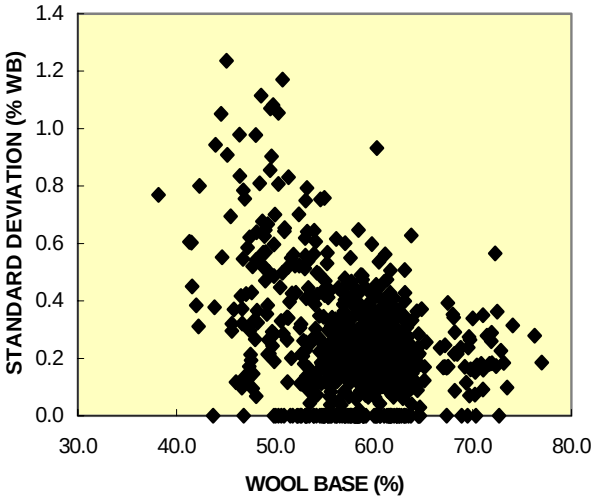
APPENDIX 1

INDIVIDUAL TRIAL DATA

WITHIN LABS STANDARD DEVIATION DATA

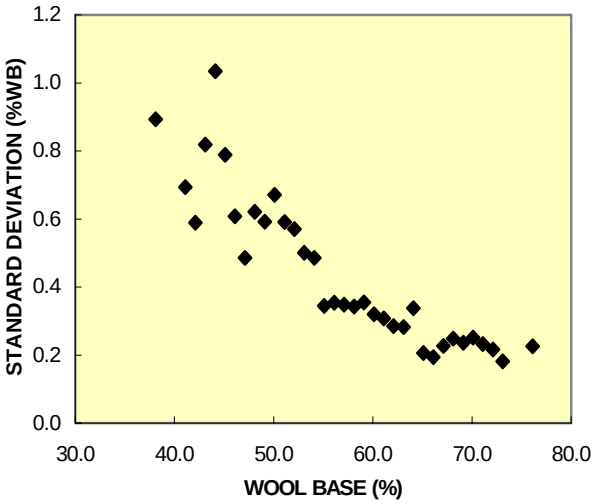


BETWEEN LABS STANDARD DEVIATION DATA

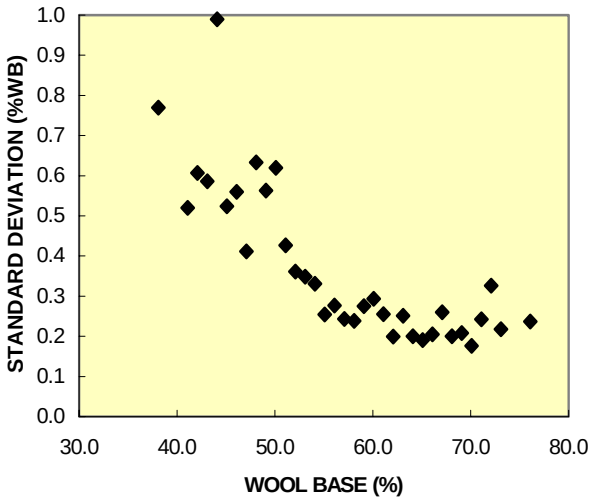


POOLED DATA IN STEPS OF 1% OF WOOL BAS

WITHIN LABS STANDARD DEVIATION DATA



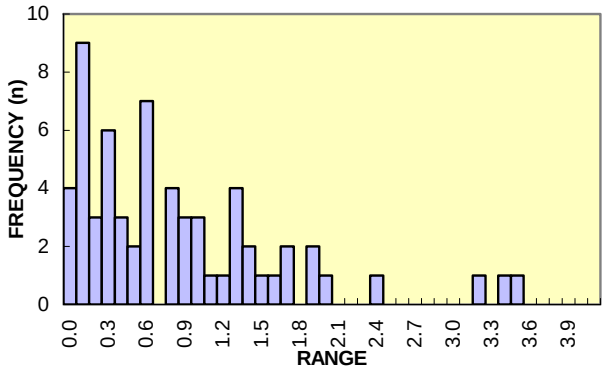
BETWEEN LABS STANDARD DEVIATION DATA



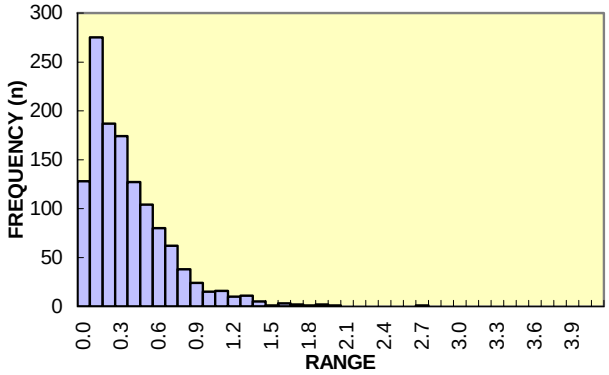
APPENDIX 2

DISTRIBUTION OF DIFFERENCES IN WOOL BASE BETWEEN THE FIRST 2 SUBSAMPLES

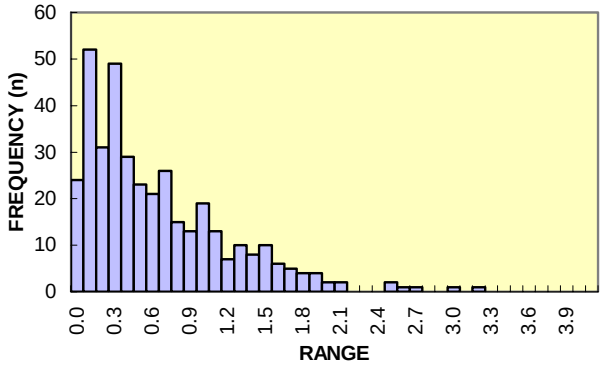
WOOL BASE 40.1- 45.0 %



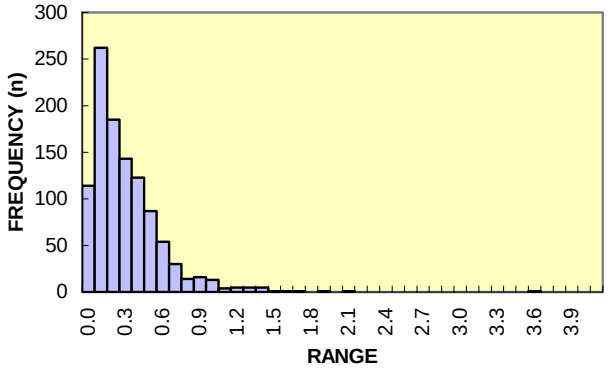
WOOL BASE 55.1 - 60.0 %



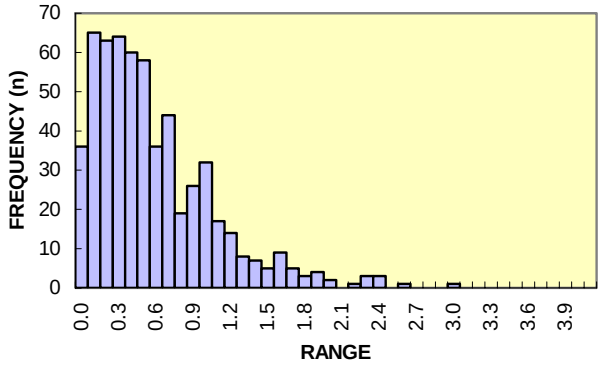
WOOL BASE 45.1 - 50.0 %



WOOL BASE 60.1 - 65.0 %



WOOL BASE 50.1 - 55.0 %



WOOL BASE > 65.0 %