Wool Trading Requirements & Technical Limitations of IWTO Test Methods

Wool Trading Requirements & Technical Limitations of IWTO Test Methods

INTRODUCTION

With the universal use of Test Certificates to define the specification of a wool trading contract, the accuracy and precision of the test results are sometimes questioned. This is particularly so as new measurements are introduced and there is no relaxation of commercial specifications in contracts.

For the new generation of wool market traders, this is an update of earlier reports (1,2,3) on this subject. It provides information to minimise the potential conflicts that can arise between the commercial wool trading requirements and the technical limitations of IWTO Test Methods and Regulations.

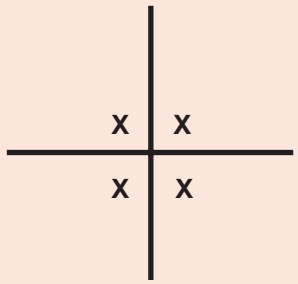
ACCURACY, BIAS & PRECISION

Many people are confused about statistical terms such as Accuracy and Precision. To understand the potential for improvement in testing, it is important to understand that Accuracy and Precision are different.

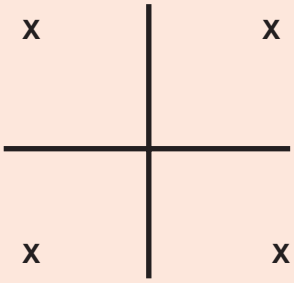
Accuracy is getting the "true" result. The "true" result is that obtained by strictly following the sampling and testing procedures and requirements laid down in the IWTO Test Methods and Regulations.

There are reasons why a difference between individual results can occur. However, if on average, a consistent difference exists, this is known as a Bias. Generally a Bias can be isolated to malfunctioning equipment or incorrect procedures in one laboratory which leads to that laboratory's inaccurate results. Correct the procedure, correct the malfunction and it can be expected the Bias will disappear.

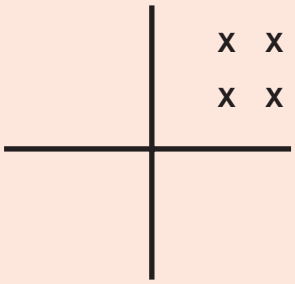
Precision is a measure of the ability to repeat a result. It can be understood by the following diagram where the cross-hair is the "true" result:



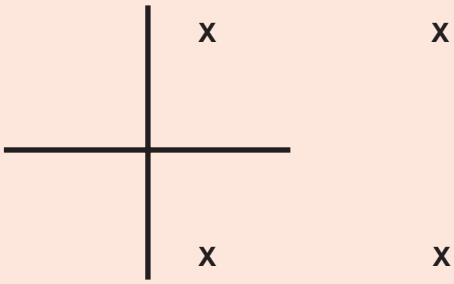
ACCURATE AND PRECISE
The 4 results are similar and close to the true result.



ACCURATE BUT IMPRECISE
The average of the 4 results is close to the "TRUE" result, but individual results are scattered.



INACCURATE BUT PRECISE
The average of the 4 results is not close to the "TRUE" result, but the individual results are similar.



INACCURATE AND IMPRECISE
The average of the 4 results is not close to the "TRUE" result and the individual results are scattered.

The trade must be able to expect that the results produced by AWTA Ltd and other testing laboratories are accurate and precise.

FACTORS AFFECTING PRECISION

Why aren't repeat results identical? Why do repeat results differ most of the time?

Genetics, environment and nutrition, management and disease influence the properties of wool as a natural fibre. Wool is a variable commodity and wool testing is used to provide an estimate of these properties based on a sample taken from the bulk. As AWTA Ltd samples and tests this variable commodity, the components of that variation, and variation introduced by the adoption of the official IWTO Methods and Regulations, contribute to each result. For example, the Confidence Limits are calculated from components of variance, which include:

- between-core or between-grab variation;
- within-laboratory variation; and
- between-laboratory variation.

Between-Core/Between-Grab Variation

This source of variation is beyond the control of AWTA Ltd, and is largely beyond the control of the wool classer, since much of the variation occurs within individual fleeces. This variation differs for wools of different origins and extreme wool types. For example, core sampling schedules are based on taking sufficient number of cores to achieve a sampling precision of ± 0.7% Wool Base. More cores/bale must be taken from bales of South American wools than for Australian wools in order to obtain a similar precision, because the bales of South American wools are usually more variable for yield than Australian wools.

Within-Laboratory Variation

Within a laboratory, minor equipment and operator differences can exist. Stringent quality control, equipment maintenance and supervision minimises this source of operator variation. The procedure of measuring sub-samples/specimens on different instruments reduces the effects of variation between machines and operators. For example, the IWTO Airflow Test Method requires 2 Airflow instruments to be used and the results averaged for certification. Similarly, staples sampled for ATLAS Staple Length and Strength certification must be prepared by at least 4 operators to minimise bias of any individual operator who might consistently draw longer or shorter staples.

Between-Laboratory Variation

The subject of bias has already been discussed. Even with bias eliminated, a component of variation between laboratories exists. Each instrument will give some small difference in performance, and laboratory procedures may differ in their interpretation.

In addition, the amount of testing conducted has a direct relationship with the precision of the answer – the greater the amount of testing, the more repeatable is the test result. Testing multiple samples randomises some of the within-laboratory effects and increases the chance of identifying an error before the result is issued.

When developing test methods, the sources of variation are determined from international inter-laboratory trials. These data form the basis for the calculation of the precision limits of the new method. Precision of a test result is also dependent upon the amount of sampling and testing conducted. The greater the amount of sampling and testing, the better the precision of the test result.

The precision of an individual test result is usually expressed as 95% Confidence Limits, ie. the limits on either side of the "true" result within which you can expect 95 of 100 repeat measurements to lie. The 95% Confidence Limits for Wool Base, Vegetable Matter Base, Mean Fibre Diameter, Colour, Staple Length and Strength measurements as defined in the IWTO Test Methods and Regulations are shown in Column A of Table 1.

Table 1 : Precision Limits & Maximum Retest Ranges

TEST TYPE	A 95% CONFIDENCE LIMIT (+/-)	B MAXIMUM RETEST RANGES (Absolute)
WOOL BASE (%)		
Up to 40.0	2.2	3.1
40.1 to 45.0	1.9	2.8
45.1 to 50.0	1.7	2.5
50.1 to 55.0	1.5	2.1
55.1 to 60.0	1.3	1.9
60.1 to 65.0	1.2	1.8
65.1 and above	1.1	1.6
VM BASE (%)		
Up to 0.5	0.1	0.3
0.6 to 1.0	0.3	0.5
1.1 to 1.5	0.4	0.6
1.6 to 2.0	0.5	0.8
2.1 to 3.0	0.6	1.0
3.1 to 5.0	0.9	2.0
above 5.0	1.0 to 2.0	3.2
MEAN FIBRE DIAMETER (um)	Airflow / OFDA / Laserscan	Airflow / OFDA / Laserscan
15.0	0.3 / 0.3 / 0.2	0.5 / 0.4 / 0.3
20.0	0.5 / 0.4 / 0.4	0.6 / 0.4 / 0.4
25.0	0.6 / 0.5 / 0.5	0.8 / 0.6 / 0.5
30.0	0.7 / 0.6 / 0.6	1.0 / 0.7 / 0.7
35.0	0.8 / 0.7 / 0.7	1.1 / 0.9 / 0.9
40.0	0.9 / 0.8 / 0.9	1.3 / 1.0 / 1.1
AVERAGE YELLOWNESS (units)	1.5	2.1
STAPLE LENGTH (mm)	Fleece / Non-Fleece	Fleece / Non-Fleece
	5 / 5	7 / 8
STAPLE STRENGTH (N/kt)	Fleece / Non-Fleece	Fleece / Non-Fleece
	6 / 6	8 / 8

IMPROVING PRECISION

As the cost of conducting tests is determined by the amount of sampling and testing, the final IWTO Method becomes a balance between the desirable level of precision and the cost of achieving it.

Some improvement in precision can be expected from better instrumentation and process control, but this will be a minor influence.

As the amount of testing on a lot has a direct relationship with precision, the simplest approach available to improve precision for commercial trading is to do additional sampling and testing. This may involve testing extra sub-samples or specimens, but most benefit will come from taking additional samples and testing extra sub-samples and specimens. The balance between increased cost and precision must be noted. Table 2 summarises the position of several strategies.

Table 2 : Strategies to Improve Precision

Strategy to Improve Precision	Approx. Improvement in Precision	Estimated increase in Sampling & Testing Costs
A. Doubling cores/lot	2%	20%
B. Doubling staples/lot	24% (length)	50%
	16% (strength)	50%
C. Duplicate coring or grabbing, testing then combine	29%	100%
D. Split-lot coring or grabbing, testing then combine	29%	100%
E. Triplicate coring or grabbing, testing then combine	42%	200%
F. 3-split-lot coring or grabbing, testing then combine	42%	200%

The greatest improvement is 42% and this is achieved when a lot is sampled and tested 3 times and each of the results combined. Again one must consider the cost versus the benefit. Considering the best precision strategies (42%), and a single lot with say 55% Wool Base; 3% VM Base; 21.0 um Mean Fibre Diameter; 90 mm Staple Length; and 30 N/kt Staple Strength, the improvement in precision would be:

Wool Base	from	± 1.5%	to	± 0.9%
VM Base	from	± 0.6%	to	± 0.3%
Mean Fibre Diameter	from	± 0.5 um	to	± 0.3 um
Staple Length	from	± 5 mm	to	± 3 mm
Staple Strength	from	± 6 N/kt	to	± 3 N/kt

At the time methods are developed and introduced, the adequacy of the precision is considered taking due regard to the cost and speed of service required.

From an exporter's point of view, once lots are purchased and combined, they achieve a very precise set of results for processing consignments. Multiple-lot consignments have a significant improvement in precision when compared with a single test on the same consignment. Table 3 illustrates the effect of combination on the precision of results. It can be clearly seen that as the number of lots in a consignment increases, so does the precision of the result obtained.

Generally, both precision and accuracy are single lot problems and as such have potentially the greatest effect on the woolgrower who traditionally sells single lots. Major concern centres on fine wools where 0.1 um can make a substantial difference to the price paid or received. AWTA Ltd recognises that some growers may require results of higher precision and offers a multiple-sampling and testing service. However, generally growers do not have one test conducted in isolation but have their entire clip tested. The multiple lot testing ensures that, on average, the clip will have an improved precision compared to the individual lots.

The question of whether to split a lot prior to sampling and testing is of interest. There is no additional improvement in precision from splitting a lot prior to sampling and testing and testing each lot independently when compared with double sampling and testing the entire lot as one test. Both processes achieve an increase in precision of 29%. However, logistically it is easier to sample split lots, and it does offer opportunities to build sub-lots into Objectively Matched Lots or to sell the sub-lot in its own right if it slots into a currently favourable section of the market.

For the exporter who prepares blends and relies on a single test after blending, the risk to achieve the specification is greater. In these situations, small blended sub-lots should be sampled and tested individually, and then combined. In this way the improvement in precision identified in Table 3 can be obtained.

Table 3 : The Effect of Combination on the Precision of Test Results (95% C.L.)

No. of Lots in Consignment	Wool Base (%)	VM Base (%)	Mean Fibre Diameter (µm)	Staple Length (mm)	StapleStrength (N/kt)
1	± 1.5	± 0.6	± 0.5	± 5	± 6
20	± 0.3	± 0.1	± 0.1	± 1	± 1
50	± 0.2	± 0.08	± 0.07	± 0.7	± 0.8
75	± 0.17	± 0.07	± 0.06	± 0.6	± 0.7

CHECK TESTS AND RETESTS

When test results are questioned by the trade, AWTA Ltd has a policy to conduct check tests and retests. The procedures are well defined in the IWTO Regulations.

Because of the inherent variation, a check test will normally give a slightly different answer to the original test even if no "error" exists. Provided it falls within a statistically based Maximum Retest Range, defined by IWTO, the original and check test data are combined and reissued. No error has occurred in this situation. When a check test or retest exceeds the Maximum Retest Range, an error is acknowledged. This may be obvious, or resolved with additional sampling and/or testing. A new result without the original data is issued.

For information, the IWTO Maximum Retest Ranges for Wool Base, VM Base, Mean Fibre Diameter, Colour, Staple Length and Staple Strength are shown in Column B of Table 1.

The key rule for retests, check tests or recore check tests is that if the extra data is compatible, ie. the difference falls within the Maximum Retest Range, then the additional data are combined with the original data and becomes the new result. If the data exceeds the Maximum Retest Range, ie. an error has deemed to have occurred, then the original result is withdrawn and the new data issued as the result.

While attention often focuses on individual errors, only 0.2% of AWTA Ltd Certificate results are requested to be checked by the trade. Only 0.02% of all Certificate results are found to be in error.

PREDICTING PROCESSING PERFORMANCE

Wool traders must take care in expecting the certified results on greasy wool to exactly replicate the certified results on the semi-processed or processed wool. Objective measurements are used to predict the processing performance, but the effect of the components of variance discussed above also apply to tests on the semi-processed and processed wool. The issue becomes more complex, as some allowance needs to be made by the trader for processing conditions. The process, the mill and the wool type can impact on the result of the semi-processed or processed result when compared to the greasy wool result. Here, the skill and experience of the trader in understanding the technical limitations of the IWTO Test Methods and the processing effect of particular wools and processors is paramount.

REFERENCES

1. *D J Ward, 1981* — *The Developing Conflict between Trading Requirements and the Technical Limitations of IWTO Test Methods.*
2. *AWTA Ltd, 1988* — *The Potential to Improve Wool Testing Precision.*
3. *AWTA Ltd, 1989* — *The Potential to Improve Wool Testing Precision, Part-2: Staple Length, Staple Strength and Average Yellowness.*

AUSTRALIAN WOOL TESTING AUTHORITY LTD

A.C.N. 006 014 106

HEAD OFFICE/ REGISTERED OFFICE:
70 Robertson Street, Kensington, Victoria 3031
PO Box 240, North Melbourne, Victoria 3051
Tel: (03) 9371 4100 Fax: (03) 9371 4190

MELBOURNE LABORATORY:
24 Robertson Street, Kensington, Victoria 3031
PO Box 240, North Melbourne, Victoria 3051
Tel: (03) 9371 2100 Fax: (03) 9371 2190

SYDNEY LABORATORY:
Cnr Byron & Military Roads, Guildford, NSW 2161
PO Box 190, Guildford, NSW 2161
Tel: (02) 9681 1200 Fax: (02) 9632 4035

FREMANTLE LABORATORY:
176 Marine Terrace, South Fremantle, WA 6162
PO Box 446, Fremantle, WA 6959
Tel: (08) 9335 5011 Fax: (08) 9335 8248

TEXTILE TESTING DIVISION:
26 Robertson Street, Kensington, Victoria 3031
PO Box 240, North Melbourne, Victoria 3051
Tel: (03) 9371 2126 Fax: (03) 9371 2102

ADELAIDE OFFICE:
Cnr Ocean Steamers Road & Santo Parade,
Port Adelaide, SA 5015
PO Box 194, Port Adelaide, SA 5015
Tel: (08) 84474633 Fax: (03) 8341 1152

BRANCHES:

Albany	(08) 9841 2177
Brisbane	(07) 3277 0866
Geelong	(03) 5229 2704
Goulburn	(02) 4821 8139
Launceston	(03) 6344 8833
Newcastle	(02) 4961 1197
Portland	(03) 5523 2986

Email: awtainfo@awta.com.au
Website: www.awta.com.au