CONTRACTS & SPECIFICATIONS COMMITTEE — CAPE TOWN CONGRESS

Product Group — **April 2014**

Chairman: Prof. C. Popescu (Germany) — **Report No: PG 01**

Wool ComfortMeter Round Trial

By

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SUMMARY

The present report has been prepared to determine the precision of the Wool ComfortMeter (WCM) based on 4 passes of the measurement head across a fabric surface. Previous reports on the WCM have been based on 10 passes. The request to reduce the test time and therefore cost came from the initial commercial users of the instrument.

The experiments conducted highlighted differences between the laboratories, operators and between samples. The 95% Confidence Limit of a test result was found to vary with the measured WCM value. However, the dependence was not significant due to large between laboratory variance.

The average 95% confidence limit for the WCM test is ± 153 units. There was evidence of bias observed in two laboratories Lab D and Lab E.

The operator effects were considered to be small at this stage as the operators were only involved with placing the fabric samples on the machine platform and running the experiments. All the samples used in different laboratories were prepared by an individual operator in one laboratory and were sent to the participants laboratories.

While the between sub-sample variance was significant the effect on the precision for more than five (5) sub-samples was realtively small. This result supports the recommendation in the proposed Draft Test method to measure five (5) sub-samples.

INTRODUCTION

The present report has been prepared to determine the precision of the Wool ComfortMeter (WCM) based on 4 passes of the measurement head across a fabric surface. Previous reports on the WCM have been based on 10 passes.

The potential to reduce the number of passes of the scanning head was investigated previously by analysing data from individual traverses of the head. It was shown that the number of passes could be reduced from 10 to 4 passes with minimal loss of precision [1]. Feedback from industry trials of the instrument had suggested a reduction in testing time, and therefore cost, would be considered an advantage. Estimates of the precision of the Wool ComfortMeter based on 10 passes, in accordance with earlier test procedures, have been reported previously [2-5]. This current trial has used samples from the same fabrics used in the earlier studies. However this trial design was changed to conform to IWTO requirements.

MATERIALS AND METHODS

Experimental Design

Experiments were carried out in 5 Laboratories; (Lab A, Lab B, Lab C, Lab D and Lab E). One set (5 subsamples) of 10 fabrics were allocated to each laboratory [4] and were tested by two individual operators. No attempt was made in the experiments to have all the operators measure all the fabrics on all the instruments:

"5 laboratories (a=5) × 10 fabrics × 2 operators (b=2) × 1 set of fabric samples (each with 5 subsamples, n=5)"

Statistical analyses

The data was analysed to determine the testing precision for each parameter. The variance components of each parameter, i.e. between laboratories, between operators and between subsamples, were calculated using ANOVA calculations described in Table 1 for each of the fabrics. The within laboratory variance is the sum of the variances between operators and between subsamples. All ANOVA calculations were done in SPSS 21.

Table 1. A General ANOVA table for WCM value

Source of variation	Degrees of Freedom	Mean Squares	Expected Mean Squares
Between Labs	a-1=4	$SS_{between\ labs}/4$	$\sigma^2+n\sigma^2_{operators}+(nb)\sigma^2_{labs}$
Between Operators	a(b-1)=5	$SS_{between\ operators}/5$	$\sigma^2+n\sigma^2_{operators}$
Between Subsamples	ab(n-1)=40	$SS_{between\ subsamples}/40$	σ^2
Total	49		

Where: σ^2 is the between-subsamples component of variance;

σ^2_{labs} is the between-laboratories component of variance;

$\sigma^2_{operators}$ is the between-operators component of variance;

SS is the Sum of squares

Based on the above table, the following variance components of each parameter were extracted for each fabric.

The 95% confidence limit (CL) was estimated using the Equation 1;

$$95\%CL = 1.96 * \sqrt{\frac{\sigma_L^2}{N_L} + \frac{\sigma_o^2}{N_o} + \frac{\sigma_{sub}^2}{N_{sub}}} \qquad \text{Equ.1}$$

Where: σ_L^2 is the between laboratory variance,

σ_o^2 is the between operators variance,

σ_{sub}^2 is the between subsamples variance,

N_L is the number of labs,

N_o is the number of operators and

N_{sub} is the number of subsamples.

RESULTS AND DISCUSSION

Estimates of variance components and testing precision

The mean, standard deviation (S.D) and the range in the Wool ComfortMeter values of the fabrics tested are listed in Table 2. Table 3 shows the overall between laboratory differences from the average of WCM value.

Table 2. Mean and range in WCM values of fabrics tested in the round trial in each laboratory and in total

Laboratory	N	WCM value	S.D.	Minimum	Maximum
Lab A	100	709.5	48.8	72.4	1626.5
Lab B	100	701.7	49.5	112.7	1648.9
Lab C	100	669.7	45.9	42.3	1464.0
Lab D	100	636.9	46.4	88.7	1578.3
Lab E	100	720.5	56.1	7.2	1740.8
	500	**687.6**	**22.1**	**7.2**	**1740.8**

Table 3. Laboratories differences from average WCM value (a=5)

		Average WCM						Differences from Average				
No.	Fabric Deakin ID	Lab A	Lab B	Lab C	Lab D	Lab E	Grand Mean	Lab A	Lab B	Lab C	Lab D	Lab E
1	100420	917	934	905	923	937	923	-6	10	-18	0	14
2	100424	991	949	1026	1079	1050	1019	-28	-70	7	60	31
3	100608	415	333	358	233	357	339	76	-6	19	-106	18
4	100609	661	559	667	431	704	605	57	-45	62	-173	99
5	100610	584	478	506	363	602	506	77	-29	-1	-143	95
6	100613	1539	1504	1362	1382	1579	1473	66	31	-111	-92	106
7	110512	103	135	73	113	33	91	12	43	-19	22	-58
8	110514	192	227	155	178	133	177	15	50	-22	1	-44
9	120301	235	325	272	368	143	269	-33	56	3	99	-125
10	120408	1456	1573	1374	1298	1666	1473	-17	100	-100	-176	193
	Average	709	702	670	637	720	688	22	14	-18	-51	33

The overall average was 688 units with the average laboratory differences 22, 14, -18, -51 and 33 respectively for Laboratory A to Laboratory E.

The individual laboratory fabric average of WCM results ranged from 91 to 1473, a range of 1382.

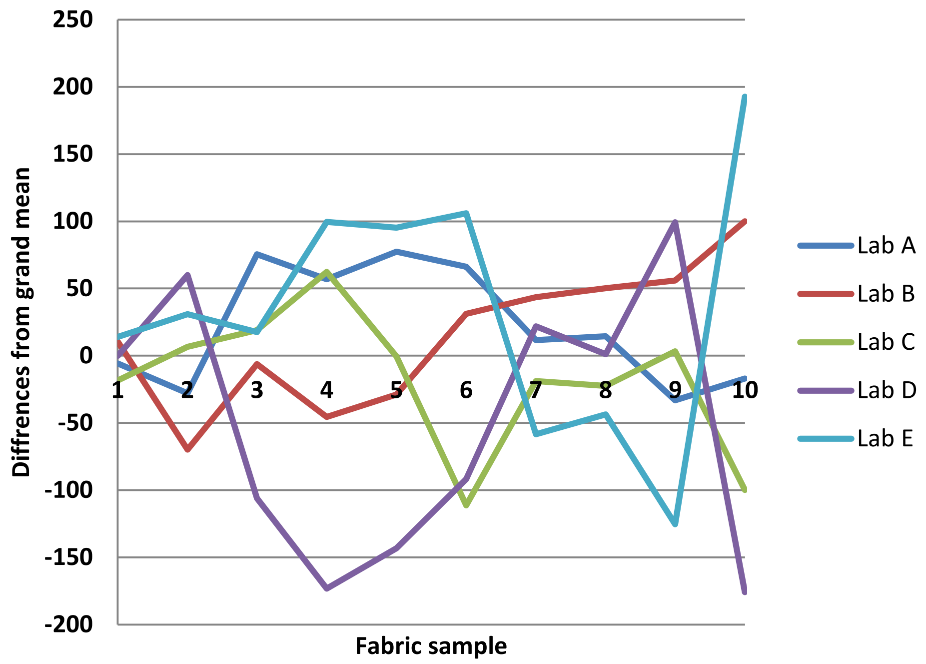

Figure 1: Between laboratory differences in WCM values by fabric

Table 4 shows the ANOVA (Analysis of Variance) result for WCM value. The within lab and between lab variance is very variable between samples. The 95% confidence limit was calculated for each fabric using a single lab (i.e. $N_L = 1$), a single operator ($N_o = 1$) and five subsamples ($N_{sub} = 5$). Two fabrics stand out with 95% CL values over 200. These are fabric 100609, (with a mean WCM value of 604), and fabric 120408, (with a mean WCM value of 1473).

Table 4. Summary of analysis of variance for WCM value

Fabric Deakin ID	Mean Result	Within-Lab Mean Square (MSW)	Between Lab Mean Square (MSB)	Within-Lab Variance	Between Lab Variance	95% Confidence Limit
100420	923	8797.1	1681.2	4554.4	0*	59.2
100424	1019	8277.5	25696.2	3353.7	2024.9	109.4
100608	339	4622.5	44204.4	1879.4	4117.3	134.7
100609	604	4078.5	122709.6	2775.5	12140.7	220.8
100610	506	3210.9	90983.2	1345.1	8894.4	189.0
100613	1473	9091.9	93413.2	5668.6	8999	197.3
110512	91	894.1	15632.8	330.9	1499.2	79.1
110514	177	1576.4	12875.8	621.7	1181	73.2
120301	269	4143.2	74532.4	2295.5	7268.5	172.3
120408	1473	9044.9	220764.7	4600.1	21632	294.3
Mean	**687**	**5373.7**	**70249.4**	**2742.5**	**6775.7**	**152.9**

* not significant at the 0.05 level.

The relationship between the estimated 95% confidence limit and WCM value has been graphed in Figure 2. The level of dependency was not significant between WCM value and 95% CL (*P*-value = 0.12) because of the large between laboratory variance. Theory suggests that the Confidence Interval should be level dependent as the residual is significantly level dependent. Therefore we have included a table of precision estimates in the Draft test method based on this Round Trial.

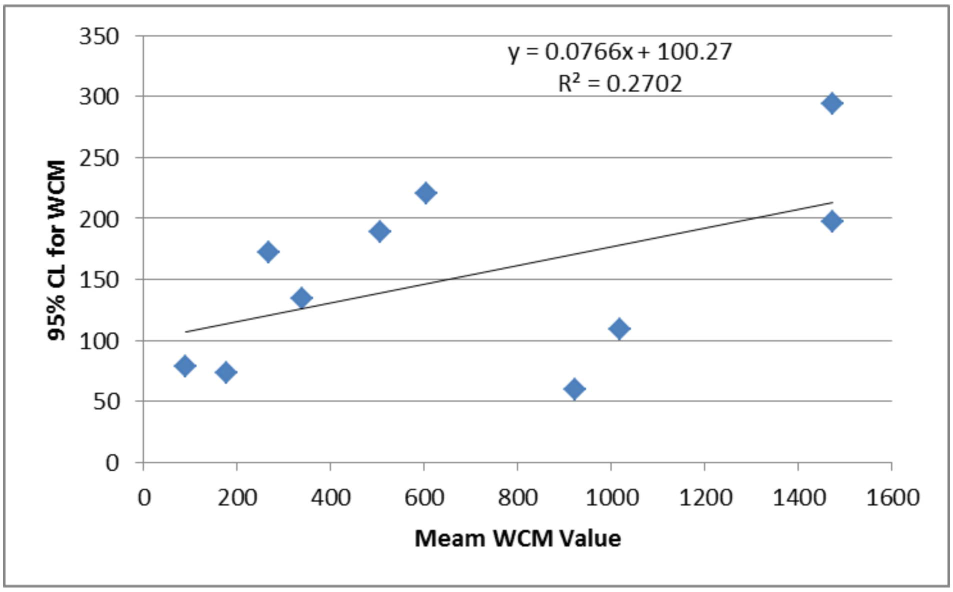

Figure 2. The relationship between the estimated 95% confidence limit and WCM value (y = 0.08x + 100.3, R^2=0.27)

Operator Effect

The effect on the precision estimates when the number of operators used is changed was calculated based on Equ.1, when the applicable N value was changed to a nominal value (N_O=1, 2, 3,…). The results have been summarised in Table 5 for up to five operators. Increasing the number of operators has no significant effect on the precision of all WCM values (P-value= 1).

Table 5. Effect on the precision of changing the number of operators (1 – 5)

	Number of operator				
Fabric	1	2	3	4	5
100420	59.2	59.2	59.2	59.2	59.2
100424	109.4	104.7	103.1	102.3	101.8
100608	134.7	132.6	131.9	131.6	131.4
100609	220.8	220.8	220.8	220.8	220.8
100610	189.0	188.2	187.9	187.7	187.6
100613	197.3	197.3	197.3	197.3	197.3
110512	79.1	78.1	77.8	77.6	77.5
110514	73.2	71.7	71.2	71.0	70.8
120301	172.3	172.3	172.3	172.3	172.3
120408	294.3	294.3	294.3	294.3	294.3
Average	**152.9**	**151.9**	**151.6**	**151.4**	**151.3**

Subsample Effect

The effect on the precision estimates of increasing the number of subsamples is calculated in Table 6. Increasing the number of subsamples above the recommended number of 5 subsamples did not have a significant effect on the precision of the WCM value (*P*-value=0.98).

Table 6. Effect on the precision of changing the number of subsamples taken (1-7)

	Number of subsample						
Fabric	1	2	3	4	5	6	7
100420	132.3	93.5	76.4	66.1	59.2	54.0	50.0
100424	143.7	123.4	115.8	111.8	109.4	107.7	106.5
100608	151.8	141.4	137.7	135.8	134.7	133.9	133.4
100609	239.4	228.0	224.0	222.0	220.8	220.0	219.5
100610	198.3	192.6	190.6	189.6	189.0	188.6	188.4
100613	237.4	213.2	204.5	200.0	197.3	195.4	194.1
110512	83.8	80.9	79.9	79.4	79.1	78.9	78.7
110514	83.2	77.1	74.9	73.9	73.2	72.7	72.4
120301	191.7	179.8	175.7	173.6	172.3	171.4	170.8
120408	317.4	303.2	298.3	295.8	294.3	293.3	292.6
Average	**177.9**	**163.3**	**157.8**	**154.8**	**152.9**	**151.6**	**150.6**

CONCLUSION

The experiments conducted highlighted differences between the laboratories, operators and between samples. The 95% Confidence Limit of a test result was found to vary with the measured WCM value. However, the dependence was not significant.

The average 95% confidence limit for the WCM test is ± 153 units. There was evidence of bias observed in two laboratories Lab D and Lab E.

The operator effects were considered to be small at this stage as the operators were only involved with placing the fabric samples on the machine platform and running the experiments. All the samples used in different laboratories were prepared by an individual operator in one laboratory and were sent to the participants laboratories.

While the between sub-sample variance was significant the effect on the precision for more than five (5) sub-samples was relatively small. This result supports the recommendation in the proposed Draft Test method to measure five (5) sub-samples.

REFERENCES

1. Number of required passes of scanning head to predict WCM value, Internal Sheep CRC report. M. Naebe, July 2013.
2. IWTO-0 (2009) Appendix D Statistical Methods. International Wool Textile Organisation.
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