Appendix A: Test Data

ADL Fabric Cycle Life Testing

Wash	g	RMC	Load Wt.	Bone Dry Wt.
1	100	45.7%	8.4 lb.	3788
2	200	37.3%	8.4 lb.	3786
3	300	32.3%	8.4 lb.	3779
4	500	27.3%	8.4 lb.	3770
5	100	47.0%	8.4 lb.	3769
6	---	---	---	3776
7	---	---	---	3774
8	---	---	---	3764
9	100	52.9%	3.0	3773
10	100	49.4%	5.7	3765
11	100	46.6%	8.4	3762
12	---	---	---	3771
13	---	---	---	3767
14	---	---	---	3757
15	300	35.5%	3.0	3755
16	300	37.7%	5.7	3769
17	300	31.5%	8.4	3751
18	300	35.5%	3.0	3749
19	---	---	---	3740
20	---	---	---	3745
21	100	45.8%	8.4 lb.	3744
22	200	36.9%	8.4 lb.	3737
23	300	31.7%	8.4 lb.	3736
24	500	26.6%	8.4 lb.	3743
25	100	46.7%	8.4 lb.	3747
26	500	---	---	3729
27	300	33.5%	5.7	3739
28	---	---	---	3730
29	---	---	---	3731
30	---	---	---	3731
31	---	---	---	3728
32	100	47.0%	8.4 lb.	3732
33	100	46.9%	8.4 lb.	3732
34	---	---	---	3722
35	---	---	---	3715
36	---	---	---	3725
37	---	---	---	3723
38	---	---	---	3727
39	100	46.9%	8.4 lb.	3723
40	100	48.0%	8.4 lb.	3714
41	---	---	---	3706
42	---	---	---	3713
43	---	---	---	3709
44	---	---	---	3714
45	---	---	---	3706
46	100	47.4%	8.4 lb.	3713
47	100	46.9%	8.4 lb.	3702

Table 1. Life Cycle Shrinkage

Lot 4	Unwashed			Set 1			Set 2			Set 3		
	1	2	3	1	2	3	1	2	3	1	2	3
H1	34.19	34.19	34.13	32.50	32.25	32.50	32.50	32.25	32.25	32.75	32.50	32.50
H2	34.31	34.13	34.25	32.75	32.50	32.63	32.75	32.50	32.75	32.75	32.50	32.75
H3	34.00	33.88	34.25	32.25	32.25	32.50	32.38	32.25	32.75	32.50	32.00	32.50
V1	22.25	22.38	22.19	20.75	20.50	20.50	20.75	20.75	20.75	20.75	20.63	20.75
V2	22.50	22.38	22.50	21.13	20.88	21.00	21.00	20.88	21.00	21.13	20.88	21.00
V3	22.31	22.25	22.38	20.50	20.63	20.75	21.88	20.50	20.88	20.63	20.63	20.75
			Max Shrinkage	**8.1%**	**8.4%**	**7.6%**	**6.7%**	**7.9%**	**6.7%**	**7.6%**	**7.8%**	**7.3%**
			Average Shrinkage	**5.9%**	**6.3%**	**6.0%**	**4.9%**	**6.2%**	**5.7%**	**5.6%**	**6.2%**	**5.8%**

Lot 5	Unwashed			Set 1			Set 2			Set 3		
	1	2	3	1	2	3	1	2	3	1	2	3
H1	33.75	34.06	33.75	31.75	31.50	31.25	31.50	31.50	31.50	31.38	31.50	31.50
H2	33.88	33.94	34.00	31.75	31.88	31.63	31.75	31.88	31.75	31.63	31.75	31.75
H3	34.00	33.75	34.13	31.62	31.50	31.75	31.75	31.75	31.50	31.50	31.75	31.50
V1	21.88	22.13	21.75	20.50	20.25	20.38	20.25	20.38	20.50	20.25	20.38	20.63
V2	22.25	22.00	22.13	20.50	20.63	20.63	20.50	20.63	20.50	20.38	20.50	20.50
V3	21.88	22.00	22.25	20.38	20.50	20.25	20.50	20.50	20.50	20.13	20.50	20.38
			Max Shrinkage	**7.9%**	**8.5%**	**9.0%**	**7.9%**	**7.9%**	**7.9%**	**8.4%**	**7.9%**	**8.4%**
			Average Shrinkage	**6.7%**	**7.0%**	**7.2%**	**6.9%**	**6.8%**	**7.0%**	**7.5%**	**6.9%**	**7.0%**

Lot 4	Unwashed			Set 4			Set 5			Set 6		
	1	2	3	1	2	3	1	2	3	1	2	3
H1	34.19	34.19	34.13	32.50	32.25	32.50	32.50	32.25	32.38	32.50	32.25	32.50
H2	34.31	34.13	34.25	32.50	32.25	32.75	32.63	32.38	32.75	32.63	32.50	32.63
H3	34.00	33.88	34.25	32.25	32.38	32.50	32.13	32.25	32.50	32.38	32.25	32.75
V1	22.25	22.38	22.19	20.75	20.75	20.75	20.63	20.50	20.63	20.75	20.50	20.63
V2	22.50	22.38	22.50	21.00	20.75	20.88	21.00	20.75	21.00	21.00	21.00	21.00
V3	22.31	22.25	22.38	20.75	20.25	20.88	20.50	20.75	20.88	20.88	20.75	20.75
			Max Shrinkage	**7.0%**	**9.0%**	**7.2%**	**8.1%**	**8.4%**	**7.0%**	**6.7%**	**8.4%**	**7.3%**
			Average Shrinkage	**6.0%**	**6.5%**	**5.8%**	**6.2%**	**6.3%**	**5.8%**	**5.7%**	**6.1%**	**5.8%**

Lot 5	Unwashed			Set 4			Set 5			Set 6		
	1	2	3	1	2	3	1	2	3	1	2	3
H1	33.75	34.06	33.75	31.50	31.38	31.25	31.75	31.38	31.25	31.63	31.50	31.50
H2	33.88	33.94	34.00	31.50	31.75	31.63	31.50	31.75	31.63	31.50	31.75	31.50
H3	34.00	33.75	34.13	31.50	31.75	31.75	31.50	31.75	31.75	31.50	31.75	31.75
V1	21.88	22.13	21.75	20.50	20.38	20.38	20.50	20.38	20.38	20.50	20.38	20.25
V2	22.25	22.00	22.13	20.50	20.50	20.63	20.50	20.50	20.63	20.38	20.50	20.50
V3	21.88	22.00	22.25	20.50	20.75	20.38	20.50	20.75	20.38	20.38	20.63	20.38
			Max Shrinkage	**7.9%**	**7.9%**	**8.4%**	**7.9%**	**7.9%**	**8.4%**	**8.4%**	**7.9%**	**8.4%**
			Average Shrinkage	**6.9%**	**6.8%**	**7.1%**	**6.8%**	**6.8%**	**7.1%**	**7.0%**	**6.8%**	**7.3%**

Table 2. Horizontal Axis Preconditioning Shrinkage

Lot 4

	Unwashed			Wash 1			Wash 2		
	1	2	3	1	2	3	1	2	3
H1	34.25	34.25	34.25	33.13	33.25	33.25	32.88	32.88	32.88
H2	34.25	34.13	34.25	33.00	33.00	33.38	32.88	32.63	33.00
H3	34.25	34.00	34.13	33.00	32.88	33.38	32.75	32.63	32.88
V1	22.25	22.25	22.25	21.75	21.88	21.38	21.63	21.50	21.38
V2	22.38	22.25	22.38	21.88	21.75	21.75	21.63	21.50	21.50
V3	22.38	22.13	22.25	21.75	21.63	21.75	21.50	21.25	21.50
		Max Shrinkage		**3.6%**	**3.3%**	**3.9%**	**4.4%**	**4.4%**	**4.0%**
		Average Shrinkage		**3.0%**	**2.6%**	**2.8%**	**3.7%**	**3.9%**	**3.8%**

Lot 5

	Unwashed			Wash 1			Wash 2		
	1	2	3	1	2	3	1	2	3
H1	34.00	33.88	33.75	32.38	33.13	32.25	32.50	32.75	32.88
H2	33.75	33.88	33.75	32.25	33.13	32.25	32.25	32.88	32.88
H3	33.75	34.00	33.75	32.50	33.00	32.38	32.13	32.75	32.75
V1	21.88	21.88	22.00	21.25	20.88	21.38	21.13	20.75	21.63
V2	21.75	21.63	22.00	21.25	20.75	21.25	21.00	20.50	21.63
V3	21.75	21.75	22.00	21.13	20.75	21.25	21.00	20.63	21.50
		Max Shrinkage		**4.8%**	**4.6%**	**4.4%**	**4.8%**	**5.2%**	**3.0%**
		Average Shrinkage		**3.5%**	**3.4%**	**3.8%**	**4.0%**	**4.2%**	**2.3%**

Lot 4

	Wash 3			Wash 4			Wash 5		
	1	2	3	1	2	3	1	2	3
H1	32.75	32.75	32.88	32.63	32.75	32.75	32.75	32.63	32.75
H2	32.75	32.63	32.75	32.63	32.50	32.75	32.63	32.38	32.75
H3	32.75	32.50	32.75	32.50	32.50	32.75	32.75	32.38	32.75
V1	21.38	21.38	21.25	21.25	21.25	21.00	21.13	21.13	21.13
V2	21.63	21.38	21.38	21.38	21.25	21.25	21.25	21.25	21.25
V3	21.25	21.13	21.25	21.25	21.00	21.13	21.25	21.00	21.25
	5.0%	**4.5%**	**4.5%**	**5.1%**	**5.1%**	**5.6%**	**5.1%**	**5.1%**	**5.1%**
	4.2%	**4.3%**	**4.3%**	**4.8%**	**4.6%**	**4.7%**	**4.8%**	**4.9%**	**4.6%**

Lot 5

	Wash 3			Wash 4			Wash 5		
	1	2	3	1	2	3	1	2	3
H1	32.50	32.88	32.13	32.25	32.50	32.13	32.13	32.63	32.13
H2	32.13	32.75	32.13	32.00	32.50	32.13	32.13	32.63	32.00
H3	32.13	32.75	32.13	32.25	32.50	32.25	32.13	32.50	31.88
V1	21.13	20.75	21.13	21.13	20.63	21.13	21.13	20.88	21.00
V2	21.00	20.50	21.25	21.00	20.50	21.13	20.88	20.50	21.13
V3	21.00	20.50	21.00	20.88	20.50	21.00	20.88	20.50	20.88
	4.8%	**5.7%**	**4.8%**	**5.2%**	**5.7%**	**4.8%**	**5.5%**	**5.7%**	**5.6%**
	4.1%	**4.3%**	**4.4%**	**4.3%**	**4.9%**	**4.4%**	**4.4%**	**4.6%**	**4.9%**

Table 3. Vertical Axis Preconditioning Shrinkage

Lot 4

	Unwashed			Wash 1			Wash 2		
	1	2	3	1	2	3	1	2	3
H1	34.19	34.19	34.13	33.00	33.00	33.00	33.13	33.00	33.00
H2	34.31	34.13	34.25	33.13	33.00	33.25	33.13	33.00	33.13
H3	34.00	33.88	34.25	32.88	32.75	33.13	32.75	32.88	33.00
V1	22.25	22.38	22.19	21.50	21.68	21.38	21.50	21.38	21.38
V2	22.50	22.38	22.50	22.00	21.75	21.88	21.75	21.50	21.75
V3	22.31	22.25	22.38	21.25	21.38	21.63	21.38	21.25	21.50
			Max Shrinkage	**4.8%**	**3.9%**	**3.7%**	**4.2%**	**4.5%**	**3.9%**
			Average Shrinkage	**3.4%**	**3.3%**	**3.2%**	**3.5%**	**3.8%**	**3.5%**

Lot 5

	Unwashed			Wash 1			Wash 2		
	1	2	3	1	2	3	1	2	3
H1	33.75	34.06	33.75	32.75	32.63	33.00	32.50	32.75	32.50
H2	33.88	33.94	34.00	32.88	32.88	32.88	32.63	32.63	32.75
H3	34.00	33.75	34.13	32.75	32.75	32.63	32.50	32.44	32.63
V1	21.88	22.13	21.75	20.75	20.63	20.88	20.63	20.75	20.63
V2	22.25	22.00	22.13	20.88	20.75	20.63	20.63	20.75	20.63
V3	21.88	22.00	22.25	20.75	21.00	20.88	20.50	20.75	21.00
			Max Shrinkage	**6.2%**	**6.8%**	**6.8%**	**7.3%**	**6.2%**	**6.8%**
			Average Shrinkage	**4.3%**	**4.6%**	**4.5%**	**5.2%**	**4.9%**	**4.9%**

Lot 4

	Wash 3			Wash 4			Wash 5		
	1	2	3	1	2	3	1	2	3
H1	32.75	32.75	32.88	32.75	32.88	32.88	32.75	32.75	32.88
H2	33.00	32.88	33.00	32.88	33.00	33.00	33.00	33.00	33.00
H3	32.75	32.50	32.88	32.50	32.75	33.00	32.75	32.63	33.00
V1	21.25	21.25	21.25	21.25	21.38	21.13	21.25	21.25	21.13
V2	21.50	21.50	21.50	21.50	21.50	21.38	21.50	21.38	21.50
V3	21.00	21.00	21.25	21.13	21.00	21.25	21.13	21.00	21.25
	5.9%	**5.6%**	**5.0%**	**5.3%**	**5.6%**	**5.0%**	**5.3%**	**5.6%**	**5.0%**
	4.4%	**4.4%**	**4.2%**	**4.5%**	**4.1%**	**4.3%**	**4.3%**	**4.4%**	**4.2%**

Lot 5

	Wash 3			Wash 4			Wash 5		
	1	2	3	1	2	3	1	2	3
H1	32.00	32.13	32.50	32.00	32.13	32.13	32.00	32.50	32.13
H2	32.38	32.50	32.50	32.38	32.50	32.25	32.25	32.38	32.38
H3	32.50	32.38	32.25	32.38	32.50	32.13	32.38	32.13	32.50
V1	20.50	20.50	20.63	20.50	20.63	20.63	20.50	20.75	20.38
V2	20.75	20.75	20.50	20.75	20.75	20.63	20.63	20.75	20.50
V3	20.63	20.88	20.75	20.50	21.00	20.56	20.63	20.75	20.88
	6.7%	**7.3%**	**7.3%**	**6.7%**	**6.8%**	**7.6%**	**7.3%**	**6.2%**	**7.3%**
	5.5%	**5.4%**	**5.5%**	**5.6%**	**5.1%**	**5.9%**	**5.7%**	**5.3%**	**5.7%**

Appendix B: Summary of Extractor Based Test Data

Table 4. ADL Extractor Test Results (September-December, 1999)

RMC Testing w/ Original Extractor (20 minute warm soak, 10 minute spin)

g	TI1A	CG1A	TI1B	CG1B	ASG	TI1920DC	Washed TIDC	Stripped ASG	TI2A	CG2A	TIDCstripped	ADL Scotchgard
weight	4.7 lb.	4.7 lb.	4.7 lb.	4.7 lb.	4.7 lb.	4.7 lb.	4.7 lb.	4.7 lb.	4.7 lb.	4.7 lb.	4.7 lb.	4.7 lb.
100	52.6%	65.3%	52.9%	65.8%	44.5%	44.6%	53.9%	45.5%	53.3%	68.2%	52.2%	37.2%
300	36.5%	41.1%	34.5%	40.2%	27.9%	30.5%	34.2%	29.4%	34.7%	41.5%	34.2%	26.0%
500	29.5%	33.4%	30.1%	33.2%	23.6%	27.3%	29.2%	24.2%	30.0%	32.5%	30.1%	22.8%

Spin Time Testing (20 Min Warm soak)

Time	TI1-5.7B	TI1A*	A	TI2	TI1	TI1	TI2
g	115 g					300 g	
weight	5.7 lb.	4.7 lb.	8.4 lb.	8.4 lb.	8.4 lb.	8.4 lb.	8.4 lb.
2	55.5%	57.9%	47.9%	53.3%	53.7%	39.6%	38.5%
4	53.4%	55.7%	43.5%	49.9%	51.0%	35.8%	35.0%
6	51.3%	52.8%	41.1%	48.3%	49.3%	34.5%	33.2%
10	48.4%	52.1%	39.1%	45.8%	47.4%	33.4%	32.0%
15	47.3%	50.9%	37.2%	45.9%	45.1%	32.1%	30.9%
20	47.7%	50.2%	36.2%	44.8%	45.6%	31.5%	30.2%
25	48.0%	52.3%	36.1%	45.7%	46.3%	31.3%	30.6%

*Original Extractor

Shrink Factor (TI lot 2)

	Vertical	Horizontal
As received	33.88	22.00
Pre-washed	32.75	21.00
After 45 washes	32.00	20.31

Soak Time Testing (10 minute spin)

time	TI 1 Warm*	TI 1 Cold*	TI 1 Warm*	TI 1 Cold*	TI 1 Cold*
	115 g		300 g		
weight	4.7 lb.	4.7 lb.	4.7 lb.	4.7 lb.	4.7 lb.
10	51.8%	55.9%	34.7%	36.8%	37.0%
20	51.1%	57.1%	34.8%	34.5%	
60	52.0%	55.2%	34.4%	36.0%	36.5%
120	56.1%	56.2%			36.2%
16 Hours	55.7%	56.2%	34.9%		36.7%
	(washer)	(washer)	(tub)	(washer)	(tub)

RMC Testing with 4 minute spin (20 minute warm soak)

g	TI1	TI2	TI3
weight	8.4 lb.	8.4 lb.	8.4 lb.
50	55.7%	54.8%	55.8%
100	50.8%	50.8%	50.7%
200	40.9%	40.4%	41.1%
300	35.7%	34.6%	35.6%
500	30.0%	29.1%	29.8%

RMC Testing w/ Bock Extractor (20 minute soak, 15 minute spin)

g	TI1 Warm	TI2 Warm	CG Warm
weight	8.4 lb.	8.4 lb.	8.4 lb.
100	46.5%	44.4%	57.2%
100	46.1%	45.0%	
200	37.4%	36.2%	44.2%
200	37.3%	35.9%	
300	33.1%	31.2%	36.9%
300	31.4%	31.3%	
500	27.1%	26.2%	29.3%
800	22.6%	23.2%	25.2%

g	TI1 Cold	TI2 Cold	TI1 Warm	TI2 Warm	TI3 Warm	TI3 Cold
Weight	8.4 lb.	8.4 lb.	8.4 lb.	8.4 lb.	8.4 lb.	8.4 lb.
50	52.8%	51.7%	50.6%	50.2%	51.4%	53.3%
100	48.3%	47.6%	46.5%	44.7%	45.9%	49.7%
200	38.2%	37.0%	37.4%	36.1%	36.4%	38.0%
300	33.4%	32.3%	33.1%	31.3%	31.7%	33.1%
500	27.3%	26.7%	27.1%	26.2%	26.7%	27.4%
800	24.1%	23.4%	22.6%	23.2%	23.3%	24.5%

Legend:

Title	Cloth
TI1A TI1B TI1 TI1-5.7B	Textile Innovators Lot 1920
TI2A TI2	Textile Innovators Lot 1967
ASG Stripped ASG A	Alliance (Scotch Guarded)
TI1920DC Washed TIDC TIDC Stripped	Textile Innovators Lot 1920 (Dry Cleaned)
CG1A CG1B	Cotton Goods Lot 1
CG2A	Cotton Goods Lot 2
ADL Scotchguard	Textile Innovators Lot 1920 (Scotch Guarded)

Table 5. ADL Washer Testing

ADL Lot 3

G	Warm Soak (100 F)		Cold Soak (60 F)	
	15 Min Spin	4 Min Spin	15 Min Spin	4 Min Spin
50	51.4%	55.8%	52.2%	59.1%
	49.6%	55.8%	53.3%	58.9%
	50.2%	55.5%	53.1%	58.9%
200	36.4%	41.1%	38.0%	43.5%
	35.7%	40.6%	37.9%	43.0%
	34.9%	39.6%	37.9%	42.8%
350	29.1%	32.1%	30.2%	35.3%
	29.9%	33.6%	30.7%	36.0%
	29.9%	33.5%	31.1%	36.1%

ADL Lot 5

G	Warm Soak (100 F)		Cold Soak (60 F)	
	15 Min Spin	4 Min Spin	15 Min Spin	4 Min Spin
50	54.8%	58.1%	56.4%	61.4%
	55.4%	59.4%	55.4%	61.9%
	53.1%	58.7%	55.8%	62.4%
200	40.1%	44.6%	41.7%	46.6%
	39.5%	44.4%	40.0%	47.6%
	39.1%	43.2%	42.4%	46.3%
350	32.8%	36.6%	35.1%	38.6%
	32.2%	36.4%	33.0%	38.7%
	32.1%	35.2%	33.7%	39.0%

ADL Lot 4

G	Warm Soak (100 F)		Cold Soak (60 F)	
	15 Min Spin	4 Min Spin	15 Min Spin	4 Min Spin
50	56.2%	61.5%	58.8%	64.6%
	57.2%	61.5%	58.0%	64.4%
	57.2%	61.1%	59.8%	63.2%
200	42.2%	46.3%	43.1%	47.9%
	42.6%	45.6%	42.2%	49.0%
	40.5%	45.5%	43.4%	48.5%
350	34.2%	37.5%	35.5%	41.5%
	34.2%	37.8%	35.4%	40.3%
	34.1%	38.5%	35.4%	41.0%

ADL Lot CG

G	Warm Soak (100 F)		Cold Soak	
	15 Min Spin	4 Min Spin	15 Min Spin	4 Min Spin
50	63.4%	70.0%	65.0%	74.6%
	62.4%	70.2%	67.0%	75.6%
	62.9%	70.9%	65.5%	75.7%
200	44.2%	47.9%	44.1%	48.4%
	42.4%	46.5%	43.8%	51.3%
	41.2%	46.2%	43.9%	49.9%
350	33.3%	39.0%	35.2%	39.9%
	31.8%	36.6%	34.5%	41.1%
	31.6%	36.1%	34.5%	39.8%

Washer-Based RMC Testing

Test #	Vertical Axis Machine				Horizontal Axis Machine			
	ADL Lot 3	ADL Lot 4	ADL Lot 5	ADL Lot CG	ADL Lot 3	ADL Lot 4	ADL Lot 5	ADL Lot CG
1	55.4%	62.5%	59.4%	70.8%	47.1%	52.7%	50.2%	60.0%
2	56.0%	62.2%	59.6%	72.8%	48.4%	50.9%	50.1%	59.3%
3	56.1%	61.7%	60.0%	72.1%	48.6%	54.3%	52.0%	60.0%
Average	55.8%	62.1%	59.7%	71.9%	48.0%	52.6%	50.8%	59.8%
Corrected	----	56.3%	56.2%	57.8%	----	47.1%	47.5%	48.7%

Appendix C:
Procedure for Using RMC Correction Factors in Clothes Washer Efficiency Tests

This document outlines a procedure for measuring, specifying, and using a remaining moisture content (RMC) correction factor to improve accuracy and consistency in clothes washer efficiency measurements.

In order to produce reasonably accurate efficiency measurements according to the J1 test procedure for clothes washer efficiency, it is necessary to consistently measure the remaining moisture content in a test load. It has been found to be rather difficult to specify the cloth in such a manner that RMC measurements are consistent for different production runs of test clothes. Different clothes that satisfy the basic specifications on fiber content, weight, and weave may still vary in the RMC measurements by 10% absolute error in the RMC value.

To resolve the inconsistent moisture-retaining properties of the clothes, a specific RMC specification has been formulated for the test cloth. This specification details the RMC values that the cloth should have under a series of water extractor tests, where the cloth is first soaked in water, and then spin-dried in a standard test extractor. The draft RMC specifications of the cloth indicate that the test cloth should attain standard RMC values in the extractor tests within 2% absolute error tolerance.

In practice it is difficult to produce cloth that fits the RMC specification. This can result in test cloth supply delays and increased test cloth costs for test cloth and for testing. To resolve this practical production problem, we propose an RMC correction procedure that can be used with non-standard clothes to predict or estimate standard RMC values in clothes washer efficiency tests. The correction procedure consists of performing RMC measurements on batches of test cloth, and using a linear fit to relate non-standard RMC values to standard RMC values. When the linear fit is calculated, a goodness of fit measure allows an evaluation of whether the non-standard cloth can predict standard RMC values within the 2% required error tolerance.

Below, we describe the procedures for the calculation and use of the RMC correction factors.

Measurement of Cloth RMC Properties

The need for an RMC correction factor and its equation is determined from the measurements of the water retention properties of the test cloth. These measurements are made in a series of water extraction tests. In these tests the test cloth is soaked in water and then spin-dried in a standard specified extractor. At the end of the spin cycle the remaining moisture content of the cloth is measured and compared to a series of standard values.

The measurement of the test cloth moisture retention properties will consist of spinning an 8.4 pound load of cloth in an extractor after soaking the cloth in water for 20 minutes. Four tests will be performed at three different spin rates. The three tests will consist of a warm soak followed by a short spin, a warm soak followed by a long spin, and a cold soak followed by a long spin. A warm water is defined as being at 100F, cold water is 60F, a short spin is four minutes, and a long spin is 15 minutes. The three spin speeds are defined by the mean g-force they produce. Low spin speed is 100g, medium spin is 200g, and high spin speed is 300g. These spin speeds were chosen as to the minimum needed to represent the range of spin conditions that may be found in a residential clothes washers. The standard RMC values for these tests are as follows:

Table 6. Remaining Moisture Content for Standard Test Cloth

G – Force	Warm Soak & Short Spin	Warm Soak & Long Spin	Cold Soak & Long Spin
100 g	50.7%	45.9%	49.7%
200 g	41.1%	36.4%	38.0%
300 g	35.6%	31.7%	33.1%

(These standard values are those obtained from the third batch of test cloth that was tested in the ADL RMC tests. It is labeled ADL3 in the RMCdata.xls spreadsheet.)

For each new batch of cloth, three tests are performed for each set of test conditions, and the average RMC is measured for each test condition. For each batch of test cloth the deviation between the new production batch, and the standard is measured. This deviation is measured as the root mean square between the set of measured RMC values and the set of standard RMC values. If this absolute deviation is below 2%, then no correction factors are needed in MEF tests using that batch of cloth. If the absolute root-mean-square (RMS) difference between the cloth RMC values and standard RMC values is above 2%, then correction factors may be applied when using the cloth to test the MEF of a clothes washer.

Calculation and Use of RMC Correction Factors.

To calculate the RMC correction factor for a batch of cloth, one takes the set of average measurements from the cloth batch tests (RMC-cloth) and performs a linear least-squares fit to relate the standard RMC (RMC-standard) using the cloth RMC:

$$RMC_{STANDARD} \sim A * RMC_{CLOTH} + B \qquad \textbf{Eq. 1}$$

where A and B are coefficients of the linear least squares fit. If the root mean square value of:

$$\{\mathbf{S}_{\text{ALL\_TESTS}}[((RMC_{STANDARD\_i} - A * RMC_{CLOTH-\_i} - B)^2)/(N-2)]\}^{1/2} < 2\% \qquad \textbf{Eq. 2}$$

where N is the number of distinct tests (9), where a sum is taken over all of the different tests, where $RMC_{STANDARD\_i}$ is the RMC standard value for the i-th test, and RMC_{CLOTH-_i} is the average measured RMC value for the i-th cloth test. Under such conditions, the test cloth can be used for MEF tests as long as a correction factor is applied. The above equation is an empirical measure that the estimates using the non-standard cloth can accurately reproduce standard RMC values within 2%.

The equation for the RMC correction factor is as follows for all MEF tests using the production batch of cloth:

$$RMC_{CORRECTION} = (A-1) * RMC_{CLOTH} + B \qquad \textbf{Eq. 3}$$

This correction factor is simply added to any RMC measurement used in the MEF test procedure to correct for the non-standard behavior of that particular batch of cloth.

Example Measurement and Use of RMC Correction Factor

In this example, we show how the RMC measurements using a cloth that does not reproduce the standard RMC values can reproduce RMC results for a standard cloth by using the RMC correction factor described above.

The particular case we use is the ADL4 cloth, for which we have test data from ADL's *RMCdata.xls* spreadsheet. For this cloth, we have test results for warm soak and short spin, along with warm soak long spin. We do not have data for this cloth for cold soak long spin, so we won't cover that case.

Table 7. Test results for the ADL4 cloth

G-Force	Warm Soak & Short Spin	Warm Soak & Long Spin
100 g	57.7%	52.7%
200 g	46.3%	42.4%
300 g	40.2%	36.1%

Note that the ADL4 cloth produces RMC values that are consistently above the standard values by more than 2%.

Using Excel, plotting RMC_standard vs. RMC_cloth and adding a trend line to the data gives the linear fit. The results are:

A = 0.88
B = 0.04

This means that the equation for the correction factor is

$$RMC_{CORRECTION} = 0.04 - 0.12 * RMC_{CLOTH} \quad \textbf{Eq. 4}$$

Now test this relation by seeing how well it predicts the behavior of the test cloth for a variety of spin speeds:

Table 8. Test Cloth Results at Different Speeds

G-Force	Test	RMC_ADL4	Correction	RMC_Est	RMC_ADL3
50 g	Warm-Short	61.5	-7.6	53.9	55.8
500 g	Warm-Short	34.1	-4.2	29.9	29.8
50 g	Warm-Long	56.3	-6.9	49.3	51.4
500 g	Warm-Long	30.4	-3.7	26.7	26.7
800 g	Warm-Long	26.8	-3.3	23.5	23.3

In the above example the root-mean-square deviation between the estimates and the measurements from the standard cloth are 4.5% before the correction is applied and 1.3% after the correction is applied. While the correction method works very well for high g forces, for very low spin speeds (and low g-force) it works less well. The correction method decreases the deviation from the standard RMC values by over 70% in this example.

In the above table “Correction” is the correction factor, and “RMC_Est” is the corrected RMC estimate, and “RMC_ADL3" is the RMC estimate obtained from a cloth that fits the standard specifications.

CONCLUSION

There exists a procedure for testing cloth batches and computing RMC correction factors for clothes that violate the RMC specifications by more than 2%. This allows us to utilize non-standard test clothes to predict RMC values for standard test clothes under a wide range of conditions. This procedure (utilizing an RMC correction factor) should produce repeatable MEF values even when cloth RMC differences are greater than 2% under the same test conditions. This procedure involves applying a relevant correction factor to the RMC values before calculating the MEF.

Appendix D: Lot 4 & 5 Correction Curves

This appendix consists of an excel spreadsheet containing the finalized correction curves and data for Lots 4 and 5. The sheets show the test data, corrected data, RMS error, and washing machine verification results for each lot. The correction curve works remarkably well with both the extractor and washing machine test data. The curve fit of the data is also excellent, with the RMS error less than 1% in both cases.

Table 9. ADL Lot 4 Extractor Test Data

G	Warm Soak (100 F)		Cold Soak (60 F)	
	15 Min Spin	4 Min Spin	15 Min Spin	4 Min Spin
50	56.2%	61.5%	58.8%	64.6%
	57.2%	61.5%	58.0%	64.4%
	57.2%	61.1%	59.8%	63.2%
200	42.2%	46.3%	43.1%	47.9%
	42.6%	45.6%	42.2%	49.0%
	40.5%	45.5%	43.4%	48.5%
350	34.2%	37.5%	35.5%	41.5%
	34.2%	37.8%	35.4%	40.3%
	34.1%	38.5%	35.4%	41.0%

RMS Error= 0.50%

Root Mean Square Error Calculation

Residual	N = 12
6.24205E-06	A = 0.967
8.49531E-06	B = -0.038
1.55367E-06	
2.51011E-07	
3.0544E-08	
3.42744E-07	
6.62548E-07	
6.20176E-07	
4.10603E-07	
6.62922E-06	
1.07147E-08	
3.05084E-09	

Test Point	Lot 3	Lot 4	Corrected	Lot 3 Average	Lot 4 Average
Warm, 15, 50	51.4%	56.2%	50.5%	50.4%	56.9%
	49.6%	57.2%	51.5%		
	50.2%	57.2%	51.5%		
Warm, 15, 200	36.4%	42.2%	37.0%	35.7%	41.8%
	35.7%	42.6%	37.4%		
	34.9%	40.5%	35.4%		
Warm, 15, 350	29.1%	34.2%	29.3%	29.6%	34.2%
	29.9%	34.2%	29.3%		
	29.9%	34.1%	29.2%		
Warm, 4, 50	55.8%	61.5%	55.6%	55.7%	61.4%
	55.8%	61.5%	55.6%		
	55.5%	61.1%	55.3%		
Warm, 4, 200	41.1%	46.3%	41.0%	40.4%	45.8%
	40.6%	45.6%	40.3%		
	39.6%	45.5%	40.2%		
Warm, 4, 350	32.1%	37.5%	32.5%	33.1%	37.9%
	33.6%	37.8%	32.8%		
	33.5%	38.5%	33.5%		
Cold, 15, 50	52.2%	58.8%	53.0%	52.9%	58.9%
	53.3%	58.0%	52.3%		
	53.1%	59.8%	54.0%		
Cold, 15, 200	38.0%	43.1%	37.9%	37.9%	42.9%
	37.9%	42.2%	37.0%		
	37.9%	43.4%	38.2%		
Cold, 15, 350	30.2%	35.5%	30.6%	30.7%	35.4%
	30.7%	35.4%	30.5%		
	31.1%	35.4%	30.5%		
Cold, 4, 50	59.1%	64.6%	58.6%	59.0%	64.1%
	58.9%	64.4%	58.4%		
	58.9%	63.2%	57.3%		
Cold, 4, 200	43.5%	47.9%	42.5%	43.1%	48.5%
	43.0%	49.0%	43.6%		
	42.8%	48.5%	43.1%		
Cold, 4, 350	35.3%	41.5%	36.3%	35.8%	40.9%
	36.0%	40.3%	35.2%		
	36.1%	41.0%	35.9%		

Washing Machine Verification

Vertical Axis Machine	Lot 3	Lot 4	Corrected
Trial 1	55.4%	62.0%	56.1%
Trial 2	56.0%	61.5%	55.7%
Trial 3	56.1%	61.2%	55.3%

Horizontal Axis Machine	Lot 3	Lot 4	Corrected
Trial 1	47.1%	53.6%	48.1%
Trial 2	49.3%	54.3%	48.7%
Trial 3	48.6%	54.5%	48.8%

Table 10. ADL Lot 5 Extractor Test Data

G	Warm Soak (100 F)		Cold Soak (60 F)	
	15 Min Spin	4 Min Spin	15 Min Spin	4 Min Spin
50	54.8%	58.1%	56.4%	61.4%
	55.4%	59.4%	55.4%	61.9%
	53.1%	58.7%	55.8%	62.4%
200	40.1%	44.6%	41.7%	46.6%
	39.5%	44.4%	40.0%	47.6%
	39.1%	43.2%	42.4%	46.3%
350	32.8%	36.6%	35.1%	38.6%
	32.2%	36.4%	33.0%	38.7%
	32.1%	35.2%	33.7%	39.0%

RMS Error = 0.44%

Root Mean Square Error Calculation

Residual	N = 12
5.00203E-06	A = 0.9975
3.73423E-06	B = -0.0319
2.88996E-06	
9.21123E-07	
1.11E-06	
7.84934E-07	
1.0868E-06	
1.95767E-07	
6.66944E-10	
6.66944E-10	
1.69264E-06	
1.81689E-06	

Test Point	Lot 3	Lot 5	Corrected	Lot 3 Average	Lot 5 Average
Warm, 15, 50	51.4%	54.8%	51.4%	50.4%	54.4%
	49.6%	55.4%	52.0%		
	50.2%	53.1%	49.7%		
Warm, 15, 200	36.4%	40.1%	36.8%	35.7%	39.6%
	35.7%	39.5%	36.2%		
	34.9%	39.1%	35.8%		
Warm, 15, 350	29.1%	32.8%	29.6%	29.6%	32.4%
	29.9%	32.2%	29.0%		
	29.9%	32.1%	28.9%		
Warm, 4, 50	55.8%	58.1%	54.7%	55.7%	58.7%
	55.8%	59.4%	56.0%		
	55.5%	58.7%	55.3%		
Warm, 4, 200	41.1%	44.6%	41.3%	40.4%	44.1%
	40.6%	44.4%	41.1%		
	39.6%	43.2%	39.9%		
Warm, 4, 350	32.1%	36.6%	33.4%	33.1%	36.1%
	33.6%	36.4%	33.2%		
	33.5%	35.2%	32.0%		
Cold, 15, 50	52.2%	56.4%	53.0%	52.9%	55.9%
	53.3%	55.4%	52.0%		
	53.1%	55.8%	52.4%		
Cold, 15, 200	38.0%	41.7%	38.4%	37.9%	41.4%
	37.9%	40.0%	36.7%		
	37.9%	42.4%	39.1%		
Cold, 15, 350	30.2%	35.1%	31.9%	30.7%	33.9%
	30.7%	33.0%	29.8%		
	31.1%	33.7%	30.5%		
Cold, 4, 50	59.1%	61.4%	58.0%	59.0%	61.9%
	58.9%	61.9%	58.5%		
	58.9%	62.4%	59.0%		
Cold, 4, 200	43.5%	46.6%	43.3%	43.1%	46.8%
	43.0%	47.6%	44.3%		
	42.8%	46.3%	43.0%		
Cold, 4, 350	35.3%	38.6%	35.3%	35.8%	38.8%
	36.0%	38.7%	35.4%		
	36.1%	39.0%	35.7%		

Washing Machine Verification

Vertical Axis Machine	Lot 3	Lot 5	Corrected
Trial 1	55.4%	59.4%	56.0%
Trial 2	56.0%	59.6%	56.2%
Trial 3	56.1%	60.0%	56.6%

Horizontal Axis Machine	Lot 3	Lot 5	Corrected
Trial 1	47.1%	50.3%	47.0%
Trial 2	49.3%	49.8%	46.5%
Trial 3	48.6%	51.9%	48.5%

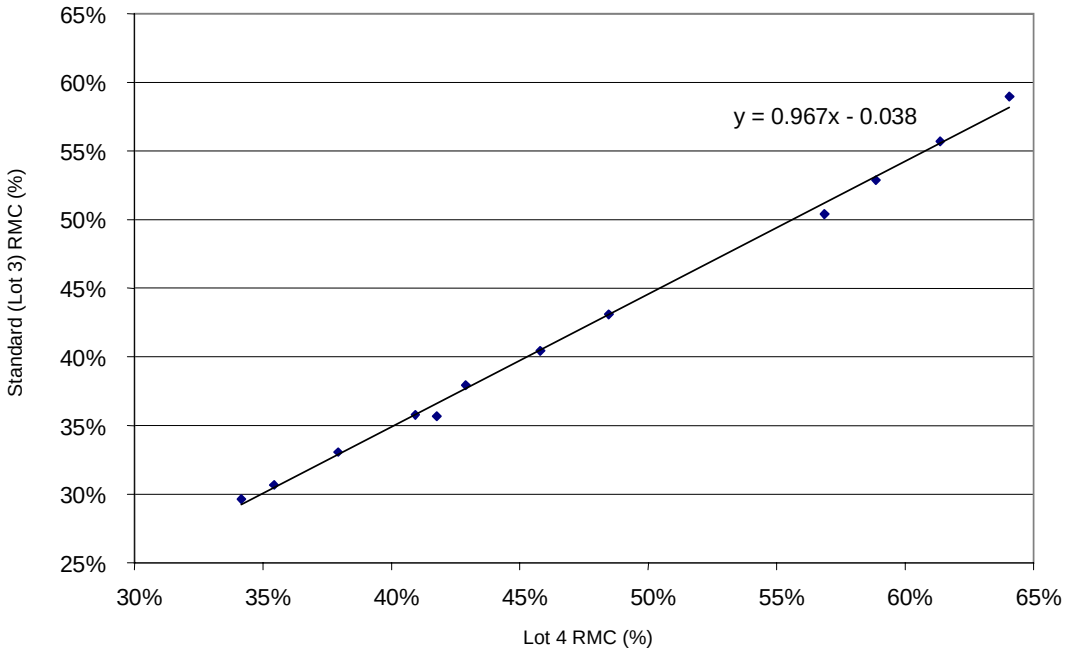

Figure 1. Correction Curve for Lot 4

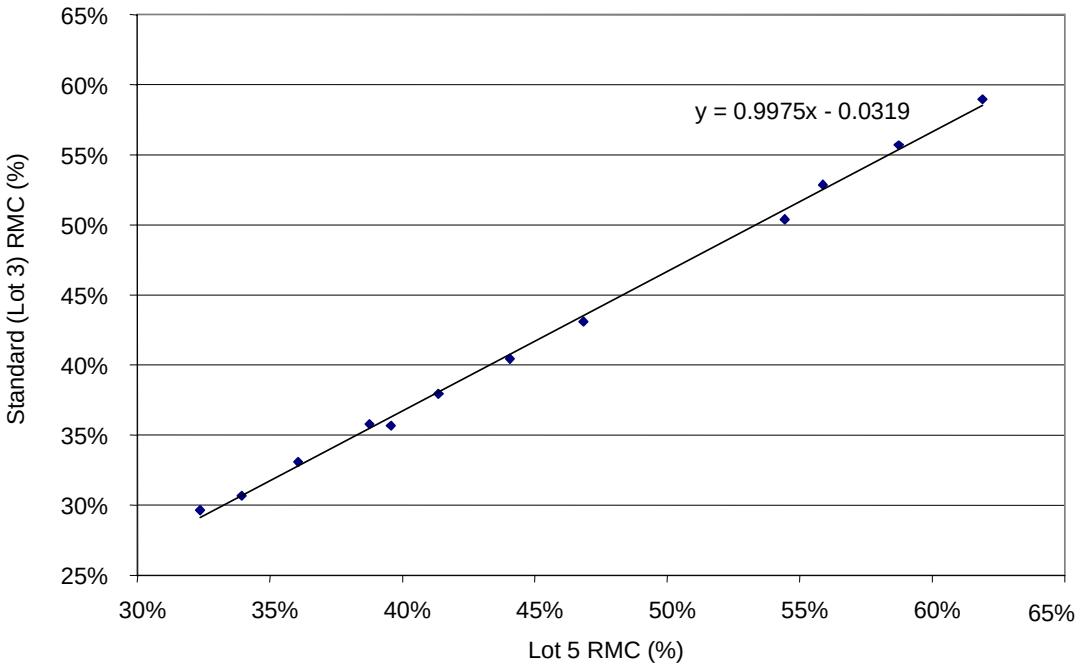

Figure 2. Correction Curve for Lot 5