Moisture Content Correction

The weight of a fabric containing a hygroscopic fibre such as cotton is affected by its moisture content, which depends on the Relative Humidity of the atmosphere that is used for conditioning. It is always recommended that test specimens should be conditioned in an atmosphere of 65% RH at a temperature of 20 Celsius, but some manufacturers can not justify the expense of a conditioned laboratory. For many purposes, and in many locations, when test specimens are allowed to condition in the ambient atmosphere, the variation introduced by day to day changes in temperature and relative humidity will not be of much practical significance. However, sometimes it is necessary to have improved accuracy in weight measurements.

This procedure allows the weight of a cotton or cotton/polyester blend specimen to be corrected to 65% Relative Humidity (RH) when it has been conditioned and measured at some other RH (X%) after conditioning from the dry side (e.g. after tumble drying).

As presented here, the procedure is valid only for RH values between X = 35 and 85%, because the equation for calculating moisture regain as a function of RH should not be extrapolated outside this range. Obviously a more complex equation could be developed to cover the whole range of RH but the range covered here is considered to be adequate for practical purposes.

Assumptions

- The relative humidity of the atmosphere in which the specimen was conditioned and weighed is continuously monitored and is noted at the time of weighing.
- Between X = 35 and 85% Relative Humidity, the moisture regain (Mr) of 100% cotton fabrics is given by the following expression, derived from detailed data published in the Shirley Institute Memoirs.

$$Mr = 2.2\, e^{0.0183\, X} \qquad (1)$$

- The cotton blend was made at a relative humidity of 50% (in the spinning mill). Thus the nominal blend ratio is correct at 50% RH.
- The moisture regain of polyester is zero at any RH. Actually it is about 0.3% at 65% RH. Therefore, in a 50:50 blend, the corresponding error must be less than about 0.05% of the specimen weight.
- The effect of temperature is neglected.

Of course, the actual conditions will not be exactly these but the errors produced by these assumptions will be negligible. For a specific set of conditions, the real figures can be determined but this will hardly be worthwhile.

Note that the largest correction that will be calculated using this procedure is about 3%. It applies to 100% cotton weighed at either 35 or 85% RH. Between 45 and 80% RH, the correction is not more than about 2%. Between 55 and 75% RH, it is not more than about 1%. Thus, the correction is required only when such levels of accuracy are necessary.

If a scientific calculator or spreadsheet program is not available for evaluating the exponential in equation (1), then a linear proportioning approximation can be used.

Thus:

$$Mr(lin) = 7.228 * X / 65 \qquad (2)$$

The constant 7.228 is the regain calculated by equation (1) for a RH of 65%. The loss of accuracy due to the linear proportioning model is very small when conditioning is in an atmosphere on the dry side of 65%, but quickly becomes larger on the wet side. Nevertheless, within X = 35 to 85% RH, the error is never greater than about 1% of the specimen weight. For example, starting from equation (1) the correction factor for 100% cotton weighed at 85% RH works out to be 0.971. Starting from the linear approximation, the corresponding correction factor is 0.980.

Definitions

X	The relative humidity that was noted at the time the specimen was weighed.
Mr	Moisture regain of 100% cotton at the given RH.
F_X	1 + Mr / 100 when Mr is the equilibrium regain for X% RH
Cn	Nominal cotton content in the original blend. For a 50:50 blend, Cn = 0.5.
Cd	Bone dry weight of cotton per gram of the original blend.
Cc	Cotton content of the specimen after conditioning to X% RH
Pd	Bone dry weight of polyester per gram of the original blend, given by (1 – Cn)
Pc	Polyester content of the conditioned specimen, given by (1 – Cc)
WF_X	Specimen weight correction factor – the result of this procedure.

Calculation Steps

1. Calculate the moisture regain and a moisture correction factor for 100% cotton conditioned in an atmosphere with the RH that was noted at the time of weighing. The regain for a given RH is calculated using either equation (1) or equation (2). The corresponding moisture correction factor (F_X) is given by the following expression.

$$F_X = 1 + Mr / 100$$

Some values of Mr and F_X calculated using equation (1) are given in Table 1.

2. If the specimen is 100% cotton, go to Step 5.

3. Given the proportion of cotton, Cn, in the original blend (at 50% RH) calculate the bone dry weight of cotton (zero moisture content) per gram of the original blend. This is achieved simply by applying the moisture correction factor for a RH of 50% to the nominal blend ratio.

$$Cd = Cn / F_{50}$$

According to Table 1, the appropriate correction factor is F_{50} = 1.0549. Some calculations are shown in Table 2, where the dry weight of the polyester component, Pd = (1 – Cn) is also shown.

4. Starting from the bone dry weight of Table 2, adjust the weight of the cotton portion according to the relative humidity in which the specimen was weighed and then calculate the weight of cotton per gram of the conditioned specimen.

The weight of the cotton portion is the bone dry weight multiplied by the moisture correction factor for the appropriate relative humidity. The weight of the polyester portion does not change. Thus the conditioned weight of the cotton is Cd * F_X, the conditioned weight of the polyester is Pd, and the weight of conditioned cotton per gram of conditioned specimen, is calculated as follows.

$$Cc = (Cd * F_X) / (Cd * F_X + Pd)$$

Table 3 shows the result of these calculations. The weight of polyester per gram of conditioned specimen is Pc = (1 – Cc).

5. Starting from the conditioned weight of Table 3, adjust the moisture content of the cotton portion to correspond to 65% RH and add on the weight of polyester. This yields the weight that one gram of specimen would have at a relative humidity of 65%. It represents a specimen weight correction factor, WF_X, for a specimen that was conditioned and weighed at X% RH.

$$WF_X = Cc * (F_{65} / F_X) + Pc$$

Results of these calculations are given in Table 4 and plotted in Figure 1. Figure 1 also shows the correction factors that would be calculated if Mr were estimated by the linear proportioning approximation of equation (2) rather than by the exponential equation (1).

6. The weight of a specimen, measured at X% RH is multiplied by the appropriate WF_X extracted from Table 4 or Figure 1 to arrive at the weight that would have been measured if the specimen had been conditioned in the standard atmosphere for testing.

Example 1

A specimen of 100% cotton fabric weighs 0.500 gram after conditioning in an atmosphere of 46% relative humidity.

1. Mr at 46% RH is found by direct calculation using equation (1), or by interpolation from Table 1. The interpolated rate of change for Mr between 45 and 50% RH is (5.493 – 5.013) / 5 = 0.096.

Therefore Mr for 46% RH is 5.013 + 0.096 = 5.109.

The corresponding moisture correction factor F_{46} is 1 + 5.109 / 100 = 1.0511.

2. Go to Step 5

5. The Weight Correction Factor for 100% cotton at 46% RH is found by calculation or by interpolation from Table 4 or Figure 1. From Table 4, the interpolated rate of change for WF_X between 45 and 50% RH is (1.016 – 1.021) / 5 = -0.001.

Therefore WF_{46} is 1.021 - 0.001 = 1.020.

6. The corrected weight is 0.500 * 1.020 = 0.510 gram.

Example 2

A specimen of 50:50 cotton/polyester fabric weighs 0.500 gram after conditioning in an atmosphere of 46% relative humidity.

1. Same as Step 1 in Example 1.

2. Continue.

3. The proportion of cotton in the bone-dry fabric is Cd = 0.5 / F_{50} = 0.474 (Table 2).

4. Adjusting the cotton portion from bone dry to 46% RH gives a cotton weight of

(Cd * F_{46}) = 0.474 * 1.0511 = 0.4982.

The weight of polyester is 0.5, so the proportion of cotton in the conditioned specimen is

Cc = 0.4982 / (0.4982 + 0.5) = 0.4991.

5. The Weight Correction Factor for 50% cotton at 46% RH is found by calculation or by interpolation from Table 4 or Figure 1. From Table 4 the interpolated rate of change for WF_X between 45 and 50% RH is (1.008 – 1.011) / 5 = -0.0006.

Therefore WF_{46} is 1.011 - 0.0006 = 1.0104.

6. The corrected weight is 0.500 * 1.0104 = 0.5052 gram.

Table 1

Moisture regain and moisture correction factor at different relative humidities

RH	Mr	F_X
35	4.174	1.0417
40	4.574	1.0457
45	5.013	1.0501
50	5.493	1.0549
55	6.019	1.0602
60	6.596	1.0660
65	7.228	1.0723
70	7.921	1.0792
75	8.679	1.0868
80	9.511	1.0951
85	10.422	1.1042

Table 2

Bone dry weights of cotton and polyester per gram of the original blend

Nominal cotton content Cn	Bone dry	
	cotton Cd	polyester Pd
0.50	0.474	0.500
0.55	0.521	0.450
0.60	0.569	0.400
0.65	0.616	0.350
0.70	0.664	0.300
0.75	0.711	0.250
0.80	0.758	0.200
0.85	0.806	0.150
0.90	0.853	0.100
0.95	0.853	0.050
1.00	0.948	0.000

Table 3

Cn	Weight of cotton per gram of blend at the given RH										
	35	40	45	50	55	60	65	70	75	80	85
0.50	0.4969	0.4978	0.4989	0.5000	0.5012	0.5026	0.5041	0.5057	0.5074	0.5093	0.5114
0.55	0.5469	0.5478	0.5489	0.5500	0.5512	0.5526	0.5540	0.5556	0.5574	0.5592	0.5613
0.60	0.5970	0.5979	0.5989	0.6000	0.6012	0.6025	0.6039	0.6054	0.6071	0.6089	0.6109
0.65	0.6471	0.6480	0.6490	0.6500	0.6511	0.6524	0.6537	0.6552	0.6567	0.6585	0.6603
0.70	0.6974	0.6982	0.6990	0.7000	0.7010	0.7022	0.7034	0.7048	0.7062	0.7078	0.7095
0.75	0.7476	0.7484	0.7491	0.7500	0.7509	0.7519	0.7530	0.7542	0.7555	0.7569	0.7585
0.80	0.7980	0.7986	0.7993	0.8000	0.8008	0.8017	0.8026	0.8036	0.8047	0.8059	0.8072
0.85	0.8484	0.8489	0.8494	0.8500	0.8506	0.8513	0.8521	0.8529	0.8538	0.8547	0.8557
0.90	0.8989	0.8992	0.8996	0.9000	0.9004	0.9009	0.9015	0.9020	0.9026	0.9033	0.9040
0.95	0.9494	0.9496	0.9498	0.9500	0.9502	0.9505	0.9508	0.9511	0.9514	0.9517	0.9521
1.00	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Table 4

Cn	Corrected weight per gram, when measured at the given RH										
	35	40	45	50	55	60	65	70	75	80	85
0.50	1.015	1.013	1.011	1.008	1.006	1.003	1.000	0.997	0.993	0.989	0.985
0.55	1.016	1.014	1.012	1.009	1.006	1.003	1.000	0.996	0.993	0.988	0.984
0.60	1.017	1.015	1.013	1.010	1.007	1.004	1.000	0.996	0.992	0.987	0.982
0.65	1.019	1.016	1.014	1.011	1.007	1.004	1.000	0.996	0.991	0.986	0.981
0.70	1.020	1.018	1.015	1.012	1.008	1.004	1.000	0.995	0.991	0.985	0.979
0.75	1.022	1.019	1.016	1.012	1.009	1.004	1.000	0.995	0.990	0.984	0.978
0.80	1.023	1.020	1.017	1.013	1.009	1.005	1.000	0.995	0.989	0.983	0.977
0.85	1.025	1.022	1.018	1.014	1.010	1.005	1.000	0.995	0.989	0.982	0.975
0.90	1.026	1.023	1.019	1.015	1.010	1.005	1.000	0.994	0.988	0.981	0.974
0.95	1.028	1.024	1.020	1.016	1.011	1.006	1.000	0.994	0.987	0.980	0.972
1.00	1.029	1.025	1.021	1.016	1.011	1.006	1.000	0.994	0.987	0.979	0.971

Figure 1