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Assessment of Crease Recovery Values of Textile Fabrics by Different Instruments

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A comparative evaluation of the crease recovery angles of textile fabrics measured using three different crease recovery testers, viz. Monsanto, Metrimpex and Shirley, has been made to assess the recovery characteristics of textile fabrics in the true sense. The effect of different factors like load, loading/relaxation period, sample size, crease length and spacer (particularly used in the Monsanto method) on the crease recovery values has also been studied. It has been observed that the evaluation of commercial samples cannot be made by the Monsanto method, as the measured angles in this case do not represent the true values. However, both the Metrimpex and Shirley testers do furnish equivalent values according to the basic physical principle of property measurement, Metrimpex tester could be used preferably, provided certain precautions are taken, as it enables measurements for more than one specimen at a time, as against the Shirley tester which can handle only one specimen. It is recommended that the standard method of determination of crease recovery values of textile fabrics should involve the formation of crease/wrinkle as per the basic physical principle without any spacer to measure the recovery values in the true sense.

With the advent of resin finished cotton fabrics and their blends in the consumer market, objective assessment of the recovery angles of a finished fabric has assumed considerable importance. Several methods have been developed for measuring and assessing the recovery characteristics of such finished fabrics[1-7]. While the evaluation of fabric recovery behaviour using photographic standards has not been favoured due to its subjective nature, new instruments are finding their way into the market for measuring the recovery angles objectively. Among the different instruments, Tootal recovery tester was the earliest, while Monsanto wrinkle recovery tester and Shirley crease recovery tester, which were developed later, are now in general use. A recent addition of interest to the crease recovery testers is the Metrimpex crease recovery tester developed in Hungary. These instruments are based on the principle of deliberately creating a fold in the specimen in question, under a given load and period and then allowing the material to recover for a given time period. The angle so formed between the two leaves of the folded fabric strip is measured with the help of a protractor. This procedure is repeated in both warp and weft directions and is applied to the material even in wet condition.

Even though the basic principle of the measurement of recovery angles is same in all these instruments, the procedures adopted differ with regard to sample size, load and loading period, relaxation period, mode of application of load on the sample and insertion of spacer in between the two folds of the specimen. These procedural differences are briefly enumerated in Table 1 to show their relevance to the recovery data of these instruments. In the present investigation, a comparative evaluation of the crease recovery angles of textile fabrics by three crease recovery testers, viz. Monsanto, Shirley and Metrimpex, has been made to assess the recovery characteristics of textile fabrics in the true sense. This would help in arriving at a uniform standard method for testing the crease recovery of textile fabrics.

Materials and Methods

Fabric samples of cotton, woollen and man-made fabrics and blends with varying constructions were used for evaluation of recovery angles. The constructional parameters of the fabrics are given in Table 2.

In the case of four cotton fabrics, viz. drill, sheeting, poplin and cambric, durable press (DP) characteristics were imparted by treating them with dimethylol dihydroxyethylene urea (DMDHEU) as the crosslinking agent.

The fabrics were evaluated for crease recovery angles using the following instruments as per the

Table 1—Standard Specifications for Different Recovery Testers

Instrument	Sample size (width × length) mm	Load g	Loading period min	Relaxation period min	Reference
Monsanto*	15.0 × 40.0	500	5	5	1
Shirley	25.4 × 50.8	2000	1	1	8
Shirley	15.0 × 40.0	1019	5	5	4
Metrimpex	20.0 × 30.0	600	5	5	9

*Spacer of thickness 0.16 ± 0.01 mm.

Table 2—Constructional Parameters of Samples Used for CRA Measurement

Sample	Code No.	Count (CC)		Threads/in		Wt/m² g	Composition %
		Warp	Weft	Warp	Weft		
Cotton sheeting	X- 2	32.0s	32.2s	138	59	174.0	100.0 C
Cotton sheeting	X- 3	33.2s	37.9s	86	51	109.9	100.0 C
Poplin control	X- 5	34.6s	54.2s	103	72	124.8	100.0 C
Cambric	X- 6	64.4s	58.2s	94	81	79.6	100.0 C
sheeting control	X- 7	17.5s	13.5s	68	49	195.8	100.0 C
Drill control	X- 9	18.0s	13.6s	107	47	246.6	100.0 C
Cambric control	X-11	64.8s	99.3s	116	88	70.6	100.0 C
Terrycot sheeting	X-14	31.0s	31.5s	90	58	118.4	19.1 P 13.4 V 67.5 C
Terrycot sheeting	X-15	32.3s	33.4s	88	58	114.8	20.0 P 14.1 V 65.9 C
Terrycot sheeting	X-16	33.1s	35.4s	86	58	103.7	11.7 P 13.3 V 75.0 C
Terrycot sheeting	X-17	33.4s	32.4s	90	58	109.4	19.6 P 14.2 V 66.2 C
Terrycot sheeting	X-18	31.3s	30.1s	92	58	114.3	19.5 P 16.3 V 64.2 C
Terrycot sheeting	X-19	30.9s	34.4s	84	72	127.9	59.9 P 40.1 C
Woollen suiting	X-21	21.3s --(2F)	22.4s W.C.--	79	58	246.2	54.8 W 45.2 P
Cotton sheeting	X-22	16.4s	13.9s	70	50	199.6	100.0 C
Cotton sheeting	X-23	17.6s	13.8s	109	50	241.0	100. 0 C
Cotton sheeting	X-24	32.5s	34.0s	136	59	166.9	100.0 C
Polyester voile	X-25	96.4s	72.5s	92	80	52.9	100.0 P
Terrycot sheeting	Y-1	31.5s	32.8s	89	59	116.2	19.0 P 13.9 V 67.1 C
Terrycot sheeting	Y-11	32.5s	31.6s	90	58	114.8	17.2 P 82.8 C
Terrycot sheeting	X-20	31.4s	31.2s	86	70	128.4	49.7 P 50.3 C

C, Cotton; P, polyester; V, viscose; W, wool.

recommended standard procedures:

(1) Monsanto wrinkle recovery tester.
(2) Shirley crease recovery tester.
(3) Metrimpex crease recovery tester.

A brief description of the instruments is given below.

Monsanto Crease Recovery Tester

A disc and a protractor are mounted coaxially on a vertical support, so that they are free to rotate about a horizontal axis. The centre of the disc-protractor assembly is marked and a vertical guideline is drawn on the support from the centre mark to the base. The disc is provided with the vernier, having a central zero point, which indicates on the protractor the angle formed by the creased specimen, when it is mounted in the clamp. The apparatus also has a provision intended to compensate for fabric thickness. A clamp is attached to the face of the disc to support the specimen holder. The important accessories include specimen holder and transparent plastic press.

Specimen holder—This consists of two superimposed 16 mm wide metal leaves of different lengths fastened together at one end. The distance between the free ends of the two leaves is 23 mm. The thickness of the top shorter leaf/spacer is 0.16 ± 0.01 mm. There is a line drawn on the top leaf parallel to and exactly 18 mm from its free end.

Transparent plastic press—This consists of two superimposed leaves of equal length (approx. 95 mm) and width (about 20 mm) fastened together at one end. A platform of the same plastic, approx. 23 mm long and as wide as the press leaves, is permanently attached to the outer surface of the free end of one leaf, with the outer edges of the leaf and platform flush.

Shirley Crease Recovery Tester

This apparatus consists of a circular dial, which carries the grips for holding the specimen. Directly under the centre of the dial are a knife-edge and an index line for measuring the recovery angle. The scale of the instrument is engraved on the dial. The important accessory is the loading device which consists of a press to apply the required load (2 kg) on an area of 25.4 × 25.4 mm of the folded specimen placed between the two flat press/glass plates.

Metrimpex Crease Recovery Tester

This apparatus consists of a vertically positioned specimen holder, which can carry five specimens. A pressure plate, the movement of which is controlled by a loading and unloading mechanism, is used for compressing all the five folded specimens held by the specimen holder. The protractor is placed in a transparent protective housing. The specimen holder, after unloading, is kept in a postion above the protractor inside the above housing. The instrument has a time indicating device, meant for registering the unloading period and for measuring the crease recovery angle (i.e. relaxation period of the specimen). During this period, a second specimen holder carrying five specimens can be placed below the pressure plate and compressed. Thus, 10 specimens can be handled simultaneously.

The fabrics were evaluated for both dry and wet crease recovery angles.

Results and Discussion

The recovery angles of textile fabrics measured by the three instruments—Monsanto, Shirley and Metrimpex—are projected in Figs. 1 and 2. It is

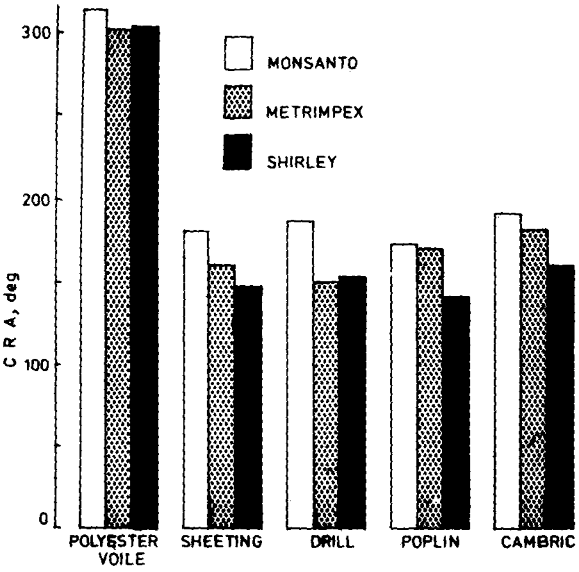

Fig. 1—Crease recovery angles of textile fabrics by different instruments

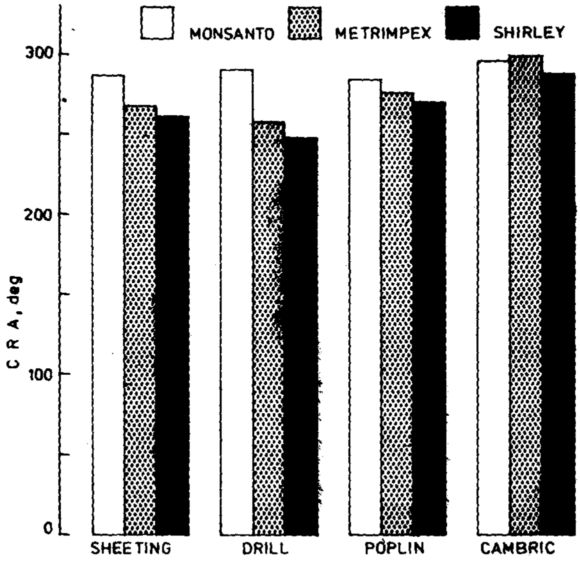

Fig. 2—Crease recovery angles of durable press treated fabrics by different instruments

interesting to observe the conspicuous outcome of the results in the case of untreated controls and DP-treated cotton fabrics of medium, coarse and fine varieties. The recovery angle values are highest for Monsanto tester and lowest for Shirley tester, irrespective of fabric type or treatment. This trend remains same even in the wet condition (Table 3). The results also reflect consistency in this trend. Further, the recovery behaviour of fabrics of different weaving constructions also shows varying CRA values of similar trend, compatible within each method. Thus, the plain weave of sheeting, poplin and cambric shows nearly uniform values, while the drill weave of coarse fabric gives considerably different values within each instrument, as expected. Table 4 illustrates this aspect well.

To investigate the possible causes for this type of discrepancy in results, an in-depth analysis of the various factors governing the procedures in the operation of these instruments has been carried out.

Table 3—Wet CRA Values Using Different Instruments

Sample description and code No.		CRA values P+T Monsanto	Metrimpex	Shirley
Sheeting control	X- 7	145	136	130
Drill control	X- 9	157	144	126
Poplin control	X- 5	152	160	125
Cambric control	X-11	198	183	131
Sheeting DP	X- 7	263	252	239
Drill DP	X- 9	255	253	240
Poplin DP	X- 5	271	259	238
Cambric DP	X-11	278	270	249

P, Warp; T, Weft.

Table 4—Effect of Weaving Pattern on Recovery Angles of Fabrics

Sample description and code No.		CRA values Monsanto			Metrimpex			Shirley		
		P	T	P+T	P	T	P+T	P	T	P+T
Drill control	F-1	80	110	190	78	76	154	75	97	172
X-9	F-2	93	93	186	74	73	147	55	80	135
Sheeting control	F-1	93	88	181	79	80	159	76	80	156
X-7	F-2	89	93	182	84	78	162	71	70	141
Poplin control	F-1	82	87	169	87	81	168	73	75	148
X-5	F-2	85	93	178	90	87	177	66	71	137
Cambric control	F-1	91	101	192	96	82	178	76	91	167
X-11	F-2	88	104	192	101	88	189	69	87	156

F-1, specimen folded face to face.
F-2, specimen folded back to back.
P, Warp; T, Weft.

Effect of Procedural Differences of Instruments on CRA Values

It has already been mentioned that the operation of these instruments varies in sample size, load and loading period and relaxation period (Table 1) in the measurement of CRA values of textiles. Therefore, the effect of these factors has been studied in detail.

Effect of load and loading period on CRA values—The effect of load and loading period on the CRA values has been studied for each of the three instruments, keeping the loading and relaxation periods constant in all the studies. The results presented in Fig. 3 indicate that the load and loading period have great influence on the CRA values. The shorter the loading period, the greater is the CRA value, irrespective of the load. At the same time, the load also plays an important role with respect to loading period; the higher the load and loading period, the smaller is the recovery value, as expected.

It is also reiterated that for the same sample, Monsanto recovery values are invariably higher than the others, irrespective of the load or loading period. Further, it is clear from the Metrimpex and Shirley recovery data (Fig. 3) that the crease recovery values measured with 500 g load for 5 min are comparable with those measured with 2000 g load for 1 min. An important observation made is that even though the load (500 g) and loading period (5 min) are same for Monsanto and Metrimpex testing, the Monsanto values are higher than those of Metrimpex. Hence, it is necessary to study the effect of other factors to arrive at the factor contributing towards higher recoveries in the Monsanto method.

Effect of sample length and crease length on CRA values—Variations in sample length and crease length, under constant pressure, do not bring about any change in the recovery values of Shirley tester (Table 5), as claimed earlier in the case of Metrimpex by Doshi and Dixit[10].

Effect of spacer on CRA values—In Monsanto tester, a metallic strip, built-in in the sample holder, serves as a spacer, while such a device is not present in the other methods of measurement of recovery angles.

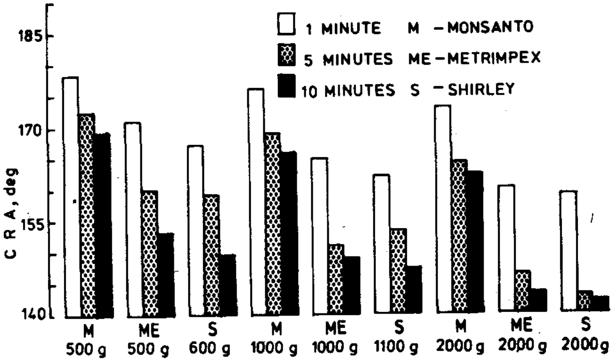

Fig. 3—Effect of load and loading period on CRA values of cotton sheeting (code No. X-7)

In this connection, it is pertinent to mention the work of Skelton[11], wherein the crease recovery tests were carried out with and without spacers of four different thicknesses in the creasing press while carrying out the theoretical and experimental investigations of the crease recovery of plain weave fabrics woven from staple yarns. The thicker the spacer, the greater was the CRA value of thermovyl fabric (Table 6).

The study of Markezich *et al.*[12] using vertical strip Monsanto tester has brought out some of the sources of error in the wrinkle recovery tester and test method, as the agreement of the data was not found good among the laboratories. The corresponding AATCC test method[1] also shows such significant differences in laboratory precision. It is rather intriguing that they have not considered the importance of the basic principle of fold/crease formation without the influence of any outside agency, like the introduction of spacer, while working on the various other sources of error contributing to the problems of obtaining inter-laboratory agreement on the recovery data.

To find out the effect of spacer on the full range of recovery angles, different fabric types, viz. cotton, man-made, blends and woollen, were measured for their recovery values with and without spacer of 0.20 mm thickness, similar to that used in Monsanto tester by Shirley method. The results (Table 7) point out that while confirming the definite effect of the spacer on CRA values, measured in the 150-280° range, it is evident that such an influence is ineffective on CRA values lower than 150° and higher than 280-300°. It is, however, interesting to observe that the insertion of spacer in between the specimen, while creating a crease/fold, has yielded values comparable to Monsanto values in the wash and wear range. A similar comparison reveals an identical trend in crease recovery values obtained using Monsanto and Metrimpex instruments with and without the spacer (Table 8). Thus, the effect of metal spacer in the Monsanto tester is the main reason for the highest values of CRA among all the three instruments.

Table 5—Effect of Sample Length (SL) and Crease Length (CL) on CRA Values

[Sample, terrycot sheeting X-18]

Size of specimen (SL × CL) mm	CRA P+T	Size of specimen (SL × CL) mm	CRA P+T
25.4 × 25.4	195	50.8 × 6.4	189
31.8 × 25.4	193	50.8 × 12.7	192
38.1 × 25.4	191	50.8 × 19.1	196
44.5 × 25.4	190	50.8 × 25.4	195
50.8 × 25.4	195	50.8 × 31.8	191

Note: In all the cases, pressure is kept constant at 1100 g/in^2 (i.e. 1.7 g/mm^2).

P, Warp; T, Weft.

Table 6—Effect of Spacer Thickness on CRA Values of Thermovyl Fabrics*

Spacer thickness cm	CRA deg
0.550	149.5
0.234	142.3
0.163	138.1
0.094	126.5
Routine test without the spacer	96.5

*Data from ref. 11.

Consequently, it derives from the present data that for proper evaluation of recovery angles, a realistic formation of crease is essential at the time of fabric

Table 7—Effect of Spacer on the Crease Recovery Values of Different Fabrics

Sample	Code No.	Crease recovery angles		
		Shirley*		Monsanto†
		Without spacer	With spacer	
Cotton fabrics				
Sheeting	X- 2	120	170	120
Sheeting	X- 3	121	172	125
Sheeting	X-22	129	178	134
Drill	X-23	142	189	141
Cambric	X- 6	147	194	151
Sheeting	X-24	147	183	147
Drill	X- 9	154	189	188
Cambric	X-11	161	215	192
Blended fabrics				
Terrycot sheeting	Y- 1	199	240	234
Terrycot sheeting	X-14	203	231	220
Terrycot sheeting	X-15	209	231	222
Terrycot sheeting	X-16	211	225	225
Terrycot sheeting	X-19	223	257	249
Terrycot sheeting	X-20	242	260	258
Woollen fabrics				
Woollen sheeting	X-21	324	331	321
Man-made fabrics				
Polyester voile	X-25	304	307	314

*Load, 2000 g; loading period, 1 min; and relaxation period, 1 min.
†Load, 500 g; loading period 5 min; and relaxation period, 5 min.

Table 8—Comparison of CRA Values of Monsanto and Metrimpex Testers

Sample	Code No.	Monsanto	Metrimpex	
			WS	WOS
Polyester	X-25	314	296	295
Sheeting control	X- 7	181	191	160
Sheeting wet		145	143	136
Drill control	X- 9	190	200	165
Drill wet		157	165	144
Cambric control	X-11	190	195	183
Cambric wet		190	196	183
Sheeting DP	(X-7 DP)	286	281	265
Sheeting wet		262	253	252
Cambric DP	(X-11 DP)	294	298	298
Cambric wet		278	272	269
Terrycot sheeting dry	X-17	235	227	201
Terrycot sheeting wet	—	—	194	188
Woollen sheeting dry	X-21	322	325	317
Woollen sheeting wet	—	—	290	289

WS, with spacer; WOS, without spacer.

bending/folding/creasing in the procedure of measurement with each of the instruments.

Further examination of the sample holder from the viewpoint of loading mechanism also affirms that apparently no uniform pressure is exerted on the specimen during the formation of crease. This is also attributed to the presence of the metallic spacer inserted between the folds of the specimen, which is fixed in the plastic holder at one end of which 500 g load is kept. As mentioned in the AATCC test method, this plastic press has a tendency to warp in usage, resulting in non-uniform distribution of load on the specimen, affecting the results thereby. The convenience of minimum sample handling has actually contributed to the higher recovery values at the expense of the basic principle of crease/bend formation. Thus, these methods cannot be compared with each other. Coupled with the multiple bends resulting from the introduction of metallic spacer, the observed crease recovery angle can be as high as 25-40° in the critical range 200-280°. The load and period of deformation and the recovery period, all need to be standardized, before the crease recovery angles as obtained from these two methods could be compared.

Mechanism of Bending

It appears that the mode of crease/fold formation plays an important role in determining the realistic CRA. The recovery of a textile fibre is dependent upon its structural characteristics, particularly the secondary bondings. To be resilient, the fibre should not resist deformation, and at the same time regain its original configuration existing prior to deformation. Given the same ability of the material to recover from the deformation, one should standardize the extent of deformation which the material is made to suffer, before any attempt is made to measure the recovery characteristics. In all the three methods, the basic mechanism involved is to form a sharp crease or wrinkle under a given load and period and thereafter allow the material to recover from the induced deformation for a given period. One has to positively make sure that the deformation (in the present case a crease) has been made in the same manner in all the three cases, before comparing the results obtained from these methods. The basic mechanism in creasing of the fabric is one of fibre bending, involving the flow characteristics of the polymer. Introduction of the metal sheet (spacer) between the leaves of the fabric, while it is being deformed, has already been found to cause considerable difference in the observations. This has been proved using strips of tracing paper creased under identical conditions with and without the spacer and examining them under a low power microscope. The resultant micrograph is shown in Fig. 4.

Fig. 4—A view of the lateral edge-on section in the micrograph

It is observed that the insertion of metal strip/spacer causes two right angle bends in the material instead of a sharp single crease. The recovery of the material at each of the right angle bends causes the overall angle between the two leaves of the strip to increase considerably. This in effect would mean that in Monsanto tester, one measures the consolidated angle of two bends as against a single bend or fold which is desired to be created under the method. In many cases, instead of multiple bends just a curvilinear bend may be formed, showing a single illusory angle (Fig. 5) whose recovery characteristics are far greater, thus leading to erroneous conclusions. However, the measured recovery angles are not affected above the DP range where there is high recovery, and below the angles of 150° where there is no significant recovery. Thus, it is clear that the sample bending mechanism in the Monsanto tester is far from what it claims to be. The measurement of the recovery of multiple folds/bends/wrinkles/creases is yet an unexplored field requiring deeper study. Hitherto, workers[10,13] have attempted to modify the Hungarian and Tootal methods to bring them at par with Monsanto method on the mistaken assumption that the latter is a standard method. Thus, we find introduction of spacers and increasing of the test specimen size to boost up the measured CRA. A notable attempt is that of Doshi and Dixit[10] who have suggested a modified Hungarian method to simulate the Monsanto values. Although the Monsanto method is highly attractive to persons engaged in resin finishing of textiles due to the high CRA values recorded by this technique, it should be clearly understood that the Monsanto instrument fails to meet the requirement when the physical principles of fold formation are examined critically.

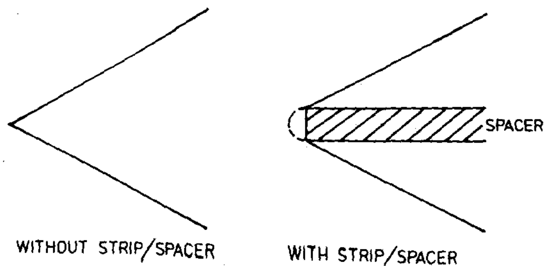

Fig. 5—Effect of spacer on crease

Table 9—Comparison of CRA Values of Shirley and Metrimpex Testers

Sample description and code No.	Shirley values, P+T		Metrimpex values, P+T			
	Control	DP	Mean of five values after deleting five end values		Mean of all the ten values	
			Control	DP	Control	DP
Sheeting X-7	148	261	155	267	161	266
Drill X-9	153	246	155	260	151	256
Poplin X-5	142	268	156	274	172	274
Cambric X-11	162	286	170	296	184	298

P, Warp; T, Weft.

Assessment of CRA Values of Shirley and Metrimpex Testers

The CRA values obtained by Metrimpex and Shirley testers compare well with each other (Table 9), the former scoring a plus, provided certain precautions are taken. In Shirley tester, only one specimen can be assessed at a time, while in Metrimpex tester, five specimens can be assessed at a time. However, it has been observed that due to the non-planarity of the sample block after continuous usage, the two end specimens always show higher CRA values than the centre specimens. It is believed that with usage, the sample mounting block, made of polyamide material, tends to warp, leading to uneven loading along the length of the block. The plane of the block should, therefore, be checked often and CRA should be calibrated against that of Shirley. Hence, the standard method of determination of crease recovery values of textile fabrics should involve the formation of crease/wrinkle as per the basic physical principle without any spacer to measure the recovery values in the true sense.

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