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A Comparison of some Properties of Wool-Rich Fabrics Containing all Wool, Wool/Nylon Core-Spun or Staple Fibre Blend Yarns

by

Miriam Shiloh

SOUTH AFRICAN
WOOL AND TEXTILE RESEARCH
INSTITUTE OF THE CSIR

P. O. BOX 1124
PORT ELIZABETH
REPUBLIC OF SOUTH AFRICA

A COMPARISON OF SOME PROPERTIES OF WOOL-RICH FABRICS CONTAINING ALL-WOOL, WOOL/NYLON CORE-SPUN OR STAPLE FIBRE BLEND YARNS

by *MIRIAM SHILOH*

ABSTRACT

Plain and twill weave light weight suiting fabrics were woven from each of three types of yarns: all-wool, 80/20 wool/nylon staple blends and 80/20 wool/nylon filament cores. The fabrics were heat set at 190°C for 45 seconds. A number of properties of the fabrics were measured.

Certain properties of the fabrics made from core-spun yarns, such as tenacity, pilling propensity, appearance after washing and dry wrinkle recovery were better than those of the staple blend fabrics. On the other hand the abrasion resistance and recovery from deformation of the core-spun fabrics appeared to be lower than that of the other fabrics.

The crease recovery of the twill weave fabrics was better than that of the plain weave fabrics while the appearance of the former after washing and after abrasion was worse. Autoclave decatizing the fabrics, at a pressure of 2 kgf/cm² (132°C) for 4 minutes, subsequent to heat setting caused a deterioration in the physical properties of the fabrics without effecting a significant improvement in the crease recovery, wrinkling performance and dimensional stability of the fabrics.

KEY WORDS

Wool/nylon blends — core-spun yarns — mechanical properties — deformability — abrasion resistance — pilling — wrinkling — plain weave — twill weave.

INTRODUCTION

The use of core-spun wool-rich yarns in woven fabrics has already been discussed in a previous study(1), where 88/12 wool/nylon fabrics were manufactured from yarns containing either a textured or an untextured nylon filament core. Although it was intended to compare properties of the fabrics from core-spun yarns with those of staple blend fabrics produced subsequently(1, 2) the comparison was not entirely valid as the fabrics differed in blend ratios as well as in the type of synthetic fibre component, viz. polyester in the intimate blend and nylon in the core-spun yarn.

In other studies(2, 3) wool rich fabrics of similar structures, were woven from blends of wool and various types of polyester staple fibres and their properties tested. It was found that the type of polyester used had a significant effect on most of the properties of the fabrics. It was found that when the percentage of wool in a wool/polyester blend decreased the fabrics became stiffer, stronger and more resistant to abrasion, while their shrinkage and wrinkling after washing decreased to acceptable levels. Autoclave decatizing improved the appearance of the wool-rich blends after washing almost as much as did the introduction of an additional 20% of polyester fibres to the blend.

The object of the present study was to compare as many properties as possible for wool-rich blend fabrics and to obtain information on the differences in properties of similar fabrics containing either core-spun yarns or staple fibres of the same fibre type. Since it was not possible to obtain polyester filament cores in deniers similar to those of the staple fibres, the study was limited to wool/nylon blends. It was also not possible to obtain nylon staple fibres and filaments of identical origin since the only commercially available staple fibres were nylon 6 while the filament yarn suitable for a core consisted of nylon 6.6. In spite of the differences in melting and annealing temperatures, identical finishing treatments were applied to the fabrics containing the above fibres and differences between the fibres were considered to be of minor importance compared with the major differences between the textured filament and staple fibre configurations.

Fabrics from core-spun wool-rich blends were the subject of a recent IWS study(4) in which fabrics from 'woolfil' yarns were compared with fabrics from core-spun yarns. 'Woolfil' yarns are similar in composition to core-spun yarns, except that the continuous filament component is wrapped around the outside of the yarn whereas in core-spun yarns, the filament is covered by the wool fibres. It was claimed that high twist factors are required to avoid stripping of the wool fibres during the weaving of the core-spun yarns. In the previous studies(1—3) high twists were found to be unnecessary as the yarns were doubled and no stripping of the wool sheath component occurred. In this respect the doubled core-yarns could be regarded as intermediate between the core-spun and woolfil yarns in their structure and performance.

EXPERIMENTAL

Wool tops of 64's quality were prescoured for 20 min at 45°C in a solution of 0,5 g/*l* Eriopon HD (Ciba-Geigy), and then submitted to a hot and a cold rinse. The tops were subsequently dyed with the following dye liquor: 2% Lanasol Orange G (Ciba-Geigy), 4% ammonium sulphite, 1,5% acetic acid (80%) and 1% Albegal B (Ciba-Geigy). The tops were finally subjected to a hot and a cold rinse. The dyed wool tops were divided into three lots. One lot was used for all-wool spinning, one for intimate blending with staple nylon 6 fibres of 3,3 dtex (3 denier) and 75 mm mean fibre length, and the third lot for core spinning with 44 dtex f13 (40/13 denier) nylon 6,6 textured filaments, as used previously(1). The nylon fibres and filaments were undyed. The all-wool yarn was taken as a basis on which the contribution of the nylon component to the various properties could be assessed.

The three types of yarns were spun into 21 tex single yarns which were then doubled to form nominal R42 tex S400/2 Z650 yarns, similar to those used in the previous studies(1–3). The core-spun yarn had a slightly higher count since 21 tex is close to the limiting count for a single yarn which can be spun from 64's quality wool with the prerequisite that the 44 dtex core is completely covered with wool fibres. For a blend ratio of 80/20 wool/nylon 22 tex yarns are obtainable.

Each of the three yarn lots was then woven into both plain weave and 2/2 twill fabrics with the same nominal sett of 22,6 picks and ends per cm, attempting to achieve a final density of 200 g/m^2 for all six finished fabrics.

Autoclave decatising applied previously(1, 2, 3) showed slight reduction in strength, mainly in the case of wool rich blends. To adequately sett wool/nylon blends higher temperatures and longer periods are required than in the case of wool/polyester blends. Precautions were therefore taken when finishing the fabrics in the present study to avoid degradation of the wool component.

The fabrics were crabbed at the boil for 20 minutes with 1 cc/*l* Tergitol Speedwet (Union Carbide) and under a top roller pressure of 1 kgf/cm^2. Subsequently they were rope scoured in a liquor containing 0,5 g/*l* Eriopon HD (Ciba-Geigy), 1 cc/*l* ammonia, 5 g/*l* sodium chloride and 0,1 g/*l* EDTA for 20 min at 38°C with a low top roller pressure. The pieces were then submitted to hot and cold rinses and washed off in the cold with dilute formic acid. Hydroextraction was followed by tenter drying and setting at 190°C for 45 seconds. Steaming and brushing, cropping and decatizing for 2 x 5 min cycles concluded the finishing process.

TEST PROCEDURES

The fibres, yarns and fabrics were tested according to the procedures used previously(1–3). In certain tests, however, much more detailed test procedures have been followed to obtain more detailed information on certain properties of the fabrics. The results of these specific tests are also reported and discussed separately.

Deformability:

It has been claimed(4) that in wearer trials fabrics from core-spun yarns show more 'bagginess' than other fabrics. Slinger and Godawa(5) suggested that the deformability of the fabrics could be measured and expressed as the percentage of non-recoverable strains in the warp and weft directions of the fabric. In addition to this measurement ("immediate deformability"), which is normally made after the immediate cycling and releasing of the stress from a 2 cm wide sample, the deformability was also measured in the present case after the fabric had been kept under the stress (4 kgf) for a period of 5 min, this deformability being designated as the "delayed deformability".

Pilling:

The pilling propensity of the fabrics was assessed by means of two different methods employing two different types of instruments: The first test was carried out on a Martindale tester, on which fabric samples were rubbed self on self, under a head weight of 800 gf. Observations were made at intervals of 50 cycles, up to 2 000 cycles. Five samples from each fabric were tested and their appearances were subjectively evaluated in the range of 1 (most pilled) to 5 (best, unchanged compared with the original fabric).

The second series of tests was carried out in an Atlas Random Tumble Pilling Tester, according to the recommended ASTM method (Standard Method of Test D1375 – 64, section F). Six specimens were tested from each fabric, one set for a tumbling period of 30 min and a second set for a period of 60 min. In addition to the subjective rating of pilling (assigning numbers in the range of 1, to 5), the density, air-permeability and bursting strength before and after tumbling were also measured, and the percentage change in these properties, due to tumbling, was calculated. Similar tests were also carried out on samples cut from fabrics which had previously been subjected to a 48 min washing cycle in a Cubex. Again, evaluations after tumbling included appearance rating and the percentage change in density, air-permeability and bursting strength of the washed fabrics.

Abrasion resistance:

The testing of fabrics produced from wool blend yarns to end point is very often meaningless as a two stage process is involved: First the wool component is worn out. Sometimes this is accompanied by 'frostiness' or change of colour. Then the stronger fibre is abraded until failure or holes are formed. Different types of abrasion tests therefore simulate different aspects of wear, and on choosing a certain test method the end use of the fabric should be considered. In practice a garment would more often be rejected due to a change in appearance than to the formation of a hole. By carrying out different tests, suggestions can be made as to the most suitable end uses of a certain fabric.

In addition to the flex abrasion and flat abrasion tests carried out on a Stoll Tester (according to ASTM D1175 – 64T), the Martindale test was also applied. Five samples were rubbed against a standard cloth, under a head weight of 800 gf. After 5 000 rubbing cycles the mass of each sample was determined and its appearance was noted. The test was continued and interrupted at 5 000 cycle intervals, up to 30 000 rubbing cycles, unless a sample failed and formed a hole prior to the full test period. Accordingly mass losses were determined at various rubbing cycles, and the rates of fuzz and pill formation and removal were noted.

Wrinkling Performance:

Both the AATCC crease recovery tester and the Shirley tester were used for determining the crease recovery angles of the fabrics. In the AATCC method, samples were creased for 5 min under a load of 500 gf and recovered for 5 min,

TABLE I
PROPERTIES OF YARNS

YARN	Resultant Linear Density (Tex)	Singles Twist (t.p.m.) Z	Folding Twist (t.p.m.) S	Breaking Strength		Extension at break (%)	Calculated Data	
				(gf)	(gf/tex)		Mean fibre tenacity (gf/tex)	Yarn to fibre strength efficiency (%)
All wool	41,6	696	383	281	6,8	23,8	14,0	49
Staple Blend	42,0	648	352	472	11,2	26,2	18,9	59
Core-spun	43,8	656	382	696	15,9	34,8	18,0	88
Approximate 95% confidence level	±2,0	±50	±20	±40	±0,9	±4,0	–	–

whereas in the Shirley method creasing took place for 2 min under 2 kgf with the recovery time set at 1 min. The samples were exposed to different atmospheric conditions prior to creasing: One set of fabrics was conditioned in an oven for 24 hours (at 90°C and 10% R.H.), the second set under standard atmospheric conditions (20°C, 65% R.H.), the third set at high humidity (27°C, 75% R.H.) and the fourth set was immersed in water at 20°C for 24 hours with the samples lightly squeezed between blotting paper prior to creasing. After creasing all samples were allowed to recover under standard atmospheric conditions. The main variables in these experiments were therefore: the two test methods, the four sets of atmospheric conditions, the two directions of each fabric, the three types of fabrics and the two structures.

The paired comparison method was used to assess the appearance of the fabrics after 48 min washing in a Cubex. As the appearance of the fabrics after this test was found to be most unsatisfactory, another test, involving a 3 min Cubex wash, was also carried out. These samples were then evaluated on a Wrinklemeter(2), based on the wrinkle-severity-index (H x T). The appearance of these samples was also assessed subjectively. The dry wrinkle-severity-index of the fabrics was measured after creasing samples on the AATCC – AKU tester, after these had previously been conditioned at high humidity (27°C, 75% R.H.) for 24 hours. After 1 hour of recovery all the fabrics were evaluated on the Wrinklemeter.

RESULTS AND DISCUSSION

Yarn Properties:

The properties of the yarns are summarised in Table I. As noted earlier the actual count of the core-spun yarn was slightly higher than the nominal count.

The breaking strength of the core-spun yarn was much higher than that of the all-wool yarn, with that of the staple yarn being intermediate. The calculated strength efficiency(2) was also ranked in the same order as strength.

Fabric Mechanical Properties:

The mean results of some of the tests are presented in Table II.

The number of picks and ends per cm of the finished fabrics was very close to the nominal, viz. 23 per cm, except for the fabrics from the core-spun yarns which had about 24 picks and ends per cm, respectively. Accordingly, and also in view of their higher yarn counts, the densities and cover factors of these fabrics were also slightly higher than those of the other fabrics.

The air-permeability of the twill fabrics was considerably higher than that of the plain weaves, which is in agreement with previous results observed on wool/polyester fabrics(3). In the present case the differences between these structures were, however, much larger than they were in the case of those fabrics from blends

TABLE II

MECHANICAL PROPERTIES OF FABRICS

FABRIC	Structure	Cover Factor	Density (g/m²)	Air-Permeability (cm³/sec)	Breaking Strength (gf/tex)	Fabric to Fibre Efficiency (%)	Extension at break (%)	Bursting Strength (kgf/cm²)	Stoll Flat Abrasion (Cycles to Hole)	Deformability (%)			
										Immediate		Delayed	
										Warp	Weft	Warp	Weft
All wool	Plain	22,8	217	5,6	7,4	53	34,0	9,7	233	1,0	3,3	1,9	5,1
	Twill	22,3	208	18,2	7,2	51	27,7	10,3	279	0,6	2,0	1,3	2,8
Staple Blend	Plain	22,3	219	5,0	13,0	69	42,0	14,3	299	1,0	1,7	2,0	3,0
	Twill	22,6	222	14,2	12,5	66	39,5	15,2	356	1,1	1,9	1,7	3,0
Core-spun	Plain	23,4	231	3,4	13,8	77	45,4	16,0	392	1,1	2,4	2,1	3,9
	Twill	23,4	236	14,4	14,2	79	45,6	16,6	455	1,2	2,4	2,3	3,6

TABLE III

MASS LOSS (%) AND PILLING EVALUATION – MARTINDALE TESTER
(Means of 5 samples)

FABRIC	Structure	NUMBER OF RUBBING CYCLES						Pilling Assessment*
		5 000	10 000	15 000	20 000	25 000	30 000	
All wool	Plain	3,0	4,2	5,4	6,6	7,4	14,9	4,6
	Twill	8,9	16,1	20,8	–	–	–	2,7
Staple blend	Plain	1,9	2,5	3,0	3,6	4,1	4,7	4,0
	Twill	4,8	6,5	8,6	11,2	13,2	16,0	2,4
Core-spun	Plain	2,1	2,9	3,8	4,6	5,2	6,0	4,9
	Twill	5,0	8,9	13,8	19,1	25,9	29,0	3,6

*After 2 000 cycles – 5 = best; 1 = worst of *treated* wool and polyester, in spite of the fact that the yarn twist, count and fabric sett were very similar in both studies. The higher difference in porosity of these two structures in the present case than in the previous study is not considered to be due to the differences between the nylon and the polyester components. It is more likely that this difference can be attributed to the different finishing procedures employed, since in the case of the wool/polyester blends, autoclave decatizing might have compacted, thereby decreasing the intersticial spaces more in the case of the twill fabrics than in the case of the plain weave fabrics.

Within the same fabric structures, the air-permeability was higher when the density was lower, in agreement with previous results obtained on wool/polyester blends[2, 3].

In accordance with the yarn tensile tests, the fabrics from the core-spun yarns had the highest tenacity, strength efficiency and bursting strength, and also gave the best resistance to flat abrasion. No significant differences were found between the results of the tensile tests of the plain weaves and the twills, and only the extension at break of the all-wool twill was lower. The flat abrasion resistance of the twill weaves was almost 20% higher than that of the plain weaves.

The results of the "immediate" and "delayed" deformabilities are also included in Table II. The fabric samples were subjected to an ultimate stress of 4 kgf on 2 cm wide samples, viz. a stress of about 2 gf/tex. It should be realized that this stress can cause much higher non-recoverable deformations in the all-wool fabrics, as it represents almost 30% of its breaking stress, while it only represents 13% to 16% of the breaking stresses of the stronger blend fabrics, and therefore, can cause smaller deformations which are much more easily recoverable. In all cases the "delayed" was higher than the "immediate" deformability and the deformability was lower in the warp directions. The fabrics from core-spun yarns tended to have slightly higher deformabilities than the intimate blend fabrics in spite of the stress being relatively greater in the latter case (16% against 13%). Comparisons between the blend fabrics and the all-wool fabrics do not appear to be valid under the present test conditions, and further studies are envisaged in which the applied stresses will vary in proportion to the breaking stress of the fabrics.

Abrasion Resistance and Pilling:

In the flex abrasion tests, the results of which have been omitted, the all-wool plain weave fabrics ruptured after about 660 cycles and the all-wool twill fabric after about 800 cycles. Even after 3 500 cycles all the wool/nylon blend fabrics did not fail and they can, therefore, be regarded as very resistant to flex abrasion.

The percentage loss in mass, as a function of the number of rubbing cycles on the Martindale abrasion tester, is given in Table III, and the appearance of some abraded samples after 30 000 cycles can be assessed from Figure 1.

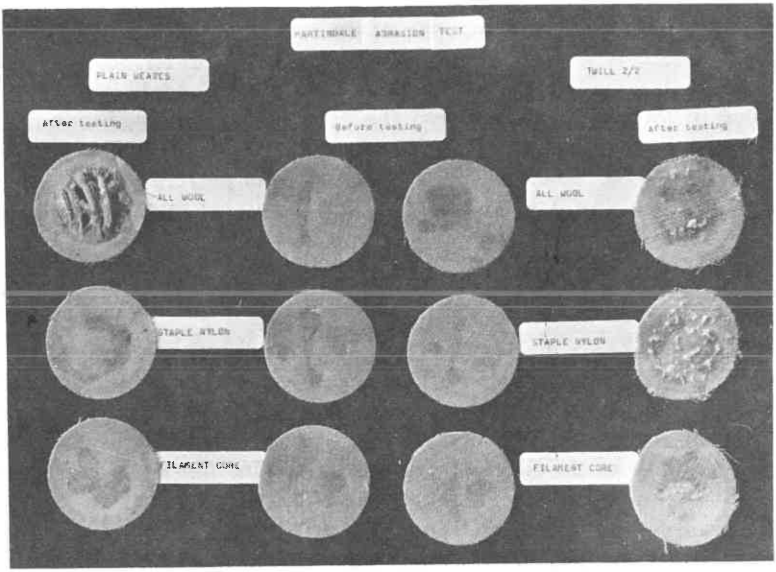

FIGURE 1

Appearance of certain of the fabrics before and after the Martindale abrasion test (30 000 cycles)

From the results it is clear that the three twill fabrics had the highest mass losses. In the case of the all-wool twill fabric the test had to be terminated after 15 000 cycles, when large holes had formed. Large pills were formed on the surface of the wool/nylon staple blend twill fabric and as the test proceeded the pills became discoloured as the orange dyed wool fuzz came off and the undyed nylon fibres remained attached to the fabric. On the other hand, the wool/nylon twill fabric containing the core-spun yarns hardly showed any sign of pills throughout the test, in spite of its mass loss being higher at all stages than that of the staple blend. This fabric became considerably discoloured towards the end of the test, however. The final mass loss (29%) of the twill fabric from core-spun yarns was apparently due to the loss of the wool fibres which were removed with the nylon filament cores remaining intact. In spite of their higher mass loss, the core-spun yarns produced fabrics which would most probably have a much better appearance after wearing than the staple blends, due to the excessive pilling of the latter. The same trends could also be observed when the three plain weaves were compared, but the effects of the abrasion test were much smaller.

The results of the Martindale abrasion tests were contrary to the flat and flex abrasion results obtained on the Stoll tester, where the twill fabrics performed

TABLE IV

TESTS RESULTS – RANDOM TUMBLE PILLING TESTER

FABRIC		ALL-WOOL		STAPLE BLEND		CORE-SPUN	
Test	**Pilling (min)**	**Plain**	**Twill**	**Plain**	**Twill**	**Plain**	**Twill**
Pilling Assessment							
Before	0	5	5	5	5	5	5
Washing	60	4,8	4	4,2	4,2	4,8	4,5
% decrease		4	20	16	16	4	10
After	0	4,2	1,5	4,2	1,5	4,4	2,5
Washing	60	3,7	1	3,6	1	3,8	1,2
% decrease		12	33	14	33	14	52
Air-Permeability (cm^3/sec)							
Before	0	5,6	18,2	5,0	14,2	3,4	14,4
Washing	60	7,5	20,1	6,1	19,1	4,0	15,3
% increase		34	10	22	35	18	6
After	0	6,3	16,0	5,9	15,7	3,7	15,0
Washing	60	5,9	15,0	6,0	15,7	3,7	15,3
% increase		*	*	*	*	*	*
Bursting strength (kgf/cm^2)							
Before	0	9,7	10,3	14,3	15,2	16,0	16,6
Washing	60	9,6	10,2	14,1	14,8	14,4	16,3
% decrease		*	*	*	3	10	*
After	0	10,3	10,7	14,5	14,0	16,2	16,0
Washing	60	10,2	10,6	14,3	14,0	15,6	15,5
% decrease		*	*	*	*	4	3
Density (g/cm^2)							
Before	0	217	208	219	222	231	236
Washing	60	210	204	214	216	227	236
% decrease		*	*	*	3	*	*
After	0	225	288	220	274	239	281
Washing	60	223	286	220	261	235	275
% decrease		*	*	*	5	*	*

* Non-significant change

better than the plain weaves. It should be noted, however, that different abrasion mechanisms are involved in the two tests. The twills seem to be more resistant to flexing and bending wear, or at any rate their point of failure is reached at a later stage than in the case of plain weaves. However, due to the higher yarn floats present in twill fabrics, fibres are more readily removed when exposed to flat abrasion, resulting in the appearance becoming unacceptable at a much earlier stage than in the case of plain weave fabrics. The benefits gained, therefore, with the inclusion of 20% nylon, which increases the abrasion resistance of the blend, can sometimes be accompanied by an increased pilling propensity.

The subjective ratings of the appearance of the fabrics after the Martindale pilling tests are also included in Table III, the samples in this test having been rubbed against the same fabrics (forming a more mild abradant than the standard cloth used in the Martindale abrasion test). Pilling was assessed subjectively, after 200, 500, 1 000 and 2 000 cycles, in order to observe pilling formation and removal throughout the test. Only the mean results after 2 000 cycles are presented in Table III. It was observed that in some cases, especially in the all-wool fabrics, fuzz and pills were formed during the test but then fell off as the test proceeded, resulting in better ratings than in the earlier stages of the test. The results, therefore confirm the results of the Martindale abrasion tests, hardly any pills being observed on the plain weaves. Fabrics from core-spun yarns showed much less pilling than those from the other yarns, both in the case of twill weaves as well as in the plain weaves.

The results of the tests which were carried out in the random tumble pilling tester are presented in Table IV, in which only the mean results after 60 min tumbling are reported. A statistical analysis, carried out on all the results and including all the individual results, showed that the results obtained after 30 min tumbling did not differ significantly from those obtained after 60 min. In the unwashed fabrics, the pilling assessment was much less sensitive (i.e. higher variability of the data) than in the case of the Martindale pilling test results. In the random tumble pilling test the rating of the fabrics from the core-spun yarns was slightly better than those of the other fabrics, and the twill fabrics were rated as only slightly worse than the plain weaves. The severe washing had caused considerable felting shrinkage and the appearance of the fabrics, in particular that of the twill fabrics, was totally unacceptable. After tumbling the appearance of the washed fabric was further worsened by additional fuzz and pill formation. The subjective rating was thus masked by the effect of washing and could not provide accurate mean results. The air-permeability of the unwashed samples had increased after tumbling, the increase being highest in the staple fibre blend fabrics, while after washing no significant changes due to tumbling could be detected. The measurements of the bursting strength did not provide any further information and the slight increases in strength after washing were mainly due to the increases in the fabric densities and compactness as a result of shrinkage. No significant losses in mass could be detected after 60 min tumbling.

TABLE V

BENDING, SHRINKAGE AND WRINKLING

FABRIC	Structure	Flexural Rigidity (mgf-cm^2 per cm)	Owen's Bending Test			Drape Coefficient (%)	48 Min Washing		Wrinkle Severity H x T (mm x 10^4)	
			Mo (mgf-cm per cm)	B (mgf-cm^2 per cm)	Mo/B (cm^{-1})		Area Shrinkage (%)	Density Increase (%)	After 3 min washing	Dry, AKU 1 hour recovery
All-wool	Plain	92	12,7	75,2	0,17	52,5	7,3	3,7	43,3	22,2
	Twill	98	22,6	72,7	0,31	49,0	28,0	38,5	67,3	17,7
Staple Blend	Plain	107	26,8	76,4	0,35	55,3	5,2	0,5	41,0	17,1
	Twill	99	29,0	67,0	0,43	50,6	18,8	23,4	61,3	14,6
Core-spun	Plain	119	23,9	77,8	0,31	56,8	2,7	3,5	36,4	15,6
	Twill	109	37,5	75,4	0,51	48,8	14,3	19,1	56,2	12,7

Wrinkling and Bending:

The results of the bending and wrinkling tests are given in Table V. The bending lengths of the various fabrics did not differ significantly, although it was slightly higher in the case of fabrics from core-spun yarns, their flexural rigidities being also slightly higher, due mainly to their higher densities. The frictional couples as measured by Owen's bending test were generally higher than those found previously for autoclave decatized fabrics of similar blend ratios. It was higher in the twill fabrics than in the plain ones, in agreement with previous results(3), but the differences between the two structures were greater in the present study. The residual curvature also followed similar trends. Only small differences in the drape coefficients were found, in accordance with the flexural rigidity results as obtained by the cantilever and owen's method.

The appearance after 48 min Cubex washing was worse in the case of the twill fabrics as a result of their much higher area shrinkage and density increase. The plain weaves appeared wrinkled but surface felting was still of an acceptable level in the case of the blend fabrics with very little surface felting occurring in the case of the all-wool plain weave. The appearance of the plain weave fabric from core-spun yarns rated best of all – the subjective assessment also being confirmed by the measured results. The same trends were also observed after a 3 min Cubex washing, where the lowest wrinklemeter readings were obtained on the plain weave fabrics, especially on the fabric consisting of core-spun yarns. The correlation coefficients between area shrinkage, density increase and wrinkle severity after washing were all highly significant.

Whereas the plain weaves performed best *after* washing, the twill weave fabrics rated best in the *dry wrinkling test.* Again, the fabrics from core-spun yarns were best, being slightly better than the fabrics from staple blends. It is, however, possible that this advantage is also due to the slightly higher densities of the fabrics from core-spun yarns. The higher capacity of the twill fabrics to recover from dry creasing can be clearly observed from these results.

The results of the crease recovery angles are summarized in Table VI. The trends observed in the washing and dry wrinkling tests could not be substantiated by the results of the crease recovery angles. The fact that no straightforward relationship between recovery angles and durable press rating could be established has already been discussed elsewhere(6). The different test conditions cause different amounts of swelling which in turn affects wrinkle resistance and recovery, so that it is difficult to compare the results of one test with those of another, especially when testing different fabrics. A full analysis of variance was carried out on all the test results. The main factors were the test methods (2), the atmospheric conditions (4), the types of fabrics (3) and the structures (2). As in each case 4 warp and 4 weft samples were tested, the total number of observations was equal to $2^3 \times 4^2 \times 3 = 384$. The analysis was carried out on the main factors and on their 1st, 2nd, 3rd and 4th order interactions. The significant sources of variance are listed in Table VII, while the non-significant factors have been omitted.

TABLE VI

CREASE RECOVERY ANGLES, (W + F) (°) : S = SHIRLEY METHOD, A = AATCC METHOD

FABRIC	Structure	CONDITIONED AT:							
		Dry, 90°C, 10% R.H.		Standard, 20°C, 65% R.H.		Humid, 27°C, 75% R.H.		Wet, 20°C, 100% R.H.	
		S	A	S	A	S	A	S	A
All-wool	Plain	260	300	298	314	272	279	283	257
	Twill	290	302	317	325	300	294	243	233
Staple Blend	Plain	256	290	297	313	271	285	265	248
	Twill	272	295	305	321	295	295	253	227
Core-spun	Plain	246	292	297	318	273	280	265	250
	Twill	270	302	304	317	287	284	251	236

TABLE VII

SUMMARY OF THE ANALYSIS OF VARIANCE CARRIED OUT ON THE CREASE RECOVERY ANGLES

Source of Variance	d.f.	Variance	'F' Values
Test Methods (T)	1	1789,7	24,8***
Conditions (C)	3	13370,8	185,3***
Fabric Type (F)	2	269,8	3,7*
Structures (S)	1	745,4	10,3**
T x C	3	2133,8	29,6***
C x S	3	1381,6	19,1***
T x C x S	3	218,1	3,0*
Residual	288	72,16	$\sigma = 8,5$
Total	383	207,50	

* = Significant at the 5% level of confidence
** = Significant at the 1% level of confidence
*** = Significant at the 0,1% level of confidence

It can be seen from the analysis that there are extreme variations when the atmospheric conditions vary. While the Shirley test results are lower under dry and standard conditions, they become higher than the AATCC test results when the fabrics are exposed to higher humidities, viz. the test methods show a strong interaction with the atmospheric conditions before creasing. The differences between the all-wool and the blend fabrics are smaller in comparison with the differences due to the former two sources of variation, and the crease recovery angles of the all-wool fabrics are slightly larger than those of the blends.

Summary of test results obtained on autoclave decatized fabrics:

From some of the previous results the impression was gained that the set applied to the fabrics had not been completely effective. Fabric samples were therefore autoclave decatized, at a pressure of 2 kgf/cm^2 (132°C) for 4 minutes, subsequent to the finishing procedures described under "Experimental" and certain of the tests were repeated on these fabrics.

In general it was found that the autoclave decatizing decreased the thickness and physical properties of the fabrics without effecting a significant improvement in the other fabric properties such as crease recovery, shrinkage due to washing and appearance after washing. It is therefore concluded that in this instance autoclave decatizing did not effect a noticeable improvement in the performance of the fabrics which had been finished as detailed under "Experimental". On the contrary a deterioration in the physical properties (bursting and tensile strength) of the fabrics was evident. This effect was, however, not very large.

CONCLUSIONS

By introducing 20% polyamide fibres into the yarns the tensile properties and abrasion resistance of wool/nylon blend fabrics are improved considerably, and the washing shrinkage is reduced. In the present series of fabrics, however, improvements in *fabric appearance* after washing were relatively small. Although the dimensional stability of the *twill blend* fabrics was inferior to that of the *plain* weaves, they were better than the all-wool twills in this respect. The plain weave blend fabrics in the present study rated worse than some 88/12 wool/nylon core-spun yarn fabrics which were studied previously.

The *plain weave* fabrics showed a much better resistance to flat abrasion and pilling than the *twill structures*, with the blends always performing better than the all-wool fabrics. The pilling propensity of the twill blend fabrics was high, with a marked difference between the two types of blends. In the fabric containing the staple blend, the pills remained attached to the surface of the fabric because of the good resistance to abrasion and flexing of the nylon fibres, while the appearance of the fabric from the core-spun yarns was only discoloured with very few pills apparent on its surface as a result of the wool fibre covering being rubbed off.

The twill fabrics recovered better from creasing under dry test conditions, while in the wet state, their recovery was less than that of the plain weaves made from the same yarns. The crease recovery angles depended upon the times and stresses applied as well as upon the atmospheric conditions before creasing. If the test methods differ in creasing time, recovery time, load and atmospheric conditions, comparisons between results obtained when testing different fabrics are inadequate and no conclusions can be drawn.

Subsequent autoclave decatizing at 2 kgf/cm^2 for 4 minutes did not effect a noticeable improvement in the wrinkling performance of the fabrics while in all the fabrics a decrease in strength was evident.

There were indications that fabrics made from core-spun yarns undergo non-recoverable deformations when subjected to stresses, i.e. show a 'bagginess' effect, more so than fabrics made from staple blends. Further studies are necessary, however, in which the absolute stresses and their times of application will be varied to confirm the present results.

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PROPRIETARY NAMES

The fact that substances with proprietary names have been used in this investigation does not imply that there are not others equally good or better.

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