

THE COMPARISON OF THE WEARING QUALITIES OF SIMILAR  
BRANDS OF SILK AND NYLON HOSIERY

by

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## INTRODUCTION

Silk has been the traditional fiber for women's full-fashioned hosiery for about two decades and consequently little thought was given to its replacement or to the idea that any fiber would be preferred for this purpose. Today nylon is the choice of many women for full-fashioned hosiery.

Nylon was first used in hosiery because women had come to demand stockings that would give them glamorous sheerness without sacrificing durability. Nylon's unusual beauty and strength made possible that combination of qualities to a remarkable degree (4). Nylon hosiery appears  $1/2$  to 1 thread sheerer than the equivalent silk hose (13).

Hosiery always has taken a large share of the average woman's clothing budget. In 1939, the average woman purchased about 15 or 16 pairs of hose during the year, which meant that 1.16 dozen pairs per capita were used (25).

During the first half of 1940 all silk hosiery accounted for 76.1 per cent of all the full-fashioned hosiery produced while nylon accounted for only three per cent. During the second half of 1940 the silk hosiery production dropped to 73.7 per cent while nylon climbed to 9.1 per cent of all full-fashioned hosiery manufactured. Silk production continued to fall during the first half of 1941 to 64.8 per cent, during the third quarter to 52.8 per cent and the fourth quarter to 23.3 per cent; all nylon hose during this same time were rising to

16.2 per cent, 19.1 per cent, then dropped to 13.2 per cent respectively. During the third and fourth quarters of 1941, nylon hose with cotton or rayon welts and feet accounted for 1.4 per cent and 13.2 per cent, respectively, of the production. Silk was also used in combination with cotton or rayon (18). From the beginning nylon has sold for a higher price than silk.

This study was made to compare by actual wear and laboratory tests the wearing qualities of silk and nylon hosiery of the same brand and to determine whether the wearing qualities of nylon hose justify their cost.

#### Silk for Hosiery

Silk is the name of the fiber secreted and spun by the silkworm. When in the caterpillar stage the silkworm secretes a fluid, which becomes silk as soon as it comes in contact with the air. After spinning its cocoon, the silkworm changes into the chrysalis stage from which it develops into a moth, ready to break through the cocoon. When the moth pierces the cocoon, it breaks the silk fibers; thus in order to save the silk, the worm is killed by heat before it reaches the moth stage. After the silkworms are killed, the cocoons are soaked in water to soften the sericin or gum so that they may be unwound. The reeling process is the unwinding of the cocoon and rewinding the silk on a reel into large skeins. Silk arrives in this country in the raw state, ready to be "thrown" or spun into usable form. After throwing, the silk is wound on spools ready to be twisted (10).

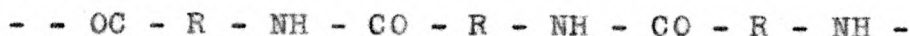
Twisting is the process of turning two or more threads of the silk together. Silk, having a great number of twists per inch, is known as "high twist" (11). A hose having a "crepe" twist is one in which the yarn is composed of two cords with 60 to 75 turns, one right and one left, doubled with two and one-half to five turns right twist per inch (20). High twist and crepe stockings are more resistant to snags than low twist yarns; they are also sheerer and duller than the low twist yarns (11).

#### How Nylon Was Developed

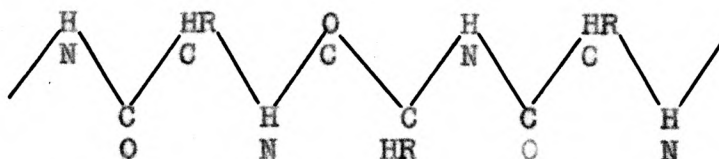
In 1928, the E. I. du Pont de Nemours Company started the research on polymerization or the formation of giant molecules, technically known as "superpolymers" from small molecules. The late Dr. Wallace H. Carothers (1896-1937) was the chief chemist in charge of this research (14). From experiments it was shown that certain small molecules could be made to unite in such a way as to form giant molecules of great length or linear superpolymers in which the small molecules were joined together end to end. Research continued until October, 1938, when the du Pont Company announced the development of new synthetic superpolymers. From these, textile fibers could be spun which surpassed in strength and elasticity any previously known textile fiber. This new family of materials was called nylon. Nylon is officially and scientifically defined as "a man-made protein-like chemical product (polyamide) which may be formed

into fibers, bristles, sheets, and other forms which are characterized, when drawn, by extreme toughness, elasticity, and strength" (23).

Nylon is similar to wool and silk fibers in molecular structure. The structure of a linear polymer is typified as



where R represents several  $CH_2$  groups. The structure of silk and wool is



These fibers differ from the cellulose fibers in that they contain the carbon-nitrogen linkage, while the cellulose fibers possess the free hydroxyl groups in their molecular structure (9).

The superpolymers which make up the polyamide family, to which the name nylon has been given, can be made in several ways. One of the simplest involves the reaction of a dibasic acid with an organic diamine. The reaction, resulting in the formation of relatively small molecules, is followed by heating to bring about the union of many of these small molecules to give the giant polyamide molecules. The raw products used for one type of nylon are a dibasic acid derived from phenol and a diamine likewise derived from phenol. Oxygen from the air is also used in making the dibasic acid and ammonia is used in making the diamine. Since phenol is derived from bituminous coal,

and ammonia is made synthetically by causing hydrogen from water to unit with nitrogen from air, this nylon is derivable from coal, air, and water (23).

As nylon is drawn from the spinneret the desired number of filaments are twisted together two turns per inch to form one thread. The thread is then stretched to four times its original length, thus reducing the twist to one-half turn per inch. This process is important as it removes a large percentage of elongation which if left would be detrimental, as nylon will not recover until it is stretched to a certain degree (21).

In order that the yarn may be handled and wound without injury, an additional twist of two turns per inch is added and about one-half of one per cent size is put on the yarn. Nylon differs from silk in that it must be sized before knitting. The size should be rapid drying, easy to handle, safe, and economical. The objective to be accomplished by the sizing operation is to give the nylon fiber the protective covering that the silk has naturally in the form of sericin (21).

#### Properties of Silk and Nylon

The qualities possessed by silk that make it desirable for stockings are its strength, great length, elasticity, its pleasing texture, and the luxurious appearance of the finished product (10).

Nylon is crystalline. Little force is required to accomplish a four-fold increase in length through stretching the filaments. The new length and decreased diameter are permanent.

Nylon shows great elasticity. When a sample was stretched four per cent, held for 100 seconds, and measured 60 seconds after the load was released, nylon showed a recovery of 100 per cent as compared to 50 per cent for silk and acetate rayon, 40 per cent for cordura rayon, and 30 per cent for viscose rayon (9). The silk fiber will stretch 15 to 20 per cent of its original length in the dry state before breaking (15).

The breaking strength of nylon is five g. per denier dry as compared with 4.5 g. per denier for silk, 3.3 g. for cordura rayon, 1.75 g. for viscose rayon, and 1.50 g. for acetate rayon.

Nylon yarn and fabrics are practically nonflammable (9). When nylon, wool, silk, viscose rayon and cotton were suspended vertically over a gas pipe burner and ignited simultaneously, the cotton was consumed in 20 seconds, viscose rayon next, and silk soon after. The wool and nylon were not ignited. The nylon softened and melted, but showed no tendency to burn (12).

Under favorable conditions silk will absorb 30 per cent of its weight in moisture and still appear dry (15). Silk decreases about 20 per cent in strength when wet, but regains its original strength upon drying (8). Nylon absorbs less water at 60 per cent relative humidity than silk, wool, viscose and acetate rayons (9).

But nylon has not as yet proved the perfect hosiery fiber. Some disadvantages that have been noted are that nylon feels cold and clammy; because it does not absorb moisture, it is resistant to perspiration and may cause discomfort and contribute to allergic conditions. The advantages of nylon are



its tenacity and elasticity and its adaptability to knit well and give good service. It resists abrasion and snags do not break easily. It takes dyes uniformly and produces products of pleasing appearance (16). The grade of silk used determines the appearance, elasticity, the evenness of texture and wearing qualities of the hose.

### Manufacture of Hosiery

As the knitting machines have been devised for the use of silk, nylon had to be adapted to these machines. Full-fashioned hosiery is knitted flat starting at the top or the welt. The leg from the top to and including the heel is knitted on a machine called the "legger." When the heel is completed the loops of yarn are transferred by hand to the machine known as the "footer," which knits the foot. To obtain a uniformity of stitch, experience has shown that for best results the yarn should be knit wet. The yarn travels from the back of the machine to the needles through guides immersed in water. As the knitting continues on the foot, reinforcing threads are introduced in the sole and toe. The completed stocking is looped at the heel and toe and seamed down the back and bottom of the foot. The stockings are now ready for the final processes of manufacture.

Nylon hose must be boarded before as well as after the dyeing process to prevent the hot dye from setting the nylon in creases which cannot be removed. Silk is boarded after the

dyeing process only (24). After removal from the boards, the nylon hose are put into dye nets and scoured to remove the spinning and knitting emulsion and at the same time to promote a better affinity for the dyestuffs (24). Silk is scoured to remove the sericin.

The stockings must not dry before dyeing. Nylon is difficult to dye with the ordinary dyestuffs used for the natural fibers and the rayons other than acetate. Neutral acid dyes are generally used on silk and with some success on nylon. Acetate dyes are better and fastness to light is practically the same on nylon hosiery as on commercially dyed silk hosiery (24). Acetate colors for dyeing are adsorbed from the solution with avidity and level on nylon more effectively than any other dye on any other fiber. Hosiery shades are generally compound colors produced by the use of two or more dyestuffs (16).

Great care is required in the finishing of nylon hosiery. The finish must be primarily a filler which increases snag resistance as nylon is smoother, finer, and slips easier in the loop of knitting than silk.

The dullness in silk which is obtained with delusterants is not necessary in nylon as delustering is an inherent part of the process. Splashproofing and waterproofing which are now done on silk are not necessary on nylon. Most silk finishes that were tried were found to be adequate only when a high concentrate was used (24). Thermoplastic resins are used as finishes for nylon as they protect the material from chafing and reduce the tendency to snag.

## REVIEW OF LITERATURE

No studies have been found on the serviceability of nylon hosiery except those reported by the producer. A number of studies have been made on silk hosiery.

In 1929, 100 Wellesley college and 100 Radcliffe college girls wore hose manufactured by the Dexdale Hosiery Mills that were their special brand of chiffon weight, 5-thread, 42 gauge full-fashioned, as well as two other brands of the same color, quality, size, and gauge (19). Records were kept of the hours worn. Each pair was laundered daily after each wearing. It was concluded from this study that the girls at Radcliffe secured 67 hours average wear, while the girls at Wellesley secured 75 or more hours average wear.

Richardson and Baker (19) made a survey in Montana dealing with selection, care, and wearing qualities of women's silk hosiery. The conclusions drawn from this study showed that 250 women chose 46 brands of hose, 10 of which were most popular, and that 24 pairs a year were most frequently purchased. The average wearing time for all service weight hose was 320 hours; for semi-service, 243 hours; and for chiffon, 79 hours.

In a study of 253 pairs of hose, Anders (1) reported that 2-thread hose were worn an average of 10 times; 3-thread, 18 times; and 4-thread, 20 times. The average cost per pair was \$ .92. More hose were purchased at \$ .79 than at any other price.

Gephart (6) reported on the serviceability of silk hosiery by obtaining data through questionnaires and record sheets from a group of college students and a group of graduate students and faculty members at Kansas State College. She concluded that serviceability was the most important factor affecting the purchase of hose. The average cost of hosiery worn by the 169 women was about \$ .067 per day. Three-thread hose cost 1.3 per cent more than the 4-thread per day. Students that wore 3-thread hose obtained 11.4 days wear while the professional group obtained 11.5 days wear from each pair. The total 169 pairs were worn an average of 17 times per pair. The average number of launderings was 15.6 times per pair.

#### PROCEDURE

Four popular brands of hosiery were selected for study, namely: Phoenix, Holeproof, Belle Sharmeer, and Van Raalte, to be designated hereafter as brands A, B, C, and D, respectively. The original plans were to have six pairs each of the silk and nylon of the four brands, but due to the length of time required to wear out the hose and the restrictions imposed upon the sale of the nylon, a smaller number was used in brands A, C, and D.

A total of 22 pairs of silk and 17 pairs of nylon hose were purchased; of these one pair of silk and nylon of each brand was used as a control. Five pairs of silk and two pairs of nylon of brand A; five pairs each of silk and nylon of brand B; three pairs each of silk and nylon of brand C; and five

pairs of silk and three pairs of nylon of brand D were worn by the four different people. All of the hose of one brand were worn by the same person. The hose were chosen for each individual taking into consideration the foot size and leg length. The silk hose were of a weight designated as 3-thread, the nylons a 30 and 40 denier.

Each person kept a record of hours worn and kinds of failure. The same directions for laundering and care of the hose were given to each person. The record chart and the directions for laundering are given in the appendix. The hose were worn out when each person considered them no longer fit to wear because of runs and holes.

The hosiery were analyzed to determine fiber content, count of wales and courses, filament count, weight in grams of the control and worn hose, measurements before and after wearing, denier, type of dye, bursting strength, color and fading.

The fiber content of the hose and the seaming thread were determined by the burning test.

By using the thread counter the number of wales to an inch and one-half was determined. The readings were taken distributed throughout the length of the stocking as welt, below the welt, calf, ankle, and instep. Likewise, the number of courses to one inch was determined.

The number of filaments in the yarn was determined by untwisting a short length of yarn and pulling out each filament separately, laying it on black velvet and counting it under the microscope.

The control and worn hose were weighed at standard conditions to the nearest tenth of a gram. Each hose was weighed separately and the two together.

The hose were measured in 13 places before and after being worn. The silk hose after being worn were dampened and pinned to muslin in the shape approximating the original. The stockings were laid on a flat surface and measured to the nearest eighth of an inch, in the following places: length of the leg from the top of the welt to the bottom of the heel; length of the foot from the toe to the heel; width of the sole reinforcement on one side of the seam at the instep; height of the heel splice; width of the heel splice on one side of the seam at the top; width of the leg at the ankle, the calf, one inch below the welt, and at the top of the welt; width of the welt; and width of the runguard or flare (Fig. 1).

The denier of the yarn used in the leg of the hose was determined by raveling the stocking to obtain 123 yards of raveled yarn. This yarn was measured by applying sufficient tension to take out the waviness, and winding on a reel. The yarn was dried at a temperature of 110° F. to constant weight, and the denier was calculated.

The type of dye used on each of the hose was determined according to the methods described by Clayton (3) and Green (7).

The bursting strength of the hose was determined by using the Mullen Tester. Ten tests were taken at the knee on both the control and worn hose. Ten tests were made at other places

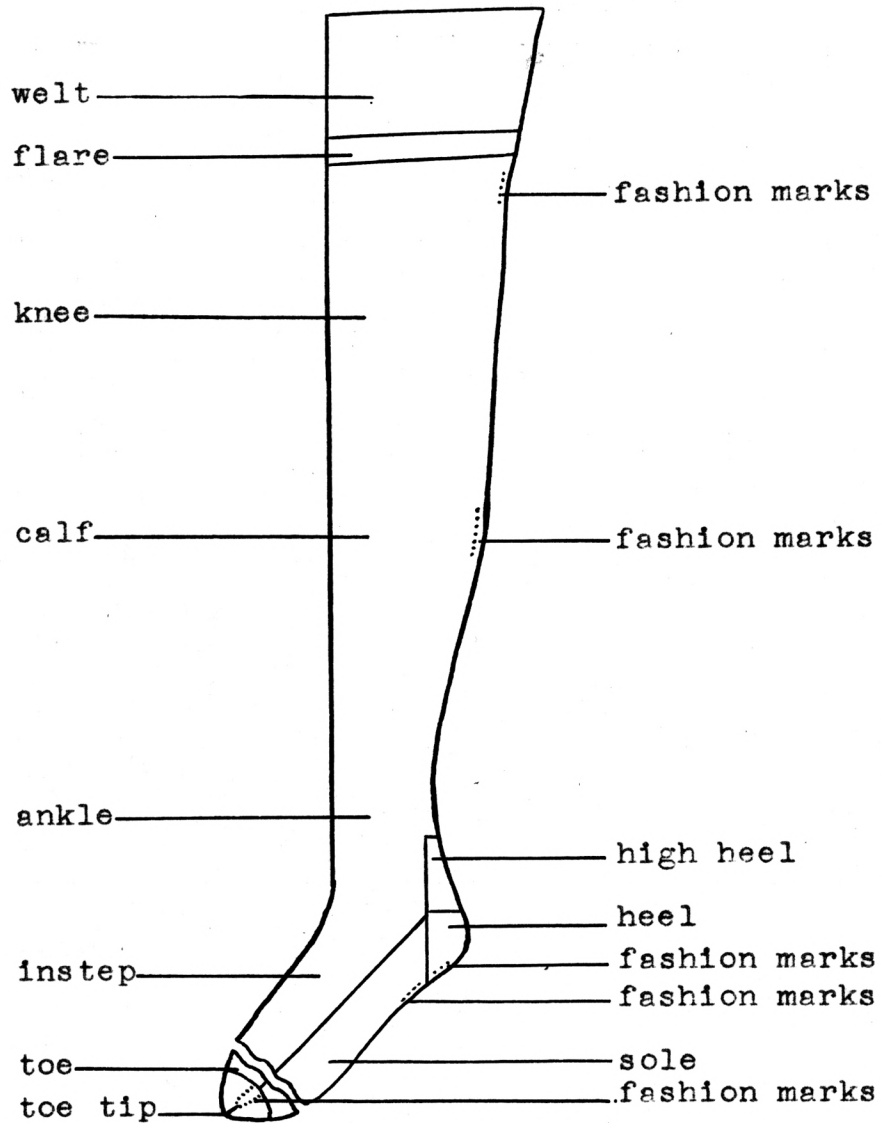


Fig. 1. Diagram showing the various parts of the hose.

on the leg on both the control and the worn hose. On the control, two tests were made on the welt, ankle, and the heel, and one test on the toe.

The color attributes of the hose before and after wearing were determined by using the HSB Color Analyzer (2). The indices of fading were calculated by using Nickerson's formula:

$$I = (C/5 d2H) + 6dL + 3dC \quad (17).$$

## FINDINGS AND DISCUSSION

### Physical Characteristics

The brands, prices, and physical characteristics of the hosiery studied are given in Tables 1 and 2, which show that the cost of the silk hose for brands A, C, and D was \$1.00 per pair; for brand B, \$1.15 per pair; that of all the nylons was \$1.35 per pair.

In the leg of the silk hose, the fiber content was found to be all silk. The seaming thread in three brands was 3-ply cotton and in the other brand 2-ply cotton and one strand silk. The nylon hose were knit of 100 per cent nylon while the seaming thread was made up of three strands of nylon in all brands.

The number of wales per one and one-half inches of the knitting frame, known as the gauge, of the silk hose was 45 as labeled but found experimentally ranged from 57.2 to 57.8. The gauge of the nylon hose as labeled was 45, but experimentally ranged from 51.0 to 56.2. The stockings are generally knitted on a fourteen inch needle bar, and are finished to slightly over 12 inches around the top of the stocking, thus accounting for the increase in wales.



Table 1. Price and physical characteristics of four brands of silk hosiery.

Brand and pairs	Price		Weight of worn hose			Denier or thread		Wales or gauge		Courses		Seaming	Fiber	Stitches per in.	Fila- ment count	Dye
	per pair		Single	Single	Pair	Exper.	Labeled	Exper.	Labeled	Exper.	Labeled					
	Whole-	Re-	Single	Single	Pair	Exper.	Labeled	Exper.	Labeled	Exper.	Labeled					
	sale	tail														
A-Phoenix																
Control	\$1.00		11.3	11.5	22.8	31.5D	3	57.2	45	46.1	47	1 strand silk	15.6		30	Acid mordant
1			10.9	11.4	22.3		30 turns					2 strands cot-	15.3			
2			11.2	11.3	22.5		per inch					ton	15.1			
3			11.1	11.0	22.1								14.6			
4			11.3	11.3	22.6								15.2			
5			10.8	10.9	21.7								15.1			
B-Holeproof	.70	1.15														
Control			11.7	11.6	23.3	31.6	3	57.8	45	44.4	50	2 ply cotton	15.0	17	24	Neutral dyeing acid
1			11.6	11.9	23.5		0-50-50/50						16.1			
2			11.9	11.5	23.4		left twist						15.8			
3			11.6	11.6	23.2								16.4			
4			11.2	11.9	23.1								15.8			
5			11.6	11.5	23.1								16.4			
C-Belle Sharmeer	.69	1.00														
Control			11.1	10.8	21.9	31.05D	3	57.5	45	44.8	49	3 strand cot-	17.6	17-18	30	Acid mordant
1			10.9	10.9	21.8							ton	17.4			
2			11.1	11.0	22.1								17.8			
3			10.8	11.2	22.0								17.2			
D-Van Raalte		1.00														
Control			10.2	10.3	20.5	31.6	3	57.7	45	47.0	50	3 strand cot-	14.9	20	30	Acid mordant
1			10.2	10.4	20.6							ton	15.7			
2			10.0	10.3	20.3								15.7			
3			10.0	10.3	20.3								16.8			
4			9.6	9.6	19.2								15.5			
5			10.2	10.1	20.3								14.5			

Table 2. Price and physical characteristics of four brands of nylon hosiery.

Brand and pairs	Price		Weight of worn hose			Denier or thread		Wales or gauge		Courses		Fiber	Seaming		Fila- ment count	Dye
	per pair		Single	Single	Pair	Exper.	Labeled	Exper.	Labeled	Exper.	Labeled		Stitches per in.	Exper.		
	Whole- sale	Re- tail														
A-Phoenix Control	\$1.35		9.7	9.8	19.5	32.4D	30D	56.2	45	50.0	48	3 strands nylon	17.3		12	Developed
1			9.7	9.8	19.5								15.4			
2			10.1	10.1	20.2								16.1			
B-Holeproof Control	.76	1.35	12.3	12.2	24.5	45D	40D	54.3	45	48.0	49	3 strands nylon	15.6	18	13	Acetate developed
1			12.5	12.3	24.8								17.0			
2			12.5	12.4	24.9								16.0			
3			12.2	12.2	24.4								16.2			
4			12.2	12.2	24.4								16.4			
5			12.8	12.6	25.4								16.7			
C-Belle Sharmeer Control	.81	1.35	11.4	11.3	22.7	44.1D	40D	51.0	45	44.4	46	3 strands nylon	19.2	17-18	13	Developed
1			11.1	11.1	22.2								18.7			
2			11.1	11.2	22.3								18.7			
3			11.2	11.1	22.3								19.7			
D-Van Raalte Control		1.35	11.7	11.5	23.2	43.8D	40D	53.1	45	48.5	48	3 strands nylon	17.7	20	13	Developed
1			11.9	11.5	23.4								17.2			
2			11.9	11.9	23.8								17.2			
3			11.6	11.6	23.2								16.7			

The number of courses to one inch ranged from 44.8 to 47 for the experimental determinations and from 47 to 50 for the labeled data on the silk hose. The number of courses in the nylon hose ranged from 44.4 to 50 for the experimental data, and from 46 to 49 for the labeled.

In the yarn in the silk hose the number of filaments was 24 in one brand and 30 in the other three brands. The nylon hose had 12 filaments in one brand and 13 filaments in each of the other three brands.

In the silk hose the denier of the yarn ranged from 31.05 to 31.60. All the silk hose were of a weight designated as 3-thread. The nylon were labeled as to denier, one brand was 30, the other three brands were 40. Experimentally the denier for the one brand was 32.4; for the other three brands it ranged from 43.8 to 45 denier. The reason for the higher denier in all cases was that the experimental data was taken on yarn that had been knit, and perhaps insufficient tension was used in winding and measuring it.

The weights of the silk hose per pair, both controls and worn hose ranged from 19.2 to 23.5 grams; for the nylon hose from 19.5 to 25.4 grams. There was not much variation within brands.

The number of stitches per inch in the seam ranged from 14.5 to 17.8 for the silk hose; the number per inch from 15.4 to 19.7 for the nylon hose.

Dyes used in the silk hose were found to be neutral acid or acid mordant dyes; for the nylon, acetate or developed dyes were used.

The measurements for the silk and nylon hose are given in Table 3. The percentage of shrinkage was calculated for the length of the leg and foot. The shrinkage in both groups was comparable. For the silk hose, the percentage shrinkage for the leg varied from -1.04 to 7.7; for the foot from -2.13 to 5.39. The percentage shrinkage for the nylon hose for the leg varied from 1.61 to 8.97; for the foot from 1.70 to 5.59.

#### Bursting Strength

The bursting strengths at the knee and in the leg on the controls and worn hose of the silk and nylon are shown in Table 4. The data were analyzed by applying the t-test to the difference of the means of the silk and nylon hose (22). A probability of .05 was regarded as significant; .01 as highly significant; and .001 as very highly significant in the interpretation of differences (5).

In all cases the bursting strength at the knee was greater for the control than the worn hose. The bursting strength for the nylon hose at the knee was higher than for the silk hose. According to the data found in Table 5 for the controls, the probability of .004 indicated that the bursting strength of the nylon was highly significantly greater than the silk. The data relative to the worn hose at the knee are found in Tables 6 and 7. In the first analysis the probability was .001 indicating that the nylon was greater than the silk by a very highly significant difference. The hose were arranged according to the number of hours worn with the least number first. In the second

Table 3. Measurements in inches and percentage shrinkage of four brands of silk and nylon hosiery.

	Silk hosiery												Nylon hosiery											
	Brand A			Brand B			Brand C			Brand D			Brand A			Brand B			Brand C			Brand D		
	Before wearing	After wearing	% shrinkage	Before wearing	After wearing	% shrinkage	Before wearing	After wearing	% shrinkage	Before wearing	After wearing	% shrinkage	Before wearing	After wearing	% shrinkage	Before wearing	After wearing	% shrinkage	Before wearing	After wearing	% shrinkage	Before wearing	After wearing	% shrinkage
Length of leg	32.08	32.42	-1.04	34.44	31.77	7.70	32.25	32.16	.27	30.79	31.50	2.25	32.66	30.96	5.20	34.22	31.15	8.97	30.56	29.79	2.51	30.40	29.91	1.61
Length of foot	9.61	9.82	-2.13	10.57	10.00	5.39	9.88	9.50	3.75	9.87	9.57	3.04	10.00	9.83	1.70	10.56	10.12	4.16	10.12	10.00	1.18	10.18	9.61	5.59
Length of heel splice	4.87	4.57		4.52	4.12		4.44	3.87		4.25	3.95		4.00	4.00		5.06	4.75		4.06	3.95		4.00	4.00	
Sole reinforcement each side of seam	.87	.85		.92	.92		.81	.81		.87	1.00		.71	.81		1.02	1.15		.87	.87		1.25	1.37	
Width of foot at toes	3.12	3.05		3.10	3.07		3.00	3.04		3.06	3.07		3.25	3.25		3.22	3.33		2.90	3.41		3.28	3.17	
Width of foot at instep	3.04	2.85		2.98	3.10		2.97	2.91		2.92	2.98		3.42	3.58		3.33	3.62		3.44	3.33		3.38	3.45	
Width of ankle	3.19	2.78		3.00	3.27		2.87	2.72		3.18	2.70		3.33	3.58		3.21	3.47		3.19	3.25		3.25	3.29	
Width at calf	4.96	4.20		5.04	4.92		5.53	4.20		5.35	4.27		5.50	5.43		5.31	5.52		5.44	5.33		5.47	5.64	
Width 1 inch below welt	6.23	4.85		6.12	5.17		5.74	4.83		6.17	5.40		6.46	6.50		6.32	7.02		6.37	6.33		6.22	6.42	
Width at top of welt	6.52	6.02		6.52	6.45		5.75	6.16		6.59	5.93		7.04	7.50		6.96	7.55		6.37	7.04		6.94	7.16	
Width of heel splice (1/2)	.56	.55		.75	.80		.50	.50		.50	.60		.42	.67		.82	.82		.50	.50		.54	.67	
Width of welt	2.03	2.12		3.60	3.28		4.50	3.87		4.80	4.43		2.64	1.92		3.54	3.32		3.94	3.83		3.70	3.58	
Width of runguard	3.31	3.60		2.27	2.27		1.63	1.50		1.46	1.32		3.16	3.58		2.15	1.78		1.34	1.25		1.74	1.84	

Table 4. Bursting strength in pounds per square inch on knee and leg and the hours worn of silk and nylon hose.

Brand and pairs	Hours worn		Bursting strength on knee		Bursting strength on leg	
	Silk	Nylon	Silk	Nylon	Silk	Nylon
A						
Control			41.8 ± 1.0	48.7 ± 0.8	45.0 ± 0.5	49.9 ± 0.6
1	56.00	350.00	38.2 ± 0.8	38.7 ± 0.8	41.7 ± 1.2	37.7 ± 1.1
2	133.00	449.50	39.4 ± 1.0	37.6 ± 0.8	39.6 ± 1.3	36.9 ± 0.8
3	134.50		38.4 ± 1.0		42.3 ± 1.0	
4	135.50		40.4 ± 0.9		38.8 ± 1.1	
5	139.00		41.4 ± 1.1		41.7 ± 1.5	
Av. Brand A	119.60	399.75				
B						
Control			43.9 ± 0.7	55.2 ± 1.5	43.4 ± 0.8	52.9 ± 1.3
1	126.50	418.50	38.8 ± 1.1	44.7 ± 1.0	34.6 ± 0.5	45.3 ± 1.3
2	170.75	664.00	38.2 ± 1.7	39.0 ± 1.1	38.1 ± 1.3	44.3 ± 0.6
3	180.75	948.16	38.4 ± 0.8	43.8 ± 1.2	37.8 ± 1.6	44.0 ± 1.0
4	191.25	1019.50	40.5 ± 1.2	42.2 ± 1.0	39.9 ± 1.3	43.3 ± 1.6
5	251.75	1248.50	39.9 ± 1.2	38.7 ± 0.9	39.7 ± 1.1	40.7 ± 1.1
Av. Brand B	184.20	859.73				
C						
Control			45.0 ± 0.6	50.7 ± 1.3	46.7 ± 0.8	53.8 ± 1.3
1	107.33	173.75	38.5 ± 1.3	45.0 ± 0.7	40.2 ± 1.8	46.6 ± 0.9
2	204.00	303.25	39.6 ± 1.3	45.1 ± 1.1	38.6 ± 1.1	45.8 ± 1.1
3	233.00	466.75	38.9 ± 1.1	44.4 ± 0.8	40.8 ± 1.4	46.3 ± 1.2
Av. Brand C	181.44	314.58				
D						
Control			42.8 ± 1.2	51.3 ± 0.6	47.0 ± 0.8	48.4 ± 1.3
1	117.75	89.33	34.3 ± 0.8	48.1 ± 0.7	42.5 ± 1.2	43.5 ± 1.6
2	133.33	255.90	34.9 ± 1.1	42.8 ± 1.6	40.6 ± 1.1	44.6 ± 0.9
3	135.83	315.67	34.3 ± 0.5	47.6 ± 0.9	42.5 ± 0.9	43.8 ± 1.8
4	149.83		36.6 ± 1.3		40.4 ± 0.5	
5	171.83		33.8 ± 0.6		40.4 ± 1.3	
Av. Brand D	141.71	220.30				
Av. Hours	156.74	448.59				

Table 5. Statistical analysis of bursting strength of knee on the controls of silk and nylon hose.

Kind	: Number : of hose	: Degrees of : freedom	: Mean pound: : per sq. in.:	Sum of squares
Silk	4	3	43.3	5.73
Nylon	4	3	51.4	22.21
		Sum = 6	$\bar{d} = 8.1$	Sum = 27.94

$$V = \frac{27.94}{6} = 4.66; \quad V_{\bar{d}} = 2.33$$

$$s_{\bar{d}} = \sqrt{V_{\bar{d}}} = 1.5; \quad t = \frac{\bar{d}}{s_{\bar{d}}} = \frac{8.10}{1.5} = 5.4$$

Probability = .004 (highly significant)

V = pooled variance;  $V_{\bar{d}}$  = variance of difference

Table 6. Statistical analysis of bursting strength of knee on silk and nylon worn hose.

Kind	: Number : of hose	: Degrees of : freedom	: Mean pound: : per sq. in.:	Sum of squares
Silk	18	17	38.0	90.38
Nylon	13	12	42.9	143.76
		Sum = 29	$\bar{d} = 4.9$	Sum = 234.14

$$V = \frac{234.14}{29} = 8.07; \quad V_{\bar{d}} = 1.07$$

$$s_{\bar{d}} = \sqrt{V_{\bar{d}}} = 1.1; \quad t = \frac{\bar{d}}{s_{\bar{d}}} = \frac{4.9}{1.1} = 4.35$$

Probability = .001 (very highly significant)

V = pooled variance;  $V_{\bar{d}}$  = variance of difference

Table 7. Statistical analysis of bursting strength of leg on controls of silk and nylon hose.

Kind	: Number : of hose	: Degrees of : freedom	: Mean pound : per sq. in.:	: Sum of squares
Silk	4	3	45.5	8.35
Nylon	4	3	51.2	19.17
		Sum = 6	$\bar{d} = 6.7$	Sum = 27.52

$$V = \frac{27.52}{6} = 4.59; \quad V_{\bar{d}} = 2.29$$

$$s_{\bar{d}} = \sqrt{V_{\bar{d}}} = 1.5; \quad t = \frac{\bar{d}}{s_{\bar{d}}} = \frac{6.7}{1.5} = 4.5$$

Probability = .007 (highly significant)

$V$  = pooled variance;  $V_{\bar{d}}$  = variance of difference

Table 8. Statistical analysis of bursting strength of leg on worn silk and nylon hose.

Kind	: Number : of hose	: Degrees of : freedom	: Mean pound : per sq. in.:	: Sum of squares
Silk	18	17	40.0	66.20
Nylon	13	12	43.3	112.69
		Sum = 29	$\bar{d} = 3.3$	Sum = 178.89

$$V = \frac{178.89}{29} = 6.17; \quad V_{\bar{d}} = .82$$

$$s_{\bar{d}} = \sqrt{V_{\bar{d}}} = .9; \quad t = \frac{\bar{d}}{s_{\bar{d}}} = \frac{3.3}{.9} = 3.7$$

Probability = .001 (very highly significant)

$V$  = pooled variance;  $V_{\bar{d}}$  = variance of difference



analysis individual differences were removed by pairing the stockings. In pairing the hose, pairs 3, 4, and 5 were eliminated in brand A and pairs 4 and 5 in brand D. The probability from this analysis was .006 indicating that the nylon was greater than the silk by only a highly significant difference.

In the statistical analysis, the bursting strength of the nylon hose in the leg of the controls (Table 7) was greater than the silk by a highly significant difference. Likewise, the data with regard to the leg of the worn hose were analyzed as shown in Tables 8 and 10. When the stockings were not paired, the probability was .001, indicating that the nylon was greater than the silk by a very highly significant difference; in pairing only .009, indicating that the nylon was greater than the silk by a highly significant amount.

The breaking strengths of the heel, toe, ankle, and welt on the controls for the silk and nylon hosiery are shown in Table 11. According to the statistical analyses as shown in Tables 12, 13, 14, and 15, there was no significant difference between the silk and nylon in the bursting strength of the heel, ankle, or welt; that of the toe of the silk was significantly greater than the nylon.

#### Wear Test

The hours of wear reported by each person are given in Table 4. The nylon hose were worn an average of 448.59 hours.

Table 9. Statistical analysis of bursting strength at knee of 13 pairs of worn silk and nylon hose.

Brand: Differences in		:	
and :bursting strength:		:	
pairs:pounds per sq. in.:		:	
A	1	0.5	
	2	-1.8	
B	1	5.9	Sum of squares of deviations = $x^2$
	2	0.8	= 291.81
	3	5.4	Standard deviation of sampling means
	4	1.7	= $s_{\bar{x}} = \sqrt{\frac{291.81}{(13)(12)}} = 1.4$
	5	-1.2	
C	1	6.5	
	2	5.5	
	3	5.5	$t = \frac{\bar{d}}{s_{\bar{x}}} = \frac{4.9}{1.4} = 3.5$
D	1	13.8	
	2	7.9	for d.f. = 12, Probability = .006**
	3	<u>13.3</u>	
Sum = 63.8			
$\bar{d} = 4.9$			

\*\* highly significant

Table 10. Statistical analysis of bursting strength of leg of 13 pairs of worn silk and nylon hose.

Brand: Differences in		:	
and :bursting strength :		:	
pairs:pounds per sq. in.:		:	
A	1	-4.0	
	2	-2.7	
B	1	10.7	Sum of squares of deviations = $x^2$
	2	6.2	= 204.78
	3	6.2	Standard deviation of sampling means
	4	3.4	= $s_{\bar{x}} = \sqrt{\frac{204.78}{(13)(12)}} = 1.1$
	5	1.0	
C	1	6.4	
	2	7.2	$t = \frac{\bar{d}}{s_{\bar{x}}} = \frac{3.6}{1.1} = 3.2$
	3	5.5	for d.f. = 12, Probability = .009**
D	1	1.0	
	2	4.0	
	3	<u>1.3</u>	
Sum = 46.2			
$\bar{d} = 3.6$			

\*\* highly significant

Table 11. Bursting strength in pounds per square inch at heel, toe, ankle, and welt of controls of silk and nylon hose.

Brand	Heel		Toe		Ankle		Welt	
	Silk	Nylon	Silk	Nylon	Silk	Nylon	Silk	Nylon
A	115 95	110 100			50 53	50 50	150 153	135 145
Mean	110.0	105.0	150.0	90.0	51.5	50.0	151.5	140.0
B	115 122	115 120			45 45	65 55	143 143	130 135
Mean	118.5	117.5	163.0	150.0	45.0	60.0	143.0	132.5
C	120 130	110 115			55 53	62 52	140 135	138 138
Mean	125.0	112.5	180.0	115.0	54.0	57.0	137.5	138.0
D	130 138	85 105			45 42	50 53	125 125	135 137
Mean	134.0	95.0	150.0	125.0	43.5	51.5	125.0	136.0

Table 12. Statistical analysis of bursting strength of heel on controls of silk and nylon hose.

Kind	: Number : of hose	: Degrees of : freedom	: Mean pound: : per sq. in.	: Sum of squares
Silk	4	3	121.9	303.19
Nylon	4	3	107.5	287.50
		Sum = 6	$\bar{d} = 14.4$	Sum = 596.69

$$V = \frac{596.69}{6} = 99.45; \quad V_{\bar{d}} = 49.72$$

$$s_{\bar{d}} = \sqrt{V_{\bar{d}}} = 7.0; \quad t = \frac{\bar{d}}{s_{\bar{d}}} = \frac{14.4}{7.0} = 2.1$$

Probability = .09

V = pooled variance;  $V_{\bar{d}}$  = variance of difference

Table 13. Statistical analysis of bursting strength of toe on controls of silk and nylon hose.

Kind	: Number : of hose	: Degrees of : freedom	: Mean pound: : per sq.in.	: Sum of squares
Silk	4	3	160.8	606.75
Nylon	4	3	120.0	1850.00
		Sum = 6	$\bar{d} = 40.8$	Sum = 2456.75

$$V = \frac{2456.75}{6} = 409.46; \quad V_{\bar{d}} = 204.73$$

$$s_{\bar{d}} = \sqrt{V_{\bar{d}}} = 14.3; \quad t = \frac{\bar{d}}{s_{\bar{d}}} = \frac{40.8}{14.3} = 2.8$$

Probability = .03 (significant)

V = pooled variance;  $V_{\bar{d}}$  = variance of difference

Table 14. Statistical analysis of bursting strength of ankle on controls of silk and nylon hose.

Kind	: Number : : of hose :	Degrees of freedom	: Mean pound : : per sq.in. :	Sum of squares
Silk	4	3	48.5	76.50
Nylon	4	3	54.6	65.69
Sum = 6		$\bar{d} = 6.1$	Sum = 142.19	

$$V = \frac{142.19}{6} = 23.70; \quad V_{\bar{d}} = 11.85$$

$$s_{\bar{d}} = \sqrt{V_{\bar{d}}} = 3.4; \quad t = \frac{\bar{d}}{s_{\bar{d}}} = \frac{6.1}{3.4} = 1.8$$

Probability = .13

V = pooled variance;  $V_{\bar{d}}$  = variance of difference

Table 15. Statistical analysis of bursting strength of welt on controls of silk and nylon hose.

Kind	: Number : : of hose :	Degrees of freedom	: Mean pound : : per sq.in. :	Sum of squares
Silk	4	3	139.2	370.25
Nylon	4	3	136.6	30.69
Sum = 6		$\bar{d} = 2.6$	Sum = 400.94	

$$V = \frac{400.94}{6} = 66.82; \quad V_{\bar{d}} = 33.41$$

$$s_{\bar{d}} = \sqrt{V_{\bar{d}}} = 5.8; \quad t = \frac{\bar{d}}{s_{\bar{d}}} = \frac{2.6}{5.8} = .4$$

Probability = .67

V = pooled variance;  $V_{\bar{d}}$  = variance of difference

The silk hose wore 156.74 hours. In the statistical analysis in Table 19, a probability of  $< .001$  indicated that the nylon hose was greater than the silk by a very highly significant difference.

#### Color and Fading

The color attributes before and after wearing and the number of launderings are given in Tables 16 and 17 which shows that the average indices of fading were 3.85 for the silk hose and 6.25 for the nylon hose. The number of launderings for the silk hose was 12.2, for the nylon, 33.5. The fact that the nylons were laundered more times than the silk accounted for the higher index of fading for the nylon. According to the statistical analysis in Table 18, the probability was .007, which indicated the fading of the nylon was greater than the silk by a highly significant amount.

#### Cost and Failures

Using a 15-hour day as the basis, the silk hose cost \$0.099 per day and the nylon \$0.045.

More holes were evident in the heels and toes of the silk than in the nylon. In brand D of nylon the heel showed wear, but no signs of a break were seen. Evidences of more holes in the sheer part of the foot were found in the silk than in the nylon. The nylon hose showed more runs in the welt than the silk, which were, no doubt, caused by supporters that were too tight. The majority of the failures in both the silk and nylon hose were due to snags that resulted in runs.



Table 17. Number of launderings and indices of fading of nylon hose.

Brand	Reading	Av.C	dH	dL	dC	I	No. laund.
A							
Control	13.76YR	<u>4.66</u>					
		5.08					
1	14.55YR	<u>4.30</u>	4.38	.79	.36	1.40	8.74
		3.68					
2	14.33YR	<u>4.24</u>	4.46	.57	.42	1.24	7.25
		3.84					
B							
Control	12.08YR	<u>4.56</u>					
		6.96					
1	12.62YR	<u>4.79</u>	6.80	.54	.23	.32	3.81
		6.64					
2	14.22YR	<u>5.34</u>	6.78	2.14	.78	.36	11.58
		6.60					
3	13.04YR	<u>4.96</u>	6.78	.96	.40	.36	5.70
		6.60					
4	13.57YR	<u>5.05</u>	6.84	1.49	.49	.24	7.74
		6.72					
5	13.68YR	<u>5.26</u>	6.92	1.60	.70	.08	8.85
		6.88					
C							
Control	14.60YR	<u>4.50</u>					
		4.46					
1	14.79YR	<u>4.90</u>	4.85	.19	.40	.78	5.11
		5.24					
2	14.87YR	<u>4.89</u>	4.79	.27	.39	.56	4.53
		5.12					
3	14.68YR	<u>4.81</u>	4.80	.08	.31	.68	4.05
		5.14					
D							
Control	13.81YR	<u>4.35</u>					
		4.56					
1	13.81YR	<u>4.23</u>	4.56	.00	.12	.00	1.63
		4.56					
2	13.34YR	<u>3.81</u>	4.29	.47	.54	.54	5.67
		4.02					
3	13.44YR	<u>3.88</u>	4.05	.37	.47	1.02	6.55
		3.54					
Average						6.25	33.5



Table 18. Statistical analysis of the indices of fading of silk and nylon hose.

Kind	: Number : of hose	: Degrees of : freedom	: Mean indices : of fading	: Sum of squares
Silk	18	17	3.96	39.9068
Nylon	13	12	6.25	81.7139
Sum = 29		$\bar{d} = 2.29$	Sum = 121.6207	

$$V = \frac{121.6207}{29} = 4.1938; \quad V_{\bar{d}} = .0556$$

$$s_{\bar{d}} = \sqrt{V_{\bar{d}}} = 0.74; \quad t = \frac{\bar{d}}{s_{\bar{d}}} = \frac{2.29}{0.74} = 3.09$$

Probability = .007 (highly significant)

$V$  = pooled variance;  $V_{\bar{d}}$  = variance of difference

Table 19. Statistical analysis of the hours worn of silk and nylon hose.

Kind	: Number : of hose	: Degrees of : freedom	: Mean of : hours worn	: Sum of squares
Silk	18	17	153.99	37013.3470
Nylon	13	12	515.60	1494871.8809
Sum = 29		$\bar{d} = 361.61$	Sum = 1531885.2279	

$$V = \frac{1531885.2279}{29} = 52823.62; \quad V_{\bar{d}} = 6998.00$$

$$s_{\bar{d}} = \sqrt{V_{\bar{d}}} = 83.6; \quad t = \frac{\bar{d}}{s_{\bar{d}}} = \frac{361.61}{83.6} = 4.32$$

Probability = < .001 (very highly significant)

$V$  = pooled variance;  $V_{\bar{d}}$  = variance of difference

## SUMMARY

This study was made to compare by actual wear and laboratory tests the wearing qualities of silk and nylon hosiery of the same brands and to determine whether the wearing qualities of the nylon hose justify their cost.

The nylon hose gave longer service than the silk hose by a very highly significant difference, the average number of hours worn for the nylon hose being 448.59, and for the silk 156.74.

Unworn nylon hose showed significantly greater bursting strength at the knee and in the leg than did the silk hose. Likewise, the worn nylon hose showed significantly greater bursting strength than did the silk hose at the knee and in the leg. On the other hand, the bursting strengths of the heel, ankle, and welt of the silk and nylon hosiery on the controls were not significantly different. The toe of the unworn silk hose was significantly greater than the nylon. However, more holes were worn in the toes and heels of the silk hose than in the nylon. The majority of the failures in both the silk and nylon hose was due to snags that developed into runs.

The average indices of fading were 3.85 for the silk hose and 6.25 for the nylon hose. The nylon hose faded more than the silk by a highly significant difference. The greater fading of the nylon hose might have been due to the greater

length of time worn and the number of times they were laundered. The silk hose were laundered an average of 12.2 times, the nylon 33.5 times.

Under these conditions and using a 15-hour day as the basis, the silk hose cost \$0.099 per day and the nylon \$0.045. Although the initial cost of the nylon hose was greater they wore so much longer under these conditions that the cost per day was about one-half that of the silk hose.

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**APPENDIX**



Genevieve Smith  
 522 Columbus  
 Benton Harbor, Mich.

RECORD CHART

Name of wearer \_\_\_\_\_  
 Brand of hose worn \_\_\_\_\_  
 Date began wearing hose \_\_\_\_\_  
 Date hose are worn out \_\_\_\_\_  
 Kind of hose \_\_\_\_\_

No. of wearings:	Hours worn each time:	Cause of failure Remarks
	:	:
	:	:
1	:	:
2	:	:
3	:	:
4	:	:
5	:	:
6	:	:
7	:	:
8	:	:
9	:	:
10	:	:

### Directions to the Wearers of the Hosiery

1. Wear the hose for general wear.
2. Keep a record on the enclosed charts of the number of hours the hose are worn.
3. Rinse hose before wearing and launder immediately after each wearing.
4. Launder the hose according to the following directions:
  1. Wash in suds of Ivory Flakes and lukewarm water.
  2. Gently squeeze the suds through them.
  3. Rinse thoroughly in warm water until the rinse water is clear.
  4. Squeeze out excess water, roll in a towel for a brief period, and hang over a smooth rod to dry. Dry away from direct heat and sunlight.
5. Report the cause of failure when hose are worn out.
6. Return the worn out hose and record charts to:

Genevieve Smith  
522 Columbus Avenue  
Benton Harbor, Michigan