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An Approach to a More Realistic Cotton Detergency Test

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FOR the past 20 years the accepted test for cotton detergency has been carried out substantially as follows:

A test fabric is first prepared by heavily soiling cotton with a solvent suspension of carbon black and fat, after which detergents are rated by their ability to wash out a portion of this soil in a Launder-Ometer.

As far back as 1933 however the Detergency Committee of the American Oil Chemists' Society (1) issued a critical report on this test, emphasizing its poor reproducibility and questionable significance. Ten years later this was followed by an even more adverse A.S.T.M. report (2), concluding that the procedure was of little value as a method for rating detergents. Nevertheless the great majority of workers in this field have continued to employ a test of this type with only minor variations.

In a recent paper (3) the authors analyzed the shortcomings of this conventional method in some detail, emphasizing in particular the need for differentiating clearly between precision (reproducibility) and accuracy (correlation with field performance). It was concluded that even though precision could be improved by closer control of variables and the use of larger numbers of swatches, the accuracy was inherently poor since the test failed to duplicate household conditions in several important respects, among which were mentioned the following:

a) The Launder-Ometer itself departs greatly in design and mechanical action from the usual household agitator-type washing machines. Particularly undesirable is the relatively feeble washing action compared to the vigorous surge of an oscillating agitator. Since this lack of mechanical action may affect some detergents more than others, it would be preferable to use a degree of agitation more closely simulating that encountered in household washers.

b) The type of soil used in the conventional test is also far from representative. Although the heavy deposits of lampblack and fat usually employed might occur on mechanics' overalls, they are hardly typical of soils normally encountered on shirts, sheets, towels, tablecloths, etc., which are usually complex mixtures of inorganic and organic particles containing very little free carbon.

c) Furthermore this soil is applied so heavily that it is practically impossible to wash out in a single operation and should really be classified as a stain rather than a normal household soil. The objective of practical laundering is complete cleanliness, necessitating removal of the last traces of ingrained soil; the conventional test method however, which washes only part way, removes merely the superficially held carbon, leaving the more tenaciously bound particles untouched. Such a test may therefore be measuring only dispersion of the more loosely held carbon black rather than true detergency.

In view of these considerations it was concluded in the above paper that a definite need existed for a more realistic cotton detergency test exhibiting not only good precision but also a higher degree of accuracy.

Practical Wash Tests

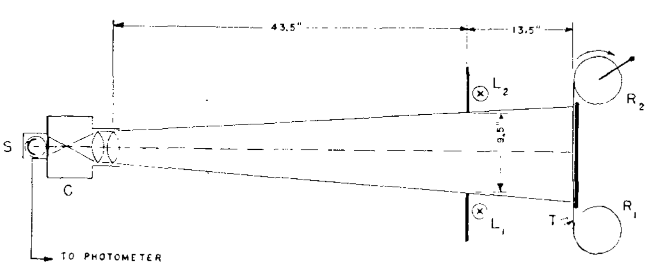
One of the greatest obstacles to evaluating any proposed test method is the lack of definite information on the actual efficiencies of different detergents in household use. Obviously there is no way of deciding whether the laboratory evaluation of a detergent correlates with practice unless the performance of that detergent in practice is known. Although manufacturers of household laundry detergents possess some information of this type, based on consumer surveys, such data are extremely difficult to present quantitatively and are subject to all the errors of personal judgment that inevitably arise in opinion polls. Furthermore the results are not generally publicized.

In order to set up a scale or "yardstick" on which a number of detergents could be rated according to their effectiveness in household use, the following procedure was employed to obtain practical laundering data:

Cotton roller towels (12" Huck towelling, 75 x 37 count, 5.7 oz./sq. yd., 75 ft. long) were placed in washrooms about the laboratory for repeated soiling in actual use. Four towels were employed in this series of tests, each being labelled with the number of the detergent to be used on it. For example, Towel I was washed with Detergent I after each soiling, Towel II with Detergent II, etc. Since the type of soil in the mechanics' washroom was heavier than in the office washroom, for example, the locations were rotated after each soiling so that each towel received all types of soil. In order to increase the amount of soil wiped onto the towels, all soap and cleaners were removed from the washrooms for the duration of the tests and ordinary borax was substituted instead.

After each soiling the towels were washed in a Maytag machine, using 0.25% of the appropriate detergent at 140°F. in filtered Easton tapwater (70 p.p.m. hardness). After washing, all towels were dried in a large cabinet to eliminate any bleaching action of sunlight. In all, eight soil-wash cycles were carried out.

In order to follow the progress of the washes the reflectance values of the towels were measured after each wash, a square foot at a time, and the results averaged for the whole towel. The reflectance measurement of such large areas was made possible by the arrangement shown schematically in Figure 1. The



INTEGRATING PHOTOMETER ASSEMBLY

FIG. 1. Arrangement of equipment for measuring roll towel reflectance.

camera (C) is focussed so that a one-foot square area of the towel (T) is imaged on the ground glass and viewed by the phototube in the search unit (S). Diffuse illumination is obtained by the two light sources (L_1 and L_2) mounted on a board with a square opening which is limiting the field. For the measurements reported in the following an Ansco Universal View Camera (5 x 7 in.) with a Zeiss Tessar 1:4.5 (F:21 cm.) was used. The photometer was a Photovolt Model 512 with search unit Model D equipped with a red-sensitive phototube. This phototube was used in conjunction with a Zeiss green filter and a Corning No. 3965 filter in order to obtain a more favorable spectral response of the photometer. Two tubular 75-watt incandescent lamps (1 in. diameter and 12 in. long) operated from a variable transformer and voltage stabilizer provided uniform illumination of the area. The light intensity and the diaphragm of the camera served as means for adjustments in daily calibrations for which cloth and cardboard surfaces of known reflectances were used. A special rack (not shown on Figure 1) with one feed roller (R_1) and one take-up roller (R_2) facilitated the taking of consecutive readings on each running foot of the roll towel.

As the number of wash cycles increased, the reflectance values of the washed towels dropped progressively from the original value of 77%, due in part to redeposition and in part to accumulation of

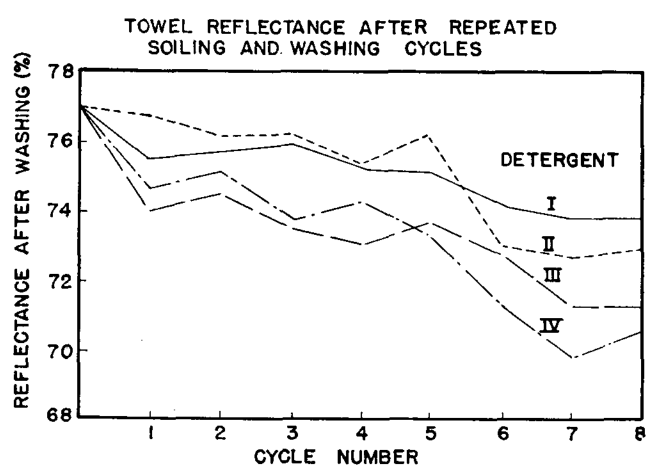


FIG. 2. Evaluation of four detergents in multicycle wash tests using roll towels.

TABLE I

Launder-Ometer Test Data

Detergent	Wash No.	Reflectance after Washing[a]	
		Run A	Run B
IV	1	30	39
	2	43	45
	3	46	48
	4	49	48
	Average	42	45
I	1	33	32
	2	39	36
	3	44	47
	4	49	50
	Average	41	41
III	1	25	25
	2	38	37
	3	49	44
	4	50	46
	Average	40	38
II	1	24	25
	2	33	34
	3	37	39
	4	42	41
	Average	34	35

[a] Initial reflectance = 16 for all swatches.

unremoved dirt. The results of this set of practical washing trials are presented graphically in Figure 2, where the reflectance of each towel (average of 70 readings) is plotted against the number of washings. The detergents used were as follows:

I. A built powdered synthetic containing 15% of nonionic detergent Antarox A200.
II. A built household soap powder containing 65% soap.
III. A solution containing 15% Antarox A200 and 3% low viscosity CMC.
IV. A 15% solution of Antarox A200.

As can be seen from Figure 2, the result of these practical wash tests was to arrange the four detergents in the following descending order of effectiveness: I, II, III, IV.

The towels were also inspected visually for streaks or smudges of unremoved dirt, and the same order was found in this way as by the photometric measurements. In addition, independent field tests in public laundries and homes had in general shown that Detergent I was preferred to Detergent II, while Detergent IV was definitely inferior; no field data was available for Detergent III however.

It is realized, of course, that the performance ratings obtained in these tests are based on somewhat special conditions (Easton soil applied wet to towelling), but the general agreement with the field trials mentioned above tends to corroborate the results.

Launder-Ometer Tests

In view of the widespread use of the conventional test employing carbon-soiled cloth in the Launder-Ometer, it was believed of interest to evaluate the above four detergents by this method.

Batches of soiled cloth were prepared by the method of J. C. Harris (4), which employs a suspension of Oildag and Wesson Oil in carbon tetrachloride. Drying was carried out by passing the soiled cloth over a steam-heated drum, then festooning in a large oven at 75°C. for 15 minutes and finally aging overnight at room temperature as recommended. The cloth was stored over calcium chloride in a desiccator when not in use and was discarded after one week. Washing was carried out in an Atlas Launder-Ometer at 140° F., using 0.25% detergent as before. It was found necessary however to cut the recommended 6 x 6½ inch swatches into four equal pieces in order to ensure uniform washing since the large swatches tended to fold up in the jars. Four successive 10-minute washes were made, as called for; a small swatch was removed after each of these washes.

The reflectances after washing (relative to magnesium carbonate) are presented in Table I for two separate runs. Regardless of whether the first wash is used as the criterion (as is usually done) or the average of all four successive washes (as Harris recommends), it is obvious that this test arranges the four detergents in the following decreasing order of efficiency: IV, I, III, II.

This is, of course, completely different from the order found in the practical wash tests. Although different laboratories using the Harris method might not all arrange the four detergents in the above order, Armstrong (5) has found unbuilt nonionics superior to soap by this method, and unpublished data from other sources have given similar results.

Actually however practical laundering experience has repeatedly demonstrated that unbuilt synthetic detergents will not wash cottons satisfactorily. The anomalous results found in this test must therefore be ascribed to the dispersing action of nonionic detergents such as Antarox A200 on the colloidal graphite used, rather than to genuine detergent action.

The results of these Launder-Ometer trials with graphite-soiled cotton have therefore merely served to confirm that this type of test, even when fairly precise, may be highly inaccurate.

A New Approach

In view of this situation it was decided to attempt the development of a more realistic cotton detergency test based on the principle that any really accurate method must duplicate service conditions as closely as possible. Since the most unrealistic features of the conventional test appeared to be the type of soil used (carbon), method of application (from solvent), and type of washing equipment (Launder-Ometer), all three of these were altered in such a way as to conform more closely to household laundering conditions.

a) *Soil Formulation.* Although cotton articles ordinarily pick up an infinite variety of complex soils in normal use, these may be classified into three main categories:

Solids: Street and house dusts, earths, clays, fly ash, skin debris, soot, etc.
Oils: Sweat stains, hair oils, lipstick, food grease, etc.
Stains: Grass, fruit, dyes, rust, graphite, etc.

In general, the solids and oils can be largely removed by an ordinary washing operation in some type of detergent solution. The stains however require special treatments such as bleaching, souring, softening with lard, etc., and fall outside the scope of the present discussion.

As mentioned before, the usual carbon type of test-soil falls into the category of a stain since it cannot normally be removed in a simple washing operation. A number of investigators have therefore attempted to change to more practical soils, thus Ringeissen (6) used the sludge from dry-cleaning plants, and the I. G. Farben laboratories (7) employed mixtures of road dust, mineral oil, and tallow, as well as synthetic road dusts consisting largely of clay.

Now real soils encountered in everyday use are many and complex and will vary with the locality, working conditions, age, and even economic status of the individual. This being the case, the best that can be done is to attempt to select a soil that is at least fairly representative of the most widespread type encountered in practice. Of course special soils might be required for certain studies (e.g. blood removal), but these would be of only secondary interest.

It was felt that ordinary street dirt represented the commonest type of soil encountered, and an investigation of this type of material was therefore initiated in an effort to develop a more representative synthetic soil. As a first step, samples of dirt from six cities were collected, screened through 200 mesh, and analyzed, with the results shown in Table II.

Examination by X-ray diffraction showed considerable free silica in the dry soil and sodium chloride in the water extracts. The question of the free carbon content of these dirts is important since so much emphasis has been placed on carbon as the major factor in soiling. Unfortunately, no method for the analysis of free carbon is available, hence an optical method was utilized to obtain semi-quantitative estimates. The tinting power of black pigments is determined in the paint industry by grinding them into zinc oxide pastes and observing the resultant degree of darkening as compared with some standard black pigment, and the same type of test was applied to the six soils listed above.

The tinting-strength test was carried out by mulling 1 g. of soil with 5 g. of Bleach White JW3 zinc oxide-oil paste, and then determining the weight of carbon black required to darken 5 g. of paste to the same extent. A relatively coarse furnace black (Molacco from Binney and Smith) was used as the standard of comparison since an ultra-fine carbon would be too far removed from soot. In general, it was found that less than 10 mg. of the furnace black gave as much darkening as 1 g. of the soil, indicating

TABLE II
Results of Chemical Analyses in Per Cent and Other Properties of Natural Dirt and Synthetic Soil

Component	Pittsburgh	Detroit	Cleveland	Buffalo	St. Louis	Boston	Synthetic
Water Soluble	15.4	13.5	15.9	11.4	14.9	15.4	9.8
Ether Soluble	10.8	4.9	7.1	6.5	12.8	7.7	5.1
Moisture	....	1.7	3.0	....	....	2.1	8.0
Total Carbon	26.4	24.7	24.0	26.9	25.6	28.9	25.8
Ash	53.8	57.8	56.3	52.0	51.2	50.5	40.9
SiO_2 (total)	25.6	25.5	26.4	24.0	24.1	21.4	21.9
R_2O_3 (total)	11.6	9.9	11.1	9.5	9.4	11.1	7.5
CaO (total)	6.2	8.4	7.7	6.9	7.4	6.4	4.8
MgO (total)	1.7	2.0	1.7	2.0	1.6	1.7	1.9
CaO (Water Soluble)	0.3	0.4	0.7	0.3	0.4	0.7	0.3
MgO (Water Soluble)	0.1	0.2	0.2	0.2	0.2	0.2	0.2
N	....	1.6	....	....	....	2.1	1.3
pH (10% slurry)	7.0	7.3	6.7	7.2	7.0	7.3	8.9
Carbon Black Equivalent (%)	0.8	0.6	0.55	0.5	0.5	0.6	1.2

that less than 1% of carbon black equivalent was present in the soil. Results are shown in Table II.

It is recognized that there may have been more free carbon than this present as coarse sooty particles, but it is believed that this would not contribute much to soiling. A similar test was also run on sweepings collected directly from a pavement in mid-town Manhattan; in spite of the apparent darkness of this dirt it was found to contain only the equivalent of 1.5% carbon black. It would therefore appear that city dirt, even from places such as Pittsburgh or New York, contains much lower amounts of finely divided carbon than is generally assumed.

The analyses listed in Table II demonstrate the remarkable similarity of dirts collected from different cities. In most cases the results are identical to within a few per cent and would indicate that in all cases the soils consist chiefly of siliceous inorganic materials together with some carbonaceous matter, oils, and minor constituents.

The nature of the roughly 10% of ether soluble oily material was not investigated since it was decided to use the results of Brown (8), who found the following fatty matter in soiled garments:

Free fatty acids (C_{18})	31.4%
Triglycerides of higher fatty acids (C_{18})	29.2
Fatty alcohols and cholesterol	15.3
Hydrocarbons (saturated and unsaturated, C_{20})	21.0
Short chain fats and acids	3.3

Based on all of the above considerations, a synthetic soil was formulated having composition shown in Table III.

TABLE III

Synthetic Soil Composition

Component	Source	%
Humus	Hyperhumus Co., Newton, N. J.	35
Cement	Alpha Cement Co. (Type I)	15
Silica	Davison Chemical Co. (200 mesh)	15
Clay	Harris Clay Co. (average grade)	15
Sodium Chloride	....	5
Gelatin	Keystone 431X	3.5
Carbon Black	Binney & Smith (Molacco Furnace Black)	1.5
Iron Oxide	C. K. Williams (Red, N1860)	0.25
Stearic Acid	....	1.6
Oleic Acid	....	1.6
Palm Oil Fatty Acids	Harshaw Chemical Co.	3.0
Lanolin	Merck (anhydrous)	1.0
n-Octadecane	Connecticut Hard Rubber Co.	1.0
l-Octadecene	Humphrey Wilkinson	1.0
Lauryl Alcohol	....	0.5

The humus was added to represent the earthy material assumed to be present in the sweepings and contributing to the high carbon analysis. It is identified as a brown fibrous grade by the Hyperhumus Company and is dug from their large, uniform lake-bottom deposits. The cement and silica were assumed to represent pavement dust; the clay might come from concrete or be blown in from the surrounding countryside. Gelatin was added to simulate skin proteins, and the oils were typical of body oils found by Brown.

The components were added to a pebble mill, together with about 1½ times their weight of water and ball-milled for 18 hours, after which the slurry was evaporated to dryness and the mixture put through a 200-mesh screen.

The final synthetic soil was a soft, free-flowing powder with the typical dark gray-brown color of the original sweepings, and slightly darker than the Pittsburgh soil (which was the darkest of the six collected samples). Chemical analysis, pH, and carbon black equivalent for this synthetic soil are listed in Table II. As will be seen, the general values are close to those of the natural soils.

Particle size distribution curves were also determined for a composite sample of the natural soil and for the synthetic mixture:

Range (μ)	Natural (%)	Synthetic (%)
0- 4	53	68
4- 8	8	16
8-12	7	8
12-16	8	4
16-20	7	2
>20	17	2

There is no great difference in size distribution, the synthetic material being only slightly finer.

Although no single soil can, of course, simulate the many different types encountered in practice, nevertheless it is believed that a composition of the type proposed here must be far more representative than the carbon-and-oil suspensions usually employed.

b) *Soil Application.* As stated previously, the conventional method of applying soil to the test fabric is from an organic solvent such as carbon tetrachloride. Recently however some investigators have turned to aqueous suspensions of carbon black (9), and some German workers (10) have sprayed aqueous suspensions of road dirt onto the cloth.

Preliminary attempts to apply the new composite soil therefore took the form of tumbling test swatches in aqueous suspensions of the dirt since this appeared to be more realistic than the use of solvents. This approach was finally abandoned however since it became evident that much of the soil was entering the cloth by a process of "redeposition" in which the finest particles penetrated deeply into the fabric. As is well known, redeposited soil is extremely difficult to wash out, and the swatches soiled in this way were in fact unusually resistant to washing, which made them unsuitable for realistic tests.

It was therefore decided to apply the soil in a dry state since in practice most dirt is actually rubbed into the dry or slightly humid fabric and not applied from suspension. Preliminary attempts to brush the dry dirt into the cotton gave poor control, and the soil was too readily removed. Tumbling the cloth in dry soil showed the same drawbacks.

The problem of dry-soiling was finally solved by the use of a modified Schiefer Abrasion Meter, which turned out to be ideally suited for this application. The mathematical principles on which this instrument is based were ably developed by Schiefer (11), who demonstrated that uniform rubbing action in all directions could be achieved by placing a small disc off-center against a larger disc and spinning both in the same direction and at the same angular velocity. A later publication (12) describes the constructional details of one model which is currently being manufactured by the S. W. Frazier Company of Washington, D. C.

Although the Schiefer machine was designed for textile abrasion studies, it seemed well adapted for use in rubbing dry soil uniformly into cotton test swatches. Since the models on the market were somewhat smaller than desired, the machine shown in Figure 3 was built at this laboratory. The upper disc-and-shaft assembly weighs five pounds and in use is lowered onto the bottom disc, over which the cotton swatch is stretched. The top disc consists of a brass ring holding a circular frosted glass abradant plate 7" in diameter (not visible in the picture). The bottom brass disc is 3" in diameter and 1" off center from the top one. Both discs are chain-driven from a single motor, the upper one revolving at 108 r.p.m., the bottom at 100 r.p.m. (this slight difference being recommended by Schiefer).

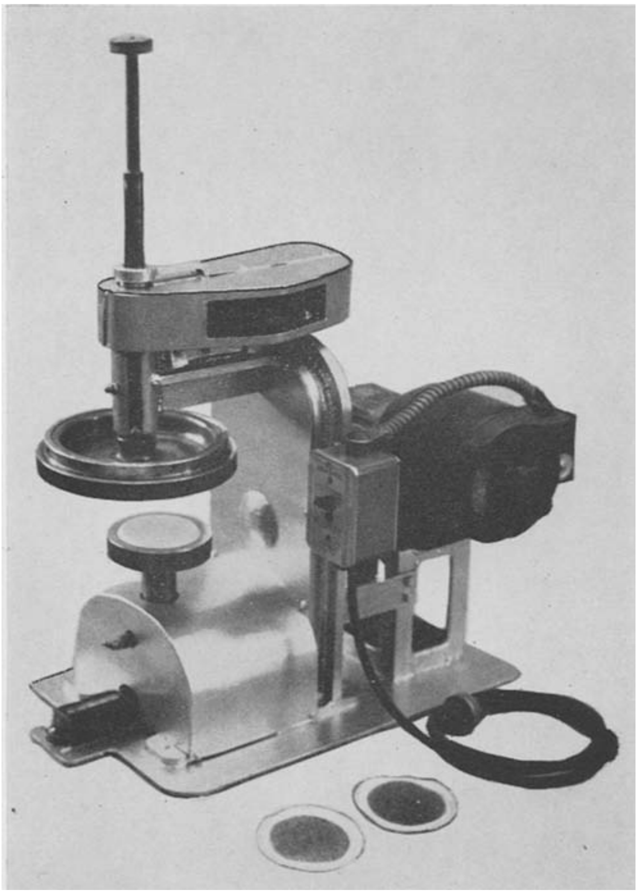


FIG. 3.

The soiling is carried out as follows: a 4-inch disc is cut from a sample of desized and scoured broadcloth (English Broadcloth, 144 x 76) and stretched taut over the lower 3-inch brass disc by an adapter. Then 20 mg. of synthetic dry soil are weighed out and sprinkled over the cloth, after which the upper disc is let down and both spun for one-half minute against each other. In this way a 3-inch circular soiled area is produced on the fabric, as can be seen from the specimens shown in the photograph (Figure 3). The choice of abradant surface is important since many surfaces such as fine screens, steel blades, etc., scrape the soil off the cloth, rather than spread it uniformly. A moderately frosted glass plate gave best results, but the degree of frosting was not critical.

It soon became evident however that a perfectly dry soiling washed out too readily. In an effort to prevent this attempts were made to humidify or dampen the cloth before applying the soil, thus simulating the dirtying of a sweat-stained fabric. This was found to be impractical as the soil could not be spread over the moist surface. As an alternative, the dirt was first rubbed in dry for one-half minute, then the glass

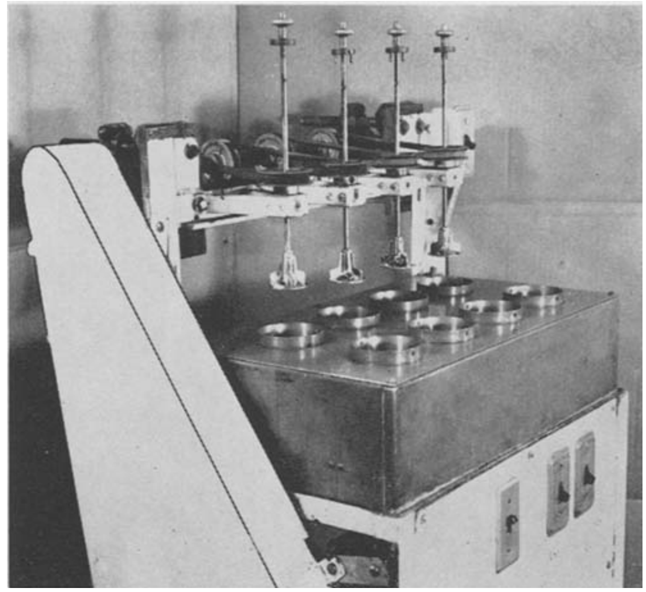


FIG. 4.

plate was slightly wetted with a moist sponge, and the soiled cloth rubbed for another half-minute with the moistened plate. This gave a moisture uptake of about 10% (of the fabric) and resulted in adequate fixation of the soil.

c. *Washing Equipment.* In an effort to devise more realistic washing equipment work was started about five years ago at this laboratory to design a miniature oscillating-agitator type of washer. One of the goals set was to achieve the same direction of water-flow as in the larger machines so that the test swatches would circulate from top to bottom during the washing, while also folding and unfolding continuously. A realistic degree of mechanical action was also sought by regulating the peripheral paddle speed and "tub" size.

Most of these requirements are fulfilled by the machine shown in Figure 4, built at this laboratory several years ago. Four chromium-plated copper cups of 400-cc. capacity are used for the washing and can be pre-heated at the front of the bath. The chromium-plated paddles are simply scaled-down models of those used on household machines, each rotates at a peripheral speed of 2,100 in./min., making three turns between reversals and oscillating 140 times/minute.[1]

In this program three soiled test swatches and one unsoiled redeposition swatch were washed in each "tub," using 140 ml. of detergent solution. Since each swatch weighed 0.85 g., this gave a liquor-to-cloth ratio of 40:1, which is admittedly somewhat higher than found in practice (about 20:1), but not drastically so.

d) *Multicycle Operation.* The test swatches described above are soiled fairly heavily (about 25% reflectance) but can readily be washed *almost* clean (over 70% reflectance) by many detergents in the agitator-type machine used. In the past it has been considered that such extensive soil removal would make it difficult to differentiate between detergents since many would wash to the same level.

[1] It may be mentioned that machines based on the one shown here can now be purchased from the Baker Instrument Company, Orange, N. J., under the name of "Terg-O-Tometer" (13).

TABLE IV

Reflectance Data From a Typical Run by New Method

Detergent	Swatches	Cycle No. 1		2		3		4		5		6		7		8	
		S	W	S	W	S	W	S	W	S	W	S	W	S	W	S	W
I	Det.	30 30 30	76 76 76	28 29 28	73 74 74	24 23 21	72 72 71	27 26 28	72 72 72	27 26 25	71 70 70	24 25 22	70 69 69	26 20 24	68 67 68	28 27 27	67 67 68
	Redep.		77		76		75		75		75		75		74		73
II	Det.	28 27 29	74 75 75	28 28 27	73 73 73	25 26 26	71 72 71	25 26 26	70 70 72	25 27 27	69 69 70	21 24 24	68 69 68	22 24 24	67 67 68	23 27 29	66 67 68
	Redep.		76		75		73		74		73		74		72		70
III	Det.	30 31 30	75 76 76	27 28 29	72 73 72	24 25 23	69 70 69	26 26 24	70 71 70	26 24 24	68 68 67	26 25 23	67 68 67	23 22 23	65 65 65	26 26 26	64 65 64
	Redep.		78		75		74		75		75		74		74		74
IV	Det.	30 29 29	75 75 75	27 30 27	71 71 71	23 25 26	68 69 68	26 26 25	68 68 68	24 24 24	64 65 65	22 23 24	64 64 64	22 22 25	62 62 63	27 24 26	62 60 61
	Redep.		77		74		72		72		71		71		69		68
Water		25 26 30	64 68 64	23 26 27	58 59 62	28 28 26	56 57 59	25 24 25	56 57 60	22 21 23	53 53 54						
	Redep.		71		62		61		60		58						

Legend: Det=Detergency Swatch. Redep.=Redeposition Swatch. S=Reflectance after soiling. W=Reflectance after washing.

In order to overcome this objection and duplicate practical use conditions it was decided to utilize multiple soil-wash cycles, rather than limit the test to a single wash. By such repeated soiling and washing of the same swatches a gradual build-up should result (due to unremoved and redeposited dirt) that would distinguish good from poor detergents after a number of cycles even though they might have appeared close together at the start. This is, of course, similar to the procedure followed in the roll-towel program or in home laundering.

The testing of any given detergent was therefore carried out as follows: three broadcloth discs were soiled in the Schiefer machine as described above and then aged overnight under room conditions. Reflectances were measured by a Photovolt Reflectometer (Model 610), using the large circular 3-inch search unit, which just covered the soiled area. These three swatches and one unsoiled "redeposition swatch" were then washed in one of the cups for 15 minutes, using 140 ml. of 0.25% detergent solution in Easton tapwater (70 p.p.m. hardness) at a temperature of 140° F. Rinsing was carried out by discarding the detergent solution, adding 140 ml. tapwater at 140°F. to the cup, then agitating for two minutes. This procedure simulated practical rinsing conditions. Finally the washed swatches were squeezed out, oven-dried at 120°F. for two hours, and then read again. This constituted a single soil-wash cycle. This whole procedure was then repeated by resoiling, washing, and rinsing again for as many cycles as desired, using the same swatches each time and following the build-up of soil.

Results

The four detergents used in the roll-towel and Launder-Ometer tests were next evaluated by the new procedure described above with the results given in Table IV, which presents the data from a typical run in detail. The results with water alone (no detergent) are also included for comparison.

In Table IV the reflectances are given for each swatch after soiling (S) and after washing (W), together with the reflectance of the "redeposition swatch" (Redep.). The desized broadcloth had an initial reflectance value of 77%.

As can be seen, the reflectances after soiling are somewhat more erratic (standard deviation 0.97) than after washing (standard deviation 0.51). This may be due to small amounts of the soil being forced through the broadcloth when being rubbed in on the soiling machine. It can however be shown that a test of this type does not require very close control of the initial soiling. This follows from the relation of reflectance to amount of soil on the fabric (3), which shows that over 95% of the soil is removed in raising the reflectance from 30% to 75%. Hence small variations in initial soiling make little difference since most of the dirt is washed out anyhow in this test. The important factor is the small amount of unremoved residual soil, as stated before.

As might be expected, redeposition was greatest for water and the unbuilt detergent (IV). The built-up soil on the swatches after washing appeared to be due about one-half to redeposited soil and one-half to unremoved soil, as calculated from the figures in Table IV taken in conjunction with the curve relating reflectance to amount of soil (cf. 3). An exception is Detergent III for which the unremoved soil contributes about two-thirds and the redeposition only about one-third towards the measured soiling effect.

In order to present the results of these tests more clearly the average reflectances of the washed swatches (Table 4) have been plotted against the number of washes in Figure 5, in exactly the same way as was done with the roll towel results in Figure 2. A comparison of these two figures will show how closely the results of the new test agree with practical washing.

In order to show the agreement between sets of runs carried out at different times, the average reflectances of the washed swatches after five cycles are listed in Table V for three separate runs.

Although the results are not in exact quantitative agreement, nevertheless the comparative ratings of the

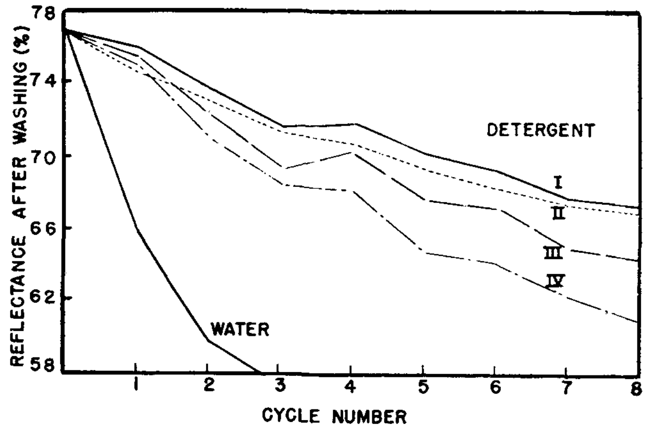


FIG. 5. Typical results obtained with new multicycle procedure.

four detergents are the same in all runs and in good agreement with the results of the roll-towel program.

The new test outlined above admittedly deals with the slow build-up of moderately light soils whereas the housewife may be more concerned with the immediate removal of stubborn dirt, such as on collars and cuffs. There is good reason to believe however that these more difficult soils are not different in composition from the lighter ones but are simply more deeply ingrained due to high moisture conditions during soiling. Since the new test procedure outlined here was designed primarily to measure removal of ingrained soil, it would be expected that detergents rating high in this test would be capable of removing tenaciously held natural soils.

TABLE V

Final Reflectances After Five Soil-Wash Cycles

Detergent	Run No. 1	Run No. 2	Run No. 3
I	70.3	70.7	69.0
II	69.3	69.7	68.3
III	67.7	68.0	67.0
IV	64.7	66.3	65.0

In order to demonstrate this some swatches were soiled on the machine under very high moisture conditions. After drying, these soils were found to be quite difficult to remove in a single wash, but again the four detergents described above were found to be ranged in the following decreasing order of effectiveness: I, II, III, IV.

It is therefore concluded that the new cotton detergency test described here shows considerable promise as a method for accurately evaluating detergents on a laboratory scale.

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Two Useful Accessories for the Beckman Spectrophotometer Model DU[1]

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THE slide carrier which comes with the Model DU Beckman Spectrophotometer for cells of various sizes is somewhat inconvenient to use especially for oil chemists. In the determination of fat compositions it often becomes necessary to change the cell lengths frequently. If the holder supplied with the instrument is used together with the regular Beckman cells, it becomes necessary to unscrew the partition and move it over when changing from one cell length to another.

To overcome this difficulty and to facilitate the use of various cells rapidly and sequentially a special holder was designed. The original suggestion for a similar design came from B. A. Brice of the Eastern Regional Research Laboratory of the U. S. Department of Agriculture. He had designed a holder for the demountable type of cells similar to the one described here. The present design was developed to hold the circular cells regularly supplied with the Beckman instrument.

A top view of the holder is shown in Figure 1. The cells are placed in the "V" grooves and are put in place in the light beam by means of the locking adjustable screws. The hole through the center axially was made merely to reduce the weight of the carrier.

Figure 2 shows a bottom view of the carrier. The small "V" on the left rides on the supporting rod in the same manner as the regular Beckman circular cell holder. The "step" on the right side of the carrier rests on the supporting rod closest to the phototube compartment. To relieve further the weight of the carrier some sections were removed from the bottom as shown in the picture.

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