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Standard Guide for Controlled Laundering Test Using Naturally Soiled Fabrics and Household Appliances[1]

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1. Scope

1.1 This guide covers a testing technique that may be used for comparing the cleaning and whitening or brightening performance of home laundering products or home laundering procedures. This testing is done on naturally soiled family items in home laundering equipment in a laboratory under controlled conditions on a paired comparison basis. As many as four detergents have been put into order by evaluating the set of matched garments two at a time. Use the standards referenced in Section 2 if instrumental readings in addition to human panelists are desired.

1.2 There is no single assessment that will give the overall performance of laundry product. A single test can only predict how products compare under the particular conditions chosen for evaluation and cannot be expected to reflect their comparative performance under the many other possible conditions of use. A series of assessments is always necessary in order to evaluate the many aspects of product performance. While there are laboratory methods of measuring individual aspects of performance (for example, redeposition, solubility), it is necessary to conduct confirming tests under controlled but practical home laundering conditions to simulate consumer experience more closely.

1.2.1 Among the variables that can affect the performance of home laundering products or procedures and that shall be considered in designing tests for their evaluation are: type of fiber, fabric construction, fabric finish, types of items to be washed, load size, kind and level of soils or stains, water hardness, water temperature, pretreatments, the presence of various laundering aids, the concentration of products in the laundering solution, sequence of addition of products, water, laundry, wash time, rate and type of agitation, spin speed, drying or ironing methods, and conditions under which the items are judged.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:* [2]

D 1729 Practice for Visual Appraisal of Colors and Color Differences of Diffusely Illuminated Opaque Materials

D 3050 Guide for Measuring Soil Removal from Artificially Soiled Fabrics (Not Suitable for Detergent Ranking)

E 179 Guide for Selection of Geometric Conditions for Measurements of Reflection and Transmission Properties of Materials

E 284 Terminology of Appearance

E 313 Practice for Calculating Yellowness and Whiteness Indices from Instrumentally Measured Color Coordinates

E 1347 Test Method for Color and Color-Difference Measurements by Tristimulus (Filter) Colorimetry

2.2 *ANSI Standards:*[3]

L14.175 Reflectance, Blue and Whiteness of Bleached Fabric

Z224.1 (AHAM HLW-1) AHAM Household Washer Performance Evaluation Procedure

3. Summary of Guide

3.1 This guide consists of comparing matched loads of laundry through a series of soiling and washing cycles. The washings are performed by using predetermined concentrations of the two or more detergents or two or more laundry additives, or both, and predetermined but identical water temperatures and water hardness conditions in the same machine or in matched machines. If more than one machine is used, it is recommended that the loads and machines be rotated. The laundry bundle from each family is separated into two or more matched loads. All loads are to have been soiled in the same

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

time period by each family. A judgment of relative performance is made at the end of each laundering cycle. It is generally necessary to continue for at least ten cycles to ascertain whether or not a significant difference exists.

3.2 This multicycle test may minimize or exaggerate the true relationship of the several detergents. Repeat tests shall be made to confirm or deny results that are questionable for any reason whatsoever.

3.3 Gross inconsistencies in soiling and staining by panelists, dye transfer from one item to others during the wash, inconsistencies in washing due to machine failure, and other such aberrations shall be watched for and reported. If they occur, they may necessitate removal of the garments or repeat tests.

4. Significance and Use

4.1 This guide defines a minimum combination of conditions to provide a reasonable basis for the visual evaluation of cleaning and whitening or brightening performance of home laundering products or procedures. To provide a more predictive and broader scope of evaluation or to assess special product types or end uses, testing should be augmented by extending specific variables.

4.2 This guide is suited to the evaluation of the cleaning, whitening or brightening properties of laundry products. This guide does not address the evaluation of some other important performance aspects of products such as: the effect on fabric life or home laundry appliances, or the physical properties such as pourability, dustiness, or solubility. However, the effect on color, feel, or odor of fabrics may be evaluated by appropriate and relatively minor changes in procedure.

5. Laundry Panel

5.1 The laundry panel shall be composed of family units consisting of an adult male, an adult female, and two or more children, with the family units being adjusted based on the number of products. The more family units involved, the greater the statistical validity is likely to be and the smaller the difference that can be distinguished. Experience suggests that ten family units can be reasonably predictive. Extra family units should be included to provide for attrition during the test period, for example, if the base is to be ten families, the test should be started with twelve families.

5.2 The families chosen for the panel should live close enough to the testing laboratory so that the soiled laundry can be brought to the testing laboratory and returned to the families' homes preferably during the same day.

5.3 Such demographic factors as age of family members, occupations, local, and type of dwelling should be recorded. This information could be important to evaluate the reproducibility of the test or to correlate this test with others.

6. Laundry Load

6.1 The load weight shall be compatible with the capacity of the test washer(s). For most top-loading automatic washers, a 5 to 7-lb (2.3 to 3.2-kg) load is satisfactory. (The U.S. median weight of all loads washed in top-loading automatics is about 6 lb.). For more than two products, extra care in recruiting panelists is needed because of the large number of articles.

6.2 Use new, moderately priced national brand garments and household items typical of the washable items found in the home. Assembling matched sets of items is extremely important. Use only items that match visually (and instrumentally if desired). The weight and composition of the bundles shall be maintained. If there is a loss of any item for any reason, replace the matched pair.

6.3 Select the loads to fit the needs of the panel so that each matched set is used during each use cycle with the objective of obtaining approximately equal soiling.

6.4 Include primarily white items to maximize sensitivity to cleaning and redeposition effects. Any colored items should be colorfast under conditions chosen for laundering. Dye transfer will interfere with evaluation of deposition, redeposition, or detergent colorant staining effects.

6.5 The test load should represent typical items found in a current family wash. Make an effort to balance the fiber content between cotton, polyester/cotton blends and man-made fibers (for example, 100 % nylon and 100 % polyester). This may change depending on test objective. Fluctuations in fiber availability and changing textile trends make it difficult to specify precise fiber contents and fabric constructions for specific items. In interlaboratory work a standard load should be agreed upon by the participating laboratories. Record and report the actual fiber composition of the items in the test load. A typical test load for each product that would allow use of some items by each person in a four member family might include:

1	twin-size bottom sheet (polyester/cotton)
4	pillow cases (polyester/cotton)
4	terry face cloths (cotton)
4	terry hand towels (cotton)
3	T-shirts (polyester/cotton)
2	man-made fiber slips, nightgowns, or pajamas
2	men's dress shirts (polyester/cotton)

6.5.1 Add extra new items if needed to bring the load up to the desired weight. For this two to four product test as described here, provide each family with two to four identical loads of the items listed in 6.5 or similar items.

7. Apparatus

7.1 *Household Automatic Washer in Good Working Condition*—Test the physical performance characteristics of any machine used in a test program to be sure the machine is operating properly. This should include an examination of water volume (fill level), timer control, rate of agitation, and spin. This is particularly important if more than one machine is involved as in interlaboratory testing. Any malfunction of a machine or any difference between machines of the same model could completely alter the results of a laundry treatment comparison. A separate test is necessary to obtain valid evaluation of product performance in other types of washers.

7.1.1 The "regular" or "normal" cycle with a 12-min wash is suggested as typical. Monitor the fill, volume, temperature, and time for each wash.

7.2 *Household Automatic Clothes Dryer in Good Working Condition*—As with washers, the physical performance characteristics of the dryer (inlet and outlet temperatures and timer operation) should be tested to be sure of proper operation. It is

important that both test loads be dried equally. Clean the lint screen of the dryer before each use.

7.3 Use either the same or matched washer(s) and clothes dryer(s) for the separate comparison loads.

7.4 Rotate washers and loads if more than one washer is used.

8. Recommended Conditions

8.1 *Water Hardness*—The water hardness shall be the same in the wash and in the rinse. If only one test is to be made, hard water (150 ppm, about 9 grains/gal (gpg) is suggested. To produce a more complete picture of product performance test at two or three additional hardness levels, use soft water (35 ppm, 2 gpg), moderately hard water (100 ppm, 6 gpg), or very hard water (260 ppm, 15 gpg).

8.1.1 *Calcium/Magnesium Ratio (as $CaCO_3$)*—It is suggested that this ratio be adjusted for different water hardnesses as follows:

Water Hardness Range, ppm (gpg)	Calcium/Magnesium Ratio
0–60 (0–3.5)	4:1
61–120 (3.6–7.0)	3:1
121 and over (7.1 and over)	2:1

These ratios are based on calculations derived from date included in *Public Water Supplies of 100 Largest Cities in The United States.*[4]

8.2 *Water Temperature*—If only one test is to be made, water at 90 ± 2 °F (32 ± 1 °C) is suggested for the wash temperature. Testing at two additional wash temperatures, water at 120 ± 2 °F (49 ± 1 °C) and water at 60 ± 2 °F (16 ± 1 ° C) will provide a more complete picture of performance per the Procter & Gamble Consumer Survey. All rinsing should be done at the "cold" setting. Measure and record the wash and rinse temperatures after one minute of agitation for each run.

8.3 *Water Fill Level*—Use the water fill level appropriate to the size of the load and machine model. For example, a 17-gal (64-L) fill is suitable for the load recommended in a top-loading agitator automatic washer.

8.4 *Ironing/Pressing*—Whenever possible it is best to eliminate ironing variability. If ironing is done, care shall be taken to establish a standard procedure. Check the temperature of the iron or irons used regularly. The number of strokes or the time of contact of the iron with the fabric is difficult to control. For this reason, avoid ironing before grading of items if possible.

8.5 *Cycles*—Ten complete soiling/laundering cycles are recommended. This is generally the minimum number of cycles that will give meaningful results. Large differences in product performance, if they persist for several washes, may be demonstrated in fewer than ten cycles.

9. Test Products

9.1 *Selection and Preparation*—Any given brand as marketed may encompass several compositions that should be evaluated separately. Sufficient quantity of a single "code" of the brand to be evaluated should be mixed or blended after the use level has been determined on the product as purchased (see 9.3) to provide a uniform composition for all test planned for the given material. The composition of the test products should be obtained and recorded together with the manufacturer's product code.

9.1.1 Test products may be experimental formulation.

9.2 *Laundering Aids*—Any laundering aid designed to be used in the laundering procedure, for example, liquid and dry bleaches, presoaks, detergent boosters, pre-spotters, fabric softeners, water conditioners, may be evaluated using these test procedures. The manufacturer's instructions should be followed for usage level and for addition to the washing machine.

9.3 *Test Product Concentration*—If only one test is to be made, it is suggested that the recommended use level for the test product (the amount stated on the package for the type of machine and water level) be used.

9.3.1 Testing at two additional use levels, for example, 20 % above and below the recommended amount, will provide a more complete picture of the performance of the specific detergent.

9.3.2 Recommended use levels are given by volume, for example, cups. Because this measurement is imprecise, the average weight of a poured unit volume (cup, cap, etc.) should be determined for the specific product to be used. The testing weight for each wash should be calculated from the use level volume desired and the determined average weight. That weight should then be used for each wash cycle.

9.3.3 When no recommended use level is given on the package, the average of the use levels extant in the marketplace on producers of similar bulk density should be use.

10. Procedure

10.1 Make a preliminary comparative evaluation of all new, unwashed items to be included in the test. It is exceedingly important that all matched items be identical with respect to the fabric, construction, and appearance. Often items in the same box or gross lots will vary. It is advisable to save one complete, unused set for reference (see 10.4).

10.2 Assemble matched sets of items (see 6.2). Arrange into sets of wash loads. Permanently code each item for identification. Weigh each load.

10.3 Follow exactly the instructions on each test product (even when the instructions differ for the two test products being compared) for the proper sequence of addition to the machine of water, detergent, laundry, and laundering aids. Add the large laundry items to the machine first, and add the small items in a random manner.

10.4 Prewash each load of new items once in the respective products or AATCC standard detergent without brightener using the test conditions decided upon. Tumble dry all items. Check to make sure that articles still match.

10.5 Pack all wash loads as one bundle so that they will be used randomly by the laundry panel. Deliver to the panel with instructions for use. The panelists should use or wear all of the items in their normal manner each cycle and be instructed to be sure each item of each matched set is used equally. In the case of clothing, the same individual in the family should wear the matched items. The panelists should be cautioned not to follow the natural inclination to wash out heavy stains. Sponging such

[4] Becker, E., and Durfor, C. N., *Public Water Supplies of 100 Largest Cities in the United States*, U.S. Government Printing Office, 1964.

items with clear water is permissible. No items are to be washed by the panelist.

10.6 At the end of a use cycle, collect the bundle from each family. Examine and evaluate types and degree of soil on each item (see 11.3). Sort the bundle into the sets of wash loads. Wash and dry each load using the test conditions decided upon.

10.7 Evaluate the matched sets (see 11.4) with the code concealed or disguised. Randomize the matched sets of identical items to minimize possible biases due to order of presentation, handedness, and direction of illumination. When more than two products are being compared, evaluate two articles at a time until the entire set can be arranged from most preferred to least preferred.

10.8 Pack and deliver each bundle as described in 10.5.

10.9 Repeat the procedure in 10.6 and 10.7 at the end of each cycle.

11. Evaluations

11.1 Compare the items to be evaluated in this guide visually for relative cleanliness and whiteness or brightness only. Other important effects of detergents and laundering aids on laundered items such as preservation or deterioration of colors, harshening or softening, removal of undesirable odors or imparting of desirable odors, and preservation or deterioration of the integrity of the item are not included but could be by changing the evaluation procedure.

11.2 Make all preliminary fabric comparisons and all test evaluations under a properly maintained lighting system that produces incandescent light for the evaluation of cleaning performance and north daylight (including ultraviolet light) for the overall evaluation of cleaning plus whitening or brightening performance.

11.3 Immediately before each laundering, examine the matched items, and evaluate with regard to types and degree of soil. Note unusual stains. In cases of extreme differences in soiling, give consideration to dropping those matched items from the test and replacing them with new items.

11.4 Immediately following the laundering and drying, three or more experienced evaluators shall grade each set of the matched items under incandescent and under north daylight conditions. Each set shall be graded in rank order by each evaluator for preference. Garments should be ranked two at a time until the entire set is put into rank order. The numerical rankings can be used for scoring and statistical calculations.

11.4.1 All evaluators should have normal color perceptions.

11.4.2 Comments of the evaluators such as, “The color of this item is better,” or “I do not like these soiled areas,” should be recorded. Such comments can be of value since they may give an indication of the reason for a preference.

11.5 At the completion of the final soiling/laundering cycle, an additional group of ten or more evaluators may individually grade each set of the matched items as described in 11.4. Comments of each evaluator shall be recorded.

12. Assembling the Data

12.1 Preference votes obtained under incandescent lighting and those obtained under north daylight lighting shall be tabulated and statistically evaluated separately.

12.2 Preference votes obtained during the test for any items lost or dropped for any reason and those for their replacements (see 11.3) shall be deleted.

12.3 The average number of preference votes obtained from the trained evaluators (see 11.4) for each separate item in the wash load shall be calculated and plotted after each cycle to determine the progress of the test.

12.3.1 The average number of preference votes obtained from the ten or more evaluators (see 11.5) at the completion of the final soiling/laundering cycle can help confirm differences, if any, between test product.

12.4 Averaged preference votes for items of similar fiber compositions (for example, cotton, nylon, polyester, and polyester/cotton may be grouped, if it is desired, in order to report the comparative performance). Other groupings of items may be: natural fibers, synthetic fibers, permanent press, delicate fabrics, and types of soil, (for example, oily, particulate, and body).

12.5 The preference votes data should be examined using standard statistical methods to determine whether the data are consistent, whether the performance of the tested detergents is significantly different and whether the performance of one is superior to the other(s) on specific items or groupings.

12.5.1 Multiple regression analysis as found in Cochran and Cox[5] may be used for the data from the trained evaluators (see 11.4).

12.5.2 A suitable method for the data from the larger evaluator group (see 11.5) could be based on the sequential two-tailed test described in Bross[6] with predetermined statistical limits. Reference the AMWAY statistical method if available.

13. Interpretation of Results

13.1 The preceding guide defines a minimum combination of conditions to provide a basis for the visual evaluation of cleaning and whitening or brightening performance of home laundering products or procedures. Included in the guide is only a single level of the following laundering factors: load composition, load size, water hardness, and hardness composition, water temperature, detergent product concentration, wash time, degree of agitation, spin speed, and drying condition. No basis exists for the extrapolation of the results of this guide to other levels of the laundering factors, either singly or in combination.

13.2 A simple procedure for appropriately weighting the preference votes on individual items into a single quantitative measure of overall preference for all items combined is not available because the relative importance of each item to different consumers is variable.[7]

14. Precision and Bias

14.1 Since the variability that is inevitable in natural soiling of household items and garments is inherent in the guide, it

[5] Cochran and Cox, *Experimental Design*, John Wiley and Sons, Inc., New York, NY 1975.

[6] Bross, I., “Sequential Analysis Based on Pair Differences,” *Biometrics*, BIOMB, Vol 8, 1952.

[7] Harrington, E. C., “The Desirability Function,” *Industrial Quality Control*, IQCOA, April 1965.

does not have the precision or reproducibility of analytical determination.