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Standard Guide for Evaluating Fabric Softeners[1]

This standard is issued under the fixed designation D5237; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This guide evaluates the performance characteristics of fabric softener products. It provides guidance for evaluating the on fabric efficacy of treatment chemicals dosed into the wash, rinse, or dryer cycle in a home laundry washer or dryer. This guide can be used for screening of fabric softener products, or to evaluate the products through multiple accumulative cycles.

1.2 The relative ranking of products assessed by these procedures may be affected by such factors as machine type and settings, fabric load composition, as well as by the washing and drying procedures used.

1.3 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.4 *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]

E313 Practice for Calculating Yellowness and Whiteness Indices from Instrumentally Measured Color Coordinates

E1958 Guide for Sensory Claim Substantiation

E2164 Test Method for Directional Difference Test

2.2 *AATCC Standard:*[3]

AATCC Test Method 110-1994 Whiteness of Textiles

3. Terminology

3.1 *Definitions:*

3.1.1 *fabric softener, n*—laundry auxiliary product or laundry detergent ingredient that gives fabrics a soft feel, smooth surface, provides fragrance, or reduces static electricity, or a combination thereof.

3.1.2 *front-loading high-efficiency (HE) washing machine/washer, n*—horizontally or nearly horizontally oriented machine used for laundry that uses varying amounts of water to launder fabrics.

3.1.2.1 *Discussion*—These washers *(1)* may not exhibit any visible free water or may show significant quantities of visible free water, *(2)* may lift and tumble the clothes load, *(3)* may employ both spinning and tumbling in both the washer or rinse processes, *(4)* may use jet sprays of wash solution or rinse solution, or *(5)* may use thermal or chemical inputs, or both, to offer sanitation or allergen claims. HE washers use considerably less water and energy than traditional deep-fill washers in the laundering process. HE washers are labeled by the appliance industry and may be recognized by the U.S. Department of Energy (DOE) and U.S. Environmental Protection Agency (EPA) as Energy Star rated machines.

3.1.3 *home laundering, n*—cleaning or conditioning, or both, of textile materials using the washing and drying equipment commonly found in the home.

3.1.4 *top-loading high-efficiency (HE) washing machine/washer, n*—vertically oriented agitation machine that is used for home laundry, with the fundamental difference from a traditional top-loading washer being that this washer uses reduced water resources during the process.

3.1.4.1 *Discussion*—This washer may *(1)* deep fill once (during the wash or rinse), *(2)* partially fill one or more times, *(3)* may have a full agitator, *(4)* may have an impeller in place of an agitator, *(5)* may use thermal or chemical inputs, or both, to offer sanitation or allergen claims, or *(6)* may use spray washing or spray rinsing technologies, or combination thereof. HE washers use considerably less water and energy than traditional deep-fill washers in the laundering process. HE washers are labeled by the appliance industry and may be recognized by the U.S. DOE and U.S. EPA as Energy Star rated machines.

[1] This guide is under the jurisdiction of ASTM Committee D12 on Soaps and Other Detergents and is the direct responsibility of Subcommittee D12.25 on Consumer Standards.

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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 Association of Textile Chemists and Colorists, P.O. Box 12215, Research Triangle Park, NC 27709.

3.1.5 *traditional deep-fill top-loading washing machine/ washer, n*—vertically oriented agitation machine that is used for home laundry.

3.1.5.1 *Discussion*—This washer fills to the basket top at least two times during the wash process: once for washing and once for rinsing. This type of washer may also include spray flushes in either the wash or rinse portions of the cycle.

4. Summary of Guide

4.1 Fabrics are evaluated for the impact of fabric softener products applied in the wash, rinse or dryer cycle for softness, whiteness retention, rewet or water absorbency, static control, or fragrance, or combination thereof, using test panels or instrumental methods.

5. Significance and Use

5.1 The methods in this guide can be used for screening of fabric softener products or to evaluate their performance, through a single cycle or multiple accumulative cycles, relative to a designated reference product or a comparative product(s).

5.2 A single assessment of each of the product characteristics tested by these methods will not predict overall performance of the softener product. A single test run under specified fixed conditions cannot be expected to reflect the comparative performance under many other possible conditions of use.

6. Fabric Preparation

6.1 *Scope:*

6.1.1 This section provides a procedure for preparing new or previously used textile specimens for further treatment and evaluation.

6.1.2 All new fabrics received directly from the mill or purchased from vendors must be stripped of mill conditioners and processing auxiliaries. Test fabrics are to be used for only a single evaluation while ballast used for load bulk may be reused indefinitely if stripping is done between each evaluation.

6.2 *Apparatus and Materials:*

6.2.1 *Automatic Washing Machine,*

6.2.2 *Automatic Laundry Dryer,* gas or electric.

6.2.3 *Test Fabrics,* white cotton or cotton/polyester loop terry cloth, or both, such as hand towels. Other fabrics suitable for fabric softener products are also acceptable. Care should be taken to use matched sets of fabrics of the same brand and manufacturing origin, and similar construction, weight, and fiber blend within each specific test.

6.2.4 *Fabric Load,* Minimum of 6 lb (2.7 kg) for each total load. Supplement test fabrics with ballast fabrics, such as pillow cases, terry towels, or commercially available yard goods cut in pieces no larger than 1 yd^2 (0.8 m^2) per piece. All ballast loads shall be the same composition for each run within a test. When running successive test loads, use fresh ballast or strip the ballast prior to use.

6.2.5 *Standard Referemce Detergent,* such as, AATCC (American Association of Textile Chemists and Colorists), liquid or powder (suggested to use without brightener formula if testing whiteness retention), or a commercially built anionic detergent, if desired.

6.3 *Stripping Procedure*—The objective of this procedure is to remove finishes or residues, or both, from the ballast and test fabrics. The procedure below is one suggested way to meet this objective.

6.3.1 Load washer with appropriate amount of fabrics. Do not overload.

6.3.2 Add appropriate dosage of built anionic detergent.

6.3.3 Set machine for hot wash temperature setting. Allow washer to fill with water and continue on through the complete wash and rinse cycle.

6.3.4 Repeat 6.3.2 and 6.3.3 four more times.

6.3.5 Wash this load of fabric through an additional complete cycle three times with no detergent. If there appears to be residual detergent (as evidenced by sudsing during the previous cycle) repeat the water only cycles one or two more times or as needed to ensure removal of residual anionic detergent to a minimal level.

6.3.6 Dry fabrics in an automatic dryer at the *normal* or *hot* setting until the load is dry.

6.3.7 If fabrics are stored prior to evaluation, protect from environmental influences such as odor, moisture, dust, etc.

7. Fabric Treatment with Fabric Softener

7.1 *Scope:*

7.1.1 This section provides the procedure for application of the test products to the textile substrates.

7.2 *Fixed Test Conditions*—All test conditions not under study should be fixed within the range of normal household practice. The following are suggested as representative of many households.

7.2.1 *Matched Washing Machines*—All washings shall be performed in the same machine or in mechanically matched units of the same model machine using a controlled experimental design.

7.2.2 *Household Automatic Washing Machine:*

7.2.2.1 *Conventional Deep-fill Traditional Top Loader*—Normal/casual with 10-14 min wash cycle, appropriate water fill for load size, and regular spin speed.

7.2.2.2 *Front-loading High Efficiency*—Normal/casual or normal/colors setting, normal soil level, and high spin speed,

7.2.2.3 *Top-loading High Efficiency*—Normal/casual or normal/colors setting, normal soil level, and high spin speed.

7.2.3 *Household Automatic Laundry Dryer,* gas or electric.

7.2.4 *Stripped Test Fabrics,* defined in 6.2 and 6.3.

7.2.5 *Water Hardness*—35 ppm (2 grains/gal); 100 ppm (6 grains/gal); 150 ppm (9 grains/gal); and 260 ppm (15 grains/gal). 120 ppm (7 grains/gal) is suggested if only one level is tested.

7.2.5.1 The calcium/magnesium ratio of the hardness minerals (expressed as $CaCO^3$) should be adjusted to attain different water hardness as shown in Table 1.

TABLE 1 Water Hardness Range

Water Hardness Range	Ca/Mg Ratio
0 to 60 ppm	4:1
61 to 120 ppm	3:1
121 ppm and over	2:1

7.2.5.2 *Hard Water Stock Solution*—For a 2:1 ratio, prepare a hard water stock solution by dissolving 2.940 g of calcium chloride dihydrate ($CaCl2{\cdot}2H_2O$) and 2.033 g of magnesium chloride hexahydrate ($MgCl2{\cdot}6H_2O$) in DI water. Dilute to a volume of 1 L with additional deionized (DI) water. This solution contains 3000 ppm hardness (expressed as calcium carbonate) with a Ca:Mg molar ratio of 2:1. For a 3:1 ratio, use 4.41 g of calcium chloride dihydrate ($CaCl2{\cdot}2H_2O$) and 2.033 g of magnesium chloride hexahydrate ($MgC12{\cdot}6H_2O$) in DI water. Larger batches or concentrations may be scaled up using this ratio of calcium chloride to magnesium chloride.

7.2.6 *Water Temperature*—Record temperature actually used. If only one treatment temperature is tested, use a warm wash/cold rinse setting. The suggested test temperatures for respective machine formats are as follows:

Conventional Deep-Fill Top Loader—86 ± 5°F (30 ± 5°C) wash cycle, 60 ± 10°F (15.6 ± 5.5°C) rinse.

Front-Loading High Efficiency—77 ± 5°F (25 ± 5°C) wash cycle, 60 ± 10°F (15.6 ± 5.5°C) rinse.

Top-Loading High Efficiency—75 ± 5°F (23.8 ± 5°C) wash cycle, 60 ± 10°F (15.6 ± 5.5°C) rinse.

NOTE 1—Within a single test, the respective wash and rinse temperature profiles should be consistent.

7.2.7 *Fabric Load Weight*—Dry ballast and test fabric load should weigh minimum 6 lb (2.7 kg). Towels preferably should be pre-weighed. Towels of similar weights (±1.0 g) should be compared, as different weights can impact results.

7.2.8 *Wash Detergent Dosage*—Use recommended dosage of AATCC Standard Reference Detergent WOB (without brighteners). If a commercial detergent is used, follow manufacturer's recommendation.

7.2.9 *Softener Product Dosage*—The amount of the softener dispersion to be used in each test is determined by the level of active softener ingredient desired per unit weight of dry fabric. If commercial products are being tested, follow manufacturer's dosage recommendations.

7.3 *Procedure*—Calculate the proper number of test fabrics to be used in your experimental design. One test fabric may be evaluated by up to five panelists. It is recommended that at least two, preferably three or more replicates are tested in each respective test wash. Multiple wash runs can also strengthen your experimental design. Determine the number of desired panelists (see Section 8) and calculate total number of test fabrics needed for each product tested.

7.3.1 *Traditional Top Load Deep Fill Washer:*

7.3.1.1 Set washer controls for *regular* or *normal* cycle with a wash period of 12 ± 2 min and a water fill level of 16 to 19 gal. The wash period and fill level chosen should be similar for all products being tested within the experiment.

7.3.1.2 Washing machine model safety and mechanical variations will impact specific procedural steps for adding product, fabric load, and fabric softener; therefore, inter-laboratory procedural steps may vary. It is recommended, if feasible, that your detergent dosage and fabric softener dosage (if applicable) are dispersed evenly into solution.

7.3.1.3 Place fabric bundle in dryer. Add dry cycle softener, if appropriate. Use the *regular* or *normal* dryer setting.

7.3.1.4 Dry fabric bundle for 45 min or until dry. Store the test fabric overnight so they equilibrate (see 8.1.2).

7.3.1.5 Equilibrate substrates to equal temperature and humidity, preferably overnight in a humidity controlled environment (see 8.1.2). Record conditions (RH and temperature).

7.3.2 *HE Washer:*

7.3.2.1 Set wash controls for *regular* or *normal* cycle, warm wash.

7.3.2.2 Place detergent and fabric softener (if applicable) in their respective dispenser drawers. If using unit dose product, place in machine drum.

7.3.2.3 Put fabric bundle in washer. Start wash.

7.3.2.4 Once finished, place fabric bundle in dryer. Add dryer cycle softener, if appropriate. Use the regular or normal dryer setting.

7.3.2.5 Dry test fabrics for 45 min or until dry.

7.3.2.6 Equilibrate substrates to equal temperature and humidity, preferably overnight in a humidity controlled environment (see 8.1.2). Record conditions (RH and temperature).

7.4 Treated test fabrics can now be evaluated for softness (Section 8), fragrance (Section 9) or absorbency (Section 10), or combination thereof.

8. Fabric Softness Evaluation by Test Panel Scoring or Instrumental, or both

8.1 *Procedure*—Fabric Softness Evaluation by Test Panel Scoring—These assessments are provided as guidance for evaluating softness by test panel scoring. Other suitable approaches may be used, for example, those referenced in Guide E1958 and sensory textbooks such as Sensory Evaluation Techniques, 4th ed.[4]

8.1.1 Note that anyone with a potential bias (for example, employees working on the development of the product) is not appropriate for conducting evaluations.

8.1.2 Condition the fabrics in a constant temperature-humidity room (if available) overnight prior to evaluation. Suggested controlled environments are between 65 to 75°F (18.3 to 23.9°C) and 50 to 65 % relative humidity. Measure and record temperature and humidity.

8.2 The panelists must clean and dry their hands and have no lotions or other products on them before handling the test fabrics. During the evaluation the panelists may need to re-clean and dry their hands to remove any softener or oily buildup that might interfere with the test.

8.3 Panelists should be chosen based on test objective and indicated in the report. "Screened" panelists are qualified or trained, or both, in a manner that indicates an ability to determine differences where differences are expected. "Naive" panelists typically have no prior training or qualification and are typically used for consumer testing. Descriptive panelists are highly trained and can also be used.

8.4 Individual panelists should use the same handling technique when evaluating each fabric in the test set.

[4] Meilgaard, Morten C., *Sensory Evaluation Techniques*, 4th Edition, CRC Press, 2005.

8.5 *Ranking Comparison*—This evaluation uses three or more products/treatments. (For more information refer to Sensory Evaluation Techniques, 4th Ed.)[4]

8.5.1 Each panelist is given a group of test fabrics for scoring (for example, A, B, C, and D). Samples should be completely randomized and balanced such that order of appearance of each treatment is evenly distributed.

8.5.2 Each set of comparisons shall consist of 3-6 products/treatments. An increased number of product comparisons may decrease sensitivity.

8.5.3 Panelists should rank the samples from least to most soft. If desired, additional comments by the panel member on the feel of the fabric can be recorded, for example, oily, waxy, greasy, etc. Panelists may allow for ties in ranking. In this case both should be assigned a half grade, for example, if 4 fabrics are tested and 2 are judged to be a tie for the most soft, they may be assigned a score of 3.5 for each.

8.5.4 After each test the scores are evaluated using Friedman Analysis and Least Significant Rank Difference multiple comparison test (see Sensory Evaluation Techniques, 4th ed., pages 110-112).[4]

8.6 *Degree-of-Difference Testing*—This evaluation compares one or more treatments versus a control.

8.6.1 Create a scale ranging from no difference (numerical value = 0) to very large difference. The scale may be as large as is useful to the product developer, but note that the panelists must be able to understand the use of each part of the scale. As a suggestion, assign a verbal scale value (for example slight difference, moderate difference, etc.) to each part of the scale. It is recommended the panelists have training using physical examples spanning the expected range to guide use of the scale. The scale may also contain positive and negative values to indicate which sample is softer in addition to the size of the softness difference.

8.6.2 Panelists are presented initially with a control sample. They are to be instructed that the test samples may or may not be different from the control sample. They then receive a series of test samples (including the blinded control) and are asked to assign a numerical value to the difference between the control sample and the test sample. Samples should be completely randomized such that order or appearance of each treatment is evenly distributed as well as the sample that it follows.

8.6.3 After the evaluation is complete, samples may be evaluated for significant-from-control differences using t-test (to compare a sample versus the control) or ANOVA + multiple comparison test (for example, Dunnett test, in the case of more than one product being compared versus control). See Sensory Evaluation in Quality Control[5] for more information.

8.7 *Directional Difference Test (Paired Comparison)*—This evaluation compares two treatments, (for example, A versus B).

8.7.1 For effective evaluation, use Test Method E2164 as a reference tool.

8.7.2 Arrange the treated fabrics in pairs. The panelist evaluates one pair.

8.7.3 A panelist is asked to feel a pair and judge which fabric is softer. The panelist must choose one of the fabrics in each pair, even if both appear equally soft. All results are recorded. An assessor who detects no difference between samples should be instructed to make a guess and select one of the samples, and can indicate in the comments section that the selection was only a guess.

NOTE 2—Softness gauges are not appropriate for Directional Difference testing.

8.8 *Instrumental Evaluation*—Within the textile industry, there are several known instruments that measure fabric hand. These instruments may be a viable way to assess fabric softeners and their attributes. As with all experiments, statistical robustness and scientific rigor should be taken into consideration when designing your experiment. Consult with the instruments manufacturer to understand the instrument's limitations and capabilities. Internal experimentation may be required to gain the knowledge necessary to understand how these instruments and their data can be used to predict consumer experience. While instruments can provide useful information, human perception needs to be considered when determining consumer performance.

9. Measurement of Fragrance Intensity

9.1 *Scope*—This section is intended to provide guidance in the assessment of fragrance intensity regardless of preference. Fragrance can be assessed at various stages of the laundering process including but not limited to neat, damp, fresh dry, and X days after drying.

9.2 *Procedure*—Fragrance Intensity Evaluation by Test Panel Scoring—Paneling fragrance intensity can be executed in the same manner as softness as expressed in Section 8 of this guide. Panelists should be informed not to provide preference judgment, but to rate the fragrance on its intensity only. Storage of garments/towels for longevity testing should be performed consistently in which all substrates are stored in the same manner. Different storage conditions (container type, temperature, humidity) may yield different intensity results.

10. Evaluation of Fabrics for Rewet (Water Absorbency)

10.1 *Scope*—This section covers the evaluation of treated fabrics for water absorbency. Test strips of treated fabrics are positioned in a dyed water solution. The height of migration of the water in a specified time is measured.

10.2 *Apparatus:*

10.2.1 *Swatches,* minimally two replicates from two separate fabrics (4 total) at a size of 2 by 5 in., cut from terry towels or other desired fabric types treated in accordance with 7.3.

10.2.2 *Aqueous Solution,* prepared with 0.010 % of a water-soluble dye which is not substantive to cellulose, such as Rhodamine B.

10.2.3 *Ring Stands,* two.

10.2.4 *Bar,* one from ring stand.

10.2.5 *Clamp Holders and Binder Clamps,* two.

10.2.6 *Laboratory Jacks,* two large.

10.2.7 *Beakers,* two 600 mL.

10.2.8 *Timer,*

10.3 *Procedure:*

[5] Munoz, Aleandra M., Civille, G. V., and Carr, B. T., Eds., *Sensory Evaluation in Quality Control*, Springer Science+Business Media, New York, 1992.

10.3.1 Same fabric preparation as in Section 6 and fabric treatment as in Section 7.

10.3.2 Attach the bar horizontally to the ring stands with two clamp holders.

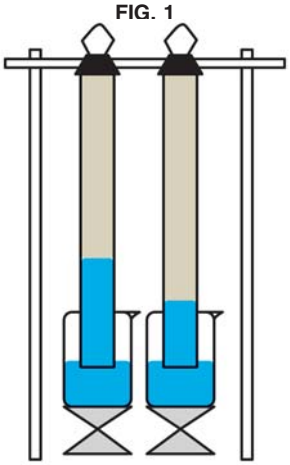
10.3.3 Mark a line 1 cm from the narrow edge of each swatch.

10.3.4 Attach the 2 by 5-in. swatches onto the bar with the binder clamps.

10.3.5 Fill the beakers equally to the same level with the dye solution.

10.3.6 Raise the beakers with the jacks until the solution level is at the 1-cm mark on the swatches. Start the timer. See Fig. 1.

FIG. 1



10.3.7 After 6 min, remove the swatches from the bar and measure the distance of migration. Because the migration line is often uneven, three readings are taken across each swatch and the readings are averaged. Record this value as mm/6 min.

10.3.8 Two swatches, containing no softener, are used for a reference control against which the treated swatches are compared.

10.4 *Interpretation of Results*—The greater the migration of the dye solution up the fabric, the better the rewet (absorbency) properties.

10.5 *Instrumental*—Within the textile industry, there are known instruments that measure moisture management. As with all experiments, statistical robustness and scientific rigor should be taken into consideration when designing your experiment. Consult with the instruments manufacturer to understand the instrument's limitations and capabilities. Internal experimentation may be required to gain the knowledge necessary to understand how these instruments and their data can be used.

11. Evaluation of Fabrics for Whiteness Retention

11.1 *Apparatus:*

11.1.1 Terry Towel or other desired fabric substrate(s), at least 8 by 8 in. Prepare fabrics according to Section 6. Minimum of 2 replicate fabrics should be used per wash run for each product tested. At least 4 wash runs are recommended to observer build-up (if any). Swatch total would equal 8 (4 wash runs/cycles × 2 reps), removing 2 swatches per wash run. Adding additional ballast to make up for lost weight after test swatches are removed is recommended.

11.1.2 *Light Source,* D65 Northern Daylight, if visual grading is desired.

11.1.3 *Spectrophotometer,* if instrumental color assessment is desired.

11.2 *Procedure:*

11.2.1 Same fabric preparation as in Section 6 and fabric treatment as in Section 7.

11.2.2 Using indelible ink, label each test swatch with an appropriate product number, wash number and replicate number. For example, if you are testing whiteness retention after 4 washes, you should have at least 8 test swatches labeled for each product; P1-wash1- rep1, P1-wash1-rep2, P1-wash2-rep1, P1-wash2-rep2, P1-wash3-rep1, P1-wash3-rep2, P1-wash4-rep1, and P1-wash4-rep2. More washes or replicates, or both, can be used, if desired. (For ease, labeling can also be performed after respective swatches are removed at each wash cycle)

11.2.3 Testing can be performed in conjunction with a softening test or designed as a separate experiment.

11.2.4 Protocol setting should be consistent with Section 7 including: ballast, machine, etc. (for Dryer Fabric Softening Sheet impact see Note 3).

11.2.5 After each wash, remove the proper test swatches for that wash number and dry according to 7.3.2.5. Drying can also be performed on a dryer rack or in a static dryer.

11.2.6 Continue with your desired number of wash replicates until finished. Put aside in a suitable container each set of replicates until all are finished and ready for assessment.

NOTE 3—For assessing the whiteness impact of Fabric Softener Sheets in the dryer stage, place all ballast and test swatches into the dryer for at least 45 min or until dry. Remove the respective wash run replicates after each dryer stage rather than wash stage in this case.

11.3 *Visual Assessment:*

11.3.1 Assessment is primarily for observing if there is a fabric discoloration concern over a period of X number of washes. Blind the labels of each sample swatch by either folding the corner and using a safety pin or some other manner of having panelists not be able to distinguish wash cycle numbers.

11.3.2 Have a sample set for each replicate laid out on a neutral gray or black background. Randomize the order of the swatches. Use an untreated towel (or other tested substrate) and the 4 (or more) wash replicates, totaling 5 towels (substrates) per replicate set.

11.3.3 Use 4-8 panelists to assess the swatches. Each panelist should be asked to rank the swatches from 1 to 5, with 5 being the whitest. Record the rank values for each swatch. Average these values and analyze their rank to see if there is a discoloration issue. Clear ranking of averages or a break in averages would indicate a discoloration build-up. Statistical analysis can be accomplished using Friedman Analysis and Least Significant Rank Difference multiple comparison test (see Sensory Evaluation Techniques, 4 th Ed., pages 111-112).[4]

11.4 *Instrumental Assessment:*

11.4.1 *Apparatus:*

11.4.1.1 Spectrophotometer or Colorimeter with UV filters.

11.4.2 *Procedure:*

11.4.2.1 Standardize your equipment as described by the manufacturer.

11.4.2.2 Using D65 10° Observer, read and average three or more locations on each swatch, including an unwashed swatch. Record the average whiteness index of each individual swatch.

11.4.2.3 UV component of the illumination will impact whitening if optical brighteners are present. Therefore, assessment may include both with and without UV by the incorporation of your instruments UV filter, if possible.

11.4.2.4 Whiteness can be calculated by a variety of indices. Many indices are available within today's instrument's software. Below are some options:

(1) Practice E313

$$WI\ CIE = Y + (800)(0.3138 - x) + (1700)(0.3310 - y)$$

where:

Y, x, y = luminance factor and the chromaticity values of the swatch

(2)

$$WI\ Ganz = Y - (1868.322\,x) + (-3695.690\,y) + 1809.441$$

where:

Y, x, y = luminance factor and the chromaticity values of the swatch.

11.4.2.5 Average these values and analyze their rank to see if there is a discoloration issue. Clear ranking of averages or a break in averages would indicate a discoloration build-up. An analysis of variance can be run to assess statistical differences in wash runs.

12. Measurement of Static Control

12.1 *Apparatus:*

12.1.1 *Same as fabric treatment* (Section 7).

12.1.2 *Fabric Bundle,* high static, weighing approximately 2.5 kg (5.5 lb) consisting of consumer relevant garments or fabric types, or both, typically found in a household. Common fabric types may include, but are not limited to, polyester, nylon, acrylic, and poly/cotton blend. Supplement with cotton ballast to equal 5.5 lb. Choosing different colored articles or serging the edges of test fabrics with color coded thread can help identify fabric types quickly.

12.1.3 *AATCC Standard Reference Detergent* or other, as desired.

12.1.4 *Hygrometer.*

12.1.5 *Thermometer.*

12.1.6 Test formulations or commercial products, or both (detergent, fabric softener, dryer sheet, or other).

12.1.7 *Instruments:*

12.1.7.1 *Electrostatic Meter or Farady Cage,* or both.

12.1.7.2 *Voltmeter,* (for instrumental method using a Faraday cage).

12.1.7.3 *Wooden Rod or Clothes Rack,* (for instrumental method using Electrostatic Meter).

12.1.7.4 *Latex/Rubber/Nitrile Gloves,*

12.1.7.5 *Timer.*

12.2 *Water Hardness*—Same as 7.2.5. Record hardness.

12.3 *Water Temperatures*—Same as 7.2.6.

12.4 *Dryer cycle*—"Normal" fabrics cycle.

12.5 *Procedure:*

12.5.1 Same fabric preparation as in Section 6 and fabric treatment as in Section 7.

12.5.2 Place fabric bundle in the dryer, which has been cleaned with isopropyl alcohol.

12.5.3 Set dryer for 60 min. Using a timer, dry bundle for at least 45 min. At 30 min, reset dryer to 60 min again. This maintains the dryer temperature and does not allow it to go into a "cool down" phase that some dryers have.

12.5.4 Record the temperature and relative humidity within the vicinity of the dryer. Variation in relative humidity will influence the degree of observed static control. (Upper limit is 40 % relative humidity.)

12.6 *Instrumental Method Using an Electrostatic Meter:*

12.6.1 Set Electrostatic Meter near dryer.

12.6.2 Ground and zero static meter in accordance with instructions.

12.6.3 After at least a 45 min drying time has elapsed, stop the machine.

12.6.4 With gloved hands, remove one garment at a time, hanging the garment or section of fabric flat over the wooden rod or clothes rack. (**Warning**—Avoid discharge of remaining fabrics.)

12.6.5 Turn on static meter and approach fabric from about 1 ft. away. Stop at exactly the desired distance from the material.

12.6.6 Read the meter and record value.

12.6.7 Ground the static meter and repeat the procedure, measuring the static for four different areas on the fabric.

12.6.8 Choose at least two garments or sections of each of the fabrics (except ballast or towels).

12.6.9 *Calculation:*

$$\text{Static Reduction, \%} = ((a - b)/a) \times 100 \qquad (1)$$

where:

a = average voltage of an untreated bundle; that is, no fabric softener, and

b = average voltage of a treated bundle.

12.7 *Instrumental Method Using a Faraday Cage:*

12.7.1 Check Farady Cage to ensure that the inner cage does not touch the outer cage.

12.7.2 Turn on voltmeter.

12.7.3 After drying time has elapsed, put on gloves and remove dried laundry from the dryer and place in Farady Cage. Avoid contact of the fabric with the body and the outer cage.

12.7.4 Follow manufacturer recommended instructions on charge assessment.

12.7.5 Press discharge button once to discharge the excess voltage on the load. This will standardize each load since the voltage in the dryer is unknown.

12.7.6 Remove articles one at a time, making sure articles do no cling together. Avoid contact of the fabric with the body of the outer cage.

12.7.7 Take reading. Record the voltage or net charge. Note and record, if articles cling.

12.7.8 Discharge by pressing the discharge button

12.7.9 Repeat 12.7.6 – 12.7.8 until all of the fabric has been removed.

12.7.10 *Calculation*—Add all the readings for a total charge of the load.