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Standard Guide for Testing Cleaning Performance of Products Intended for Use on Resilient Flooring and Washable Walls[1]

This standard is issued under the fixed designation D 4488; 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.

ε[1] NOTE—A warning note was changed editorially in August 2001.

1. Scope

1.1 This guide covers the evaluation of the cleaning performance of products intended for use on resilient flooring or washable walls. Such evaluations specifically exclude windows, mirrors, carpets, ceramic tiles, and laminated counter tops. This guide provides techniques for soiling, cleaning, and evaluating performance of detergent systems under controlled, but practical, hard-surface cleaning conditions.

1.2 Such systems include any detergent intended for cleaning hard surfaces such as resilient flooring, washable wall surfaces, and other hard surfaces, but excluding glass, ceramic, or other glossy surfaces. They may consist of solutions of soluble powdered detergent, dilutions of concentrated liquid detergent, or products intended to be used full strength, for example, foams, sprays, liquid, or paste.

1.3 There is no universal soil/substrate combination that is representative of the many soil-removal tasks required of this type of cleaner in actual use conditions. Choice of soil/substrate and cleaning conditions should be by agreement between the testing laboratory and those using the data to evaluate cleaning performance relative to user experience.

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.* Material Safety Data Sheets are available for reagents. Review them for hazards prior to usage. Specific precautionary statements are given in .

2. Terminology

2.1 *Definitions of Terms Specific to This Standard:*

2.1.1 *soil*—in hard surface cleaning, foreign matter on a hard surface.

2.1.2 *substrate*—the soiled surface that is being cleaned.

3. Summary of Guide

3.1 Soils are artificially applied in a standardized manner to specified floor or wall substrates. The soiled surfaces are cleaned using a straight-line washability apparatus, and the cleaned substrates are evaluated instrumentally or visually by a panel of judges.

4. Significance and Use

4.1 This guide suggests methodology for cleaning tests. Soil/substrate combinations are generally designed to be analogous to soiled surfaces commonly encountered. This methodology can be used with most soil/substrate combinations. Some example test methods that have worked well in other labs are provided in the annexes. There is no requirement for using the soils listed in the annexes. It is the responsibility of the user to select the appropriate battery of tests for the desired end results.

4.2 The results of tests based on this guide are regarded as diagnostic screening values useful in formulation studies, quality control, and ingredient raw material qualification. This guide is intended to allow a choice in test conditions and soil/substrate combinations appropriate to the evaluation at hand. For interlaboratory comparisons, exact test conditions must be established before test results are compared.

4.3 This guide is applicable to testing all types of multipurpose household cleaners, whether the detergent is prepared by dissolving a soluble powder, a dilutable liquid, or is a prediluted product. It may also be useful for evaluation of products or conditions normally associated with industrial or institutional cleaners.

5. Preparation of Soil/Substrate Combinations

5.1 Cleaning performance of a test product depends on the particular combination of test soil and substrate. Soils and substrates to be cleaned should be selected as pairs. The usual criteria for appropriate soil/substrate combinations are: relative ease of discriminability among cleaners to be tested; reproducibility of the test performed; and correlation of test results with consumer experience.

5.1.1 While it may be reasonable to assume that lab tests

[1] This guide is under the jurisdiction of ASTM Committee D12 on Soaps and Other Detergents and is the direct responsibility of Subcommittee D12.16 on Hard Surface Cleaning.

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using soil/substrate combinations found in normal practice should correlate with actual cleaning experience, no particular soil/substrate combination is sufficiently representative by itself to provide a reliable index of cleaning performance for all cleaning tasks. Also, lab screening systems are usually much more heavily soiled than those found under real-use conditions, in order to optimize discriminability. It is possible, however, that soil/substrate combinations not actually found in normal usage may provide a test system that correlates well with some actual cleaning conditions.

5.1.2 Preparation of the substrate, such as abrading finished floor tiles, may be necessary.

5.1.3 Natural or accelerated aging of soil, such as baked-on greasy soil, may be desirable for the purposes of enhanced discrimination or better correlation of actual home-use conditions.

5.2 For reliable test results, and to obtain the most information from lab testing, details of soiling and substrate preparation should be documented for appropriate reporting of final results.

6. Experimental Cleaning Test Procedure

6.1 Replication is essential for generation of reliable hard-surface cleaning test results. The number of replicate runs required depends on the soil/substrate combination selected, as well as the intended use of the results.

6.2 Experimental design may range from a simple paired comparison with three replicate runs using three tiles to multiple comparisons extending over days of testing.

6.3 A complete cleaning evaluation will usually require analysis of an appropriate composite result, taking into account several different soil/substrate combinations, and possibly more than one set of test conditions, for example, use-dilution, water hardness, etc.

6.4 Appropriate controls should be considered when testing. For example, a test control could be a commercial liquid detergent for which the test lab has established some index of cleaning performance prior to the test at hand. Another control could be water without detergent.

6.5 Test conditions that should normally be reported in all tests include the following:

6.5.1 Conditions pertinent to scrubbing apparatus, for example, weights (if any), cycles per test, brushes, sponges, or other scrubbing substrate used (specify).

6.5.2 Water used for dilution, if any, including temperature and hardness.

6.5.3 Use-dilution of detergent with water.

7. Performance Evaluation

7.1 Cleaning performance is frequently taken as a linear function of reflectance using a reflectometer, color difference meter, or gloss meter (specify). Other methods such as visual rating may be useful, depending on the needs and capabilities of the lab. See the examples in the annexes.

8. Statistical Evaluation and Interpretation of Results

8.1 It is strongly recommended that appropriate statistical analysis of test results be conducted to establish confidence limits on test results and to establish a basis for comparison with subsequent or previous test results.

ANNEXES

(Mandatory Information)

A1. GENERAL

A1.1 The following procedures are included as an aid to the development of uniform methodology for lab cleaning tests. The methods described below have been found to work well in other laboratories. For inter-laboratory tests, exact test conditions, including preparation of soils and substrates, must be specified.

A2. GREASY SOIL/PAINTED MASONITE WALLBOARD TEST METHOD[2]

A2.1 *Summary of Test Method*—Latex painted masonite wallboard is soiled with a mixture of melted, oily soils containing a small amount of carbon black, and allowed to set overnight. The detergent is applied to a sponge that scrubs half the soiled substrate using a straight-line washability apparatus. The other half of the soiled substrate is scrubbed with a second detergent. Cleaning performance is taken as a linear function of reflectance value.

A2.2 *Apparatus:*

A2.2.1 *Reflectometer*[3], any photometer capable of accurately measuring changes to substrate reflectance. See Fig. A2.1.

A2.2.2 *Template*, see Fig. A2.1.

A2.2.3 *Straight-Line Washability Apparatus*[4].

[2] Johnson, M. A., "A Greasy Soil Hard Surface Cleaning Test," *Journal Am. Oil Chem. Soc.*, Vol 61, 1984.

[3] Photovolt Model 670 with Search Unit 610Y and Green Tristimulus, or its equivalent, has been found suitable for this purpose. Available from Photovolt, Inc. NY, NY.

[4] BYK-Gardner Model AG-8100 available from BYK-Gardner USA, Silver Spring, MD, or the Gardco D-10 available from the Paul N. Gardner Co., Pompano Beach, FL, or equivalents, have been found suitable for this purpose.

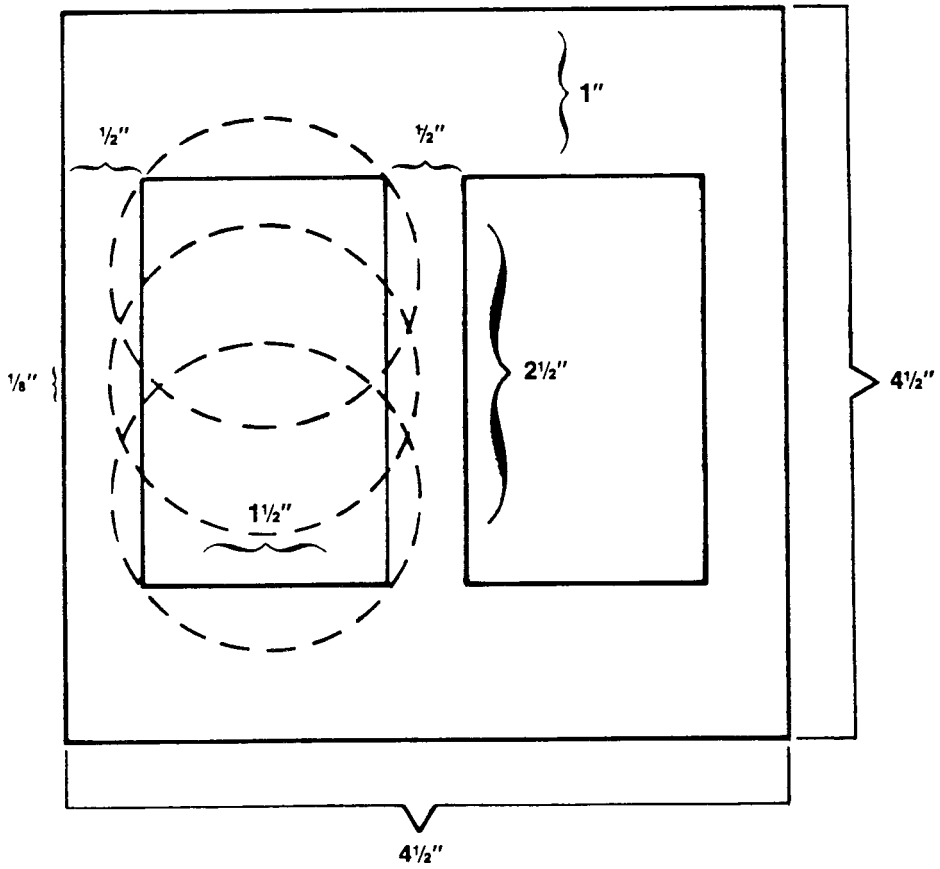

FIG. A2.1 Template for Use With Reflectometer

A2.2.4 *Graduated Cylinder*, calibrated to deliver 100 mL, and

A2.2.5 *Graduated Volumetric Pipet*, 10 mL.

A2.3 *Materials and Manufacture:*

A2.3.1 *Masonite Wallboard Tiles*—⅛-in. thick, cut 4½ by 4½ in.

A2.3.2 *Latex Paint*[5]—non-yellowing flat white.

A2.3.3 *Vegetable Shortening*[6]—from local grocery store.

A2.3.4 *Lard*[7].

A2.3.5 *Partially Hydrogenated Soybean Oil*[8]—with polyglycerol esters of fatty acids added.

A2.3.6 *Carbon Black*[9].

A2.3.7 *Sponges*[10]—cellulose sponge cut to size, 1¾ by 3⅝ by 1½ in.

A2.3.8 *Tap Water*—80 ppm hardness, as $CaCO_3$.

A2.3.9 *Cheesecloth Wipes*[11], 18 by 36 in.

A2.3.10 *Large Binder Clip*[12], 1- in. capacity.

A2.4 *Procedure:*

A2.4.1 *Tile Preparation*—Double-coat masonite tiles with latex paint using a paint roller, and allow to set overnight. Cure tiles at 45°C for 24 h.

A2.4.2 *Soil Preparation*—Blend a melt of 33 g vegetable shortening, 33 g lard, and 33 g vegetable oil with 1 g carbon black on a steam bath. Prepare fresh soil each day.

A2.4.3 *Soil Application*—Fold the cheesecloth in half several times to end up with a 2½ by 2-in. piece. Put the binder clip on the open 2½-in. long edge of the folded cheesecloth. Using the clip as a handle, soak the cheesecloth in the hot soil and apply the soil to the white-painted masonite wallboard tiles using six strokes. (see Fig. A2.2). The soil temperature should be maintained and the soil should be stirred throughout the application process. Allow the soiled substrate to dry overnight at room temperature.

A2.4.4 *Cleaner Preparation*—Prepare all cleaner dilutions volumetrically as necessary. Water is at an ambient temperature (20 to 30°C) and a specified hardness.

[5] California Paints, or equivalent, have been found suitable for this purpose.

[6] Crisco, or equivalent, has been found suitable for this purpose (trademark of Proctor and Gamble, Cincinnati, OH).

[7] Armour lard, or equivalent, has been found suitable for this purpose (trade mark of Armour Co., Phoenix, AZ).

[8] Pathmark vegetable oil, or equivalent, has been found suitable for this purpose (trademark Supermarkets General, Woodbridge, NJ).

[9] Neo Spectra Mark II Powder, or equivalent, has been found suitable for this purpose (trademark of Cities Service Co., Tulsa, OK).

[10] Shop-Rite brand sponges, or equivalent, have been found suitable for this purpose (trademark of Wakefern Corp., Elizabeth, NJ).

[11] VWR catalog No. 21910-105, or equivalent, has been found suitable for this purpose. Available from VWR Scientific, Plainfield, NJ.

[12] ACCO brand, No. 72100, or equivalent, has been found suitable for this purpose.

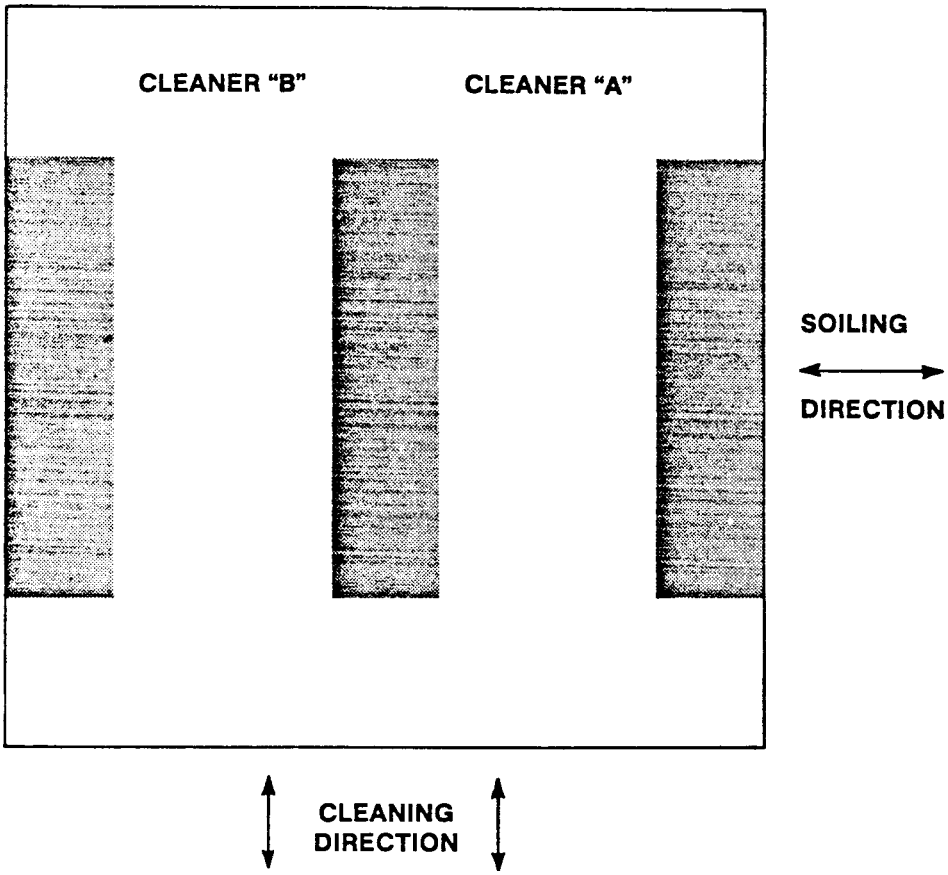

FIG. A2.2 Soiled Tile After Cleaning

A2.4.5 *Cleaning Test*—Use a new (previously unused) sponge for each cleaning procedure. Weigh 15 g of cleaner solution onto a pre-wet sponge that has been thoroughly pressed by wringer to remove most of the water then placed in the straight-line washability apparatus without weights. Sponge and holder weigh about 350 g. Place sponge so that the manufactured edge, not a face or edge that has been cut, is the scrubbing surface. Place the tile in the apparatus so that scrubbing action is perpendicular to the direction of soiling (see Fig. A2.2). Set the test apparatus at the predetermined number of cycles established according to the procedure described in A2.4.6. Operate the wash apparatus over one of the soiled areas. Shift the scrubber table and repeat the washing test over the remaining soiled area with the second detergent and a new sponge.

A2.4.6 *Establishing a Standard Number of Cycles for Test Product Evaluation*—Place tiles in the washability apparatus with the line of soil on the tile running perpendicular to the cleaning direction of the scrubbing apparatus. Using extra tiles, run standard products to determine product performance profiles. It is suggested that the standard reference products remove approximately 75 % of the soil, in order to allow for maximum product differentiation. Identify the cycle number at which maximum differences in product performance are demonstrated. Run all test products with this predetermined standard number of cycles.

A2.4.7 *Reflectometer Measurements*—After zeroing the instrument, adjust reflectance to 100 on a standard white reflectance and color tile. For example, one that has worked well has the following values: 76.3 % y, 77.6 % x, and 76.6 % z. Place a template (Fig. A2.1) over a scrubbed board so that only the scrubbed area to be measured shows through the cut-out portions. Take three readings in each cut-out portion, moving from one end to the other. Estimate readings to the nearest tenth reflectance unit. Record and average these three readings.

A2.5 *Data Handling.*

A2.5.1 Record reflectance values (three per cleaned area) and established and compared mean values using appropriate statistical methods. Paired comparisons may use a simple T-test. Multiple comparisons require some multi-variate statistical analysis.

A3. IRON OXIDE PIGMENT/LINOLEUM TEST METHOD[13]

A3.1 *Summary of Test Method*—Linoleum is soiled with an iron oxide pigment dispersed in an oil-solvent system. Soil is applied using a pastry brush or other applicator. A fine-celled sponge scrubs the soiled substrate, which is immersed in the detergent system being tested. Cleaning performance is evaluated by comparing reflectance measurements made on the clean, unsoiled test panel and on the soiled panel after scrubbing using a colorimeter[14]. Results are reported as percent soil removed.

A3.2 *Apparatus*:

A3.2.1 *Straight-Line Washability Apparatus*[4].

A3.2.2 *Test Sponge Holder*—Standard brush holder for the straight-line washability apparatus unit, ⅞-in. deep with one open face, nominally 1½ by 3½ in.

A3.2.3 *Test Sponge Mounting Block*—A ¾-in. thick piece of polymethyl methacrylate[15] cut to nominal 1½ by 3½in. dimensions (block should fit loosely in sponge holder).

A3.2.4 *Metal Template*—A ¾- in. thick, 4 by 17¾-in. aluminum plate, with a center cut-out of 2 by 16 in., used to hold the substrate in place, provides a reservoir for test scrubbing solution, and functions as a guide for the sponge holder. It is designed to prevent splashout loss of solution during operation. See Fig. A3.1.

A3.2.5 *Rubber Template Insert*—A ⅛-in. thick, 4 by 17¾-in. rubber template insert, with a 3 by 6-in. cut-out to accommodate the test substrates. If the test substrate is less than ⅛-in. thick, a spacer should be used to bring the test substrate flush with the surface of the rubber insert. If the thickness of the test substrate is more than ⅛ in., a heavier gage rubber insert can be used.

A3.2.6 *"C" Clamps*—Four clamps large enough to hold the template to the scrubbing machine table.

A3.2.7 *Soil Applicator*—Pastry brush[16].

A3.2.8 *Reflectometer*[3]—Any photometer capable of accurately measuring changes in substrate reflectance.

A3.2.9 *Drying Oven.*

A3.3 *Materials:*

A3.3.1 *Test Substrate*—Off-white drawing board desk pad[17], felt-back lineoleum (0.80 in.).

A3.3.2 *Test Sponge*—A 1½ by 3½-in. section cut from a ½-in. thick sheet of foam[18] containing 60 to 80 pores per linear inch. This material is a fine-celled, reticulated, open-pore, chemically resistant, ester-type polyurethane foam.

NOTE A3.1—A uniform, fine-celled, cellulose sponge should be employed if a more chemically resistant sponge is required.

A3.3.3 *Test Sponge Mounting Adhesive*—The test sponge is

[13] "*A Hard Surface Cleaning Test Method for Artificial Soil Removal from Linoleum Surfaces*," Technical Bulletin SC: 135-81, Shell Chemical Co.

[14] Gardner LX-23 Tristimulus Colorimeter, or equivalent, has been found suitable for this purpose. Available from Pacific Scientific, Silver Springs, MD 20910.

[15] Lucite brand acrylic plastic, or equivalent, has been found suitable for this purpose (trademark of E. I. duPont de Nemours and Co. Inc., Wilmington, DE).

[16] EKCO No. 06640 CA, or its equivalent, has been found suitable for this purpose, (trademark of EKCO Housewares Co., Franklin Park, IL).

[17] A desk pad found suitable for this purpose is available from Kieffer International Products, Inc., Grand Rapids, MI. An equivalent may be used.

[18] Scott Industrial Foam, or equivalent, has been found suitable for this purpose. Available from Scott Paper Co., Foam Division, Chester, PA.

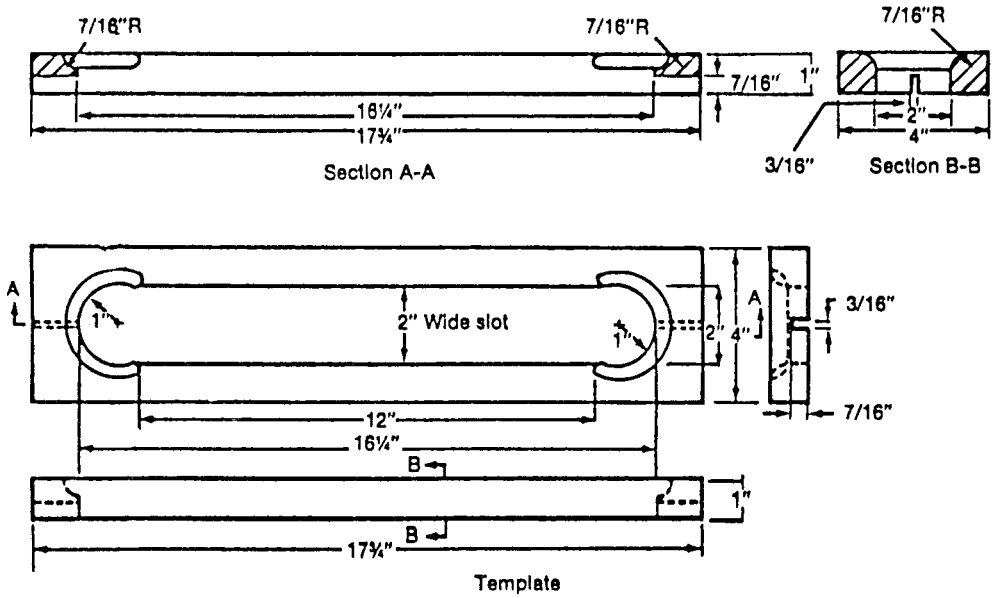

FIG. A3.1 Reservoir Template

attached to the mounting block, using rubber cement[19] by applying adhesive only around the perimeter of the sponge. (**Warning—**Complete attachment across the entire 1½ by 3½-in. face causes warping of the sponge.)

A3.3.4 *Pigment*—Metallic brown oxides[20].

A3.3.5 *Mineral Oil*[21]—Liquid petrolatum.

A3.3.6 *Turbine Base Oil*[22]—A 50–50 blend of 100 HVI neutral and 250 HVI neutral oil stocks with an aromatic content approximately 40 millimoles per 100 g and a viscosity of about 30 centistrokes at 40°C, or equivalent.

A3.3.7 *Vegetable Oil*.

A3.3.8 *Jet Turbine Fuel*[23]—A kerosene-range turbine fuel. It contains, typically, 18 to 19 % aromatics and boils in the range of 310 to 572°F.

A3.3.9 *Naphthenic Hydrocarbon Solvent*[24], boiling in the 318 to 360°F range and containing, typically, 96 % paraffins, 2 % aromatics, and 2 % olefins.

A3.3.10 *Non-Ionic Surfactant*[25].

A3.3.11 *Anhydrous Tetrapotassium Pyrophosphate*.

A3.4 *Procedure:*

A3.4.1 Prepare soil by adding parts by weight of the following in the order listed: 1.0 of vegetable oil, 1.0 of mineral oil, 1.0 of base oil, 12.0 of jet turbine fuel, 20.0 of metallic brown oxides, and 12.0 of naphthenic hydrocarbon solvent[24].

A3.4.2 *Soil Blending*—Add vegetable oil, and jet turbine fuel to a high-shear blender, and then add pigment slowly with the mixer speed set to create a slight liquid vortex. Run the covered blender at high speed for 15 min after all pigment has been added. Cool the container (ice bath), and add napthenic hydrocarbon solvent and continue mixing only long enough to achieve homogeneity. Transfer the product to a wide-mouth bottle that can be sealed. At this point, the finished soil blend has a high viscosity due to entrained air that should be expelled before using. Accomplish this by stirring the mixture, using a magnetic stirrer, or by rolling the bottle of soil, perhaps as long as overnight.

A3.4.3 *Substrate Preparation*—Wash each 3 by 6-in. test coupon using a commercial hand dishwashing liquid diluted 1:125 (1 oz/gal) with warm water. Utilizing a large cellulose sponge, scrub each panel 25 strokes with pressure applied to the sponge, and then rinse well with warm water, front and back. Hang the washed panels to dry at room temperature for about 16 to 18 h (overnight) in such a way that air passes freely across all surfaces. Prepare only the number of panels that will be soiled and scrubbed the next day.

A3.4.4 *Substrate Soiling*—Blend approximately 0.40 to 0.50 g of the well-mixed soil, that is continually kept in a dispersed state using a magnetic stirrer, and apply it with a dropper to the test coupon. Using a pastry brush, spread the soil quickly over the entire surface of the substrate, followed by more brushing to improve the uniformity of the film.

A3.4.5 *Curing the Soiled Coupon*—After application, allow the soiled coupon to set for 1 h at room temperature. Then cure the soiled panel for 20 min at 100°C in a forced-draft oven, followed by a 2-h conditioning period at room temperature, before it is ready to be scrubbed. Good repeatability results when panels are scrubbed the same day they are soiled.

NOTE A3.2—With the oven set at 100°C, no change in the level of achievable soil removal occurred with cure times between 15 to 40 min. Soil-removal rates became slightly erratic when cure times less than 15 min were used. At 110°C, equivalent soil-removal values were obtained with 15 and 20 min cures, but soil became significantly more difficult to remove after 25 min. Thus, setting cure conditions at 20 min at 100°C provides a safety margin for producing very uniform soiled substrates for measuring the efficacy of cleaning solutions.

A3.4.6 *Scrubbing Operation*—Place the cured, soiled coupon in the 3 by 6-in. cut-out of the rubber template insert, placed in the straight-line apparatus wash tray, overlaid with the aluminum template, and clamped tightly, using C-clamps to form a seal between the linoleum and the template. The template cut-out forms a reservoir and a guide path in which the test sponge housing box travels in an oscillatory mode. Add 75 mL of test solution to the reservoir and allow to stand 1 min before positioning the sponge on the substrate. Place the test sponge, which has been saturated with water and shaken hard to release free water, onto the substrate and start the machine and run for as many cycles (1 pass in each direction) as necessary for the desired level of soil removal from the substrate being tested. Scrub three soiled coupons with each test solution, and an average cleaning value (Y_s) determined for each sample. In each day's run, a set of soiled coupons should be scrubbed using only water, and the average cleaning value obtained taken as zero soil removal (Y_{H_2O}). Using this procedure, the amount of cleaning accomplished by the water portion of the aqueous test solutions is cancelled, making it convenient to compare ingredient effectiveness of the test samples.

NOTE A3.3—Drying the sponge by squeezing brings on premature cellwall fatigue, which reduces the sponge's cleaning quality. Remove the scrubbed coupon from the apparatus, rinse under running cold tap water, and hang up to dry at room temperature, allowing air to pass freely across all surfaces.

A3.4.7 *Cleaning Sponge Travel Distance*—Set the path of sponge travel in the confines of the template cut-out at approximately 12½ in. through adjustments of the driving cam gear and attachment cables of the scrubbing apparatus. This eliminates loss of cleaning solution from the reservoir through excessive sloshing at the ends, but provides sufficient cleaned path length on the substrate to make the necessary number of reflection measurements.

A3.4.8 *Evaluating the Scrubbed Coupon*—Permit the scrubbed coupon to dry a minimum of 1 h before making measurements. No changes in reflectance values were found to occur if the panel dried overnight before taking readings.

[19] Duco Cement, or equivalent, has been found suitable for this purpose (trademark of E. I. duPont de Nemours and Co. Inc., Wilmington, DE).

[20] Code B-01085, or equivalent, has been found suitable for this purpose. Available from Pfizer Minerals, Pigments and Metals Div., New York, NY.

[21] Nujol, or equivalent, has been found suitable for this purpose (trademark of Plough Inc., Memphis, TN).

[22] Tellus, or equivalent, has been found suitable for this purpose (trademark of Shell Chemical Co., Houston, TX).

[23] ASTF-640, or equivalent, has been found suitable for this purpose. Available from Shell Chemical Co., Houston TX.

[24] Shell Sol 340, or equivalent, has been found suitable for this purpose. Available from Shell Chemical Co., Houston, TX.

[25] Neodol 23.6.5, or equivalent, has been found suitable for this purpose. Available from Shell Chemical Co., Houston, TX.

A3.4.8.1 The entire scrubbed coupon can be handled when making reflectance measurements on a reflectometer. The cleaned path centered on and running the length of the coupons is approximately 1½-in. wide. The light beam emitting from the instrument has a diameter of about 1¼in. Centering the coupon over the hole through which the light beams, five measurements are made ¾ in. apart, starting 1½ in. from one end. The five readings are averaged to obtain a reflectance value for the test coupon.

A3.5 *Data Handling:*

A3.5.1 *Cleaning Effectiveness*—The cleaning effectiveness of a test sample, as measured by this method, is its ability to remove the test soil from the test substrate and may be expressed in the following ways:

A3.5.1.1 When performance of the standard for a particular days run is not at significant variance with an established norm for the standard, test sample results may be expressed simply as % soil removed according to the following equation:

$$\% \text{ soil removed} = (Y_s - Y_{H_2O}/Y_o - Y_{H_2O} \times 100) \quad \text{(A3.1)}$$

where:

Y_s = % average reflectance after scrubbing soiled coupon with test solution,

Y_{H_2O} = % average reflectance after scrubbing soiled coupon with only water, and

Y_o = % average reflectance of original coupon before soiling.

A3.5.1.2 The least significant difference between any two mean values at the 95 % confidence level (LSD_{95}) for % soil removed is approximately five.

A3.5.1.3 If, however, it is apparent from the performance level of the standard that cleaning values may be at variance with the norm, test results for the sample should be normalized. Normalization is achieved by relating the performance of the test sample to that of the standard for that day's run as follows:

$$\text{cleaning performance, \% of standard} = (\text{\% soil removed by sample/\% soil removed by standard}) \times 100 \quad \text{(A3.2)}$$

where:

in each, % soil removed is calculated as shown above.

A3.6 *Method Precision:*

A3.6.1 *Substrate Uniformity, Initial Reflectance (Y_o):* Average reflectance values obtained for a large number of test coupons from a single lineolum lot, after washing and drying, had a standard deviation of only 0.06, attesting to a good product uniformity. It is recommended, therefore, that an average Y_o value for a lot of linoleum be determined to reduce the number of reflectance measurements that need to be made while using that lot.

A3.6.2 *Substrate Preparation*—Using the prescribed preparation techniques, the cured, soiled panels are remarkably uniform in appearance with average reflectance values having a standard deviation of only 0.25.

A3.6.2.1 *Soiled Panels Scrubbed with Only Water (Y_{H_2O}):* When it is determined that repeatable (*Y*) values are obtained for coupons scrubbed with only water, using data accumulated during early runs, an average (Y_{H_2O}) value (found to be consistently in the 18 to 21 range) may be established and used as a constant in calculating % soil removed. A 0.47 standard deviation for (Y_{H_2O}) values has been found.

A3.6.2.2 *Soiled Panels Scrubbed with Test Solution (Y_s):* In determining the average Y_s value, one of the following procedures is used:

(1) A simple arithmetic average of the Y_s values is obtained from the 3 replicates used for each evaluation, or,

(2) If the set of 3 Y_s values contains a divergent value, that value qualifies for rejection if its deviation from the mean is approximately four times the average deviation calculated from the other two replicates according to the formula:

$$\text{(deviation of doubtful results/average deviation)} = 4 \quad \text{(A3.3)}$$

A3.6.2.3 In that case, an average of two replicates is used as the Y_s value. Using either procedure, the standard deviation for the Y_s varies slightly with the level of cleaning achieved, as follows:

Y_s Range	Standard deviation	% Soil removed range
26 to 43	2.2	10 to 50
43 to 60	1.3	50 to 90

A3.7 *Discussion:*

A3.7.1 Occasionally, the absolute cleaning value of surfactants is influenced slightly by identified inherent test variables. However, the conclusion drawn from cleaning results of many sets of non-ionic surfactants that differed only in hydrophile-lipophile balance (HLB) is that, while absolute values may change, performance rank order remains constant from set to set. It has been found useful, therefore to include a standard cleaner formulation as part of the set of samples run on a given day. This internal standard provides a benchmark for the method, and serves to indicate when test method variables are affecting test results adversely. Further, test results can be reported relative to cleaning by the standard; and its inclusion, when working with other test methods, permits comparisons to be made between the methods.

A3.7.2 Neodol 23-6.5 can be selected as the surfactant for the standard because its practical level of cleaning (75 %) is in the range where good test repeatability occurs. TKPP, with its high water-solubility and moderately high pH (ca. 10) appears to be a satisfactory choice for builder. A suggested internal standard test solution, therefore, is 0.60 % w non-ionic surfactant and 0.12 % TKPP in softened water. However, the choice of surfactant and builder comprising the standard is a discretionary one.

A3.7.3 General soil-substrate interactions vary widely, depending on the type of soil and substrate being interfaced. In this test, the effectiveness of cleaning solutions is measured against a non-polar, oily soil mixture on a hydrophobic substrate. Poor performance in this test provides behavioral information in that environment, but does not predict performance against the same soil on a hydrophilic substrate or against polar soil on a hydrophilic or hydrophobic substrate. Interpretation of results from this test, therefore, should take these considerations into account.

A4. MOHAIR CLOTH/MODIFIED GARDNER STRAIGHT-LINE WASHABILITY AND ABRASION APPARATUS TEST METHOD[26]

A4.1 *Summary of Test Method*—Three separate areas of a soiled-substrate plate are simultaneously cleaned by three different test formulations using a modified straight-line washability and abrasion apparatus. Strips of mohair cloth are used instead of brushes or sponges for improved reproducibility. Cleaned substrate areas are evaluated instrumentally to determine relative cleaning performance. A cleaning index is determined using the reflectance difference between the soiled and cleaned substrate and the number of washing strokes.

A4.2 *Apparatus:*

A4.2.1 *Straight-Line Washability and Abrasion Apparatus*—Modified as shown in Figs. A4.1-A4.5 and Table A4.1 and Table A4.2.

A4.2.2 *Reflectometer*—Colorimeter.

A4.3 *Materials:*

A4.3.1 *Mohair Cloth*[27]— 1½ in. wide.

A4.3.2 *Substrate Plates*—4 by 8 by ⅛ in.

A4.3.3 *Example Soils*:

A4.3.3.1 *Grease*—Lubricating grease with 1 % charcoal, well blended.

A4.3.3.2 *Wax*[28].

A4.3.3.3 *Particulate*—Graphite powder[29].

A4.3.4 *Example Substrates*:

A4.3.4.1 *White Latex Paint*—Two coats, on masonite board.

A4.3.4.2 *White Vinyl Floor Tile*.

A4.3.4.3 *Stainless Steel*.

A4.4 *Procedures:*

A4.4.1 *Soiling*—Apply soil to a 2 in.-wide center strip of the substrate. Take care to maintain soil-thickness uniformity.

A4.4.1.1 *Grease Soil*—Apply grease/charcoal mixture to substrate plate using a 1½-in. paint brush. Spread soil evenly over substrate using a strip of mohair cloth stretched over the edge of a thin plate.

A4.4.1.2 *Wax Soil*—Apply black wax soil by making multiple passes with the wax marker over the substrate using a straight edge. Then melt the soil using a heat gun, and spread the soil evenly over the surface with a piece of mohair cloth.

A4.4.1.3 *Particulate Soil*—Make particulate soiled substrate by simply rubbing an excess of graphite powder onto the surface area.

A4.4.2 *Substrate Preparation*—Substrates should be clean prior to soiling. Area to be soiled (center 2 by 6-in. strip) should be bordered by masking tape during soiling procedures.

A4.4.3 *Cleaning Evaluation*:

A4.4.3.1 Attach mohair strips (1½ by 8 in.) to polymethylmethacrylate blocks giving a 1½ by 3½–in. cleaning surface. Press-fit each block into a weighted holder. All three weighted mohair cloth assemblies weigh 575 ± 10 g.

A4.4.3.2 Select a prepared soil/substrate plate, and measure and record the reflectance of each test area to be cleaned. Secure the soil/substrate plate tightly in modified straight-line washability apparatus.

A4.4.3.3 Place each mohair scrub assembly in approximately 50 mL of premixed solution for about 15 s. Then transfer the scrubbers to the sample assembly holder and start the test apparatus. Scrubbing results from the solution-wetted mohair strips passing over the soil/substrate plate. Cleaning continues until one test area subjectively approaches the reflectance of the unsoiled substrate.

A4.4.3.4 Remove the soiled/substrate plate from test apparatus, rinse with cold water, and allow to dry. After drying,

[26] Cox, M. F., and Matson, T. P., "Optimization of Nonionic Surfactants for Hard Surface Cleaning," *Journal of Am. Oil Chem. Soc.*, Vol 61, 1984.

[27] A mohair cloth found suitable for this purpose is available from National Novelty Brush Co., Lancaster, PA. An equivalent may be used.

[28] A Blaisdell 373-T black wax marker has been found suitable for this purpose. Available from Berol Corp., Danbury, CT. An equivalent may be used.

[29] Fisher Grade No. 38 has been found suitable for this purpose. Available from Fisher Scientific Co., Pittsburgh, PA. An equivalent may be used.

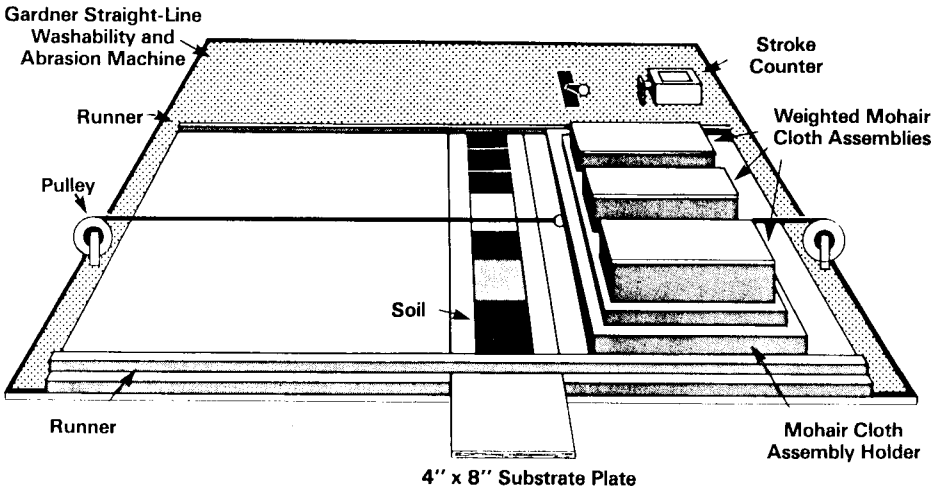

FIG. A4.1 Schematic of Hard Surface Cleaning Test Apparatus

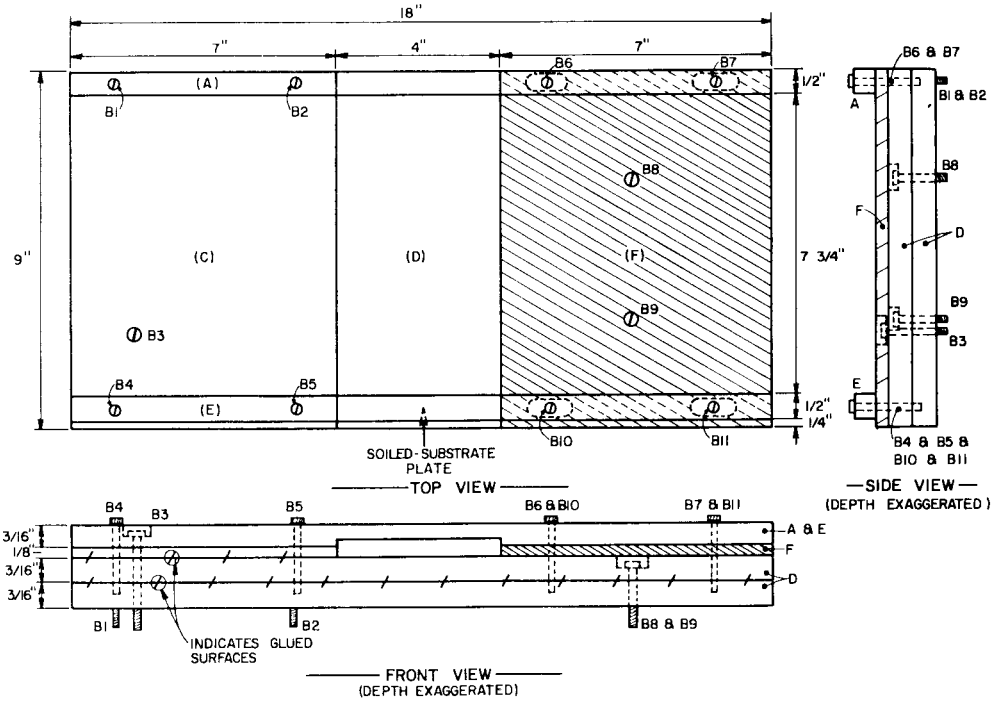

FIG. A4.2 Schematic Diagram of Modifications Made to Gardner Washability and Abrasion Machine

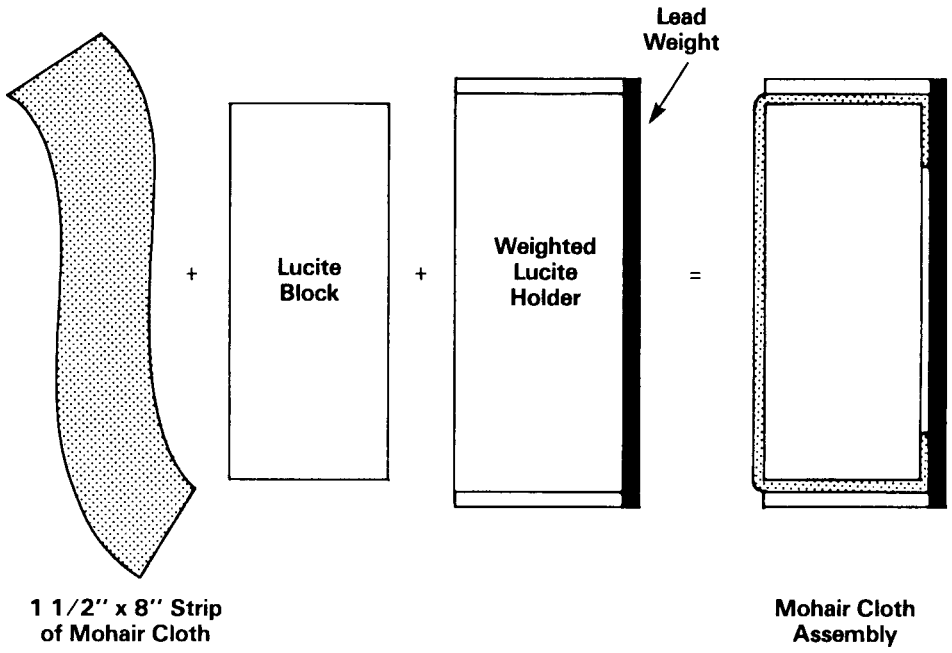

FIG. A4.3 Construction of Mohair Cloth Assembly

measure and record, the reflectance of each cleaned substrate area.

A4.5 *Data Handling:*

A4.5.1 The cleaning index or relative cleaning performance is determined by dividing the difference between the reflectance (R_d) of the soiled substrate and the cleaned substrate by the number of test strokes:

$$\text{Cleaning Index} \frac{(R_d \text{ cleaned}) - (R_d \text{ soiled})}{\text{number test strokes}} \quad \text{(A4.1)}$$

An example calculation of cleaning index is shown in Table A4.3. The higher the cleaning index, the better the cleaning performance.

A4.5.2 Cleaning indices are relative, and reflect the performance of test solutions under a given set of conditions. Results within a single test normally vary by less than 10 %. To correlate results between different tests, one of the test formulations can be employed in each run as a reference. Also, since the number of test strokes versus cleaning index is nonlinear, the number of test strokes for each soil should be maintained constant when testing a series of similar surfactant solutions.

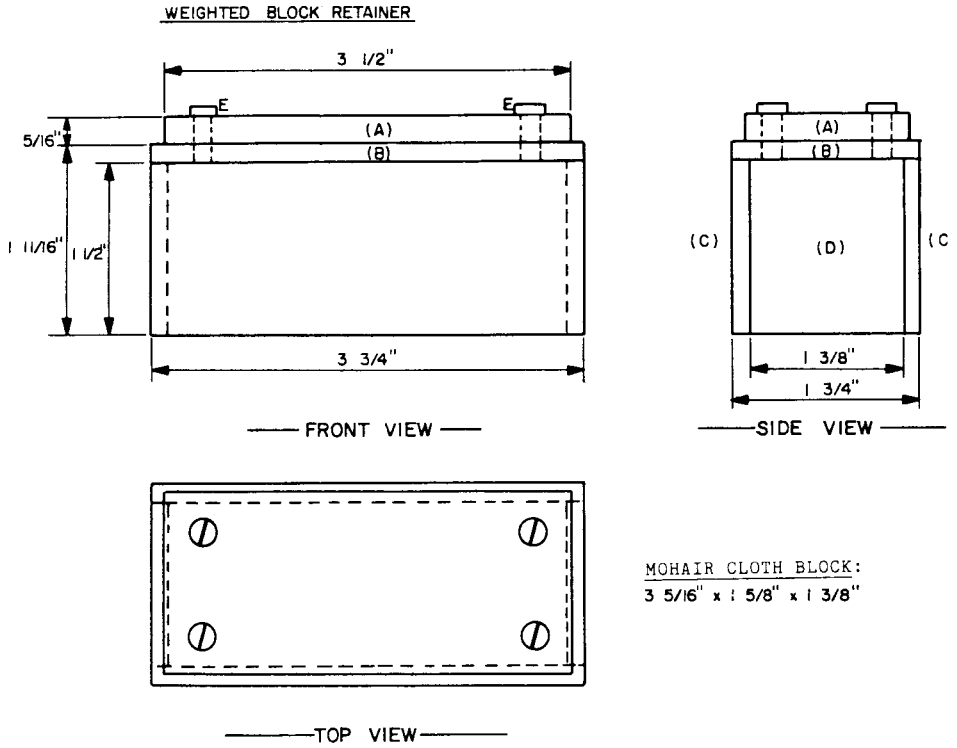

FIG. A4.4 Schematic of Weighted Mohair Cloth Assembly Unit

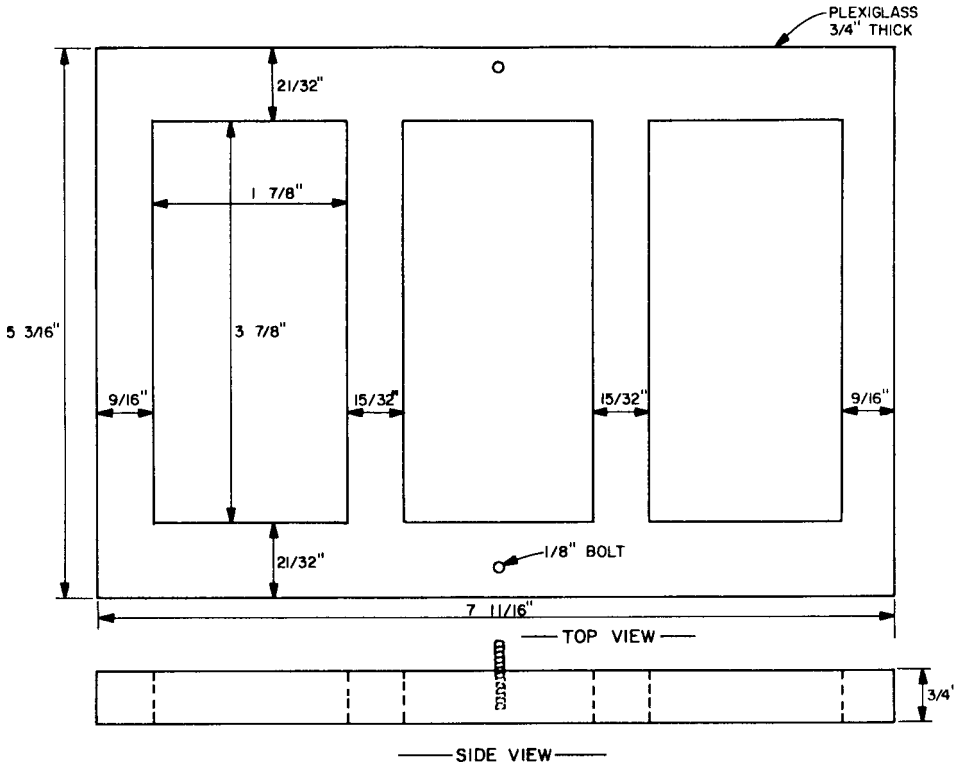

FIG. A4.5 Mohair Cloth Assembly Holder

A4.5.3 It is not feasible to use a specific number of test strokes for all tests since different solutions and soils require varying degrees of mechanical abrasion.

TABLE A4.1 Description of Parts

Part No.	Modifications Made to Straight-line Washability and Abrasion Machine
A	*Back runner*, (18 × ½ × 3⁄16-in. polymethyl methacrylate).
B 1	*Machine bolt*, (10–32 × 1 in.)—Connects back runner and test board (C and D) to chassis.
B 2	Same as B1.
B 3	*Machine bolt*, (10–32 × 1 in.)—Connects test board to straight-line washability apparatus chassis; recessed into C.
B 4	Machine bolt, (8–32 × ½ in.)—Connects front runner to test board; test board is tapped (threaded) for bolt.
B 5	Same as B4.
B 6	*Machine bolt*, (8–32 × ½ in.)—Connects back runner to test board; test board is tapped (threaded) for bolt, bolt is loosened to adjust position of F.
B 7	Same as B6.
B 8	*Machine bolt*, (10–32 × ⅝ in.)—Connects test board (D) to straight-line washability apparatus chassis; bolt recessed into D under F.
B 9	Same as B8.
B 10	*Machine bolt*, (8–32 × ½ in.)—Connects front runner to test board; test board is tapped (threaded) for bolt; bolt is loosened to adjust position of F.
B 11	Same as B10.
C	*Top of test board (left side)*, (7 × 7¾ × ⅛-in. polymethyl methacrylate)—Glued to D with methylene chloride.
D	*Test board base*—Two sheets of polymethyl methacrylate (18 × 7¾ × 3⁄16 in.).
E	*Front runner*, (18 × ½ × 3⁄16-in. Lucite)—Area 4 in. long by 1⁄16 in. deep removed (bottom/center) to prevent scraping of soil when soiled substrate plate is inserted.
F	*Adjustable slide plate*, (7 × 7¾ × ⅛-in. polymethyl methacrylate)—Adjusts to hold securely soiled substrate plate; elongated, oversized holes for B 6, B 7, B 10, and B 11 allow plate to be moved back and forth.

TABLE A4.2 Description of Parts

Part No.	For Weighted Mohair Cloth Assembly Unit
A	*Lead weight*, (approximately 3½ × 1½ × 5⁄16-in.)—Designed to make final weight of assembled unit (with mohair cloth) = 575 ± 10 g; attached to top of block retainer (B) with four bolts.
B	*Top of block retainer*, (3¾ × 1¾ × 3⁄16-in. polymethyl methacrylate)—Tapped (threaded) to receive bolts (E) which secure A; glued to Parts C (2) and D (2) using methylene chloride.
C	*Sides (2) to block retainer*, (3¾ × 1½ × 3⁄16-in. polymethyl methacrylate)—Glued to Parts B and D (2) using methylene chloride.
D	*Edges (2) of block retainer*, (1⅜ × 1½ × 3⁄16-in. polymethyl methacrylate)—Glued to Parts B and C (2) using methylene chloride.
E	*Bolts*, (X × ½ in.) to secure lead weight to B.

TABLE A4.3 Example of Cleaning Index Calculation

For Evaluation of Mohair Cloth Cleaning Performance				
Sample	Soiled Rd	Cleaned Rd	No. Test Strokes	Cleaning Index
A	4.1	37.6	10	3.4
B	5.2	67.1	10	6.2(Best)
C	4.7	49.3	10	4.5

For Solution A Cleaning index = (Cleaned Rd − Soiled Rd/Number Test Strokes) = (37.6 − 4.1/10) = 3.4.

A5. PARTICULATE AND OILY SOIL/VINYL TILES TEST METHOD

A5.1 *Summary of Test Method*—Vinyl tiles soiled in the prescribed method are washed on the straight-line washability apparatus. Reflectance values before and after soiling, and after washing are determined. Reflectance values are used to calculate percent soil removal.

A5.2 *Apparatus:*

A5.2.1 *Straight-Line Washability Apparatus*[4].

A5.2.2 *Tristimulus Colorimeter*[30].

A5.2.3 *Brass Template*, 4½ by 9 in. with 2 by 4-in. hole cut in center.

A5.3 *Materials:*

A5.3.1 *White Vinyl Floor Tiles*[31], (12 by 12 by ⅛ in., cut to 4½ by 9 in.).

A5.3.2 *Natural Humus*[32].

A5.3.3 *Paraffin Oil*[33].

A5.3.4 *Used Crankcase Motor Oil*. (Obtain from any local auto service station.)

A5.3.5 *Portland Cement*[34].

A5.3.6 *Carbon, Lampblack*[35].

[30] Minolta Chroma Meter, Model CR-110 with Data Processor DP-100 has been found suitable for this purpose. Available from Minolta, Ramsey, NJ.

[31] Amitco Luxury Vinyl Tiles have been found suitable for this purpose.

[32] Available from Earthgro Inc., Lebanon, CT.

[33] JT Baker S894-07 has been found suitable for this purpose. Available from Phillipsburg, NJ.

[34] Type I/II, Magnolia Brand has been found suitable for this purpose.

[35] Fisher Chemical, Cat. No. C198-500 has been found suitable for this purpose. Available from Fisher Scientific, Pittsburgh, PA.

A5.3.7 *Silica*[36].
A5.3.8 *Iron Oxide*[20].
A5.3.9 *Bandy Black Clay*[37].
A5.3.10 *Stearic Acid*[38].
A5.3.11 *Oleic Acid*[38].
A5.3.12 *Kerosene*, low odor[39].
A5.3.13 *Stoddard Solvent*[40].
A5.3.14 *SAE 10 Motor Oil*[41].
A5.3.15 *All-Vegetable Shortening*[6].
A5.3.16 *Olive Oil*[42].
A5.3.17 *Linoleic Acid*[43].
A5.3.18 *Squalene 97 %*[44].
A5.3.19 *1-Octadecene, tech., 90 %*[45].
A5.3.20 *Paper Toweling*.
A5.3.21 *Cellulose Sponges*[10], cut to 1¾by 3⅝ by 1½ in.

A5.4 *Procedure:*

A5.4.1 *Particulate Soil Preparation*—Prepare particulate soil by adding, in the order listed:

Constituent	Weight, %
Natural humus	38.0
Paraffin oil	1.0
Used crankcase motor oil	1.5
Portland cement	17.7
Silica	18.0
Carbon, lampblack	1.5
Iron oxide	0.3
Bandy black clay	18.0
Stearic acid	2.0
Oleic acid	2.0
	100.0

A5.4.1.1 Mix by hand in a glass beaker. Transfer this composition to a ball mill. Measure out one and one-half times its volume of water in the empty beaker. Swirl water around vigorously several times to suspend any of the soil mixture that may be adhering to the sides of beaker. Add water, with remaining suspended soil particles, to the soil mixture in ball mill. Mix for 18 h using a combination of large (1¼ in. diameter by 1¼ in.) and small (½in. diameter by ½ in.) ceramic cylinders. Transfer to large shallow tray and air dry. (Tray may be placed in 120°F oven to accelerate drying time.) Soil should be turned over occasionally to allow for drying of bottom surface. When completed dry, pulverize using mortar and pestle, and screen through 300-mesh screen.

A5.4.2 *Oil Blend Preparation*—Prepare oily material by blending the following over a steam bath:

Constituent	Parts
Kerosene	12
Stoddard solvent	12
Paraffin oil	1
SAE 10 motor oil	1
Vegetable shortening	1
Olive oil	3
Linoleic acid	3
Squalene	3
1-Octadecene	3
	39

A5.4.2.1 Mix all-vegetable shortening in appropriate sized glass beaker over steam bath. Then add paraffin oil, SAE 10 motor oil, and olive oil. Cover beaker and blend in remaining ingredients. Continue to mix until uniform, straw-colored liquid is obtained.

A5.4.3 *Soil Application*—Cover vinyl tile with brass template. Place 50 mg (0.05 g) of particulate soil in the center area. Wet a double thickness of paper toweling (1¼ by 2½ in.) with 5 drops of the oily blend. Set the paper towel over the soil mound and leave in place for about 10 s. This helps to wet out the dry particulate. Begin rubbing the soil into the tile using a circular motion and moderate pressure. Continue application until the framed area is evenly soiled. Be aware that too much pressure may result in tiles that appear to have a light coating of soil, but are harder to clean. This seems to result from the fact that more soil is left behind on the towel, but the dirt that is applied is more imbedded in the tile. In any event, for a given set of tiles, the soil application steps should be done by a single operator.

A5.4.3.1 Allow soiled tiles to air dry for 24 h before cleaning. In general, shorter drying time will result in tiles that are easier to clean.

A5.4.4 *Reflectometer Measurements*—After proper calibration of the tristimulus colorimeter set its data processor to L, a, b mode. For this test, it is only necessary to use the “L” value, since it measures on a black and white scale (0 = black, 100 = white). Read reflectance of vinyl tiles before and after soiling by taking 3 readings per tile. The “before” reading will not vary significantly if the tiles are sourced from the same manufacturer. An average may be obtained after measuring 3 tiles (9 readings), and this can be used in the calculation from test to test. Readings after soiling can vary greatly from tile to tile, so these should be carefully recorded.

A5.4.5 *Cleaning Test*— Place the soiled tile on the washability apparatus using additional pieces of tile to hold the soiled panel in place. Wet the panel, in the center of the soiled area, with 20 mL of the test solution and allow to stand for 1 min. After approximately 30 s has elapsed, pour an additional 50 mL of the test solution onto the wrung-out wet sponge in the sponge holder. When 1 min is up, invert the sponge so that the wet side is in contact with the soiled tile. Scrub for ten cycles. Remove panel and rinse with tap water. Discard sponge. A fresh sponge should be used for each panel.

A5.4.6 *Evaluation of Cleaning Test*—Read the reflectance of the cleaned tiles (3 readings per tile) and use the mean of the three readings to calculate % cleaning efficiency:

$$\%\ \text{cleaning efficiency} = \frac{R1 - R2}{R3 - R2} \qquad \text{(A5.1)}$$

[36] Tamsil 30 has been found suitable for this purpose. Available from Unimin Specialty Minerals Inc., Elco, IL.
[37] Available from H. C. Spinks Clay Co., Paris, TN.
[38] Available from Acme-Hardesty, Jenkintown, PA.
[39] Cat. No. 32946-0, available from Aldrich Chemical Company, Milwaukee, WI, has been found suitable for this purpose.
[40] Rule 66 Mineral Spirits have been found suitable for this purpose. Available from Ashland Chemical Co., Columbus, OH 43216.
[41] Valvoline SAE 10 W non-detergent has been found suitable for this purpose.
[42] Italica Spanish 100 % Pure has been found suitable for this purpose. Available from Italica Imports, Scarsdale, NY.
[43] Cat. No. 23,392-7, available from Aldrich Chemical Company, Milwaukee, WI, has been found suitable for this purpose.
[44] Cat. No. 22,316-6, available from Aldrich Chemical Company, Milwaukee, WI, has been found suitable for this purpose.
[45] Cat. No. 0-80-6, available from Aldrich Chemical Company, Milwaukee, WI, has been found suitable for this purpose.

$R1$ = reflectance of soiled tile after cleaning, $R2$ = reflectance of soiled tile before cleaning, and $R3$ = reflectance of tile before soiling.

A6. OIL, CARBON BLACK AND CLAY/WHITE ENAMEL PAINTED STAINLESS-STEEL PANELS TEST METHOD

A6.1 *Summary of Test Method*—An oil, carbon black, clay soil on white-enamel painted stainless-steel panels is scrubbed with a straight-line washability apparatus. Products that contain organic solvents should not be used with this test method.

A6.2 *Apparatus:*

A6.2.1 *Forced Draft Oven*[46], ±2°C control.
A6.2.2 *Fume Hood*.
A6.2.3 *Straight-Line Washability Apparatus*.
A6.2.4 *Reflectometer*.

A6.3 *Materials:*

A6.3.1 *20-Gage Sheet Stainless Steel*.
A6.3.2 *Metal Shears*.
A6.3.3 *White Satin Gloss Enamel*[47].
A6.3.4 *Odorless Paint Thinner*[48].
A6.3.5 *Wire Dish Rack*, plastic-covered sufficient to hold steel panels at 55 to 70° angle.
A6.3.6 *Gloves*, polypropylene or latex.
A6.3.7 *Cardboard Sheets*.
A6.3.8 *Beaker*, 400 mL.
A6.3.9 *Wooden Support Block*—4 by 4 by 1 in. or similar.
A6.3.10 *Paint Applicator Replacement Pad*[49].
A6.3.11 *Polyurethane Pad*, 3¾ by 3 in. or 1½ in., or equivalent.
A6.3.12 *C-clamp*, 2 in. adjustable.
A6.3.13 *Double-Faced Tape*, 1½ in.
A6.3.14 *Heavy Mineral Oil*[50].
A6.3.15 *Graphite Powder*[29].
A6.3.16 *Clay*[51].
A6.3.17 *Car Wash Sponge*[52].
A6.3.18 *Template*, cut from aluminum or other suitable material, to dimensions in Fig. A2.1.
A6.3.19 *Non-Ionic Surfactant*[53].
A6.3.20 *Tetrasodium Salt of EDTA*[54].
A6.3.21 *Tetra Potassium Pyrophosphate*.
A6.3.22 *Paper Toweling*.
A6.3.23 *Acetone*.

A6.4 *Procedure:*

A6.4.1 *Panel Preparation*—Stainless-steel sheeting should be cut into 6 by 6-in. squares. Do not bend the panels. Slight bending by the cutter blader may occur at the edges.

A6.4.1.1 Panels should be wiped clean with a paper towel and acetone to remove any oil finish from the steel. As later steps will bend panels, the same surface should be painted for each use. Inspect panels for flatness. Bent panels should be straightened carefully on a flat surface. Note any distortion at the edges; any bending should be downward. Panels should be marked so the same surface will be painted for each use.

A6.4.2 *Paint Preparation*—A mixture of white satin gloss enamel and mineral thinner is used to paint the panels. Place 200 to 230 g of well-stirred paint into a 400-mL beaker. Total weight of finished paint is:

(Original Weight/0.94)

A6.4.2.1 The total weight is made by adding the requisite 0.94 amount of thinner to the uncut paint and blending thoroughly. Paint should be prepared fresh for each use. Stir paint thoroughly before each panel preparation, as some separation occurs.

A6.4.2.2 Pour 20 to 30 g of the prepared paint mixture onto the panel to be painted. Tip the panel so that paint flows over the entire panel, except for about ½ in. along the top. Excess paint that flows off the panel can spill onto a second panel placed on the wooden block. When the surface is covered, lean the panel against the washability apparatus so that paint drains onto another panel. Replace the panel on the wooden block with a clean one, and repeat the procedure with this panel.

A6.4.2.3 When 5 panels have been painted and are draining, the first painted panel should be placed in the dish rack. Continue the process. A total of 24 panels can easily be prepared from 230 g of prepared paint in this manner. When all panels are painted, place the dish rack in the fume hood to dry, situating the rack so as best to pass air across the panels. Lower door of hood partially to increase draft. Air dry panels for 6 to 7 h.

A6.4.2.4 After air drying, place panels into the wooden holding racks. Place these panels into oven at 54.5°C for 16 to 17 h. Cool panels for 6 h at room temperature before soiling.

A6.4.3 *Soil Preparation*—The soil is prepared in a 4-oz round glass jar. Weigh the following into the jar:

Paint Thinner	50 g
Vegetable oil	4 g
Mineral oil	10 g
Clay	10 g
Graphite Powder	4.5 g

Place a magnetic stirring bar into the jar, and agitate well for 30 min. The soil should be prepared 3 days before use. The soil may be used up to 2 months after preparation.

[46] An oven found suitable for this purpose is available from Blue M. Corp., Blue Island, MI. An equivalent may be used.
[47] Dutch Boy #510 has been found suitable for this purpose (trademark of Dutch Boy Co., Holland, MI). An equivalent may be used.
[48] Nankee "Pollution Free" paint has been found suitable for this purpose (trademark of Cantor Bros., Farmindale, NY). An equivalent may be used.
[49] Shur-Line has been found suitable for this purpose (trademark of Shur-line Mfg. Co. Inc., Lancaster, NY). An equivalent may be used.
[50] Material from Squibb and Sons, NY, NY has been found suitable for this purpose. An equivalent may be used.
[51] Kaolinite Hydrite #121 has been found suitable for this purpose. Available from Georgia Kaolin, Elizabeth, NJ. An equivalent may be used.
[52] Rallye Sponge has been found suitable for this purpose (trademark of E. I. dupont de Nemours and Co. Inc., Wilmington, DE). An equivalent may be used.
[53] Triton X-102 has been found suitable for this purpose. Available from Union Carbide. An equivalent may be used.
[54] Seques trene No. 4 powder has been found suitable for this purpose. Available for Ciba Giegy Corp. Greensboro, NC. An equivalent may be used.

A6.4.4 *Assembly of Soiling Pad*—The soiling pad is assembled by placing three 3 in.-strips of two-sided tape into a paint applicator pad with the nap of the bristles down and pointed towards the assembler. Place the foam pad onto the paint applicator. Press down to ensure a good contact. Place a small mark on the pad to show the proper orientation of the pad in the holding block.

A6.4.5 *Conditioning New Soiling Pad*—Place the soil applicator into the straight-line washability apparatus holding block so that the face is toward the operator. Place one panel on the right side of the apparatus. This panel will remain there as a marker panel for panels to be soiled. A second panel should be C-clamped on the left side of the straight-line washability apparatus so that the panels to be soiled will fit between the marker panels. The new applicator must be conditioned before use. A panel should be placed into the tray next to the C-clamped marking panel. Eight drops of mineral spirits should be placed onto the panel, and the apparatus run for 10 cycles to soil the applicator. Repeat this procedure 3 times. The soiling mixture should then be applied to the panel in the same manner. This should be repeated 10 times.

A6.4.6 *Soiling Panels*— Before soiling panels, the applicator pad must be conditioned in the same manner described above, except only soil mixture should be used. The pad should be run 5 times with 8 drops being applied each time to the "dummy" panel. The drops should be placed so that they contact each other in a row across the width of the applicator pad. They should be drawn over to contact each other with the eye dropper if they do not touch.

A6.4.6.1 When the pad is suitably prepared for use, the panels to be soiled are put onto the tray. As above, 8 drops of soil are placed onto the panel across the width of the pad and touching. The machine is then run for 10 cycles. Care should be taken in shutting off the machine so that a regular soil finish is applied (if the machine is shut off too early, marks will be created in the soil finish when the pad slows and stops).

NOTE A6.1—Alternatively, the soiled panel may be removed from the Gardner while it is still cycling, although care should be taken to avoid catching oneself in the machinery. This procedure is continued with each panel to be soiled. When an excess of the soil builds up on the marking panel, the edge of the soil build up should be removed with a paper towel. Any other excess of soil on the edge of the test panels should also be removed with a paper towel.

A6.4.7 *Curing Soiled Panels*—The soiled panels are allowed to air dry for 30 min. They should then be placed into a 54.5°C forced-draft oven for 16 to 17 h. The painted surfaces are tilted slightly toward the draft of air so that all panels will receive equivalent heating.

A6.5 *Cleaning Procedures:*

A6.5.1 *Recording Soiled Readings*—After allowing the soiled test panels to cure the required number of hours, they are cooled to room temperature. Warm up photovolt reflectometer for at least 30 min. The search unit with amber filter should be placed onto the white enamel standardization panel during the warm-up period. Adjust the meter according to manufacturing instructions. The panels should be numbered on the upper painted surface for identification.

A6.5.1.1 Four readings of each panel should be taken using the template. Readings can be taken from right-to-left or left-to-right, but note and record which direction is used. Record each reading.

A6.5.2 *Sponge Preparation*—The car wash sponge must be conditioned to obtain uniformity of cleaning action. Rinse the sponge in a 0.05 % solution of non-ionic surfactant, and twist the sponge tightly 20 times. The sponge should then be dampened and cut carefully to 9.5 by 7 cm. A single-edge razor blade has been found useful for this function.

A6.5.2.1 After cutting, the sponge should be rinsed again in a 0.05 % of non-ionic surfactant solution and crushed well to remove any stiffness.

A6.5.2.2 The sponge should then be run 200 cycles over a spare panel. The sponge is squeezed out in clean water after each 100 cycles, and 150 mL of the 0.05 non-ionic surfactant solution is placed onto the sponge before each series of cycles is run.

A6.5.2.3 Rinse the sponge well in 25°C water to remove any surfactant residue. Squeeze damp dry before use.

A6.5.3 *Reference Solution*—A reference cleaning solution concentrate can be made according to the formula below. This has been found to be stable for at least 6 months.

Standard Cleaning Solution Concentrate

Constituent	Weight %
Non-ionic surfactant	5.0
Tetra Potassium Pyro Phosphate	2.0
EDTA-Na-4	0.5
Distilled Water	92.5
	100.0

Weigh all ingredients into a suitable beaker and stir until uniform.

A6.5.4 *Test Product*— Test product dilutions should be prepared from ambient tap water, with hardness specified. Use dilutions should be prepared fresh for each test, and should be made at the manufacturer's recommended cleaning dilution.

A6.5.4.1 Dilutions should be made on a weight/volume basis (for example, a 1-oz to 1-gal dilution would be made by diluting 1 gram of product with 127 mL of water). The internal standard dilution should be made in the same manner at a 1:100 dilution.

A6.5.5 *Panel Washing*— The panel to be washed should be placed squarely into the tray supplied with the straight-line washability apparatus. Clean panels are placed on either side of the panel, and a C-clamp is used to clamp the test panel onto the machine.

A6.5.5.1 Place the damp-dry sponge into the housing box of the straight-line washability apparatus. Total weight of the box should be 1 lb ½ oz. Carefully place 150 mL of test solution onto the sponge. Place the sponge in operating position and wash the test panel for 35 cycles. Shut off the straight-line washability apparatus, remove the C-clamp from the panels, rinse the panel under a light stream of 25°C tap water, and set aside to dry. Rinse the tray and side panels also.

A6.5.5.2 Remove the sponge from the housing, rinse and squeeze damp-dry. Five tiles should be run for each product. The sponge is cleaned between products by washing it with a 0.5 % solution of sodium dodecyl benzene sulfonate. Rinse the sponge well before reuse, and squeeze damp-dry. The sponge should be used for 6 products at most (3 each side), after which

a new sponge should be used.

A6.6 *Treatment of Results:*

A6.6.1 *Mean Value of Experimental Standard*—The percent cleaning efficiency of the standard reference solution should first be calculated:

$$(R^c - R^s/R° - R^s) \times 100 = \text{cleaning efficiency} \quad \text{(A6.1)}$$

where:
R^s = unsoiled reflectance of the panel, and
R^c = cleaned reflectance.

A6.6.1.1 Each reading should be calculated (4 readings per panel). The average of the readings should then be calculated with the formula:

$$\bar{E} = (\Sigma E/n) \quad \text{(A6.2)}$$

where:
$\bar{E}$ = average % cleaning efficiency of reference cleaning solution,
E = % cleaning efficiency of each reading, and
n = number of readings.

A6.6.1.2 The value of $\bar{E}$ will be used to adjust experimental values to values expected from "ideal" conditions.

A6.6.2 *Adjusted Cleaning Efficiency of Test Products*—The % cleaning efficiency of the test products is calculated and adjusted to ideal conditions using the formula:

$$\% \text{ cleaning efficiency} = \frac{(R^c - R^s)}{(R° - R^s)} \times (\text{adjustment value}) \times 100 \quad \text{(A6.3)}$$

where:
R^c = cleaned reflectance,
$R°$ = original reflectance,
R^s = soiled reflectance, and
$\bar{E}$ = experimental standard cleaning efficiency.

Each reading should be calculated (4 per panel) and recorded.

A6.6.3 *Determination of Adjustment Value*—This value adjusts experimental c.e. data (at experimental conditions) to ideal c.e. data (at ideal conditions).

$$(S/E) = \text{Adjustment Value} \quad \text{(A6.4)}$$

where:
S = experimental standard, and
E = 84.30 (ideal value).

If the adjustment value is lower than 0.9 or larger than 1.1, the values obtained for the test products should not be used to develop a 95 % confidence limit for the product. Only comparative results between the products run at the same time may be reported.

A6.6.4 Calculation of the mean and the standard deviation. The mean of the values should be calculated by the formula:

$$\bar{X} = (\Sigma X/n) \quad \text{(A6.5)}$$

where:
$\bar{X}$ = mean (average) cleaning efficiency,
X = cleaning efficiency (from A6.6.2), and
n = number of readings.