Designation: D4265 – 21

Standard Guide for Evaluating Stain Removal Performance in Home Laundering[1]

This standard is issued under the fixed designation D4265; 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 is a guide for evaluating stain removal performance of home laundry products or home laundering conditions. It provides guidance for the selection, preparation, application, and examination of various types of stains on test fabrics that are subjected to controlled but practical stain removal treatment conditions.

1.2 There is no single combination of stain and fabric that will predict the overall performance of a product or treatment method. A single test, even with a variety of stains/fabrics, can only predict how products or treatment methods compare under the particular conditions chosen for evaluations. A series of assessments is necessary to evaluate the many aspects of stain removal performance and to simulate consumer experience more closely.

1.3 In this guide, the use of both traditional top-loader washing machines as well as front and top-loading high-efficiency washers is addressed.

1.4 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.

1.5 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D1729 Practice for Visual Appraisal of Colors and Color Differences of Diffusely-Illuminated Opaque Materials

2.2 *AATCC Standard:*[3]

Test Method 130-2010 Soil Release: Oily Stain Release Method

3. Terminology

3.1 *Definitions:*

3.1.1 *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.

3.1.1.1 *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 use 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 the U.S. Environmental Protection Agency (EPA) as Energy Star rated machines.

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

3.1.3 *pretreaters, n*—usage of a product designed to treat fabric stains not likely to be removed using detergent in wash alone in the normal household laundering process.

3.1.3.1 *Discussion*—Pretreaters can be found in many forms

[1] This guide is under the jurisdiction of ASTM Committee D12 on Soaps and Other Detergents and is the direct responsibility of Subcommittee D12.15 on Physical Testing.

Current edition approved Jan. 15, 2021. Published January 2021. Originally approved in 1983. Last previous edition approved in 2014 as D4265 – 14. DOI: 10.1520/D4265-21.

[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 (AATCC), P.O. Box 12215, Research Triangle Park, NC 27709, http://www.aatcc.org.

such as sprays and liquids and detergents themselves can be used as a pretreater when applied directly to the stain.

3.1.4 *stain, n*—a local area of undesired foreign matter on a textile material, differing in appearance from the textile substrate.

3.1.5 *top-loading 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.

3.1.5.1 *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.

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

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

4. Summary of Guide

4.1 Stains are artificially applied in a repeatable manner to specified fabric substrates. After a prescribed time for setting the stains, the test swatches are treated with the products or procedures being compared or both, and the relative degree of removal is assessed.

5. Significance and Use

5.1 This guide suggests a number of staining agents that are representative of stains commonly encountered in household laundry. The assessment need not be limited to this suggested list of stains, especially if special product types or end uses are being evaluated. This guide can be used to compare stain removal performance of products; however, there is no confirmed basis for correlation of this controlled laboratory technique with consumers' ranking of stain removal performance.

5.2 The evaluations generated by this guide should be regarded as diagnostic screening tests that are useful in formulation studies, quality control, and ingredient raw material qualification. This guide provides considerable flexibility in choosing specific stains, washing conditions, and laboratory equipment appropriate to the objective of the evaluation. This procedural latitude may result in a reduced level of interlaboratory precision and such comparison of results must be evaluated with caution.

5.3 The procedure is applicable to all types of home laundry products including detergents, presoak and prespotter products, bleaches, and detergent boosters and is expected to be applicable to horizontal and vertical axis machines.

5.4 It is not intended for the evaluation of products or conditions normally associated with commercial laundering or dry cleaning establishments.

6. Selection and Preparation of Fabric Swatches

6.1 The relative effectiveness of various laundry products or procedures for removing different types of stains will be influenced by the nature of the fabric. If interest is in cleaning on more than one fabric, testing may encompass more than one fiber composition (for example, cotton, polyester/cotton blend, or polyester) and fabric construction (for example, wovens or knits) with results tabulated separately for each. The fabric types most common for the U. S. laundry are polyester/cotton blends, 100 % cotton, and 100 % polyester.

NOTE 1—When ordering pre–cut swatches, the vendor must be alerted that identification of the face side and grain (thread direction) of the swatches is an important testing criterion. These factors must also be considered when bulk yardage is purchased from any source by the experimenter for eventual cutting into test specimen swatches.

6.2 Fabric test swatches should be washed prior to application of stains, if necessary. This is done to eliminate residues of mill finishing agents which might influence stain removal results and also to better simulate the fabric condition when staining incidents occur in household use.

6.2.1 Sufficient yardage of test fabric is pre-washed to cover the need of the test series. The washing is more sufficiently done before the cloth is cut into individual swatches, but can be accomplished with the pre-cut swatches if this is the fabric form that has been purchased.

6.2.2 Minimum pre-washing conditions should be two wash cycles in a household automatic washer (see Note 2) with 120-140°F (48.8-60°C) (less than 50-ppm) water and ambient (less than 50-ppm) water rinses. The first cycle should include a recommended usage level of a standard detergent such as American Association of Textile Chemists and Colorists (AATCC) liquid or powder standard detergent without brightener. Recommended usage level of liquid hypochlorite bleach may also be added. Additional washes with no detergent are recommended until no suds are present.

NOTE 2—Any brand of industrial or household automatic washer (or electric dryer) is acceptable. For household machines, refer to AATCC recommendations as a general guideline.[4] There may be special circumstances in which other conditions may be required in testing (for example, emerging washing machine types). Testing in different machines and different conditions may yield different results. Data comparison can only be made under the same test conditions.

6.2.3 Dry the test cloth 35 to 40 min at 150 ± 10°F (65.5 ± 6°C) in a home dryer after the last wash cycle (see Note 2).

6.2.4 Wash and dry carrier towels or ballast fabrics to be used with the stained test swatches in accordance with 6.2.2 and 6.2.3, but separately from the test fabrics.

6.3 Iron the fabric on permanent press setting if necessary to obtain a flat, smooth surface.

[4] http://www.aatcc.org/testing/supplies/washers.htm

6.4 Cut washed test fabric into desired size swatches.

6.4.1 Orientation of the test swatch can influence the observed staining/wicking characteristics of the test stain and also the stain removal perceived by either visual grading or instrumental reflectance. It is therefore important to identify the fabric grain (direction of the threads relative to the selvage edge) and the face side of the fabric when the test specimens are made. Devise a swatch marking system to ensure that all specimens in the same test series are stained and graded with the same fabric orientation.

6.4.2 Size of the test swatch is not critical, though swatches of about 12 to 120 in.^{2} (77 to 800 cm^2) in area are suitable for all phases of the testing procedure. To maintain orientation consistency, it is suggested to use rectangular rather than square swatches.

7. Stain Material

7.1 The key recommendations for inclusion of a stain are that it is relevant to home laundering and is a useful performance sensor. Suggested performance measures include but are not limited to sensitivity, reproducibility, precision, and dynamic range. A stain may be selected to indicate various cleaning objectives, such as representing a specific cleaning mechanism (enzymatic break-down, particulate suspension, surfactant roll-up, bleaching, and so forth), or predicting an important consumer stain or stain class (grass, coffee, greases, clays, and so forth). It is recommended that preliminary research is done to ensure that the stain set can sufficiently discriminate between products in which product differences are expected.

7.2 The spectrum of selected staining materials can greatly influence the relative performance assessment of the stain removal products. The stain types most appropriate for a specific test series are usually dictated by experience. Staining materials most often recommended for stain removal assessments are tea, coffee, wine, grape juice, mustard, spaghetti sauce, gravy, blueberry puree or jam, chocolate syrup, grass, human or animal blood, ball point ink, drawing ink, facial makeup base, dirty motor oil, artificial sebum/particulate soil, clay, mud, chocolate ice cream, meat drippings, butter and oil. See Annex A2 for more detailed descriptions and preparation information for these staining materials. Please note it is not necessary to test all of these stains, but is instead a list of non-exhaustive stain options to select from.

7.3 Testing of six or more stain types is suggested for characterizing the performance profile of a stain removal product, especially if more than one functional ingredient (for example, oxidizing agent, enzyme, solvent, and so forth) is present in the tested formulations.

8. Procedure

8.1 Before testing, the administrator shall ensure that all unwashed stains are matched across treatments. Demonstration of matching could include prereading of stains using instrumental evaluation (strongly recommended), certification of stain matching by the supplier, or visual inspection. Stains must be preread instrumentally when utilizing the SRI equation (see 10.3.1.2).

8.2 Set aside clean, unwashed samples of each fabric type tested to be used as reference standards for each equation.

8.3 Design the test protocol to generate at least three replicated values for each type of test specimen subjected to the individual variable (product or procedure) under study. Multiple runs are suggested to increase statistical confidence. The mixing of different kinds of stains in the same wash treatment is acceptable. However, the mixture of stain types and total number of stained swatches (soil load) should be the same in each treatment wash. Caution should be used not to overload in the same wash treatment as too much soil may impact the ability to differentiate products.

8.3.1 Other test protocol factors may present a constraint on the number of test swatches per wash load. Accommodating test designs should still have the stain type and soil level variables balanced across the treatment washes.

8.4 *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:

8.4.1 *Matched Washing Machines*—All washings shall be performed in the same machine or in mechanically matched units of the same model machine.

8.4.2 *Washer Settings:*

8.4.2.1 *Conventional Deep-fill Traditional Top-loader*—Normal/casual setting, 10-14 min wash cycle, appropriate water fill for load size, regular spin speed.

8.4.2.2 *Front-loading HE*—Normal/casual or normal/colors setting, normal soil level, high spin speed.

8.4.2.3 *Top-loading HE*—Normal/casual or normal/colors setting, normal soil level, high spin speed.

8.5 *Temperature*—Temperature tolerance within a test is recommended to be ±2°F (1°C).

8.5.1 *Conventional Deep-fill Top Loader*—86 ± 5°F (30 ± 3°C) wash cycle, ambient rinse.

8.5.2 *Front-loading HE*—77 ± 5°F (25 ± 3°C) wash cycle, ambient rinse.

8.5.3 *Top-loading HE*—75 ± 5°F (23.8 ± 3°C) wash cycle, ambient rinse.

8.6 *Hardness*—35 ppm (2 grains/gal); 100 ppm (6 grains/gal); 120 ppm (7 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.

8.6.1 The calcium/magnesium ratio of the hardness minerals (expressed as $CaCO_3$) should be adjusted for different water hardness as follows:

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

8.7 *Fabric Load*—Minimum of 6 lb (2.7 kg) for each total load. Supplement test swatches 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. When running successive test loads, use fresh ballast or rewash and dry for each load. Natural or artificially soiled ballast may add

realism to the testing conditions, but a high level of testing variability may be introduced unless this factor is rigorously standardized.

8.8 *Product Concentrations*—Use products according to manufacturer's label recommendations.

8.9 *Pretreating Methods (if applicable)*—Multilple stain types and replicates are often evaluated when testing stain removal performance of pre-spotters or pre-treat products.

8.9.1 When directly applying prespotter or pretreater products to stains, equalize contact, time, nature, amount of product, and amount of mechanical energy (if any) to all stains. Follow label instructions when provided.

8.9.2 If no directions are provided for pre-spotting or pre-treating a stain directly, the following procedure is recommended: apply enough product to cover the stain (suggested amounts for a 2-in. (5-cm) stain are 0.03 fluid oz (1.0 mL) for liquid and spray products (see Note 3) and 1 tsp (5 mL) for pastes of dry detergents made with sufficient water to give it a toothpaste-like consistency). These amounts may be adjusted to ensure even coverage of different size stains.

NOTE 3—Liquid prespotters or pretreaters packed in aerosol containers should be applied as a liquid without propellant; spray into suitable container collecting an appropriate quantity needed for the test treatments. Allow all pretreated stains to sit for a consistent amount of time before adding to the wash water.

8.9.3 If prespotting or pretreating stains with a liquid detergent, it is acceptable to use product in addition to the recommended dosage, but additional foam testing may be needed to avoid oversudsing in HE washing machines.

8.9.4 *Order of Addition to Wash Cycle*

8.9.4.1 *Conventional Deep-fill Traditional Toploader:*

(1) Fill water, add hardness if needed and start agitation,

(2) Add detergents, or additives, or both, and place dosing cup in the drum,

(3) Stop machine and add test fabrics and ballast,

(4) Close lid securely, and

(5) Start agitation at beginning of cycle.

8.9.4.2 *Front-loading HE:*

(1) When evaluating unit dose products, add the product according to manufacturer's instructions. If no instructions are provided, the recommendation is to add the unit dose product to the drum before adding test fabrics and ballast.

(2) When evaluating powder, liquid detergent, additives, or combination thereof, add product to the dispenser in the assigned compartment and place the dosing cup in the drum after adding test fabrics and ballast.

(3) Add hardness if needed and when appropriate, close the door and dispenser drawer securely, and start machine.

8.9.4.3 *Top-loading HE:*

(1) When evaluating unit dose products, add the product according to manufacturer's instructions. If no instructions are provided, the recommendation is to add the unit dose product to the drum before adding test fabrics and ballast.

(2) When evaluating powder, liquid detergent, additives, or combination thereof, add product to the dispenser in the assigned compartment and place the dosing cup in the drum after adding test fabrics and ballast.

(3) Add hardness if needed and when appropriate, close the door and lid securely, and start machine.

8.10 *Machine Drying Conditions*—High setting (160 ± 10°F (71.1 ± 6°C) max outlet temperature) for 45 min or until dry. Air drying, out of direct sunlight, is also acceptable.

8.11 *Miscellaneous Guides:*

8.11.1 Attaching small test swatches to suitable carrier substrates is strongly advised for collection of small swatches for operational efficiency and to simulate normal mechanical agitation and spin drying action in the washing machine and minimize test swatch wrinkling. Test specimens are most appropriately attached by one edge around the perimeter of the carrier substrate. The carrier substrate should not be positioned as a backing for the test swatch. Attachment can be accomplished by sewing, by noncorrosive pins or staples, or plastic fasteners commonly used for apparel hang tags.

8.11.2 Wrinkled swatches may be manually smoothed; avoid pressing the swatches with an iron.

8.11.3 Evaluate test swatches within 24 h after removal from dryer. Wrap or store swatches in a dark place until evaluation is started.

9. Visual Evaluation

9.1 The treated test swatches are displayed on a flat, neutral colored (gray) non-glare finished surface under lights simulating standard daylight (see Note 4).

NOTE 4—A simulated daylight source is intended (6500 ± 300°K). Refer to Practice D1729.

9.1.1 Orient swatches in the same direction, for example, length of the swatch perpendicular to the viewer.

9.1.2 Group the swatches by stain and fabric type but randomize the replicated treatment variables within each grouping to minimize treatment/judgement bias.

9.2 Place the AATCC Stain Release Replica[5] at the top of the test swatch display. Compare the residual stain on the test specimens with the replica value it most closely matches in intensity. Three or more judges shall independently rate each test specimen to the nearest 0.5 rating.

9.2.1 Rating 5 = No residue stain.

9.2.2 Rating 4 = Residual stain equivalent to Replica 4.

9.2.3 Rating 3 = Residual stain equivalent to Replica 3.

9.2.4 Rating 2 = Residual stain equivalent to Replica 2.

9.2.5 Rating 1 = Residual stain equivalent to Replica 1.

9.3 The number of test specimens rated at one time should not be enough to fatigue the individual judges. Generally, there should be no more than about 100 specimens rated at one time.

9.4 Calculate the mean and standard deviation for each stain and fabric type for each treatment. Statistical analysis of variance can establish significant differences between the test treatments and the influence of fabric type and stain type.

[5] These replicas were developed for use with AATCC Test Method 130 and are available from AATCC, P.O. Box 12215, Research Triangle Park, NC 17709.

10. Instrumental Evaluation

10.1 Measure the reflectance of residual stains with a device suitable for measuring such as a digital camera, spectrophotometer or photoelectric colorimeter. Refer to the instrument operation manual for proper use.

10.1.1 Carefully present each swatch to the instrument with the same orientation, for example, long direction perpendicular to operator. A consistent backing should be used throughout the test when collecting reflectance data.

10.2 Illuminate swatches with visible light. Standard filters for eliminating ultraviolet light from the light source should be used if applicable and the cutoff wavelength noted.

10.3 There are two suggested equations for this guide. The equations result in different interpretations of stain removal performance. One equation measures stain removal (SRI) and one measures stain residual (RSI). Result values between equations will not be similar, but product performance ranking similarities are expected.

10.3.1 *Stain Removal Index (SRI):*

10.3.1.1 Measure reflectance of the unwashed, unstained background fabric region (UF) (unwashed fabric samples can be used as references for all products tested). (See 8.2). Multiple regions or pieces of this unwashed fabric should be averaged.

10.3.1.2 Prior to washing, measure the reflectance of the unwashed stain area (US) (See 8.1).

10.3.1.3 After washing and drying the test stains, measure the reflectance of the washed stain region (WS).

10.3.1.4 Determine the CIE L*, a*, b* color values from the reflectance measurements.

10.3.1.5 Calculate SRI using the following equation:

$$SRI = 100 * \frac{\Delta E^*_{(US\ -\ UF)} - \Delta E^*_{(WS\ -\ UF)}}{\Delta E^*_{(US\ -\ UF)}} \quad (1)$$

where:

US = Unwashed stain area,
UF = Unwashed (unstained) fabric area,
WS = Washed stain area.
$\Delta E^*_{(US\text{-}UF)}$ = Delta-E color difference between the unwashed stain and the unwashed fabric, and
$\Delta E^*_{(WS\text{-}UF)}$ = Delta-E color difference between the washed stain and the unwashed fabric.

10.3.1.6 The value delta E* is calculated as:

$$\Delta E^* = \sqrt{\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2}} \quad (2)$$

10.3.2 *Residual Stain Index (RSI):*

10.3.2.1 Measure reflectance of the unwashed, unstained background fabric region (UF) (unwashed fabric samples can be used as references for all products tested). (See 8.2). Multiple regions or pieces of this unwashed fabric should be averaged.

10.3.2.2 After washing and drying the test stains, measure the reflectance of the washed stain region (WS).

10.3.2.3 Determine the CIE L*, a*, b* color values from the reflectance measurements.

10.3.2.4 Calculate RSI using:

$$RSI = 100 - \Delta E^* (UF - WS) \quad (3)$$

where:

UF = Unwashed (unstained) fabric area, and
WS = Washed stain area.

10.3.2.5 The value Delta-E* is calculated as:

$$\Delta E^* = \sqrt{\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2}} \quad (4)$$

10.4 Calculate the SRI or RSI mean for each stain type and each treatment. Statistical analysis of variance is required to establish significant differences between the test treatments and the influence of fabric and stain type.

11. Interpretation of Results

11.1 This guide defines a number of fixed and variable parameters that may be selected to observe the stain removal performance of a household laundry product or procedure. Since the spectrum of types of materials that can potentially stain household fabrics is very large, no selected list of staining agents can be expected to predict precisely the broad range of stain removal results in all household situations. Conclusions must be limited to the observed relative performance at the specific set of conditions of the test.

12. Keywords

12.1 home laundering conditions; home laundry products; stain removal performance