Designation: ~~D3556 – 14~~ D3556 – 23

Standard Guide for Deposition on Glassware During Mechanical Dishwashing[1]

This standard is issued under the fixed designation D3556; 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 covers a procedure for measuring performance of a mechanical dishwashing detergent in terms of the buildup of spots and film on glassware. It is designed to evaluate household automatic dishwasher detergents but can be used as a screening test for institutional and commercial dishwashing products.

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

1.3 *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. Summary of Test Method

2.1 Glass tumblers are given multiple washes in a mechanical dishwasher in the presence of food soil and the levels of spotting and filming allowed by the detergents under test are compared visually.

3. Significance and Use

3.1 This test method is intended as a laboratory screening test to determine performance of the detergent under actual use conditions, but will not necessarily predict performance under all end-use conditions.

4. Apparatus

4.1 *Automatic Dishwasher(s)*—Typical household machines should be selected. If more than one machine is required, pairs with consecutive production numbers are recommended. For further refinement, two or more pairs of differing makes, models, or ages (pair to pair) may be used.

4.2 *Clear Undecorated Glass Tumblers,* from 8 to 15 per machine, a larger number being used if it is planned to remove one tumbler at intervals throughout the test (see Note 5 in Section ~~6~~6.7.3). Ten tumblers simplify scoring.

4.2.1 Before each use, even if new, the glass tumblers may be cleaned in a machine, first in a 1 % solution of citric acid and then with a household automatic dishwashing detergent at the manufacturer's recommended use level, each in a normal wash cycle. Use deionized or distilled water for the rinses during this cleaning procedure. Do not use the drying cycle of the machine until the

[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.

Current edition approved ~~Nov. 1, 2014~~Jan. 1, 2023. Published ~~December 2014~~ January 2023. Originally approved in 1976 as D3556–76 T. Last previous edition approved in ~~2009~~2014 as ~~D3556–85(2009).~~D3556–14. DOI: ~~10.1520/D3556-14.~~10.1520/D3556-23.

tumblers appear to be free of soil or film. No "water break" (droplet formation) should be evident when the tumblers have been rinsed. ~~Any other procedure (such as hand washing and polishing) which yields tumblers that are spot- and film-free may be used.~~

4.3 *Standard Tableware* (Note 2) (optional, see Section 6):

4.3.1 Suggested tableware is as follows, *Dinner plates*, ~~10-in.~~10 in. diameter, *Salad plates*, ~~7-in.~~7 in. diameter, *Cereal bowls*, ~~6-in.~~6 in. diameter, *Saucers*, ~~6-in.~~6 in. diameter, and *Cutlery*, stainless steel.

NOTE 1—A mixture of china and plastic dishes is recommended but is not essential; any standard quality type of dishware is satisfactory.

4.3.2 For each machine used, six dinner plates, six knives, six forks, and six spoons are required, plus optionally enough of the other dishes to fill the lower rack of each machine (see Section 6).

4.4 *Light Box for Visual Evaluation of Tumblers*—A typical light box is rectangular, open to the front, and has dead black inside surfaces. It is large enough to hold up to 15 tumblers side by side. Fluorescent lights are mounted in the base of the box in such a manner that light passes up through the tumblers. It is preferable to have the light come only through the tumblers and have the area surrounding them blocked out by suitable means. Adding dividers between tumblers is also recommended to aid in the assessment.

5. Materials and Manufacture

5.1 *Standard Food Soil Components:*[2] ~~nonfat~~ nonfat powdered milk, margarine, and wheat-based cooked cereal (optional).

5.2 *Standard Food Soil Preparation*—A mixture of 80 weight % of margarine and 20 weight % of powdered milk is prepared. The margarine is warmed until fluid (not over ~~100°F (37.8°C))~~100 °F (37.8 °C)) and the powdered milk is sifted in and mixed thoroughly. The mixture should be refrigerated when not in use and not kept more than 2 weeks.

5.3 *Optional Food Soil Preparation*—This mixture consists of 70 % margarine, 15 % powdered milk, and 15 % cooked cereal. The cooked cereal is separately prepared as follows: Add 45 g of cereal to 228 g of water, heat to boiling, and boil for 5 min. Dissolve 100 g of powdered milk in 500 g of water and stir this solution into the cooked cereal. Continue stirring as portions are removed to be combined with margarine and powdered milk that have been blended as in 5.2. This mixture should be made up as required. (Use of this optional soil makes the test more realistic by adding another difficult-to-remove component.)

6. Procedure

6.1 Using a spatula or a food brush, distribute a total of 40 g of food soil equally across the six dinner plates, so that each plate has 6.66 g of soil. Load the machine as follows: In the lower (plate) rack, distribute the six soiled dinner plates uniformly with the smaller plates and bowls, if used (Note 2), placed alternately about the dinner plates until the rack is fully loaded. In the upper (glass) rack, distribute the glass tumblers evenly. If eight or ten are used, place them along each side, four or five to a side. Optionally, use extra tumblers, so that one can be removed periodically for comparative purposes.

NOTE 2—Optionally the smaller chinaware pieces may be omitted and only dinner plates used.

6.1.1 In the silverware rack or holder, place six each of the stainless steel knives, forks, and spoons.

6.2 *Water Temperature*—Maintain a water temperature of ~~130~~130 °F ± ~~5°F (54.45~~ °F (54.4 °C ± ~~3.8°C)~~3.8 °C) in the dishwasher. (The water supply may have to be controlled at a higher temperature because of heat losses in the piping etc.) Preheat the machine by running a preliminary cycle with the machine empty. Allow the contents of the machine to cool to about ~~75°F (23.9°C)~~75 °F (23.9 °C) before making evaluations or starting another wash cycle.

6.3 *Water Quality*—Use water of consistent hardness and well-defined composition. If only one test is made, use a level of 120 ppm (about 7 grains/gal). It is advised to test in both ~~hard and soft (0 to 50 ppm) water,~~ moderate and hard water, (120 ppm and 300 ppm), since water hardness is a very critical factor in these tests. ~~It is preferable to make~~ Make up a synthetic hard water using

[2] Any commercial brand of these items is satisfactory.

deionized or distilled water to which calcium and magnesium salts have been added. ~~Use a~~Refer to Table 1~~3:1 ratio~~ for the correct ratio of calcium to magnesium ion. ~~If~~ Although not recommended, if natural water is used it should be characterized as to total hardness (ppm), bicarbonate content (ppm), Ca:Mg mole ratio, total solids, and content of trace metals such as iron, all of which can affect test results. ~~There~~ When working with an external or other laboratory, there shall be mutual agreement between laboratories as to the quality and hardness of the water used.

6.3.1 The calcium/magnesium ratio of hardness minerals (expressed as CaCO3) should be adjusted to attain different water hardness as shown in Table 1.

6.3.2 *Hard Water Stock Solution*—For a 2:1 ratio, prepare a hard water stock solution by dissolving 2.940 g of calcium chloride dihydrate ($CaCl_2 \cdot 2H_2O$) and 2.033 g of magnesium chloride hexahydrate ($MgCl_2 \cdot 6H_2O$) in deionized (DI) water. Dilute to a volume of 1 L with additional 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 ($CaCl_2 \cdot 2H_2O$) and 2.033 g of magnesium chloride hexahydrate ($MgCl_2 \cdot 6H_2O$) in DI water. Larger batches or concentrations may be scaled up using this ratio of calcium chloride to magnesium ~~chloride.~~chloride. Caution should be used when storing batches of hard water concentrate as microbial growth may form and impact performance.

6.4 *Detergent Concentration*—Use the quantity of detergent specified by the manufacturer. ~~For a thorough investigation, evaluate at over and under usage.~~

6.5 *Dishwasher Cycle Selection*—To ensure that each dishwasher performs similarly for each product tested, it is recommended to avoid any soil sensing or "smart sensing" technology that your machine may have programmed. Use a constant time wash cycle, if available.

6.6 *Number of Cycles*—Multiple cycles, with the food soil reapplied after each one, are needed to obtain significant comparisons. From ~~5~~5 (typical) to 15 cycles are usually required.

6.7 *Rating*—Rate the tumblers visually after your desired cycle number(s) (cycle 5, for example) or after each cycle for film and spotting. Note each tumbler's location and ensure to return the respective tumblers to the same location throughout the test. Failure to do this will cause potential machine issues to go unnoticed (Note 3). For these evaluations, view the tumblers upside down in the light box described in 4.4 (in handling, pick up the tumblers by the base to avoid fingerprints on the sides). Multiple trained raters are recommended and their ratings averaged. Visual evaluation ~~should be made 24 h after the cycle has ended. Use the~~ can be assessed once tumblers reach ambient temperature. Use the scales depicted in Fig. 1 and Fig. 2 for rating the tumblers.

NOTE 3—Hard water build-up may occur, especially if a citric acid wash is not executed between tests. This buildup may create inconsistent spraying and increased variability in tumbler location to location data. This variability can be noticed when analyzing your test data.

NOTE 4—In instances of high filming, the ability to grade spotting may be diminished.

6.7.1 When several machines and sets of tumblers are used in the same test series, rate each set of tumblers against the other.

6.7.2 Obtain number ratings by averaging the ratings for individual tumblers, keeping spotting and filming results separate. Levels of acceptability may be agreed upon by the laboratories ~~involved.~~ involved. Statistics (Analysis or Variance), may be incorporated and is recommended to aid in the comparison of product performance. Photographs of the tumblers in the light box make reasonably accurate standards for comparison.

6.7.3 Use ~~8~~8-10 tumblers throughout the test, or optionally, 15 may be used initially with one representative tumbler being removed periodically, as for example after the fourth, sixth, eighth, tenth, etc. ~~cycles.~~cycles Note 5.

TABLE 1 Water Hardness Range

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