A Greasy Soil Hard Surface Cleaning Test

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ABSTRACT

A laboratory screening test for greasy soil removal from hard surfaces using lard, vegetable shortening and vegetable oil darkened with finely divided charcoal on white, latex-painted masonite wallboard is described. Cleaning by a wet sponge in the Gardner apparatus is measured by reflectometer. Statistical evaluation of results based on comparisons of 8 competitive cleaners is documented. Curves showing performance vs concentration of cleaners are given.

INTRODUCTION

Although market research has shown that removing greasy soil is one of the most vexing problems confronted by homemakers, and several leading brands of liquid household cleaner have run major advertising campaigns stressing their products' cleaning performance on grease, no universally accepted method for removing greasy soil has appeared in the technical literature.

A laboratory screening test for removing greasy soil from hard surfaces has been developed in our laboratory. The soil is a mixture of lard, vegetable shortening and vegetable oil darkened with finely divided charcoal. The substrate is white, latex-painted masonite wallboard. Cleaning is done by a wet sponge in a Gardner straight-line washability apparatus. Performance is taken as a linear function of reflectance as measured by Photovolt reflectometer. Test replication allows statistical evaluation of precision and ranking judgments. This paper describes the test and shows some results comparing several different commercial products.

Eight competitive products, including the leading pine-oil cleaner and disinfectant and 2 other pine-oil cleaners, leading phosphate-built detergent cleaners and their no-phosphate counterparts, a nonpine-oil cleaner and disinfectant and a pine oil and solvent cleaner that is not a disinfectant were compared in concentrations ranging from full-strength to 1:64 dilution. Comparisons of these products at the different concentrations are graphically displayed with statistical significance. Also, concentration curves showing the relative performance for each cleaner over the concentration range are shown. Derived by curvilinear regression analysis, these curves allow some general conclusions about grease cleaning and the relative performances of competitive commercial products.

The test's biggest source of variation is day-to-day differences in soiled tiles. Multiple comparisons are desirable for such tests. To make multiple comparisons, we used a balanced incomplete block (BIB) statistical design for efficiency and to reduce uncertainties resulting from day-to-day variations. A summary of the method, apparatus and materials, and a description of the procedure are given below.

EXPERIMENTAL PROCEDURES

Summary of Method

Latex-painted masonite wallboard is dried, then 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 Gardner straight-line washability apparatus. The other half of the soiled substrate is scrubbed with a second detergent.

Apparatus and Materials

Apparatus. Reflectometer: Photovolt Model 670 with Search Unit 610Y and Green Tristimulus Filter, template (see Fig. 1), Gardner straight-line washability apparatus, graduated cylinder, calibrated to deliver 100 mL and graduated volumetric pipette, 10 mL.

Materials. Masonite wallboard tiles (1/8" thick cut 4½" × 4½"), latex paint (Ox-Line Ruberol 171 nonyellowing white), vegetable shortening (Crisco), lard (Armour), partially hydrogenated soybean oil with polyglycerol esters of fatty acids added (Pathmark Vegetable Oil, distributed by Supermarkets General Corp., Woodbridge, NJ), carbon black (Cities Service Neo Spectra Marke II Powder—ASTM #SL 1995), sponges (Shoprite—distributed by Wakefern Food Corp., Elizabeth, NJ—cellulose sponge cut 1¾" × 3 5/8" × 1½") and tap water (80 ppm hardness as $CaCO_3$).

Formulations Tested

Table I describes the formulations tested. All products other than the leading pine oil cleaner and experimental pine oil cleaner were purchased in the Clifton, NJ area, from January through March, 1978. The leading pine-oil cleaner was manufactured at Jackson, MS. The experimental pine-oil cleaner was formulated in our laboratories.

Procedure

Tile preparation. Masonite tiles are double-coated with latex paint (diluted by adding 20% water), using a paint roller, and allowed to set overnight. Tiles are cured at 45 C for 24 hours.

Soil preparation. A combination of melted Crisco vegetable shortening (33 g), Armour lard (33 g) and Pathmark vegetable oil (33 g) with 1 g of carbon black is blended in a steam bath. The soil is freshly prepared each day.

Soil application. The hot soil is applied to masonite wallboard, which has been painted white, with 6 strokes of a cheesecloth swatch soaked in the liquid soil (Fig. 2). The

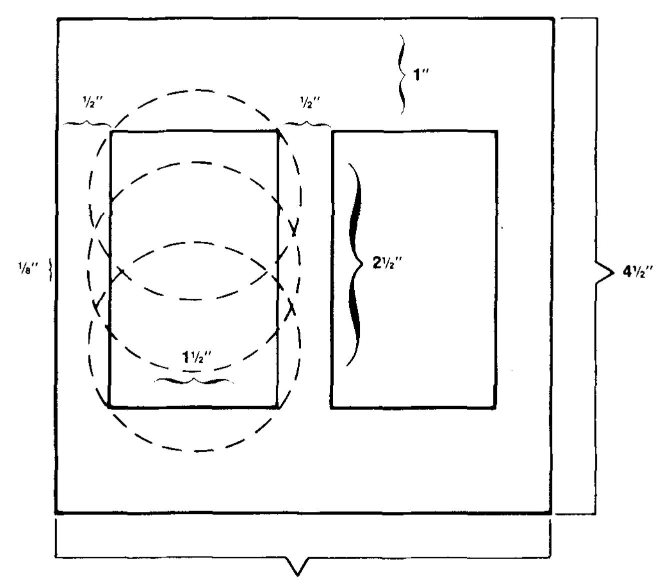

FIG. 1. Template for use with reflectometer

TABLE I

Formulations Tested

Number	Description
1	Leading pine-oil cleaner and disinfectant
2	Experimental pine-oil cleaner and disinfectant
3	Pine-oil cleaner and disinfectant
4	No-phosphate detergent
5	Pine-oil/solvent cleaner
6	Nonpine-oil cleaner disinfectant
7	No-phosphate detergent
8	No-phosphate detergent
9	Phosphate-built detergent
10	Phosphate-built detergent

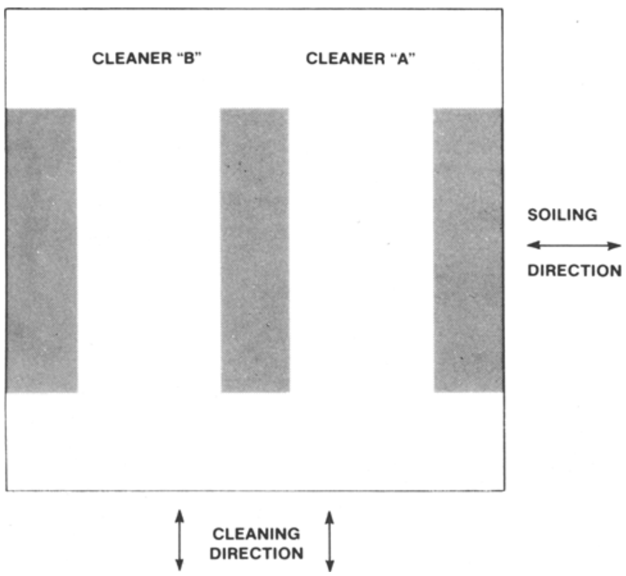

FIG. 2. Soiled tile after cleaning.

soiled substrate is allowed to dry overnight at room temperature.

Cleaner preparation. All cleaner dilutions are prepared volumetrically as necessary. Water is at ambient temperature (20-30 C).

Cleaning test. Fifteen g of cleaner is weighed onto a prewet sponge that has been thoroughly pressed by wringer to remove most of the water, then placed in the Gardner apparatus without weights. Sponge and holder weigh ca. 350 g. The tile is placed in the apparatus so that scrubbing action is perpendicular to the direction of soiling. The wash apparatus is operated for 10 cycles (20 strokes) over one of the soiled areas. The scrubber table is then shifted and the washing test repeated over the remaining soiled area with the second detergent (Fig. 2). A new sponge is used for each cleaning procedure.

Reflectometer measurements. After setting the instrument on zero, reflectance is adjusted to 100 on a standard white reflectance and color tile (the one we use has the following values–76.3% Y; 77.6% X, 73.6% Z). A template (Fig. 1) is placed over a scrubbed board so that only the scrubbed area to be measured shows through the cut-out portions. Three readings are taken in each cut-out portion, moving from one end to the other. Readings are estimated to the nearest tenth reflectance unit. These 3 readings are recorded and averaged (see below).

Statistical Methods

Experimental design. The basic unit of the experimental design is a BIB. The BIB simply pairs all possible combinations of the 10 cleaning agents, each to a tile. The total number of possible pairs is 45 and each treatment (i.e., liquid cleaner) was replicated 9 times. The BIB is illustrated in Figure 3. The cleaning agents are designated 1-10 and the comparisons are organized into 9 distinct replicates of each treatment (e.g., with Formula 1, 2 and so forth). Because 45 tiles are difficult to run in a single day, the BIB is run over the course of 2 days, with 25 tiles on one day and 20 tiles on another.

The BIB design was used 8 times, once for each of the 8 dilutions. Because each BIB requires 2 work days, the entire experiment required 16 work days. The 8 concentrations were randomized over the 16 days to counteract any systematic bias caused by day-to-day variation. Randomization was also applied to the order of the treatment pairs within each replicate, and treatment assignment of left- and right-hand side application was balanced.

Comparison of cleaners. The reflectance for each treatment (each side of each tile) is taken with the reflectometer and the difference between them calculated. These reflectance values are subjected to an analysis of variance that accounts for possible variations within cleaner replications. Possible

First Day's Comparisons

Block Rep. I	Rep. II	Rep. III	Rep. IV	Rep. V
(1) 1 2	(6) 1 3	(11) 1 4	(16) 1 5	(21) 1 6
(2) 3 4	(7) 2 7	(12) 2 10	(17) 2 8	(22) 2 9
(3) 5 6	(8) 4 8	(13) 3 7	(18) 3 10	(23) 3 8
(4) 7 8	(9) 5 9	(14) 5 8	(19) 4 9	(24) 4 10
(5) 9 10	(10) 6 10	(15) 6 9	(20) 6 7	(25) 5 7

Second Day's Comparisons

Rep.VI	Rep. VII	Rep.VIII	Rep. IX
(26) 1 7	(31) 1 8	(36) 1 9	(41) 1 10
(27) 2 6	(32) 2 3	(37) 2 4	(42) 2 5
(28) 3 5	(33) 4 6	(38) 3 5	(43) 3 6
(29) 4 9	(34) 5 10	(39) 6 8	(44) 4 7
(30) 8 10	(35) 7 9	(40) 7 10	(45) 8 9

FIG. 3. Balanced incomplete block.

sources of variation include controlled variables such as differences in cleaner use-dilutions, painted tiles, soil preparation and soil application, as well as uncontrolled variables.

The sums of squares for these sources of variation were calculated to recover interblock information. Treatment means, adjusted for differences in the tiles, were calculated, and paired comparisons using the Newman-Keuls procedure were made. Typical reflectance values for soiled tiles are ca. 5 units, whereas typical reflectance values for unsoiled tiles are ca. 85 units. Variation among replications of the same cleaner will range ±2-3 units.

Dilution-response curve estimation (Fig. 12). Two functional forms were considered as possible models for the relationship of response to dilution:

$$\text{Resp} = a + b\,(\text{pcta}) + c\,(\text{pcta}^2)$$

or

$$\text{Resp} = a + b \ln(\text{pcta})$$

where: Resp = reflectance reading and pcta = percent active product, which equals 1/(1 + No. parts H_2O) and a, b and c are estimated coefficients to obtain the best fit. The adjusted treatment means obtained from an analysis of variance at each dilution were used to estimate the coefficients.

For each cleaner the functional form chosen to represent its dilution-response relationship is the one yielding the highest R-squared statistic. This statistic measures the proportion of variation among the adjusted means, which is explained by the function chosen. Using this rule, the first function was chosen for cleaners 4, 6, 7, 8, 9 and 10 and the second function was chosen for cleaners 1, 2, 3 and 5. The R-squared values obtained ranged from 0.68 to 0.95 with 6 of the R-squared values above 0.90.

The significance of the residual variation (lack of fit) was tested using a pooled error estimate from the analyses of variance comparing the cleaners at each dilution. This pooled estimate was the simple mean of the mean square errors in these tables. Lack of fit was significant only for cleaners 9 and 10; however, more complicated functional forms were not explored for these cleaners. This lack-of-fit test was perhaps too conservative for cleaners 9 and 10 because variation within dilution by cleaner cell was excessively high for them.

RESULTS AND DISCUSSION

Mean Reflectance Values

General. Figures 4-11 are bar graphs that show the mean reflectance values for the tests, ranging from full-strength to 1:64 dilution. The reflectance values are given in descending order from left to right. Lines connect those values that show no significant differences at the 95% confidence level for each bar chart.

Full-strength. At full-strength, Formulas 3, 2 and 1 show no significant differences (Fig. 4), but that these 3 pine-oil cleaner products are significantly better in greasy soil cleaning performance under these conditions than the others. The next 5 products, formulas 5, 4, 10, 9 and 6 are significantly better than the 2 poorest formulations under these conditions, formulas 8 and 7.

Figures 5-10 show similar results on dilution with water of the various products from 1:1 down to 1:32. Figure 11 shows the relative performance of the commercial products at 1:64, or normal recommended use-dilution for most commercial concentrated liquid cleaners.

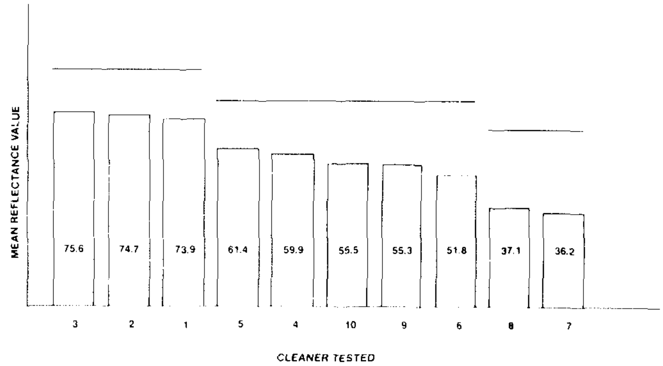

FIG. 4. Greasy soil removal by all-purpose liquid cleaners—full strength.

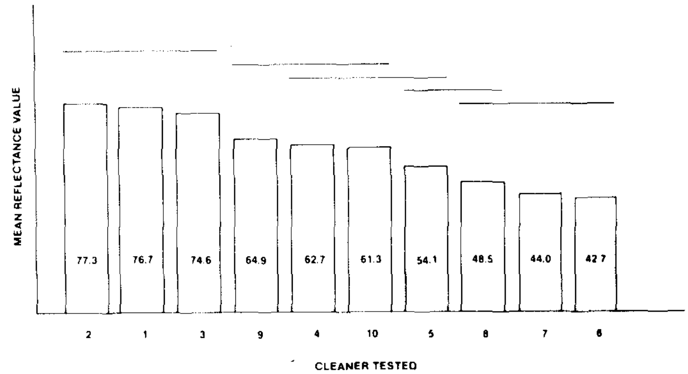

FIG. 5. Greasy soil removal by all-purpose liquid cleaners—1:1 dilution.

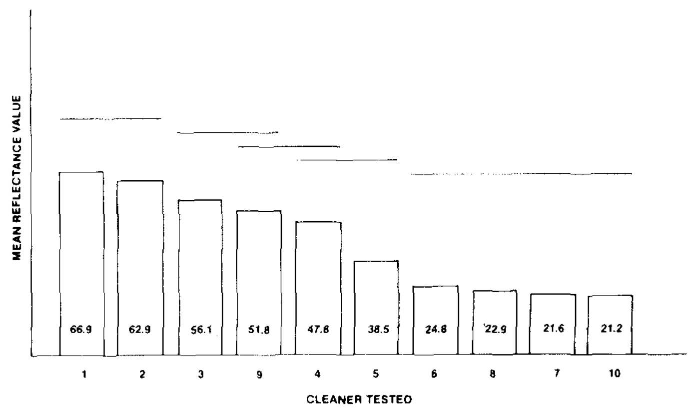

FIG. 6. Greasy soil removal by all-purpose liquid cleaners—1:2 dilution.

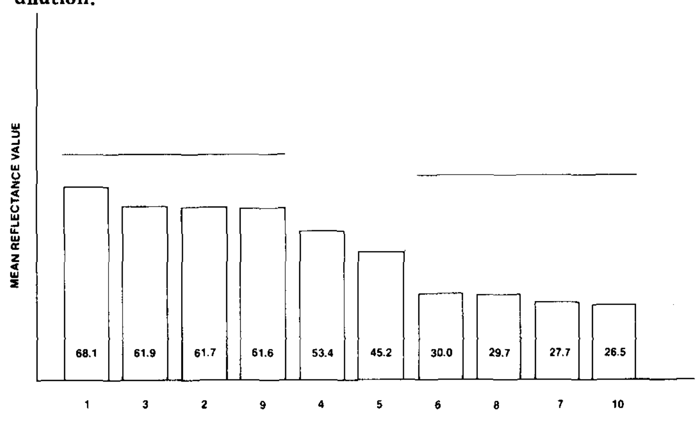

FIG. 7. Greasy soil removal by all-purpose liquid cleaners—1:4 dilution.

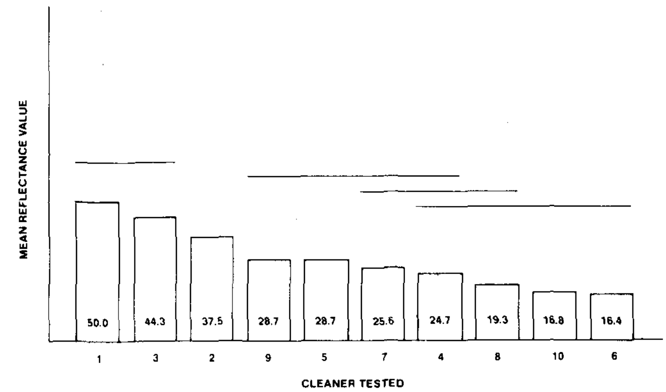

FIG. 8. Greasy soil removal by all-purpose liquid cleaners—1:8 dilution.

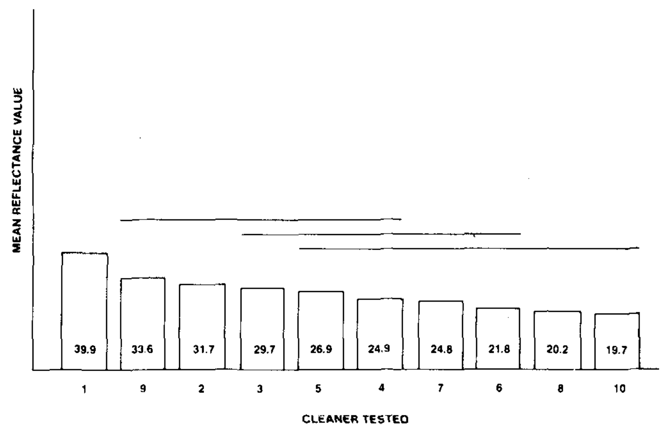

FIG. 9. Greasy soil removal by all-purpose liquid cleaners—1:16 dilution.

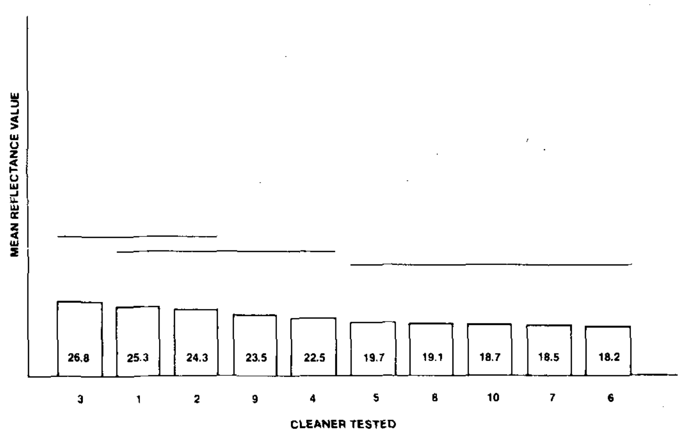

FIG. 10. Greasy soil removal by all-purpose liquid cleaners—1:32 dilution.

At 1:64 use-dilution, however, no significant differences are seen among any of the products compared under the conditions of this test, even though trends established at higher cleaner concentrations persist at 1:64 use dilution.

Figure 12 is a line graph summarizing linear regression analysis of cleaning performance data vs use-dilution for each of the 10 commercial cleaners. All formulas show decreasing cleaning performance with increasing use-dilution (decreasing cleaner concentration in the bucket).

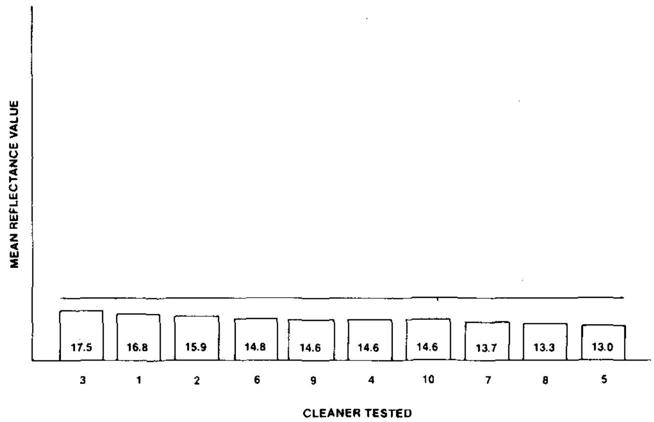

FIG. 11. Greasy soil removal by all-purpose liquid cleaners—1:64 dilution.

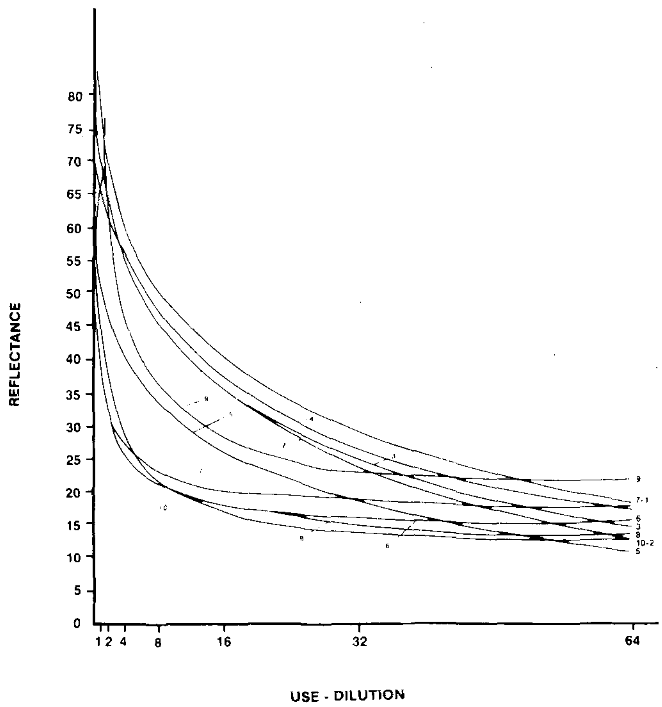

FIG. 12. Cleaning performance of competitive products vs use—dilution.

An interesting observation from this graph is that solvent based cleaners like Formulas 1, 2, 3 and 5 are generally superior grease cleaners from full-strength down to about 1:32 use-dilution. The decline in performance is relatively more gradual to 1:32 and continues to decline well into 1:64 use-dilution. The water-based formulas, e.g., as Formulas 7, 8, 9 and 10, are less efficient cleaners at full-strength and decline more sharply with water dilution. However, at about 1:16 use-dilution, these cleaners have nearly flat cleaning performance curves down to 1:64.

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