used in large-scale tests and offers the advantage of a low initial investment. The use of multiple labels in the radiotracer method reduces the number of experimental runs while increasing the amount of data collected, an important consideration when conducting a large number of tests.

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Soiled cloths are used in testing

The following is based on a talk given by George C. Feighner of Scientific Services, Oakland, New Jersey.

Throughout time, people have tested detergents. Until recently, testing was done subjectively by housewives using soap on their laundry. Now, there is a science dedicated to correlating and predicting consumer acceptance of laundry products with laboratory tests.

Standard soiled cloths are an important part of testing. The diversity of soils and stains is one problem; the variety of fabrics and laundry practice is another. Controlled conditions of laundering standard soiled cloths in a Terg-O-Tometer or full-scale washing machine produce results which can predict to some extent results in the home and, more importantly, allow scientists to evaluate solutions and innovations in the laboratory.

Since the discovery of soap, people have been comparing their laundry results. Application of scientific principles to study of the cleaning process has resulted in a considerable body of knowledge about testing new detergent developments. Laboratory testing of detergents requires controlled conditions and artificially soiled cloths which predict cleaning of real-world soils and stains.

In the laboratory, we like to see really dirty fabric become nearly white. With real-life laundry, soils are relatively light and any one stain uncommon. Redeposition, whether perceived or not, is probably the most serious laundry problem. Real life needs to be kept in mind in selecting soiled cloths for testing detergents, and the developer should remember that laboratory tests are an abstraction of reality. Although there are some common denominators in household laundry problems, there also is tremendous diversity.

There are two types of laundering—household and institutional or commercial. The requirements for the two are quite different. The information discussed here is based on use of soiled cloths for testing household products, although some of the data will be applicable to commercial laundry.

Artificial vs. natural soils, stains

Natural soils can't be standardized; they change with time. In order to standardize and control soil variables, many artificial soils have been used. Because artificial soils can't duplicate the diversity and complexity and changing nature of laundry soils, detergent researchers eventually test their products with natural soils and stains. Experienced laboratories develop the ability to predict the relation between bench tests with the Terg-O-Tometer, bundle tests run under controlled conditions, in-home tests and normal usage in the home.

Laboratory vs. practical testing

Soiled cloths are used universally in research stages of product development and evaluation. Before a new product is marketed, bundle testing and in-home tests are usually run. The problem is to relate the results with standard soiled cloths to real-world results.

We expect a suite of laboratory tests with soiled and stained swatches to give rankings which correlate with preference rankings in home laundry. Because consumer perception is so important to success in the detergent business and because the science of psychology has not been integrated with Terg-O-Tometer tests, there is much work to be done. In the meantime, detergent scientists must do the best they can with rather imprecise tools and use a lot of statistical inference.

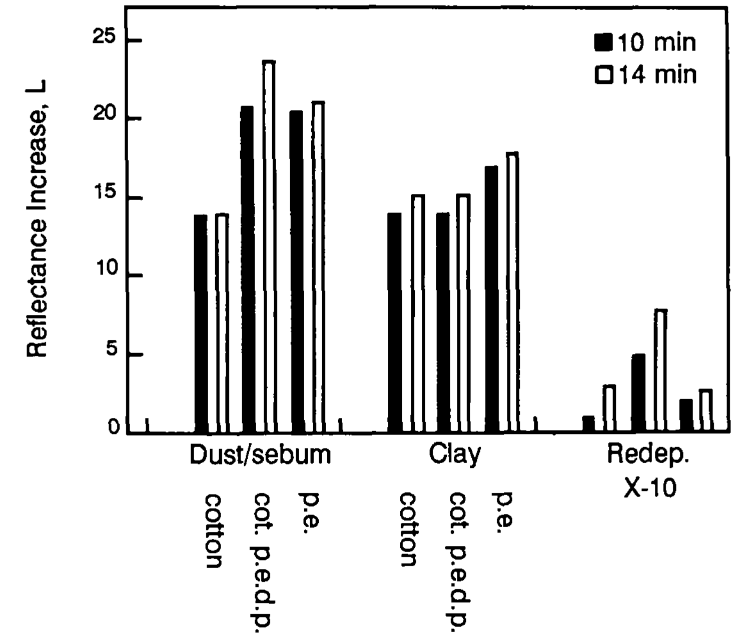

FIG. 1. Effect of wash time on detergency.

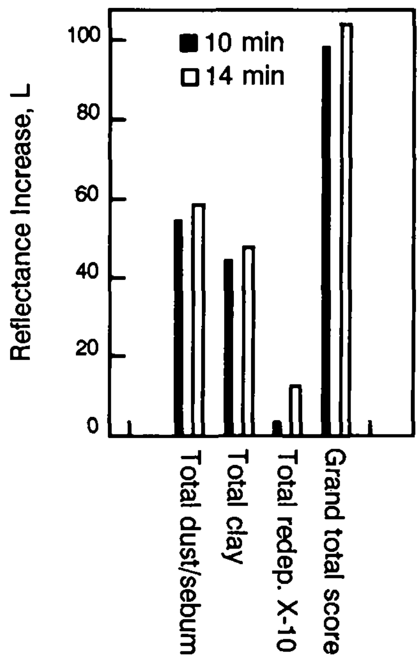

FIG. 2. Wash time, total scores.

Soils vs. stains

Soils and stains can be viewed as two separate problems. Soils are more or less evenly spread over the laundry load and are universally present. Stains are much more varied and are found in distinct areas. Soil removal results in clean clothes with a bright white look. Removal of a stain changes the visual contrast between the stained and unstained area.

There are four types of soils commonly encountered, although there may be others that are important in home laundry. The four are:

- Dust/sebum—oil, wax, skin cells
- Clay—mud
- Food and beverage—protein, carbohydrate, fat
- Redeposited soils—gray-yellow dingy clothes

In our laboratory, we use a mixed load of dust/sebum and ground-in-clay-soiled swatches plus clean cloths to screen detergents. Removal of two soils from three fabrics with redeposition onto three clean fabrics helps give an overall assessment of detergency.

Stains are grouped under three categories: body stains, food stains and environmental stains. They include:

- Body stains—blood, perspiration, fecal matter and urine.
- Food stains—baby formula, blueberry and other berries, catsup, chocolate syrup, ice cream, milk, pudding, cocoa, coffee, cooking grease, grape juice, gravy, mustard, spaghetti sauce, tea and wine.
- Environmental stains—ball point ink, car door latch grease, clay and humus (mud), cosmetic make-up, grass, lipstick and used motor oil.

Stains are as numerous as the things man rubs against or touches. Probably the number listed could easily be doubled, but these are in the *ASTM D-4265—Standard Guide for Evaluating Stain Removal* and in suppliers' catalogs.

The soil most widely used for detergent testing is that described by Spangler (1). It simulates ring-around-the-collar or soil from human skin which is transferred to garments and linens. It is a mixture of airborne particulates (dust) and synthetic sebum. Airborne dust is unique in its soiling effect. Sebum is a mixture of unsaturated fats, fatty acids, waxes and oils that present unusual problems in laundering. Removal of the natural dust-sebum soil is the most universal laundry need.

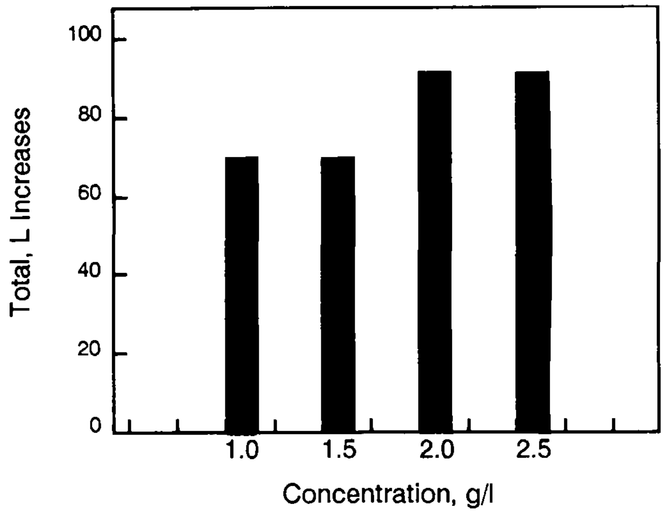

FIG. 3. Effect of concentration on detergency.

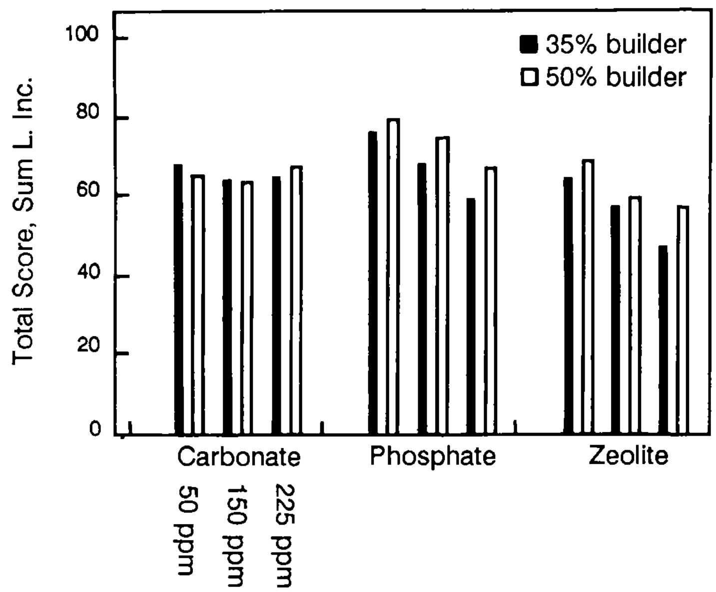

FIG. 4. Hardness and builder effects on detergency.

The ground-in clay soil used in the tests described is representative of ground-in-soils such as jean knees common in home laundry. The soil is a mixture of natural clays and includes a red iron-stained clay. The type of soil is similar to the one described previously (2), but a mud rather than dry dust is ground in.

Some suppliers of soiled and stained cloth for testing detergents are: AHAM, Textile Innovators Corp., Dallastown, PA; EMPA, Federal Testing Station, Switzerland; Scientific Services, Oakland, N.J.; Testfabrics Inc., Middlesex, N.J.; and Waescherei Forschungs Inst., Krefeld, West Germany. Methods used in testing include ASTM methods D-3050, D-4008 and D-4265 (3). ASTM committee D-12 deserves credit for bringing scientific standardization to our work. CSMA has published a book of pertinent test methods with an excellent bibliography referencing AHAM, AATCC and other methods (4).

Sensitivity of soils and stains

A good soiled or stained test cloth will allow for measuring the effects of one or more variables which affect removal and/or redeposition of soil. Variables encountered are water hardness, wash temperature, time and agitation, soil age, redeposition, fabrics and finishes, surfactants, builders, bleaches, enzymes and fabric softeners.

Some standard soiled cloths are sensitive to a particular factor, such as a protein stain reacting to an enzyme detergent. Some soils are particularly sensitive to a single surfactant type, and care must be taken not to give too much weight to these kinds of results.

Interpretation of results

Soil removal is usually measured in the laboratory by changes in reflectance. Radioactive tracers are also used. Stains tend to be colored and the changes as measured on the a and b scales are used in addition to the black-white L scale. Other reflectance scales and various transformations of the data are employed to make results more understandable. Calculation of the percentage of soil removal (3), Δ E, stain removal index (5) and whiteness indices (2) are examples. We need results that are relevant, namely, that are proportional responses to real-life problems.

Standard detergents usually are run with experimental products to give relative results which can be correlated with later experiments. As reproducibility is always a problem, lots of replicates are run. The calculation of statistical differences permits conclusions to be drawn in spite of the imprecision of the data. However, we must beware of drawing statistical conclusions which exceed the precision of perception by actual consumers.

Computers help in the organi-

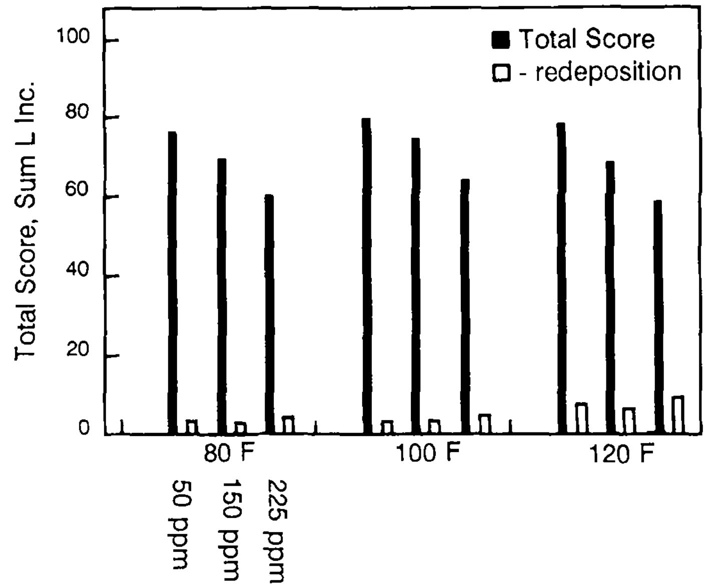

FIG. 5. Temperature effects on detergency.

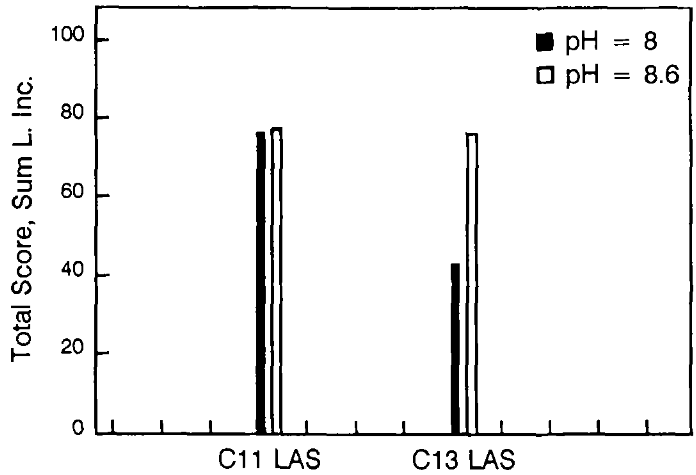

FIG. 6. Effect of pH on detergency on citrate detergents.

TABLE 1

Effect of pH and Silicate Level on Detergency

	LAS C11		LAS C13	
	ph 8.0	ph 8.5	ph 8.0	ph 8.7
Na Citrate				
Total detergency score	78	79	44	76
NTA				
Total detergency score		99		97

zation and interpretation of the data from soil and stain removal studies. Large laboratories are automating the process.

Illustration of effects

In the following section, a number of effects of variable detergency results are shown. These data are selected from sensitivity studies in our laboratory. The soil cloth load consisted of two swatches each of dust/sebum and ground-in-clay soiled cotton, cotton-polyester with durable press finish, and polyester fabrics. We included one swatch each of the three fabrics for redeposition.

The various effects encountered in the use of soiled cloths are illustrated in Figures 1 and 2. This experiment was to determine the effect of wash time. The grand total score indicates that longer wash time gives more soil removal. This is reassuring. Both soil totals show a positive effect. However, redeposition gets worse, probably because more soil is available to deposit. Each individual soil-fabric reacts in parallel.

In this typical experiment, individual differences probably are not statistically significant, but the group and overall differences are. Discrimination between products can be made as fine as desired by increasing the number of replicates.

Using the same standard soiled cloth and clean cloth load, we see the effect of four concentration levels in Figure 3. The test gives better results as more detergent is used, which makes sense. The effect of three water hardnesses on the total detergency scores for three builders is shown in Figure 4. This shows that builder ranking differs in a reasonable way, that more builder gives better results, and that increased hardness adversely affects performance.

The effect of temperature, as illustrated in Figure 5, is not as expected. With the system used, an increase in temperature does not lead to the expected increase in soil removal. As temperature increases, redeposition gets out of hand, especially in hard water. These results are typical of problems formulators face in balancing conflicting factors. Standard soiled cloths are used in the laboratory to test new formulations designed to resolve such conflicts.

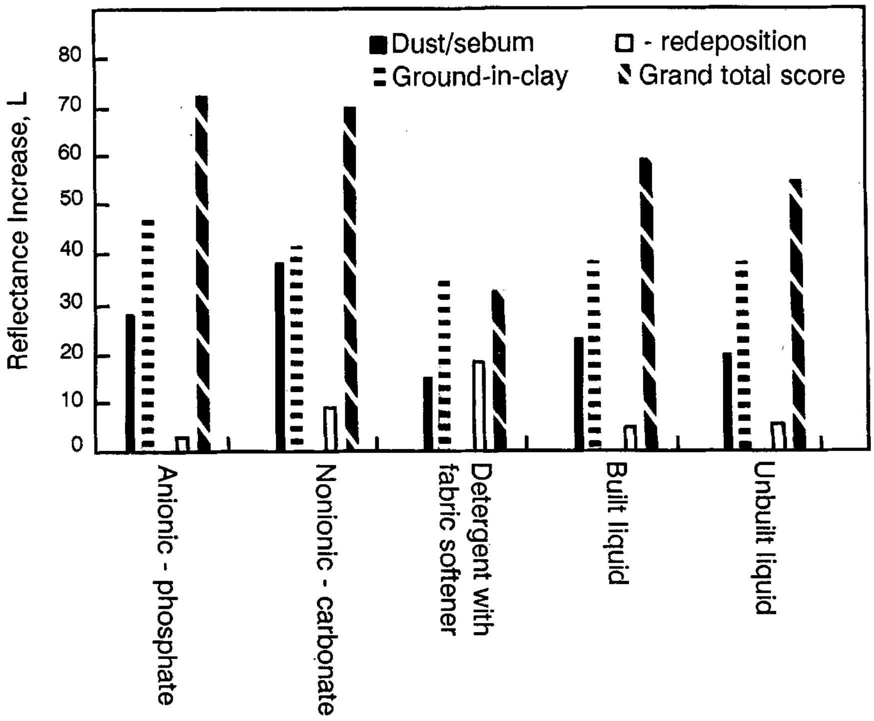

FIG. 7. Performance of commercial products on detergency.

Table 1 and Figure 6 show an interaction of pH and surfactant. Two levels of sodium silicate were used to change the pH of the wash bath. Only at the elevated pH is the higher molecular weight LAS effective. Here, soil cloth tests show why the C13 LAS is used in built alkaline detergents. Note that the top part of the table shows results with sodium citrate builder. The same effect is not seen with NTA builder. LAS surfactant is sensitive to pH and hardness.

Figure 7 presents data on soil removal for several commercial detergents. The purpose is to show differing responses to soils and redeposition with changes in product type. We think that the use of a mixed load in detergent screening can keep the focus on overall performance. Also, differences in individual performance suggest areas for research to improve results. By comparing the results of bundle tests and Terg-O-Tometer tests, we increase our confidence in the predictive value of tests run with soiled cloths.

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