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Detergency Evaluation

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IN setting out to evaluate detergents certain decisions will perhaps already have been reached, probably on the basis of the field of application involved. If it is one of flat surfaces, as in metal cleaning, dish washing, or floor maintenance, then some one type of experimental equipment will have been decided upon. If it is a problem in the dry cleaning of garments, a different approach will be required. In the textile line the decision may depend upon the stage in processing of the fiber or fabric chosen, and certainly will depend upon what fiber is involved. If laundering of garments is the problem, this may arbitrarily be divided into commercial and home laundering phases.

J. C. Harris

Decisions will necessarily be made concerning the following factors: Surface (fiber or hard surface), soil encountered and standard soil for laboratory evaluation, test machine, test method, evaluation of test pieces, and evaluation of data.

Hard Surface Cleaning

Probably the greatest volume of work on hard surfaces has been reported for metal cleaning. This work has not yet been standardized, but ASTM Committee D-12 has suggested a procedure which can be very helpful (1). A thorough survey of this general field is available (2).

The early work on cleaning painted surfaces resulted in a Bureau of Ships Specification 51S46 (3) and Federal Specification P-C-431 (4). Recent work using the apparatus described (Figure 1) has indicated its considerable utility (5).

Work on asphalt tile cleaning is represented by the work done by Trusler in furthering committee work for the Chemical Specialties Manufacturers' Association (6).

Glass washing has been the subject of considerable investigation, the most recent being that of Mann and Ruchhoft (7, 8). Here an especially designed machine was used in the evaluation of detergents.

All of the foregoing methods possess the same general characteristics of requiring a selection of those elements listed above, not the least of which is the standard soil chosen for investigation.

These fields have perhaps received less investigational effort, and perhaps represent a smaller tonnage outlet for detergents than the textile field, and reference should be made to the individual papers given in the bibliography.

Textile Operations

Much effort has been given to the evaluation of detergents for textile purposes. The American Association of Textile Chemists and Colorists has been foremost in promoting investigation of this field. Under its auspices the Detergent Comparator has been developed for the evaluation of detergents used for wool, in knitted tubular form (9), in a manner similar to mill scouring conditions. Leonard and coworkers (10, 11) have developed a laboratory method for continuous scouring of grease (raw) wool which has also been the subject of investigation by a special committee of AATCC. This latter method closely approximates the results obtained in a mill for the scouring of raw wool. Reference should be made to the original papers and to the 1951 AATCC Technical Manual and Yearbook for a discussion of the soils and methods used.

Many papers have been published on dry cleaning detergency. The most pertinent are those written by Fulton (12) of the National Institute of Cleaning and Dyeing. Standardization work on evaluation has been attempted by ASTM Committee D-12, but no satisfactory laboratory evaluation method has as yet been developed.

Garment Cleaning

Probably the greatest single market for detergents is for the wet cleaning of wearing apparel, so entitled to distinguish it from textile mill operations and dry cleaning.

Aside from garments which must be dry cleaned, there are two arbitrary classes of garments which can be wet-cleaned. Those are represented by wool and wool-like fabrics and cotton (or cellulosic) fabrics. Different detergents and washing methods are indicated for these two classifications while a further breakdown may be made as to whether the garments are to be washed in the home, by hand or machine, or in commercial power laundries.

Power Laundries. Experimental work in power laundering may be carried out initially in pony wheels (as low as 25-pound dry-weight loads) but should be verified in commercial size wheels. Frequently the small-wheel work is dispensed with entirely, and investigation carried out on large scale wheels.

The American Institute of Laundering has for years been the leader in the standardization of equip-

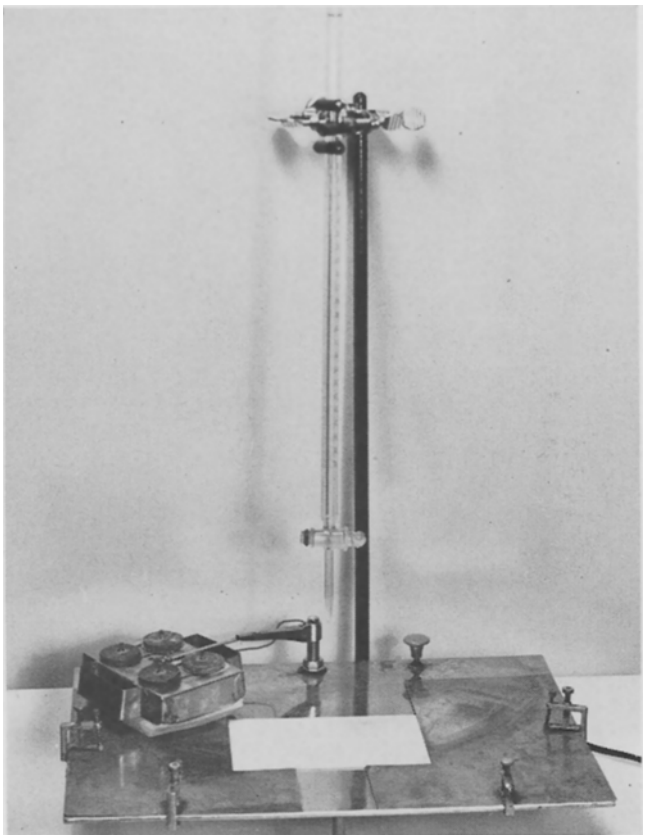

FIG. 1. Painted surface washability apparatus.

ment and methods for commercial power laundries, but there apparently are no published standardized methods available for investigation.

Home Laundering. Home laundering can be of two kinds: hand or machine.

The manufacture of washing machines is big business, several million new units having been produced last year. The American Home Laundry Manufacturers Association has made available to its members, for research purposes, a standard washing machine and washing procedure. This is of material assistance as it sets up a standard of known characteristics for reference purposes. Here, naturally, the machine is the important item, rather than the detergent used, though the latter can be of much assistance in optimum operation.

Many investigators have used regular home washing machines for laboratory evaluation purposes. The machines require but a 7- to 9-pound wash load and do not demand excessive amounts of detergent. An immediate advantage is that the data thus produced are upon a full scale basis. When using such machines, any type of mechanical agitation as developed by the manufacturer may be used, and the wash loads may either be normally soiled, or be comprised of blank loads of fabric with which are included soiled swatches.

Laboratory Evaluation

Laboratory evaluation of detergency may arbitrarily be divided into wool washing and cotton washing. The former has received considerably less investigation than the latter, probably because the potential detergent volume is less. The volume of reports on laboratory procedures for wool washing is less than for cotton, but a moderately satisfactory screening method is represented by that described in Quartermaster Corps Specification OQMC No. 100A. Either hand or machine washing may be followed in the evaluation.

Fabric. Cotton detergency represents the largest bulk of the cleaning that is done hence is the field most broadly covered in the papers on this subject. This fiber and its fabrics are generally the choice made in detergency work. A widely used fabric is white Indianhead (Textron Inc.).

Soil. The actual soil present on the fiber, yarn, or fabric will depend upon the point in processing chosen. For example, fiber ordinarily is free from gross contamination in the case of synthetics, while wool, and to a lesser degree, cotton, contains materials which must be removed before the fiber can be further processed. In the textile mill the removal of wool grease and additional organic or inorganic soil from the sheep wool will pose a problem. Cotton will contain waxes and lignin-like material which should be removed for greatest workability and quality. The synthetic fibers may contain materials carried over in them from the spinning process, but ordinarily these are relatively well removed by thorough washing before the processor receives them for yarn and fabric manufacture.

Fabrics after weaving will contain extraneous materials added either to simplify the manufacturing procedure, to impart certain strength-giving characteristics, or to improve the general quality of the fabric during the manufacturing process. Wool will have been oiled to minimize friction and to permit the preparation of a satisfactory yarn and fabric. Cotton goods as well as synthetic fabrics may, and probably will, contain sizing agents added to minimize friction produced during the weaving process. All of these fabrics probably will contain additional soils which result from manufacture, such as graphite stains, lubricating oil, and miscellaneous undesirable coloring materials.

In the design of a standardized soil for the evaluation of effectiveness of detergents in such soil removal, it is understandable that much difficulty has been encountered in covering the entire range of soils encountered. Much difficulty is further evidenced in the many attempts which have been made to produce a satisfactory soil, either for simulation of mill practice or simulation of soil deposited from personal wear.

Very early work in detergency was done, using some fabric to which was applied a natural soil or dirt. That such cycles of thought exist is evidenced by the more recent work of Sanders and Lambert

FIG. 2. Raw wool scouring train.

(13). A new twist was applied in the latter case, in that a "standardized" soil was prepared, based upon analyses of several natural soils encountered and in the manner of application of the soil to the fabric.

Several factors must be considered in the selection of a soiling agent to make it entirely suitable:

a) It must act as a means to provide quantitative measurement of soil retention or removal.
b) It may or may not be completely removed.
c) It should permit reproducibility of preparation of the fabric and washing results.

The most generally selected material is carbon in the form of oil black, gas black, or graphite. Seldom is it applied alone but generally is used in combination with a binding agent, such as an oil.

The earliest cooperative effort to solve this problem in this country was that of the American Oil Chemists' Society (14). Later attempts by ASTM Committee D-12 were little more successful in consolidating opinion on the subject of detergency testing. Of the many investigators who have developed "standard" soils, a representative idea may be had by reading the accounts of Bacon (15) and Utermohlen (16).

Harris and Brown (17) have more recently outlined the trials and tribulations which occur in standardizing a soil to be used in detergency testing and have carefully and fully outlined the factors which must be controlled in this operation. It is their opinion that detergency tests are best made as a routine operation since they are largely a matter of technic. They hardly resemble a minor analytical method, to be applied as the occasion demands.

Certainly the preparation of a standardized soil is difficult, but several suppliers of soils are available:

American Conditioning House. Prepares several types of soiled cotton and wool fabrics and will custom-prepare as required.

Foster D. Snell Inc. Prepares its own cotton and wool soiled fabrics and handles the Pennsylvania State College power laundry fabric.

Test Fabrics Inc. Prepares a printed cotton fabric and has a wool soil.

FIG. 3. Terg-O-Tometer.

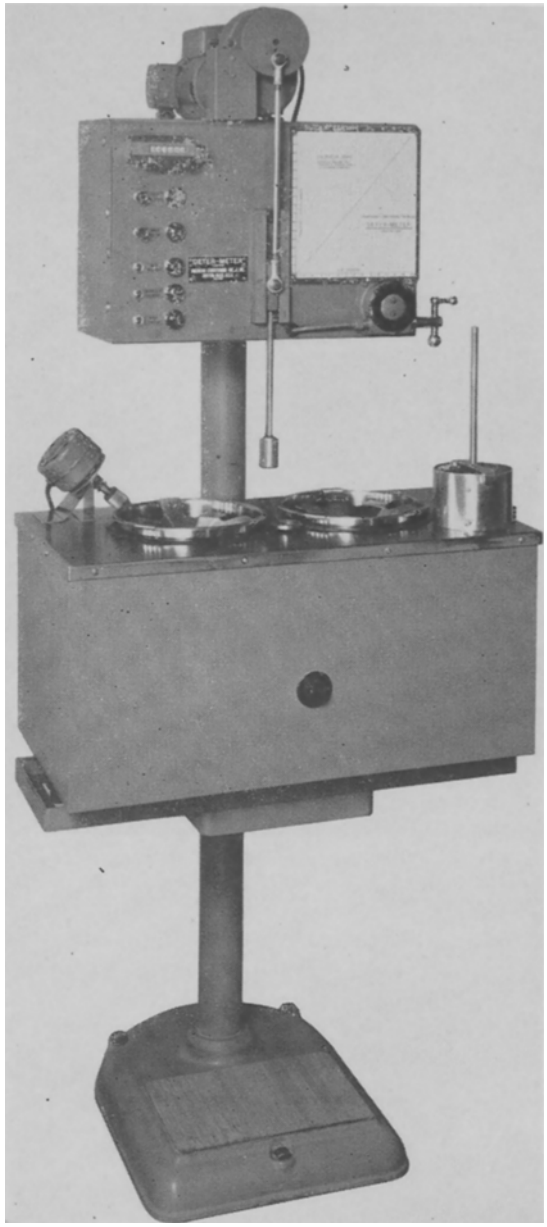

FIG. 4. Deter-Meter.

U. S. Testing Company. Prepares cotton and wool soiled fabrics.

Machine for Washing. Many ideas exist as to the type of machine which is best suited to perform the washing operation in the laboratory. Many attempts have been made to reproduce practical cleansing operations by developing miniature wash wheels or washing machines of various types. Others have disregarded miniaturization and have developed machines which could be made more reproducible in the application of mechanical force in the presence of detergents. Some of these have no bearing whatever upon practical washing machines, except that the removal which they produce can be directly related to removal under practical conditions.

Bacon and Smith (18) demonstrated that one of the major factors in the removal of soil was the amount of work applied during the washing operation. Whether the work be represented by "elbow grease" in hand washing, or by use of a machine,

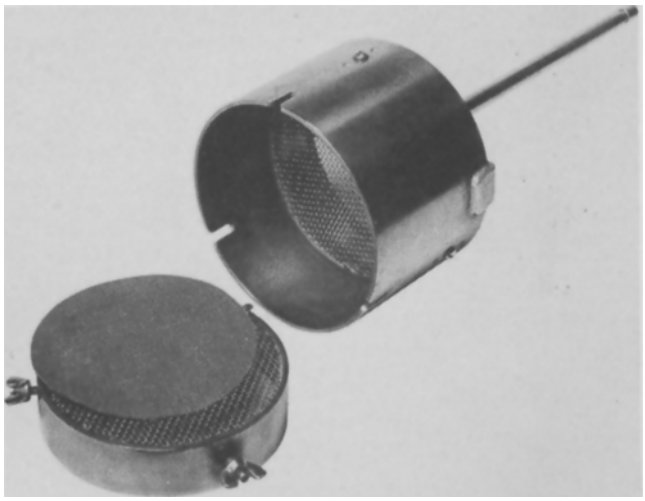

FIG. 5. Deter-Meter washing cylinder and soiled swatch.

it must nevertheless be controlled for laboratory evaluation.

One of the best known machines for laboratory evaluation is the Launder-O-Meter, as adopted by the American Association of Textile Chemists and Colorists. Complaints about container size have recently been overcome by Atlas Electric Devices Company, the manufacturer, by adding quart and two-quart metal containers. The mechanical action is imparted to the soiled fabric by rotation of the container about an axis, rubber or steel balls being used to impart mechanical action (impact) for the washing operation.

A recently devised machine for detergency evaluation, based upon the home washer agitator principle is the Terg-O-Tometer (U. S. Testing Co.). In contrast to the Launder-O-Meter, the Terg-O-Tometer attempts to reproduce the action of a full-scale agitator type home washer.

The Deter-Meter (American Conditioning House Inc.) is a device for comparison of detergency whose principle is that of beating soiled fabric suspended in a screened cylinder within the solution under test. In this case the mechanical action imparted to the fabric resembles a power washer, where the "drop" of the load brings about soil removal.

In addition to the conventional washer of the American Home Laundry Manufacturers' Association, many tests have been made in regular sized conventional washers.

Test Method. A suitably reproducible test method must be developed regardless of what machine is chosen for imparting the mechanical action required. The method should naturally minimize the amount of work necessary and yet be as nearly reproducible as possible. Preferably the method should provide sensitiveness to differences in detergents, and the values obtained should be reproducible.

Test methods have probably been as varied as the test soils used. Several were investigated in the first paper of an evaluation series (19). No general recommendations as to a standardized test procedure can be given, but another paper (20) has demonstrated that control of the work input can result in close correlation of results with two of the described machines.

Evaluation of Test Pieces. Having chosen the fiber and fabric, soil, machine, and test method, there some cases the evaluation has been accomplished by measuring the amount of soil removed through measurement of the turbidity of the wash solution (21). In other cases, solvent extraction of a tracer dye from the washed fabric or yarn has been accomplished, and the retained tracer dye can then be measured quantitatively. Generally, evaluation for removal of soil is obtained directly by reflectance measurement of the test pieces of soiled fabric which have been subjected to the washing operation. Many suitable instruments have been developed for this purpose. We regularly use either the Photovolt 610 (Photovolt Corp.) or the Hunter Multi-Purpose Reflectometer (Henry A. Gardner Laboratories).

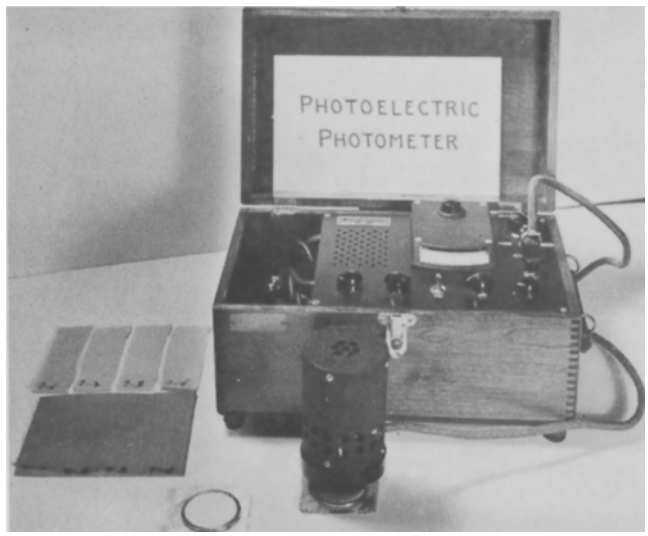

FIG. 6. Photovolt reflectometer and soiled swatches.

naturally must be some means for evaluation of the test pieces produced by this series of operations. In

Considerable variation in reflectance values between cooperating laboratories can result unless the instruments are standardized against reflectance standards, as was ascertained by the AATCC Committee on Standard Soils.

Evaluation of Data. Having performed the washing operation and having measured the reflectance of the test pieces, it is then necessary to decide whether differences between detergents or other tested variables are really significant. To do this the test must be made a sufficient number of times so that statistical methods for analysis of data can be applied.

The probability of a set of data being reasonably reproducible, or of two or more samples tested simultaneously being different, are questions which must be considered. The chances for an analytical method to provide reproducible values is generally put at 99.75 out of 100. There is always a small chance for variation.

Detergency methods are hardly analytical in character, and when one considers the tremendous number of variables to be controlled (17), the question is where to set the limits. Some investigators have indicated as satisfactory a 95% probability level while others have indicated that 90% is more reasonable.

Methods for statistical analysis of detergency data were the subject of a symposium at the March 1952 Meeting of ASTM Committee D-12. Publication of these papers will prove valuable to those working in this field.

While reference to recent papers will indicate methods used for differentiation currently used, the least that an investigator in the detergency field can do is to be sure that a sufficient number of replications has been made, then indicate the mean value, the number of test replicates used to attain that mean, and the standard deviation and standard error (22).

An attempt has been made to review the various types of detergency evaluation, to indicate cooperative and association effort in this field, and to suggest methods, wash test equipment, soiled fabrics, and evaluation of data as available from the literature so that a detergency laboratory might be more readily established.

Acknowledgment

The courtesies of American Conditioning House Inc. and the U. S. Testing Laboratories in furnishing illustrations for this paper are sincerely appreciated.

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Some Aspects of Inventory Control in the Soap Industry

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SKILL in controlling inventories is one of the hardest tests of business management. Government reports show that this is one of the most common causes of business failures. Both big and small companies are vulnerable.

Inventory control has a special importance to soap companies as a large portion of the cost of soap is dependent on the price of fats and oils. Note in Figure 1 that in one year (1947) the price of fancy

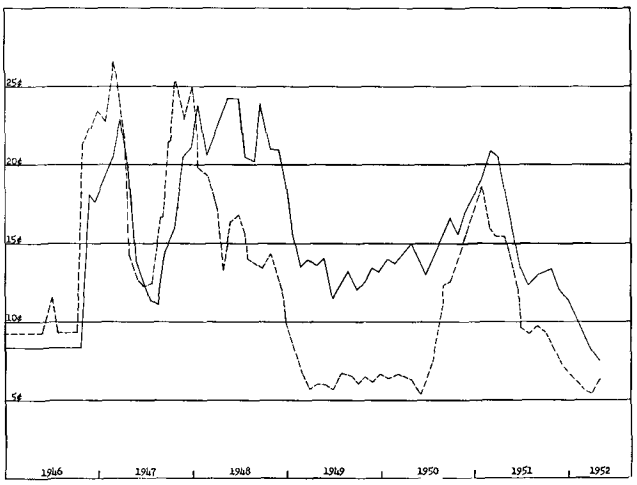

FIG. 1. Price range for tallow (broken line) and coconut oil (solid line).

tallow started out at around 23c, went down to 12¼c, and then went up again in the last portion of the year to 25c. Now if your company is to buy fat at 20c a pound and you are competing with a company that bought theirs at 12c, you can readily see your disadvantage. This fats and oils inventory problem is so important in the soap industry that it is usually handled as a separate inventory item with top executives making the decisions of how much to carry. However whether the business is making soap, autos, or safety pins, inventory control means dollars saved. It is not hard to visualize how high inventories tie up capital with heavy carrying cost and expensive warehousing. Also you run the risk of possible obsolescence due to changes in method or products, deterioration due to age, and of price reductions. On the other hand, if inventories are too low, costs are raised through uneconomical buying on a rush order basis, inefficient production scheduling, and possibly even a loss of business due to not being able to deliver goods on time.

Finished Goods Control

In considering how to control inventories, problems peculiar to the business concerned must be analyzed. Finished goods inventories depend on six main factors.

1. *Methods of Sales.* Companies such as mail order houses which sell directly to a retailer or to the consumer must have large stocks of finished goods ready for immediate delivery upon receipt of order. Companies, such as machine tool manufacturers, which work on a contract or job-lot basis, on the other hand, need not carry such a heavy inventory of finished goods.

The large soap companies sell directly to the retail stores. They have their salesmen going to thousands of grocery stores throughout the nation taking orders. When these orders are sent in to the plant or branch warehouses, there must be sufficient soap on hand to fill the order. This order probably consists of at least four or five different types of soap. If any of these soaps are not on hand when the order arrives, it means the order must be held or shipped short. As an average branch warehouse handles several hundred orders a day, it is very important that there be an uninterrupted flow. The billing systems are designed for shipment and not for revisions. It has been estimated that revisions cost anywhere from 50 to 75c for