known fatty acids, effect of one or more acids on the solubility and hydrion concentration of the resultant mixtures, double bond effects in the chain, effects of isomerism and double bond hydroxy effects. In general, the K soaps are more irritant than Na soaps, but there are exceptions in the work to date. Females for most soaps are more subject to irritation than males. As noted above, more work must be done on simpler mixtures of fatty acids before any final conclusions can be drawn as to the relative irritant action of these soaps of refined oils.

(1) Emery, B. E. and Edwards, L. D., Jour. A. Ph. A., to be published.

The Use of Standards in the Control of Soap Plant Operations

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IN ESTABLISHING a system of controls over the operation of soap plant processes, the use of standards constitutes a most effective method for providing the plant superintendent with information vital to maintaining high efficiency of operation and minimizing wastages of materials.

The application of standards is not a new idea. Most plants, small or large, have some sort of operating controls. Many of these, however, have never been examined critically to determine whether they are based on adequate facts and sound reasoning and thus represent the best practice after all factors have been considered, or whether they are merely traditional; handed down "from father to son," with their original basis obscure. Arbitrary standards, which rest on nothing but an opinion, have little positive value. In many cases economic conditions, equipment and methods within a plant change so that what were good standards a few years ago may be economically unsound today.

Standards may be used to control many phases of plant operations, for example:

1. The output of processing units, such as soap kettles, soap dryers, glycerine evaporators, stills, etc.
2. The loss of materials, such as caustic soda, salt, fats and glycerine during processing.
3. The quality of products.
4. The efficiencies of packing units, such as soap presses, wrappers, chip filling machines, etc.
5. The labor and controllable burden costs of various unit operations.
6. The wastage of packing materials used in finishing operations, such as wrappers, cartons, containers, etc.
7. The amount of allowable scrap in operations such as bar soap cutting and pressing, spray soaps, etc.

A good standard should be a measure of the normal performance to be expected under good operation. It must never be set so high that it is rarely attained, for under such conditions foremen and operators soon get discouraged and lose interest. Rather, the standard should be designed so as to reveal losses of efficiency or materials that can definitely be traced to improper operating technique, time delays, poor mechanical equipment, poor materials, and other causes that should not exist, or at least should be tolerated only within known limits.

It is also obvious that standards should never be set by merely taking an average of past performance. Intelligent studies of each operation, by personnel thoroughly familiar with the processes and equipment involved, are required. It is sometimes necessary, when the person assigned to this work is inexperienced in the particular process he wishes to standardize, for him first to learn the operations by working on them long enough to get his basic information "first hand." He must avoid the danger of taking anything for granted. For example, an operation may have been done in a certain way for many years, but this could mean no more than that no one ever questioned it. A natural tendency among new operators is to accept what the former operator tells him. Perhaps this former operator did not understand the process as well as he should have and passes along this misinformation to the new-comer. The person seeking to examine the process for standardization purposes must have sufficient experience and judgment to sift the information so as to retain the facts and discard the rest.

To illustrate, let us consider a few of the standardizable operations listed above. Inasmuch as conditions may vary greatly from one plant to another, due to differences in types of equipment used and products made, there may be no universal standards applicable to all conditions. It would be misleading to assign numerical values to them in a general discussion such as this. Therefore, the examples given will illustrate principles and methods as being the most important part of the subject, and will be confined to considerations of the first two groups listed, as applied specifically to two of the important processing divisions of a soap plant, namely, the kettle room and the glycerine refinery.

Capacity Standards:

In the kettle room, the value of a standard for the output of a given number of kettles is two-fold; first, it establishes the maximum "normal" capacity of the plant and avoids the otherwise all too frequent differences of opinion on this point. Second, when the full plant capacity is not required, a steam economy may be gained by reducing the number of kettles in active use, thus decreasing radiation losses.

In setting a standard for the capacity of a kettle room, one must determine the fair minimum number of hours required to perform all of the boiling operations, eliminating from consideration all unnecessary delays, such as excess loss of time waiting for the delivery of raw materials from another department (fats, rosin, salt, caustic), failure of mechanical equipment (pumps, pipe lines, valves, etc.). To this must be added the minimum settling time necessary to yield kettle soap of the desired quality, and the fair minimum time necessary to deliver the settled soap to the next operation and prepare the kettle for the next boil. Here again, any unnecessary delay, such as waiting for a storage tank to pump into, or lack of co-ordination (such as the framing or drying department not being ready to use the kettle soap) is not included. All operations are timed at their normal speed; no "stunt performance" is considered. To the hours thus accumulated, must be added a careful estimate of the time normally lost due to routine maintenance and cleaning, and to nominal delays which cannot be entirely avoided.

A relation is thereby established between the available hours in the week, and the number of hours required for a complete turnover of a kettle. This relation is the normal "kettle cycle," and may be expressed as "boils per kettle per week." Knowing the kettle equipment available, the overall weekly or monthly capacity of the kettle department may be calculated. The kettle cycle sometimes varies for different types of kettle soap, which makes it even more desirable to establish it for each type produced.

When maximum kettle turnover is desired, and standards are not being met, investigation will locate the trouble. If it is found to be in lack of co-ordination between the kettle department and the departments delivering materials to it or taking soap from it, this fault can be corrected by better supervision, more definite assignment or responsibility, and better production scheduling. Often, the addition of a pump, or an inexpensive change in piping layout may eliminate considerable lost time. The point is that a good standard will reveal abnormal conditions and lead to improvements which make it possible to get the most out of existing equipment, sometimes to the point of saving expenditures for new equipment.

As a further example of "capacity" standards, let us consider a glycerine still. In this case, the equipment has usually been designed for some definite output. Setting a standard requires a series of test runs under competent supervision. The observer must assure himself that the still has been properly operated, that unnecessary delays have been eliminated, and that the crude used and the distillate made were of normal average quality. In the course of such work, the observer may detect possibilities for improvement in operating technique or in mechanical details. After a sufficient number of test runs (not less than 10, preferably 20) a standard can be developed to show both the rate of production on a "machine hour" basis and on an "overall basis."

The "machine hour" basis will show the rate during the active distillation period, which may be taken as the number of hours that steam is being supplied to the open jets in the still. Such a standard is really a machine efficiency standard, showing the performance of the machine while it is running. The "overall" basis includes all of the hours in the complete cycle of a still run, from the first operation during preparation before the actual distillation begins, until the run is finished, the still clean and empty, ready for the next run. The value of the overall production rate is that the useful capacity of the equipment may be calculated to a weekly or monthly basis.

Failure to meet the production rate on the "machine hour" basis may reveal either faulty operating practice, steam supply, crude, or mechanical trouble. Failure to meet the "overall" standard may reveal unnecessary delays between runs or in starting up at the beginning of a week or in shutting down at the end of a week, delays in cleaning the still, or in preparation.

"Loss of Material" Standards:

Passing on to this group of standards, we might consider the following examples:

Loss of Alkali:

In the soap boiling process, one well-known source of loss is the alkali remaining in the spent lye sent to the glycerine refinery, and in waste lyes run to the sewer. Taking up the case of spent glycerine lye first, it is seen that there is a double expense involved here. Not only is the alkali lost, but acid or other chemical must be used to neutralize it in the lye treatment operation. The natural reaction in this case is to ask: "why not consume all the alkali in the kettles?" This is not impossible; it can be done by first absorbing as much of it as possible in the saponification of the main kettle charge, and then pumping in enough fatty acids exactly to neutralize the balance. But if fatty acids cost more than fats, it may not be economically sound to do this. An alternative is to have an excess of fats (glycerides) present and to boil a longer time. But each added hour of boiling consumes steam and cuts into the kettle output by lengthening the turnover cycle. The task then becomes one of finding the economic balance between the cost of extending the time of boiling, or using fatty acids, and the cost of leaving the alkali in the spent lye. This cannot be decided arbitrarily; it must be the result of careful consideration of all factors involved, and may require plant tests under each condition. The ultimate standard will be expressed as the maximum allowable percent alkali in spent lye.

There is a second standard necessary here, to obtain complete control; namely, the maximum allowable quantity of spent lye in relation to the fat stock saponified. It is of no benefit to have a comforting low value for the percent of alkali in the spent lye, only to find that the bulk of the lye is twice as large as it needs to be. Here, the "lye bulk" must be determined by consideration of the particular type of kettle system used (counter-current or non-counter current), whether the kettles are boiled with open or closed steam, and the desired recovery of glycerol. Once established, the standard "lye bulk," together with the standard percent alkali, will show the normal wastage of alkali from this source, in relation to the usage in soap making. The "lye bulk" standard for spent lye has a further value in avoiding excessive treating and evaporating expense later.

Another source of alkali loss in the kettle room is in wastes lyes run to the sewer from the processing of the darker fats for soap powders and rosin for laundry soaps. The usual method for improving the color of these stocks is to give them one or more alkali washes. The resulting lyes are dark in color, contain little or no glycerol, and are usually discarded. The problem here is to find the minimum amount of waste lye that must be discarded, and its minimum percentage alkali, consistent with the desired quality of kettle soap. If the "lye bulk" can be reduced, a secondary saving will be realized in the salt usage. The method followed in establishing a standard loss in waste lye is to accumulate data on the system in use at present, and then to examine each step in the process and decide what changes, if any, are possible and to observe operations under the modified system for a suitable period before setting the new standard.

Loss of Soap:

Still under the heading of loss of materials, we have the loss of soap dissolved in spent glycerine lye and waste lyes. All lyes contain a small amount, ranging normally from 0.20 — 0.50%, of dissolved soap. As this is a direct loss, it is important to operate within the standard "lye bulk" in each case. Further, in spent lyes, a high soap percentage becomes a triple expense, as the soap must be removed in the lye treatment operation at an increased cost for chemicals and loss of glycerol in the increased amount of filter press mud.

To avoid an excessive percentage of soap in these lyes, it is advisable to have a standard for the Baume (or specific gravity) of the lyes before they leave the kettles, so as to provide a salt content high enough to insure a minimum percentage of soap in solution. This is rather simple, being a matter of accumulating enough data to get a curve in which the soap content is plotted against specific gravity or Baume. The minimum standard Baume should be one or two degrees higher than the point where the soap content becomes constant. The maximum Baume should be two degrees above the minimum, as an excessively high salt content becomes a burden on the glycerine department, increasing the expense of recovery and return of the salt. If necessary, a direct standard for the per cent soap in lyes can be set, but as this requires the analysis of the lyes, the Baume standard is easier for practical use.

Loss of Glycerol:

Under this heading we find numerous points at which glycerol is lost, some of which are:

1. Glycerol left in kettle soap delivered.
2. Glycerol in lyes run to the sewer.
3. Glycerol in filter press muds from lye treatment.
4. Glycerol in foots discarded after distillation.
5. Glycerol in "unaccounted for" losses.

For item No. 1, the standard allowable loss involves a detailed survey of whatever system is in use, after which, the added cost for each additional increment in recovery can be calculated. Additional steam will be used as the number of washes given the soap is increased; additional expense may be caused if there is an increase in the "lye bulk;" the additional time consumed in kettle operations may be enough to demand additional equipment; labor costs may or may not increase. The point to be emphasized is that all conditions must be considered to get the true balance between the additional amount of glycerol that would be recovered and the cost of getting it. The safest way is to set up two columns, "System A" and "System B," under which will be listed every component of the cost in the kettle department. If the lye bulk will be changed, it will be necessary to follow the effect of this through the lye treatment and evaporation departments also. Certain expenses will remain fixed, others will vary, but by listing all of them, the total cost of operation and the total glycerol recovered under each system can be found. The difference can be expressed either as the unit cost for the additional glycerol recovered, or as the overall unit cost of all the glycerol recovered. At some point, the further recovery of glycerol will be overbalanced by the additional cost, and it is necessary to standardize at the point where a satisfactory profit is realized. The final standard is best expressed in terms of direct analytical percentage of glycerol allowable in the delivered kettle soap.

Under item No. 2, "Glycerol in lyes run to the sewer," the procedure is the same as already described for alkali losses. The bulk of sewer lye and its necessary glycerol content form the basis for the standard. The possibility of a saving lies in finding means to reduce either the lye bulk or the glycerol percentage. For example, in graining a soap kettle with salt, it is sometimes necessary to use recovered salt from the glycerine refinery. This salt contains glycerol which is lost if the lye is run to the sewer. Even when the lye is a spent glycerine lye which returns to the glycerine department, the glycerol in the salt used is never fully recovered. The obvious need in this case is to establish a maximum allowable standard for the glycerol content of recovered salt.

Item No. 3, the loss of glycerol in filter press muds obtained from the lye treatment operation, requires a determination of the point at which the value of the glycerine recovered by use of additional wash water becomes offset by the increased cost of evaporating the water. By a series of test runs, the glycerol content of the wash water flowing from the press can be determined at suitable equal intervals during the washing cycle and the value of the increments of glycerol obtained can be compared to the added evaporation costs. When the point of economic balance is found, the corresponding analysis of the filter press cake is noted and set as the standard for control.

The method recommended for an ordinary size press is to divert the wash water into a series of receivers (ordinary 55 gal. drums are suitable) which can be set on a scale. Each successive 200 lbs. of wash can be caught in a separate drum, mixed, sampled and analyzed to obtain the lbs. of glycerol in each increment.

The above test is satisfactory for establishing a standard for a given piece of equipment already in use. A full study of the problem requires further investigation in which the washing efficiency of different types of filters is compared.

Item No. 4, the loss of glycerol in foots from distillation, is somewhat more complicated, and depends on whether the foots are discarded directly or are treated for further recovery. This point must be decided first. The cost of foots treatment and the subsequent re-evaporation and re-distillation costs must be known and plotted against the value of glycerol recovered, for various "foots yields" from distillation. (The "foots yield" is the lbs. of absolute glycerol in the foots divided by the lbs. of absolute glycerol fed to the still.) If this yield is already below the point at which enough glycerol can be recovered to pay the operation costs, the foots will be discarded directly, and the standard will depend upon the following considerations:

In a plant having no foots treatment equipment, or where the recovery does not pay, the standard foots yield will be determined by test runs in which distillation is continued until the increment of glycerol obtained for each interval of added distillation time is too small to balance the costs for steam, power, and any other element of the cost that varies directly with time. In a plant of limited capacity, labor costs may increase also, as the overall capacity of the still is decreased. Thus, the standard is not necessarily the lowest foots yield that can be obtained, although it will usually be close to it, as steam and power costs are small and it requires only a few lbs. of glycerol to equal an added hour of distillation expense.

Item No. 5, the glycerol in "unaccounted for" losses, is a difficult standard to develop. This is the difference between the total glycerol entering the system in the fats used, and the sum of the glycerol accounted for in the finished glycerine produced plus all of the known losses. As far as physical operating losses are concerned, it is necessary to make sure that all known losses are being correctly reported and that all samples of glycerol-bearing materials flowing from one process to another are representative. Special cases must not be overlooked, such as occasional discards of sludge from tank cleanings, etc. After this has been taken care of, those processes in which physical losses can occur, such as evaporation and distillation, can be isolated and test glycerol balances can be run over a long enough period to establish the normal loss. Tests of this kind must be very carefully run, and repeated over a fairly long period. On a glycerine still, for example, a series of ten to twenty runs is advisable. The observer must be satisfied that the operation was properly done, but that no special attention was given that would not be adhered to in routine runs. Input and output should be weighed, sampled and analyzed. Each run should be accounted for separately and if a consistent set of results is obtained, the average of these will be a proper loss standard for that part of the operation.

Where such losses appear excessive, the process should be investigated to find possibilities for mechanical improvement or better operating technique. Automatic controls, recording instruments and warning signals may be indicated as aids to the operator. Scale equipment may be needed to insure accurate accounting of the flow of materials from one process to the next, in order to isolate and locate losses more effectively.

The sum of these "unknown" losses is the total "unknown" that should be expected for good operation. To this, however, we must add a tolerance to cover the difficulties encountered in the analysis of fats, and the materials "in process" for glycerol. It is a recognized fact that some fats and oils show a greater glycerol content, especially by dichromate analysis, than actually exists, due to the oxidation of organic impurities by dichromate. Fortunately, these same impurities are to some extent carried through the system and appear in some of the known losses, such as filter press muds and distillation foots, etc. The probability is that not all of the oxidizable impurities will be found, as we have possible sources of loss in the vapors leaving the evaporators, in the insoluble salts in the filter press muds, and in destruction of glycerol in the still.

The allowance to be made for analytical overstatement of the original glycerol charge into the system will vary with the type of fats used, and will probably range from 1.0% to 2.0%, but may be greater in some cases.

If a better analytical method can be found, that can be applied to all of the glycerol-bearing materials passing through a soap plant, such as fats and oils, spent soap lyes, foots, filter press muds, kettle soap, salt, crude glycerine, sweetwaters, etc., which will avoid the inclusion of organic impurities in the indicated glycerol content, such a method would be of great value to the soap industry. The Glycerine Analysis Committee of the A.O.C.S. has been working on this and we hope that a solution may be found in the near future.

In the foregoing discussion, we have considered only a few of the ways in which standards are of value in controlling soap plant operations, such as in yielding economies through bettering the efficiency of operations and minimizing losses of materials in process. Many other examples can be found among the various classifications listed earlier in this discussion. The value of standards for the quality of finished products is obvious. Control of the wastage of packing materials usually results in worthwhile savings. Labor and overhead can be better controlled through definite standards. Time does not permit a detailed review of the entire field, but it is safe to say that control standards, based on sound principles, can be applied to practically every phase of soap manufacturing operations. Thus, a yard-stick is provided by which to measure actual performance effectively and profitably.