Another very important step has been the establishment by the State Board of Health of regulations for the control of recreational uses of domestic water supply reservoirs. During the last year or so, proposed regulations have been debated up and down the state of California in many meetings. During these hearings, all agencies affected have had an opportunity to make their suggestions. All of them, whether on one side of the question or the other, have learned a lot from these deliberations. They have all learned a little bit about give and take. As a result, there has emerged a set of regulations that appears to be workable and agreeable to all concerned. As adopted on December 7, 1956, they are acceptable to the California Section of the AWWA, and they appear to be acceptable to sportsmen's groups. Naturally, only a period of experience working with these regulations will prove them out. The water purveyors are willing to enter into such a period.

Reference

1. Proceedings of Conference on Recreational Use of Impounded Water, Richmond, Calif., Dec. 13–14, 1956. Committee on Research in Water Resources, University of California, Berkeley, Calif.

Correction

The paper "Biological Oxidation of Hexadecanol Under Laboratory Conditions" by F. J. Ludzack and M. B. Ettinger (July 1957 JOURNAL, Vol. 49, pp. 849–858) contained an editorial error. The charts for Fig. 1 and 2 (pp. 851 and 852) were transposed. The drawing that appears on p. 852 should appear as Fig. 1, "Carbon Dioxide Production With Substrate No. 1" (p. 851); likewise, the drawing that appears on p. 851 should appear as Fig. 2, "Carbon Dioxide Production With Substrate No. 2" (p. 852).

Experimental Evaluation of 'Water Conditioner' Performance

Rolf Eliassen and Rolf T. Skrinde

A paper presented on May 15, 1957, at the Annual Conference, Atlantic City, N.J., by Rolf Eliassen, Prof. of San. Eng., and Rolf T. Skrinde, Research Asst., both of Massachusetts Institute of Technology, Cambridge, Mass.

WATER is the most important and widely used commodity sold in this country today. Unfortunately, the chemical and physical characteristics of a particular water cannot be ideal for all purposes for which it must be used. Therefore, to make it suitable for industrial as well as domestic purposes, it must often be subjected to many complex and costly methods of treatment. Each municipality and each industry has a different situation, which may require modifications of the treatment process.

Scientific research and development are continuously progressing toward more efficient and less expensive processes of water treatment. The water works profession prides itself on utilizing the latest discoveries of science and engineering in the thousands of municipal and industrial treatment plants being built or improved each year to meet the increasing demands of modern technology for water of better quality in greater quantities. Evidence of the great strides made in keeping pace with latest research and scientific development is clearly indicated by the tremendous progress made since this Association was founded 76 years ago.

But there are many water consumers who are not willing to wait for scientific development. Their quest has been for a simple and inexpensive device which will solve the universal water-conditioning problem. They would rather take a shortcut and use a unit which they are willing to accept on the basis of unfounded pseudoscientific theory. Eliassen and Uhlig (*1*) have discussed many of the pseudoscientific claims made by manufacturers and salesmen. The statements are liberally sprinkled with technical-sounding terminology calculated to impress prospective buyers of "magic" water-conditioning units.

On Feb. 5, 1954, the Federal Trade Commission issued a complaint against the Evis Manufacturing Company of San Francisco, Calif., for false advertising. The magazine *Science* reported on this case (*2*) in an article entitled "Evis Water Conditioner." The following is quoted from that article:

> The company manufactures a product, the Evis Water Conditioner, which looks like an expanded pipe coupling with a vertical post integrally cast in the center of the internal chamber. The "conditioners" range in size from those that may be fitted into a 0.5-inch pipe to models

045.

that are intended to be fitted into large industrial or marine pipes and in price from $25 for the smallest model to $3,700 for the largest bronze model. All models are made of either zinc-coated cast iron or bronze, and they are "intended to be fitted into water systems for the purpose of beneficially treating and conditioning water."

The task for the government in pressing its charges of false advertising was made more difficult by the fact that the respondents averred that treatment with the "conditioner" did not affect the chemical or physical properties of the water in any detectable way, but only the *behavior of the water in use.*

Hearings were held by a hearing examiner of the Federal Trade Com-

Photo by authors.

Fig. 1. Evis Water Conditioner (Screw Type)

mission. These resulted in a formal order for dismissal of the complaint against the Evis Manufacturing Company on Apr. 26, 1956. On Dec. 31, 1956, however, the commission issued a subsequent order to the hearing examiner to reopen the case to receive further scientific evidence.

The authors of this article know of no scientific principle which could explain any successful action of a unit of this type. The authors agree with that portion of the second paragraph of the above quotation (*2*) from *Science* "that treatment with the 'conditioner' did not affect the chemical or physical properties of the water in any detectable way." But the authors question the validity of claims of the manufacturer of the Evis unit on the ability of this unit to "affect . . . the *behavior of the water in use,*" as mentioned in the above quotation (*2*). The purpose of the work reported in this paper was to evaluate the effects of the Evis Conditioner on the *behavior* of waters of different types by scientific experiments conducted in accordance with standard water works practice.

The more common screw-type Evis Water Conditioner, shown in Fig. 1, allows direct contact between the unit and the water. Another model of the conditioner which merely clamps on the

Photo by authors.

Fig. 2. Evis Water Conditioner (Clamp-on Type)

outside of the water pipe is pictured in Fig. 2. In this case the water supposedly being "conditioned" does not even come into contact with the unit! Two of the screw-type conditioners were purchased on the open market by the authors in order to conduct tests on the *behavior* of the waters in use. After the tests, one of the units was sawed in half in order to examine the interior. A photograph of one half is shown in Fig. 3. The threaded connections of this unit had begun to rust quite noticeably during its short period of use for these studies.

Claims by Evis Water Conditioner Manufacturer

The sales promotional campaign of distributors of the Evis Water Conditioner is based upon claims (*3–9*) of soap savings, reduced laundry water requirements, reduced corrosion of metals, improved taste and odor of drinking water, prevention of scale formation in water works structures and boilers, removal of old scale and rust already formed, reduced cost of heating water, elimination of harshness of water to the hands, improved agricultural irrigation, improved food flavors, and other supposed benefits. Many of these claims have been investigated previously by competent and unbiased research workers, but their results have not been published in technical journals. The work reported herein does not constitute a complete evaluation of all of the claims made by the manufacturer of the Evis Water Conditioner, but merely examines some of the claims in the light of comparisons between the *behavior* of Evis-treated waters and untreated waters in tests which are important and well established in the water works profession.

In setting up the test installation care was taken to eliminate electrical disturbances from the Evis Water Conditioner in accordance with the recommendations (*3*) of the manufacturer, who has stated: "The most important single rule which applies to all Evis installations is—make sure that the piping system carrying Evis-ized water is free from electrical disturbances throughout its length. When this simple rule is followed the Evis always performs at its top efficiency because the delicate change of molecular organization established by Evis-izing is then freed from the interference of electric currents."

Effect of Metallic Cations

Manufacturer's claims. The manufacturer claims that the Evis device "makes most hard waters behave 'Tame'!" (*4*); that "Evis conditions hard water by improving its physical characteristics by use of a Special Processed Metal. Nothing is added, no beneficial natural minerals are removed!" (*4*); that it "gives 'soft results' simply by changing the disposition of natural forces already in water.

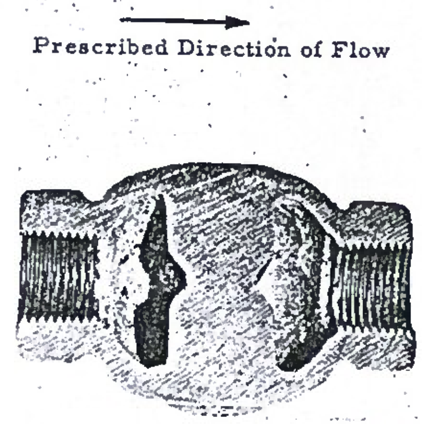

Photo by authors.

Fig. 3. Sectional View of Evis Screw-Type Conditioner

The new disposition prevents stickiness of scales, curds, and sediments" (*5*); "that the functional results of Evis Water Conditioner treated water and those of softened water are almost identical" (*5*).

Laboratory studies. Ethylenediaminetetraacetic acid and its sodium salts form chelate complexes with metal cations. This complexing action is the basis of the EDTA test for water hardness. Results of EDTA hardness tests on Evis-treated Cambridge tap water, as compared with plain Cambridge tap water, are summarized in Fig. 4. As

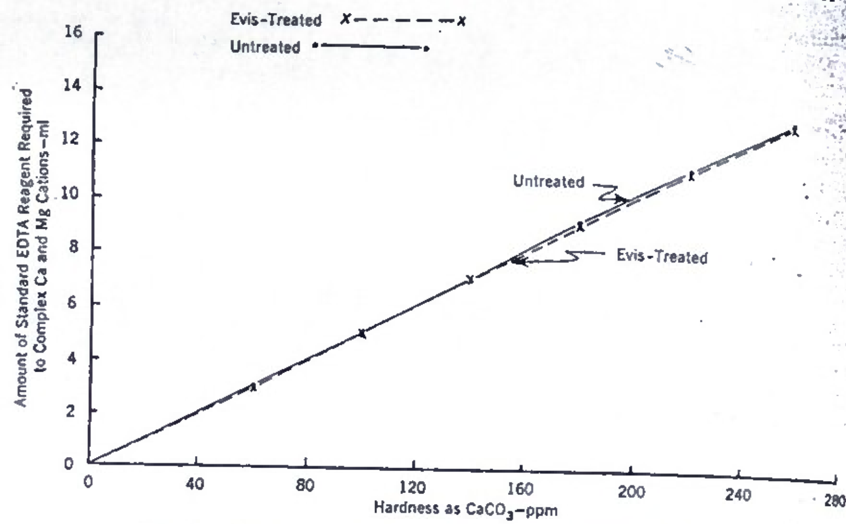

Fig. 4. Effect of Evis Treatment on EDTA Hardness Test

Cambridge tap water with hardness added was used.

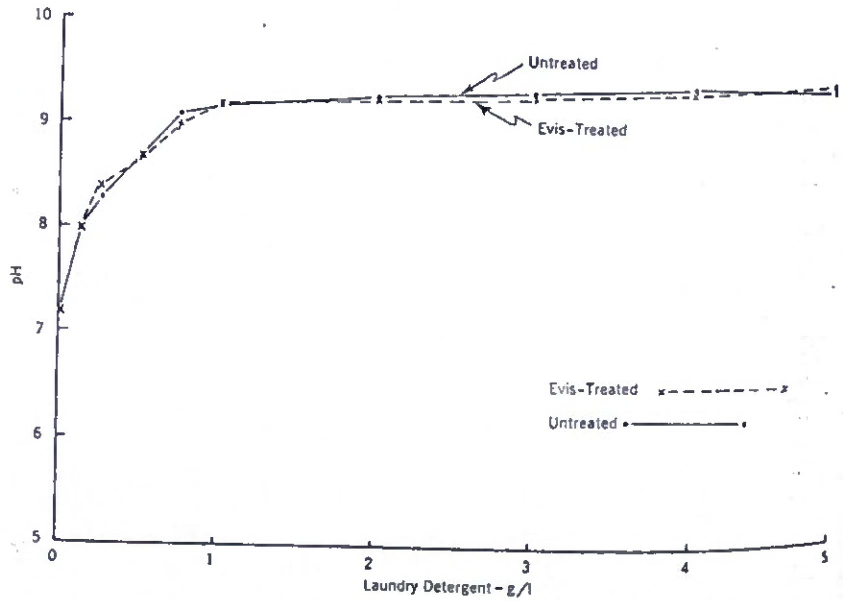

Fig. 5. Effect of Evis Treatment on pH of Detergent Solutions

Laundry detergent was added to Cambridge tap water, which was stirred for 10 min.

can be seen by the two curves, which can be considered identical within the precision of experimental measurements, there is no apparent change in "the disposition of natural forces" as evidenced by the complexing action in the two waters. Therefore, in this respect, the behavior of the metallic cations is indicated to be unchanged by the Evis Conditioner. It should also follow that soap-consuming and scale-forming properties would not be affected, as these properties are indicated by the EDTA test.

Laundry Water pH and Soap Requirements

Manufacturer's claims. The manufacturer makes, among others, the following claim (*6*) regarding laundry applications in a test comparing Evis-treated with untreated wash water: "During the washing process there is a tendency for soap to lose some of its power. This can be measured by the pH factor. Tests were made at the beginning of the wash and even though less soap was used with Evis water, the pH was found to be the same as with raw water (9.5)."

Laboratory studies. The effect of increased or decreased soap consumption in laundry operations by water conditioning is an item of great importance in water works practice. Savings in soap consumption have justified the building of large softening plants in many areas of the United States. To test the effect of adding various amounts of a popular household laundry detergent (made up of alkyl benzene sulfonate and polyphosphates) to Evis-treated and normal Cambridge tap water, a series of controlled studies was carried out. The results of the effect of laundry detergent on the pH of wash waters are plotted in Fig. 5. As may be seen from these curves, the pH increased rapidly up to the amount of 1 g of detergent per liter, and leveled off to slowly increasing pH values thereafter. The two curves showing the effects in both the Evis-treated and untreated waters followed along the same line within the limits of experimental readings. These studies do not confirm the report that the pH would be the same when less soap was used, as stated by the manufacturer. The Cambridge tap water used in these studies had the chemical composition shown in Table 1.

TABLE 1

Chemical Composition of Cambridge Tap Water

Characteristic	Quantity *ppm*
Total hardness ($CaCO_3$)	62
Total solids	114
Alkalinity ($CaCO_3$)	24
Dissolved oxygen	8
Chlorides	14
Sulfates	30
Sodium	9
Silica	4
Iron	0.1
pH	7.2

Standard Soap Consumption Test

Manufacturer's claims. "The Evis converts most waters into smoother water. You can taste and feel the difference. And you can see the difference in the dishpan and the laundry! You get richer, longer-lasting suds from your favorite soaps and detergents, and it's amazing how much farther they go in Evis Conditioned Water. Hundreds of users report greatly reduced soap requirements for every sort of household washing. A single box of soap goes a lot farther than it does in ordinary tap water, in many types of waters soap efficiency has been increased 50%" (*4*). Another bulletin (*6*) states that "39.8%

more soap was required to form initial suds in raw water." In another bulletin (7) the claim is made: "If the hardness of the raw water is less than 10 grains, Evis treatment alone saves enough soap through increased efficiency to justify bypassing the softener. Over 10 grains, the softener should be kept in service but used only for the wash operation. (For domestic use the advantages and economy of Evis far outweighs a softener in any hardness of water.)"

Laboratory studies. Such claims as stated above can be analyzed for their validity by the standard soap titration test (10). This is a practical test as well as one which gives accurate and highly reproducible results. Sufficient soap solution is added to the water samples to precipitate all of the hardness-producing cations, and a slight excess, the lather factor, permits the formation of a stable foam upon shaking. The foam must be stable for a period of 5 min. Figure 6 compares the effects of Evis treatment and of no such treatment of Cambridge tap water on the formation of soap suds which remain stable for a specified interval of time. As can be seen from the two curves, the same number of milliliters of standard soap solution was required for the formation of suds in untreated waters as in Evis-treated waters. These results indicate that there was no soap saving which could be attributed to the use of the Evis Conditioner.

During these studies the waters were also tested for differences in sensations claimed to be experienced by rubbing the skin. The authors observed no dif-

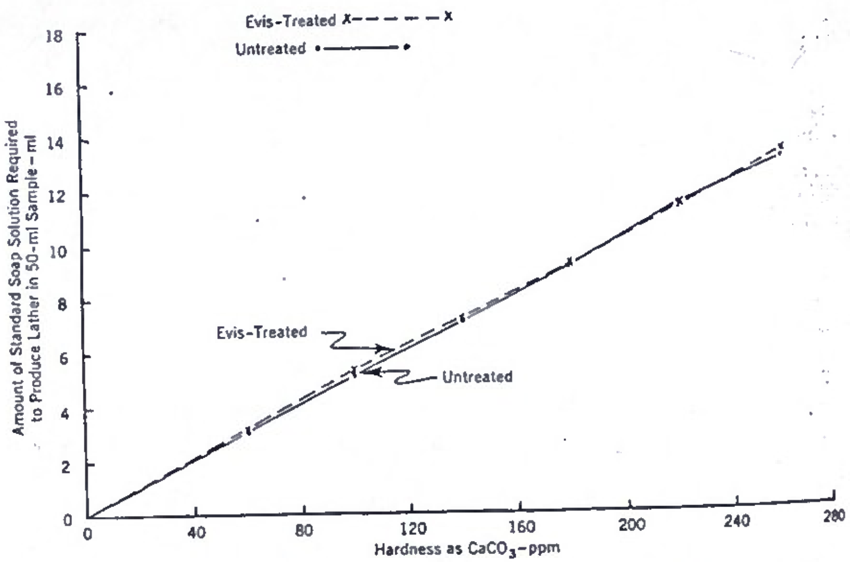

Fig. 6. Effect of Evis Treatment on Soap Consumption

Cambridge tap water with hardness added was used.

ference in "feeling," such as "smoothness" or "texture," between the raw and Evis-treated waters.

Laundering Efficiencies

Manufacturer's claims. "For fluffier, whiter, cleaner clothes Evis water is better for your laundry" (4). After a test on laundry wash water the manufacturer made the claim (6) that: "Before the wash water was drained at the end of the wash cycle another test was run. There was a consistently higher pH in Evis water which indicates that the soap had lost less of its power and that the soap curds were not in clothes where additional time and water would be required to rinse them out."

Laboratory studies. Cotton cloths were laundered in controlled tests using Cambridge tap water and various amounts of the household laundry detergent previously discussed. pH measurements were carefully made before and after washing uniform weights of cloth to show the effect of "conditioning" on the pH change in laundry waters, if any. The pH measurements at the end of the washing cycle, Fig. 7, can be compared with Fig. 5, which shows the pH before the washing action began. There was no significant change in the pH during the washing cycle. At the end of the cycle, the pH values of the Evis-treated waters were identical with those of the untreated waters within the limits of laboratory measurements. If pH changes show loss of power, as previously quoted from the manufacturer's claims (6),

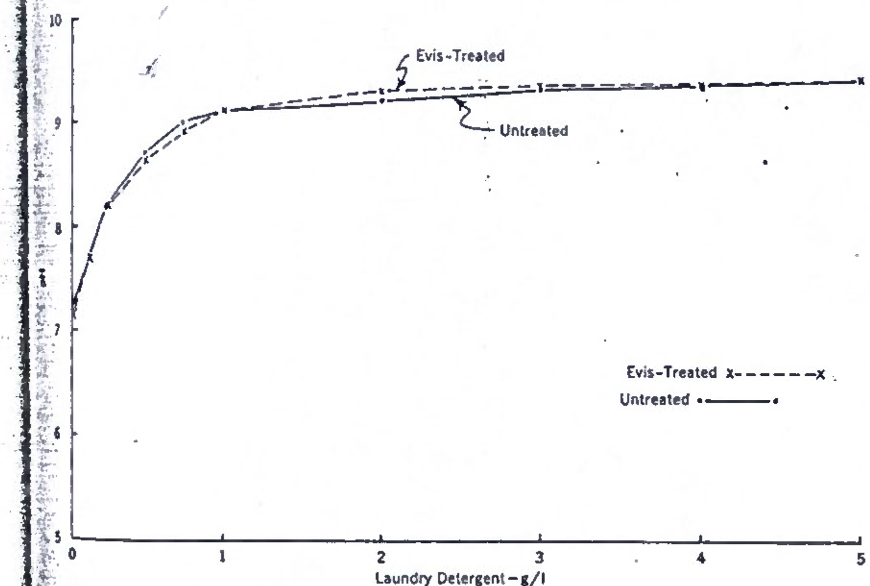

Fig. 7. Effect of Evis Treatment on pH of Laundry Effluent

Laundry detergent was added to Cambridge tap water. Washing time was 20 min.

then it can be concluded that there was no difference in "loss of power" during the laundry cycle when the water was passed through the Evis Conditioner.

The soap suds looked exactly the same in raw and "conditioned" waters in which similar amounts of soap were used. There was no observed difference in fluffiness or cleanliness between the cloths in raw and "conditioned" waters after washing.

Laundry Rinsing Action and Water Consumption

Manufacturer's claims. "Cold hard (any hardness) Evis Conditioned Water is highly suitable for rinsing, and will not only save heat and softening, but also at least one rinse water. Evis rinses stop caustic carryover, which means that less soap and more alkalies can be used. Scouring acid may be cut in half, and starch will take hold" (*7*). Laboratory studies described in one bulletin, quoted previously (*6*), led to the following claim:

A significant point in the laboratory report regarding the first rinse is that the pH raised ten times out of ten with raw water and only seven times out of ten with Evis water. This would indicate that the alkali had been largely drained away with the wash water instead of adhering to the clothes.

A second rinse was needed ten times out of ten with raw water, and in every case the pH raised about three points. With the Evis water there was a pH rise in only two runs during the second rinse which is further proof that Evis-treated

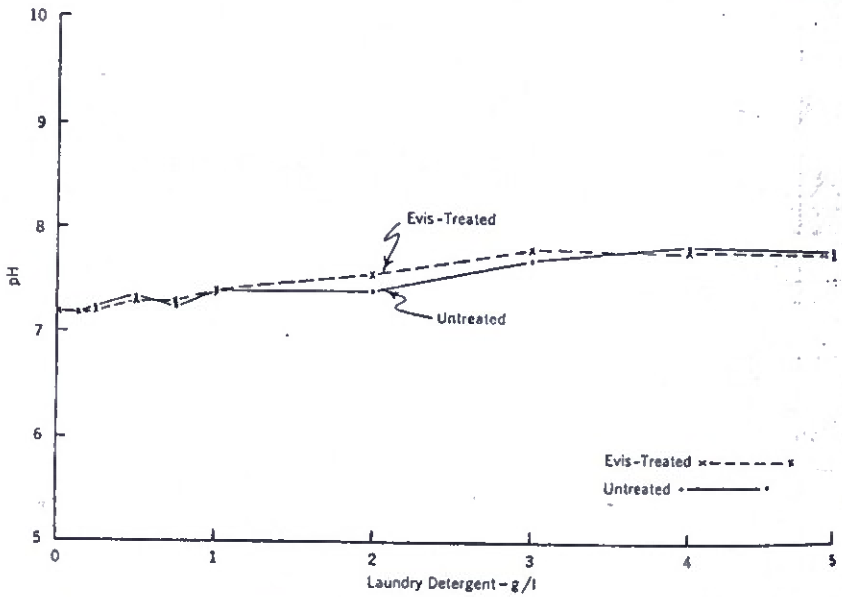

Fig. 8. Effect of Evis Treatment on pH of Laundry Rinse Water—First Rinse

Cambridge tap water was used. Rinsing time was 10 min.

water has a better rinsing ability. On the third rinse the raw water washes continued to show a pH rise in nine out of ten runs, but with Evis treatment there was nothing left to rinse out in eight of the runs, so the third rinse was run on only two runs and one of these failed to show a rise in pH. A fourth, and perhaps a fifth, rinse would have been required in nine out of ten raw water runs to completely rinse out the alkali. Raw water required 66⅔% more [rinses] than Evis water.

The same bulletin (*6*) quotes a testimonial from the Sudsy Duds Washateria in Lubbock, Tex., as follows: "It makes fine suds with any soap and the rinsing quality of the Evis conditioned water is far superior."

Laboratory studies. Water shortages and forced curtailment of water use are tremendously important in the water works news these days, and any method which may save water should be thoroughly studied. The claims of water savings made above were based upon pH changes in laundry rinse waters. Therefore, pH determinations were made on rinse waters from washes containing various amounts of laundry detergent, using both untreated and "conditioned" Cambridge tap waters. As can be seen from Fig. 8, the pH was greatly reduced in the first rinse in both raw and Evis-treated waters. Contrary to the manufacturer's claims, however, the pH was not higher in the untreated waters. The difference between the two waters was negligible and well within the limits of experimental error.

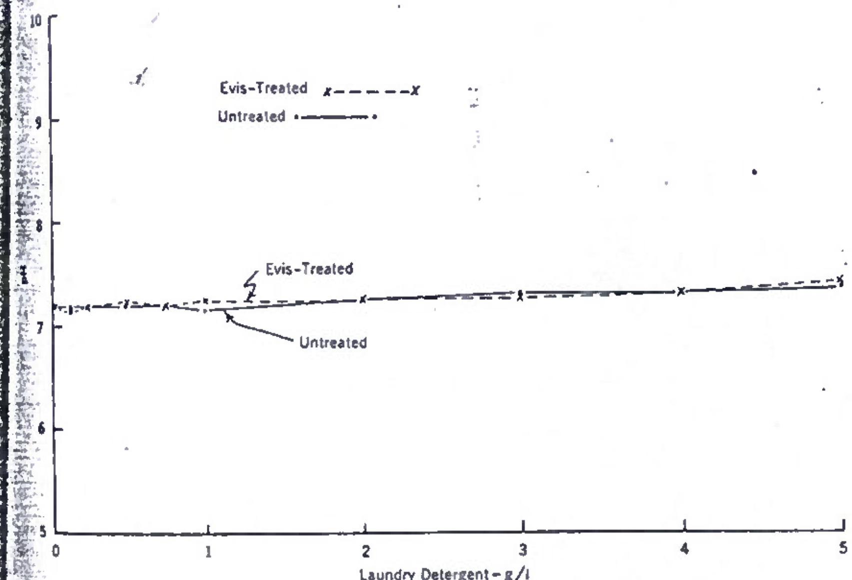

Fig. 9. Effect of Evis Treatment on pH of Laundry Rinse Water—Second Rinse

Cambridge tap water was used. Rinsing time was 10 min.

formance tests. A clue to the flocculent or granular structure of precipitates can readily be obtained by measuring the filtration characteristics of lime precipitates formed in Evis-treated and untreated waters. Adherent flocs would filter much more slowly than the "granules . . . like small grains of sand" referred to in the above quotation (*9*).

Solutions of calcium carbonate were made up with Evis-treated and untreated waters. An excess of calcium carbonate was added to cause precipitation. The solutions were then filtered and the volumes of filtrate were measured with time. Results of these filtration studies are shown in Fig. 11. It may be observed that the density of calcium carbonate buildup on the filter paper resulting in loss of filter action was the same with both Evis-treated and untreated waters. It follows that the granular nature of the calcium carbonate was the same in both waters. These tests indicate that there was no physical difference in the calcium carbonate precipitate due to the Evis Conditioner.

Conclusions

On the basis of the foregoing laboratory studies on the *behavior* of water "conditioned" by the Evis Water Conditioner, the following conclusions may be drawn:

1. The *behavior* of the water was not changed with respect to the complexing of calcium or magnesium by EDTA.
2. "Conditioning" did not affect the pH values of water used for laundering, either before or after the washing cycle.
3. During laundering operations the amount of soap required to produce stable suds was not affected by "conditioning" in the Evis unit.
4. The *Standard Methods* soap hardness test was not affected by this type of "conditioning" of waters of various degrees of hardness.
5. "Conditioning" did not affect the pH of rinse waters, and therefore no saving of rinse water was accomplished.
6. "Conditioning" did not affect the rate of solution of substances commonly found in hard-water scales.
7. No effects were noted in some of the pertinent physical characteristics of calcium carbonate as the result of "conditioning" in the Evis unit.

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Factors to Be Considered in House Piping Sizes and Selection of Meters

C. M. Mathews

A paper presented on Oct. 24, 1956, at the Alabama-Mississippi Section Meeting, Mobile, Ala., by C. M. Mathews, Asst. Supt., Public Service Com., Yazoo City, Miss.

To the average person, the size of a meter and the size of a service are synonymous. Ignorant of the amount of water he may use in a month, he prefers to allow the water department to judge the necessary meter size. The water department, as a rule, can inform him of the smallest meter available or, in case of doubt, can advise him to install an oversize meter. An oversize meter is no solution, however, for it creates an unnecessary expense to the customer and decreases the water department's revenue by underregistering consumption.

Considerable study has been made on service sizing; meter sizing is a phase of this. A study applicable to the country as a whole is usually based on averages, so that care must be taken in using results for actual installation.

Fixture Demand

An ample supply of water at an adequate pressure is dependent on several things: [1] the fixture (or fixtures) being used; [2] the pressure at the main; [3] the elevation of the fixture; and [4] the length and size of service line. The results of one of the most widely accepted studies (*1*) on rate of flow and pressure requirements are shown in Table 1.

A satisfactory water system may be designed using Table 1 as a guide, by assigning similar values for fixtures comparable to those shown in the table. The system probably would have a far larger capacity than is necessary and be very expensive, as it would be designed for all fixtures being open at the same time—which is very unlikely.

The more fixtures there are on a line, the less likelihood is there of all of them being in use simultaneously. No one has the facilities or the time to correlate the amounts of water used by the different fixtures, the time at which valve is likely to be open, the likelihood of any number of units being in operation at any one time, and the likelihood of a time-overlap for use of these fixtures.

Flow quantity, time of operation, and frequency of use, expressed as fixture units, were used in a study (*1*) to calculate the most probable demands made upon certain fixtures. The results of this study, shown in Table 2, have proved to be accurate and reliable under field conditions, even though slight drops in pressure and quantity of water for a few minutes each day might be evidenced.

In order to calculate the demand in gallons per minute made upon a service, the total number of fixture units should be added from the figures given in Table 2 and then read off on the chart shown as Fig. 1. As the esti-