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# Experimental Performance of 'Miracle' Water Conditioners

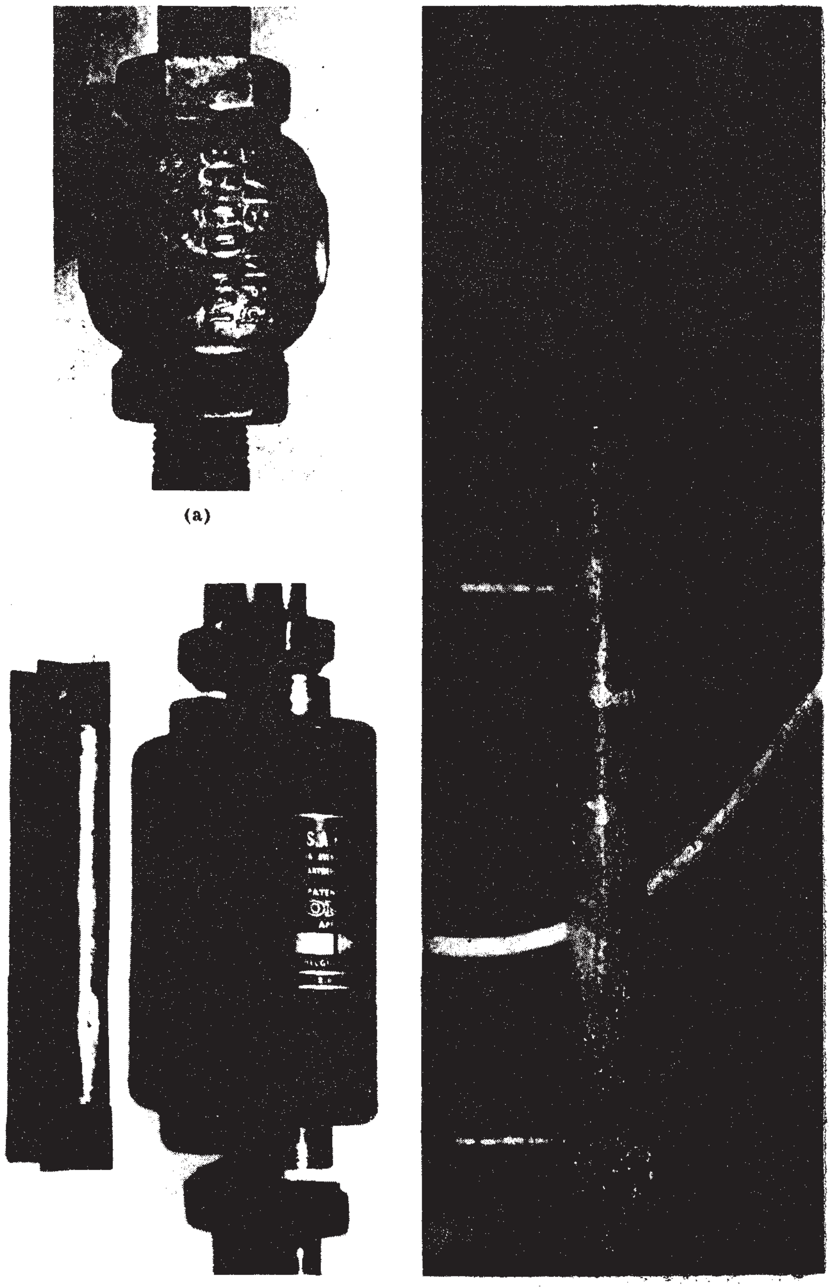
—Rolf Eliassen, Rolf T. Skrinde, and William B. Davis—

*A paper presented on Apr. 24, 1958, at the Annual Conference, Dallas, Tex., by Rolf Eliassen, Prof. of San. Eng., Rolf T. Skrinde, Research Asst., and William B. Davis, Research Asst., all of Massachusetts Inst. of Technology, Cambridge, Mass.*

WATER, the universal solvent, contains many impurities caused by the solution of compounds with which it comes into contact. Even rain as it falls to the earth is not pure water, because it picks up dusts and dissolved gases from the atmosphere. Ground waters leach other products from the soil. In some cases the impurities in water lead to increased corrosiveness, while in others the dissolved solids tend to form scale on surfaces such as in pipelines and boiler tubes. Treatment of water to prevent scale and corrosion is therefore necessary in most industries and municipalities. Unfortunately, there is no single treatment process which will be a utopian answer for all purposes. Certain chemical additives to control corrosion may lead to increased scaling tendencies. On the other hand, demineralization to prevent scale buildup may lead to increased water corrosiveness. It may readily be seen that there could be a tremendous potential market for a simple water-conditioning device which would prevent scale and corrosion in small individual installations such as steam boilers, air-conditioning units, and household water lines.

Such a simple water-conditioning device, based on sound scientific principles, has never been developed and proved by precise measurements of its physical and chemical effects on the mineral constituents of water. In an attempt to produce a simple water-conditioning device, many people have promoted gadgets for which many claims have been made. Some members of the water works profession have referred to these gadgets as "miracle water conditioners." They have been sold in great numbers, as pointed out in the "Perspectives" column of *Product Engineering* (*1*) in 1953: "Despite the frequent charges of quackery raised against them, the antiscaling water conditioners are big business. One of the current best sellers costs from 50 to 3,000 dollars, depending on size. The manufacturer claims to have sold 100,000. Observers think he's being modest; the correct figure is probably closer to 150,000."

Welder and Partridge (*2*) have defined these gadgets as "special devices requiring substantially no technical control which are alleged to treat water by nonchemical means so that the familiar troubles caused by deposition of scale or sludge, by corrosion and cracking, or by the accumulation of organic slimes, will plague us no more." The dictionary defines "mira-



(a) (b) (c)

**Fig. 1. Water "Conditioner" Units**

(*a*) *Evis;* (*b*) *Cepi;* (*c*) *Packard.*

cle" as: "an event or effect in the physical world . . . deviating from the known laws of nature."

Over the past century a substantial number of these miracle gadgets have been promoted vigorously for a while and then have fallen into oblivion, as shown by Henricks (*3*). An earlier article by Eliassen and Uhlig (*4*) discussed several of the gadgets which were available in 1952, described the promotional methods used, and discussed the electronic, nuclear, or other principles involved. In almost all cases no technical data are presented by the manufacturers to substantiate the claims discussed in that paper.

## Description of Conditioners Studied

Despite past water "conditioner" reports, requests for further information on and evaluation of gadgets not mentioned in the above papers have come to the attention of the authors. These requests have concerned mostly the three units which are described below—the Evis Water Conditioner, manufactured by the Evis Manufacturing Company of San Francisco, Calif.; the Packard Water Conditioner, made by Packard Water Conditioner, Inc., Jacksonville, Fla.; and the Cepi-Comav, manufactured in Belgium and distributed by Cepi-American, Inc., River Forest, Ill. The authors believe that all of these come under the definition previously quoted from Welder and Partridge (*2*) in that they are "special devices requiring substantially no technical control which are alleged to treat water by nonchemical means, etc." The means of "conditioning" employed in each of the three units are different and are worth comparing in a side-by-side presentation. Exterior views of the three units are shown in Fig. 1 and interior views in Fig. 2.

The Evis Water Conditioner (Fig. 1a and 2a) is a pipe fitting shaped like an oversized pipe coupling. It contains an interior cross post or protuberance around which the water flows. The manufacturer states (*5*) that, by the use of a specially processed metal, it "performs the function of a Catalytic 'Promoter' or 'Activator' by so altering the electronic structure of water molecules that the adsorption properties of its solutes and contaminants are thereby altered." One bulletin (*6*) states that Evis "removes old pipe

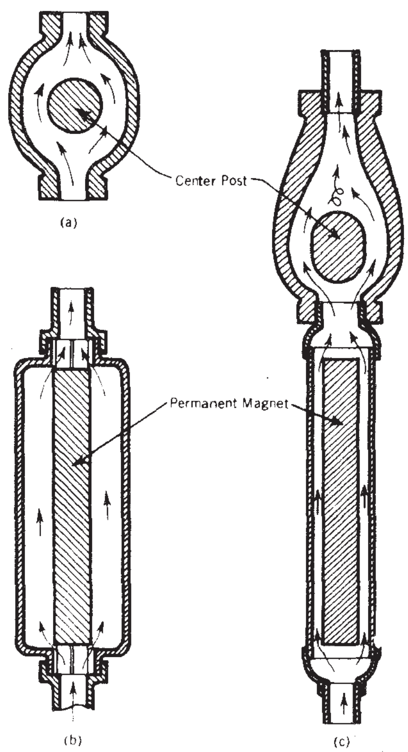



**Fig. 2. Schematic Diagram of Water "Conditioner" Units**

*(a) Evis; (b) Cepi; (c) Packard.*

scale—prevents new scale from forming," and others discuss the use of Evis for corrosion control. A report of a laboratory study of this unit by Eliassen and Skrinde (*7*) was published in 1957.

The Cepi unit (Fig. 1b and 2b) consists of one or more permanent magnets placed in a housing so that the water flows through the magnetic field. The following rather extensive and complicated explanation of Cepi action has been prepared by its distributor (*8*):

The principle and theory of the magnetic process consists of conducting the liquid through concentrated magnetic fields of measured intensity, relative to the concentration of ions and their dipole moment. Liquid passing through these magnetic fields, results in a change so that at the moment of crystallization of the salts, the polarization between the zones of strong ionization will be diminished and the cohesive forces will be neutralized. This action results in a cleavage of the crystal into very thin layers and an orientation of the ions as per one magnetic axis. The resulting action upon crystals of the scale forming salts is that instead of forming scale, the crystals precipitate as a fine amorphous powder that is non-adherant to metal and other surfaces, nor to each other, and can be removed by draining, blow-down or flushing. The same phenomena takes place when old scale is in contact with the treated fluid as it becomes soft, dehydrated, and finally falls loose as a powder or soft flakes as the treated water has the ability to transfer its' treatment to the water molecules in the scale and effecting the scale crystals. Corrosion is neutralized partially or entirely, depending upon the composition of the liquid, by diminishing the electrostatic

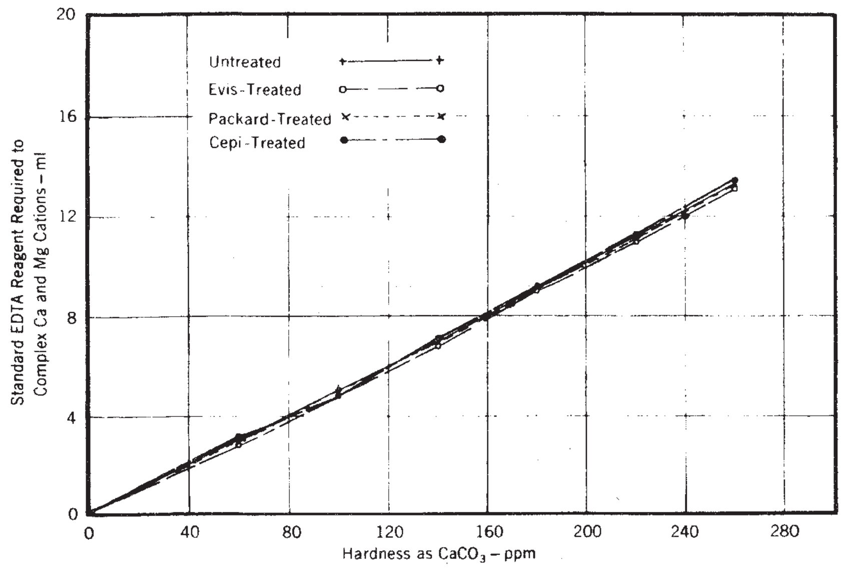



**Fig. 3. Effect of Water "Conditioning" Devices on Complexing Properties of Scale-Forming Components**

tension forces on the surfaces of the zones of strong ionization.

The Packard Water Conditioner, shown in Fig. 1c and 2c, appears to combine the physical features of the Evis and Cepi units, in that the Packard employs both a center post around which the water flows, and a permanent magnet in its long, double-chamber housing. The components of this device are described by its manufacturers as follows (*9*):

The dispersing cell contains the "Perma-Core," a kinetic energy generator made of a patented metal of extreme density whose energy shows itself in alternating fields of unusual magnetic intensity. The "Perma-Core" is a permanent well of static energy. This energy force modifies the structure of the molecules of minerals and salts in the water. . . . The homogenizing or mixing chamber is an alloy casting containing a core against which the flow of water is directed in such a way that the water is tumbled upon itself to produce a homogeneous energy distribution within the molecules of the solution.

The Packard manufacturers claim (*9*) that their conditioner "is the first important application of nuclear physics principles to the effective treatment of water to combat scale and corrosion. It prevents scale and corrosion by imparting added energy to the atoms of the water solution. The added energy . . . establishes a uniform electrolytic potential within the system and stops corrosion."

## Scope of Studies

Claims such as these have no significance to the water works profession unless they can be substantiated by experimental evidence obtained in a manner similar to that used in evaluating other water treatment processes.

An attempt has been made to study the performance of these units in the laboratory and in the field, and to measure the performance in terms of the latest scientific methods applicable to water works practice. The measurements and tests were directed toward the effects of the "conditioners" on water, in the light of some of the claims made by one or more of the manufacturers. The laboratory tests sought to evaluate claims such as those regarding effects on ionic structure of water constituents, effects on scale formation (using stable and radioactive calcium), effects of strong magnetic fields on scale formation, and effects of the "conditioned" water on scale dissolution and on the corrosion of iron. Field tests were directed toward evaluating the effects of water "conditioned" by these devices on the corrosion of steel pipe.

## Effect on Ionic Structure

As mentioned previously, claims have been made including such phrases as "altering the electronic structure of water molecules" (*5*), "diminishing the electrostatic tension forces on the surfaces of the zones of strong ionization" (*8*), and "modifies the structure of the molecules of minerals and salts in the water" (*9*). Because the metallic ions of calcium and magnesium are so important in the formation of scale, the authors contend that any alterations in ionic or molecular structure should have a measurable effect on the complexing action on calcium and magnesium in "conditioned" water. Tests which involve complexing and its precise measurement have been perfected in the past decade by water chemists through the use of ethylenediaminetetraacetic acid (EDTA).

Laboratory studies were made on the three water "conditioners" with respect to any changes which could be observed in any complexing effects, as measured by the standard EDTA test (*10*). Cambridge tap water, with various degrees of hardness added, was passed through each of the three units. Tests were made on the complexing of the calcium and magnesium in the three "conditioned" waters and also in untreated water as a control. The results are presented in Fig. 3, which indicates that no significant difference was observed in the complexing properties of the scale-forming components of the hard waters tested. The soap-consuming property, one of the most significant chemical attributes of hard waters, was not affected by these "conditioners" as shown by the results of these tests.

## Effect on Scale Formation

Water "conditioners" of the type discussed above have many claims made for their effectiveness in the prevention of scale and removal of existing scale. Field tests to evaluate the effect of these devices on scale formation are difficult to perform because long periods of time are required, municipal treatment procedures may change during the course of the test, and it is hard to maintain identical conditions in boilers or other structures using treated versus untreated waters. A laboratory study is much

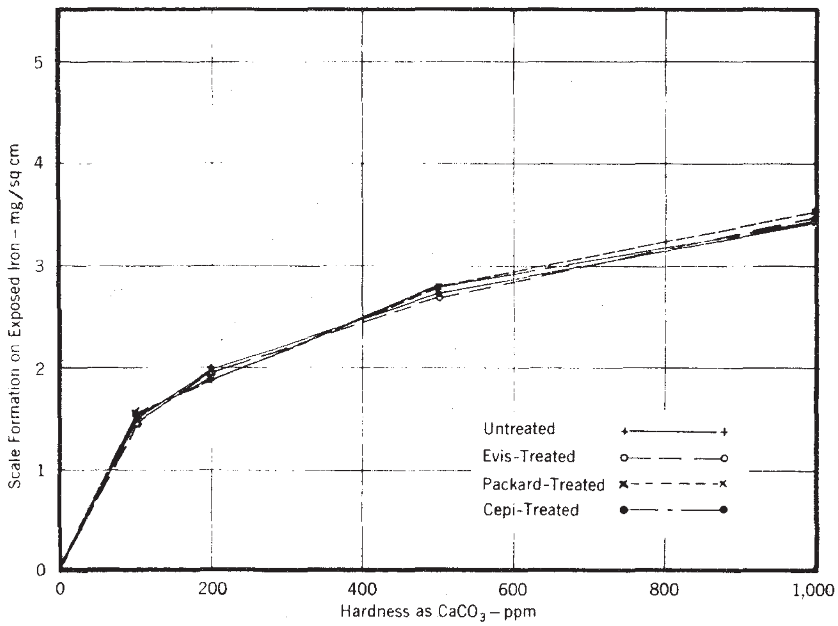



**Fig. 4. Effect of Water "Conditioning" Devices on Scale Formation**

more accurate in maintaining controlled conditions and making precise measurements.

Scale formation through heat was investigated with water of various compositions which had been "conditioned" by the three devices. Strips of steel were suspended in flasks containing the "conditioned" waters and untreated controls, and heated on a water bath to cause evaporation with the production of steam. At the completion of the evaporation process the strips were weighed to determine the amount of scale formed. Figure 4 shows that the scale formation was the same in quantity in both the "conditioned" and the untreated waters. It was also noted that the steel specimens became quite rusty during the evaporation period. The samples placed in the "conditioned" waters corroded to the same extent as those in the control flasks. The results of these tests indicated that scale and corrosion, at least during the initial stages on bare metal, were not affected by any of the three "conditioning" devices.

### Radioactive-Calcium Studies on Scale Formation

An extremely effective method of measuring the deposition of calcium precipitates, and a new scientific technique in water analysis, is the use of radioactive tracers. Radioactive calcium 45 is a beta emitter with a half-life of 163 days. With an energy of 0.25 Mev, it is well suited for counting with a Geiger-Muller radioactivity counter. A known quantity of calcium 45 is added to the sample. The amount of radioactive calcium deposited on steel surfaces during evaporation processes is then an indication of the amount of calcium precipitating out as scale.

Samples of water with a high hardness content were treated with the three devices and placed on a steam bath for evaporation. The steel specimens were cut from 0.9-in. diameter bars and were machined to fit into nickel-plated counting planchets. As the water evaporated away with time, the scale deposition increased as shown in Fig. 5. The deposition of radioactive calcium 45 on steel was not affected by "conditioning." The results of this test, using the latest radiochemical techniques, supplement the previous scale formation study and serve to verify the results in Fig. 4.

### Effect of Strong Magnetic Fields on Scale Formation

Changes in the scale-forming properties of water as a result of subjecting it to magnetic fields have been claimed by two of the manufacturers of water "conditioning" devices. Although the magnets are strong for their size, the use of any tremendously large magnets of great magnetic field intensities by the manufacturers is evidently not commercially feasible, especially for the ordinary small installations.

Claims are made that the strong permanent magnets impart energy to water passing through the magnetic field. The Packard statement reads: "prevents scale and corrosion by imparting added energy to the atoms of the water solution." This claim is made in the face of the additional claim of using a permanent magnet—one which will not lose energy as time goes on. This is contrary to the most fundamental laws of nature such as the well established Second Law of Thermodynamics, which maintains that as energy is taken up by one body it must be given up in like amount by

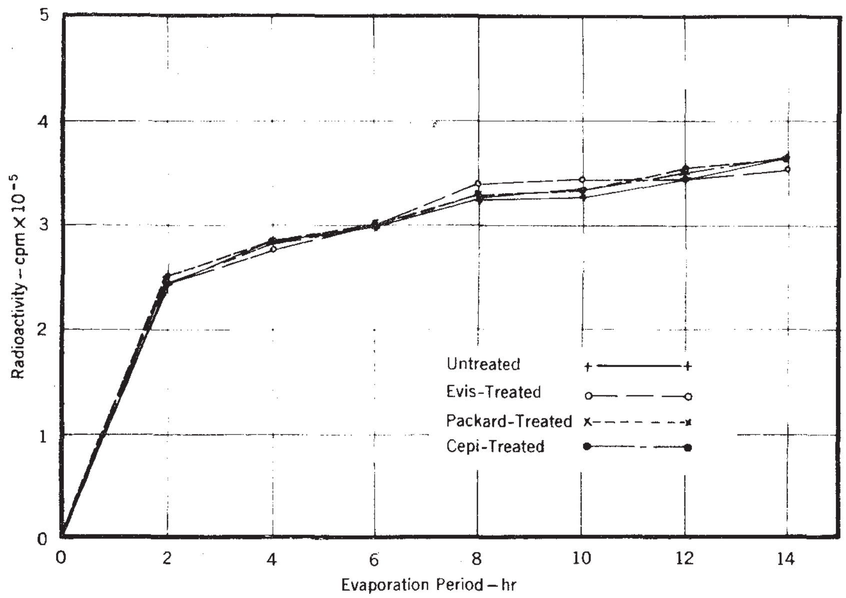



**Fig. 5. Effect of Water "Conditioning" Devices on Radioactive Scale Formation**

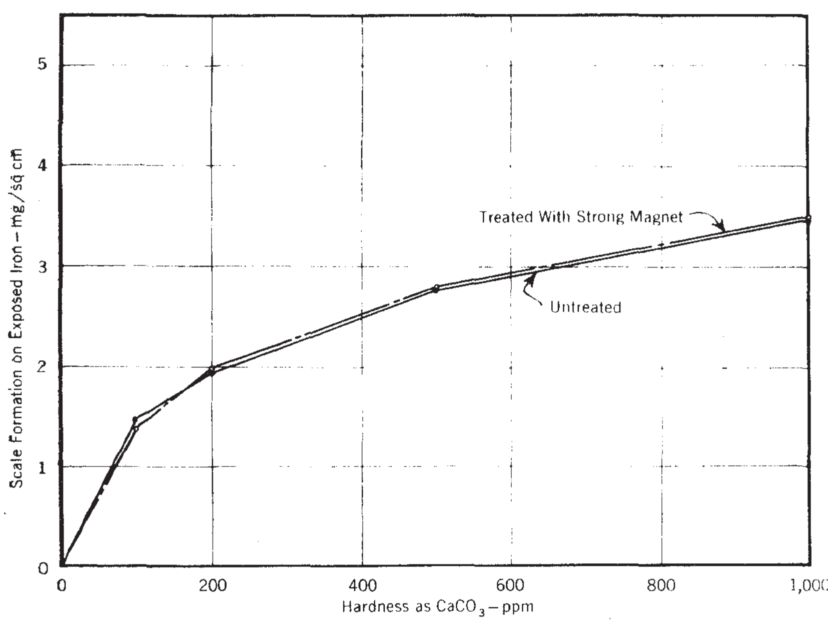



**Fig. 6. Effect of Strong Magnetic Fields on Scale Formation**

another body, whether the energy is electrical, mechanical, or chemical—in other words, energy must come from some source which must be expended, and not from a permanent nonexpendable source. For instance, at Massachusetts Institute of Technology, an extremely high continuous magnetic field of 100,000 gauss has been created by Francis Bitter, dean of the School of Science. "To accomplish this he must keep filling his coil with magnetic field as fast as it leaks out—a procedure involving a million-watt generator for power and part of the Charles River for coolant" (*11*).

Physicists have shown (*11*) that even this huge field is not enough to influence the particles within atoms. Magnetic fields of the order of magnitude of 1,000,000 gauss are needed "to dominate the motions of charged particles within atoms" (*11*). This field strength is equivalent to an energy density of about 5,000 joules/ml. By contrast, an energy density of only 0.5 joule/ml was caused by the magnets used in the magnetic water "conditioners" tested. There is a 10,000-fold difference in energy densities!

Even so, it was deemed advisable to run experiments with a very strong magnetic field to obtain an indication of the effect on scale formation of a very strong magnetic field on water at a low flow rate. Samples of water of varying hardness were subjected to approximately twenty times the degree of magnetic treatment imparted by some of the devices. The rate of flow was 1 gpm. Such treatment should be much stronger than that accomplished by magnetic treatment through ordinary water "conditioning" devices, and should presumably have a greater effect on scale formation. The test method was the same as previously described with regard to scale formation on steel strips. Figure 6 shows that, even with such a strong magnetic treatment, the weight of scale deposited was not significantly different from that of the untreated waters.

### Effect on Scale Dissolution

The water "conditioning" devices tested have been recommended by their proponents for use in cleaning scale from old water lines. Some data have been presented by the manufacturers in support of their claims in this respect, but the authors have seen no data from manufacturers based on studies in which controls of untreated waters were tested under identical conditions and rigorous comparisons made.

Two types of laboratory studies were made. In the first tests, scale was placed in separate vessels containing "conditioned" waters and untreated waters. The amount of scale passing into solution was measured by the EDTA hardness test. The results of this investigation are shown in Fig. 7. The curves are virtually superimposed and indicate that water "conditioned" by the devices in the laboratory had no measurable effect on the rate of scale dissolution. It would thus appear that in these tests the water "conditioning" devices did not change the characteristics of the water so that it would penetrate the scale and dissolve it more readily.

In another investigation of scale solubility produced by using "conditioned" versus untreated waters, scale containing radioactive calcium 45, which was coated on metal specimens, was allowed to dissolve in distilled water. At regular intervals samples of the water were evaporated in planchets and measured for calcium 45 concentration in a Geiger-Muller counter. The amount of calcium 45 passing into

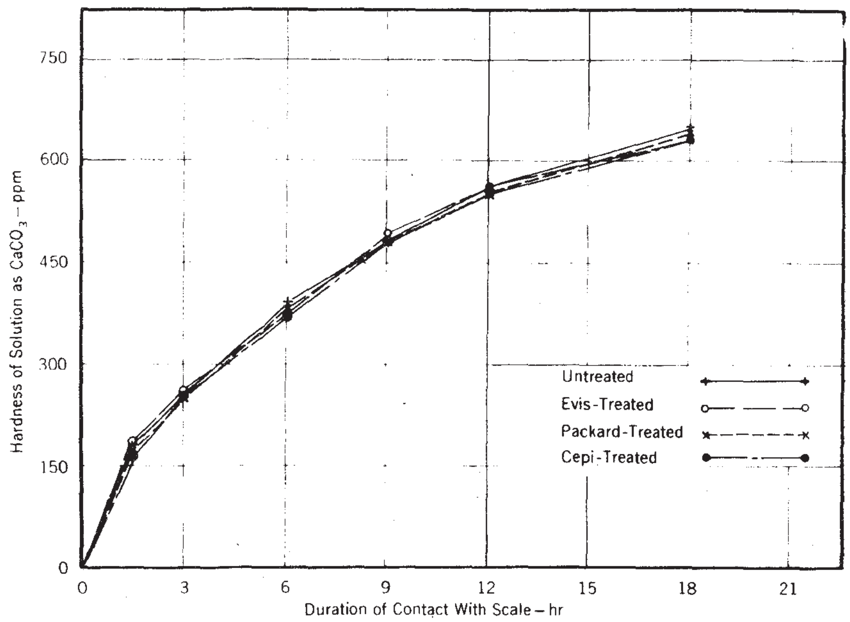



**Fig. 7. Effect of Water "Conditioning" Devices on Removal of Scale**

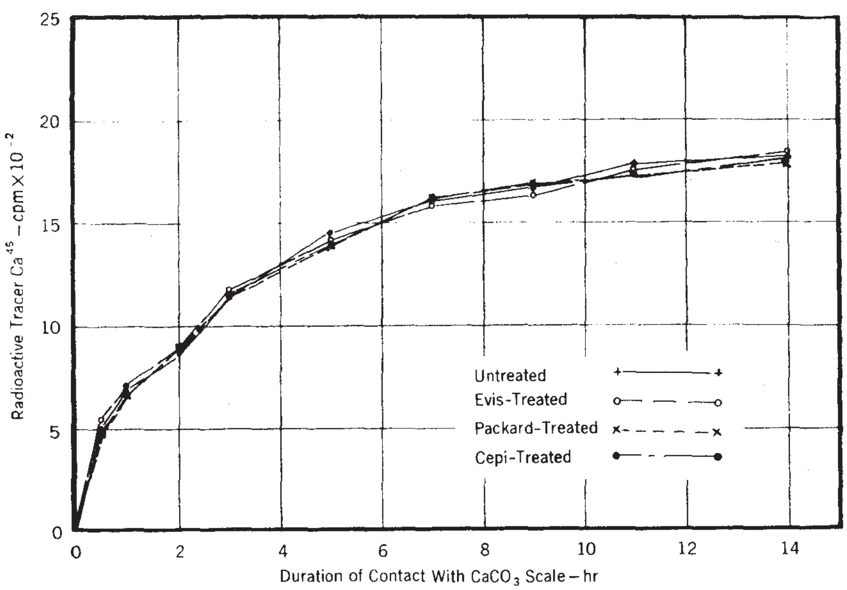



**Fig. 8. Effect of Water "Conditioning" Devices on Dissolution of Calcium Carbonate**

solution was used as an indication of the rate of scale dissolution. The results of these tests are plotted in Fig. 8. It is evident that the three water "conditioning" devices did not affect the solution of scale as measured by the radioactive-tracer method.

## Effect on Corrosion

The control of corrosion in pipelines and other surfaces in contact with water is one of the claims made for these water "conditioners." If the magnetic, catalytic, or other effects produced by the "conditioners" could prevent corrosion, the savings in the United States alone would amount to billions of dollars per year. The theory as to how the "conditioners" might control corrosion is not clear in statements made by the manufacturers. Many years of water works practice has led to the commonly used lime or soda ash addition to neutralize free carbon dioxide and provide an eggshell calcium carbonate coating in water lines, or to the addition of metaphosphates or silicates. These methods have been described in the JOURNAL on many occasions (*12*).

For field testing, the three water "conditioning" devices were placed in water lines at the Cambridge Filtration Plant. Cambridge tap water was piped into four identical pipelines, one of which was a control line. Specimens of black-iron pipe were especially prepared in the laboratory to make them uniform for corrosion studies. They were then weighed and inserted into the four pipelines. At periodic intervals specimens were removed from each line and analyzed for rust or scale formation and weight loss upon removal of the deposits. Results of the weight loss determinations are

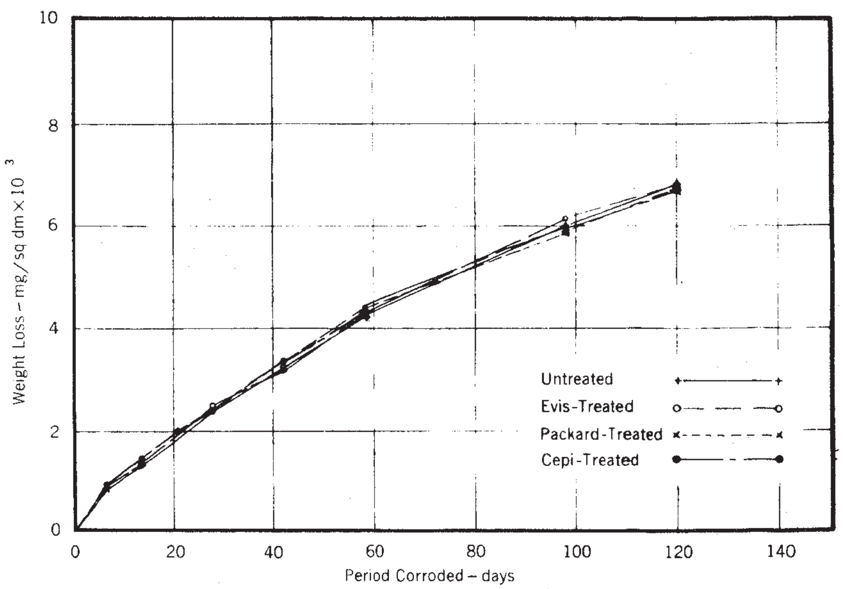



**Fig. 9. Effect of Water "Conditioning" Devices on Iron Pipe Corrosion**

presented in Fig. 9. It can be seen from the curves that there was no difference in corrosion as determined from weight loss studies over a period of 4 months. The corrosion products of light-brown rust were the same in quantity and physical appearance in all of the test lines. The rust appeared as small pinpoints at first, and then grew until the whole surface of the pipes became covered with a thin layer. to its oxide form during the corrosion process. The direct method of Warburg was used, in accordance with the standard analytical procedure described in detail by Umbreit and colleagues (*13*). The Warburg method of measuring oxygen utilization is based on the change in pressure of a constant-volume system resulting from the uptake of oxygen from that system. Chemical methods of oxygen utiliza-

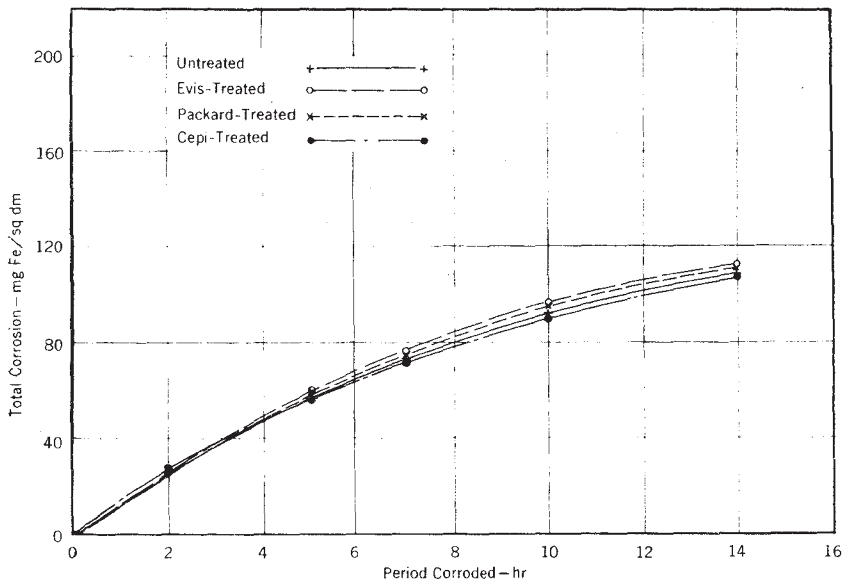



**Fig. 10. Effect of Water "Conditioning" Devices on Accelerated Corrosion of Iron**

Even the water "conditioning" units themselves were not immune to corrosion and scaling. At the end of the test a heavy rust deposit was found in each water conditioner.

## Accelerated Laboratory Corrosion Tests

Further corrosion studies were made in the laboratory by measuring oxygen utilization caused by the rusting of iron

tion have often been applied previously for measuring the corrosion of iron, but the use of the Warburg respirometer for this purpose is a new scientific technique which should find considerable application in the corrosion control field.

The results of corrosion studies using the Warburg respirometer are presented in Fig. 10. In these studies, the water samples were taken from the pipelines containing the "conditioning" units at the Cambridge Filtration Plant. The iron specimens were equal lengths of iron wire 0.008 in. in diameter and of uniform cross-sectional area. Figure 10 shows that the corrosion of iron in the "conditioned" waters was slightly higher than the control in two cases and slightly lower in one case, but the corrosion rates are not significantly different and are well within the limits of experimental error.

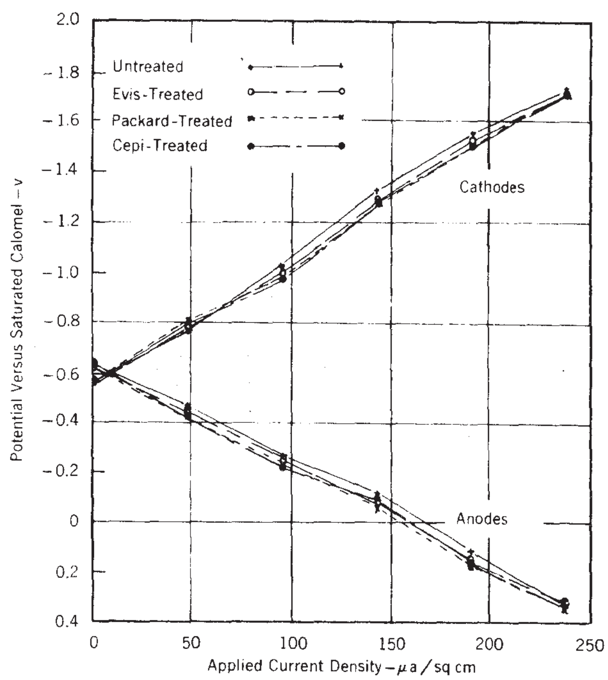



**Fig. 11. Effect of Water "Conditioning" Devices on Electrolytic Properties of Iron Surfaces**

## Polarization Studies

Some manufacturers claim changes in the electrolytic behavior of pipes or other metallic surfaces due to the "conditioned" waters. Statements of changes in electrode potentials, or other metal surface phenomena of an electrolytic nature, relate to corrosion, as corrosion is an electrochemical reaction. The variation in potentials of anodes and cathodes of corroding surfaces with current flow is known as polarization. Polarizing characteristics of separate anodes and cathodes under a given set of conditions may be determined by varying the rate of current flow between the electrodes and measuring the potential of each electrode against that of a standard reference cell. Information obtained in such studies is of great value to corrosion scientists in studying corrosion phenomena (*14*).

The results of polarization studies using water "conditioned" by the three units, with untreated water as a control, are shown in Fig. 11. Steel specimens were placed in corrosion cells. With variations in applied current density obtained by a power supply, electrode potentials were measured against saturated calomel. Treatment with the three "conditioner" units caused neither a significant change in the electrode potential of the metal nor a change in the polarization characteristics of the anodes and cathodes of corrosion cells. No changes in corrosion tendencies of the metals could thus be observed by polarization tests, whether or not the water had been subjected to "conditioning."

## Conclusions

On the basis of the foregoing field and laboratory studies on the effect of Evis, Packard, and Cepi "conditioning" on water properties which are considered to be important in the water works profession, 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 scale-forming properties of water evaporated to produce steam.
3. Precipitation of the scale-forming cation, calcium, upon evaporation of a hard water to steam was not affected by the three "conditioning" devices.
4. Water which was passed through magnetic fields as strong as, and much stronger than, that of the "magnetic" water conditioners was unaffected with respect to scale formation.
5. "Conditioning" did not affect the rate of solution of substances commonly found in hard-water scales.
6. The rate of solution of radioactive calcium 45 from scale was not affected by "conditioning."
7. In field studies, "conditioning" did not affect the rate of corrosion of steel pipes over a 4-month period.
8. Accelerated laboratory corrosion tests indicated no significant effects on corrosion rates by "conditioning."
9. "Conditioning" did not affect the corrosion characteristics of steel surfaces as determined by polarization tests.

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