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## **So-called Electrical and Catalytic Treatment of Water for Boilers**

**By Rolf Eliassen and Herbert H. Uhlig**

*A paper presented on May 5, 1952, at the Annual Conference, Kansas City, Mo., by Rolf Eliassen, Prof. of San. Eng., and Herbert H. Uhlig, Assoc. Prof. of Metallurgy, both of Massachusetts Institute of Technology, Cambridge, Mass.*

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Control your scale electrically"; "Just plug it in"; and "Costs no more than an electric clock to operate!" These are headings on an advertisement for a so-called electric scale-control unit. Simplicity and economy have long been the lures which attract so many operating engineers when purchasing equipment for use in boiler water treatment. A host of simple gadgets for conditioning of water is flooding the market again. Riding on the crest of the electronic age, manufacturers are making all sorts of claims for their little wonder-packages which can be connected into the water line and, by a little current from internal galvanic action between plates of two dissimilar metals, an external applied current, or some mysterious catalytic action, answer all of the problems of boiler feedwater treatment — and many other problems as well. Promoters are claiming that some of these simple cure-all devices will eliminate operating difficulties arising from scale, corrosion, turbidity, algae and bacteria. Frequently, engineers and operators have neglected to ask whether equipment really works as claimed and whether it is based on sound scientific principles.

Members of the water works profession should not be taken in by these

extraordinary claims. The excellent research that has been accomplished and published in technical journals establishing the basic principles is not to be swept aside and circumvented "just like magic," as one advertisement states.

The water works engineer, when approached by a salesman for the magic type of water treatment equipment, should:

1. Subject the performance claims of the manufacturer to critical analysis and experimental evaluation.
2. Examine the pseudoscientific terminology which usually forms part of the advertising literature.
3. Compare the operating facts of the apparatus with known scientific principles.

### Manufacturers' Claims

The manufacturers' extraordinary claims are all directed toward eliminating well-known troublesome problems in the fields of scale and corrosion control. Most of the units claim to control scale with no addition of chemicals, merely by application of a small electric current measured in microamperes or by the introduction of some mysterious catalyst. Some manufacturers throw in corrosion control for good measure.

One manufacturer makes the following claims for the addition of a little catalytic tank to the water line:

#### Bacteria

"Bacteria in potable water has \*always been a major problem for city water dispensing authorities. The general water treating process currently being used merely kills the bacteria, but does not kill the larvae. Larvae finds a natural breeding ground in the deposits of scale, some algae, humus, and all other deposits from the source of the water plant through the carriers to the consumers. By the use of water through [this process] and the elimination of scale, humus, some algae, etc., the larvae must cease to exist and thus reduce, if not eliminate the bacteria."

#### The Facts

Bacteria do not have larvae nor do they exist in the larval stage. The whole statement indicates that the manufacturer knows very little about the problems of the water works engineer.

#### Odors

"Odors are generally created by deposits in the water carriers, which deposits take the forms of scale, some types of algae, humus, etc., and by the introduction of chlorine for combatting the bacteria, a chemical reaction occurs. The combination of the chlorine with the humus or certain algae creates a phenol that increases the unpleasant odors. Through the use of [this process], the humus, scales, and some algae are removed and thus the odors decrease."

*\*No attempt has been made to correct the grammar in the manufacturers' literature.*

#### The Facts

Most odors are caused by substances present in the original water supply, not from pipeline deposits. Chlorine reactions do not create phenols.

#### Turbidity

"By the dispersion created by [this process], the elements that give water its turbidity having been dispersed, the water takes on a crystal-clear optical appearance."

#### The Facts

If mineral substances could be dispersed by a long-lasting catalyst (a small tank may last 6 months) all coagulation, settling and filtration problems could be ended. This claim is absurd.

#### Scale

"As to the already existing scale and corrosion, these are all formed by impurities of the water and are paramagnetic elements. The activated water created by [this process] activates the layer of scale with which it first makes contact and causes a microscopic swelling of these layers. The enlarged layer created by this swelling process is then subjected to a process of dispersion and gradually depolymerizes into the flow of water. It must be understood that this swelling process, layer by layer, and the resultant elimination is a slow process and each layer receives the same treatment until all of the scale is removed."

#### The Facts

So-called depolymerization is only a fancy term for the return of calcium carbonate and other mineral crystal into solution. This return to solution may be

caused by acids present in the water, such as carbonic acid, or by added chemicals. As the installation of these depolymerization units is usually accompanied by the cessation of chemical addition to boiler water, a different chemical balance presents itself. But the chemicals were added for a purpose - to precipitate in-crustants as a sludge to be blown off, and to prevent corrosion. Without these chemicals, boiler failure may result.

### Corrosion

"By removing the deposits of iron oxide, the galvanic current that it creates is reduced in direct proportion to the size of the deposit of the iron oxide and thus reduces the corrosion. The fact that the elements are dispersed by [this process] in itself reduces their corrosive tendencies."

### The Facts

Water works experience in the the cleaning of tuberculated water mains has shown that, with corrosive waters, the removal of tubercles and rust exposes fresh iron surfaces, increases the overall rate of corrosion, and stimulates further tuberculation. Deposits of iron oxide are not necessarily the prime cause of corrosion — they are the result of iron lost from the pipe by the action of corrosion, and usually reduce the rate of attack.

### Catalysis

"It must be understood at the outset that [this process] does not in any way change the chemical structure of water. The catalytic action is that of setting up an increase of the molecular magnetic susceptibility of water, creating a great dispersion of the elements in water that have an affinity that cause scale, rust and

corrosion." This dispersion is explained at great length and the manufacturer bases all conclusions on the statement that, "the catalytic process produces a variable magnetic field in the water passing through the \_\_\_\_\_ apparatus, and this field has the power of converting unstable parahydrogen to orthohydrogen."

### The Facts

These complex pseudoscientific claims fall down because the conversion of parahydrogen to orthohydrogen does not apply to hydrogen in combination with oxygen as in water, but only when hydrogen exists as a diatomic molecule ( $H_2$ ). Even with  $H_2$ , the reaction is a second order effect related to the non-equilibrium state of nuclear spins when hydrogen is brought from a very low temperature to room temperature. In addition, magnetic fields have doubtful influence on scaling, corrosion, or dispersion of salts in water.

The most ridiculous of this company's claims is set forth in the statement: "Periodically an inhibiting action must be provided for, to counter the acclerative catalytic action. This inhibiting action suppresses the magnetic field in the \_\_\_\_\_ apparatus. The active, catalytic period must last for two consecutive days, and the subsequent inhibiting period for five successive days." In other words, water passes through for only two days a week: the remainder of the week the apparatus must be drained and vented to the air.

### Additional Pseudoscientific Terminology

1. One manufacturer explains an electrical gadget for water conditioning in these terms:

"[This unit] creates that neutral corpuscle of electricity creating physical

change. When an atom loses one or more of its electrons, it becomes incomplete and immediately joins another of like or different material in order to complete its circle of electrons. [The unit] makes inert those elements that cause corrosion or destruction. [The unit] makes positive those elements that become inert under heat, pressure and cold, thus eliminating scale formation as these particles remain minute and in solution."

#### *The Facts*

No "neutral corpuscle of electricity" is created in galvanic circuits or by catalysis. Electrons flowing through a wire are negatively charged. An atom in solution minus an electron does not immediately join another atom or ion, but remains positively charged as an ion, such as  $\text{Na}^+$ . The selectivity of making some elements inert and some positive is double-talk, particularly as scale is made up of compounds of several elements. These compounds precipitate when the solution becomes saturated. Saturation occurs as steam is generated and the solution becomes more concentrated. Certain organic colloids are used as chemical feeds to produce a soft sludge, but precipitation still takes place.

2. Another manufacturer, in his description of a gadget employing radiation instead of electricity states that his particular equipment employs "the use of hermetically sealed cylinders which contain a specially prepared formula. This formula emanates an energy or potential which can be likened to, but not compared with, heat waves. This very absorbable radiation causes an alteration to the normal physical characteristics of the mineral deposits. This radiation imparts a particular form of mole-

cular energy to the water, producing a state of activation of the molecules or molecular aggregates. There is a transference of this energy from the water to the scale, causing changes in the surface electrical condition of the scale particles themselves, and between the particles and the metal surfaces of the boiler."

In attempting to explain these mysterious effects the manufacturer further states: "Chemically, the water treated by [this process] is exactly the same at the time that it enters the preheater or boiler as it was when it was raw untreated water — thus there is no chemical theory. [The process] neither adds nor removes any ions or salts; it merely 'disturbs' the balance of those ions or salts present through the use of a molecular energy (or through an ionic activation) imparted to the water. In other words, [this] is an 'ionic' not a 'chemical' process, and we are thus able to accomplish 'physically' (without theory) what has been attempted for years in following a 'chemical theory'."

#### *The Facts*

This ecstatic outpouring of mumbo jumbo speaks for itself. Chemical processes and ionic processes cannot be separated. The standard chemicals used in boiler water treatment provide ions, such as  $\text{PO}_4^{---}$ , which react with other ions such as  $\text{Ca}^{++}$  and  $\text{Mg}^{++}$ , to produce insoluble compounds which thus remove scale-forming minerals as sludge.

3. Another supplier of an electrical device claims: "The [process] unit makes no chemical change in the water, creating instead a purely physical change. Consequently, a chemical analysis taken before and after the water passes through a [process] cylinder will be the same. Nothing is taken out of the water, nor

is anything added to it by [the unit's] operation. A clearly defined cream line develops in 'regular' milk. In homogenized milk the cream is just as truly present, but it is controlled. Similarly [process] units control the separation of particles which would otherwise build up scale on metal surfaces."

#### The Facts

The statement, "Nothing is taken out of the water, nor is anything added" is undoubtedly true.

4. The claims which are noted here are typical of manufacturers who promote this kind of equipment for the control of scale. One manufacturer made such startling claims as:

"Just like magic — conditions your water supply — electrically, no chemicals or compounds required . . . Any industry or institution can now be assured of a regular flow of uniformly pure water free from corrosive acids, plant, or mineral matter. Most water contains various salts in solution or in a colloidal state. The [process] conditioner electrically charges these scale-forming, acid and corrosive substances so that they are repellent to each other as well as the metal surfaces of all equipment, water and steam lines. Algae and foreign growths are eliminated. This boon for industry is achieved easily, quickly and economically through the magic electrodes of [this process]."

Perhaps the most extraordinary claims are those made by the manufacturer of the same kind of gadget employing a small impressed current between an anode and a cathode. With this apparatus, some of the sweeping claims include: "Does away with boiler compounds. Prevents scale formation in boilers and boiler systems. Prevents corrosion by eliminating its cause. Prevents foaming, priming, bumping. Prevents embrittle-

ment and cracking."

This promoter goes even further in claiming miracles for household water units:

"Makes bathing water positive to the body.

"Makes cooking easy, for all flavors are natural, there being no radicals in the water to hinder correct emulsions by natural processes.

"Four-fifths of all foods are water, therefore you eat less as you have the perfect base.

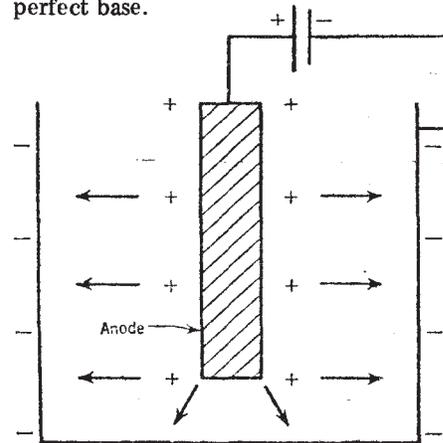


Fig. 1. True Cathodic Protection of Water Tank

The tank wall and bottom form the cathode and are protected by current over the entire surface.

"Aches, pains, sour-stomach, indigestion, and the ailments come from pressure or excess radicals; drink pure [process] treated water for one week, it will tell you the story, regarding Natural, Physical Rehabilitation, Internal or External . . . After using [process] treated water for ten days, then, you feel distressed, you better see your doctor, for you are beyond natural rehabilitation due to some extreme pressure."

### The Facts

The reader may judge the facts. Claims of all sorts could be given *ad infinitum*, as the zeal of the medicine men apparently knows no bounds. Experimental work conducted on a scientific basis, time-consuming though it is, often is required to

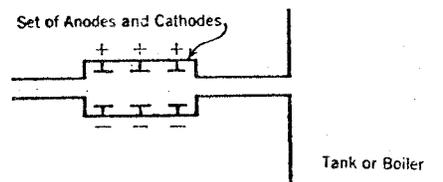


Fig. 2. So-called Electrical Treatment Units

*The set of anodes and cathodes is remote from the tank or boiler. There is no flow of current through the water to the walls of the tank or boiler.*

uncover the fallacies in claims by questionable promoters. But many times the claims are so wild that experiments would be almost superfluous. Promoters in this class almost always resort to testimonial letters from "satisfied" users of their equipment. In most instances, the letter writers are not technically trained and are easily deluded into thinking they have derived benefit, at least up to a point. It is well to beware of these testimonial letters unless the source is well known.

The real answer to the boiler water problem comes from engineering experiments of the kind conducted by Hurley and coworkers (1), who observed scaling in low-pressure boilers at various stations in England, with and without electrical treatment of the feedwater. They concluded that the differences in observed scale deposits in various boilers "do not appear to be associated in any way with the electrical treatment of the feedwater, and they [the differences] are equally apparent whether electrical treatment is used or not."

ment is used or not."

The authors conducted a brief correspondence with two American manufacturers, one of electrical and one of catalytic devices, but received, in return, more claims, testimonials, and evasive answers. The engineering data that were sought were not supplied, nor was there anything to indicate that data of this kind had at any time been obtained by the companies.

### Scientific Principles

Years of research have established the facts of scale formation (2). As water evaporates in the boiler to form steam, the mineral salts in the water become more concentrated. When the solution becomes saturated with any particular mineral, crystals of the salt begin to form at the point of greatest concentration or highest alkalinity — usually at the heat-exchange surface. No amount of mysterious dispersion by small so-called electrical forces will prevent this crystallation. The only means of prevention is to treat the feedwater by adding chemicals, at times both inorganic and organic, to the water to remove the scale-forming substances in the form of a soft sludge, either ahead of the boiler or in the boiler.

While in solution, the mineral salts exist as ions — positive ions such as  $\text{Ca}^{++}$ ,  $\text{Mg}^{++}$ , and  $\text{Na}^+$ , and negative ions such as  $\text{HCO}_3^-$ ,  $\text{SO}_4^{--}$ , and  $\text{Cl}^-$ . Small galvanic currents work but add or subtract total charges from the solution. Ionization is a function of known physical and chemical factors and not minute currents flowing in some mysterious manner in one small part of a system. Ionization occurs immediately when a salt is dissolved, and no electric current will do any more dispersing or ionizing as claimed.

Corrosion is an electrochemical phen-

omenon, the proof and understanding of which are based on much sound research. Basically, galvanic cells form on metallic surfaces. Depending on a number of factors, anodes and cathodes occur at many places on the surfaces of pipes and boilers. Loss of iron occurs at the anodes according to the reaction:



To stop this reaction by a counter-current is possible and is accomplished by the process known as cathodic protection. This process has been applied successfully to water tanks, to the protection of thousands of miles of buried pipelines, and to other equipment. It employs an impressed direct current using a set of auxiliary anodes, or a galvanic current derived from sacrificial anodes (Mg), placed in such a way that the current reaches every square inch of exposed metal surface being protected. It is difficult to accomplish this protection inside pipes and boilers because the anodes would have to be installed inside each tube.

Cathodic protection is entirely different from the so-called electrical apparatus for water conditioning which employs a small current between anodes and cathodes located at a considerable distance from the boiler or pipe surface being purportedly protected. Figures 1 and 2 show a comparison of the electrolytic effects. To be protective, the current must reach the corroding surface and must be adequate to suppress the corrosion reaction. No claim is made for the control of scale by the legitimate process of cathodic protection.

### Summary

A study has been made of the advertising literature of some of the manufacturers of so-called electrical and catalytic methods for the control of scale in boilers. Extravagant claims have been analyzed on the basis of scientific facts. The prospective purchaser of equipment for which mysterious or magical claims are made should investigate the fundamental basis for performance of the equipment. Unless claims for it can be substantiated by an analysis based on well-established scientific principles, or by adequate laboratory or engineering experiments, the purchaser should be skeptical.

Many frauds are being perpetrated on an unknowing and gullible public. The water works profession has reached a high state of development through the appreciation of sound principles of science and engineering because it has subjected each new proposal to a critical scientific study. Many new and sometimes radical changes have been introduced, but they have always had a sound background for acceptance. Fraudulent devices and processes come and go, necessitating vigilance on the part of engineers who should be willing to accept new ideas based on scientific facts and engineering performance, but who should equally reject proposals, no matter how attractive, supported, at best, by testimonials.

### References

1. Hurley, Ingelson, *Et Al. Electrical Treatment of Boiler Feedwater. Jour. Inst. Wtr. Engrs.*, 5:686 (Nov. 1951)
2. *Water Quality and Treatment. Am. Water Works Assn., New York, (2nd ed., 1950)*