the shaft. The solution to that is, do not use that method to hold the belt on the pulley.

Most of our accidents in the cake and meal warehouse occur when an employee tries to tear down a stack by pulling one sack out of the corner of the stack and the stack falls on him. We finally broke up this procedure when we had two serious injuries in this way in consecutive years. We had an employee lose his life when he jumped from the top of one oil storage tank to another. The top of the tank gave away, and he fell into the tank of oil. Our superintendent was standing there, telling him not to jump.

It appears from our experience that after you have applied all your knowledge toward accident prevention, you will still have some accidents. Heaven only knows what our record might have been had we not had a safety department. Through the efforts of our department and the cooperation of management, supervisors, and the employees we have had our compensation insurance rate reduced from a debit of 93% of the base rate to a low of 19% credit.

Accidents can be prevented. It behooves us therefore to employ the highest type labor available, indoctrinate them in the job assigned to them, and follow up. The best safety device in the world is between the ears of the individual employee.

Present Practices in Industrial Water Conditioning

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OUR industrial economy demands an abundance and a great variety of raw materials. The one universal and most important of these is water. It is required in larger quantities than any other raw material: for example, to produce one ton of gasoline requires 15 tons of water, one ton of steel requires 100 tons of water, and the production of one ton of rayon utilizes 830 tons of water. Furthermore for almost every other raw material some substitute has been developed, but not for water.

The use of water by industry may be classed in three general categories, as follows: a) as a source of heat and energy through the generation of steam; b) as a cooling medium, and c) as a raw material in the manufacturing process itself.

In each of these applications of the utilization of water serious difficulties and economic losses can develop—and often do. In the generation of steam we must combat such problems as:

1. Scale.
2. Adherent sludge.
3. Corrosion of boiler metal.
4. Priming or "carry-over."
5. Turbine corrosion.
6. Turbine depositions.
7. Corrosion of condensate return systems.

In the cooling systems of industrial plants, where the majority of all the heat generated in the operations must be dissipated, numerous problems present themselves, such as:

1. Scale and/or sludge depositions.
2. Corrosion.
3. Bacteria and algae.
4. Cooling tower deterioration.

Where water is used in the actual manufacturing of a given product, varied difficulties are encountered. These may take the form of one or several of the following:

1. Discoloration due to the presence of iron or manganese.
2. Precipitation of calcium soaps.
3. Undesirable bacterial growth.
4. Corrosion of equipment.
5. High total dissolved solids.
6. High turbidity and suspended matter.

Let us then review briefly what has been accomplished in the way of properly conditioning water to offset these problems. This field of scientific endeavor had its beginning about 100 years ago, when it was first realized that ordinary hardness in water, the cause of scale and sludge deposition, could be decreased by the addition of lime. Shortly after this the discovery was made that, under certain conditions, even further softening could be accomplished by the addition of sodium carbonate, or, soda ash. Thus came into being the cold lime-soda process of hardness removal from water for general uses. From this meager beginning advancement has been made until today most or all of the difficulties can be overcome by proper choice of treating methods, correct design of equipment, and exact control and operation.

THIS discussion will be a review of the methods available for treatment of boiler water and cooling water. For boiler water conditioning let us divide the subject into two parts: a) pre-treatment or external treatment and b) internal treatment.

By external treatment we mean any treating done before the water is fed to the boilers. Here is the field where the greatest advances have been made, and careful judgment must be exercised to select properly the correct method of treatment for the best and most economical results. A review of the various methods available and recent developments are in order.

The old lime-soda process has already been mentioned. This method is still used extensively. Basically, the process consists of adding sufficient lime to react with the bicarbonates present in the water or, in other words, to remove the "so-called" temporary hardness, and then adding eenough sodium carbonate to remove the permanent hardness. Coagulants, such as aluminum sulfate, ferrous or feerric sulfate, and sodium aluminate may or may not be used. The major advancement accomplished in the use of this process is the introduction of the so-called sludge contact or sludge blanket equipment. In these units the raw water and freshly added treating chemicals are passed through a blanket of sludge, or a large volume of sludge is circulated so as to come in contact with the incoming water. The usual recirculation ratio is about 5 to 1. By this method residual hardness values of 2 gpg. readily can be obtained. The advantages of this develo,ment are: a) more complete utilization of chemicals added; b) less area required for plant installation; and c) smaller capital investment.

Hot process treatment was developed to accomplish the softening, by the use of lime and soda ash, with the least possible size of equipment and to obtain the lowest possible residual hardness. In this process treatment is carried out under a pressure of 5 to 15 p.s.i., and a temperature of 220 to 250°F. With proper care and control, residual hardness values of ⅓ gpg. or less can be obtained. These units, like the cold process, have been improved by providing means of passing the freshly treated water through a sludge blanket. The intimate contact provided between the water and the sludge blanket is particularly helpful when it is desired to obtain good silica removal.

The successful removal of dissolved silica from water was first accomplished by the hot process treating plants. This treatment depends on the use of magnesium. The source of magnesium can be either the soluble salts, such as magnesium sulfate or magnesium chloride, either present in the raw water or fed to the system. Or the magnesium can be fed as the oxide, either from dolomitic lime or special burned magnesium oxides. Regardless of the source, the use of magnesium permits the removal of dissolved silica to values as low as 0.3 of a part per million if desired. In a number of cases troubles have developed in the boilers due to too low a silica content of the boiler feed water.

While discussing advancement in hot process treatments, it is well to digress briefly to mention a development that has won wide acceptance during the last three to four years—hot zeolite plants. In this process the effluent from the hot lime-soda or hot lime plant is passed through base exchange units, resulting in a treated water of essentially zero hardness. This operation was made possible by the development of the polystyrene type base exchange material. These units are now operating successfully at temperatures as high as 250°F.

Aside from the benefit of producing essentially zero hardness water, the hot base exchange systems have the additional advantage of overcoming one inherent weakness of hot process units, namely, excessive alkalinity. In the standard hot process unit, softening to the desired range is accomplished by maintaining a definite carbonate excess—usually in the range of 1 epm. Such operation results in high boiler water alkalinity and high CO_2 content of the steam. With the advent of hot base exchange it is not necessary to operate with a carbonate excess. In fact, it is common practice to operate with a carbonate deficiency, or, in other words, an excess of calcium. This results in a low alkalinity feed water and consequently low alkalinity boiler water, also with what is sometimes even more important, low carbon dioxide in the steam.

NOW let us revert back to the field where the greatest advancements have been in the pretreatment of industrial water—the field of base exchange. The process of base exchange originated with the discovery of certain minerals that possessed the ability to exchange their sodium ions for the detrimental calcium and magnesium ions in water, and furthermore they had the characteristic that they could be regenerated by bringing concentrated brine into contact with the mineral. This process has been used extensively and, unfortunately, in many places where it should not have been selected. Generally this process gave a satisfactorily soft water but offered no control of alkalinity, and no means of silica removal.

From this somewhat meager beginning great advances have been made by the development of the synthetic base exchange materials of various types. In fact, such a wide range of exchange materials has been developed that today it has become quite an art to select the proper medium to use. The developments however have been made in a very logical and stepwise manner.

The first big limitation of base exchange that needed overcoming was the lack of a means of alkalinity control. This was accomplished by the resins that could operate in the so-called "hydrogen cycle," *i.e.*, the cations in the water such as sodium, calcium, and magnesium, are exchanged for hydrogen in the resin. Thus the bicarbonates are converted to carbonic acid, which can be removed in degasifiers, correspondingly lowering the alkalinity of the water and also the total dissolved solids.

The next desired result was to accomplish further lowering of the total dissolved solids. This meant that it was necessary to develop a material that could absorb anions from the water. To accomplish this base exchange, resins containing amino groups were produced. These resins act somewhat differently from previous products in that the whole acid molecule, such as HCl, H_2SO_4, H_2CO_3, is adsorbed whereas cation units simply exchange one ion for another. Now by first passing the water through the hydrogen cycle exchangers and then through the anion exchangers, water essentially devoid of dissolved solids is obtained.

With the perfection of this process only one further basic improvement was needed. The early anion resins could not absorb silicic acid and hence did not provide a means of silica removal. For a period this deficiency was overcome by adding soluble fluorides to the water and then removing the silica as fluorosilicic acid. This manner of operation was successful but relatively expensive.

Research soon overcame this weakness, in the demineralization process, with the production of highly basic anion resins. These resins permit the direct absorption of silicic acid. Thus today it is possible to remove completely all dissolved solids from water and obtain a water with a silica residual of less than 0.1 ppm.

It is obvious that a process such as the above will be expensive on the basis of chemical consumption, but at times it is necessary to produce water of a certain quality, regardless of cost. In other cases the quality and cost of raw water are such that complete demineralization can easily be justified over other methods of water conditioning.

A modification, or improvement in demineralization, is the so-called "Monobed" system. Here the cation and anion resins are placed in the same vessel. In effect, this is equivalent to passing the water through a whole series of anion and cation exchangers. Hence water of exceedingly high purity can be realized. It is not unusual for the performance guarantee for such equipment to specify an effluent water with a resistance of 2 to 4 million ohms. However one of the anticipated results in the use of this system has had to be revised—the lowering of the silica residual to an exceedingly low value. Today it is recognized that no lower silica values can be obtained by monobed operation than by conventional demineralization.

There is one further development in base exchange treatment that should be mentioned, primarily because of its adaptability to small plants, where supervision and qualified operating personnel are limited. By this means softening and dealkalizing can be accomplished with only the use of salt as a regenerant. This end is obtained by using a cation exchange unit, operating in the sodium cycle, and then passing the water through an anion exchanger that has been regenerated with salt, thus converting it to the chloride form. In this condition the anion resin will exchange chloride ion for HCO_3, SO_4, and sulfides.

Thus with present base exchange methods it is possible to attain almost any degree of treatment from simple softening, by exchanging calcium and magnesium for sodium, to complete demineralization with silica removal.

All of the above treatments have been planned for the proper preparation of boiler feed water, and from the standpoint of scale-forming constituents and dissolved solids the desired results can be obtained by intelligent choice of equipment and control limits. Up to now one feature characteristic of all water supplies has not been considered—namely, the dissolved gases content, primarily carbon dioxide and oxygen. The accepted means of removing these has long been purely physical, consisting of dispersing the liquid into fine particles in an atmosphere of steam. Development of equipment for this purpose has been primarily a matter of improvement in design. Nevertheless the advancements are noteworthy, as evidenced by the degree of deaeration obtainable. Not too far in the past the guarantees for oxygen removal ranged from 0.1 to 0.03 ppm. whereas today the usual guaranteed value for residual oxygen is 0.005 ppm. Suffice it to say that this rigid guarantee is successfully met by all reputable equipment manufacturers. In fact, at present the toughest problem in connection with deaeration has been the development of analytical procedures and testing techniques sufficiently accurate to determine the remaining oxygen.

At times additional preparation of feed water, such as oil and iron removal, is necessary, but these cases are too specialized for detailed discussion at this time.

EXPERIENCE has shown that, no matter how carefully boiler feed water is prepared, proper internal treatment and control are necessary for successful operation of modern high pressure, high rating steam generators. This matter of internal treatment of boiler water has gone through various stages of development.

For a considerable period of time we experienced what might be called the "Compound Era." During this time materials of every description were compounded, bagged, or barrelled, and sold with a promise to cure any and all evils of boiler operation. You would be surprised at the chemical composition of some of these compounds if I had the time to quote you from some of the analyses in our files. Admittedly some had merit, but mostly their greatest merit was the way they enhanced the financial status of the seller.

Certainly one should not forget to mention the innumerable mechanical and electrical gadgets for solving our problems that have appeared from time to time, and still do, and which supposedly function by some unknown and mysterious chemical or physical phenomena. If results could be obtained that even approached the claims made, life would truly be beautiful. As an example, one such gadget, which was fastened to the outside of the boiler, was proclaimed to stop scale formation, prevent corrosion, and avoid priming and foaming in the boiler. Then after this was accomplished, the active constituent, whatever it was, would penetrate the tubes and remove any soot deposits, and lastly it would indefinitely protect the fire brick in the furnace walls.

In regard to these gadgets it is realized that some of you may, from time to time, be called upon to evaluate their merits and the indicated results obtained. In this case just be sure that all variables have been taken into account. Usually any results obtained are due to some variable, such as blowdown or feed water quality, that has been changed and not properly taken into account.

The present scientific internal treatment of boiler water particularly, insofar as scale formation is concerned, had its origin in the research work done at the Bureau of Mines under the direction of R. E. Hall. Here the fundamental concept of scale formation, namely, that those salts with a negative solubility curve will deposit as scale, was formulated. From this it followed that to prevent certain salts, such as those of calcium, from forming scale, they must be converted to a salt with a positive solubility curve, and one whose solubility constant is less than that of the scale-former.

This work led to the universal acceptance of the soluble phosphates as the ideal means of preventing scale formation in boilers. Improvement of this method over the past twenty-odd years has been simply a matter of refinement in the method of feeding, residuals required under given conditions, and improvement in analytical control methods.

FOR proper internal conditions it has long been recognized that proper alkalinity of the boiler water must be maintained. However no particular advancements have been made in this matter in the last few years. Naturally there are times when these values must be varied for certain sets of conditions, but these cannot be discussed here.

One condition of internal treatment that caused considerable concern for years was the matter of boiler metal embrittlement. A great deal of research was done by numerous investigators. For a long time it was contended that, to avoid this difficulty, it was essential to maintain certain ratios between the sulfate and hydroxide concentrations in the boiler water. This idea has been proved to be fallacious and has been abandoned by all reputable water-treating engineers. It has been proved that the nitrates exhibit a more positive effect, and the use of sodium nitrate for overcoming the embrittling tendencies of water has been widely adopted. It might be said that no cases have been recorded where the proper use of sodium nitrate has not completely overcome any tendency of the water to embrittle the metal.

A relatively recent advancement of interest to power plant operators is the use of amines for the prevention of corrosion in condensate return systems. These materials are of two general types: the neutralizing type, which combines with the carbon dioxide and increases the pH of the condensate, and the film-forming type, which protects the system from the ravages of CO_2 and O_2 by the formation of a protective film on the metal. There are a number of these materials sold today under various trade-names, and due precaution must be exercised in the selection of the proper material.

Additional chemicals are often used to accomplish desired ends, such as dispersing agents and anti-foaming agents. Suffice it to say that, properly used, these can be very helpful, but proper precaution must be exercised or the damage done can do far more than offset any advantages gained.

The treatment of water used for industrial cooling has become as prominent and critical as that of boiler water. And, as may be expected, the problems encountered are as numerous and complex.

The first of these is our old friend—scale. As the water in cooling systems is heated, the equilibrium point between $HCO_3 \leftrightarrows CO_3$ shifts so as to create higher carbonate concentrations. This causes the deposition of calcium carbonate scale.

To overcome this difficulty several methods of approach have been adopted. One means that has been advocated is the stabilization of the water to the correct Langelier Index by the addition of sulfuric acid. This has often not proved too successful because the Langelier Index is dependent on temperature. Hence, in a cooling system with a wide range of temperatures existing, the best that can be done is to adjust the index for an average condition or for the most critical point in the system. With such control it means that scale-forming conditions will prevail in the higher temperature ranges, and corrosive conditions will be realized in areas of lower temperatures than the average for which controls have been set up.

PROBABLY the single most important development in the field of cooling water treatment was the adoption of the so-called Threshold Treatment. With this treatment 2 to 4 ppm. of sodium metaphosphate is maintained in the cooling water. Pioneering work in this field must be credited to Calgon Inc. This use of the threshold amounts of metaphosphate permits a supersaturation, with respect to calcium carbonate in the water, without scale deposition. This treatment has proved to be very successful, but, like other methods of water treatment, is not a "cure-all" and must be used with proper judgment.

About 10 or more years ago Calgon Inc. began using a method of treatment that has since, in one form or another, found wide acceptance in the cooling water field. The procedure here adopted is lowering the pH to a point where no carbonate deposition can occur. In other words we definitely render the water corrosive and control corrosion by the maintenance of proper sodium metaphosphate residuals, in the order of 12 to 15 ppm. The pH values of the recirculating water are established at somewhere between 6.0 and 7.0.

This type of treatment has given excellent results in a great number of plants. The major objection to its use is the fact that careful control of the pH must be observed. This requires careful supervision because, at these pH values, practically all buffering agents in the water have been eliminated. Should the pH be allowed to rise much above the set limits, calcium phosphate sludge becomes troublesome. On the other hand, a much lower pH of the water will destroy the protective phosphate film on the metal and permit corrosion to occur.

Cooling systems are not different from other equipment constructed of steel and other metals and are subject to attack by corrosive agents, such as oxygen, sulfides, and bacteria. We discussed above one method of combatting this problem, namely, the use of relatively high metaphosphate residuals. Other means that have been adopted in the last few years involve the use of such materials as silicates, dichromates, and organic chromates. The choice of the best methods to use frequently becomes quite a subject for discussion and sometimes requires quite a bit of experimental work. Our experience has shown that where the low pH-high metaphosphate treatment cannot be justified, the use of metaphosphate and dichromate, in moderate concentrations, gives excellent results.

The use of chlorine or other biocides is absolutely essential in cooling water systems, both from the standpoint of controlling slime and algae growth, and also of preventing corrosion from bacterial action. Algaecides and bacteriocides are today almost as numerous as there are manufacturers, but chlorine still has the widest acceptance in the industry. Admittedly there are conditions where chlorine cannot be used, such as organic leaks in the system, or where we encounter reducing agents, such as hydrogen sulfide. Wherever possible, chlorine is preferred, and for best results it should be added intermittently. The usual recommendations are to build up a residual of 2 to 3 ppm. once a day.

A problem in connection with cooling systems that has come into great prominence during the past few years, and justifiably so, is the deterioration of cooling towers. It has been necessary to spend enormous sums of money for cooling tower repairs by various companies.

Early investigators classified all of these troubles as delignification of the wood, with high sodium carbonate content in the water being the offending element. We now know that this is not the only source of trouble. The growth of fungi in towers can and does cause another type of attack which is possibly even more serious than so-called delignification. Unfortunately these fungi grow best in warm, moist areas, rather than water-washed areas of the tower, so that it is impossible to build up proper concentrations of algaecides and thus control this action.

There are other possible causes of the deterioration, such as: a) tower design, b) inferior wood, and c) other chemicals present or added to the water.

A great deal of effort is being expended at the present time to overcome this difficulty by, among others, the Cooling Tower Institute and the California Redwood Association. The ultimate solution has as yet not revealed itself, but let us hope that the answers will be found shortly.

At present a very concerted effort is being exerted by various groups of investigators to develop a radically different means of improving water quality. Fundamentally this is a process of electrolysis, using resinous membranes preferentially permeable to either positive or negative ions, as the case may be. This work is now in the pilot plant stage and has great promise, particularly from the standpoint of water conservation. The popular concept of this process seems to be the production of potable water from sea water. That is hoping for too much for the present—at least, at anything that would be a reasonable cost. However there are certainly numerous practical and economically feasible applicaitons for this means of water improvement when it is developed.

In this brief discussion an effort has been made to present some of the practices and recent developments in the field of industrial water conditioning. It can readily be seen that there are numerous and varied means of attacking the problems as they arise, and in most cases they can be successfully overcome. Let it be understood however that all the difficulties have not been eliminated, and further research and development must continue. However it is fully realized that the modern high pressure, extreme rating boilers, and complex cooling systems could not be operated without scientific practices in water conditioning.

Materials-Handling at Oil Mills

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MATERIALS handling in one form or another has presented its problems to man since the beginning of time. To Archimedes, about the year 300 B.C., goes the credit for conceiving the principle of the Archimedes screw, developed originally to lift water for irrigation purposes in ancient Greece. To Joseph, about the year 1900 B.C., goes the credit for outstanding performance on a huge grain-handling job. Pharoah had him store a supply of corn in the granaries of ancient Egypt during the seven years of plenty so that millions of people would have food during the seven years of drouth which was to follow.


C. S. Vercoe

But to Hercules goes the credit for the biggest materials-handling job performed single-handedly. In Greek mythology we read that King Augeas sheltered 3,000 oxen in a stable, which had not been cleaned for 30 years. The local sanitary commission finally put the heat on the king to clean up his stables and to do it in a hurry. King Augeas commissioned Hercules, the local materials-handling engineer, to do the job in a single day. Hercules had the know how and the brawn. He changed the courses of the rivers Alpheus and Peneus, ran them through the stables, and cleaned out the 30 years' accumulation within a single night.

So to Hercules goes the credit for solving one of the world's first big materials-handling jobs. And to King Augeas goes the doubtful honor of being a filthy housekeeper and the first man on record to put off the installation of materials-handling equipment for 30 long years. It is to be regretted that in our time many men are following the lead of King Augeas and putting off from day to day the installation of modern materials-handling systems which would speed production, reduce costs, save manpower, or clean up a filthy plant area.

In our modern oil extraction plants we cannot rely on the brawn of a modern Hercules to meet the capacities of exacting requirements which govern all of our operations of today. We therefore must secure the services of a good materials-handling engineer and a reliable manufacturer of equipment in order that the proper equipment be specified for the job. In so doing, needless delays in the production line and excessive maintenance costs will be eliminated.

Let's consider basic information required for nearly every job, keeping in mind that the more detailed and correct the data submitted, the better the installation should prove to be.

1. Material characteristics.
   a. What material is to be handled?
   b. Weight in pounds per cubic foot—not packed.
   c. Moisture content.
   d. Temperature.
   e. If lumpy, what are the sizes of lumps and the percentages of each?
   f. Is it corrosive?
   g. Is it abrasive?
   h. It is free-flowing?
   i. Does it flow in a sluggish manner?
2. Required capacity.
   a. Per minute, hour, and day.
   b. Total days per year.
   c. Will material be fed uniformly?
   d. Will there be surge loads—state maximum?
3. Distance material is to be moved.
4. Location of feed inlets and discharge openings.
5. Is equipment to be used only temporarily, or is the installation to be designed for long life?
6. Will the installation be made primarily for one or more of the following reasons:
   a. Reduce costs.
   b. Save manpower.
   c. Control or improve quality.
   d. Increase production.
   e. Improve working conditions.

Some of these factors naturally are of more vital consequence than others to the selection of conveying equipment for a given job. For instance, the varying physical characteristics of many materials to be handled form a major item in the proper selection of an elevating or conveying medium.

Take soybeans for an example. Are we to consider whole soybeans, cracked soybeans (with or without hulls), soybean flakes (raw or extracted), soybean cake, or soybean meal? The temperature and moisture content of the material while being handled also figure prominently in the proper selection of conveying equipment.

Or perhaps we should consider cottonseed (raw or delinted), cottonseed meats (raw or cooked), cottonseed cake (hydraulic press or screw press type), cot-