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Hon. Editor—R. G. ROGERS, "ELMFIELD," STONE, AYLESBURY, BUCKS.

CONFIDENTIAL BULLETIN FOR THE USE OF MEMBERS.

EDITORIAL.

IN the latter part of the year 1943, shortly after the formation of this Institution, I designed a crest, embodying a motto, which I thought might at some time be adopted as the official badge of the Institution. It has been so accepted and now appears on the cover of this page *Newsletter*, and I trust will meet with the approval of the members. It will also appear on the Certficates of Membership which will be issued as soon as the necessary signatures are appended.

The Council met on 6th December 1947, at the National Hospital, London, at which all the members were present. Before commencing the business on the agenda paper the members were warmly welcomed by Mr. Ewart-Mitchell the House Governor, who said how pleased he was to be able to place the board room at the disposal of the Council. The Chairman in reply thanked Mr. Ewart-Mitchell for his kindness in once again extending to the Council such excellent facilities for the conduct of our business.

Council dealt with 19 applications for membership and of these 3 were admitted to full membership, 11 as associate members, 1 as Graduate, 2 were referred back for further details and 2 were rejected. Four associate members applied for transference to full membership and Council agreed.

The Vice-Chairman reported on his recent visit to Northern Ireland, details of which appear under Northern Ireland branch news.

The question of modification of Branch areas was discussed with a view to bringing these into line with the area covered by the Regional Boards. It was resolved that the branches be asked to consider the matter and report back to the Hon. General Secretary'

The matter of the arrangements for the entrance examination of the Institution was discussed and a detailed report was submitted by Mr. Tomlinson. He said that unforeseen delays had occurred and in all probability the first examination would be held in January or February 1948.

A full report of the two meetings between the Ministry of Health and the organisations claiming to represent various categories of Hospital employees was given by the delegates who attended. They explained that there was a good deal of competition among the delegates present in their claims to represent the various sections of Hospital employees, but as far as the I.H.E. were concerned, we undoubtedly had the largest membership in our own particular field and therefore claimed proportionate representation. The Chairman and Hon. Secretary were appointed to represent the Institution at a meeting of the Whitley Council (Professional and

Technical Staff : Functional Council "B"), to be held on January 12th, 1948. At this meeting the Functional Council decided to divide into 4 groups which would be known as Committees of the Functional Council. These four Committees consist of :—The Medical Laboratory Technicians ; Dental Technicians , Dispensers; and Hospital Engineers. The Hospital Engineers' Committee is now composed of 15 members with the following representation :—

Institution of Hospital Engineers	4
Institution of Engineers in Charge	2
National Association Local Government Officers	2
Association of Scientific Workers	1
Con: of Health Service Employees	2
National Union of Public Employees	2
Association of Supervisory Staffs & Eng. Technicians	2

A further meeting of this Committee was held on the 9th March and the next meeting is convened for 13th April, 1948. Your duly elected representatives attended the former of these, and will also be present at the latter, to represent your interests.

The first entrance examination of the Institution was held at King's College, Strand, London, on 22nd and 23rd March, 1948. The examination was conducted entire by the College staff including the marking of the Candidate's papers. Six candidates took Part "A" and one candidate took Part " B " of the examination. The examiners congratulated the Education Sub-Committee on the excellent manner in which the details for the examination had been prepared and arranged.

The first Council meeting for 1948 was held at The Leeds Royal Infirmary on 3rd April, 1948, when Council had the honour of meeting our President, Lord Calverley. His Lordship attended the Council meeting and listened with great interest to the matters under discussion. He said he was glad to have the opportunity of attending as he felt that by so doing he could get a better picture of the working of the Institution and the aims and objects which we are pursuing.

Members of Council also had the pleasure of meeting Mr. Clayton-Friers, the House Governor of The Leeds Infirmary. He addressed the members and expressed his pleasure at being able to place the Board room at the disposal of the Council. He said he was sure we were working on the right lines in endeavouring to set a standard of efficiency in Hospital Engineering and wished the Institution every success.

There were 33 applications for membership, 5 were accepted as Members, 16 as Associate Members, 6 as Graduates, 1 was referrred back and 5 were rejected. Six applications for transference from Associate Membership to full membership were received, 4 were granted, and two were referred back to Branches. One application for transfer from Graduate to Associate Member was received and granted.

The Hon. Secretary stated that he regretted to report the death of a member, Mr. H. D. Watts of Wakefield. The Council stood in silence as a token of respect.

A resolution from the Edinburgh Branch regarding the issue of membership cards was not agreed to.

A resolution from Wales that Associate Members be eligible for office on Council was not agreed to.

A resolution from Yorkshire that the examinations be held in various centres was discussed and it was agreed that examinations may be held at centres other than London if there are sufficient candidates to warrant such a course.

The Hon. Secretary read a letter from the Society for Cancer Relief appealing for Funds and the Council agreed to make a donation of £5 5s. 0d.

Arising out of the report on Whitley Council machinery the Hon. Secretary explained that the I.H.E. are now entitled to four representatives on the Functional Committee Professional and Technical Staffs, Group "B". Council therefore appointed the following members to serve on this Committee : Mr. J. Hargreaves, Mr. R. E. Rogers, Mr. R. G. Rogers and Mr. R. H. Smith of Glasgow.

The question of dual representation of membership by the various bodies represented on the functional Council was discussed, and it was pointed out that it was obvious, that in many cases, more than one body was claiming representation of the same person when stating their membership figures in support of their claims for representation of the Functional Council. It was thereupon suggested that in order to clarify the position that any member of the I.H.E., who is also a member of another organisation, but wished to be represented by the I.H.E. on the Functional Council, should write immediately informing the Hon. Sec. of his decision, and also write to any other body represented on the Functional Council, and of which he is a member, stating that he does not wish the other body to claim representation on his behalf. Thus the true state of representation will reveal itself.

The modification of Branch areas was considered with a view to amending these to coincide with the areas covered by the Regional Boards. Reports were read from six Branch areas, and after discussion it was resolved that the areas remain as at present.

The matter of transference from one grade of membership to another was discussed, and it was resolved that when a member makes application for elevation from one grade to another, he shall complete a fresh application form, and attach it to his letter applying for elevation. Council rose at 9.50 p.m.

I am deeply indebted to R. H. Burns, Esq., B.Sc., F.R.I.C. for permission to publish the summary of his paper on "Boiler Feed Water Treatment," which he so kindly read to the London Branch at their meeting on October 18th, 1947, and which appears in this issue. Mr. Burns wishes to make it clear that the paper is not by any means the whole story on feed water treatment, but merely a summary of some of the salient points. I am sure it will be read with great interest.

EDITOR.

SUMMARY OF PAPER ON "BOILER FEED WATER TREATMENT"

BY

R. H. BURNS, B.Sc., F.R.I.C.

Boiler feed water treatment includes any process applied to the make-up or feed water which has as its object the ensuring of the minimum trouble in and the maximum efficiency of the boiler plant. It is only possible to run boiler plant efficiently if the feed water has been properly treated and lack of proper attention in this direction leads to failure which may be due to scale, corrosion, priming or caustic embrittlement.

Cause and Effect of Scale.

The main constituents of most scales are calcium carbonate, calcium silicate and/or calcium sulphate though at times other constituents such as magnesium salts, organic matter, iron oxide, etc., may also be present. So-called hard water contains appreciable quantities of calcium and magnesium salts and it follows, therefore, that if hard water is fed to a boiler without some form of treatment then sooner or later scale will be formed in the feed lines, in the economiser or on the heating surfaces or in all three places. Alternatively, a soft water is one that contains little if any calcium and magnesium salts and in consequence if used as boiler make up scale formation should be negilgible though as will be mentioned later other troubles may arise which can be equally serious.

Hardness in a water is of two varieties, temporary and permanent. Temporary hardness is due to the bicarbonates of calcium and magnesium which are thrown out of solution with the liberation of carbon dioxide when the water is heated. It is this form of hardness that gives rise to the deposits found in the feedlines and economisers, etc. The other salts of these metals present in water which are not destroyed by heat are termed permanent hardness and it is these that can cause the greatest trouble and give rise to hard adherent scales in boilers.

Of all the theories advanced to explain scale formation, the " seam bubble theory" is supported by the majority of evidence to hand. This theory holds that if a bubble is formed on a heating surface then a temporary insulation is formed between the water and the metal surface in which case the latter will become overheated at that point. Around the edges of the bubble there will be only thin layers of water and the salts present in this will very rapidly become supersaturated and deposition will occur. When the bubble bursts a ring of salts is thus left which will act as nuclei for further scale formation.

Another possible source of scale or deposit in a boiler is the suspended matter present in some water. Filtration of the water in question with or without some process of flocculation will be necessary in such cases.

It is the aim of any controlled boiler water treatment to precipitate those scale-forming solids which find their way to the boiler plant as a soft non-adherent sludge. Even if this is achieved this sludge can at times settle on the heating surfaces and become baked and form a layer which if not difficult to remove can act as an insulating layer and so impair he efficiency of a boiler.

It is now generally accepted that the effect of scale on fuel consumption is a function of the design of the boiler plant and in general the simpler the design the greater is the effect of scale.

There have been many and conflicting figures given for the loss of heat transfer due to scale,but Partridge, who carried out a classical research on this subject in America, considers that the average value of the heat conductivity coefficient is approximately 15 B.T.U. /sq. foot/hour/°F/inch for dense compact scales while porous scales may have a coefficient as low as 0.6. This authority considers that the actual heat loss due to 1/16" of scale is about 2% but points out that a much more serious result is the overheating of the metal which is of growing importance as boiler pressures and rates of driving increase.

It can be calculated for a boiler working at 100 lbs. pressure that if the safe maximum temperature for the tubes is taken to be 900°F. a coating of scale of only 1/7" thickness may be sufficient to cause this limiting temperature to be reached provided the scale has a thermal conductivity of 18 B.T.U./sq. ft./hr./°F./inch thickness and the heat input rate is 70,000 B.T.U./sq. ft./hour.

Softening.

It need hardly be stressed that when a hard water is the only source of supply for boiler make-up purposes then this water must be treated before it can be used safely in boiler plant.

There are two general standard methods of treating water for the prevention of scale and these are aptly termed (a) external and (b) internal treatments. (a) refers to those methods which treat the water before it is fed to the boiler plant and include the well-known softening processes such as the lime-soda and the base exchange methods. (b) includes treatments applied to the feed water at some point in the boiler plant to ensure that the solids which are thrown out of solution are, as far as possible, in a soft sludge form.

The two methods are to a great extent interconnected because it is seldom that a water from any type of softener is entirely suitable as boiler make-up and in consequence an additional treatment or final conditioning has to be applied to the feed water to ensure satisfactory results. Of all the methods available there is no doubt that the ideal is external softening by the lime soda process.

It is hardly necessary to go into full details of this well-known process but several points are worthy of special attention:—

(1) There must be ample capacity for allowing the precipitates to settle from the softened water and the time allowed for this should be at least 4 hours.
(2) If the water contains appreciable quantities of magnesia the use of sodium aluminate as an additional reagent is often of benefit.
(3) The efficiency of the process is greater when the treatment is carried out at an elevated temperature, i.e. preferably above 70°C.
(4) Wood wool is a satisfactory filtering medium ; sand filters are not advocated because of the tendency of the alkaline water resulting from the softening process to dissolve silica out of the sand and this is liable to give rise to silicate scales in the boiler.
(5) Any filter used should be changed periodically.
(6) With wood wool filters 2ft. 6ins. has been found to be a useful minimum thickness of the bed and the rate of flow through the bed should be kept as low as is practicable.

The function of the lime in the softening process is to combine with any free carbon dioxide and to react with the calcium bicarbonate in both cases with the formation of relatively insoluble calcium carbonate. Secondly to convert any magnesium salts into insoluble magnesium hydroxide. In the case of the permanent hardness due to magnesia another result of the reaction is the formation of an equivalent amount of permanent hardness due to calcium. This latter, together with any other permanent hardness due to calcium salts is dealt with by the soda ash added which converts it into insoluble calcium carbonate and a soluble sodium salt.

The chemicals used in the lime soda process should obviously be pure, some grades of lime for example contain appreciable quantities of silica. Again it is a relatively simple matter to calculate the required amounts of chemicals but if these are not of reasonable and standard quality the plant cannot function efficiently.

The softened water from a lime soda softening plant should be slightly alkaline in character having a small percentage of this alkalinity as the caustic variety and should have a total hardness of approximately 2 to 3 grains per gallon. It is very seldom possible with an ordinary cold process plant to reduce the hardness below this figure as calcium carbonate has a solubility of about this order.

Zeolite Softening.

The other class of softener in fairly constant use is the Zeolite or base exchange type of apparatus. Plants of this type in good working order are capable of producing a water of zero or near Zero hardness. They consist, fundamentally of a bed of natural Zeolite or synthetic material which have the property of replacing calcium and magnesium ions by sodium ions when water is allowed to flow through the material. After a time the bed becomes exhausted and no further exchange of calcium and magnesium ions for sodium will take place. The bed has then to be regenerated by using sodium chloride or as it is more commonly called, salt or brine. The brine process has the effect of replacing the calcium and magnesium ions absorbed by the bed during the softening run by sodium salts and after washing the plant is again ready to carry out its normal softening functions.

Large base exchange softeners are usually of the pressure type, that is, the water is softened under the pressure existing in the mains without appreciable loss of head. Hard water is allowed to flow through the softening material and the softened water is drawn off through nozzles and collecting pipes. The concentration of brine used for the regeneration process is usually between 5 and 10%. In most cases, prior to using the salt solution, water is allowed to flow in an upward direction through the softener and away to waste for a few minutes. This back washing removes any dirt which may have been filtered out of the water and re-arranges the bed. It should be emphasised, however, that the base exchange material should not be regarded as a combined softener and filter. Back washing should not be relied on to remove suspended solids deposited from a water and such impurities should be removed before treatment.

After the brine treatment the bed is finally washed out downwards with hard water until the effluent is of zero hardness. In the salt recovery system the spent brine from the previous regeneration is not run to waster but is used for the first stage of the next regeneration. After this used brine has been in contact with the base exchange material it is replaced by a freshly made salt solution and is run to waste.

A fairly recent innovation and improvement is the salt saturator type of brine tank. In this a saturated salt solution is always maintained in the brine tanks and a calculated amount of this is ejected on to the bed when required. The ejector is operated by water from the supply pipe to the softener and this water serves to dilute the saturated brine to a reasonable concentration. Thus there is no weighing of salt and no dissolving by hand.

Rapid strides and developments have been made in this branch of water treatment in the last few years but most of these are beyond the scope of a paper of this nature. It is now possible, for example to obtain a demineralised water which is virtually distilled water by the use of two softening beds. It is possible that the running costs of these processes may at some time in the future be reduced to such an extent that they become a practicable proposition as far as boiler plant work is concerned.

Of interest to all users of this type of plant is the improvement brought about in the synthetic softening materials. At one time these suffered in comparison with the natural zeolites owing to their lack of permanence but this has to a very large extent been overcome. Weight for weight most of the synthetic materials have a greater exchange capacity than the naturally occurring compounds and in consequence the softener can be made to yield a greater quantity of softened water between regenerations or if preferred the size of the plant can be reduced.

Both the lime soda and the base exchange methods of softening have their advantages and disadvantages but summing up and considering the question of softening for boiler feed the only benefit of the base exchange treatment is the production of a softer water. On the other hand the greater dissolved solids content of such a supply as compared with a lime soda softened water necessitates much more frequent blow down being practised. Again the excessive alkalinity of a base exchange softened supply, particularly in the case of a water high in temporary hardness, gives rise to many complications in operating boilers. On the whole it can be taken that as far as boiler feed water is concerned it is unwise to soften by the base exchange process.

Evaporated Water.

Undoubtedly evaporated water constitutes the purest form available but unfortunately evaporators are subject to many of the troubles common to boilers such as scaling and priming. In consequence they should themselves be fed with treated water. Further, there are certain salts in an ordinary make-up which are beneficial, for example, sodium sulphate which is an inhibitor against possible caustic embrittlement and this compound will be removed by evaporation as well as the harmful impurities. In addition, evaporated water is nearly always acid in character and requires treatment with alkali before it can be introduced into the feed lines. For normal working, therefore, it is seldom an economical or practicable proposition to employ this treatment unless the only water supply is of such a character that it is not amenable to ordinary chemical treatment.

Rain Water.

An alternative possibility as far as boiler make-up purposes are concerned, is the use of rain water. Rain water is the purest form in which water occurs in nature but unfortunately it is always acidic in character due to atmospherical electrical discharges and the sulphurous gases in the air formed in the combustion of coal and coke. Owing to this acidity rain water will dissolve out salts from the collecting surfaces and/or storage tanks. These salts are often those undesirable as far as boiler feed water is concerned—in particular the silica content of so-called rain water is often high. On the whole it is unwise to rely too much on this source of supply even if an adequate amount is available.

Internal Treatments.

It must be stressed that whenever possible it is by far the best practice to soften a boiler make-up by the lime soda process. The decision, however, as to whether or not a softening plant should be installed depends on several factors : a water for example that could be used with safety in Lancashire boilers with an internal treatment might cause severe troubles in water tube boilers. Again some waters are low in hardness and need only a final conditioning to give satisfactory results. Other considerations that have to be taken into account are the cost of a softener, the space required and the supply position. Further, if a softening plant is installed then it must be carefully controlled and one or two men detailed to maintain the plant. A badly run plant may be a greater source of danger than relying on the ordinary unsoftened supply. Even if a softener is in operation it is not advisable to rely entirely on this and it is usual even in such even in such cases to condition the softened water to ensure the minimum of scale formation and other inherent troubles.

As temporary hardness is destroyed by heat and the permanent variety by sodium carbonate in theory it should only be necessary in the internal treatment to add sufficient soda ash to unite with the permanent hardness of the feed water. This, however, is seldom sufficient and it is usually necessary to add one or more additional chemicals to ensure satisfactory working.

One of the simplest forms of internal treatment and one employed with considerable success in the London County Council hospitals and institutions is the controlled dosage of the feed water with soda ash and a tannin.

Tannins belong to a class of chemical compounds known as colloids and substances in colloidal solution have a very high surface area on which absorption can take place. The scale forming salts in the boiler water tend to precipitate on and concentrate on the colloidal particles and in this way become coated with tannin which prevents them from adhering to the metal or to one another and a true sludge is formed.

Another useful property of tannins as far as boiler feed water is concerned is that of coagulation. Most colloids carry an electrical charge when they are dispersed in water and these charges neutralise those of opposite sign carried by other particles resulting in mutual precipitation.

Colloids have also proved effective in reducing the rate of corrosive attack but this will be dealt with at a later stage.

As already mentioned the internal treatment with soda ash and tannin has been used with considerable success in the L.C.C. service. It is the usual practice and is only varied where it is found by experience that the character of the make-up water or some other local factors give rise to conditions unsuitable for this simple form of treatment. The chemicals are mixed together and dissolved in water and the solution slug fed to the boilers through the feed tank at a time when the feed pumps are working at their maximum capacity. It will be appreciated that if a sludge is formed in the boiler plant then the best locality for this to deposit is in the boiler itself. Here it will present the least difficulty from a celaning and removal aspect and this is the reason why slug feeding is advocated for by this means the chemicals are transferred to the boiler itself in the shortest possible time. There are some grounds for the belief that whereas this is true as far as the soda ash is concerned there are times when it is of benefit to add the tannin as a continuous dripfeed. By this means the particles of solids thrown out of solution by the action of heat, i.e., the calcium carbonate resulting from the destruction of the temporary hardness, are coated with tannin and in this way deposition in the economiser and feed lines is considerably reduced.

Another class of chemical which has come very much to the fore in the last few years, as far as the internal treatment of boiler feed water and final conditioning are concerned, are the phosphates. At one time these compounds were reserved for high pressure work owing to the expense involved but lately they are being used with considerable benefit in low pressure boilers.

The calcium phosphate formed under correct boiler water conditions is one of the most insoluble salts known. Further, this compound is soft and non-adherent so that the advantage in boiler work are obvious. In cases where the feed water contains any appreciable amount of silica it is very difficult to remove this and so ensure the absence of scale. In these circumstances the best procedure is to render the calcium and magnesium so insoluble that there are no salts of these metals left in solution to combine with the silica to form scale. It is in this direction that the phosphates have proved so invaluable.

There are three phosphates in general use for boiler water treatment—these are sodium hexameta phosphate, disodium phosphate and tri-sodium phosphate. Each has its own particular properties and uses.

With correct conditioning of the boiler water when using the phosphate treatment the calcium salts are converted into and precipitated as hydroxy apatite and the only points to be observed are that there must be a reserve of soluble phosphate within the boiler water and a definite alkalinity present. The reserve of phosphate usually recommended is about 50 parts per million and this is maintained to safeguard against the possible influx into the boiler of a water of higher hardness than normally encountered. The alkalinity is required to precipitate the phosphate in the correct physical form and also serves the additional purpose in that it minimises boiler corrosion.

Sodium hexametaphosphate is sold in the country under the trade name of Calgon and this form of phosphate offers certain advantages over the other two forms used in boiler water treatment as the precipitation of the insoluble form of calcium phosphate is delayed somewhat ; in consequence a greater proportion of the precipitation takes place in the boiler and not in the feed lines. Actually except when the feed water consists of condensate and evaporated make-up or where the feed lines are very short it is inadvisable to use the disodium or the tri-sodium phosphate unless these can be added direct to the boiler.

The three phosphates mentioned when dissolved in water give rise to solutions of very different pH values. By pH value is meant a measure of the acidity or alkalinity of a liquid ; a pH of 7 signifies a neutral solution, above 7 alkaline and below 7 acid. Calgon gives a near neutral solution, but the pH value of a 1% solution of the disodium and tri-sodium phosphates are 9.3 and approximately 12 respectively. In consequence these last two phosphates may be used to increase the alkalinity of the feed if necessary which is particularly useful if the make-up water is acid in nature.

On the whole it is preferable to use Calgon and to make any adjustment necessary in the alkalinity of the feed by the addition of soda ash when required.

Many people advocate the use of a tannin with a phosphate and from experience gained in the L.C.C. it would appear that where economisers are installed the addition of tannin is of benefit but otherwise the phosphate alone is generally sufficient.

Besides its well-known characteristic of locking up and preventing premature deposition of calcium salts, Calgon has also the property of dissolving up and loosening old existing scale. In order to take advantage of this latter property the Calgon should be fed to the boiler in shots because only by doing this is it possible to have the desired concentration of metaphosphate present at any one time. When a phosphate treatment is first started on a boiler care should be exercised and if necessary, the blow down increased as the aforementioned loosening of old scale may cause trouble from priming or blockage of blow down valves.

Blockage of Internal Feed Pipes.

Whenever water of appreciable hardness is fed to a boiler there is always a possibility of deposits forming in the feed line which may necessitate taking the boiler off the line. Various and ingenious devices have been used in an endeavour to overcome this difficulty but there does not appear to be any certain or sure remedy. In America they claim to have had considerable success by the slug feeding of Calgon by means of a special pump connected to the feed check valve.

At those hospitals and institutions in the L.C.C. where the full phosphate conditioning is in operation it has been found that the condition of the internal feed pipe after a normal steaming period is infinitely better than is the case with any other form of treatment.

There are many proprietary boiler water compounds on the market of varying degrees of efficiency but it is seldom that a complicated mixture is required. Soda ash and tannin conditioning or phosphate conditioning with or without tannin will give the best results depending on the water and the local conditions involved.

Electrical Devices.

There are several so-called electrical treatment devices for the treatment of boiler feed water and in all of these a small current is passed through the feed water on its way to the boiler and it is claimed that by this means a physical alteration in the water is effected that results in the prevention of scale.

With certain water and under certain conditions these processes appear to bring about an improvement. Unfortunately there is no way of forecasting the success or otherwise of the treatment.

In the L.C.C. laboratories some years ago a comprehensive test was carried out on one of the best known types and in consequence the maker's theories as to how the apparatus worked were definitely disproved. Following the laboratory experiments the treatment was tried out at a hospital under conditions and with a water that, according to the maker's, were entirely suitable. The process was, however, not a success and the boiler was found to be badly scaled.

The great disadvantage is that if reliance is placed on such methods for the removal of scale and the prevention of new deposits there are no known methods of ascertaining during the steaming period the success or otherwise of the process.

Testing of Water.

If any treatment is to be applied successfully it is imperative for periodical routine tests to be carried out. These tests need not be elaborate and are well within the capabilities of any intellignet boiler or plant operator.

If a softener is an integral part of the boiler plant then tests on the water must be carried out to determine if the output is satisfactory and to regulate the dosage of chemicals required. Equally important are the tests on the boiler water.

Probably the best position from which to draw the boiler water sample is from the blow down valve, but unless a continuous blow down system is in operation this is seldom practicable. The obvious alternative is from the gauge glass cock and although a sample so drawn may not be truly representative of the main bulk of the boiler water the results are usually sufficiently accurate for control purposes. If possible a cooling coil or similar apparatus should be employed to minimise the error due to flash off of steam. At least a pailful should be run off before taking the sample and if the guage glass cock is used the top cock should first be closed to prevent dilution with steam and the feed water should be shut off while the sample is being taken.

The water should be collected preferably in a clean iron or steel vessel although glass or stoneware is satisfactory if the sample is cooled and silica determinations are not required. Tinned or galvanised vessels should be avoided.

The sample so drawn should be cooled quickly out of contact with the air and the necessary tests carried out without delay.

Routine control tests should include estimations of the total and caustic alkalinity, hardness and total dissolved solids content and when the phosphate treatment is in operation a determination of the phosphate reserve.

At times a complete analysis of the boiler water should be made, particularly in cases of failure of treatments and where other complications arise. These comprehensive tests require the facilities of a chemical laboratory but nevertheless the regular routine testing of boiler waters is of incalculable benefit in regulating the feed water treatment.

It has been found in the L.C.C. service that an alkalinity of 50–60 grains per gallon of which the caustic variety is approximately 50% will give a zero or near zero hardness without giving rise of any complications in other directions. The maximum permissable total dissolved solids content must vary with the type of boiler and the nature of the make-up but as a general rule for Lancashire boilers 500 to 750 grains per gallon is a safe figure and for water tube boilers 300–400 grains per gallon.

Priming.

Both suspended and dissolved solids play a part in priming and various types of suspended matters have different effects. Normally however, a boiler water reaches its priming condition at a definite concentration of dissolved solids.

It has been stated that a condition of priming always exists in a boiler though in most cases this is of negilgible proportions.

If the boiler is not suited to the work for which it is being used or if a boiler is forced appreciably the moisture content of steam may be very appreciable. This moisture may be present as a finely divided spray or it may be carried over as slugs of water. The latter condition may arise from the sudden opening of a valve or valves but if the boiler water is badly conditioned then suspended solids will also be present and a condition of foaming is said to exist.

A number of anti-foam materials have been put on the market, notably castor oil, but these are inconsistent in their effects.

Blow Down.

It is obvious that unnecessary use of the blow down valve constitutes a grave and very real loss of sensible heat, particularly where no heat exchange system is in operation. On the other hand the heat saved in this way can easily be discounted if priming occurs.

The objects of blowing down are to lower the concentration of sodium salts in the boiler and to remove sludge which may assist priming or become baked on the heating surfaces.

The normal use of the blow down does little towards the removal of sludge as the latter is only cleared from an area approximately 2 feet in diameter around the blow down orifice every time the blow down valve is operated. In consequence if it is found necessary for example, to blow down a particular boiler two inches a week it is far better to carry this out by blowing down, say, four separate ½ inches than by removing the two inches at one time. The use of tannin in the boiler feed water treatment leads to an imporvement in this direction as more of the suspended solids are distributed in the main bulk of the water and in consequence more are removed when the blow down is carried out.

There are many advocates of the continuous blow down system and there is no doubt that the removal of sludge is far greater by this process. Again by the use of this method the dissolved solids content of the boiler water can be kept at any desired figure whereas with the occasional opening of the blow down valve the concentration of the water would be at the desired minimum only once per period.

Another point in favour of the continuous blow down system is that this process is much less likely to place appreciable strain on the run of pipe line in the blow down system. The sudden increase of temperature encountered with intermittent blow down must be expected to have a detrimental effect unless allowances for expansion are made.

Summing up the position all that can be said with confidence is that all boilers do at times requre a certain amount of blowing down and the quantity required will vary with the type of boiler and the nature of the feed water, etc. The only satisfactory method is to find the maximum permissable concentration of dissolved solids for the particular boiler in question and to keep the solids below this figure by the intelligent and controlled use of the blow down valve or by the continuous blow down system.

Corrosion and Erosion.

One possible source of corrosion in a boiler plant is the presence of certain unstable salts, such as magnesium chloride and calcium nitrate in the feed water. Fortunately, however, if the water is satisfactorily conditioned, i.e., if the water is alkaline, then no trouble should be experienced in this direction. A high chloride content is another potential source of danger in that the chloride ion is known to have film-destroying properties and thus to favour corrosion by preventing the formation of protective coatings. In order to control this sufficient alkalinity should be present to maintain a pH value of certainly not less than 10.5.

If ammonia is present in a steam boiler corrosion is almost inevitable, deep channels and jets being formed in the steam lines and the metal is converted into a nitride having the appearance of bitumen. The presence of large quantities of ammonia in water is rare and is usually due to sewage pollution. Great caution should, however, be exercised before any water that has been used in or is liable to be contaminated by an ammonia gas refrigerator plant is allowed to be used in a boiler plant.

The most serious corrosion encountered, however, in boiler plant is that due to oxygen and carbon dioxide, either singly or in combination and of the two oxygen is by far the worst offender.

In all cases of corrosion pitting is by far the most serious variety. A slight general wastage can continue for years without ill effect but the same amount of metal removed from a few localised areas may be sufficient to perforate the metal in a comparatively short time.

At one time it was considered that pitting was the result of the heterogeneity which exists in any metal but this cannot be the entire explanation. Mainly due to the work of Professor U. R. Evans, who put forward the differential aeration theory, it is now admitted that any corrosion is electro-chemical in character. The galvanic theory assumes that one part of the material corroded becomes positive (anodic) and another negative (cathodic), since salts in solution are dissociated into positive and negative ions, for example, in the case of common salt ($NaCl$), positive ions (Na), and negative ions (Cl), are formed. The negative ion (Cl) will be attracted to the anode where an acid (hydrochloric HCl), is formed and the positive ion (Na), to the cathode where an alkali (caustic soda—$NaOH$), is produced. In this way the anode will be attacked by acid while the cathode will be surrounded by an alkali zone which inhibits corrosion. It can be shown experimentally that if two identical strips of iron are immersed in a dilute salt solution and if oxygen (or air) is bubbled around one strip then an electrical cell is formed. The strip in contact with the oxygen becomes the cathode and the other being the anode is attacked and a loss in weight occurs. It is easy to see, therefore, that if oxygen is present, any part of a tube or plate that is protected is liable to corrosion which may result in severe pitting. As the pit holes become deeper a rust cone is formed and the metal becomes still further protected from the oxygen and the corrosion increases until the metal is perforated.

Similarly corrosion may take place beneath a pile of iron filings or even boiler sludge which prevent oxygen from reaching the affected area.

At one time it was considered good practice to form a thin scale in the boilers in the expectation that this would afford protection against corrosion. Theoretically, this may be sound but unfortunately in practice this is very difficult to realise. Any scale formed is seldom homogeneous or continuous and in consequence it is possible that any attempt in this direction will increase corrosion and certainly localise the attack rather than improve conditions.

Another type of attack due to galvanic action is the corrosion often resulting when two dissimilar metals are in contact. A connection between a copper and an iron pipe in the presence of an electrolyte such as feed or boiler water may result in attack on the iron. Further examples are the practice of suspending zinc plates in a boiler—the zinc being corroded preferentially, and by certain electrical protective treatments which aim at making the boiler a cathode in an electric cell. All treatments based on galvanic theories are, however, difficult to control and may cause corrosion in new localities even if they cure the original trouble.

Naturally soft and zeolite softened waters are known to be corrosive. Many naturally soft waters are acid in character and all soft waters have a great affinity for oxygen. In addition there is always the risk with a base exchange softened water that the brine used in regeneration is not completely removed and this again will increase the corrosiveness of the supply.

Corrosion is bound to be active if oxygen is present in the system and frequently in such cases the blame is placed on the feed water treatment, particularly as the absence of scale reveals the extent of the attack. An oxygen content in the feed water of over 0.05 ml. per litre is liable to cause serious trouble.

Graphite wastage in economisers is another type of attack due to oxygen. The tubes may appear quite sound but they can be cut easily with a knife. Cast iron is a metal which is very susceptible to shock and is considerably weakened thereby. It has been found that in places where bomb damage was sustained during the war the economiser tubes more likely are to be affected by corrosive conditions than elsewhere.

Another form of corrosion often encountered is the wastage and channelling of calorifier tubes and condense lines. In such cases carbon dioxide appears to be the main cause. If water containing temporary hardness is fed to a boiler then carbon dioxide will be liberated and carried away with the steam. Whilst the steam remains as such and the carbon dioxide is in the gaseous state no serious attack need be anticipated, but when the steam condenses the carbon dioxide goes into solution with the formation of carbonic acid and corrosive attack will take place. Another source of carbon dioxide in the steam is from the decomposition in the boiler of the sodium carbonate used in water treatment. This is but one example of the difficulties which arise in water treatment. Alleviation of trouble in one direction may easily give rise to other difficulties and a compromise has to be sought.

Excessive alkalinity in a boiler water is neither necessary nor desirable. Trouble will be experienced by attack on guage fittings, safety plugs and gauge glasses if the water is highly alkaline in character. Similarly the jointing materials will be softened and eventually leaks will occur. Experiments in the L.C.C. laboratories on typical jointing materials have shown that this attack by alkali should not be serious if the total alkanaility of the boiler water is maintained below 100 grains per gallon.

A form of attack on guage glass cocks and blow down valves often attributed to corrosion is more often due to erosion. The suspended solids formed in any boiler water will tend to lodge in and score fittings and eventually by the action of steam or hot water a channel is formed in the metal.

Corrosion Remedies.

It is far easier to list and comment on the various types and causes of corrosion that is it to put forward remedies. Usually a compromise has to be sought. There are, however, certain measures which can be taken and which do much to alleviate the troubles found and lead to greater efficiency of the plant.

The first point is that any water introduced into the boiler plant at any time must be alkaline. This is easily achieved and is a direct outcome of any correct form of boiler feed water treatment.

Next external softening by the lime-soda process is by far the best procedure. In this process the carbon dioxide present in the water is neutralised by the lime. Again the temporary hardness, another source of carbon dioxide, is greatly reduced and the sludge formed in the boiler reduced to the minimum. The latter entails less blowing down and consequently less make up, as oxygen is introduced with the make up the less this is in amount the better will be the all round conditions.

Tannins besides having the properties already listed are claimed to have oxygen absorbing properties and they certainly tend to form a protective coating on any bared metal surface.

Protective paints, such as those containing graphite, have their uses, particularly in the case of new plant. Unless the metal surface is cleaned thoroughly, however, these paints may localise the corrosion and do more harm than good.

Deaerators afford a valuable contribution towards minimising corrosion as they remove most of the oxygen and the carbon dioxide as well.

A chemical method for dealing with the oxygen is by the use of sodium sulphite or bisulphite. This method is effective but is usually only applied to the effluent from a deaerator on economic grounds and also because the chemicals used will increase the dissolved solids content of the boiler water. In consequence the oxygen content of the feed water should be decreased mechanically which will result in less sulphite being required.

Corrosion in steam lines, calorifiers and condense lines can be decreased by paying special attention to the quality of the steam. Prevention of priming and foaming and the elimination of oxygen and carbon dioxide from the feed will reduce this trouble to the minimum. There are also apparatus on the market by which chemicals, usually caustic soda, sulphite and tannin are injected into the steam line and are claimed to eliminate corrosion.

Protection of idle boilers will depend upon the time for which the boilers may be expected to be idle. When the boiler is to be out of use for a short time it should be filled completely with deaerated alkaline water. It is recommended that water tube boilers should be filled from the bottom upwards where practicable and arrangements made to extract air from the highest point to all parts of the boiler. Where deaeration cannot be assured chemical treatment with sulphite is advocated.

When the boiler is to be idle for long periods it should be placed in a state of preservation. Thorough cleaning of the water and gas surfaces should first be carried out and the boiler should be dried out by using ordinary airing stoves and quicklime in shallow sheet iron trays placed inside. A shallow sheet iron tray of burning coal well coked should be introduced into the boiler which should then be closed hermetically.

Most, if not all, the above-mentioned preventatives and remedies are practicable under normal working conditions and few require special and expensive plant. Certainly all are worth the trouble involved and many are essential for efficient working of boiler plant.

Caustic Embrittlement.

Another type of corrosion or failure and one which has given rise to much controversy is what is generally called caustic embrittlement of boilers. The identification of this type of attack has been made possible by the discovery that cracks resulting in steel from the action of caustic soda are intercrystalline and show no marked deformation of the grain whereas those due to fatigue or corrosion failure are trans-crystalline and are associated with grain deformation.

Laboratory work has shown that the following conditions must be present to cause embrittlement of mild steel :—

(1) The actual stress must be above the region of the yield point of the metal.

(2) The concentration of caustic soda must be in excess of 100 grammes per litre, and

(3) Silica must be present.

The composition of the boiler water must be the determining factor with regard to (2) and (3) and in many cases where embrittlement has occurred the feed water supply was derived from deep wells which contain considerable amount of sodium bicarbonate or where the make up water has been softened by the zeolite process. In both these types of water the sodium bicarbonate decomposes in the boiler with the ultimate formation of caustic soda.

It has been argued that the concentration of caustic soda developed in this way should never reach 100 grammes per litre in a boiler water. It has been confirmed, however, that greatly increased concentration takes place in cracks and seams and it is in such places also that the metal may be overstrained due to deformation by riveting, etc. That embrittlement occurs in the seams and cracks in a boiler has been amply substantiated by examination of suspected cases.

Since it was considered impracticable to alter the conditions of strain attention was directed to the possible influence of inhibitors which might be introduced into the boiler water. In this connection several chemicals were suggested and tried but of those normally present in a boiler water, sodium sulphate and sodium carbonate were found to be the most effective. As, however, sodium carbonate is slowly converted into caustic soda within the boiler and is thus a potential source of caustic alkalinity, it was considered safer to base the inhibition of embrittlement on control of the sulphate concentration.

The prevention of attack is due to the preferential deposition of sodium sulphate as opposed to sodium hydroxide, thus protecting the metal. Working along these lines investigation in America established what concentration of sodium sulphate was necessary at various temperatures to obtain this preferential deposition should the caustic soda content of the water ever approach the dangerous strength of 100 grammes per litre.

As the result of this work, it is now generally accepted that in order to eliminate the possible danger to embrittlement the ratios given below should have as minimum value the following figures :

Sodium sulphate in the boiler water
Caustic soda in the boiler water   Not less than 2.5.

Sodium sulphate
Total alkalinity   Not less than 1.

Knowledge on this subject is admittedly small and many people maintain that caustic embrittlement in low pressure boilers is not possible. Again tannins and phosphates are claimed to be efficient inhibitors. Nevertheless until further information is available it would seem advisable to continue to observe the sulphate ratios given above which have been found to give good results in practice.

De-oiling of Condensate.

It is essential to ensure that the feed water does not contain any dangerous amount of oil either as an emulsion or in suspension. In the emuslified state oil will increase foaming and carry over whilst suspended oil will adhere to the plates and tend to give rise to overheating of the metal.

Suspended oil may be separated quite efficiently by mechanical means as, for example, by passage through a baffle plate system. Vapourised oil, however, will not be separated in this way and will be condensed with the steam. It is good practice, therefore, to adopt some method which is equally applicable to suspended or emulsified oil and probably the best practice is that of coagulation and filtration.

The reagents usually employed are sodium aluminate or aluminium sulphate with caustic soda or sodium carbonate. When these are mixed and added to water the aluminium hydroxide formed traps the globules of oil and carries them to the bottom of the reaction vessel when they can be filtered out or withdrawn as a sludge. Sometimes a mixture of sodium aluminate and aluminium sulphate is used and in which case the dosage of each is adjusted so that the treated water is alkaline and therefore non-corrosive.

Of recent years several plants have been marketed which separate the oil electrically. The condensate is fed into a tank and a small current passed through two electrodes immersed in the water. By this method it is claimed that the oil particles are attracted to one of the electrodes and may be removed.

NORTHERN IRELAND BRANCH.

The above branch was favoured with a visit from Mr. J. J. Tomlinson, A.H.A., Chief Engineer of King's College Hospital, London, and Vice-Chairman of the Institution on the 22nd Nov. 1947, to meet the Irish members. Mr. Tomlinson flew over on the evening of the 21st November, and returned again by air on the 26th November ; during his stay he visited several of the largest hospitals in Northern Ireland including the Royal Victoria Hospital Belfast, Mr. R. Armstrong, Chief Engineer ; the Belfast Mental Hospital at Purdysburn, Belfast, Mr. L. Campbell, Chief Engineer ; the Whiteabbey Chest Hospital and Orthopaedic Hospital, Greenisalnd, Mr. M. Gray, Chief Engineer ; also the 'Ards District Hospital, Newtownards, Mr. J. Milliken, Chief Engineer and Purdysburn Fever Hospital, Purdysburn, Belfast, Mr. W. Gillespie, Chief Engineer. Mr. Tomlinson's visits were greatly appreciated by the Hospital Engineers, and his comments were both very interesting and instructive. On addressing the members at the War Memorial Hostel, Belfast, on Saturday afternoon, 22nd November, 1947, he emphasized the importance of ensuring that we kept the standard high and complimented the Chairman and Branch members on the care exercised before accepting Proposal Forms to put before the Council for Membership. He congratulated the Branch on the regular average attendance which is of a high order and hoped to renew the visit at an early date.

Mr. Tomlinson accompanied by the Branch Chairman and the Branch Secretary interviewed a Minsiter of Health representative at Parliament Buildings, Stormont, Belfast, and good progress resulted from the visit towards recognition.

All the Irish members expressed delight at Mr. Tomlinosn's visit and hope for an early return; they also expressed satisfaction at the progress made in view of the New Health Bill pending.

Irish members extend Greetings to their fellow members in all other Branches of the Institution of Hospital Engineers.

M. GRAY, *Hon. Secretary.*

Editorial Notice.

NEW BRANCH OF SPIRAX.

We are informed that the goodwill and business of Messrs. Ogden and Cunliffe, the long-established Manchester Engineering firm, has been purchased by Messrs. Spirax Manufacturing Co. Ltd., of Cheltenham and London.

Perhaps the most important among the products now added to the Spirax range as a result of this development, is the renowned "Ogden" Patent Automatic Pump (of Pumping Trap). This pump is widely used for lifting condensate to a higher level when discharge pressure is very low and is in considerable demand for an increasing number of condensate recovery schemes. The pump is used also in pumping petrol, oil, and various process liquors, including caustic, ammonia and others.

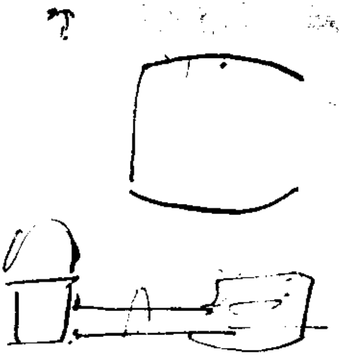
Mr. F. J. Cunliffe will continue in charge of technical management of this new branch of Spirax with the backing of the existing technical organisation of the Spirax Company. But no immediate changes are contemplated in the direction of service and supply.

GLASGOW BRANCH.

On Saturday, 10th January, the members and friends of the Glasgow and district branch enjoyed their third annual outing to the Kelvin Hall. Meeting at 4 p.m. for high tea in town, the party then made their way to the Carnival and Circus, where a most enjoyable time was had by all.

We are grateful to our Social Secretary for the excellence of the arrangements, and we trust this event will not be allowed to lapse, and we look forward to the time when more of the members in Scotland will avail themselves of this opportunity to join us in this annual social event.

R. H. SMITH, *Branch Secretary.*



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