
The President, Mr. W. H. Dobson, occupied the chair.

The minutes of the last General Meeting, held 22nd April, 1948, were read and approved on a motion moved by Mr. W. R. Pollock, and seconded by Mr. L. L. Pemberton.

Relevant correspondence was reviewed and notices given.

A ballot for admission as members of Mr. Alfred James Oxland and Mr. Victor Ernest Donkin, was conducted. Messrs. W. E. Mead and J. D. W. Ebeling were appointed as scrutineers.

A paper was presented by Mr. Geo. Parsonage, entitled “Water Treatment for Boiler Plant.” General discussion ensued.

Mr. Dobson (President) thanked Mr. Parsonage for his worthy effort, and asked for a vote of thanks. Mr. L. L. Pemberton moved, and Mr. W. R. Pollock seconded, and the vote of thanks was sustained by acclamation.

The ballot was declared in the affirmative for both candidates.

Meeting concluded with light supper.

Confirmed, 23rd June, 1948.

W. H. Dobson, Chairman.

Paper

Feed-Water Treatment for Boilers

By Geo. Parsonage

First of all, I wish to thank the President and Council of the Victorian Institute of Engineers for the opportunity of reading this paper.

I do not wish to convey to you fellow-members any degree of originality, but just a result of research and practical observation of my subject, being reasonably divorced from a chemical aspect.

Therefore, my subject shall deal with Feed Water troubles as pertaining to their causes and remedies.

Causes of Incrustation.

The purification of feed-water and maintenance of proper boiler water conditions are essential to the efficient operation of steam boilers.

The troubles to be guarded against are: 1. Scale. 2. Corrosion. 3. Caustic embrittlement. 4. Foaming and Priming, which in marine practice, may be referred to as (i) sea water, (ii) animal and vegetable oils, (iii) air, and (iv) galvanic action.

The treatment of boiler feed water has been a “bug bear” to many marine engineers and power-house operatives.

James Watt first found that water having heat applied to it in a vessel, when under control could do useful work, and as steam is given off,
the capacity of the remaining water is reduced, and without any “make-up” the impurities which did not pass over with the steam remained behind, thus causing the density of the water to rise, and this would increase until a point of saturation is reached.

So, as we must keep a constant water-level in the boiler, extra water must be pumped into it, and this causes a constant changing of the mass of water, and the impurities are being left behind to do their work of destruction. So it follows that for an efficient operation this water must be treated externally, and this is the point where chemical co-ordination is essential.

Many feed-waters used in boilers are impregnated with salts of lime and magnesia, generally in the form of carbonate or sulphate. These give to the water its property of hardness.

When such water is used in a boiler without previous treatment, it deposits the salts in the form of scale or powder, according to its chemical composition, inside the boiler.

**Temporary Hardness.**

This is due to the presence of carbonates, and can be removed by boiling, which drives off the carbonic acid, and causes the carbonate of lime or magnesia to be precipitated.

**Permanent Hardness.**

This is mainly due to the presence of sulphates, and heating up to ordinary boiling point (212° Fah.) does not practically affect the solubility, but, by evaporation, slow concentration takes place until saturation point is reached, when the sulphate is slowly precipitated and forms a hard tenacious scale.

But, as the temperature of a boiler is much higher than 212° Fah., depending on pressure, the solubility of sulphates becomes less with the rise of temperature, as shown in the following table.

**Influence of Temperature of Solubility of Sulphate.**

<table>
<thead>
<tr>
<th>Pressure</th>
<th>Solubility</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 lbs. sq. in.</td>
<td>212° Fah.</td>
</tr>
<tr>
<td>38 lbs. sq. in.</td>
<td>284° Fah.</td>
</tr>
<tr>
<td>79 lbs. sq. in.</td>
<td>323° Fah.</td>
</tr>
<tr>
<td>130 lbs. sq. in.</td>
<td>355° Fah.</td>
</tr>
</tbody>
</table>

The precipitation of sulphates will take place rapidly in a boiler under the effect of temperature and concentration of solution.

In an economiser the sulphates seldom form scale, as the solubility at the temperature there met with enables the water, except extreme cases, to hold in solution all the sulphates it contains.

If a boiler is allowed, however, to cool down with the water inside it a portion of the sulphate scale is redissolved, and can be easily removed in a wet condition.

But, on the other hand, the boiler is blown down, this action does not take place, but the scale adheres tenaciously to the shell and the tubes, etc.

The diminishing solubility of the sulphates as the temperature rises has suggested the method of precipitating them in a separate part inside the boiler by allowing the water to trickle over a series of trays, and to become rapidly heated, but this method is obviously of no use unless the amount of sulphate is greater than the water in the boiler can hold in solution.
Waters may contain both carbonates and sulphates in solution. The effect of the sulphates is to bind the carbonate scale into a hard compact mass, difficult to remove unless the water in the boiler is cooled down slowly and the scale removed in a wet state.

**Degrees of Hardness.**

The hardness of the water is usually expressed in degrees, one degree being equivalent to a solution of one part by weight of sulphate, carbonate or other hardening salts in one hundred thousand parts of water.

Some well waters contain as much as 30 degrees of hardness. With such a feed water, an ordinary mill boiler, burning say 25 tons of coal, and evaporating eight lbs. of water per lb. of coal, would deposit about 1½ cwts. of scale per week.

Occasionally waters are met with containing 80 degrees of hardness. Sometimes the hardening salt is expressed in grains per gallon, and a gallon (10 lbs.) contains 70,000 grains; therefore, one grain per gal. equals 1 3/7 degrees of hardness.

Each 100,000 gallons of water will deposit in the boiler 143 lbs. of scale-forming matter for every 10 degrees of hardness at the rate of 215 lbs. for every 15 degrees of hardness.

For example, a 30 ft. x 8 ft. dia. Lancashire boiler, working about 140 hours a week, with a water of 15 degrees of hardness, will deposit between 1½ to 1¾ cwts. of solids during that time.

**Sea or Salt Feed Water.**

Sea water contains from 3 to 4 per cent. by weight of salt, i.e., about 5 ozs. to the gallon, or 1/32 part by weight. The saturation point is reached when 35 ozs. to the gallon are present. Further concentration causes salt to be deposited. The density of the water is measured by a hydrometer or salimeter, an instrument consisting of a glass stem with a mercury containing bulb at the lower end; the salimeter is usually of brass, and graduated in 1/32 per gallon.

When floating in fresh water, at say 60° Fah, the zero mark is at the water surface, and when in clean salt water the 1/32 mark is at the surface. In marine practice, with surface condensers, the boilers can be marked up to 7/32 in naval practice; 1/32 corresponds to 10 degrees of hardness.

**Softening of Feed Water.**

When feed water is heavily charged with salts of lime or magnesia, the only satisfactory way of dealing with it is to treat it chemically, or by some water-softening process before entry into the boiler.

The addition of boiler compositions can, at most, only convert a hard scale into a soft one. Many of them are mere "nostrums." They may in no way reduce the amount of material to be removed, and do not prevent, but on the contrary, sometimes tend to accentuate its accumulation in the feed-water pipes and economiser tubes, from which its removal is both expensive and troublesome.

The installation of a water-softening plant may be rather expensive in the first instance, as compared with use of boiler compositions, but it may prove more satisfactory in the long run.

If the salts in the feed water are too small in quantity to justify the expense of a water-softening plant, and form a hard scale in the boiler, the simplest and best reagents to use are either caustic soda or soda ash, but these must be pure.
The quantity can only be determined by analysis, and it should be introduced along with the feed-water in a continuous stream; not spasmodically and at irregular intervals.

The fact that the water is clean and bright gives no indication as to the suitability of such water for boiler feed purposes.

In fact, it often happens that a town supply, which is in universal domestic use, causes more trouble in steam boilers than does a rather dirty-looking local stream.

If waters from both these sources require softening before being fit for use, it is most likely that the river water, containing an appreciable quantity of suspended matter, would cost less per thousand gallons to treat than the clean town supply. Whether the softening should be carried out in a heater, softener, or a cold water machine depends upon whether there is a plentiful supply of exhaust steam or not; but the fact that most steam users are making use of exhaust steam from reciprocating engines to drive exhaust steam turbines, makes it likely that in future most plants will treat the water when cold.

In considering the installation of a softener, it is desirable that the plant should be of ample capacity, and the settling tank should be of such dimensions that the water takes at least 24 hours in its passage through the tank.

A well-known water-softener company makes a standard practice of allowing a minimum settling capacity of three hours, while on some machines, which this same company has installed, a settling capacity of even six hours has been allowed.

One of the patents of this company's process consists of a revolving "sludge" gear, designed to eliminate internal cleaning of the settling tank. Two revolving hollow arms in a half a revolution will remove the accumulated sludge, so that the manhole door only requires to be opened at the annual inspection.

A great advantage obtained by treating hard, muddy water is that the softening process clears the water of suspended matter.

**Grease and Floury Deposit.**

Some waters, especially those impregnated with salts of magnesia, throw down a fine floury deposit in the boiler. With such waters the presence of a little grease derived from exhaust steam may give rise to serious trouble from overheating. Straining and leakage at the seams and the rivets are the commonest signs of distress, but in extreme cases the furnace plates may be bulged, and even ripped. In surface-condensing plants great care requires to be exercised to prevent grease getting into boilers. If engines are lubricated, oil should be sparingly used, especially when swabbing the piston-rods, and oil filters or separators adopted to intercept the grease in feed-water.

**Corrosion.**

Corrosion in steam boilers may arise from a variety of causes. Some causes are acid in feed water, decomposition of acid salts in the scale, air introduced with the feed water, and galvanic action. Whatever its cause, however, the ill-effects can generally be reduced or neutralised by means of an alkali such as soda ash, or, in the case of air, the use of air pumps and a feed-water heater.

The soda ash should be dissolved and introduced in a small, continuous stream along with the feed-water, and for this purpose a small subsidiary pump is very convenient.
FEED-WATER TREATMENT FOR BOILERS.

In marine practice, especially with Scotch boilers, where a large volume of water is contained, protection against corrosion is afforded by securing zinc blocks to various parts of the boiler.

It is essential, however, that thorough metallic contact between the surfaces should be made to get full advantage of the protective influence of the zinc, which is comparatively limited in its radius.

Air has been a well recognised cause of corrosion for many years. Many instances of rapid corrosion have been proved to have been caused by the feed pumps sucking in air from the hot well, and the feed being delivered to the boiler at a level considerably below the water line.

Small bubbles of air expelled from the water on boiling attach themselves tenaciously to the heating surfaces.

The oxygen in these air bubbles at once begins war on the steel, and forms iron rust, making a thin crust or excrescence, which when washed away by the circulation or dislodged by the expansion and contraction of the steel, leaves beneath a small pit. "Pitting" once started progresses rapidly, as each indentation forms an ideal resting place for further bubbles of air, and at the same time present increased surfaces to be attacked.

It is mostly at the water level this pitting is in evidence.

Fresh water at 32° Fah. absorbs 4.9 per cent. of its own bulk of oxygen; at 50° Fah., 3.8 per cent.; and at 68° Fah., 3.1 per cent., whilst salt water absorbs more air than fresh water.

To prevent the introduction of air into the boiler, the hot water should be pumped to a filter tank situated 8 to 10 feet above the feed pump suction valves.

By doing this, a large amount of air rises and is liberated from the surface of the water, and a head of water at the suction valves of the feed pump is assured.

Cost of Softening Feed-Water.

The cost of softening water depends on the nature and quantity of the salts in solution. To remove calcium carbonate (carbonate of lime), lime alone is necessary, and this is cheap. To remove calcium sulphate (sulphate of lime), however, it is necessary to use sodium carbonate (soda ash), whilst for the removal of magnesium salts caustic soda is necessary.

Another Water Softening Process.

Depends for its action on the fact, well known to agricultural chemists, that certain minerals, termed zealites, possess the property of exchanging their alkaline base for a calcium equivalent, and an investigation of the bearing of this on the nourishing plants led Dr. Gaus, of Berlin, to discover a method of preparing zealites artificially. These compounds, which he terms "permuctts" (i.e., exchangers), on account of their capacity to effect chemical change can be applied to the softening of hard waters. The one generally used for this purpose is a double silicate of aluminium and sodium.

The process of softening is affected by simply passing the water through a bed of this "permuctt." This causes the hardening salts in the water, viz., the carbonates or sulphates of lime and magnesia, to be converted into carbonates or sulphates of sodium, which are very soluble and may be passed into the boiler with less liability to form scale or deposit.

The softening action continues until all the soda base of the "permuctit" is exchanged for a lime or magnesia base.

The "permuctit" then becomes inert and incapable of exerting any further chemical action on the water.
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