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BOILER WATER CONDITIONING

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1 Claim. (Cl. 210—23)

This invention relates to boiler water treatment.

In use of a steam generating boiler it is of importance that the water introduced to the boiler be freed, or substantially freed, of dissolved oxygen prior to its introduction. This is for the reason that oxygen in the boiler water is an active adjunct to boiler corrosion. It is also of importance that in the boiler there be maintained favorable conditions of such nature as to inhibit the formation of encrustations on the inner surface of the boiler wall.

I have succeeded in inhibiting both oxygen produced boiler corrosion and boiler encrustation by introducing into the boiler feed water a water soluble phosphite. As dissolved in the boiler feed water, phosphite performs the dual function of reducing agent and encrustation inhibiting agent.

The phosphites of the alkali metals, sodium, potassium, and ammonium are all suitable for my purpose, all being adequately water soluble. Thus I have found advantageously usable disodium phosphite (Na_2HPO_3); acid sodium phosphite (NaH_2PO_3); sodium hypophospnite ($Na_2H_2P_2O_6$); potassium phosphite (K_2HPO_3); potassium hypophosphite (KH_2PO_2); ammonium phosphite ($NH_4H_2PO_3$); and ammonium hypophosphite ($NH_4H_2PO_2$).

In each instance the phosphite may be added in appropriate quantity to the boiler feed water, and is carried to the boiler. In solution in the feed water, and/or in the boiler concentrate, the phosphite molecules each take up oxygen to pass into the form of the appropriate phosphate. In the presence in the boiler of an adequate excess of the basic radical, it also passes into the tribasic form.

As all well conditioned boiler concentrates carries more or less sodium hydroxide, or its equivalent, there will normally be maintained in the water an excess of sodium radical, or potassium radical. If, therefore, a sodium or potassium phosphite be used, there is normally present in the boiler a sufficiency of the appropriate radical to produce the tribasic phosphate.

The reactions involved are thus, for example:

$$2Na_2HPO_3+O_2\rightarrow 2Na_2HPO_4$$

$$Na_2HPO_4+NaOH\rightarrow Na_3PO_4+H_2O$$

Under boiler conditions, therefore, the initial sodium or potassium phosphite, in performing the useful function of deoxidation, is converted into a phosphate reactive with compounds of calcium and magnesium. These latter are the agencies producing boiler encrustation, as they may exist in the boiler in the form of calcium or magnesium sulphate or carbonate. To give a typical reaction for this effect, trisodium phosphate (Na_3PO_4) reacts both with calcium sulphate (Ca_3SO_4) and calcium carbonate (Ca_2HCO_3) as follows:

$$2Na_3PO_4+3CaSO_4\rightarrow Ca_3(PO_4)_2+3Na_2SO_4$$

$$2Na_3PO_4+3CaCO_3\rightarrow Ca_3(PO_4)_2+3Na_2CO_3$$

The reactions with the compounds of magnesium normally present in the boiler water are identical.

Of the products of reaction, calcium phosphate precipitates. This, however, is a sludge forming precipitate and not a crust forming precipitate. In proper proportions, sodium sulphate and sodium carbonate are not objectionable in the boiler water.

Ammonium phosphite being used for the boiler conditioning, the first result of reaction is an oxidation, with the formation of mono-ammonium phosphate. In the presence of sodium hydroxide, this mono-ammonium phosphate, in turn, reacts with it to produce tribasic sodium phosphate. The formulæ for these reactions may be given as follows:

$$2NH_4H_2PO_3+O_2\rightarrow 2NH_4H_2PO_4$$

$$NH_4H_2PO_4+3NaOH\rightarrow Na_3PO_4+3H_2O+NH_3$$

We thus have, from the addition of ammonium phosphite also, an inclusion of the trisodium phosphate in the boiler water. As above explained, and illustrated, this secondary product of reaction reacts with the compounds of calcium and magnesium normally present to produce the sludge forming calcium phosphate and magnesium phosphate.

The ammonia (NH_3) goes over with the steam, and performs a conditioning effect thereon. In any condensate of the steam, as it occurs in lines, cylinders, turbines, or the like, the ammonia reacts with any contained carbon dioxide to produce ammonium carbonate. In this manner the ammonia carried over with the steam prevents carbon dioxide corrosion, as may be illustrated by the following formula:

$$2NH_3+CO_2+H_2O\rightarrow (NH_4)_2CO_3$$

The advantages attending the use of a potassium phosphite are identical with those obtained by the use of a sodium phosphite. The specific advantage attendant upon the production of ammonia in the boiler is, therefore, that it is car-

ried over with the steam, and is thus enabled to nullify the corrosive tendency of carbon dioxide in any connections and equipment to which the steam passes. For this reason I prefer to utilize a phosphite of ammonium.

To summarize: a soluble phosphite added to the boiler feed water deoxidizes the water, thus fully performing the reducing function previously performed by sodium sulphite, and incidentally exhibiting an increased deoxidizing activity as compared with that compound; it further performs the additional function of inhibiting boiler encrustation, by reaction with calcium and magnesium, in its progressive activity in the boiler. If a phosphite of ammonium be used, the third function, attributable to ammonia, of inhibiting carbon dioxide corrosion by the steam passing from the boiler is obtained.

While I have disclosed as peculiarly suitable the phosphites of sodium, potassium, and ammonium, I do not intend to limit the scope of my invention to the utilization of the phosphites of these alkali metals. Any adequate water-soluble phosphite is capable of performing both the function of removing oxygen from the boiler water, and the function of forming a phosphate reactive with the encrustation forming substances, calcium and magnesium.

On the quantitative side, the secondary effect obtained by adding a water-soluble phosphite to the boiler feed water, and the tertiary effect of adding ammonium phosphite to the boiler feed water, is dependent upon the presence of oxygen content in the water adequate to effect saturation of the phosphite. If, then, the water has initially a notably low oxygen content, it may be desirable to introduce into the boiler a water-soluble phosphate in order that the encrustation inhibiting reaction may be complete, or to lessen the calcium and magnesium content, by appropriate treatment of the boiler feed water. It cannot be considered, however, that occasional initial preponderance of calcium and magnesium content over oxygen content in the boiler water detracts from the sequential completeness of the favorable result obtained by the use of phosphite.

It will be understood from the above that the phosphite employed should be added to the feed water in combining proportion with the determined oxygen content of the water available for use in the boiler.

I claim as my invention:

The method herein described of conditioning boiler water and steam generated therefrom which comprises deoxidizing the water by the reducing action of ammonium phosphite thereon, by sequential reactions of the phosphate produced by oxidation in the boiler water removing from the water the encrustation forming content thereof, and in the sequential reactions of the phosphate produced by oxidation of ammonium phosphite liberating ammonia to pass from the boiler with steam generated in the boiler.

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