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TREATMENT OF STEAM BOILER WATER

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The present invention relates to the treatment of steam boiler water, and more especially to the prevention of corrosion of the boiler metal in a steam boiler in which the alkalinity of the boiler water is maintained relatively low so as to prevent objectionable carry-over of water in the steam.

Most of the water treating compounds used for preventing boiler scale are alkaline in character, resulting in considerable alkalinity in the water in the boiler. This alkalinity is of advantage in minimizing corrosion of the steel metal of the boiler, but is likely to cause trouble by the carry-over of water with the steam, particularly in boilers having small steam space, such as locomotive boilers. The alkalinity tends to cause foaming the boiler, which results in entrainment in the steam of the water in the foam. If the alkalinity be reduced to the point where foaming and carry-over of water with the steam are prevented, then the corrosion difficulties encountered are greatly increased.

I have found that the foaming and carry-over of water with the steam can be substantially prevented, and at the same time the corrosion of the boiler metal and the deposition of scale substantially prevented. This is accomplished preferably by supplying to the boiler a phosphate which maintains a sufficiently low alkalinity in the boiler water to prevent foaming and carry-over, and at the same time prevents the deposition of adherent scale. The tendency to increased corrosion under the decreased alkalinity maintained in the boiler water is counteracted by a chromate which maintains an oxide film on the boiler metal, thereby substantially preventing corrosion.

In carrying out my process I preferably supply to the boiler water sodium metaphosphate or sodium pyrophosphate, preferably a mixture of sodium metaphosphate and sodium pyrophosphate, together with an alkali-metal chromate, preferably sodium chromate.

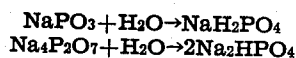
I use the expression "molecularly dehydrated phosphate" to distinguish the meta- and pyrophosphates from the orthophosphate. Sodium metaphosphate may be prepared by strongly heating monosodium dihydrogen orthophosphate, whereupon a reaction occurs as follows:



Similarly, sodium pyrophosphate may be prepared by strongly heating disodium monohydrogen orthophosphate, the reaction occurring as follows: $2\text{Na}_2\text{HPO}_4 \rightarrow \text{Na}_4\text{P}_2\text{O}_7 + \text{H}_2\text{O}$. In each case

there is a rearrangement of the atoms within the molecule and water is driven off from the orthophosphate during heating. This may be spoken of as molecular dehydration, as distinguished from dehydration resulting in heating a salt to drive off water of crystallization.

When solutions of sodium metaphosphate and sodium pyrophosphate are subjected to prolonged heating, especially at the temperatures encountered in boiler water, the metaphosphate and pyrophosphate are rehydrated, the reactions occurring as follows:



The acid salts thus formed yield acid hydrogen which neutralizes any excess alkalinity in the boiler water. The orthophosphate produced by the rehydration combines with the calcium in the boiler water, producing tricalcic phosphate which is deposited as a non-adherent sludge removable by blowdown. The conversion of the calcium into the non-adherent tricalcic phosphate salt prevents the formation of adherent calcium-sulphate scale.

I prefer to employ a mixture of sodium metaphosphate and sodium pyrophosphate so proportioned as to yield the requisite amount of acid hydrogen to maintain the desired low alkalinity in the water in the boiler. The sodium metaphosphate upon rehydration yields more acid hydrogen and consequently an increase in the proportion of sodium metaphosphate gives a greater alkali-neutralizing capacity to the mixture. If desired, sodium metaphosphate may be used alone or a small amount of caustic soda or sodium carbonate may be mixed with it which will neutralize acid hydrogen beyond that required for maintaining the properly reduced alkalinity in the boiler water.

The reactions occurring in the boiler water upon the rehydration of the sodium metaphosphate or sodium pyrophosphate, and the alkalinity control secured thereby, are described in detail in the Hall and Jackson Patent No. 1,903,041, of March 28, 1933. The action of the orthophosphate in forming the non-adherent sludge and in preventing adherent scale is described in detail in the Hall Patents Nos. 1,613,656 and 1,613,701 of January 11, 1927. The exact amount of the phosphate to be added to any particular boiler water may be calculated according to the directions set forth in the patents referred to above. A sufficient amount of sodium metaphosphate and/or sodium pyrophosphate should

be added so as to precipitate the calcium in the boiler water as non-adherent tricalcic sludge, and to maintain the alkalinity of the boiler water at a point where objectionable foaming and carry-over will be prevented. Ordinarily, the alkalinity should be maintained at a pH value of not over about 11.

The low alkalinity thus secured minimizes foaming and carry-over of water with the steam. It also simplifies the protection of the boiler from any embrittling action by making smaller the required sulphate concentration recognized as requisite in relation to the alkali. The low alkalinity of the boiler water, however, tends to allow corrosion of the boiler metal to proceed much more rapidly than with a more highly alkaline boiler water. The corrosion problem is particularly serious in boilers using natural undeaerated waters, or in boilers such as locomotive boilers in which the metal parts exposed to the boiler water are subjected to severe strains.

I have found, however, that the control of the carry-over and the prevention of boiler scale by the use of the sodium metaphosphate and/or sodium pyrophosphate may be secured without substantial corrosion of the boiler metal by introducing into the boiler water an alkali-metal chromate such as sodium chromate or sodium bichromate. The action of the chromate is apparently to maintain a thin oxide film on the surfaces of the boiler metal which prevents corrosion.

The chromate may also serve as a buffer salt as a safeguard against too great acidity or too great alkalinity. A normal chromate by its conversion into bichromate supplies a considerable capacity for the neutralization of acidity without interfering with the maintenance of the desired low alkalinity in the boiler water, since the pH value of the normal chromate is about 7.5. A bichromate by its conversion into the normal chromate in an alkaline water supplies a considerable capacity for the neutralization of too great alkalinity. The metaphosphate may be supplied to the user as a mixture containing metaphosphate and a bichromate in case greater alkali-reducing capacity is required than that furnished by the metaphosphate itself. A mixture of sodium metaphosphate and a normal chromate may be supplied in case the metaphosphate alone would cause too great acidity in the boiler water.

The chromate, whether in the form of a normal chromate or the bichromate, when added to the feed water protects the feed water storage and supply apparatus against corrosion, as well as protecting the boiler metal against corrosion. The chromate also furnishes some protection against embrittlement of the boiler metal.

Enough chromate should be supplied to insure the maintenance of an adequate protecting film and to serve as a buffer salt. Ordinarily, a concentration of not less than about 100 parts of sodium chromate per million parts of water should be maintained in the boiler water.

I prefer to use sodium metaphosphate in the form ordinarily known as "Graham's salt" or sodium hexametaphosphate. This is a readily soluble salt which may be obtained by heating strongly monosodium dihydrogen orthophosphate and quickly cooling the fused mass. I prefer to use the pyrophosphate in the form of tetrasodium pyrophosphate which is readily soluble. However, other sodium meta- and pyro-phosphates may be employed, as well as the other alkali-metal molecularly dehydrated phosphates such as po-

tassium metaphosphate or potassium pyrophosphate. Also, while for most purposes I prefer to use sodium chromate, I may use sodium bichromate, or I may use other alkali-metal chromates such as potassium chromate or potassium bichromate. I intend the words "alkali-metal chromate" to include the bichromates as well as the normal chromates. While I prefer to employ the metaphosphates or pyrophosphates for the control of the alkalinity, the alkalinity may be otherwise controlled, as, for example, by the addition of acid orthophosphate such as monosodium dihydrogen phosphate, disodium monohydrogen phosphate, or phosphoric acid. These phosphates not only furnish acid hydrogen to neutralize excess alkalinity, but also furnish phosphate to prevent the deposition of adherent boiler scale. However, the low alkalinity may be secured by the use of other chemicals which will yield acid hydrogen to neutralize excess alkalinity, such, for example, as acid salts like sodium acid sulphate, or even acids themselves.

While I have specifically described the preferred embodiment of my invention, it is to be understood that the invention is not so limited, but may be otherwise embodied and practiced within the scope of the following claims.

I claim:

1. The process of treating the water in a steam boiler, which comprises supplying to the boiler water a chemical containing a molecularly dehydrated phosphate radical which is rehydrated in the water in the boiler to a condition of greater alkali-neutralizing capacity, and an alkali-metal chromate which protects the boiler metal against corrosion.

2. The process of treating water for steam boilers, which comprises supplying to the water an alkali-metal metaphosphate and an alkali-metal chromate.

3. The process of treating water for steam boilers, which comprises supplying to the water an alkali-metal pyrophosphate and an alkali-metal chromate.

4. The process of treating water for steam boilers, which comprises supplying to the water an alkali-metal metaphosphate, an alkali-metal pyrophosphate and an alkali-metal chromate.

5. The process of treating water for steam boilers, which comprises supplying thereto a molecularly dehydrated phosphate radical which is rehydrated in the water in the boiler to yield acid hydrogen which neutralizes excess alkalinity in the water in the boiler and orthophosphate which prevents deposition of adherent boiler scale, and an alkali-metal chromate which protects the boiler metal against corrosion.

6. The process of treating water for steam boilers, which comprises supplying thereto a sufficient amount of molecularly dehydrated phosphate radical to yield upon rehydration in the water in the boiler sufficient acid hydrogen to maintain the alkalinity therein at a pH value of not over about 11 and to yield sufficient orthophosphate to prevent the deposition of adherent boiler scale, and an alkali-metal chromate in sufficient amount to maintain a concentration in the water in the boiler of not less than about 100 parts per million of alkali-metal chromate.

7. The process of treating water for steam boilers, which comprises supplying thereto a phosphate which yields acid hydrogen to control the alkalinity of the boiler water and orthophosphate to prevent deposition of adherent

boiler scale, and a chromate which protects the boiler metal against corrosion.

5 8. A composition for the treatment of water for steam boilers, comprising a chemical containing a molecularly dehydrated phosphate radical which is re-hydrated in the water in the boiler to a condition of greater alkali-neutralizing capacity, and an alkali-metal chromate which protects the boiler metal against corrosion.

10 9. A composition for the treatment of water for steam boilers, comprising an alkali-metal metaphosphate and an alkali-metal chromate.

15 10. A composition for the treatment of water for steam boilers, comprising an alkali-metal pyrophosphate and an alkali-metal chromate.

11. A composition for the treatment of water for steam boilers, comprising an alkali-metal metaphosphate, an alkali-metal pyrophosphate, and an alkali-metal chromate.

12. A composition for the treatment of water for steam boilers, comprising a molecularly dehydrated phosphate radical which is re-hydrated in the water in the boiler to yield acid hydrogen which neutralizes excess alkalinity in the water in the boiler and orthophosphate which prevents deposition of adherent boiler scale, and an alkali-metal chromate which protects the boiler metal against corrosion. 5

13. A composition for the treatment of water for steam boilers, comprising a phosphate which yields acid hydrogen to control the alkalinity of the boiler water and orthophosphate to prevent deposition of adherent scale, and a chromate which protects the boiler metal against corrosion. 10 15

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