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CORROSION INHIBITION IN FUEL FIRED EQUIPMENT

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10 Claims

ABSTRACT OF THE DISCLOSURE

The invention relates to corrosion inhibiting composition adapted to be painted onto heating equipment surfaces that operate in a temperature range below about 400° F. The composition comprises a liquid suspension of about 23% to about 57% by weight of particles ranging in size from about 1 to about 25 microns of magnesium hydroxide and/or magnesium oxide with 1% to about 5% by weight of an alkali metal aluminate binder.

This application is a continuation-in-part of application Ser. No. 566,257, filed July 19, 1966 now abandoned.

This invention relates to a composition and method for preventing corrosion in fuel-fired equipment.

Corrosion problems arise in many types of low-temperature fuel-fired equipment, including domestic warm-air furnaces, domestic hot-water or low-pressure steam boilers, commercial package or field-erected hot-water or low-pressure steam boilers, industrial hot-water or low-pressure steam boilers, low-temperature auxiliary heat recovery equipment such as economizers and air preheaters, and flue gas ducting. The term "low-temperature" as employed in this specification has reference to metal surfaces that operate in the temperature range below 400° F. and which may be exposed to flame impingement either intermittently or continuously.

Manufacturers and users of heating systems of the aforementioned type have been faced with severe corro sion problems and more particularly the corrosion of low-temperature or "cold end" surfaces by sulphuric acid that is condensed from flue gases. The problem is especially pronounced in package boilers. Furthermore, corrosion rates are greatly accelerated when residual fuel oils containing over ½% sulphur are employed to fire equipment such as hot-water or low-pressure steam boilers.

When accelerated corrosion occurs, it is common practice to replace tubes and tube sheets every two or three years and, in some cases, every year. In many boilers, corrosion rates of the order of 50 mils per year, which is well in excess of the economic limit of 0–5 mils per year, are not uncommon.

Efforts to find a solution of the corrosion problems described have been the subject of much research. However, existing remedial measures, including the use of fuel oil additives, sulphur-free fuels and corrosion resistant materials are either only partially effective or are uneconomical in practice. Use of a fuel low in sulphur is an effective remedy but such fuels are usually much more costly than sulphur containing fuels. Moreover, there are no readily available acid resistant metals that can successfully withstand the wide range of acid concentrations existing in firetube boilers. Acid-inhibiting fuel oil additives are at most only about 35% effective when used in recommended dosage rates. The reason for this is that over 80% of the additive as blended in the oil escapes to the atmosphere in the flue gases, leaving less than 20% to deposit on the boiler surfaces subject to acid condensation. Moreover, in many instances, and particularly in the case of the heating class of boiler used in large numbers in apartments, office buildings, schools, and the like, it is uneconomical to install additive blending and mixing equipment in the small oil tanks of such boilers.

The invention seeks to provide a composition and method for inhibiting sulphuric acid corrosion of low-temperature heating equipment surfaces in a simple, effective and economical manner.

When sulphur-bearing fuels are burned, most of the sulphur is oxidized to sulphur dioxide (SO_2) while a smaller portion, usually less than 5%, is further oxidized to the trioxide (SO_3). At temperatures below 550° F., SO_3 combines with water vapour (H_2O), always present in flue gases, to form H_2SO_4 vapour. The sulphuric acid then condenses on surfaces cooler than the acid dewpoint temperature. Acid dewpoint is known to vary from 140° F. to 350° F. depending on the concentration of SO_3 and the partial pressure of the water vapour.

As previously indicated, heating equipment surfaces, such as those of low pressure steam and hot water boilers, normally designed to operate with metal temperatures ranging from 120° F. to 275° F., when burning residual fuel oils containing 1% to 3% or more of sulphur by weight, are extremely susceptible to sulphuric acid or low-temperature corrosion. Furthermore, these metal surfaces are prone to moisture corrosion during periods of "start-up" and "shut-down" and during summer storage when water condensation often occurs.

Various corrosion mechanisms have been postulated, but practical experience together with related thermal-chemical considerations indicate that corrosion of steel and iron boiler surfaces may proceed as follows:

(i) H_2O (water vapour) $+SO_3 \rightarrow H_2SO_4$

(ii) Fe (tube metal) + dilute $H_2SO_4 \rightarrow FeSO_4 + H_2$

If free or excess sulphuric acid is present, the ferrous sulphate ($FeSO_4$) is further oxidized to ferric sulphate [$Fe_2(SO_4)_3$] which accelerates tube wastage by combining with moisture to form sulphuric acid and by acting as a catalyst to promote oxidation of sulphur dioxide to sulphur trioxide in the vicinity of tube surfaces.

In accordance with this invention, a corrosion inhibiting composition in a liquid carrier is applied directly by brushing or spraying to boiler or other metal surfaces where temperatures are continuously or intermittently below acid dew point and at the same time exposed to flame of fuel containing sulphur.

The corrosion inhibitor of the present invention is chemically and physically stable in the presence of flame and comprises a suspension in a liquid carrier of finely divided particles of magnesium hydroxide and/or magnesium oxide. The particles range in size from about 1 to about 25 microns, said particles being in the range of about 23% to about 57% by weight of said suspension. The carrier will ordinarily be water.

Particles in the mentioned size range are essential for the reason that in the presence of particles larger than about 25 microns any condensed sulfuric acid will preferably corrode the steel surface rather than reacting with the inhibitor ingredients due to inadequate reactive surface in the inhibitor. In addition, such larger particles tend to be eroded or removed by the hot high velocity gas stream. If the particles are less than about 1 micron the inhibitor forms a dense coating which is difficult to remove.

A suitable extender is desirably employed in the suspension. The extender may be of any conventional type, such as bauxite, bentonite, gilbrite, clays, diatomaceous earth or aluminum hydroxide, but the aluminum hydroxide is preferred. The extender may constitute about 14% to about 44% by weight of the suspension.

It is critical that an alkali metal aluminate binder (which is water soluble) be incorporated in the suspension. In the absence of such a binder the active ingredients will not adhere to the surfaces under treatment when exposed to hot high velocity combustion gases. Such binders also act to neutralize condensed sulfuric acid. Neutral salt binders do not have acid neutralizing capacity. The binder suitable for use in the present invention does not react with the active ingredient in order to exert its binding action on the treated surface. Thus, the effectiveness of the magnesium active ingredient is not suppressed in any manner. Suitable alkali aluminate binders are the sodium and potassium aluminates. Because of its low cost and ready availability, sodium aluminate is preferred and may comprise, for instance $Al(OH)_2ONa$, $Al(OH)\cdot(ONa)_2$ and $Al(ONa)_3$. It is employed in the range of 1% to about 5% by weight of the suspension.

The following are the chemical and physical properties of a suitable inhibitor.

Property:	Composition or value
Active ingredient	$MG(OH)_2$ and/or MgO
Extender	$Al(OH)_3$
Binder	$Al(ONa)_3$
Carrier fluid	Water
Solids content—percent by weight	50–80
Magnesium:Aluminum (element) ratio range	1:1–3:1
Particle size range—microns	1 to 25
Particle size distribution—50% by wt. microns	5 to 10
Specific gravity—70° F.	1.70
Viscosity at 80° F.—cps.	
Brookfield Spindle:	
No. 4 at 5 r.p.m.	29,400
No. 4 at 2.5 r.p.m.	39,800
No. 6 at 20 r.p.m.	17,300
No. 6 at 10 r.p.m.	21,900

The inhibitor is painted as by brushing or spraying onto the metal heat transfer surfaces to be protected. The inhibitor is spread uniformly throughout the extent of such surfaces and forms thereon a thin, uniform, non-insulating, non-combustible coating that remains in place when exposed to flame. The coating is of highly porous nature and has a multiplicity of minute, interconnecting pores. This is provided by the magnesium active ingredient, with its large specific surface, and the extender which produces a heavily flocculated suspension of solids that leaves a highly porous residue on drying. The binder, which is compatible with the flocculated suspension ensures that the inhibitor will adhere to the metal surfaces during application.

Thus, the coating soaks up and reacts chemically with any condensed sulphuric acid, and no acid remains for reaction with the steel of the equipment. The coating is thus capable of physically absorbing and chemically reacting with the condensed sulphuric acid.

The constituents of the described inhibitor are all non-combustible, non-corrosive, non-odorous and non-toxic. Therefore, it is quite safe in use and harmless to humans and property.

Although the inhibitor is of beneficial effect even when applied to partially clean surfaces, it is preferably applied to the boiler surfaces after a normal or routine cleaning thereof. It is also desirable that it be applied to these surfaces at the end of a heating season to protect them during the summer months from water and any residual sulphuric acid corrosion. The surfaces may be either hot or cold during application.

It has been found possible to achieve substantially complete effectiveness with periodic (say, every one to four weeks depending upon furnace operating conditions) applications of the inhibitor.

Furthermore, use of the inhibitor facilitates the cleaning of the heat transfer surfaces to which it has been applied since the inhibitor-coating after reacting with sulphuric acid becomes a non-acidic, water-soluble, lightly-adherent scale that is not tenaciously bonded to the metal surfaces.

We claim:

1. A corrosion inhibiting composition that is chemically and physically stable in the presence of flame for heating equipment surfaces, said composition comprising a liquid suspension of about 23% to about 57% by weight of particles ranging in size from about 1 to about 25 microns of a compound selected from the group consisting of magnesium hydroxide and magnesium oxide and 1% to about 5% by weight of a binder consisting of an alkali metal aluminate.

2. A corrosion inhibiting composition for heating equipment surfaces as defined in claim **1**, wherein said binder is a sodium aluminate.

3. A corrosion inhibiting composition for heating equipment surfaces as defined in claim **1**, wherein said liquid carrier is water.

4. A corrosion inhibiting composition for heating equipment surfaces as defined in claim **1**, wherein said suspension also contains about 14% to about 44% by weight of an extender.

5. A corrosion inhibiting composition for heating equipment surfaces as defined in claim **4**, wherein said extender is aluminum hydroxide.

6. A method of inhibiting sulphuric acid corrosion of low-temperature heating equipment surfaces which comprises forming in a liquid carrier a suspension of particles ranging from about 1 to about 25 microns in size of a compound selected from the group consisting of magnesium hydroxide and magnesium oxide containing about 23% to about 57% by weight of said particles, and 1% to about 5% by weight of said suspension of a binder consisting of an alkali metal aluminate, and periodically painting said liquid suspension onto substantially the entire extent of heating equipment surfaces that operate in a temperature range below about 400° F. to produce thereon a substantially uniform coextensive coating.

7. A method of inhibiting sulphuric acid corrosion of low-temperature heating equipment surfaces as defined in claim **6**, wherein said binder is a sodium aluminate.

8. A method of inhibiting sulphuric acid corrosion of low-temperature heating equipment surfaces as defined in claim **6**, wherein said suspension is sprayed onto said surfaces.

9. A method of inhibiting sulphuric acid corrosion of low-temperature heating equipment surfaces as defined in claim **6**, wherein said carrier liquid is water and said suspension is brushed onto said surfaces.

10. A method of inhibiting sulphuric acid corrosion of low-temperature heating equipment surfaces as defined in claim **6**, wherein said suspension also contains about 14% to about 44% by weight of an entender to increase the surface area of said particles in said coating.

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