

# GASES IN STEAM

William P. Moir  
Chemax, Inc.  
Portland, Oregon

## INTRODUCTION

This paper is concerned with four problems associated with non-condensable gas contamination of steam that can reduce dry kiln performance. The sources of non-condensable gas contamination will be discussed and some of the methods available to reduce or eliminate the impact of these contaminants.

The four problems include:

- 1) impeded heat transfer through dry kiln fin pipe
- 2) depressed steam temperatures in dry kiln fin pipe
- 3) malfunctioning steam traps due to non-condensable gas locking
- 4) corrosion of condensate piping from oxygen pitting or low pH condensate

For the purposes of this paper we are most interested in the effects of oxygen, carbon dioxide, and nitrogen. These are non-condensable gases which are readily available in air and boiler make-up water.

### Heat Transfer

The dry kiln is a condition controlled room utilizing steam coils as a heat source to dry lumber. The rate at which heat flows from steam to the conditioned air in the kiln depends on a number of factors. The heat (contained in the steam) must first pass through a film of condensate and non-condensable gases, then possibly a layer of rust or scale, the metal tube, usually a layer of metal oxide on the outside of the fin pipe, a layer of stagnant air, and finally the air for which heat was originally intended.

The film of air (non-condensable gases) in the dry kiln fin pipe is a poor conductor of heat and it is therefore a very effective insulator.

The table below compares the thermal conductivities of several common materials.

<u>Material</u>	<u>Thermal Conductivity</u> <u>Btu/hr-ft<sup>2</sup> - °F/in</u>
Copper	2620
Iron	340
Water	5
Air	.2

This table demonstrates that a one-inch thick air film is as resistant to heat transfer as a wall of copper 1,000 feet thick. For the operation of dry kilns it is extremely important that fin pipes have as little condensate and air film as possible. If air and condensate films do build on internal fin pipe surfaces, the rate at which the kiln will heat is greatly reduced.

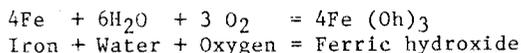


## Corrosion of Condensate Piping

There are two methods of corrosion in condensate systems and non-condensable gases are involved in each.

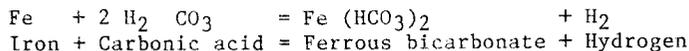
### Oxygen Pitting

Oxygen pitting is severe if a source of oxygen is available to the moist iron rich environment of dry kiln fin pipe and condensate return systems. The corrosion reaction for dissolved oxygen is illustrated as follows:



### Carbon Dioxide

Carbon dioxide is another non-condensable gas, dissolves in water and forms carbonic acid. This is a weak acid but produces corrosion as illustrated.



This reaction occurs rapidly at a pH of 5.9 or less.

### SUMMARY OF PROBLEMS

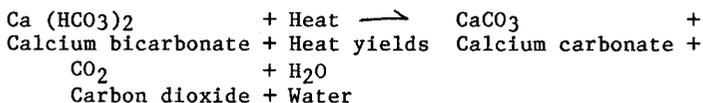
The above discussion indicates that any non-condensable gas will impede heat transfer, depress steam temperatures, and cause many steam traps to perform less than optimally. In addition, the specific non-condensables of oxygen and carbon dioxide will cause corrosion which destroys our capital investment in dry kiln fin pipe and condensate return systems. The remainder of the paper discusses sources of the non-condensables, oxygen and carbon dioxide and some of the solutions.

### Sources of Dissolved Oxygen

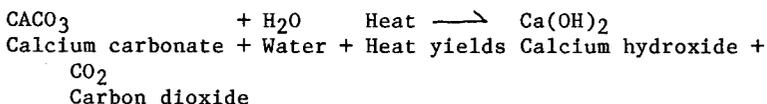
Oxygen may originate from boiler make-up water or enter at various points in the condensate system. Oxygen is present in most make-up waters and unless properly scrubbed and vented in a deaerator will remain in the boiler feedwater. While condensate that is returned under pressure will usually be free of oxygen, infiltration can take place in dry kilns when they are intermittently turned on and off.

### Sources of Carbon Dioxide

Carbon dioxide is the leading cause for condensate corrosion. The main source of carbon dioxide is the bicarbonate and carbonate alkalinity of the boiler make-up water. The carbon dioxide generation is illustrated as follows:



There is further breakdown as illustrated below:



Corrosion in piping is proportional to the carbon dioxide concentration in condensate. For plants located in areas of hard water we can anticipate that all of the previously discussed problems will be magnified.

#### Solutions to Non-Condensable Gas Contamination

Realizing that the two major sources of gas are boiler make-up water and air infiltration in the condensate system, several methods for eliminating or reducing their impact are:

- 1) Deaeration - Many dry kiln boilers are equipped with deaerators but frequently only the boiler make-up water is deaerated and the return condensate is returned to the storage section of the D.A. tank. Because air can easily be introduced in modulating dry kiln systems the deaerator should be sized to scrub all the plants feedwater.
- 2) The condensate piping should be large enough to insure good flow towards the steam trap. While the primary condensate handling trap may be a float or bucket, a thermostatic trap should be plumbed in parallel to insure maximum gas venting capacity.
- 3) Reduction of carbon dioxide in make-up water can be accomplished with equipment such as a dealkalizer or a degassifier. A dealkalizer takes softened make-up water and passes it through a second ion exchange unit which removes the anions of bicarbonate and carbonates. These anions are replaced with chloride. A degassifier takes softened make-up water and acidifies it with sulfuric acid. The acid frees carbon dioxide from the bicarbonate and carbonate ions which is scrubbed from the solution, the non acidified make-up water is neutralized with caustic soda, and pumped to the deaerator.

#### CONCLUSIONS

Gases in steam can cause significant dry kiln problems. Each plant requires its own system analysis, but if efficiency and reliable operation are of paramount importance to the dry kiln operation then consideration of the following is important.

- 1) Location and selection of steam traps
- 2) Full deaeration of all boiler feedwater

- 3) Improved condensate return system to reduce quantity of boiler make-up water required
- 4) Pre-treatment of boiler make-up water to remove carbon dioxide

#### BIBLIOGRAPHY

Betz Laboratories (1962). "Betz Handbook of Industrial Water Conditioning."

Liberty Bell Corrosion course, 1969.

Locke, R.C. "Condensate Corrosion Control."

Northcroft, L.G. and Barber, W.M. (1968). "Steam Trapping and Air Venting."

Sarco Hook-up Designs, 1974.