Technical Bulletin
#105

OXIDATION OF ALUMINUM FOIL FACINGS USED IN REFLECTIVE INSULATION

Introduction

Aluminum is the material of choice to produce low-emittance facings. Aluminum has an emittance as low as 0.03, but as with many metals, oxidation can occur. This bulletin sets out to clarify the process of aluminum oxidation, its effect on surface emittance, and its effect on a facing's overall performance.

The Process of Aluminum Oxidation

Aluminum oxidation is a chemical reaction between oxygen and aluminum. If bare aluminum is exposed to an oxygen-rich environment, then a process called *passivation* will occur. Passivation is the spontaneous formation of a thin, protective oxide film which limits the potential for further corrosion. This process – for aluminum - can be expressed by the following reaction:

$$4Al + 3O_2 = 2Al_2O_3$$

The process can be described as aluminum reacting with atmospheric oxygen, to produce an aluminum-oxide barrier. Over time - as this barrier grows - the ability of oxygen molecules to diffuse down to the metal surface is diminished. The process of aluminum oxidation will actually protect the metal's surface, slowing the rate of oxidation to near zero.

The rate at which aluminum-oxide forms, depends upon a number of factors including: metal purity, atmospheric conditions, and the presence of an existing oxide film.

Aluminum Oxidation and Surface Emittance

A low-emittance surface is the key component in any reflective insulation system; as such, the preservation of a facing's emittance value is essential in maintaining optimal thermal performance. Concerning the timeline for aluminum-oxide formation, it should be noted that industry testing of surface emittance is carried out on finished product – or at the very least, aluminum material which has already accumulated its protective layer of aluminum-oxide.

Most non-metallic substances have a relatively high emittance value. In normal applications, however, the thickness of a naturally occurring oxide-film is too small to have a significant impact on a facing's emittance. Reflective insulation is aimed at preventing the transfer of radiant heat – or energy carried by electromagnetic waves in the infrared band. It has been shown that the presence of an oxide-film increases emittance only within the [0.5µm – 1.0µm] range of the EM spectrum. Since the infrared band comprises wavelengths within the [1.0µm – 1000µm] range, we can conclude that the presence of an aluminum-oxide film will not have a negative impact on the emittance of aluminum-faced reflective insulation.

Aluminum Oxidation and Corrosion

In addition to its use in reflective insulation, aluminum has become the most widely used non-ferrous metal in the world, across a broad range of industries. A primary reason for aluminum's popularity is its ability to resist damaging corrosion. This resistance can be attributed to the protective aluminum-oxide film that naturally forms when the metal is exposed to an oxygen-rich atmosphere like air.

In aqueous media, oxide film has been shown to be stable in pH values anywhere between 4.0 and 8.5. Across most of North America, the normal pH value of clean rain is found to be about 5.6 to 5.8, and acid rain has values of 4.2 to 5.0 – well within the tolerance of aluminum-oxide film.

Note: *This technical bulletin does not purport to address all potential chemical reactions that can occur with aluminum. The intent of this bulletin is to detail the reaction of atmospheric oxygen with bulk aluminum foil only. The effects of oxidation on metallized films will be discussed in a subsequent technical bulletin.*

For more information:

1) An Introduction to Metallic Materials - William F. Gale - Auburn University, Materials Research and Education Center
2) Emissivity of Aluminum and its Importance for Radiometric Measurement – J. Bartl, M. Baranek – Institute of Measurement Science, Slovak Academy of Sciences
3) Some Reflection and Radiation Characteristics of Aluminum – C.S. Taylor, J.D. Edwards – Heating, Piping, and Air Conditioning
4) Aluminum Corrosion – www.corrosion-doctors.org
5) Acid Rain – Natural 'Acid' Rain – C.E. Ophardt -Virtual Chembook – Elmhurst College
6) High Temperature Corrosion Kinetics – www.corrosionsource.com
7) Reference Data Sheet for Aluminum – W.D. Sheridan, CIH, CHMM
8) Oxidation of Aluminum – Thickness – www.memsnet.org
9) Oxidation of Aluminum Surfaces on CD-ROMS – P. Gasper, Washington University
10) pH of Rain and Creek Waters – Dr. Ken Rubin, University of Hawaii, Honolulu
11) Acid Rain and Water – Environment Canada – www.ec.gc.ca/acidrain/acidwater

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