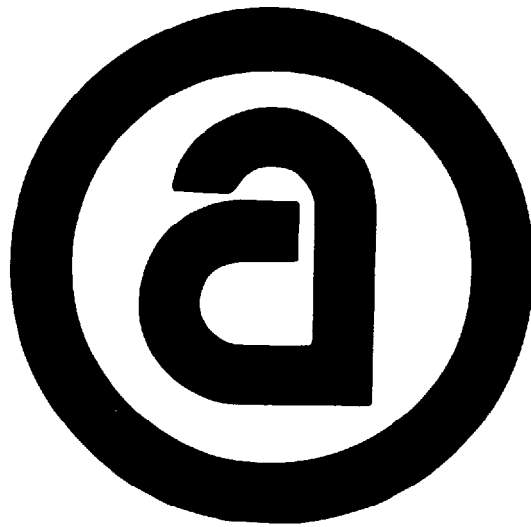


ALUMINUM-PIGMENTED COATINGS FOR INDUSTRIAL MAINTENANCE APPLICATIONS

The Aluminum Association 



ALUMINUM-PIGMENTED COATINGS
FOR
INDUSTRIAL MAINTENANCE APPLICATIONS

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PREFACE

No other metallic pigment can equal aluminum in terms of useful diversity. Aluminum's unique properties, in conjunction with useful specific vehicle formulations, contribute to coatings known for exceptional durability and economy. That makes aluminum-pigmented coatings especially suitable for industrial maintenance. The following information, in a very condensed form, was developed to aid the general understanding of the function and value of aluminum-pigmented coatings.

After reading this handbook, do not hesitate to contact the contributing manufacturers listed on page 22 for samples and additional information.

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ALUMINUM-PIGMENTED COATINGS FOR INDUSTRIAL MAINTENANCE APPLICATIONS

I. Introduction

Aluminum pigments are manufactured from pure aluminum and possess many of the characteristics of the base metal itself. Typical purity of the aluminum used to manufacture powders and pastes range from 99.0% to 99.97% depending on the grade being produced. When milled into a pigment or flake, the most striking feature is the geometry of the particle itself. This flakelike shape is responsible for many of the beneficial characteristics of aluminum pigment. Aluminum flakes have excellent corrosion resistance, are highly reflective, and repel both infrared and ultraviolet radiation.

Aluminum pigments, unlike most nonmetallic pigments, have a lamellar geometry. This scalelike configuration, along with the metallic nature of the pigment, provides a combination of unique aesthetic and physical properties. Leafing grades may vary in appearance from a flat silver color to a highly polished, almost chromelike effect. When incorporated into a coating, the flakes orient themselves in layers parallel to the substrate and film surface. The nonleafing grades provide metallic or polychromatic effects with varying degrees of sparkle and color.

Aluminum flakes viewed under a microscope appear as flat, irregularly shaped particles. The many perimeter indentations and surface irregularities result from the ball milling process. The actual size of the flakes will vary depending on the grade. Commercial grades will range from 0.1 to 2.0 μm in thickness and 0.5 to 200 μm in diameter.

II. History of Aluminum Pigments

The production and use of aluminum pigments dates back to the early Egyptians, who developed the art of overlaying wood, bone and other materials with metallic powders.

The process consisted of hammering or rolling metal between strips of leather until they were reduced to thin sheets. These leaflike scraps were then rubbed through fine screens to form a powder that could be used in paints for art work and printing.

Mechanical means to process aluminum were developed during the 19th century by Sir Henry Bessemer. This process was first used to produce a "gold" bronze pigment; specifically a copper zinc alloy, but was later adapted to produce aluminum pigments. The process used mechanical stamps that worked like hammers to reduce the foil to flakes. Lubricants such as lard and stearic acid were used to prevent cold welding and gave the flakes their ability to leaf or float in a paint vehicle. To add surface brightness, the flakes were placed in a drum fitted with rotating brushes and polished with additional lubricant.

The father of aluminum paste and flake production was E.J. Hall, late Professor and Executive Officer, School of Mines, Columbia University, New York City. In 1916, he established the Metals Disintegrating Company, Inc. to produce zinc dust. During World War I, Capt. Samuel Wiley of the U.S. Army Ordnance Department asked Professor Hall if it were possible to produce aluminum flake in granular form. Capt. Wiley was familiar with aluminum flake in pyro-

technic formulations and thought a granular shape might be more stable in ordnance applications. Hall tried and was successful. Because of his work, substantial amounts of aluminum were supplied for the war effort and used by both the U.S. and its allied forces.

In 1930, Hall developed a lower cost method for aluminum flake and paste production which substantially reduced the risk of explosions and greatly improved product quality. This process, a wet ball milling technique, is still used today to manufacture most aluminum pigments, not only because of its excellent efficiency, but also because by eliminating dry grinding, the process is very safe.

III. Methods of Manufacture

With the Hall process, three raw materials are charged into the ball mill: aluminum powder, mineral spirits, and a suitable fatty acid, generally stearic or oleic. The mill is operated at a speed which allows the steel balls to cascade onto the aluminum particles, thus flattening and breaking them into tiny flakes. The lubricant prevents cold welding of the metal, and a sufficient amount of mineral spirits is charged in the formulation to maintain a wet slurry. The length of time for ball milling typically varies from 3 to 40 hours, depending upon the grade being manufactured and the particle size desired. When the grinding operation is complete, the slurry is discharged from the ball mill and passed over an appropriate mesh screen for separation. This process, along with the length of milling, differentiates one grade from another. Oversized flakes are returned to the mill for further grinding, while the remaining aluminum flakes pass into a filter press where excess solvent is removed. This process results in a filter cake having a volatile content of approximately 20%.

The final step in the manufacture of a paste involves combining the filter cake in a mixer with a solvent. A pastelike consistency is obtained with a finished volatile content of approximately 26-38%, depending on the grade. During this mixing operation, final adjustments are made to

ensure that the paste meets proper specifications.

Figure 1 shows a flow diagram of this process.

Modifications to the solvent portion of the paste can be accomplished to allow for environmental compliance and compatibility with various coating, ink, and plastics systems. Products designed for the plastics industry have the solvent portion replaced by various plasticizers to allow for compatibility while avoiding the dangers of a dry powder. Other modifications include the addition of moisture scavengers, leaf stabilizers, or surfactants to enhance water dispersion.

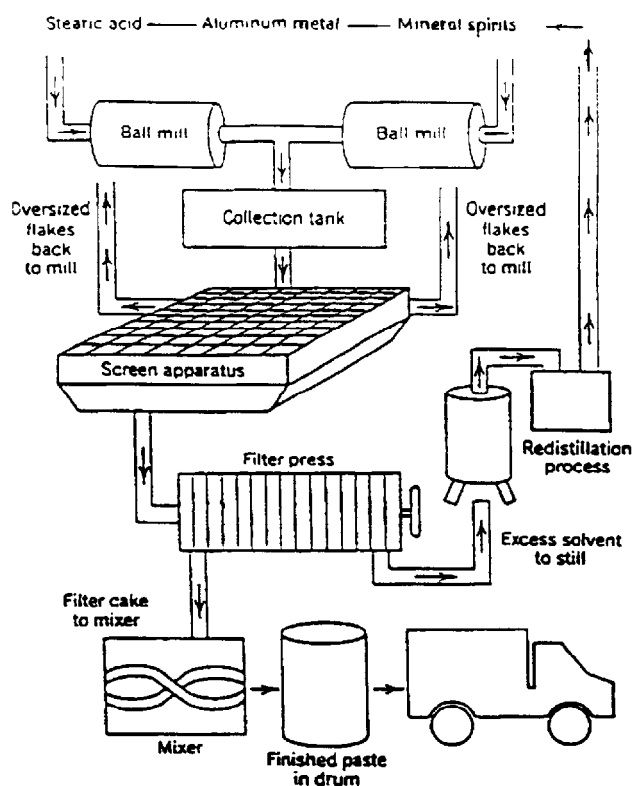


Figure 1. Flow diagram for production of aluminum paste

IV. Types of Aluminum Pigments

Leafing Pigments

Leafing Pigments, typified by their ability to "leaf," form one of the two major categories of aluminum flake pigments.

This "leafing" is a function of the fatty acid lubricant used in the milling process. Generally, a saturated fatty acid such as stearic is employed, which coats the metal surface providing both hydrophobic and oleophobic characteristics. The nonwetting characteristics provide the leafing properties of the pigment. When properly formulated and applied, coatings containing leafing pigments provide a bright silver finish. The flakes are at or near the film surface, oriented in a parallel and overlapping fashion, providing a continuous metallic barrier. The leafing phenomenon is a function of several physical characteristics including surface tension, solvent evaporation, convection currents, and coating viscosity.

Evaporation of solvents from a pigmented coating sets up convection currents which permit movement of these flakes to the surface of the film. Once at the surface, flakes are suspended by a combination of factors including

interfacial tension between flakes and vehicle and increasing system viscosity.

Nonleafing Pigments

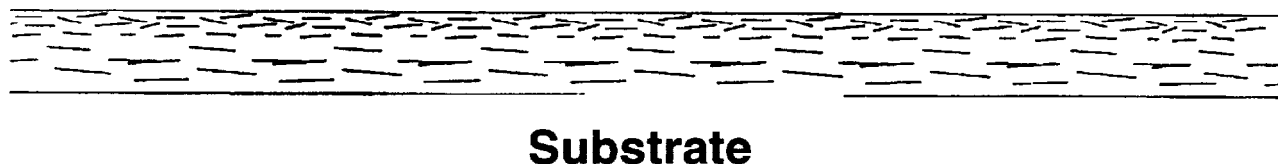
Nonleafing grades are distinguished from leafing grades by their orientation in a coating film. Rather than orienting at or near the film surface, they are distributed evenly throughout the entire film. This distribution is due to the use of an unsaturated fatty acid such as oleic as a lubricant employed during the milling process.

Figure 2 illustrates the difference between the cross sections of typical leafing and nonleafing aluminum-pigmented coatings.

V. Classification of Grades

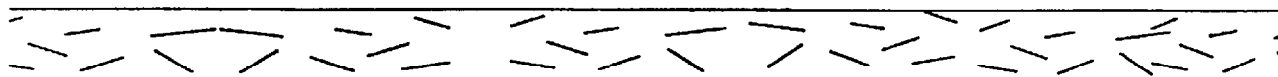
Aluminum pigments are broadly categorized into two types, leafing and nonleafing pigments. Each type is further classified by the particle size. Generally, classification of the pigments follows the outline in ASTM D962 (Table 1). Additional information and test methods can be found in ASTM D480.

Leafing Aluminum



Substrate

Nonleafing Aluminum



Substrate

Figure 2. Cross-sections of typical leafing and nonleafing aluminum-pigmented coatings