

Aesthetic Issues with Spray-Applied Fluoropolymer Coating System

Kimberly Steiner
Wiss, Janney, Elstner Associates, Inc.
330 Pfingsten Road
Northbrook, IL 60062
USA

ABSTRACT

A large building in a municipal area of the coastal United States was partially clad with aluminum panels. Due to the exterior and coastal service environment, the panels were coated with an AAMA⁽¹⁾ 2605-compliant fluoropolymer-based coating system. However, after installation of some of the panels, the contractor noticed an unacceptable “streaked” appearance, particularly under post-dawn and pre-dusk low-light conditions.

An investigation was undertaken to document and understand the nature of the streaked appearance. The investigation consisted of the following: 1) on-site measurement of color, gloss, and coating system thickness along the length of installed panels, 2) comparative measurements on accepted visual on-site mock-up panels, 3) observations of coating application and quality control processes at the coating applicator’s facility, and 4) laboratory analysis of the coating system color, gloss, thickness, distribution, composition as well as an evaluation of the underlying substrate. The investigation found issues with primer application that may affect long-term performance, and inconsistencies in application of the topcoat that led to the unacceptable appearance.

Key words: coating finish anomalies, fluoropolymer, coating application, thickness, coating uniformity

INTRODUCTION

A building, partially clad in fluoropolymer coated aluminum panels, was observed to have an aesthetically unacceptable appearance while still under construction. Once installed on the building, many of the panels exhibited a vertical streaked appearance under certain conditions. When the panels were at ground level, or when the sun was bright, the streaky appearance was not noticeable. However, in conditions of low light, such as during early morning, dusk, or on cloudy days the streaky appearance was reported to become apparent. A visual mock-up, consisting of multiple coated panels that had been approved by the architect as a guide to the anticipated appearance were also present

¹ American Architectural Manufacturer’s Association, 1900 E Golf Rd, Suite 1250, Schaumburg, IL 60173. Known as Fenestration & Glazing Industry Alliance (FGIA) since 2020.

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on-site as a reference. This visual mock-up was used as a reference for acceptable appearance of the coated panels.

Up-close observations and limited testing including thickness, color, and gloss measurements were made of the panels onsite in the installed condition. Selected panels were removed from the site for laboratory evaluations including thickness, color, gloss, roughness and microscopical evaluations. In addition to the on-site and laboratory evaluations, visits were made to the coating applicator to observe their processes.

The on-site and laboratory evaluations indicated differences in coating thickness and coverage between panels prepared for installation and the Visual Mock-Up panels. These differences, particularly including low color coat thickness and incomplete color coat thickness, affected the visual appearance of the panels and lead to the streaky appearance.

EXPERIMENTAL PROCEDURE

Panels were tested for color, gloss, and coating system thickness in the field. Additionally, panels were tested in the laboratory for surface roughness and microscopical evaluation of the coating system, including thickness measurements of individual coating layers.

Color Measurements

Instrumental color measurement was carried out using a Konika-MinoltaCR-400[†] colorimeter using a D65 standard illuminant and 2-degree observer to provide a numerical representation of color in the CIELAB scale. Changes in color are measured by changes in the numerical representation of the color. The instrument provides uniform, consistent illumination to the surface being measured and blocks out ambient illumination, so the measured color will be the same, regardless of exterior light levels.

Color is measured in the CIELAB color space with three coordinates: L* is the lightness, a* is the degree of redness or greenness, and b* is the degree of yellowness or blueness. Color difference between multiple readings on one sample or readings between samples is measured according to ASTM⁽¹⁾ D2244¹.

Gloss Measurements

Gloss was measured with a Rhopoint IQ[†] gloss meter to evaluate surface gloss and haze. The instrument makes six separate measurements of how light interacts with the surface. The gloss meter measures gloss values at incident angles of 20°, 60° and 85°. An angle of 0° would be perpendicular to the surface, while an angle of 90° would be parallel to the surface. Further, the gloss meter measures the haze of the surface, and returns values of log (Haze) which is a numerical representation of the halo or bloom observed on glossy surfaces. RIQ or reflected image quality is a function of the sharpness of a reflected image, where a surface that exhibits a perfect undistorted image returns a value of 100 and the value decreases as the image becomes less discernible. Finally, RSpec is the peak specular reflectance, which is a numerical representation of surface texture. A smooth surface will have a measured RSpec value equal to the gloss measurement of the surface, and RSpec will decrease as the surface texture increases.

Coating System Thickness

Total dry film thickness (DFT) was measured according to ASTM E376² with an Elcometer 456T[†] coating thickness gage with a ferrous/nonferrous probe.

[†] Trade name.

¹ ASTM International, 100 Barr Harbor Dr., West Conshohocken, PA 19428-2959.

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Surface Roughness

Surface roughness measurements were conducted with an M1Perthometer[†] profilometer. The profilometer moves a sensitive needle across the surface and measures displacement of the tip as it moves. Several surface roughness parameters are reported: Ra, the average roughness, Rz, the average roughness depth, and Rmax, the maximum roughness depth, and Rpc, the peak count, reported as the number of peaks per inch (in⁻¹).

Microscopical Examination

Specimens were cut from the larger samples and examined on the surface and in cross-section. Microscopy was conducted using a Nikon SMZ 800[†] stereomicroscope, a Leica DMR[†] inverted reflected light microscope, and JEOL 6010LA[†] scanning electron microscope with energy dispersive x-ray spectrometer operated at 20 kV. Chemical analysis of the coating system was carried out using scanning electron microscopy with energy dispersive x-ray spectroscopy (SEM/EDS). Thicknesses of individual coating layers was measured with calibrated imaging software attached to the reflected light microscope using procedures outlined in ASTM B487³.

RESULTS

Review of Specifications and Submittals

The project specifications indicate that a three-coat fluoropolymer system should be applied with an 0.8 mil (20.3 μm) thick primer, 0.8 mil (20.3 μm) PVDF (polyvinylidene fluoride) color coat and 0.8 mil (20.3 μm) PVDF clear coat should be applied. Other sections of the specifications indicate that the specified coating meets all requirement of AAMA 2605⁴.

The project submittal provided information on a three-coat fluoropolymer system from a different manufacturer than that specified. The information on this product data sheet indicate that the coating thickness should be as follows: primer 0.2 - 0.4 mil (5.1 - 10.2 μm), color coat 1.0 - 1.2 mil (25.4 - 30.5 μm), and clear coat 0.4 - 0.6 mil (10.2 - 15.2 μm), and the 60° gloss is to be 25 to 35%. The product data sheet also indicates that the coating system meets several provisions of AAMA 2605. This submittal was approved by the architect and this coating system was applied.

Review of AAMA 2605

AAMA 2605 which was the standard version in effect at the time of specification provides specifications and performance standards for coatings on aluminum, including minimum DFT, color uniformity, and gloss. Composite coating thickness should be a minimum of 1.2 mils (3.5 μm) on at least eighty percent of readings, with no more than 5 percent of the total readings having a film thickness less than 1.0 mil (25.4 μm). Color should be evaluated on random samples visually under a uniform light source at multiple angles and measured instrumentally. A maximum deviation of 2 Δ E is recommended from a given sample to an agreed upon color standard. Section 8.1.2 provides the following guidance when mica flakes are present: "Pearlescent mica and metallic flakes reflect and scatter light in random patterns; therefore, exact color uniformity should not be expected. Slight color shifting should also be expected when viewing from varying angles and distances." Specular gloss should be measured with a 60-degree gloss meter. Values shall be within 5 units of the manufacturer's specified range; the data sheet of the product used indicates a 60 degree gloss of 25 to 35. Therefore, 60-degree gloss measurements from 20 to 40 would be permissible under AAMA 2605.

Site Visit Observations and Test Results

At the time of the site visit, panels had been installed on less than one-quarter of the façade. A streaky appearance, running vertically, was observed on many of the installed panels (Figure 1). Where present, the streaks typically appeared in a similar repetitious pattern (i.e., the streaks had the same general spacing). However, most panels did not exhibit streakiness that was uniform along the height a

[†] Trade name.

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given panel; instead, the height of the vertical streaks varied from top to bottom of a panel, or the appearance of the streaks was more apparent on one end of a given panel compared to the other. The streaky appearance was more noticeable during the early morning hours and when the panels were under shadow.

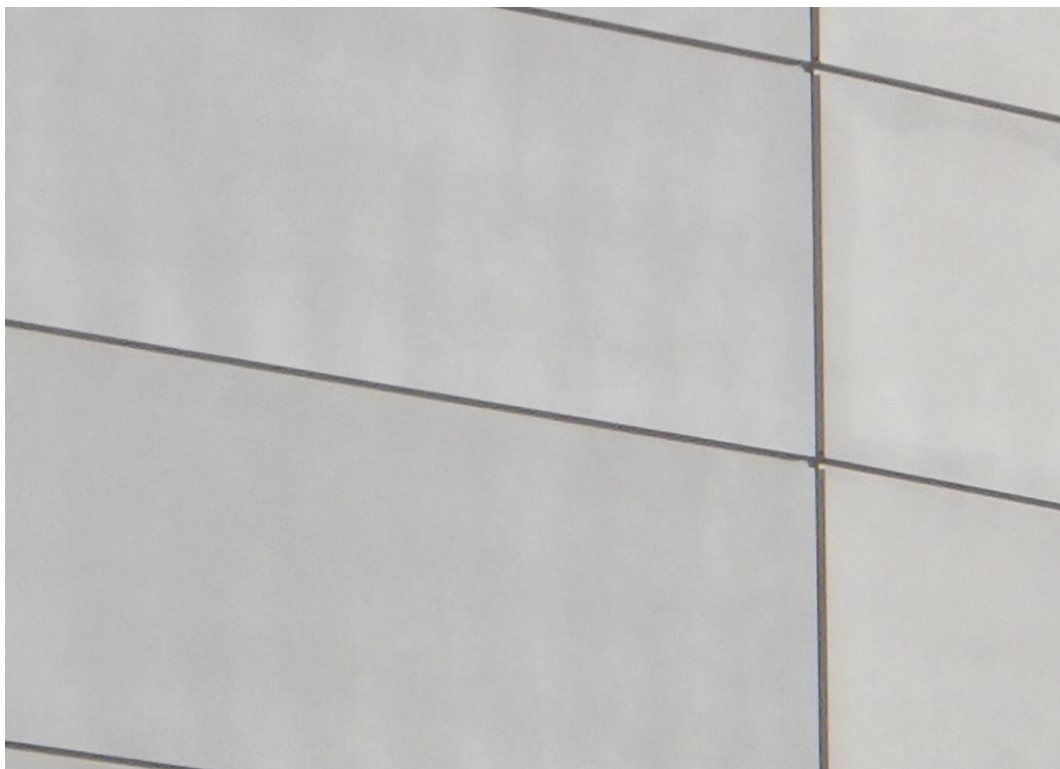


Figure 1: A photograph of the streaky appearance of the façade panels.

Close-up observations and measurements were taken on selected panels installed on the building from an aerial lift. Personnel on the ground used a laser pointer to highlight areas that appeared “dark” on selected panels. These areas were marked by personnel in the aerial lift with masking tape. Areas approximately centered between the marked dark areas were in turn marked as “light” areas. The panels appeared more uniform in color/gloss when viewed up close at a 90-degree angle to the panels (i.e., perpendicular to the panel), but the streaky appearance became noticeable when viewed at an oblique angle nearly parallel to the panel.

Seven panels were examined on site. Five were installed on the façade, and two were part of the Visual Mock-Up. Four of the five installed panel exhibited a noticeable streaky appearance. One of the streaky installed panels and one of the Visual Mock-Up panels were provided for later laboratory studies.

Measurements indicated slight variations in gloss and color along the length of the panels. However, review of the data did not show obvious substantial differences between areas with a light and dark appearance.

Visit to Coating Applicator

A visit to the coating applicator’s facility was conducted to observe the coating process for panels for this building. The entire coating process, from initial racking of the panels to final quality checks was observed. Final DFT of the coating system is measured after completion of the process; wet film thickness of individual coating layers was not measured. Of key importance for this project was the manner in which the final clear coat was applied. The clear coat was spray applied by first using side-