technical note technical

Adsil Glass Coating Study

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16. Abstract

Paint markings on runways and taxiways are damaged from ultraviolet rays, stained by aircraft fuel, and discolored. Glass coatings, used as a sealant for the paint, have shown promise as a possible solution to these problems.

The research effort described in this report investigates the effectiveness of an Anchored Dendritic Silicate Interactive Linkages (Adsil) Ambient Temperature Cure glass coating material in protecting the color and retro-reflectivity of the paint markings. The paint markings in this study included two types of beads for better visual acquisition.

Testing was conducted at the Jacksonville Naval Air Station and Whitehouse Outlying Landing Field. The tests measured resistance to abrasion, mildew, rust staining, oil staining, and ultraviolet weathering.

The results of the tests showed Adsil glass coating reduced retro-reflectivity. The white markings with type I beads and Adsil reduced the retro-reflectivity by 66% from 318 to 109 millicandelas per meter squared per lux (mcd/m^2/lx). The white markings with type III beads and Adsil reduced the retro-reflectivity by 57% from 1270 to 549 mcd/m^2/lx. The yellow marking with type I beads and Adsil reduced the retro-reflectivity by 34% from 144 to 94 mcd/m^2/lx. The yellow markings with type III beads and Adsil reduced the retro-reflectivity by 44% from 475 to 265 mcd/m^2/lx. The combination of Adsil coating with type I beads was not recommended due to the very low retro-reflectivity of 109 mcd/m^2/lx for white and 94 mcd/m^2/lx for yellow. When using type III beads, the retro-reflectivity, while still reduced (549 mcd/m^2/lx for white and 265 mcd/m^2/lx for yellow), was not as low as with type I beads. In the second case, Adsil should only be considered when other benefits such as resistance to mildew, rust staining, and oil staining would make the reduced retro-reflectivity an acceptable compromise.

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LIST OF ACRONYMS

Adsil	Anchored Dendritic Silicate Interactive Linkages
ATC	Ambient temperature cure
FAA	Federal Aviation Administration
ICAO	International Civil Aviation Organization
IOR	Index of refraction
JNAS	Jacksonville Naval Air Station
OLF	Whitehouse Outlying Land Field
R&D	Research and development
UV	Ultraviolet

EXECUTIVE SUMMARY

Paint markings on runways and taxiways are damaged by ultraviolet rays, stained by aircraft fuel, and discolored. Glass coatings, used as a sealant for the paint, have shown promise as a possible solution to these problems.

The research effort described in this report investigates the effectiveness of an Anchored Dendritic Silicate Interactive Linkages (Adsil) Ambient Temperature Cure (version AD490) glass coating material in protecting the color and retro-reflectivity of the paint markings. The paint markings in this study included two types of beads for better night visibility.

Testing was conducted at the Jacksonville Naval Air Station and Whitehouse Outlying Landing Field. The tests included resistance to abrasion, mildew, rust staining, oil staining, and ultraviolet weathering.

The tests showed that Adsil glass coating reduced retro-reflectivity. The white markings with type I beads and Adsil reduced the retro-reflectivity by 66% from 318 to 109 millicandelas per meter squared per lux (mcd/m^2/lx). The white markings with type III beads and Adsil reduced the retro-reflectivity by 57% from 1270 to 549 mcd/m^2/lx. The yellow marking with type I beads and Adsil reduced the retro-reflectivity by 34% from 144 to 94 mcd/m^2/lx. The yellow markings with type III beads and Adsil reduced the retro-reflectivity by 44% from 475 to 265 mcd/m^2/lx. The combination of Adsil coating with type I beads was not recommended due to the very low retro-reflectivity of 109 mcd/m^2/lx for white and 94 mcd/m^2/lx for yellow. When using type III beads, the retro-reflectivity, while still reduced (549 mcd/m^2/lx for white and 265 mcd/m^2/lx for yellow), was not as low as with type I beads. In the second case, Adsil should only be considered when other benefits such as resistance to mildew, rust staining, and oil staining would make the reduced retro-reflectivity an acceptable compromise.

INTRODUCTION

PURPOSE.

This research effort was conducted to determine whether Anchored Dendritic Silicate Interactive Linkages (Adsil) Ambient Temperature Cure (ATC) glass coating material would be a viable solution to protecting paint markings on airport surfaces. The Airport Technology Research and Development (R&D) Branch in response to a request from the Federal Aviation Administration (FAA) Airport Engineering Division, AAS-100, conducted this study.

OBJECTIVE.

The objective was to determine the effectiveness of the Adsil ATC glass coating material at protecting color and retro-reflectivity of paint markings with type I and type III glass beads.

BACKGROUND.

Often times paint markings on runways and taxiways display damage caused from ultraviolet (UV) rays, staining from aircraft fuel, and discoloration. Using the Adsil ATC glass coating as a sealant for the paint showed promise as a possible solution to these problems. This research was important because the paint markings, without some sort of coating, are turning from black to gray, from white to yellow, and vice versa. Consequently, this causes the pilot problems in distinguishing the paint markings in the daytime and comprehending their meaning.

In addition to the glass coating material, two types of glass beads were included in this evaluation. The glass beads are used in paint markings to reflect light toward the pilot, giving the pilot better visual acquisition of the paint marking during nighttime operations. Glass beads are characterized by their index of refraction (IOR), which is a scale index of the rate at which a material refracts light toward the source. The characteristics that change the IOR are the basic composition of the two types of glass beads used. Both are detailed in the Federal Specification TT-B-1325C type I (1.5 IOR) and type III (1.9 IOR). Type I beads are used for roadway markings as well as airport markings, and type III beads are used exclusively for airport markings.

DISCUSSION.

The Adsil ATC glass coating material and the type I and type III beads were installed at the Jacksonville Naval Air Station (JNAS) and Whitehouse Outlying Landing Field (OLF) and evaluated for 1 year starting in August 2003. The airport pavement markings consisted of waterborne paint at 15-mil wet film thickness with either type I or type III drop-on beads and the Adsil glass coating applied over the beads and paint.

During the study, the Adsil glass coating was subjected to mildew, oil staining, rust staining, and exposed to accelerated UV weathering. A certified laboratory conducted these particular tests for the Navy, while the FAA team collected color and retro-reflectivity readings of the paint markings.

Although the FAA has no standard for retro-reflectivity limits, a paint marking study conducted by the Airport Safety Technology R&D team determined that the recommended retro-reflectivity minima for paint markings to be acceptable were 100 millicandelas per meter squared per lux ($mcd/m^2/lx$) for white and 70 $mcd/m^2/lx$ for yellow. The research report that elaborates on this topic is DOT/FAA/AR-TN03/22, "Development of Methods for Determining Airport Pavement Marking Effectiveness."

RELATED DOCUMENTATION.

Related document dealing with this evaluation project are:

- FAA Advisory Circular 150/5370-10A, "Standards for Specifying Construction of Airports," Item P-620, "Runway and Taxiway Painting," February 17, 1989, with changes.
- Specification TT-P-1952D, "Paint, Traffic and Airfield Marking, Water Emulsion Base," January 7, 1994.
- Specification TT-B-1325C, "Beads (Glass Spheres) Retroreflective," June 1, 1993.
- DOT/FAA/AR-02/128, "Paint and Bead Durability Study," March 2003.
- FAA Advisory Circular 150/5340-1H, "Standards for Airport Markings," December 1, 2000, with changes.
- ICAO Annex 14, Volume I, "Aerodrome Design and Operation," August 9, 2000.
- ASTM-E-2177-01, "Standard Test Method for Measuring the Coefficient of Retroreflected Luminance (R_L) of Pavement Marking in a Standard Condition of Wetness," December 2001.

EVALUATION APPROACH

METHOD.

The Airport Safety Technology R&D team took quarterly readings on several pavement markings at the JNAS and the Whitehouse OLF for 1 year (figures 1 and 2) using a retro-reflectometer (retro-reflectivity) and spectrophotometer (color). Figure 1 shows a white arrow with type I beads applied to the stem and type III beads on the arrowhead. Figure 2 shows three yellow lines: type III beads were applied to the top line, type I beads were applied to the second line, and no beads were applied on the bottom line. Adsil was evaluated at two coatings (1- and 2-mils wet) and applied to each of the base coatings. Figure 3 shows how the paint markings look with Adsil applied.

RETRO-REFLECTIVITY. The retro-reflectivity was obtained with a retro-reflectometer, which has a 30-meter geometry. The instrument has a tolerance of $\pm$5%. Prior to each use, the

instrument was calibrated. Retro-reflectivity readings were taken after initial painting was completed. Once the Adsil glass coating was applied, another reading was taken, with quarterly readings thereafter for 1 year (see figures 4 and 5).

In addition to the color and retro-reflectivity readings, the following tests were performed for JNAS by a certified laboratory: abrasion resistance, mildew resistance, resistance to rust staining, and resistance to oil staining, and accelerated (UV) weathering. All laboratory tests were performed without the addition of glass beads.

COLOR CHROMATICITY. Color chromaticity was performed using a spectrophotometer. This data was obtained by placing the machine on the pavement marking and activating the device. Color readings were taken after initial painting was completed; once the Adsil glass coating was applied, another reading was taken, this continued every quarter for 1 year. The readings were charted on an International Commission on Illumination standard illuminant D_{65} chromaticity chart found in the International Civil Aviation Organization (ICAO) Annex 14, Volume I – Aerodrome Design and Operations, pages 131 and 132 (see figures 6 and 7). The FAA boundaries for aviation yellow are not the same as for ICAO yellow. The region for the FAA in-service yellow was obtained and is documented in figure A-5 in appendix A of DOT/FAA/AR-TN03/22, "Development of Methods for Determining Airport Pavement Marking Effectiveness." The region for white is the ICAO white region; there was no need to change this region. A yellow data point that crossed over the FAA in-service aviation yellow region was considered failed. A white data point that crossed over the ICAO white region was considered failed.

A listing of the equipment used to perform the research on the Adsil marking material project and the evaluation participants that helped in the evaluation of the Adsil marking material is shown below.

- Equipment Description

  - Retro-Reflectometer, Flint Trading, Inc., 30-meter geometry, LTL-X, built by Delta Lights and Optics of Denmark. This instrument was used to determine the pavement marking retro-reflectivity.

  - Spectrophotometer, Color-guide 45°/0°, BYK-Gardner USA, 20 mm, 6805-SVC, built by BYK-Gardner of Germany. This instrument was used to determine the chromaticity or color of the pavement markings.

- Evaluation Participants

  - JNAS, Whitehouse OLF, Spiedel Construction Inc., Flex-O-Lite, Inc., and Adsil Corporation participated in this evaluation.

DATA COLLECTION.

The data was collected using a spectrophotometer and a retro-reflectometer. The spectrophotometer produced (Y, x, y) coordinates in its readouts. The retro-reflectometer produced millicandela per meter squared per lux readings.

TEST RESULTS

RETRO-REFLECTIVITY TEST.

At the beginning of the evaluation, the white paint markings with type I beads had a 66% reduction (318 to 109 mcd/m^2/lx) when Adsil glass coating was applied. At the end of the evaluation, the difference between coated and uncoated white markings resulted in a 70% reduction (351 to 107 mcd/m^2/lx). Retro-reflectivity for the white paint markings with type I beads without Adsil glass coating increased by 10% to 110%, though the white paint marking with Adsil decreased by 2% to 98% (see tables 1 and 2 and figures 4 and 8).

Retro-reflectivity for type III beads had a 57% reduction (1270 to 549 mcd/m^2/lx) when Adsil glass coating was applied at the beginning of the evaluation. At the end of the evaluation, there was a 54% difference between coated and uncoated with beads (1111 to 508 mcd/m^2/lx). The type III beads without the Adsil glass coating decreased by 13% to 87%, while the white paint marking with Adsil decreased by 7% to 93% (see tables 1 and 2 and figure 4).

Yellow paint markings with type I beads had a 35% reduction (144 to 94 mcd/m^2/lx) when Adsil coating was applied at the beginning of the evaluation. At the end of the evaluation, there was a 34% difference between coated and uncoated with beads (140 to 93 mcd/m^2/lx). Retro-reflectivity for yellow paint markings with type I beads without Adsil glass coating decreased 3% to 97%, though the yellow paint markings with Adsil decreased by 1% to 99%, (see tables 3 and 4 and figure 5).

At the start of the evaluation, yellow paint markings with type III beads had a 44% reduction (475 to 265 mcd/m^2/lx) when Adsil glass coating was applied. At the end of the evaluation, there was a 27% difference between coated and uncoated with beads (301 to 220 mcd/m^2/lx). Retro-reflectivity for yellow paint markings without Adsil glass coating decreased 37% to 67%, while the yellow paint markings with Adsil glass coating decreased 17% to 83% (see tables 3 and 4 and figure 5).

CHROMATICITY TEST.

The acceptability range for the white x coordinate is 0.2895 to 0.3442 and the y coordinate is 0.3100 to 0.3650. The acceptability range for the yellow x coordinate is 0.4261 to 0.5266 and the y coordinate is 0.4300 to 0.5346. The data indicated that two readings fell outside the acceptable range for white and one for yellow; both markings were uncoated. All of the coated markings for both white and yellow fell within their acceptable ranges (see tables 5 and 6). When the readings were taken 2 years out, the paint marking without Adsil was within the acceptable range, but the paint marking with Adsil was not.

SUMMARY

Retro-reflectivity quality of the paint markings were influenced by the type of beads applied. The recommended retro-reflectivity minima for paint markings to be acceptable were 100 mcd/m²/lx for white and 70 mcd/m²/lx for yellow. Type III beads offer a greater retro-reflective value than type I at initial application.

The white markings with type I beads coated with Adsil reduced the retro-reflectivity by 66% from 318 to 109 mcd/m²/lx. The final reading for type I beads coated with Adsil was 107 mcd/m²/lx. While little change occurred, this value was very close to the recommended minimum of 100 mcd/m²/lx for white paint. The uncoated marking's final reading was 351 mcd/m²/lx. The white markings with type III beads coated with Adsil initially reduced retro-reflectivity 57% from a value of 1270 to 549 mcd/m²/lx. The final reading for type III beads coated with Adsil was 508 mcd/m²/lx. Again, while not as close to the recommended minimum as the markings with type I beads, it was significantly closer than the uncoated. The uncoated markings final reading was 1111 mcd/m²/lx.

The yellow markings with type I beads coated with Adsil reduced the retro-reflectivity by 34% from 144 to 94 mcd/m²/lx. The final reading for type I beads coated with Adsil was 93 mcd/m²/lx. This value was very close to the recommended retro-reflective minimum of 70 mcd/m²/lx for yellow paint. The uncoated marking's final reading was 140 mcd/m²/lx. The yellow markings with type III retro-reflectivity coated with Adsil initially reduced the retro-reflectivity by 44% from 475 to 265 mcd/m²/lx. The final reading for type III beads coated with Adsil was 220 mcd/m²/lx. The uncoated marking's final reading was 301 mcd/m²/lx.

CONCLUSIONS

Based on the results of this evaluation effort, it was found that the Anchored Dendritic Silicate Interactive Linkages (Adsil) Ambient Temperature Cure (version AD490) glass coating, reduced the retro-reflectivity of the beads. The data clearly indicated that when Adsil was applied, the retro-reflectivity readings with the type I beads were very close to the minimums for white and yellow paint. Adsil should not be used with type I beads due to the very low retro-reflectivity when the coating was applied. When using type III beads, the retro-reflectivity, while still reduced, was not as low as with type I. In this case, Adsil should only be considered in an application where the other benefits resistance to mildew, rust staining, and oil staining would make the reduced retro-reflectivity an acceptable compromise.

The chromaticity readings for white and yellow markings with retro-reflective material shows that the Adsil product slows the color fading. Several of the readings showed that without Adsil on the white and yellow paint markings, some faded outside the acceptable ranges, while all markings with Adsil glass coating remained in the acceptable ranges. When the readings were taken again at the 2 year mark, the color had started to fade out of the acceptable range for the Adsil glass coating markings.

FIGURE 1. WHITE ARROW WITH TYPE I (STEM) AND TYPE III (ARROWHEAD) GLASS BEADS

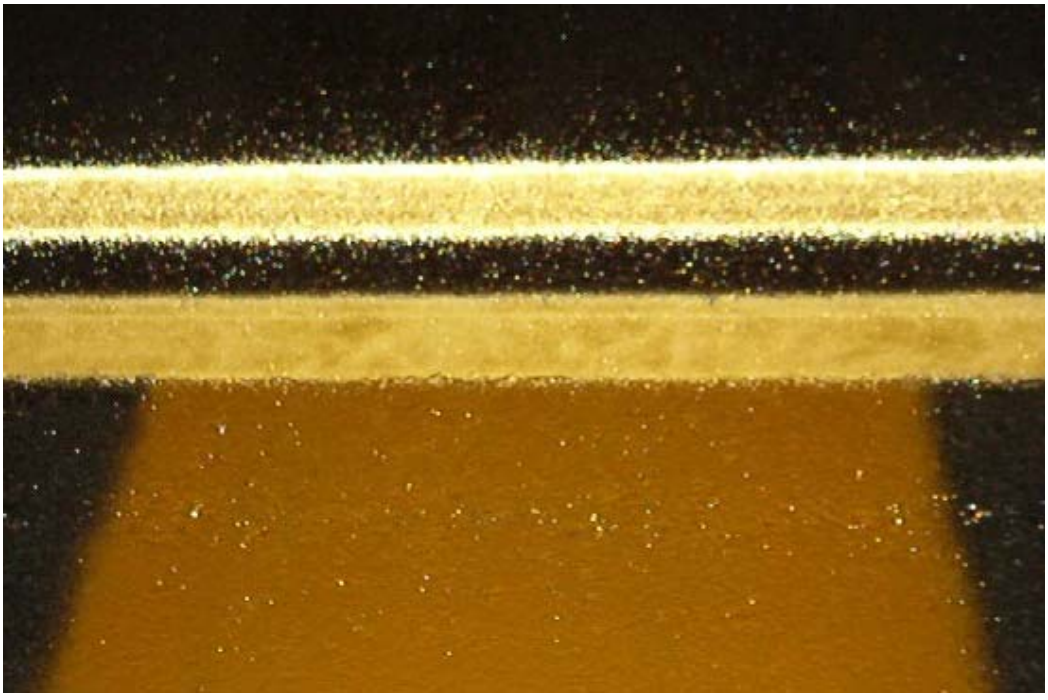

FIGURE 2. YELLOW PAINT MARKINGS WITH TYPE III, TYPE I, AND NO GLASS BEADS

FIGURE 3. WHITE PAINT MARKINGS WITH ADSIL AND TYPE I BEADS

TABLE 1. RETRO-REFLECTIVITY READINGS FOR WHITE PAINT MARKINGS

Date	Type I No Coat	Type I Coat	Reduction (%)	Type III No Coat	Type III Coat	Reduction (%)
November 2003	318	109	66	1270	549	57
August 2004	351	107	70	1111	508	54

TABLE 2. PERCENT REMAINING FOR RETRO-REFLECTIVITY (WHITE)

White	November 2003	August 2004	Remaining (%)
Type I no coat	318	351	110
Type I coat	109	107	98
Type III no coat	1270	1111	87
Type III coat	549	508	93

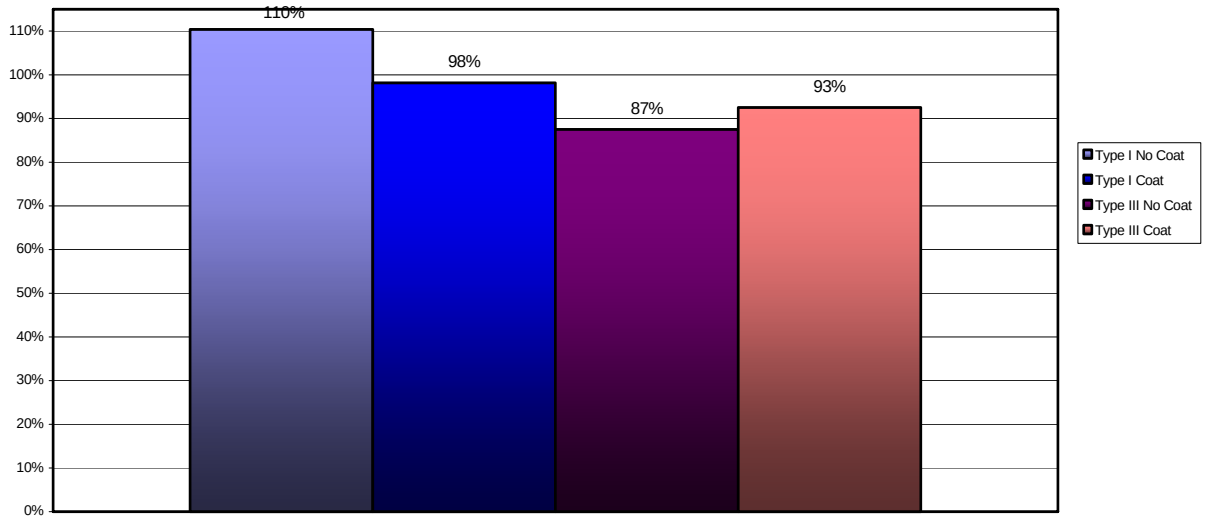

FIGURE 4. RETRO-REFLECTIVITY READING PERCENTAGES FOR WHITE PAINT MARKINGS

TABLE 3. RETRO-REFLECTIVITY READINGS FOR YELLOW PAINT MARKINGS

Date	Type I No Coat	Type I Coat	Reduction (%)	Type III No Coat	Type III Coat	Reduction (%)
November 2003	144	94	35	475	265	44
August 2004	140	93	34	301	220	27

TABLE 4. PERCENT REMAINING FOR RETRO-REFLECTIVITY (YELLOW)

Yellow	November 2003	August 2004	Remaining (%)
Type I no coat	144	140	97
Type I coat	94	93	99
Type III no coat	475	301	63
Type III coat	265	220	83

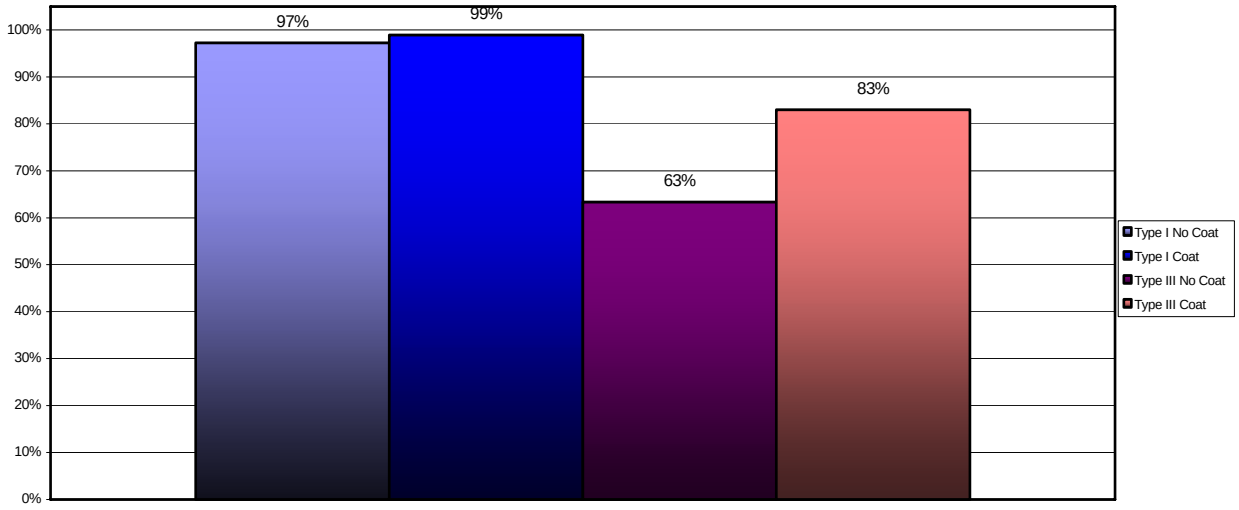

FIGURE 5. RETRO-REFLECTIVITY READING PERCENTAGES FOR YELLOW PAINT MARKINGS

TABLE 5. COLOR READINGS FOR WHITE PAINT MARKINGS

Month	Adsil	Acceptability Range 0.2895-0.3442 X-reading	Acceptability Range 0.3100-0.3650 Y-reading
November	Uncoated	0.3329	0.3503
November	Coated	0.333	0.353
February	Uncoated	0.3456	0.365
February	Coated	0.3332	0.3535
June	Uncoated	0.3457	0.366
June	Coated	0.3242	0.3462

Outside Acceptability Range in **red**

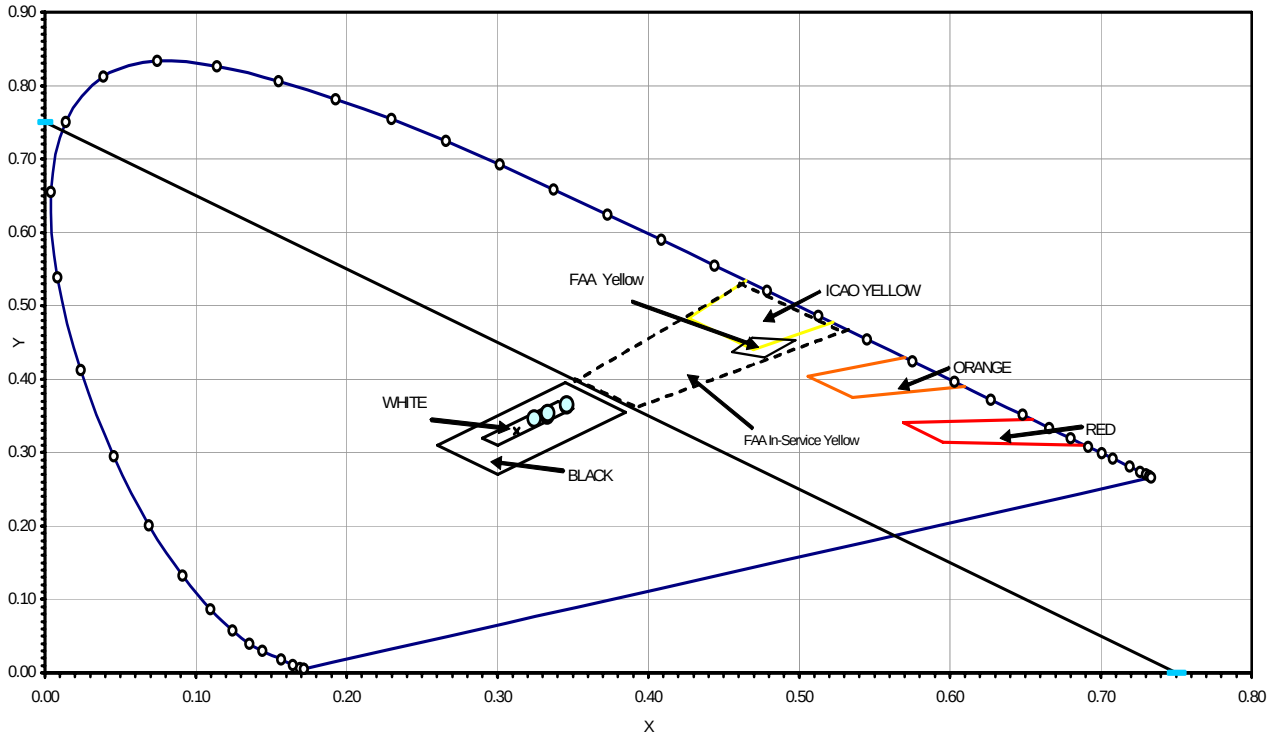

FIGURE 6. COLOR READINGS FOR WHITE PAINT MARKINGS

TABLE 6. COLOR READINGS FOR YELLOW PAINT MARKINGS

Month	Adsil	Acceptability Range 0.4261-0.5266 X-reading	Acceptability Range 0.4300-0.5346 Y-reading
November	Coat	0.4862	0.4372
November	No coat	0.4914	0.4352
November	Coat	0.4952	0.4352
November	No coat	0.4902	0.4355
February	Coat	0.4859	0.4374
February	No coat	0.4834	0.3459
June	Coat	0.4876	0.4371
June	No coat	0.4913	0.435
August	Coat	0.4734	0.4306
August	No coat	0.4737	0.4334

Outside Acceptability Range in **red**

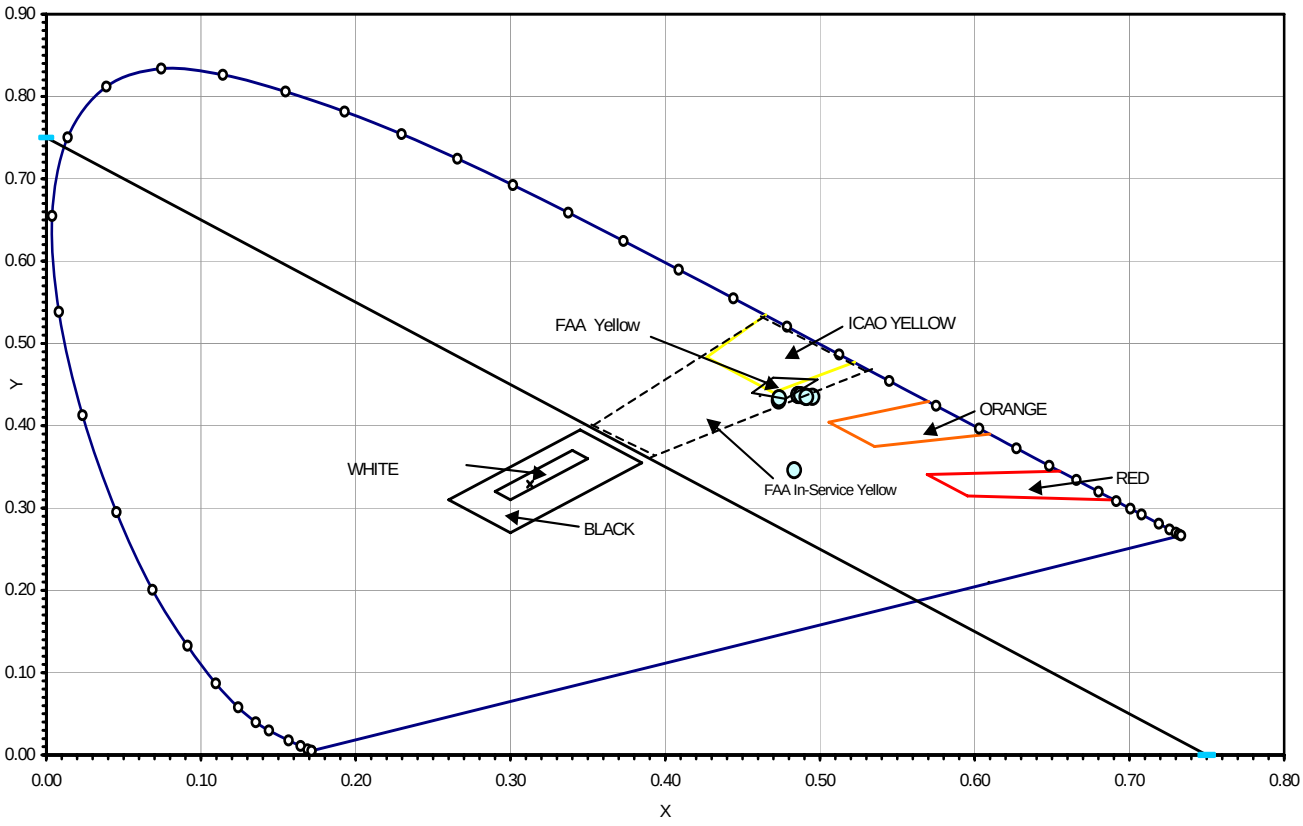

FIGURE 7. COLOR READINGS FOR YELLOW PAINT MARKINGS

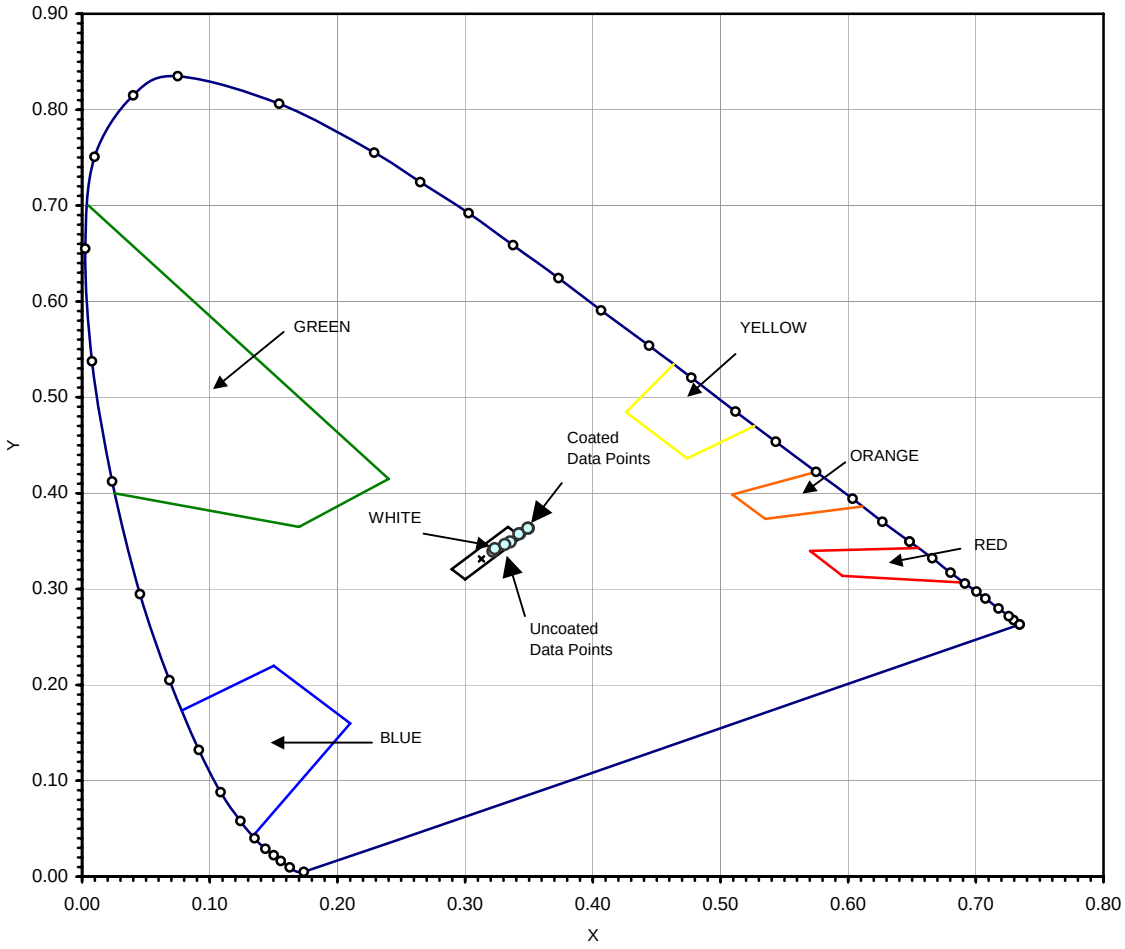

FIGURE 8. WHITE ADSIL COATED VERSUS WHITE UNCOATED PAINT