FINAL REPORT

COST-BENEFIT EVALUATION OF ENHANCED SPECIFICATIONS FOR EPOXY PAVEMENT MARKING MATERIAL

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INTRODUCTION

Numerous studies and project evaluations have demonstrated the cost-effectiveness of pavement markings as a means of increasing both traffic safety and mobility. Pavement markings separate travel lanes along with helping to delineate travel paths and the edge of the roadway.

The National Cooperative Highway Research Program reported that "the estimated total money spent throughout the United States and Canada on pavement markings in the year 2000 was $1,548,616,821 on 3,818,688 centerline-miles of highways." Last year the Colorado Department of Transportation (CDOT) spent over $15 million on pavement marking materials for its 9,144 centerline-miles of highways.

Several years ago, a concern over the poor performance of pavement marking material became an operational issue. CDOT traffic and maintenance personnel were restriping large portions of roadways at about half the expected life of epoxy-based paint. In 2004, CDOT initiated this study to evaluate enhanced specifications to improve the performance of epoxy-based paint.

BACKGROUND

It is CDOT's policy to employ durable pavement markings on all mainline interstate projects and on other selected roadways based on traffic volumes and/or the need for durable markings. To accomplish this policy, CDOT uses various types of materials for marking pavements.

The three primary types used by CDOT are paint (water or epoxy-based), thermoplastic, and tape. Each one of these compositions has its own unique set of characteristics related to durability, resistance to wear from tires and shearing effects from snow plows, placement cost and life cycle. These three materials account for more than 95 percent of the pavement markings used by CDOT. Of these, epoxy striping material is mainly used and specified for roadway construction or rehabilitation projects. The epoxy-based paint is expected to last four to five years. In order to maintain safety, these markings must be visible to the driver at all times under varying driving conditions. The reflective properties as well as the pavement marking materials decay over time requiring CDOT forces to re-stripe over the top until the next rehabilitation project.

Reflective properties are typically attained by glass beads. The beads are either dropped or sprayed on immediately after applying the paint. A typical application system is shown in Figure 1 with the glass beads being dropped about 3 inches behind the paint nozzle.

Figure 1. Application of paint then glass beads

In order to produce reflective properties, a light source, such as a vehicle's headlight, interacts with the glass beads and pigment in the pavement marking binder to reflect a portion of the incoming light rays back toward the driver. This quantifiable property is known as retroreflectivity. Greater retroreflectivity results in an increase in pavement marking visibility and preview distance. Survey results indicated that drivers were more satisfied with pavement markings with higher retroreflectivity values than those with lower values. Participating drivers over the age of 65 were generally less satisfied with brightness of the pavement markings than were participating drivers under the age of 65. Many factors can influence the initial retroreflectivity of a particular marking, including bead gradation, binder viscosity, pigment, and installation procedures. Following the application, the reflective properties as well as the marking materials are subject to environmental factors resulting in brittleness, fading pigments, binder detachment, bead fracture and bead loss. It should be noted that abrasion from traffic typically results in a loss of the marking material and glass beads, decreasing both daytime and nighttime visibility.

The most common way to evaluate the retroreflectivity of pavement marking is through the use of a retroreflectometer. This apparatus is capable of quantifying nighttime luminance under daytime conditions. The retroreflectometer replicates an entrance angle of 88.76 degrees and an observation angle of 1.05 degrees. These angles represent a typical driver's perspective of the marking from 30 meters ahead of the vehicle. All measurements are reported in millicandelas per square meter per luminous emittance, or mcd/m^2/lux. Figure 2 shows a typical view for the driver's perspective.

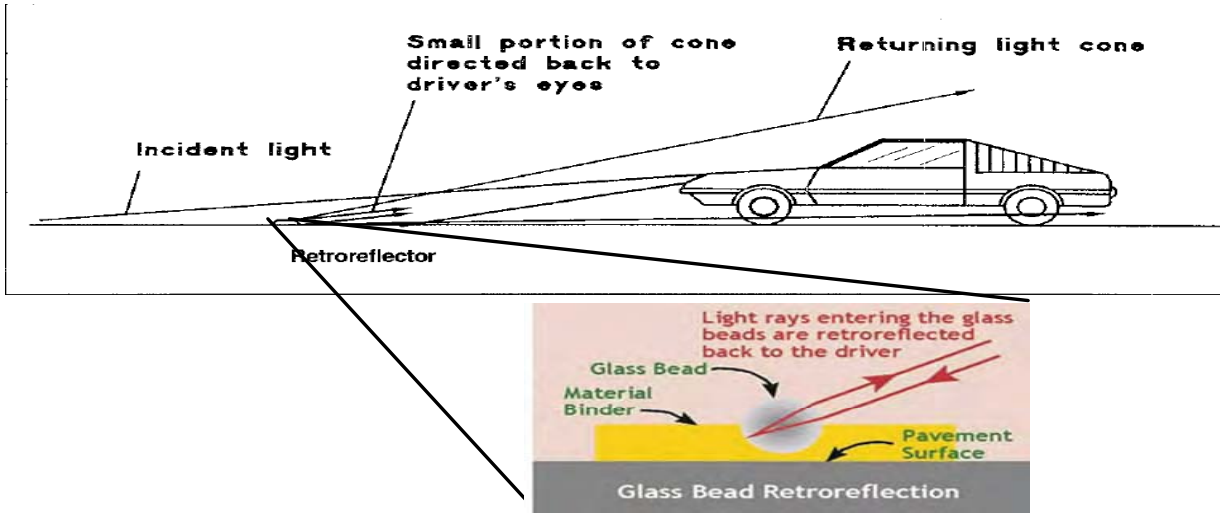

Figure 2. Light returned by the pavement markings

Epoxy-Based Paints

Epoxy-based paints generally consist of two materials: pigment and binder. Typical epoxy-based paints are comprised of 18 to 25 percent pigment for white or 19 to 29 percent pigment for yellow, and 71 to 82 percent binder. Typically, glass beads are added to the pigment and binder as it is being applied to the pavement surface. The binder is comprised of two materials: resin and catalyst. When combined, these components chemically react to form a hard material that bonds the color pigments and glass beads to the surface of the pavement.

Epoxy-based paints are significantly more expensive than the latex or alkyd paint, but offer longer life and higher levels of retroreflectivity. Based on a four-inch wide longitudinal strip, the installed costs range from $020 to $0.30 per linear foot.

Like conventional paints, the life of epoxy-based paints is dependent on traffic levels and the use of sand, abrasives, or snowplows.

Initial retroreflectivity levels for epoxy-based paints are higher than latex or alkyd paints: approximately 300 mcd/m^2 /lux for white and 180 mcd/m^2 /lux for yellow. These retroreflectivity levels are achieved when an application rate of 25 pounds of glass beads per gallon of epoxy-based paint is utilized.

Pavement Marking Task Force

The desire to improve pavement marking operations and obtain better life expectancies for traffic paint led to the establishment of a Pavement Marking Task Force in 2002. The Task Force is comprised of various programs within CDOT. The goal of the Task Force is to obtain higher quality pavement marking operations by attempting warranty

specifications and updated quality control specifications. In November 2002, the Task Force organized an industry meeting to discuss the preliminary version of the warranty specification and to listen to industry concerns and improvement recommendations before finalizing the plans and specifications. The Task Force was also instrumental purchasing retroreflectometers for each region of CDOT and in developing Table 1a and b for the minimum retroreflectivity values for the evaluation of pavement marking material.

Table 1a. Rating for White Material

Level of Service	Rating	Retro reflectivity (mcd/m^2 /lux)
A	4	>300
B	3	299 - 251
C	2	250 - 201
D	1	200 - 151
F	0	150 or less

Table 1b. Rating for Yellow Material

Level of Service	Rating	Retro reflectivity (mcd/m^2 /lux)
A	4	>225
B	3	224 - 175
C	2	174 - 140
D	1	139 - 101
F	0	100 or less

OBJECTIVE

The objective of this research is to evaluate the cost-effectiveness of using enhanced specifications with selected performance measures on a few pilot projects. Groups other than CDOT have studied various pavement markings with the goal of determining which is more cost-effective. However, these studies were not performed in Colorado. Therefore, their results may not be applicable because of different weather conditions, traffic volumes, pavement surface types and installation procedures. The Task Force recommended constructing four pilot projects. Two projects were constructed with a two-year warranty specification. The warranty specification can be found in Appendix A. Two projects were constructed with an incentive/disincentive specification. The incentive/disincentive specification can be found in Appendix B.

Warranties

Over the past 10 to 20 years, the use of warranties on roadway construction projects has been viewed as an alternative to the standard practice of state highway agencies. Currently, the way projects are typically bid provides contractors with little opportunity for innovation. Contractors have few opportunities to deviate from standard specifications and, providing that the specifications are met, are not liable if a roadway is found to be defective once it is placed in service. The current CDOT specifications are designed as a prescriptive specification to yield a pavement marking material that performs in a way which ensures the most cost effective project to the public. A new approach, using warranties, would specify the desired outcome.

Under a warranty specification, the contractor is allowed to use innovative practices to provide the desired quality during construction. By removing some of the prescriptive specifications such as the type of pigment and gradation of the glass beads, contractors are encouraged to be innovative and develop new means and methods for longer-lasting stripes. By placing the responsibility (and risk) into the contractor's hands, the contractor is more motivated to follow good construction practices.

There is an increased awareness that contractors should be more responsible for the quality and the durability of their work. The purpose of the warranty is to incorporate a mechanism into the bidding process that would allow a better technical solution and a higher quality of work.

The goal of instituting short-term warranties on projects is to improve the quality and durability of the pavement marking material by allowing a longer timeframe to accept the work. Using this philosophy, the contractor is held liable for the performance of his product within specific retroreflectivity and adherence thresholds for which the contractor has control. With short-term warranties, the quality control during construction is shifted to the contractor thereby decreasing the overall level of CDOT resources needed for project delivery.

By specifying a short-term warranty, any deficiencies related to construction or material properties of the pavement marking are the responsibility of the contractor while under warranty. At the very least, these warranty projects should perform as well as the pavements constructed

with standard construction practices while providing visible pavement markings over their intended lives at reasonable costs.

Before 1991, the Federal Highway Administration (FHWA) restricted the use of warranties because the FHWA considered them to be an extension of routine maintenance operations and routine maintenance work was excluded from federal funding. On an experimental basis, the 1991 Intermodal Surface Transportation Efficiency Act permitted warranty projects using Federal-Aid funds. Warranty projects were advanced through the FHWA Special Experimental Program (SEP #14 – Innovative Contracting) on new or rehabilitation projects.

On May 21, 1997 the Colorado Senate approved Senate Bill 97-128. The Senate Bill established a pilot program for the warranty of hot mix asphalt projects. CDOT has extended this bill to include two pilot pavement marking material projects.

Incentives/Disincentives

Since 1969, CDOT has had a statically based acceptance specification which includes procedures for measuring the percent within tolerance for various construction materials. Formulas are included for disincentive (penalties) payments to the contractor for those materials not in reasonably close conformity with the specifications. There were no provisions for incentive payments for improved quality and uniformity beyond the minimum requirements of the specifications. Very little headway was made toward shifting the responsibility for process control of materials to the industry. Contractors and producers relied heavily on CDOT acceptance tests for necessary process control information.

Around 1988, CDOT and the asphalt industry began to develop interest in quality control /quality assurance (QA/QC) type specifications. The primary components of QA/QC specifications are; a statistical acceptance plan by CDOT, well developed process control procedures by the contractor, and reasonable payment schedule. This schedule may include disincentives and incentives payments based on the statistical measure of quality.

By 1992, CDOT was successfully using QA/QC specifications for hot mix asphalt. Shortly thereafter, QA/QC specifications for Portland cement concrete pavement were implemeted.

PROJECT SCOPE

The main objective of this research was to determine the cost-effectiveness of epoxy pavement marking material used by CDOT on newly constructed projects. Epoxy striping material is mainly used and specified by CDOT for construction or rehabilitation projects on the roadway. The epoxy is expected to last four to five years. Maintenance forces are required to re-strip over the top until the next rehabilitation project.

The remaining sections of this report outline the projects, data collection procedures, reduction of data sets, and a life cycle cost analysis. To determine cost-effectiveness, the initial cost, retroreflectivity, and service life of each project were used.

Data Collection Methods

In brief, a minimum of five test site locations were established throughout the length of the four pilot projects as well as the four control project. All test sites were randomly selected. Each test site incorporated all white and yellow edge lines as well as white skip lines and yellow centerlines. Data collection was carried out on a periodic basis at all pilot and control locations. Efforts were made to conduct testing within 14 days of application in order to comply with ASTM D6359, "Standard Specification for Minimum Retroreflectance of Newly Applied Pavement Marking Using Portable Hand-Operated Instruments." Figure 3, provided below, displays a typical site.

Figure 3. Looking south in the northbound lane ON us 285 at MP 224

All retroreflectivity readings were collected with an LTL 2000 Retroreflectometer in accordance with ASTM E 1710, "Standard Test Method for Measurement of Retroreflectivity Pavement Marking Materials with CEN-Prescribed Geometry Using a Portable Retroreflectometer." Adhesion tests were conducted in accordance with ASTM D 4541, "Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers." The hardness of the newly constructed epoxy-based paint was measured in accordance with ASTM D 2240, Standard test Method for Rubber Property – Durometer Hardness." Visual assessments of loss were conducted in accordance with ASTM D 913, "Standard Test Method for Evaluating Degree of Resistance to Wear of Traffic Paint." The resistance to abrasion was performed in accordance to ASTM C 501, "Standard Test Method for Relative Resistance to Wear of Unglazed Ceramic Tile by the Taber Abraser." The film thickness was measured by dividing the number of gallons with a correction factor by the length and width of the stripe. All retroreflectivity and durability readings were recorded onto the appropriate field forms and then entered into project specific spreadsheets. A copy of the field form is provided in Appendix C.

Data collection was carried out on the pilot projects and the control projects during the same day. When applicable, the pavement markings were cleaned with water to remove and salt, dirt, or other debris and then thoroughly dried prior to data collection.

Establishing Pilot and Control Projects Comparison Sets

In this step, the pilot and appropriate control projects were selected using the established guidelines from the task force. In order to minimize any bias in the analysis, the control projects for each pilot project were selected based on their similarity in terms of traffic, project type, location, and year of construction. In most cases, the characteristics were similar, but not necessarily identical.

Cost-Effectiveness Analysis

The approach taken was to combine cost, effectiveness, and service life to measure cost-effectiveness. The measure of cost-effectiveness used in this study is equal the total installed cost per square yard over a five year period. The end of service life is when a retroreflectivity value reaches the level of service F shown in Tables 1a or b.

User Cost

These costs are considered to be indirect "soft" costs borne by the facility user in the work zone as they relate to roadway condition, maintenance activity, and rehabilitation work. These costs include user travel time and increased vehicle operating costs (VOC). Though these "soft" costs are not part of the actual spending for CDOT, the costs are inherent in the cost of road repair and are included in maintenance fees. For the value of travel time, CDOT used $17.00 per hour for passenger cars, $35.00 per hour for single unit trucks, and $36.50 per hour for combination trucks. To determine the user cost, we used software called WorkZone –Road User Cost developed for CDOT. In practice, if vehicles are queuing up behind the paint truck, the marking crew will pull over to release the queue and reduce delay. Since the projects varied in size, the user cost was determined in dollars/square foot.

Estimating Effectiveness

For warranty projects, the contractual threshold of performance indicators was established by CDOT to reflect minimum acceptable retroreflectivity and the minimum amount of loss of marking material over the warranty period. The contractor is obligated to perform remedial work if the thresholds are exceeded at any time during that period. Such thresholds on warranty projects are not the same minimums for replacement.

For QA/QC projects, the contractor is paid an incentive if the test element exceeds the target values set by the task force. The target values were determined from constructed projects that performed with good performance characteristics. The selected performance elements that were tested are; hardness, abrasion resistance, in-place adhesion, in-place thickness and in-place retroreflectivity.

PROJECT INFORMATION

C R600-211 (Warranty)

This warranty project is at three locations in Region 6. The first location is on Wadsworth Boulevard from Brook Drive to Parkhill and consisted of 32,000 square feet of marking material. The second location is on I-70 from I-225 to Tower Road and consisted of 34,000 square feet of material. The third location is on Federal Boulevard from US 36 to 120th Avenue and consisted of 65,000 square feet of material. For reference, the Colorado sub-account number is14564.

The control project is at two locations also in Region 6. The first location is on I-25 in the northbound direction from 38th Avenue to US 36 and consisted of 30,000 square feet. The second location is on I-25 in the southbound direction from exit 216 to 38th Avenue and consisted of 44,000 square feet. For reference, the Colorado sub-account number is M6024.

A comparison of the information from both the warranty and control projects is summarized in Table 2 below. The information in the following table represents the approximate quantity of epoxy pavement marking material used to bid the projects.

Table 2 Comparison summary

	Warranty Project	Control Project	Rehab Project
Award Date	September 9,2003	March 6, 2003	April 13, 2006
Begin Construction Date	October 1,2003	April 1, 2003	May 10, 2006
Project Acceptance Date	November 21,2003	June 20, 2003	August 31, 2006
Quantity	131,000	74,000	63,000
Bid Price, $/Square foot	0.80	0.61	0.72
2-Year Warranty $/Square foot	1.50	n/a	n/a

Initial Construction Cost

Using the information from the previous table, the unit cost of the warranty project (including the warranty period) totaled $1.69 per square foot more than the control project. Based on the approximate quantity, the warranty project cost $221,390 (1.69 * 131,000) more than if the project was constructed without a warranty specification.

Performance Data

The retroreflectivity data shown in Figure 4 indicates that the warranty project had better performance as the control project. While both projects performed well over the 2-year warranty period, the control project needed to be restriped three years after the start of the research study.

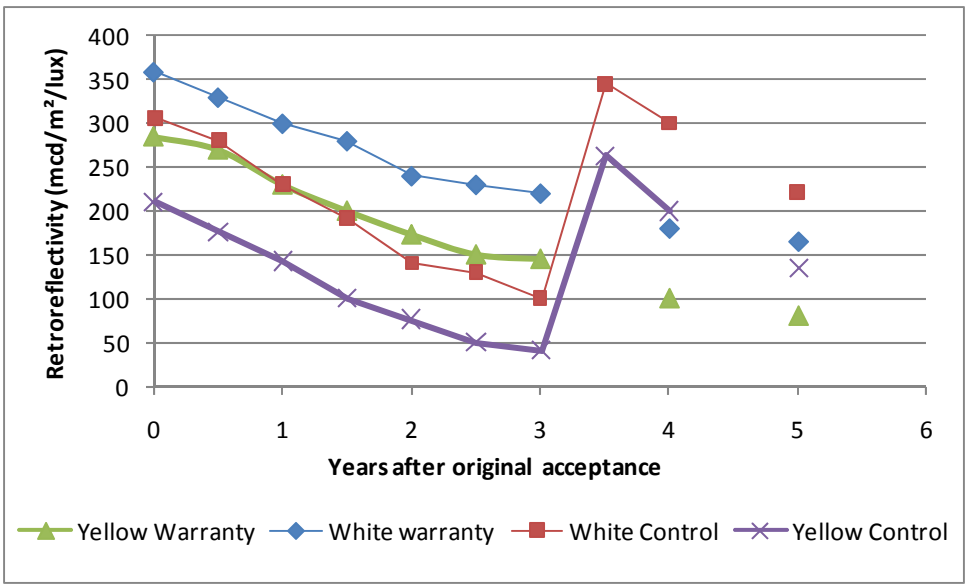

Figure 4. Region 6 projects

User Cost

The total user cost associated with the restriping of the control project was 1,613 or $0.02 per square foot.

Cost-effectiveness

Based on the performance data shown in Figure 4, the service life of the warranty project is about 5 years for white and 4 years for yellow. The service life of the control project is 3 years for both with and yellow material. Over the five year period, the total unit cost of the warranty project is $2.3 per square foot while the control project cost is $1.35 per square foot. Since the warranty project exceeds the cost of the control project by $0.95 per square foot, the warranty project is not worthwhile.

MC R300-118 (Warranty)

Due to a miscommunication, the warranty project was not separate project from the control project. The warranty segments are located at two locations in Region 3. The first location is on US 6 between Edwards and Dowd Junction from milepost 164.0 to milepost 173.0 and consisted of 92,300 square feet of marking material. The second location is on SH 82 from Glenwood Springs to Cottonwood Pass Road from milepost 1.4 to milepost 8.0 and consisted of 40,600 square feet of material. For reference, the Colorado sub-account number is14743.

The control segments are at various locations throughout Region 3 and consisted of 4,765,400 square feet. In order to monitor performance, sites adjacent to the warranty segments were selected. The first location is on US 6 between Edwards and Dowd Junction from milepost 142.0 and milepost 164.0 and consisted of 183,900 square feet of marking material. The second

location is on SH 82 from Cottonwood Pass Road to Snowmass canyon from milepost 8.0 to milepost 26.8 and consisted of 164,400 square feet of material.

A comparison of the information from both the warranty and control projects is summarized in Table 3 below. The information in the following table represents the approximate quantity of epoxy pavement marking material used to bid the projects.

Table 3 Comparison summary

	Warranty Project	Control Project
Award Date	February 12, 2004	February 12, 2004
Begin Construction Date	March 1, 2004	March 1, 2004
Project Acceptance Date	July 15, 2004	July 15, 2004
Quantity	132,900	4,765,400
Bid Price, $/Square foot	0.30	0.30
2-Year Warranty $/Square foot	0.20	n/a

Initial Construction Cost

Using the information from the previous table, the unit cost of the warranty segments (including the warranty period) totaled $0.20 per square foot more than the control project. Based on the approximate quantity, the warranty segments cost $26,580 (0.20 * 132,900) more than if the project was constructed without a warranty specification.

Performance Data

The retroreflectivity data shown in Figure 5 indicates that the warranty segments performance as well as the control segments. While both projects performed well over the 2-year warranty period, the both needed to be restriped four years after the start of the research study.

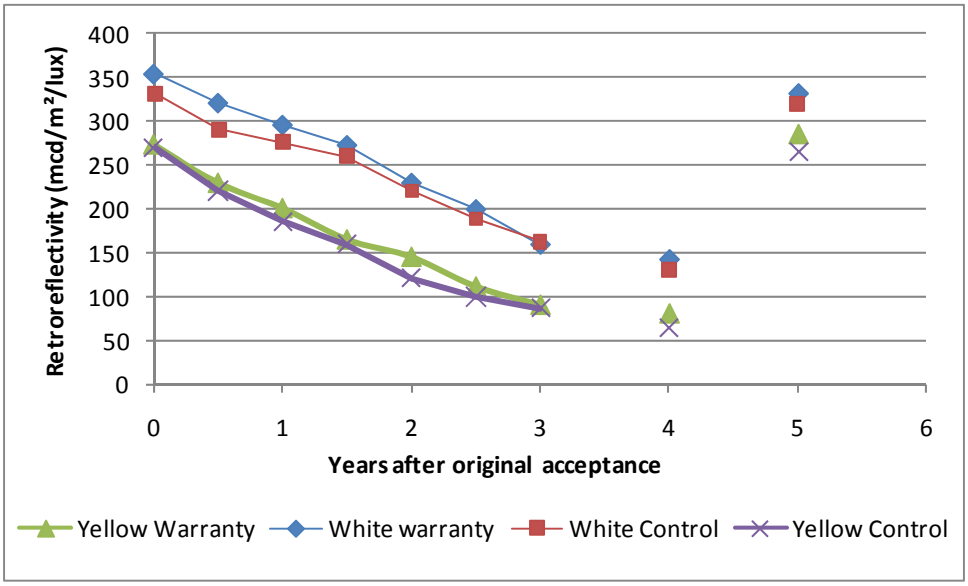

Figure 5. Region 3 locations

User Cost

The user cost associated with the restriping the warranty and control segments had the same unit cost per square foot therefore; the cost was not included in this analysis.

Cost-effectiveness

Based on the performance data shown in Figure 5, the service life of the warranty and control segments is about 4 years for white and yellow. Since the warranty and control segments were restriped at the same time in 2009, the total unit cost of the warranty locations is $0.5 per square foot while the control locations cost is $0.3 per square foot. Since the warranty project exceeds the cost of the control project by $0.20 per square foot, the warranty project is not worthwhile.

MTCE 04-048 (QA/QC)

The QA/QC project is located in Region 4 on US 34 from milepost 98.51 to milepost 121.93 with a no work segment in Evans (milepost 111.98 to milepost 112.97). The project consisted of 273,407 square feet of marking material. For reference, the Colorado sub-account number is M4048.

The control project is also located in Region 4 on US 34 from milepost 159.0 to milepost 259.51 and consisted of 778,000 square feet. For reference, the Colorado sub-account number is M4050.

A comparison of the information from both the QA/QC and control projects is summarized in Table 4 below. The information in the following table represents the approximate quantity of epoxy pavement marking material used to bid the projects.

Table 4 Comparison summary

	QA/QC Project	Control Project
Award Date	August 5, 2004	March 11, 2004
Begin Construction Date	September 1, 2004	April 1, 2004
Project Acceptance Date	September 30, 2004	July 15, 2004
Quantity	273,407	778,000
Bid Price, $/Square foot	0.65	0.32

Initial Construction Cost

Using the information from the previous table, the unit cost of the QA/QC project segments is $0.33 per square foot more than the control project. Based on the approximate quantity, the QA/QC project cost $90,224 (0.33 * 273,407) more than if the project was constructed without a QA/QC specification.

Performance Data

The retroreflectivity data shown in Figure 6 indicates that the QA/QC project performed as well as the control project. While both projects performed well, the contractor was assessed a total disincentive of $2,743.25 or $0.01 per square foot for their retroreflectivity and thickness measures. Both projects needed to be restriped five years after the start of the research study.

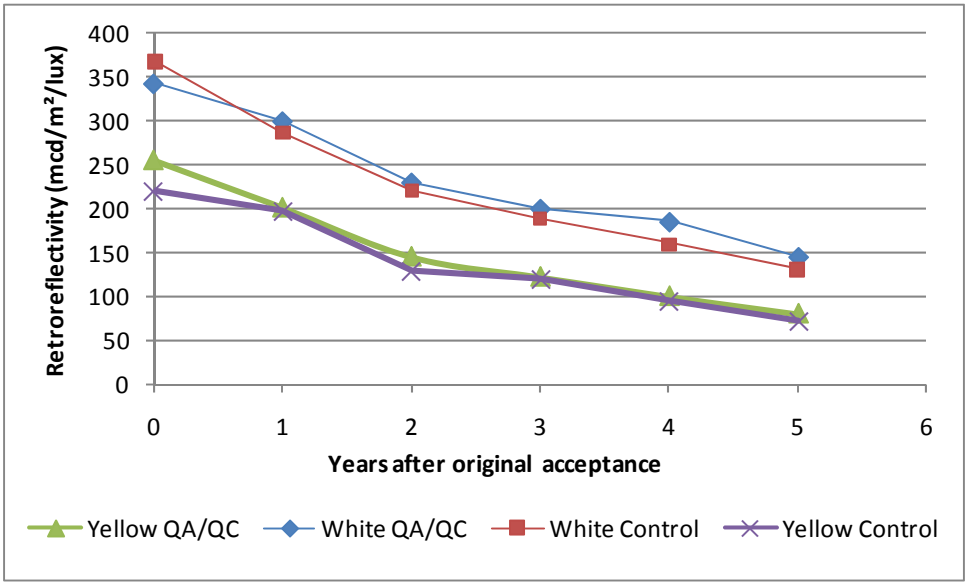

Figure 6. Region 4 Projects

User Cost

The user cost associated with the restriping the QA/QC and control project had the same unit cost per square foot therefore; the cost was not included in this analysis.

Cost-effectiveness

Based on the performance data shown in Figure 6, the service life of the QA/QC and control projects is about 5 years for white and yellow. CDOT has scheduled these projects to be restriped in 2010, the total unit cost of the QA/QC project is $0.64 per square foot while the control locations cost is $0.32 per square foot. Since the QA/QC project exceeds the cost of the control project by $0.32 per square foot, the QA/QC project is not worthwhile.

MTCE 01-033 (QA/QC)

The QA/QC project is located in Region 1 on US 285 near Bailey from milepost 222.5 to milepost 242.5. The project consisted of 231,000 square feet of marking material. For reference, the Colorado sub-account number is M1033.

The control project is also located in Region 1 however; it was at various locations throughout the region which totaled 2,764,800 square feet. The selected control segment is on US 285 from milepost 183.0 to milepost 222.5 and consisted of 456,225 square feet. For reference, the Colorado sub-account number is M1035.

A comparison of the information from both the QA/QC and control projects is summarized in Table 5 below. The information in the following table represents the approximate quantity of epoxy pavement marking material used to bid the projects.

Table 5 Comparison summary

	QA/QC Project	Control Project
Award Date	January 8, 2004	January 8, 2004
Begin Construction Date	March 1, 2004	March 1, 2004
Project Acceptance Date	April 30, 2004	June 18, 2004
Quantity	231,000	2,764,800
Bid Price, $/Square foot	0.75	0.29

Initial Construction Cost

Using the information from the previous table, the unit cost of the QA/QC project segments is $0.46 per square foot more than the control project. Based on the approximate quantity, the QA/QC project cost $106,260 (0.46 * 231,000) more than if the project was constructed without a QA/QC specification.

Performance Data

The retroreflectivity data shown in Figure 7 indicates that the QA/QC project performed as well as the control project. While both projects performed well, the contractor was assessed a total incentive of $454.04 or $0.002 per square foot for their retroreflectivity and thickness measures. Both projects needed to be restriped five years after the start of the research study.

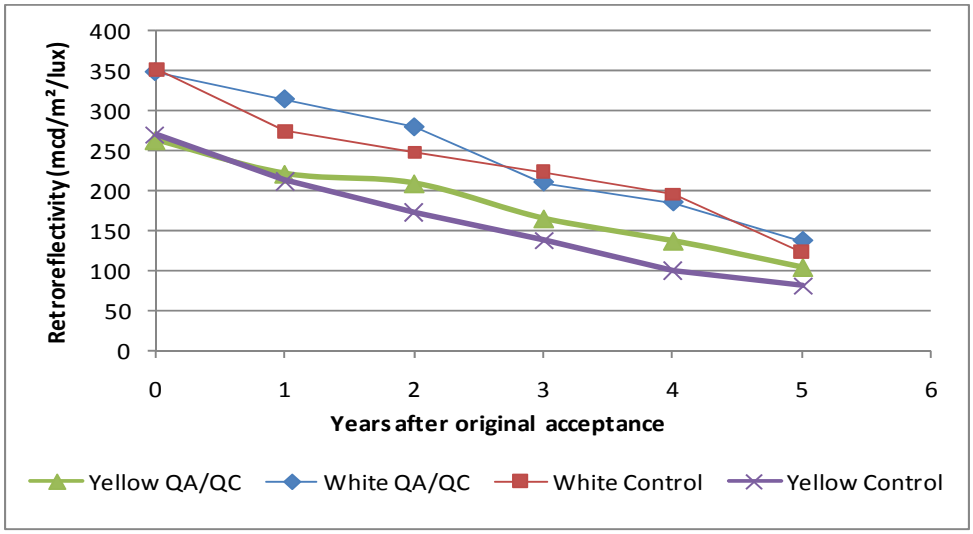

Figure 7. Region 1 Projects

User Cost

The user cost associated with the restriping the QA/QC and control project had the same unit cost per square foot therefore; the cost was not included in this analysis.

Cost-effectiveness

Based on the performance data shown in Figure 7, the service life of the QA/QC and control projects is about 5 years for white and yellow. The total unit cost of the QA/QC project is $0.75 per square foot while the control locations cost is $0.29 per square foot. Since the QA/QC project exceeds the cost of the control project by $0.46 per square foot, the QA/QC project is not worthwhile.

PROJECT SUMMARY

Each project was individually evaluated to determine if there was an overall cost savings that resulted from the enhanced specifications. Another evaluation was the performance life from these specifications. Based on the data from this report, none of these projects had an overall cost savings and only one project out-performed the control project. The summary of this information is shown in Table 6.

Table 6 Project Summary

Project	Specification	Years of Service Life	Overall Cost Savings	Overall Difference in Unit Cost	Overall Difference in Cost
C R600-211	Warranty	5	No	$0.95/sq. ft.	$124,450
MC R300-118	Warranty	4	No	$0.20/sq. ft.	$26,580
MTCE 04-048	QA/QC	5	No	$0.32/sq. ft.	$87,490
MTCE 01-033	QA/QC	5	No	$0.46/sq. ft.	$106,260

CONCLUSIONS

In conclusion, the enhanced specifications for pavement marking material did not perform much better than the control projects. All enhanced specification projects cost more to construct. Some of this cost can be attributed to the contractor's risk for building these innovative specifications by CDOT. However, the service life for epoxy-based marking material appears to be near the anticipated life. Based on the evaluation of these projects, the implementation of these enhanced specifications is not a cost-effective tool for CDOT.

Appendix A

REVISION OF SECTION 105
ACCEPTANCE

Section 105 of the Standard Specifications is hereby revised for this project as follows:

Delete subsection 105.16(b) and replace with the following:

(b) *Job Acceptance.* Job acceptance will occur upon the satisfactory completion of all work in the original bid schedule. Upon notice from the Contractor of presumptive completion of the entire project, the Engineer will make an inspection. If the work provided for by the Contract has been satisfactorily completed, that inspection shall constitute the final inspection and the Engineer will notify the Contractor in writing of job acceptance indicating the date on which the project was inspected and accepted.

If the inspection discloses any unsatisfactory work, the Engineer will give the Contractor a written list of the work needing correction. Upon correction of the work another inspection will be made. If the work has been satisfactorily completed, the Engineer will notify the Contractor in writing of the date of final inspection and job acceptance. Job acceptance under this subsection does not waive any legal rights contained in subsection 107.21.

The 2-year warranty period shall start upon satifactory completion of all Warranted Epoxy Pavement Marking.

(c) *Final Acceptance.* Final acceptance will occur upon the completion of the 2-year warranty period and all warranty work.

REVISION OF SECTION 109
PARTIAL PAYMENTS

Section 109 of the Standard Specifications is hereby revised for this project as follows:

In subsection 109.06(a) delete the last sentence and replace with the following:

The amount retained will be in effect until such time as final payment is made, with the following exceptions which require the Contractor's written request and consent of the Surety: Upon completion and job acceptance of the project, after the project quantities are finalized, and the Contractor has submitted the required documentation, the Engineer will make reduction in the amount retained.

REVISION OF SECTION 627
WARRANTED EPOXY PAVEMENT MARKING

Section 627 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

This work consists of the construction of warranted epoxy pavement marking in accordance with these specifications. This work consists of furnishing, installing, inspecting, maintaining and if necessary replacement of pavement markings designed to last for a period of two years from the date of acceptance.

MATERIALS

Long-term epoxy pavement markings are those materials that provide a durable marking warranted by the Contractor for a period of at least two years. Water-born and low VOC solvent base paint and polyester pavement marking products are not acceptable materials.

The Contractor shall provide material that:

(a) Satisfactorily adheres to new and existing portland cement concrete pavement and hot bituminous pavement, including grooved and tined surfaces.

(b) Conforms to pavement contours, breaks and faults.

(c) Resists abrasive action of traffic, snowplows and winter maintenance services.

White and yellow epoxy pavement markings shall consist of high-quality materials and pigments blended to provide consistent daytime and nighttime color conforming to standard highway colors. The Contractor shall provide certification from an independent testing laboratory that the color of white and yellow material without glass beads conforms to the color limits set forth in the following table of daytime chromaticity coordinates measured by 45 degrees/0 degree geometry CIE Illuminant C, 2 degree standard observer.

Color	Chromaticity Coordinates (Corner Points)							
	1		2		3		4	
	x	y	x	y	x	y	x	y
White	0.355	0.355	0.305	0.305	0.285	0.325	0.335	0.375
Yellow	0.560	0.440	0.490	0.510	0.420	0.440	0.460	0.400

The Contractor shall furnish eight sample plates of each color of the material. The Contractor shall prepare four plates without glass beads and four plates with the proper amount and type of glass beads for each different batch of material. After approval, the Department will retain these plates for field comparisons during the term of the contract.

The manufacturer has the option of deciding the amount and type of yellow pigment for yellow material. An independent testing laboratory shall document that pavement marking material and component formulations are free of any of the heavy metal materials listed in the Department of Environmental Quality's Hazardous Waste Management Regulations, e.g., lead, cadmium, and chromium.

Within 14 to 30 days after placement of the material, the Engineer will measure the pavement markings using a Department retroreflectometer with CEN 30 meter geometry (88.76 degree entrance angle and 1.05 degree observation angle) in accordance with ASTM D 6359. The pavement markings shall exhibit an initial minimum average retroreflectivity of 300 mcd/m 2/lux for white and 250 mcd/m 2/lux for yellow in any 161 m (528 foot) section. Construction traffic control shall be performed in accordance with Section 630 at the Contractor’s expense.

CONSTRUCTION REQUIREMENTS

(a) General. The Contractor shall furnish a copy of the manufacturer's installation recommendations including the removal requirements, surface preparation, application rate, line thickness, type of epoxy pavement marking material and glass beads, bead embedment and bead application rate to the Engineer at least two weeks prior to the start of construction.

When the Contractor determines that removal of existing pavement marking is necessary, acceptable methods are sand blast, shot blast, water blast, or grinding. Gouging or grooving of the pavement to more than 1/16 inch during removal shall not be permitted. The area of removal shall be limited to the area of the marking plus one inch on all sides. The Contractor shall prevent damage to transverse and longitudinal joint sealers, and repair any damage according to Section 412. The Contractor shall collect and properly dispose all residues from this operation.

The Contractor shall apply markings to satisfy the dimensions shown or indicated. The cycle length for skip lines shall be maintained at a tolerance of plus/minus 6 inches per 40 feet and the line length of +/- 3 inches per 10 feet. Line widths shall be maintained within a tolerance of +/- 1/8 inch.

The Contractor shall prevent splattering and over spray when applying markings. Unless material is track free at the end of the Contractor's convoy, traffic cones

shall be used to protect markings from traffic. When a vehicle crosses a marking and tracks it or when splattering or over spray occurs, the Contractor shall remove the affected marking and resultant tracking and apply new markings at no additional cost to the Department.

The Contractor shall maintain a daily log showing the work completed, results of the above tests, pavement and air temperatures, relative humidity, the presence of any moisture on the pavement, and any material or equipment problems. Entries shall be legible, in ink, signed and delivered to the Engineer by the end of each workday. Environmental data, e.g., pavement and air temperatures, relative humidity, shall be entered into the log prior to starting work each day and at two additional times during the day.

(b) Acceptance. Markings will be unacceptable for any of the following reasons:

(1) Line dimensions do not conform to specifications.
(2) Initial retroreflectivity is less than 300 mcd/m 2/lux for white markings or less than 250 mcd/m 2/lux for yellow markings as determined using a Department retroreflectometer.
(3) Color does not conform to appropriate daytime chromaticity coordinates for white or yellow.

The Contractor shall remove and replace with new material or restripe any epoxy pavement marking that fails to meet the minimum criteria. Material that fails to meet the minimum criteria within 5 percent may remain at the discretion of the Engineer but with a 20 percent reduction in the payment for that item.

(c) Performance Bond and Liability Insurance. The Contractor shall furnish a warranty performance bond equal to 100 percent of the contract price for the warranted epoxy pavement markings. The bond shall be kept in effect to satisfy the performance criteria throughout the warranty period. The Contractor's public and property damage liability insurance, as specified for all contract operations, shall be maintained throughout the two-year warranty period during the time he is performing warranty work.

The Contractor shall meet or exceed the following criteria in order to be released from responsibility at the end of the two-year warranty period:

(1) The performance requirements shall have been met throughout the warranty period.
(2) All warranty work requirements such as inspection, removal of inappropriate markings, restriping, repair, replacement, traffic control, performance bond,

liability insurance and incidentals shall have been accomplished at no additional cost to the Department.

(d) Warranty. The Contractor shall replace or restripe defective pavement markings as indicated herein at no cost to the Department throughout the two-year warranty period beginning at the time the Department accepts the last section of pavement markings. The Contractor shall replace or restripe unacceptable markings damaged by traffic, anti-skid materials, studded tires, tire chains, chemical deicers, snowplowing or other loss of marking material regardless of the cause. If the markings are damaged by pavement failure or by Department's painting, crack sealing, or pavement repair operations, the Contractor is released from all warranty requirements for the damaged section.

A two-member team will evaluate warranty provisions. The team will consist of one member from the Department designated by the Region Traffic Engineer and one member from the Contractor. A third person that is mutually acceptable to the Department and the Contractor shall be added to the team when the two-member team cannot agree to a decision on warranty work. The Department will cover expenses associated with performing the duties of the Department member and the mutually agreed upon third party. The Contractor shall cover expenses associated with performing the duties of the Contractor member.

The Department representative will be responsible for scheduling surveys, preparing the reports, and notifying the Engineer when warranty work is required.

At least twice a year, beginning with the year after acceptance, the team will:

(1) Observe the Department taking readings by a Department retroreflectometer, or review Department records of such evaluation.
The number of readings will be as large as necessary to ensure that all minimum criteria are satisfied. All readings will be taken during the periods from March through April and August through September, when the pavement is clean and dry.

(2) Determine the magnitude of material loss.

Within two weeks after each testing, the team shall prepare a list of defective areas and/or areas requiring additional inspection and evaluation to decide where material may need to be replaced or restriped.

Traffic control for conducting the surveys during the warranty period will be the responsibility of the Department.

When notified by the team that warranty work is required, the Engineer will notify the Contractor and Surety, in writing. If the Contractor or Surety fails to respond to the team

or the Engineer in writing within 15 days after receiving written notice from the Engineer, Department may make repairs or contract to have the repairs made. The Contractor and Surety shall be responsible and reimburse Department for the total cost of these repairs including lane rental fees.

The Contractor shall replace or restripe, at his expense, all failed or defective markings in the entire section of defective markings within 30 days after notification when any of the following exists during the warranty period:

(1) The average retroreflectivity within any 528-foot section is less than 125 mcd/m 2/lux for white pavement markings and 100 mcd/m 2/lux for yellow pavement markings when tested in accordance to ASTM D 6359. Testing shall be performed on clean markings as approved by the Engineer.

(2) More than 15 percent of the area of a continuous line, or more than 15 percent of the combined area of all skip lines, within any 528-foot section of roadway is missing.

The Contractor shall replace or restripe epoxy pavement marking material under the warranty using the original type material, unless an equal or better material is submitted to and approved by the Department. All warranty work shall be done in accordance with the same standards used in the initial construction and shall be coordinated with the Engineer. Warranty work shall be performed during the times of day and days of week specified for the original contract work. Construction traffic control for warranty work shall be performed in accordance with Section 630 at the Contractor’s expense.

The Contractor shall pay a daily lane rental fee for the closure of each lane or portion of a lane that constricts the normal flow of traffic within the project limits during the warranty work. For example, if a lane is closed at one section and the same lane or another lane is closed at a different section in one day, then only one day will be charged for the lane rental fee. This fee will be assessed for each calendar day or portion thereof, during the warranty work, that the traffic is restricted to less than the number of lanes in the final configuration as shown in the original construction plans.

The Contractor shall be responsible for the lane rental fee. The fee will be based on the applicable rates for any closure whether work is performed or not. This fee is not a penalty, but is a rental fee based upon road user cost to occupy lanes.

The lane rental fee for this project after pavement acceptance shall be $_____ per day. The warranty shall be continued to the end of the original two-year period even when replacement or restriping materials have been installed as specified.

REVISION OF SECTION 627
WARRANTED EPOXY PAVEMENT MARKING

METHOD OF MEASUREMENT

Warranted Epoxy Pavement Marking and Epoxy Pavement Marking (Two-Year Warranty) will be measured by the square foot complete in place and accepted. Quantities will not be remeasured but will be the quantities designated in the Contract. Exceptions will be made when field changes are ordered or when it is determined that there are discrepancies on the plans in an amount of at least plus or minus two percent of the plan quantity.

BASIS OF PAYMENT

Warranted epoxy pavement marking, measured as provided above, will be paid for at the contract unit price per square foot of material. Furnishing, preparing, and placing all materials, glass beads, testing, record keeping, sampling, and all labor, tools, and equipment during construction and incidentals necessary to complete the work will not be paid for separately but shall be included in the unit price bid.

The Epoxy Pavement Marking (Two-Year Warranty) will be paid at the contract unit price, which will be full compensation for the warranty and warranty bonds, for performing warranty work and for materials, labor, tools and equipment used during performance of warranty work, and incidentals necessary to complete the warranty work.

Payment will be paid under:

Pay Item	**Pay Unit**
Warranted Epoxy Pavement Marking	Square Foot
Epoxy Pavement Marking (Two-Year Warranty)	Square Foot

Appendix B

REVISION OF SECTIONS 105, 106 AND 627
QUALITY OF EPOXY PAVEMENT MARKING

Sections 105, 106 and 627 of the Standard Specifications are hereby revised for this project as follows:

Subsection 105.03 shall include the following:

Conformity to the Contract of all epoxy pavement marking material will be determined by tests of hardness, abrasion resistance, adhesion, in-place thickness and retroreflectivity in accordance with the following:

All work performed and all materials furnished shall conform to the lines, dimensions and material requirements, including tolerances, shown in the Contract.

When the Engineer finds the materials or work furnished, work performed, or the finished product are not in conformity with the Contract and has resulted in an inferior or unsatisfactory product, the work or material shall be removed and replaced or otherwise corrected at the expense of the Contractor.

Using a stratified random procedure the Department will determine the locations where the Contractor shall take samples or measurements. Material samples or measurements shall be taken in the presence of the Engineer and shall be tested by the Contractor's independent laboratory and/or independent firm in accordance with Section 106 and with the applicable procedures. The approximate maximum quantity represented by each sample will be set forth in Section 106. Additional samples may be selected and tested as set forth in Section 106 at the Engineer's discretion.

A process for hardness and abrasion resistance will consist of one or more values resulting from tests of the Contractor's material. A process for adhesion, in-place thickness and retroreflectivity will consist of values resulting from in-place tests of the Contractor's work. The in-place adhesion, thickness and retroreflectivity process will consist of one or more test results. All materials produced will be assigned a process. A process normally will include all materials produced prior to a change in the lot or in the width of the epoxy pavement marking material. The Engineer may separate a process in order to accommodate unusual variations for in-place adhesion, thickness and retroreflectivity.

Evaluation of materials for Pay Factors (PF) for hardness, abrasion resistance and in-place adhesion will be done using only the test results from the Contractor's independent laboratory and/or independent testing firm. Evaluation of materials for Pay Factors (PF) for in-place thickness and retroreflectivity will be done using the results from the Department. Each process will have a PF computed in accordance with the requirements of this Section. Test results determined to have testing errors will not be used. An element PF less than zero shall be zero.

REVISION OF SECTIONS 105, 106 AND 627
QUALITY OF EPOXY PAVEMENT MARKING

(a) Representing Small Quantities. When it is necessary to represent the hardness, abrasion resistance, in-place adhesion, thickness, or retroreflectivity by one or two tests, each individual test shall have a PF computed in accordance with the following:

If the value of the test result is greater than or equal to the maximum specified limit, then

$$PF = 1.00$$

If the value of the test result is below the minimum specified limit, then

$$PF = 1.00 - [0.25[(T_L - T_O)/V]]$$

Where: PF = Pay Factor
T_O = the individual test result.
T_L = lower specification limit
V = V factor from Table 105-8

If the pay factor of any of the above calculations is less than 0.75 for any element, the acceptance of the work will be evaluated in accordance to subsection 105.03(d).

(b) The following procedures will be used to compute the incentive/disincentive payments (I/DP), quality level (QL), and pay factors (PF) for processes represented by three or more tests:

1. Quality Level (QL) will be calculated in accordance to CP-71.
2. Compute the PF for the process. When the process has been completed, the number of tests (Pn) it includes shall determine the formula to be used to compute the final pay factor in accordance with the following:

   A. For hardness, abrasion resistance, and in-place adhesion:

   When $Pn \geq 3$
   If $QL \geq 85$, then $PF = 1.00$
   If $QL < 85$, then $PF = 1.00 + [(QL - 85) \times 0.005208]$

   B. For in-place thickness:

   When $Pn \geq 3$
   If $QL \geq 85$, then $PF = 1.00 + [(QL - 85) \times 0.001333]$
   If $QL < 85$, then $PF = 1.00 + [(QL - 85) \times 0.005208]$

C. For retroreflectivity:

When Pn $\geq$ 3
If QL $\geq$ 85, then PF = 1.00 + [(QL – 85) x 0.002000]
If QL < 85, then PF = 1.00 + [(QL – 85) x 0.005208]

3. Compute the I/DP for the process:

I/DP = (PF-1)(QR)(UP)

Where: QR = Quantity Represented by the process.
UP = Unit Price bid for the item.

The total I/DP for an element shall be computed by accumulating the individual I/DP for each process of that element.

(c) As test results become available, they will be used to calculate accumulated QL and I/DP for each element and for the item. The test results from the Contractor's independent laboratory and/or independent firm shall be given to the Engineer within 24 hours after receipt from the laboratory or firm. The I/DP calculations will be made available to the Contractor as early as reasonably practical. When determining the amount of I/DP for a process, the calculated QL and PF for each individual element will be used to determine the I/DP for the element. The total I/DP for each process shall be the sum of the I/DP for each individual element.

I/DP will be made to the Contractor in accordance with subsection 627.13. During production, interim I/DP will be computed for information only. The Pn will change as production continues and test results accumulate. The Pn at the time an I/DP is computed shall determine the formula to be used.

(d) When the PF of every element in a process is 0.75 or greater, the finished quantity of work represented by the process will be accepted at the appropriate PF. If the PF for any element within any process is less than 0.75, the Engineer may:

1. Require the Contractor to remove and replace the material with specification material at no additional cost to the Department.

2. Where the finished product is found to be capable of performing the intended purpose and the value of the finished product is not affected, permit the Contractor to leave the material in place. If the material is permitted to remain in place the PF for the process shall not be greater than 0.75.

(e) The Contractor will not have the option of accepting a price reduction or disincentive in lieu of producing specification material. Continued production of non-specification material will not be permitted. Material, which is obviously defective, may be isolated and rejected without regard to sampling sequence or location within a process.

Table 105-8
"V" Factors and Maximum Incentive Payment
Epoxy Pavement Marking

Element	V Factor	Maximum Incentive Payment	Lower Tolerance Limit, T_L
Hardness	**4**	**0.0%**	**75 shore D units**
Abrasion Resistance	**5**	**0.0%**	**70 wear index**
In-Place Adhesion	**5**	**0.0%**	**100% failure in pavement**
In-Place Thickness	**0.5**	**2.0%**	**20.0 mils**
In-Place Retroreflectivity	**10**	**3.0%**	**White = 300 mcd/m^2/lx Yellow = 250 mcd/m^2/lx**

Subsection 106.03 shall include the following:

All epoxy pavement marking material, Item 627, shall be tested in accordance with the following acceptance testing procedures:

(a) Acceptance Testing. The Contractor's independent laboratory and/or firm shall be responsible for acceptance testing of hardness, abrasion resistance, and in-place adhesion elements at the minimum frequency listed in Table 106-5. Acceptance testing for hardness, abrasion resistance and in-place adhesion shall be performed at the expense of the Contractor. In the presence of the Engineer the Contractor shall obtain at least two, one-pint blended samples of epoxy pavement marking material for each color as directed by the Engineer.

The Engineer will take immediate possession of the two samples of each component. The Engineer will submit one sample of each component to one of the Contractor's independent testing laboratory for testing and retain one sample of each component until project acceptance. The Department will be responsible for acceptance testing of in-place thickness and in-place retroreflectivity at no additional cost to the Contractor.

REVISION OF SECTIONS 105, 106 AND 627
QUALITY OF EPOXY PAVEMENT MARKING

1. Point of sampling. The material for acceptance testing shall be sampled by the Contractor in the presence of the Engineer using approved procedures. Acceptable procedures are AASHTO and ASTM. The order of precedence is AASHTO procedures and then ASTM procedures. The Engineer will designate the location where material samples are to be taken.

2. Testing Standards. Acceptable standards are AASHTO and ASTM. The order of precedence is AASHTO procedures and then ASTM procedures.

3. Laboratory Testing or Firm Qualifications. The Contractor shall supply a list of at least three independent laboratories or independent firms capable of testing epoxy pavement marking material prior to the start of work. The three laboratories or firms responsible for acceptance testing shall be currently accredited by AASHTO, American Material Reference Laboratory (AMRL), or American Association for Laboratory Accreditation (AALA) in testing epoxy pavement marking material.

4. Testing Supervisor Qualifications. The person in charge of and responsible for the testing and reporting shall possess one or more of the following qualifications:

    A. Registration as a Professional Engineer.
    B. Member of the American Chemical Society (ACS) along with being a Senior Chemist of the firm.

5. Technician Qualifications. Technicians performing the tests, if other than the person in responsible charge, shall have a minimum of two years experience in testing epoxy pavement marking material.

6. Testing Schedule. All samples used to determine I/DP by quality level formulas in accordance with Section 105, will be selected by a stratified random process.

REVISION OF SECTIONS 105, 106 AND 627
QUALITY OF EPOXY PAVEMENT MARKING

Table 106-5
Testing Schedule - Item 627 Pavement Marking
Epoxy Pavement Marking Material

Element	Testing Procedure	Minimum Testing Frequency Contractor's Acceptance Laboratory or Firm	Minimum Testing Frequency CDOT Acceptance Testing
Hardness	ASTM D 2240	Min. 1/1,000 gallons or fraction thereof	Witness by the Engineer
Abrasion Resistance	ASTM C 501	Min. 1/1,000 gallons or fraction thereof	Witness by the Engineer
In-Place Adhesion	ASTM D 4541 or approved equal	Min. 1/1,000 gallons or fraction thereof	Witness by the Engineer
In-Place Thickness	See Formula in Subsection 713.17 (o)	Not Applicable	1/day for each width and color
In-Place Retroreflectivity	ASTM D 6359	Not Applicable	20 tests per 528 feet for each mile or fraction thereof

Subsection 627.04, second paragraph, shall include the following:

The Contractor shall provide equipment that will accurately determine the volume of epoxy pavement marking material placed to within $\pm$ 1%. The equipment shall have the capability to be calibrated. The calibration shall be done in the presence of the Engineer on a daily basis.

Subsection 627.13 shall include the following:

Incentive/Disincentive payments (I/DP) will not be made on interim estimates. I/DP will be made when the epoxy pavement marking material has been completed and all the data for computing the I/DP is available.

Payment will be made under:

Pay Item	**Pay Unit**
Epoxy Pavement Marking Material	Square Feet

The width of the pavement marking material will not be measured but shall be the width shown in the plans.

The price per square feet of epoxy pavement marking material shall be full compensation for furnishing and placing all materials including all sampling and testing for hardness, abrasion resistance, in-place adhesion, in-place thickness, and in-place retroreflectivity.

REVISION OF SECTIONS 713
TRAFFIC CONTROL MATERIAL

In Subsection 713.17 delete the first paragraph and replace with the following:

Only epoxy pavement marking material that meets the requirements of this section shall be used on the project.

Subsection 713.17 shall include the following:

(n) *In-Place Adhesion.* When tested in accordance with ASTM D 4541, shall have such a high degree of adhesion to the surface that there shall be no cohesive failure by the layer and shall have no adhesive failure by the interfaces.

(o) *In-Place Thickness*. The epoxy pavement marking material shall be applied at a minimum wet film thickness of 15 Mils (380 micrometers), without consideration for solvent loss, when tested in accordance with the following formula:

$$M = (G * 19{,}300) / (D * W)$$

Where M = Average wet film thickness of paint placed for the day, Mils (rounded to the nearest 0.1 Mils)
G = Gallons of paint used for the day, (rounded to the nearest 1.0 gallon)
D = Distance striped, in feet (rounded to the nearest 1.0 feet)
W = Width of stripe, in inches

(p) *In-Place Retroreflectivity*. When tested in accordance with ASTM D 6359, white epoxy pavement marking material shall have an average minimum initial retroreflective luminance of 300 mcd/m^2 /lx and 250 mcd/m^2 /lx for yellow epoxy pavement marking material when tested within 15 to 30 days after placement for each mile or fraction thereof.

Appendix C

Permanent Pavement Marking Inspection Sheet

Region: SH # Project #

MP to MP: Project length: Date installed: Time:

Pavement marking Material

Epoxy	Thermoplastic	Preformed Plastic	Raised Markings	Others
❒Acrylate ❒None Acrylate ❒Double drop ❒Standard ❒Lead-free	❒Thermoplastic ❒Preformed ❒Inlaid ❒Profiled	❒Preformed Plastic ❒Tape ❒Tape (Inlaid) ❒Tape (Intersection Grade) ❒Tape (contrast Tape)	❒In cut groove ❒Snow plowable ❒Glass ❒Recessed Marker	❒Acrylic Paint ❒Polyester Methyl ❒Methacrylate ❒Latex (waterborne) ❒Armour Stud ❒Tri-methylol free epoxy

Model: **Thickness** Mils **Bead's Type**: □Type I □Type II □Visi □Ceramic □ Floating □ None Floating

Marking manufacturer

❒Morton ❒Linear Dynamics ❒Rohm & Haas ❒Colorado paint ❒3M ❒Armourstud ❒Stimsonite ❒Swarco

❒Pervo ❒Hwy Safety Beacon ❒Epoplex ❒PolyCarb ❒LDI ❒Others

Marking condition

Installer/Contractor: **Tel:** **Striping Equipment:**

Dry Time: **Pavement type:** **Asphalt** ❒new ❒old **Concrete** ❒new ❒old

Type of the road: ❒Mountain ❒Rural ❒Urban Arterial ❒Urban two lane ❒ Interstate Urban ❒ Interstate Rural **AADT:**

Surface condition: ❒Smooth ❒Rough **Temperature**: Time of Installation:

Type of line: ❒Edge Wt.. ❒Skip ❒EdgeYl. ❒X-Walks **Weather condition** ❒Sunny ❒Cloudy

Reading Equipment: ❒Laserlux ❒LTL2000 ❒Retrolux ❒ Mirolux **Cost :$** ❒Sq/ft ❒Gallon

Reflectivity Readings (mcd/m^2/1x)

Reading Information [1]	White Edge Line [2]					White Skip Line [2]					Yellow Center / Edge Line [2]				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
As installed Date: Operator:															
Day time condition \ Visibility															
3 month Date: Operator:															
Day time condition \ Visibility															
6 month Date: Operator:															
Day time condition \ Visibility															
9 month Date: Operator:															
Day time condition \ Visibility															
12 month Date: Operator: Day time condition \ Visibility															

Comments

Note: **1- Reflectometer must be checked for correct calibration at the time of recording the data.**
2- Five readings per mile is recommended.