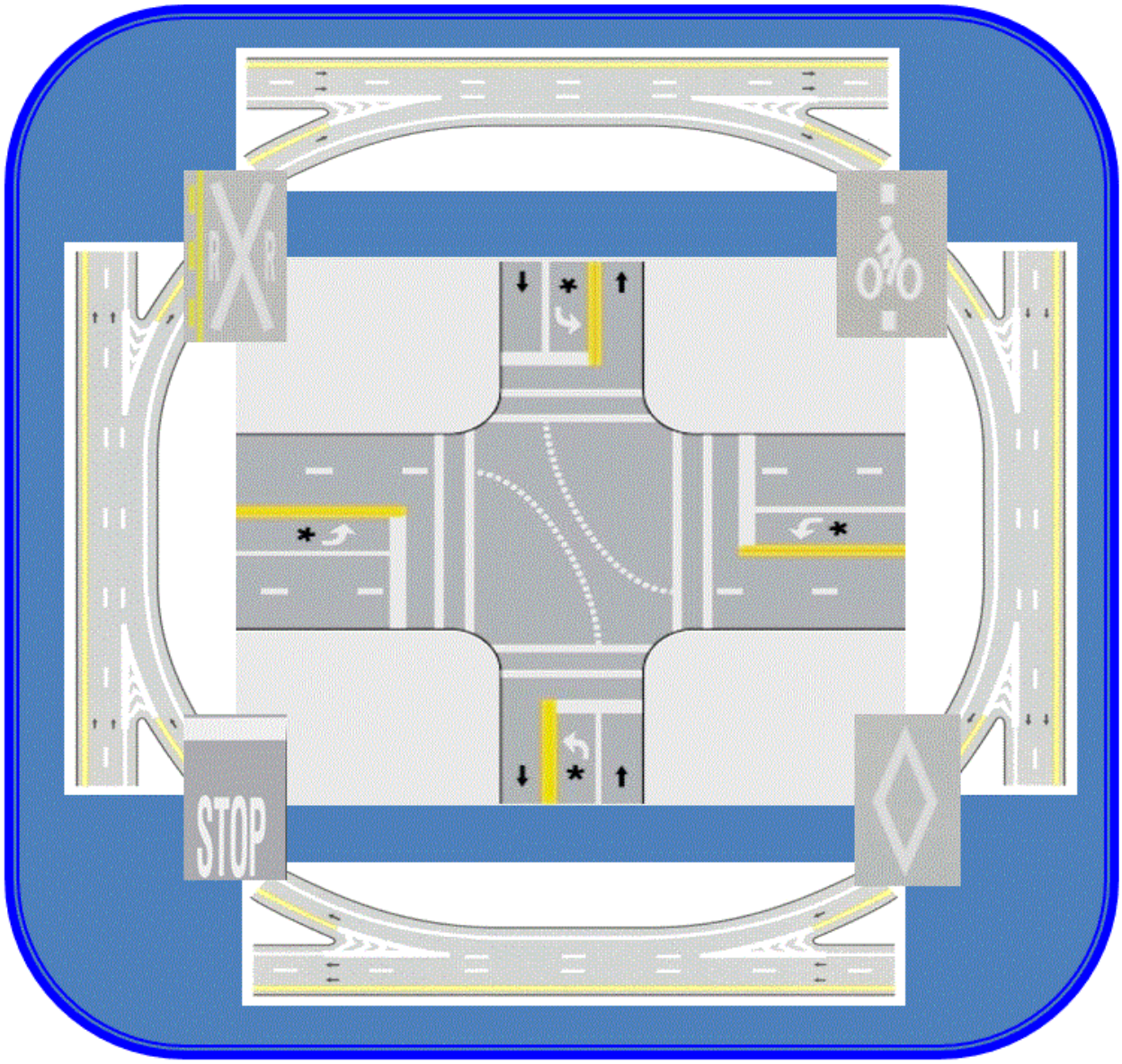
COLORADO
Department of Transportation




# CDOT Pavement Marking Practice Guide

2020 Edition

# ACKNOWLEDGEMENTS

K.C. Matthews (CDOT Safety & Traffic Engineering)
Esayas Butta (CDOT Safety & Traffic Engineering)
Anthony Vu (CDOT Safety & Traffic Engineering)
Shane Chevalier (CDOT R1 Traffic)
Laurel Jones (CDOT R2 Traffic)
Paul Mendoza (CDOT R2 Traffic)
Andi Staley (CDOT R3 Traffic)
Andres Micolta (CDOT R3 Traffic)
Jonathan Woodworth (CDOT R4 Traffic)
Mark Connelly (CDOT R4 Traffic)
Daniel Thomas (CDOT R4 Traffic)
Julie Constan (CDOT R5 Traffic)
Jennifer Allison (CDOT R5 Traffic)
David Peyton (CDOT R5 Traffic)
Mitch Gipson (Caltrans Office of Roadway Materials and Testing)

*Guideline for Selecting Materials and SSPs for Traffic Striping and Pavement Marking*
*December 2011 (Version 2.0)*

Published on 11/05/2020
by HQ Traffic and Safety Engineering
2829 West Howard Place, 4th Floor
Denver, CO 80204
Telephone: (303) 757-9662
Fax: (303) 757-9219

COLORADO
Department of Transportation

# I. Introduction

Numerous studies and project evaluations have repeatedly demonstrated the cost-effectiveness of pavement markings as a means of enhancing both traffic safety and mobility. Pavement markings separate travel lanes and help delineate travel paths and the edge of the roadway. They may stand alone to indicate certain traffic rules and regulations or may be used to supplement regulations or warnings given by other traffic control devices. For a myriad of reasons, the value of viable, visible pavement markings cannot be overstated.

In recognition of the value of pavement markings, the Colorado Department of Transportation (CDOT) provides center line, edge line, auxiliary lane, crosswalk and other pavement markings on all roads under its jurisdiction. All such markings are designed and installed in accordance with the guidelines and standards contained in the latest versions of the federal Manual on Uniform Traffic Control Devices (MUTCD), the Colorado Supplement to the MUTCD, Section 627, 708 and 713 of the 2019 CDOT Standard Specifications for Road and Bridge Construction and CDOT Standard Plan S-627-1.

# II. Selection of Pavement Marking Materials

## A. Longitudinal Pavement Markings

Colorado's unique combination of traffic, weather and necessary snow and ice control measures can be quite detrimental to the longevity of pavement markings. IT IS CDOT's POLICY TO EMPLOY **DURABLE** PAVEMENT MARKINGS ON ALL MAINLINE INTERSTATE/ FREEWAY PROJECTS AND ON OTHER SELECTED ROADWAYS BASED UPON TRAFFIC VOLUMES AND/OR THE REGION'S DETERMINATION OF THE NEED FOR DURABLE MARKINGS.

"Durable" pavement marking materials are those materials capable of providing a longer service life than conventional traffic paint. Use of durable materials not only provides longer-lived markings, it can reduce the frequency of exposure of workers and the traveling public to the hazards of the pavement marking operation itself.

During the project design phase, the pavement and existing markings should be inspected. The AADT and Terrain should be reviewed to aid in selecting the appropriate pavement marking material. Appendices A and B (attached) provide general guidelines for the selection. Other considerations in the selection process may include the desire to employ lead-free materials that do not contain Volatile Organic Compounds (VOC's). **In addition, unique climatic conditions may require the use of a more durable type marking.** The pavement marking marketplace is very dynamic with new materials constantly becoming available. CDOT supports and encourages the testing, evaluation, and use of these new materials.

For lane markings on a paved pedestrian/bicycle path, it is recommended that hi-build waterborne paint be used in accordance with Sections 627.04 (for installation of pavement markings) and 708.05 (material specifications) of the CDOT Standard Specifications for Road and Bridge Construction. If additional traction of the marking surface is needed, corundum can be applied on the marking surface at a drop rate of 3 – 4 pounds per gallon of paint. Retro-reflectivity is not typically required for pedestrian/bicycle path markings and the addition of glass beads is typically omitted in this case. If there is a desire to provide retro-reflectivity to the pavement marking, the designer may add glass beads at a drop rate of 6 – 7 pounds per gallon of paint. However, it should be noted that adding glass beads would reduce traction on the marking surface. In this

case, extra care should be taken to ensure that loose beads are removed prior to the surface being open to the public.

In the design or construction of temporary markings that are not expected to be in place for more than 30 days, a reduced application of Hi-build (100 to 110 sf/gal) may be used. The Engineer should consider the traffic volumes, traffic type, and weather conditions anticipated during this period when determining the desired application rate. A reduced thickness of Hi-build paint is strongly discouraged on high volume roadways under any duration.

## B. Transverse Marking and Symbols (Stencils)

Transverse markings include such items as stop bars, crosswalk lines, railroad crossing approaches, turn arrows, and word or symbol messages.

For placement of Transverse Markings and Symbols (Stencils) refer to CDOT Standard Plan S-627-1.

The materials used for Transverse markings are typically Preformed Thermoplastic, Preformed Plastic Tape, and Methyl Methacrylate (MMA).

Preformed Thermoplastic is preferred in locations where there are turning movements.

As listed on Table 13-2 of the CDOT Standard Specifications for Road and Bridge Construction there are three different types (Type I, II and III) of Performed Plastic Tape.

**Type I** – High performance, durable, preformed patterned pavement marking tape that can be used as an “inlaid” pavement marking recessed into grooves in ACC & PCC surfaces in good condition.

Minimum thickness is 75 mils, with reflectivity meeting requirements of ASTM D4505 Reflectivity Level I, achieved with Ceramic or a combination of glass and Ceramic optics. The minimum refractive index shall be 1.7 and with a surface pattern with a minimum of 31 mils in accordance with ASTM D4505. For more material requirement see table 713-2 of the CDOT Standard Specifications for Road and Bridge Construction

Type I tapes are recommended for lane lines, gore markings and edge-lines. See Appendix A1-3. “Pavement Marking Material Selection Guidelines for Transverse Marking and Symbols” for selection guidelines.

**Figure 1.** Type I Preformed Plastic Tape

**Type II** – High performance durable, retro-reflective, preformed patterned pavement marking tape that can be used as an “inlaid” pavement marking recessed into grooves in PCC surfaces in good condition.

Minimum thickness is 75 mils, with reflectivity meeting requirements of ASTM D4505 Reflectivity Level I, achieved with Ceramic or a combination of glass and Ceramic optics. The minimum refractive index shall be 1.7 and with a surface pattern is a minimum of 31 mils in accordance with ASTM D4505. For more material requirement see table 713-2 of the CDOT Standard Specifications for Road and Bridge Construction

Type I and Type II are essentially the same except that Type II comes with contrast coloring.

Type II tapes are recommended for lane lines, gore markings, and edge-lines, where CONTRAST pavement markings are desired on PCC. See Appendix A1-3. “Pavement Marking Material Selection Guidelines for Transverse Marking and Symbols” for selection guidelines.

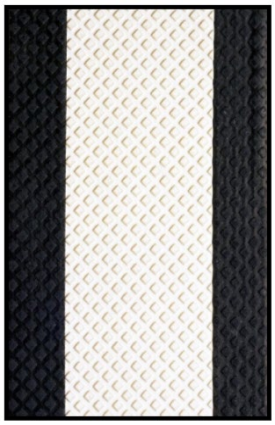


**Figure 2.** Type II Preformed Plastic Tape

**Type III** – Retro-reflective, preformed pavement marking tape that can be used as an “inlaid” pavement marking recessed into grooves in ACC and PCC surfaces in good condition.

Minimum thickness is 60 mils, with reflectivity meeting requirements of ASTM D4505 Reflectivity Level II achieved with glass optics. The minimum refractive index shall be 1.5. For more material requirements see table 713-2 of the CDOT Standard Specifications for Road and Bridge Construction.

**Figure 3.** Type III Preformed Plastic Tape

See Appendix A1-3. “Pavement Marking Material Selection Guidelines for Transverse Marking and Symbols” for selection guidelines.

CDOT typically doesn’t use Type III and it is not recommended for use.

## III. Installation

All Pavement markings shall be installed in accordance with sections 105, 202, 627, and 713 of the CDOT Standard Specifications for Road and Bridge Construction. Prior to project advertisement and continuing throughout construction, CDOT personnel should verify that they are referencing the most current revision of the CDOT Standard Specifications for Road and Bridge Construction at: https://www.codot.gov/business/designsupport/cdot-construction-specifications/2019-construction-specifications/2019-specs-book.

## IV. Evaluation, Testing, and Acceptance

The information outlining the process for submitting a product for evaluation for inclusion on the CDOT Approved Products List (APL) is located at: https://www.codot.gov/business/apl.

For all products delivered to projects, testing must be completed in accordance with Sections 106.12 (Certificates of Compliance) or 106.13 (Certified Test Report) of CDOT Standard Specifications for Road and Bridge Construction.

Products are added to the APL as soon as their evaluation has been completed. All pavement marking products are required to undergo the evaluation procedure outlined in Colorado Procedures 11 – Part I, Sub-Part 6. Pavement Marking Materials at: https://www.codot.gov/business/apl/documents/notice-to-manufactures. Products may be removed from the APL if justifiable concerns arise as to their quality or safety.

The pavement marking products that are available for use are located on the APL: https://apps.coloradodot.info/apl/AplSearch.cfm.

## V. Maintenance of Pavement Markings

**NOTE:** Sections A and C through F are referenced from CDOT Standard Specifications for Road and Bridge Construction Section 627.03. Section B is referenced from the CDOT PD 1502.1 Traffic Control for Planned and Unplanned Work.

### A. Definitions

*“Temporary Pavement Markings”* are full-compliance markings used during construction projects or ongoing maintenance operations.

*“Full-Compliance Markings”* are those meeting all the requirements of CDOT Standard Plan S-627-1.

*“Control Point”* is a four-inch by one-foot mark at 40-foot intervals placed as a guide marker for the installation of temporary or final pavement markings. A raised flexible pavement marker may be substituted for this mark. Control points shall not be used as a substitute for any required marking.

*"Raised Flexible Pavement Markings"* serve as control points to guide marking crew personnel during final striping operations. Prior to final striping, they also provide some minimal travel path delineation to motorists.

## B. Work Duration

| Work Duration | MUTCD Definition | PD 1502.1 Definition |
|---|---|---|
| Long-Term Stationary | More than three (3) days | More than three (3) days |
| Intermediate-Term Stationary | One daylight period up to three (3) days, or nighttime work lasting more than one (1) hour | More than one work shift (of twelve hours) but no more than three days |
| Short-Term Stationary | More than one (1) hour within a single daylight period | A single work shift of no more than twelve (12) hours |
| Short Duration Planned | Up to one (1) hour | Up to one (1) hour |
| Mobile | Moves intermittently or continuously | Moves continually |
| Unplanned and Emergency | Not defined | A serious, unexpected, and potentially dangerous situation that poses an immediate threat to the employee(s) and/or the traveling public |

## C. Pavement Marking Plan

When pavement marking location details are not provided in the Contract, the Contractor shall submit a layout of existing conditions to the Engineer for approval or modification. This layout is to be used as the final pavement marking plan.

## D. Roadways Closed to Traffic During Construction

Full-compliance final markings shall be in place prior to opening the roadway to traffic.

Pavement markings on detour routes shall be full-compliance markings.

## E. Roadways Constructed Under Traffic

Full compliance final pavement markings shall be placed within two weeks after final surfacing is completed. Full compliance pavement markings shall also be placed on any roadways opened to traffic when the project pavement work is discontinued for more than two weeks.

## F. Temporary Pavement Markings

Temporary pavement markings and control points for the installation of those pavement markings for roadways that are being constructed under traffic shall be installed as follows:

1. When one roadway of a normally physically divided highway is closed, and a crossover is constructed, full-compliance pavement markings shall be placed along the tapers and through the median crossovers to the two-way traffic section. Pavement markings through the two-way traffic section shall be as shown on the plans.

   All temporary paved roadways shall have full-compliance center line, lane line, and edge line markings before they are open for traffic.

   Upon removal, markings applied to a final surface shall not leave a scar that conflicts with permanent markings.

2. The following criteria apply to all construction on roadways open to traffic other than (E)1. above:

   Full-compliance center line, lane line, and edge line temporary markings shall be in place at the end of each workday.

   No-passing zone restrictions shall be identified by full-compliance no-passing zone markings. No-passing zone markings shall be in place daily.

   Temporary pavement stencils (SCHOOL, RR Xing, etc.) are not required unless specified in the plans.

   Temporary pavement markings shall be installed according to the manufacturer's recommendations in such a way that the markings adequately follow the desired alignment.

3. Control Points consisting of 4-inch by 1-foot marks at 40-foot intervals may be placed as guide markers for the installation of temporary or final pavement markings. Raised flexible pavement markers may be substituted for these marks. Control points shall not be used as a substitute for any required marking.

## G. Pavement Marking for Seal Coats

1. Raised flexible pavement markers, suitable for use on seal coats, shall be installed as follows:

   No-passing zones shall be marked with two markers placed side-by-side at 40-foot intervals throughout the zone.

   Passing zones shall be marked with one marker at 40-foot centers. Closer spacing shall be used on curves, as deemed appropriate.

   Raised flexible pavement markers, installed on 40-foot centers, may also be used to mark lane lines through multi-lane roadway sections. Auxiliary lanes and shoulder lines may be marked with flexible markers on 80-foot centers or as appropriate.

2. Full-compliance final pavement markings shall be placed within one week of completion of the seal coat project.

## H. Field Inspection

The following are recommended QA/QC practices for pavement marking paint:

- **Mil Thickness Plate Test** – Place small sheets of aluminum across the pavement marking line and apply the paint across the sheets without bead application to check mil thickness. NOTE: Monitor the process to ensure the paint truck maintains a constant speed over the plate. Slowing will result in a thicker application and will make it appear that the truck is applying the material down at a thicker rate.

Once the paint is applied to the plate, the thickness can be determined by inserting a comb gauge directly into the paint at a perpendicular angle to the plate and observing where paint is visible on the gauge. It is important to make the measurement of the paint thickness immediately after application to get an accurate reading. Traffic paint begins to dry immediately upon application and any delay in testing will result in a lower wet film thickness.

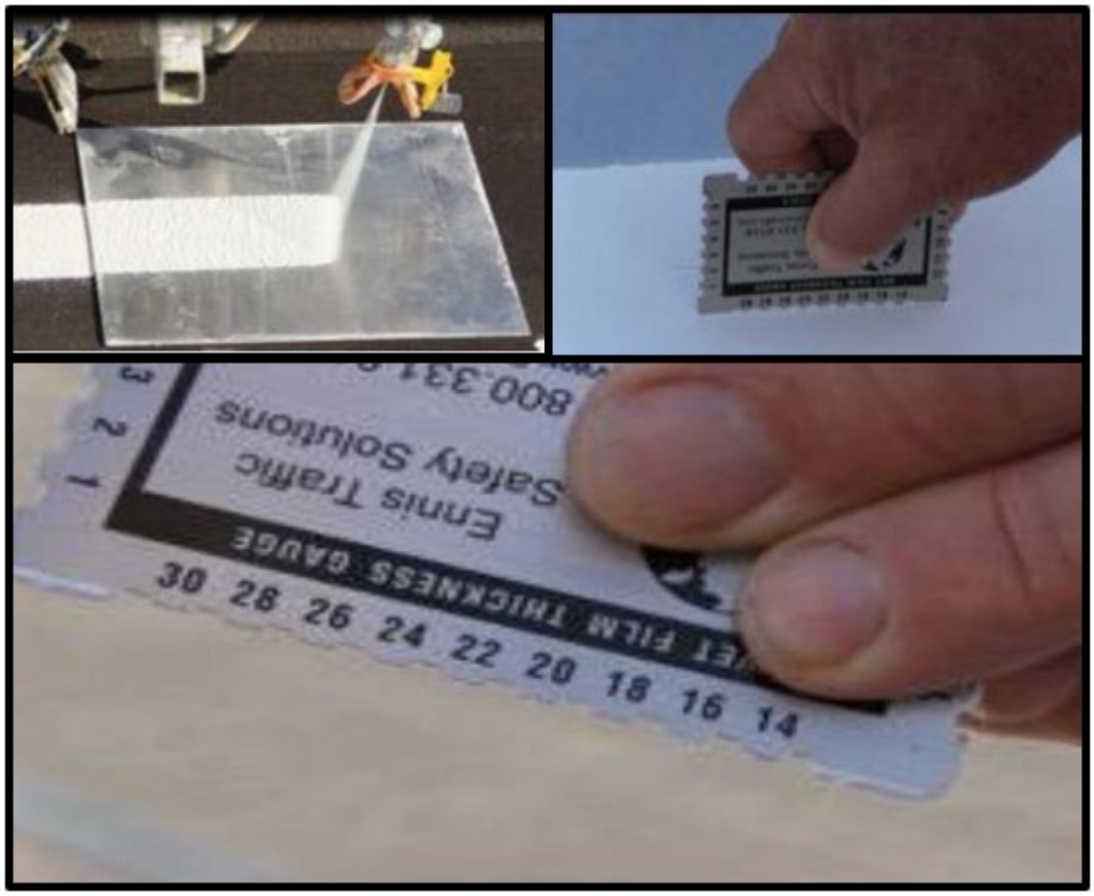



**Figure 4.** Wet Film Gauge

- **Tank Stabs** – Tank stab measurements can be used to verify or approximate the application rate by calculating the volume of material used over the corresponding application area. To use this method, read and record the paint tank level before the work begins and at the end of work or when the truck is refilling. Measure to the top of the fluid level from a fixed point or use the gauge installed in the tank, if available. The difference in the height of the fluid level corresponds to the volume of material used, based on the tank charts from the manufacturer. NOTE: It is important to take this measurement to the nearest ¼ inch and to verify that you are referencing the correct chart for the tank. Plural component materials, such as modified epoxy pavement markings, are applied as a combination of resins and catalysts from separate tanks. In this case, tank stabs must be recorded for each tank and the volumes combined to determine the total volume (gal) applied. The area of applied pavement markings (sf) can be divided by the total volume applied to calculate the application rate (sf/gal).

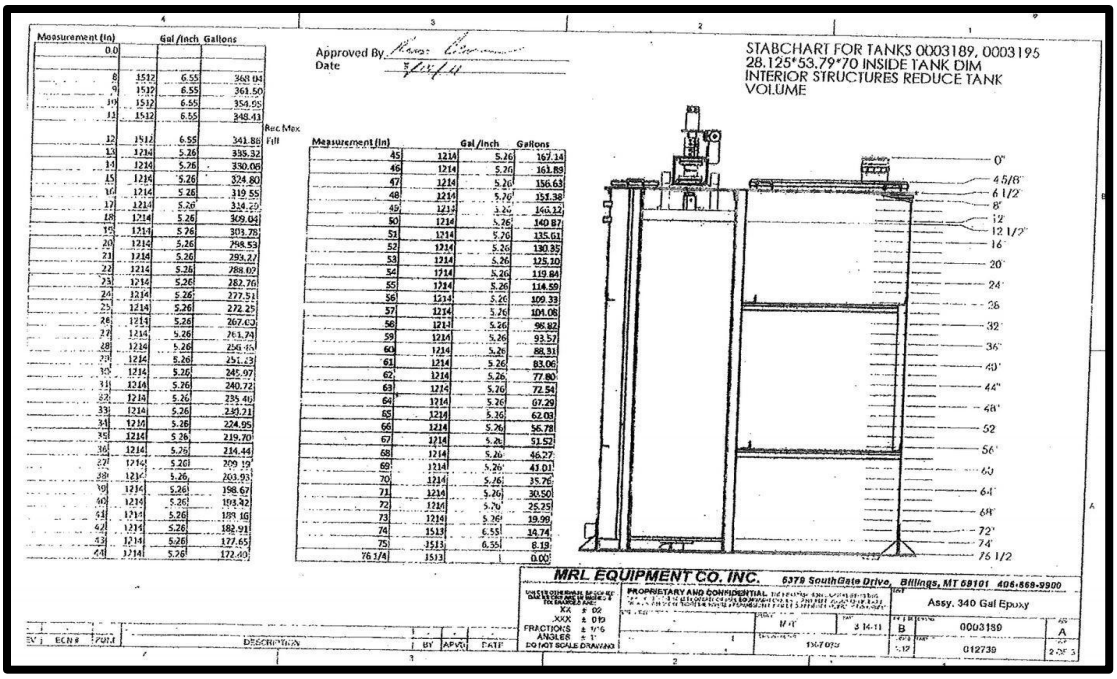



**Figure 5.** Example Tank Stab Chart from Manufacturer

- **On-Board Computers** – Newer paint trucks have computers to determine the gallons used and mil thickness applied based on the average truck speed and the material weight in the tank. The computer can give updated information to the driver as often as every 300 feet. **NOTE:** Most of the contractors use 1000 ft. reading increments but measuring every 300 ft. is more accurate and allows for earlier adjustments, if needed. Tank stabs should still be taken at the beginning of the project and periodically as a quality assurance check.

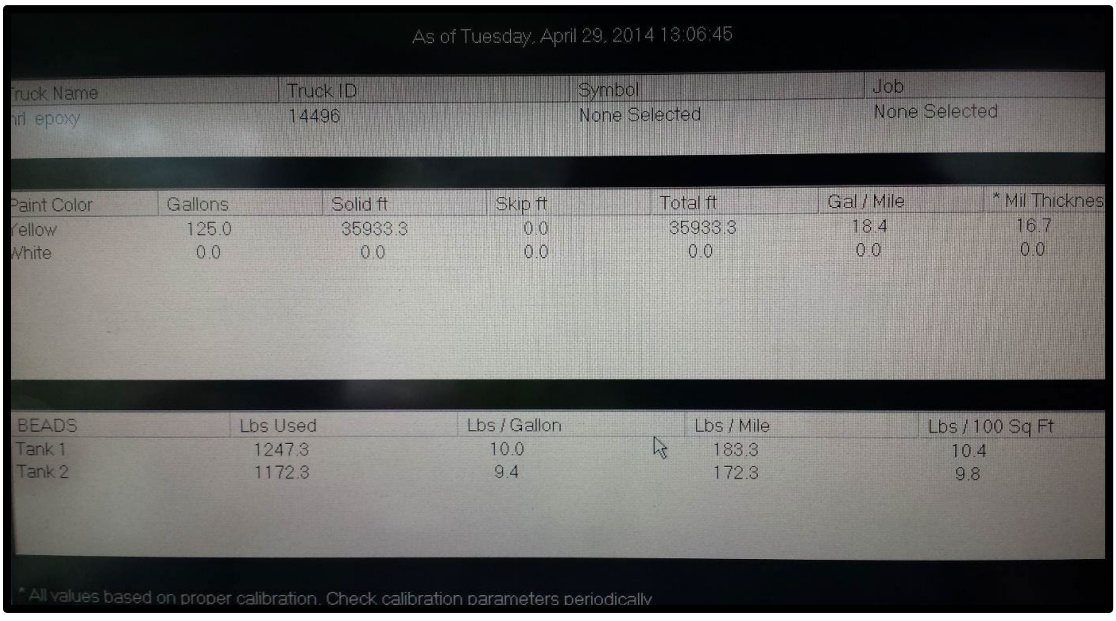



**Figure 6.** Example Report from On-Board Computer

- **Bead Gun Calibration** - Bead guns can be calibrated using the rate charts available in the Appendix. Run the bead guns for 10 seconds and collect the dispensed beads in a container marked with liter increments. The volume and/or weight of beads in the container can be used to estimate the bead rate in lbs./gallon on the ground using the charts in Appendix A2.

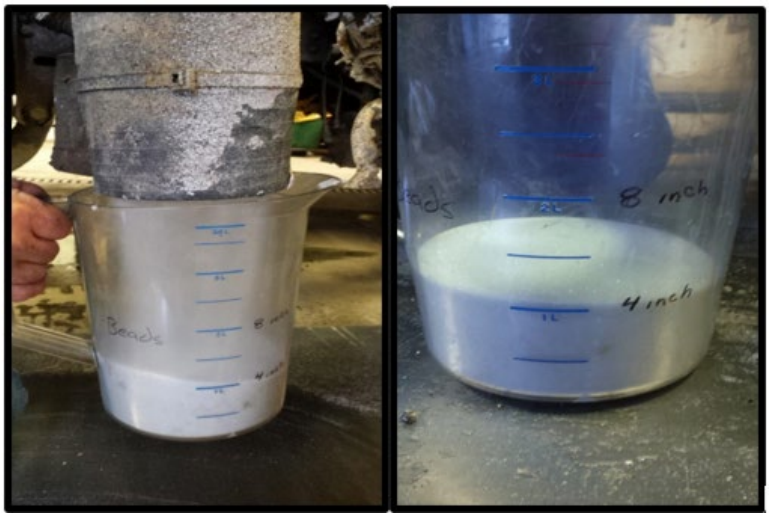



**Figure 7.** Example of Bead Collection Technique

- Retro-reflectivity Requirement – For final alignment pavement markings, retro-reflectivity readings may be required as a quality assurance check in accordance with section 105.03 of the CDOT Standard Specifications for Road and Bridge Construction. This usually occurs no sooner than 3 days and no later than 21 days after the marking is tack free. **NOTE:** Several factors can affect the reliability of these readings. It is important to follow the requirements in the Specification carefully.

**Figure 8.** Handheld Reflectometer

## I. Special Removal Requirements

No more than two layers of permanent pavement markings are recommended on CDOT roadways. Prior to installation of Epoxy Pavement Markings and any surface-applied Preformed Plastic Pavement Markings, existing markings should be removed from the pavement to the maximum extent possible. Methods that do not materially alter or damage the surface or texture of the pavement should be used to avoid “ghost” lines or grind marks that may appear to be pavement markings under some conditions. Non-destructive methods, such as water blasting or

similar, are strongly recommended where “ghost” lines might lead to driver confusion or conflict. Methods that do not produce the desired result, damage the pavement, or may constitute a hazard to the traveling public should not be permitted. Existing pavement markings designated to be removed should be removed before any change is made in traffic patterns to avoid driver confusion. Temporary marking Preformed Plastic Tape sections longer than one foot should be removed before placement of the final pavement course. All temporary striping should be removed where it conflicts with revised traffic lanes prior to opening of new lanes to traffic.

> **NOTE:** Roadway sections paved prior to 2004 and seal coats applied within the last three years are more susceptible to damage caused by removal of striping by grinding, snow plowing and other sources of surface damage, particularly at the centerline joint. It is recommended that pavement marking removal methods other than grinding be considered first on these roads and grinding only be allowed after consultation with the Region Materials staff.

After removing existing markings by grinding, water blasting, or other similar methods, all material on the existing roadway which is loosened in the process of preparation of the surface for striping should be immediately cleared off the roadway using a sweeping pick-up broom or vacuum sweeper. The roadway surface should also be blown clean with a compressed air jet supplied by a compressor with a minimum rating of 125 cfm at 80 psi to remove any latent material. Sweeping and blowing are generally not paid for separately and are incidental to other pay items.

Material removed, used in the removal process, or used to prepare the surface (including water) should not be allowed to run off into any storm drain system, vegetative swale, waterway, stream, wetland, or adjacent property. If runoff occurs, the contractor should immediately stop work until adequate protection can be installed to protect the storm drain system, vegetative swale, waterway, stream, wetland, or adjacent property. Runoff prevention and protection are generally not paid for separately and are incidental to other pay items.

## J. Temporary Pavement Marking Basis of Payment

Removal of temporary pavement markings should be in compliance with Section 202.05 of the CDOT Standard Specifications for Road and Bridge Construction.

Each application of temporary pavement markings should be paid for separately rather than included in other pay items.

Removal of pavement markings should be paid for based on the specified square footage of pavement marking material reinstalled rather than the actual area of removal. If new pavement markings are not planned to be installed, removal should be paid based on the CDOT or manufacturer’s standard dimensions for the pavement marking removed. Field measurement of the actual removal area should not be required to determine the pay quantity. If the temporary pavement markings are removed in the process of recessing the permanent pavement markings, removal of the temporary markings should not be paid for separately but shall be included in the payment for recessing the permanent markings.

# Appendix A. Pavement Marking Material Selection Guidelines

## A1. Longitudinal Lines

### Table A1-1. Longitudinal Lines on Asphalt

*The highest recommended material is emphasized in bold.*

| PAVEMENT CONDITION | CENTER, LANE LINE, & CHANNELIZER (ADT > 25,000) | EDGE & GORE (ADT > 25,000) | CENTER, LANE LINE, CHANNELIZER (ADT 6,000-25,000) | EDGE & GORE (ADT 6,000-25,000) | CENTER, LANE LINE, CHANNELIZER (ADT < 6,000) | EDGE & GORE (ADT < 6,000) |
|---|---|---|---|---|---|---|
| New | **Preformed Plastic Tape**<br>**Modified Epoxy**<br>Polyurea<br>MMA | **Preformed Plastic Tape (Gore only)**<br>**Modified Epoxy**<br>Polyurea<br>MMA | **Preformed Plastic Tape**<br>**Modified Epoxy**<br>Polyurea<br>MMA<br>**Hi-Build Paint** | **Preformed Plastic Tape (Gore Only)**<br>**Modified Epoxy**<br>Polyurea<br>MMA<br>**Hi-Build Paint** | **Preformed Plastic Tape**<br>**Modified Epoxy**<br>Polyurea<br>MMA<br>**Hi-Build Paint** | **Preformed Plastic Tape (Gore Only)**<br>**Modified Epoxy**<br>Polyurea<br>MMA<br>**Hi-Build Paint** |
| Good/ Fair | **Preformed Plastic Tape**<br>**Modified Epoxy**<br>Polyurea<br>MMA | **Preformed Plastic Tape (Gore only)**<br>**Modified Epoxy**<br>Polyurea<br>MMA | **Preformed Plastic Tape**<br>**Modified Epoxy**<br>Polyurea<br>MMA<br>**Hi-Build Paint** | **Preformed Plastic Tape (Gore Only)**<br>**Modified Epoxy**<br>Polyurea<br>MMA<br>**Hi-Build Paint** | **Preformed Plastic Tape**<br>**Modified Epoxy**<br>Polyurea<br>MMA<br>**Hi-Build Paint** | **Preformed Plastic Tape (Gore Only)**<br>**Modified Epoxy**<br>Polyurea<br>MMA<br>**Hi-Build Paint** |
| Poor | **Modified Epoxy**<br>Polyurea<br>MMA | **Modified Epoxy**<br>Polyurea<br>MMA | **Modified Epoxy**<br>Polyurea<br>MMA<br>**Hi-Build Paint** | **Modified Epoxy**<br>Polyurea<br>MMA<br>**Hi-Build Paint** | **Modified Epoxy**<br>Polyurea<br>MMA<br>**Hi-Build Paint** | **Modified Epoxy**<br>Polyurea<br>MMA<br>**Hi-Build Paint** |

**Table A1-2. Longitudinal Lines on Concrete**

*The highest recommended material is emphasized in bold.*

| PAVEMENT CONDITION | CENTER, LANE LINE, & CHANNELIZER (ADT > 25,000) | EDGE & GORE (ADT > 25,000) | CENTER, LANE LINE, CHANNELIZER (ADT 6,000-25,000) | EDGE & GORE (ADT 6,000-25,000) | CENTER, LANE LINE, CHANNELIZER (ADT < 6,000) | EDGE & GORE (ADT < 6,000) |
|---|---|---|---|---|---|---|
| New | **Preformed Plastic Tape**<br>**Modified Epoxy**<br>Polyurea<br>MMA | **Preformed Plastic Tape (Gore only)**<br>**Modified Epoxy**<br>Polyurea<br>MMA | **Preformed Plastic Tape**<br>**Modified Epoxy**<br>Polyurea<br>MMA<br>**Hi-Build Paint** | **Preformed Plastic Tape (Gore Only)**<br>**Modified Epoxy**<br>Polyurea<br>MMA<br>**Hi-Build Paint** | **Preformed Plastic Tape**<br>**Modified Epoxy**<br>Polyurea<br>MMA<br>**Hi-Build Paint** | **Preformed Plastic Tape (Gore Only)**<br>**Modified Epoxy**<br>Polyurea<br>MMA<br>**Hi-Build Paint** |
| Good/ Fair | **Preformed Plastic Tape**<br>**Modified Epoxy**<br>Polyurea<br>MMA | **Preformed Plastic Tape (Gore only)**<br>**Modified Epoxy**<br>Polyurea<br>MMA | **Preformed Plastic Tape**<br>**Modified Epoxy**<br>Polyurea<br>MMA<br>**Hi-Build Paint** | **Preformed Plastic Tape (Gore Only)**<br>**Modified Epoxy**<br>Polyurea<br>MMA<br>**Hi-Build Paint** | **Preformed Plastic Tape**<br>**Modified Epoxy**<br>Polyurea<br>MMA<br>**Hi-Build Paint** | **Preformed Plastic Tape (Gore Only)**<br>**Modified Epoxy**<br>Polyurea<br>MMA<br>**Hi-Build Paint** |
| Poor | **Modified Epoxy**<br>Polyurea<br>MMA | **Modified Epoxy**<br>Polyurea<br>MMA | **Modified Epoxy**<br>Polyurea<br>MMA<br>**Hi-Build Paint** | **Modified Epoxy**<br>Polyurea<br>MMA<br>**Hi-Build Paint** | **Modified Epoxy**<br>Polyurea<br>MMA<br>**Hi-Build Paint** | **Modified Epoxy**<br>Polyurea<br>MMA<br>**Hi-Build Paint** |

## A2. Longitudinal Line Performance and Anticipated Service Life Matrix

| MATERIAL | MOUNTAINOUS (ALL ADT LEVELS) | URBAN & RURAL (ADT > 45,000) | URBAN & RURAL (ADT 15,000-45,000) | URBAN & RURAL (ADT > 15,000) | INSTALLED PRICE[1] | DRY TIME (MIN) |
|---|---|---|---|---|---|---|
| Preformed Plastic Tape | 3 years | 5 – 6 years | 6 – 7 years | 7 – 8 years | $10/SF | N/A |
| MMA (60 MIL) | 2 – 3 years | 2 – 3 years | 4 – 5 years | 5 – 6 years | $15/SF | 5 – 10 |
| Polyurea | 2 – 3 years | 3 – 4 years | 4 – 5 years | 5 – 6 years | $125/Gal | 3 – 5 |
| Modified Epoxy | 1 – 2 years | 3 – 4 years | 4 – 5 years | 4 – 5 years | $60/Gal | 7 – 10 |
| Hi-Build Paint | ½ - 1 year | 1 year | 1 year | 1 – 2 years | $27/Gal | 10 – 12 |

[1] All prices are approximate. Removal of pavement markings and grinding for recessed markings adds an additional cost to the installed price in the table above.

**Notes:**

- Performance is based on the removal and replacement of the existing pavement markings. Performance will vary if applied over the existing pavement markings (retrace).
- Performance of recessed materials typically exceeds the values in the above table.
- Performance on mountain passes may be substantially less than values in the above table.
- Retro-reflectivity readings should be verified annually to ensure MUTCD compliance.
- Employment of the VISILOK® waterborne paint drying agent can reduce the dry time of waterborne paint by more than 50%. VISILOK® manufacturer recommendations should be followed if this method is employed.
- Material UV Stability (Daytime Whiteness) decreases as you move down the above table from PREFORMED PLASTIC TAPE to PAINT.
- Abrasion resistance decreases as you move down the above table from PREFORMED PLASTIC TAPE to PAINT.

## A3. Transverse Markings and Symbols

**Note:** All products listed in Table A3-1 and A3-2 require application of ceramic of class bead optic packages to obtain retro-reflectivity. Friction surface treatment can be added to all products listed above for increased traction.

Includes but is not limited to Extruded Thermoplastic, Hi-Build Paint, Modified Epoxy, Polyurea, and Methyl Methacrylate (MMA).

**Table A3-1. Transverse Markings and Symbols on Asphalt**

*The highest recommended material is emphasized in bold.*

| PAVEMENT CONDITION | CROSSWALK / STOP BARS MARKING TYPE | WORDS / SYMBOLS MARKING TYPE |
|---|---|---|
| New | **Preformed Plastic Tape**<br>**Preformed Thermoplastic**<br>▲ Liquid Durable | **Preformed Plastic Tape**<br>**Preformed Thermoplastic**<br>▲ Liquid Durable |
| Good/ Fair | **Preformed Plastic Tape**<br>**Preformed Thermoplastic**<br>▲ Liquid Durable | **Preformed Plastic Tape**<br>**Preformed Thermoplastic**<br>▲ Liquid Durable |
| Poor | **Preformed Thermoplastic**<br>▲ Liquid Durable | **Preformed Thermoplastic**<br>▲ Liquid Durable |

**Table A3-2. Transverse Markings and Symbols on Concrete**

*The highest recommended material is emphasized in bold.*

| PAVEMENT CONDITION | CROSSWALK / STOP BARS MARKING TYPE | WORDS / SYMBOLS MARKING TYPE |
|---|---|---|
| New | **Preformed Plastic Tape**<br>**Preformed Thermoplastic**<br>▲ Liquid Durable | **Preformed Plastic Tape**<br>**Preformed Thermoplastic**<br>▲ Liquid Durable |
| Good/ Fair | **Preformed Plastic Tape**<br>**Preformed Thermoplastic**<br>▲ Liquid Durable | **Preformed Plastic Tape**<br>**Preformed Thermoplastic**<br>▲ Liquid Durable |
| Poor | **Preformed Thermoplastic**<br>▲ Liquid Durable | **Preformed Thermoplastic**<br>▲ Liquid Durable |

# Appendix B. Glass Bead Calibration

## B1. Calibration by Volume

### Table B1-1. Blend 4-inch Wide, 17-18 Mil Thick, with a Drop Rate of mL per 10 seconds

| Speed (MPH) | 6 #/gal | 8 #/gal | 10 #/gal | 12 #/gal | 14 #/gal | 16 #/gal | 18 #/gal | 20 #/gal | 22 #/gal | 24 #/gal |
|---|---|---|---|---|---|---|---|---|---|---|
| 10 | 954 | 1268 | 1583 | 1908 | 2222 | 2537 | 2851 | 3175 | 3491 | 3805 |
| 9 | 860 | 1141 | 1431 | 1711 | 2001 | 2280 | 2571 | 2851 | 3142 | 3422 |
| 8 | 757 | 1012 | 1268 | 1524 | 1780 | 2026 | 2280 | 2537 | 2793 | 3048 |
| 7 | 664 | 885 | 1106 | 1327 | 1559 | 1780 | 2001 | 2222 | 2443 | 2665 |
| 6 | 672 | 757 | 954 | 1141 | 1327 | 1524 | 1711 | 1908 | 2094 | 2280 |
| 5 | 447 | 639 | 792 | 954 | 1106 | 1268 | 1431 | 1583 | 1745 | 1908 |
| 4 | 384 | 511 | 639 | 757 | 885 | 1012 | 1141 | 1268 | 1396 | 1524 |
| 3 | 290 | 384 | 477 | 570 | 664 | 757 | 860 | 954 | 1046 | 1141 |
| 2 | 187 | 256 | 315 | 384 | 442 | 511 | 570 | 639 | 698 | 757 |

### Table B1-2. Blend 6-inch Wide, 17-18 Mil Thick, with a Drop Rate of mL per 10 seconds

| Speed (MPH) | 6 #/gal | 8 #/gal | 10 #/gal | 12 #/gal | 14 #/gal | 16 #/gal | 18 #/gal | 20 #/gal | 22 #/gal | 24 #/gal |
|---|---|---|---|---|---|---|---|---|---|---|
| 10 | 1431 | 1902 | 2375 | 2862 | 3333 | 3806 | 4277 | 4763 | 5237 | 5708 |
| 9 | 1290 | 1712 | 2147 | 2567 | 3002 | 3420 | 3857 | 4277 | 4713 | 5133 |
| 8 | 1136 | 1518 | 1902 | 2286 | 2670 | 3039 | 3420 | 3806 | 4190 | 4572 |
| 7 | 996 | 1328 | 1659 | 1991 | 2339 | 2670 | 3002 | 3333 | 3665 | 3998 |
| 6 | 1008 | 1136 | 1431 | 1712 | 1991 | 2286 | 2567 | 2862 | 3141 | 3420 |
| 5 | 716 | 959 | 1188 | 1431 | 1659 | 1902 | 2147 | 2375 | 2618 | 2862 |
| 4 | 576 | 767 | 959 | 1136 | 1328 | 1518 | 1712 | 1902 | 2094 | 2286 |
| 3 | 435 | 576 | 716 | 855 | 996 | 1136 | 1290 | 1431 | 1569 | 1712 |
| 2 | 281 | 384 | 473 | 576 | 663 | 767 | 855 | 959 | 1047 | 1136 |

## B2. Calibration by Weight

### Table B2-1. Blend 4-inch Wide, 17-18 Mil Thick, with a Drop Rate of lbs. per 10 seconds

| Speed (MPH) | 6 #/gal | 8 #/gal | 10 #/gal | 12 #/gal | 14 #/gal | 16 #/gal | 18 #/gal | 20 #/gal | 22 #/gal | 24 #/gal |
|---|---|---|---|---|---|---|---|---|---|---|
| 10 | 3.41 | 4.53 | 5.65 | 6.82 | 7.93 | 9.06 | 10.18 | 11.34 | 12.46 | 13.59 |
| 9 | 3.07 | 4.08 | 5.11 | 6.11 | 7.15 | 8.15 | 9.18 | 10.18 | 11.22 | 12.22 |
| 8 | 2.70 | 3.62 | 4.53 | 5.44 | 6.36 | 7.23 | 8.15 | 9.06 | 9.97 | 10.89 |
| 7 | 2.37 | 3.16 | 3.94 | 4.74 | 5.57 | 6.36 | 7.15 | 7.96 | 8.72 | 9.52 |
| 6 | 2.40 | 2.70 | 3.41 | 4.08 | 4.74 | 5.44 | 6.11 | 6.82 | 7.48 | 8.15 |
| 5 | 1.70 | 2.29 | 2.83 | 3.41 | 3.94 | 4.53 | 5.11 | 5.65 | 6.23 | 6.82 |
| 4 | 1.37 | 1.82 | 2.29 | 2.70 | 3.16 | 3.62 | 4.08 | 4.53 | 4.99 | 5.44 |
| 3 | 1.04 | 1.37 | 1.70 | 2.04 | 2.37 | 2.70 | 3.07 | 3.41 | 3.74 | 4.08 |
| 2 | 0.67 | 0.92 | 1.12 | 1.37 | 1.58 | 1.82 | 2.04 | 2.29 | 2.49 | 2.70 |

### Table B2-2. Blend 6-inch Wide, 17-18 Mil Thick, with a Drop Rate of lbs. per 10 seconds

| Speed (MPH) | 6 #/gal | 8 #/gal | 10 #/gal | 12 #/gal | 14 #/gal | 16 #/gal | 18 #/gal | 20 #/gal | 22 #/gal | 24 #/gal |
|---|---|---|---|---|---|---|---|---|---|---|
| 10 | 5.12 | 6.80 | 8.48 | 10.23 | 11.90 | 13.59 | 15.27 | 17.01 | 18.69 | 20.39 |
| 9 | 4.61 | 6.12 | 7.67 | 9.17 | 10.73 | 12.23 | 13.77 | 15.27 | 16.83 | 18.33 |
| 8 | 4.05 | 5.43 | 6.80 | 8.16 | 9.54 | 10.85 | 12.23 | 13.59 | 14.96 | 16.34 |
| 7 | 3.56 | 4.74 | 5.91 | 7.11 | 8.36 | 9.54 | 10.73 | 11.9 | 13.08 | 14.28 |
| 6 | 3.60 | 4.05 | 5.12 | 6.12 | 7.11 | 8.16 | 9.17 | 10.23 | 11.22 | 12.23 |
| 5 | 2.55 | 3.44 | 4.25 | 5.12 | 5.91 | 6.80 | 7.67 | 8.48 | 9.35 | 10.23 |
| 4 | 2.06 | 2.73 | 3.44 | 4.05 | 4.74 | 5.43 | 6.12 | 6.80 | 7.49 | 8.16 |
| 3 | 1.56 | 2.06 | 2.55 | 3.06 | 3.56 | 4.05 | 4.61 | 5.12 | 5.61 | 6.12 |
| 2 | 1.01 | 1.38 | 1.68 | 2.06 | 2.37 | 2.73 | 3.06 | 3.44 | 3.74 | 4.05 |

## B3. Mil Thickness Versus Gallons

| **Mil Thickness** | 10.0 | 12.0 | 14.0 | 16.0 | 18.0 | 20.0 | 22.0 | 24.0 | 26.0 |
|---|---|---|---|---|---|---|---|---|---|
| **Gallon per Mile (4-inch)** | 11.0 | 13.2 | 15.4 | 17.6 | 19.7 | 21.9 | 24.1 | 26.3 | 28.5 |
| **Linear Feet per Gallon (4-inch)** | 481 | 401 | 344 | 301 | 267 | 241 | 219 | 201 | 185 |
| **Square Feet per Gallon (4-inch)** | 160 | 134 | 115 | 100 | 89 | 80 | 73 | 67 | 62 |
| **Gallon per Mile (6-inch)** | 16.5 | 19.7 | 23.0 | 26.3 | 29.6 | 32.9 | 36.2 | 39.5 | 42.8 |
| **Linear Feet per Gallon (6-inch)** | 321 | 267 | 229 | 201 | 178 | 160 | 146 | 134 | 123 |
| **Square Feet per Gallon (6-inch)** | 160 | 134 | 115 | 100 | 89 | 80 | 73 | 67 | 62 |




COLORADO
Department of Transportation