

# Vermont Agency of Transportation Pavement Marking and Optics Guidance

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# Pavement Marking and Optics Guidance

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## **Purpose:**

This guide is intended to assist staff with distinguishing the various types of pavement marking materials as well as optic materials available for use, per the VAOT 2011 Standard Specifications for Construction. This guide defines the different marking and optic materials and provides a reference for when and how these materials are to be used and what acceptance requirements are associated to each material. The information provided herein is intended for use by Construction Inspectors, Office Engineers, Resident Engineers, Contractors, the Materials Acceptance Unit, as well as anyone else involved with VTrans Construction Contracts or materials acceptance.

## **Material Descriptions:**

**Pavement Marking Materials:** Pavement marking materials are pigments (binders/resins) used to mark the roadway with white or yellow lines, including stop bars, letters, and symbols. VTrans currently has 11 different permanent marking materials outlined in the 2011 Specifications for use, which are divided into two categories: Paint for Pavement Markings (Non-Durable) and Durable Pavement Markings.

**Paint for Pavement Markings - 646.06:** Paint for Pavement Markings includes Waterborne Paint and Low VOC Traffic Paint; both are non-durable pavement markings and expected to last between six (6) to twelve (12) months. Typically, only glass beads are used as an optic material for non-durable pavement markings, however, other optic materials are not precluded from use on non-durable pavement markings. Retro-reflectivity testing is not required for non-durable pavement marking optics, regardless of which optic material is actually used. Testing of the paint itself is required. Non-durable pavement markings may be used in any application, including long lines, letters, and symbols.

Low VOC traffic paint - 708.08(b): There are two types of Low VOC paint in the 2011 Specifications, chlorinated rubber and acetone based paint. Both types of Low VOC traffic paint require a Type A certification; however, Low VOC paint materials are rarely used.

Waterborne - 708.08(d): Waterborne paint is the most commonly used type of non-durable pavement marking material. The waterborne paint requires a Type A Certification.

**Durable Pavement Markings - 646.07:** Durable Pavement Markings include Polyurea, Epoxy, Methyl-Methacrylate, Thermoplastic (Types A & B), and Pavement Marking Tapes (Types A, B, C, & D). Durable pavement markings are expected to last more than 3 years. Typically, Premium Optics will be used as an optic material if the pavement marking material requires a “drop-on” optic material; however, other optics can be added to ensure minimum retro-reflectivity is met. Retro-reflectivity testing is required for all durable marking optics, regardless of which optic material is used.

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Polyurea - 708.08(a): Polyurea may be used in all situations for traffic marking, including long lines, letters, and symbols. Any optic material (Glass Beads, Premium Optics, and/or Wet Recoverable and Wet Reflective Optics) may be used to achieve the specified retro-reflectivity minimums. If wet reflective/wet recoverable optics are called out on a project, polyurea most likely will be used as the binder. Polyurea paint must be chosen from the APL and documented by a TA556.

Epoxy - 708.08(c): Epoxy may be used in all situations for traffic marking, including long lines, letters, and symbols. Any optic material (Glass Beads, Premium Optics, and/or Wet Recoverable and Wet Reflective Optics) may be used to achieve the specified retro-reflectivity minimums. Epoxy paint is required to be chosen from the APL and shall be documented with a TA556.

Methyl-Methacrylate - 708.08(e): Methyl-Methacrylate can come as paint, extruded, or a structured material; however, it is rarely used by the Agency. When the paint form of this material is used a Premium Optic will typically be applied as a “drop-on” optic. When the extruded or structured forms of this material are used Glass Beads will typically be intermixed; in addition the extruded material may need an additional optic added as a “drop-on” in order to achieve the minimum retro-reflectivity. Acceptable products for all versions of this material can be found on the APL and shall be documented with a TA556.

Thermoplastic, Type A - 708.10(a): Thermoplastic, Type A is also known as extruded thermoplastic. Thermoplastic, Type A can be used for long lines, stop bars, letters, symbols, crosswalk markings, and railroad crossing symbols; however, is not commonly used for letters. This extruded material must be chosen from the available Type A Thermoplastic products on the APL and documented with a TA556. Glass beads are already included in the thermoplastic mix when it is extruded, and therefore these glass beads do not require a separate certification. However, another optic material may be used as a “drop-on” in addition to the glass beads, and if another optic is used, it will either require certification or must be chosen from the APL (depending on what optic is chosen).

Thermoplastic, Type B - 708.10(b): Thermoplastic, Type B is also known as preformed thermoplastic. Thermoplastic, Type B can be used for stop bars, letters, symbols, crosswalk markings, and railroad crossing symbols; however, will most commonly be used for letters. This material will not be used for long lines. This preformed material must be chosen from the available Type B Thermoplastic products found on the APL and documented by submitting a TA556. Optics are already built in to the preformed material; no additional optic material shall be used.

Pavement Marking Tape - 708.12: Pavement Marking Tape is a durable marking material with optics built in; no additional optic material is used. All types of Tape are to be from the APL and documented with a TA556. Retro-reflectivity testing is required for all long line applications to ensure that the retro-reflectivity advertised by the manufacturer is the retro-reflectivity observed after application.

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Pavement Marking Tape Type A - 708.12(a): This item will be used for long line, HIGH Annual Average Daily Traffic (AADT) applications only. This material will not be used for stop bars, letters or symbols, crosswalk markings, or railroad symbols.

Pavement Marking Tape Type B - 708.12(b): This material will be used for long line, LOWER Annual Average Daily Traffic (AADT) applications only. This material will not be used for stop bar, letter or symbol, crosswalk marking, or railroad symbol items.

Pavement Marking Tape Type C - 708.12(c): This material will be used in applications for intersections, for long lines, letters, or symbols.

Pavement Marking Tape Type D - 708.12(d): This material is a Type A, B, or C Tape that is cut in the field to create desired letter or symbol shapes.

**OPTICS:** Optics materials are used in the application of pavement markings to enhance the retro-reflectivity of the marking material. Optics are typically dropped onto the marking material after it is applied to the pavement. However, optic materials may also be intermixed into the resin, such as with Type A Thermoplastic. Optics may be used in recessed, inlay, or surface applications. The Agency currently recognizes three classes of optic materials:

**Glass Beads - 708.09(a)**: Glass Beads are a class of optics that will produce average dry retro-reflectivity; they are micron-sized glass spheres that are typically used as a “drop-on” material. When used as a “drop-on”, glass beads require a Type A Certification. When the glass beads are intermixed into the marking material, such as with Type A Thermoplastic, they do not require their own certification.

**Premium Optics - 708.09(b)**: Premium Optics are a class of optics that will produce a higher dry retro-reflectivity than Glass Beads alone; they are Microcrystalline ceramic beads and elements (usually the color of the paint) as well as glass beads used in binders and pigments which are applied via “drop-on”. This material is required to be on the Approved Products List (APL) and should be documented with the submission of a TA556.

**Wet Reflective/Wet Recoverable Optics - 708.09(c)**: Wet Reflective/Wet Recoverable Optics encompasses any material that specializes in creating high retro-reflectivity in wet conditions. Wet Reflective beads are usually larger than glass beads and premium optics, and may come in a variety of colors. In some cases, depending upon the manufacturer the Wet Reflective bead may have an angular shape instead of being rounded. This optic is generally used in high annual average traffic volume (AADT) and high accident locations. Wet Reflective beads on their own do not produce high retro-reflectivity in dry situations; they will most likely be used in combination with glass beads and/or premium optics. Wet Reflective materials are relatively new and are intended for very specific use, VAOT rarely specifies this optic. Any Wet Reflective optic material used is required to be from the APL and should be documented using a TA556.

## Pavement Marking and Optics Guidance

### Material Application & Acceptance Requirements Chart

Pavement Marking Material						“drop-on” Optic Options		
Durability	General Information		Notes	Requirements		Glass Beads	Premium Optics	Wet Reflective/ Wet Recoverable
	Material No.	Material Name		Acceptance (SM Requirement)	Marking Material Test (SM Requirement)			
Durable	708.08(a)	Polyurea		APL (TA556)	None*	X	X	X
Non-Durable	708.08(b)	Low VOC Chlorinated Rubber	Rarely Used	Type A Certification (CT-TYPEA00)	Paint Test (PT-PAINT11)	X	can be used but not common	can be used but not common
		Low VOC Acetone Based	Rarely Used	Type A Certification (CT-TYPEA00)	Paint Test (PT-PAINT11)	X	can be used but not common	can be used but not common
Durable	708.08(c)	Epoxy		APL (TA556)	None*	X	X	X
Non-Durable	708.08(d)	Waterborne		Type A Certification (CT-TYPEA00)	Paint Test (PT-PAINT11)	X	can be used but not common	can be used but not common
Durable	708.08(e)	Methyl-methacrylate Paint	Rarely Used	APL (TA556)	None*	X	X	X
Durable	708.08(e)	Methyl-methacrylate Structured & Extruded	Rarely Used	APL (TA556)	None*	N/A – Optics built in		
Durable	708.10(a)	Thermoplastic, Type A	Extruded – for all applications	APL (TA556)	None*	X	X	X
Durable	708.10(b)	Thermoplastic Type B	Preformed – for Letters	APL (TA556)	None*	N/A – Optics built in		
Durable	708.12(a)	Pavement Marking Tape, Type A	For HIGH AADT Long Lines	APL (TA556)	None*	N/A – Optics built in		
Durable	708.12(b)	Pavement Marking Tape, Type B	For LOWER AADT Long Lines	APL (TA556)	None*	N/A – Optics built in		
Durable	708.12(c)	Pavement Marking Tape, Type C	For Intersections, Letters, Lines, Letters, Symbols	APL (TA556)	None*	N/A – Optics built in		
Durable	708.12(d)	Pavement Marking Tape, Type D	For Letters or Symbols cut in field	APL (TA556)	None	N/A – Optics built in		

\* Retro-reflectivity testing is performed on **durable marking systems** comprised of a marking material and optics incorporated into the marking material.

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### Optic Materials

(when used as a “drop-on”)

Material No.	Material Name	Notes	Requirements	
			Documentation	Testing
708.09(a)	Glass Beads	Usually used alone for non-durable markings. Can be used in conjunction with Premium Optics for non-durable or durable markings.	Type A Certification ( <i>CT-TYPEA00</i> )	None*
708.09(b)	Premium Optics	Used for durable markings to meet the retro-reflectivity minimums	APL ( <i>TA556</i> )	None*
708.09(c)	Wet Reflective/Wet Recoverable Optics	Use only when specified in a contract for high accident & urban areas	APL ( <i>TA556</i> )	None*

\* Retro-reflectivity testing is performed on **durable marking systems** comprised of a marking material and optics incorporated into the marking material.

### Marking System Retro-Reflectivity Testing

Pavement Marking Durability	Application	Color	Retro-Reflectivity Requirements	Notes
Non-Durable	Any	Any	None	
Durable	Long Lines	Yellow	Retro-reflectivity Test ( <i>PT-708-DY, PT-708-SY</i> )	Pick test based on Double Yellow (DY) or Single Yellow (SY) line
		White	Retro-reflectivity Test ( <i>PT-708-SW</i> )	
	Symbols, Stop Bars, etc.	Any	None	
Temporary	Any	Any	None	

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### **General Guidelines for Paint and Optic Material:**

1. All durable pavement markings shall be installed within 2 weeks of placement of the wearing course.
2. As soon as it is determined which optic material(s) will be applied to the durable marking material to achieve the required retro-reflectivity, the Resident Engineer will need to inform the Materials Acceptance Unit at [AOT.MaterialsAcceptance@vermont.gov](mailto:AOT.MaterialsAcceptance@vermont.gov) so they can make any necessary adjustments to the Materials Acceptance requirements set up in SiteManager for the contract.
3. Retro-reflectivity testing will need to be performed within 3 to 30 days after lay down of the durable marking material (long lines only). The Resident Engineer will need to contact Bill Gray at either 802-371-5506 or [william.gray@vermont.gov](mailto:william.gray@vermont.gov) to schedule the testing. Bill Gray will need to know the following information: what optic material(s) was used and if the testing will be performed on a single or double yellow line or single white line.
4. Prepare for testing by:
  - Randomly select locations to be tested in accordance with 646 Section of the Spec as modified by the General Special Provisions. The contractor shall not be informed of the randomly selected locations to be tested.
  - Advanced layout of the randomly selected test sections is required before testing personnel arrive onsite. Each evaluation section is two miles in length with a randomly selected 400' test section selected within each of the two mile evaluation sections. Each 400' test section is divided into twenty 20' spot test locations.
  - Schedule traffic control for the retro-reflectivity testing, including but not limited to flagging, UTO's, sign packages, and lane closures.
  - Schedule for personnel to record values dictated to them during testing.
5. Once the retro-reflectivity testing is performed, the Resident Engineer should forward all the results to the Construction Paving Engineer and save the information in the contract files. The Contractor should also be informed of the results. If the results are not going to be logged into Site Manager, the Materials Acceptance Unit will need to be notified and be provided a copy of the results after Final Inspection.

### **Retro-Reflectivity Failure:**

Though the VTrans Specifications do not provide clear guidance regarding corrective actions for retro-reflectivity failures, the following has been determined to be the acceptable way to resolve failing retro-reflectivity tests on a durable marking system:

1. Upon a failure, the Resident Engineer should instruct the Contractor via a Written Order to either remark the failed sections or remove (grind off) the failed marking system and remark those sections. The decision to simply remark vs. remove and remark will depend upon the thickness of the failed marking system. If remarking, without removal, causes the marking system to be subject to plow damage, grinding and remarking will be necessary. The cost to remove as well as to remark the failed system shall be at the Contractor's expense.
2. The Resident Engineer can consult with both their Regional Engineer as well as the Construction Paving Engineer for assistance with determining which option is best.

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## Helpful Hints for Inspection:

1. To achieve VTrans specified retro-reflectivity for durable pavement marking systems, a premium optic will likely be used in conjunction with glass beads or another optic product. This requires three (3) guns on the paint truck (one for each optic material as well as one for the binder/resin). However, the Contractor may choose to use only one (1) optic material to achieve the specified retro-reflectivity.
2. When applying a Type A Thermoplastic material, the shoe extruding the thermoplastic material should be in contact with the surface of the wearing course. Otherwise there will be a loss in heat transfer and will sacrifice the bond between the resin and the pavement.
3. To calculate the applied thickness of any paint use the following formula:

**T = V / (C x L X W)** where:

- T = paint application thickness in mils
- V = paint volume used in gallons
- C = a constant in gal / (lf x mil x in)  
 For liquid products, use 0.00005219 gal / (lf x mil x in)  
 For dry products, use 0.0009091 lbs. / (lf. x mil. x in.)
- L = application length in linear feet
- W = applied line width in inches

For example:

V <sub>1</sub> Gallons before installation*	V <sub>2</sub> Gallons after installation*	V <sub>2</sub> - V <sub>1</sub> = V Gallons used in installation	L Linear feet installed	W Line width
40	23.5	40 - 23.5 = 16.5	5280	4

\* To determine the gallons of paint in the truck before and after installation, witness the foreman measure it before the start of application and again after application.

Liquid Product: 16.5 gallons / (0.00005219 gal / (lf x mil x in) x 5280 lf. x 4 in.) = 15 mils

Dry Product: 16.5 gallons / (0.0009091 lbs. / (lf. x mil. x in.) x 5280 lf. x 4 in.) = 0.86 mils

Polyurea and Epoxy Paints generally contain a ratio of 2:1 (yellow or white resin : hardener). The Inspector should generally be looking for the total gallons to be used. If the mix ratio is incorrect, the line may not cure correctly on the pavement. If there is a question about the ratio, the following calculation may be used as long as the intended ratio is 2:1.

### Resin Ratio

Total Gallons = 16.5 gallons x 2/3 = 11 gallons of resin

### Hardener Ratio

Total Gallons = 16.5 gallons x 1/3 = 5.5 gallons of hardener