North Carolina
Department of Transportation

PAVEMENT MARKING CERTIFICATION TRAINING

LEADING THE WAY TO QUALITY
HIGHWAY DELINEATION

Class 1: Paint and Markers

OVERVIEW

Paint

- Used in North Carolina as a premarking, temporary pavement marking in a work zone or permanent pavement marking on a low volume secondary roadways.
- All paint used in NC is waterborne
- Last approximately 2 years (depending on Average Daily Traffic, snowplow frequency and application rates).
- Applied in 2 layers at 15 mils thickness each for permanent situations.
- Normal Curing Times (Drying **or** No Track times) for paint are between 1-2 minutes based on air and pavement surface temperatures.
- When restriping with paint for line maintenance, it is very important the surface is clean before placing the paint.
- When restriping with paint for line maintenance, it is important to review the job prior to marking to make sure passing zones and driveway breaks haven't changed.

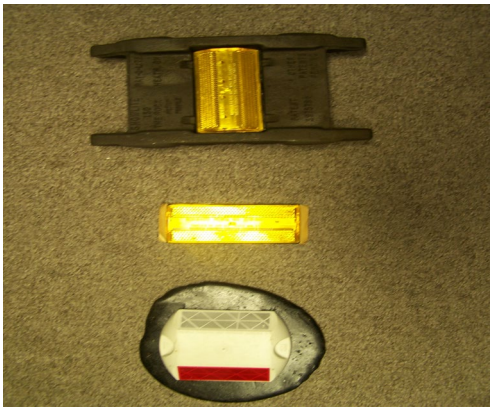
Premarking

- Always premark each installation of pavement marking prior to application on new pavement.
- Premarking may be required when existing markings are being replaced, except where existing markings are visible.
- Premarking (or layout marking) is small paint spots used to establish locations of final pavement markings.
- Get premarking inspected and approved before placing new markings.
- Review and record existing pavement markings prior to resurfacing in order to re-establish the marking after obliteration.
- Submit a pavement marking plan to the Engineer 7 days in advance of placing pavement marking for resurfacing projects.

Interim Paint

- Interim paint is a thin layer of pavement marking paint applied at the striping contractor's option to maintain traffic, instead of durable pavement markings. This is typically applied 5 to 8 mils thick with a bead rate of 1 to 3 lbs/gal of paint.
- Interim paint is typically applied to comply with time limitations and shall be no more than ¼" less than the specified line width of the existing markings.

Markers



- Permanent Raised Markers (Snowplowable or Stick-on) are typically used on roadways with greater than 4000 ADT.
- "Stick-on" Raised Markers are typically used on moderate to lower volume roadways and low snow plowed areas.

SPECIFICATIONS FOR PAINT

Material Certifications for Paint:
Division 1, Section 106 of the NCDOT Standard Specifications

Furnish a Bill of Lading with lot numbers from the manufacturer for Paint **BEFORE** placing markings.

Furnish a Type 3 Certification for Paint in accordance with Article 106-3 **BEFORE** placing markings.

Type 3 Certification – Manufacturer's Certification:
A manufacturer's certification shall be a certified statement that the material actually shipped to the project was manufactured by production processes which are periodically and routinely inspected to assure conformance to specification requirements.

Material Specifications for Paint:
Division 10, Section 1087 of the NCDOT Standard Specifications

- Paint must be a ready mixed type paint conforming to US Federal Specification Number TTP 1952F with suitable spraying consistency.
- Yellow and white pavement markings must be retroreflective.
- All pavement markings, without drop-on beads, shall visually match the color chips that correspond to the Federal Standard Number 595b. White must meet Color 17886 and Yellow must meet Color 13538.
- All pavement marking materials must be free from all skins, dirt, and foreign objects.
- Must be able to adhere to asphalt and concrete.
- Pavement markings materials upon heating must not exude fumes, which are toxic, or injurious to person or property.
- **Water or other additives are not allowed to thin out paint**

INSTALLATION OF PAINT

Application Equipment
Division 12, Section 1205 of the NCDOT Standard Specifications and Construction Manual

- Truck-mounted pneumatic or airless spray machine with suitable nozzles and controls to obtain the specific markings.
- Paint applicator must have at least 2 paint tanks, each one having an agitator, and 1 glass bead tank.
- The glass bead applicator must be operational automatically and simultaneously with the paint applicator.
- Pneumatic spray guns must be used for hand application for detail markings. A hand-operated push type applicator with a glass bead dead dispenser may also be used.
- The higher the paint gun is from the ground, the wider the line and fuzzier the edges.
- The main determining factor of paint thickness is the speed of the paint truck.
- Truck speeds of 10-12 mph will result in a paint thickness of 15-18 wet mils without beads.
- A wire brush is recommended for any paint crew equipment compliment to remove debris from existing marking.
- Initial Retroreflectivity requirements as measured with a LTL 2000, a LTL-X, or an approved mobile retroreflectometer:
  - ❖ White 225 mcd/lux/m2
  - ❖ Yellow 200 mcd/lux/m2

- See the Construction Manual for more detailed information on the acceptable application equipment.

Paint General Requirements
Division 12, Section 1205 of the NCDOT Standard Specifications

Thickness

- 15-18 wet mil thickness per coat

How Many Coats of Paint?

- New marking on final wearing surfaces needs two applications of 15-18 wet mil thickness paint.
- The second application is needed to compensate for paint that is absorbed into the pavement during the first application.
- 2 applications of paint will last longer than one.
- BST pavements are very porous and open graded. A minimum of 2 coats of paint is recommended on these types of surfaces.
- When applying paint for temporary traffic patterns, the line should be the proper width.
- Any interim paint should be the no less than ¼" of the existing or proposed width.
- When placing paint for a temporary pattern on new asphalt surfaces, some of the first application of paint is absorbed into the asphalt. Therefore, depending on the length of time the intermediate pattern is in place, the time of year, or whether thermoplastic will be placed over the paint in the spring, a second application of paint will be necessary to ensure acceptable thickness is obtained.

Weather Limitations
Division 12, Section 1205 of the NCDOT Standard Specifications

- Apply paint only when the air and pavement temperature is 40 degrees F and rising.
- As with any marking, paint is adversely affected by wet, cold and windy weather.

Moisture Testing Procedures
Division 12, Section 1205 of the NCDOT Construction Manual – Inspection of In-Place Pavement Marking Material (Pre-Installation Inspection Procedures)

Some materials are sensitive to the amount of humidity. Remember that moisture can affect bonding. Use Plastic Wrap Test to check for moisture.

Bond Testing Procedures
Division 12, Section 1205 of the NCDOT Construction Manual – Inspection of In-Place Pavement Marking Material (Installation Inspection Procedures)

Bond is very important to the life of pavement marking lines. Check with a knife or screwdriver to see if the marking can be "flaked" off the pavement.

Thickness Measurement Procedure
Division 12, Section 1205 of the NCDOT Construction Manual – Inspection of In-Place Pavement Marking Material (Installation Inspection Procedures)

In order to get the longest life out of a pavement marking line, the material must be the proper thickness. Measure the thickness of the paint material while it's still "wet" and without beads. The required "wet film" thickness is 15-18 mils per application as measured by a wet film thickness gauge.

Uses for Paint Pavement Markings

- Short Term Maintenance
- Temporary patterns during construction

PREMARKING

Premarking is one of the first and most important steps towards a quality pavement marking installation. By premarking and getting that premarking inspected prior to pavement marking installation, mistakes and changes can be avoided without having to remove brand new pavement marking.

Premarking may not be necessary if existing pavement marking is being replaced in the same location.

When resurfacing, re-establish the new pavement markings using the record of existing markings in conjunction with the *2018 Roadway Standard Drawings*. Unless otherwise directed by the engineer, new pavement markings not meeting the current standards should be updated to the *2018 Roadway Standard Drawings.* Have existing or proposed "passing zones" reviewed by the engineer before installation. Submit the record of the existing pavement markings seven calendar days before the obliteration of any pavement markings.

LINE REMOVAL

Proper line removal will not mislead or misdirect motorists. Insufficient line removal appears to the motorists as a true pavement marking line especially at night in the rain.

Remove conflicting pavement marking down to the surface of the pavement. After removal, use black paint or tape to cover any remaining conflicting marking (asphalt surfaces only).

Equipment with multiple heads typically results in better line removal. Take great care, especially any time there could be misdirection by line removal (traffic shifts, lane narrowing, etc.). Do not use high pressure water blasting on Asphalt.

In order to get proper bonding when removing existing pavement marking and replacing with new pavement marking, use of a vacuum to remove dust and/or debris as a result of the removal operation may be required. In some cases, using a blower and/or broom may be sufficient.

When pavement surfaces are already in their final pattern (especially concrete), other less damaging methods of removal should be considered and may be required.

TYPES OF PAVEMENT MARKERS AND CERTIFICATIONS

Material Specifications for Pavement Markers: Division 10, Section 1086 of the NCDOT Standard Specifications

Raised Pavement Markers (Temporary and Permanent) and Raised Snowplowable Markers

Section 106-3 – Furnish a Type 2 Certification in accordance with Article 106-3 for all raised pavement markers and raised snowplowable pavement markers onsite **BEFORE** placing markers.

Type 2 Certification – Typical Certified Mill Test Report:
A typical certified mill test report shall be a certified report of tests conducted by the manufacturer on samples taken from a lot which is typical of the material actually shipped to the project, but which may or may not be from the lot shipped.

INSTALLATION METHODS AND PROCEDURES FOR PAVEMENT MARKERS

Moisture Testing Procedures
Division 12, Section 1205 of the NCDOT Construction Manual – Inspection of In-Place Pavement Marking Material (Pre-Installation Inspection Procedures)

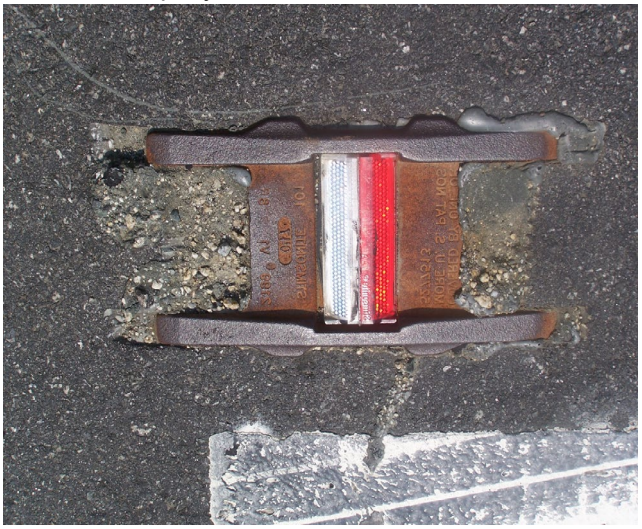
Some materials are sensitive to the amount of humidity in the air and moisture in the pavement. Remember that moisture can affect bonding. Use the Plastic Wrap Method to test for moisture in the pavement.

Factors to Consider When Installing Pavement Markers: Division 12, Sections 1250 of the NCDOT Standard Specifications

- Insure that the color of the reflector corresponds to the pavement marking that the marker supplements.
- Red reflectors may be required in combination with crystal or yellow reflectors to indicate wrong way movement when viewed in the direction opposing the flow of traffic.
- Space pavement markers as shown in the Roadway Standard Drawings.
- In certain conditions, markers may be spaced closer (sharp curves, fog prone areas, etc.)
- Position pavement marker lenses perpendicular to the flow of traffic as shown in the NCDOT Roadway Standard Drawings.

For Snowplowable Markers:

- Saw cut grooves according to dimensions provided by the manufacturer.
- Contact all leveling lugs to the pavement surface.
- Mount Reflectors to casting with adhesive.
- Using methods recommended by the marker manufacturer and approved by the engineer.
- Casting mounted in saw cut grooves with epoxy adhesive.



Maintenance of Permanent and Temporary Raised Pavement Markers and Snowplowable Raised Pavement Markers Division 12, Section 1250 of the NCDOT Standard Specifications

Maintenance

- Replace all damaged or missing temporary or permanent raised pavement markers if any of the following occurs:
  - ❖ Three segment failures occur in any roadway section. **Three consecutive damaged or missing markers in any group of seven represents a segment failure.**
  - ❖ Twenty percent of total numbers of markers in any roadway section are damaged or missing.

- ❖ Engineer determines if replacement is necessary.

Uses for Pavement Markers

- Night time Delineation
- Wet night delineation

ADHESIVES AND SPECIFICATIONS

Adhesives:
Division 10, Section 1081 of the NCDOT Standard Specification

Epoxy:

- Used for installation of Snowplowable Markers on concrete and asphalt surfaces.
- Used for the installation of raised markers on concrete surfaces only.
- Used for installation Permanent Raised Markers on concrete surfaces only.
- Can be used for installation Temporary Raised Markers on non-final pavement surfaces only.
- Epoxy must meet the NCDOT Standard Specification Section 1081-4. Four types may be used:
  - ❖ Type I - Rapid Setting, High Viscosity, Epoxy Adhesive. This type of adhesive provides rapid adherence to traffic markers to the surface of pavement.
  - ❖ Type II - Standard Setting, High Viscosity, Epoxy Adhesive. This type of adhesive is recommended for adherence of traffic markers to pavement surfaces when rapid set is not required.
  - ❖ Type III - Rapid Setting, Low Viscosity, Water Resistant, Epoxy Adhesive. This type of rapid setting adhesive, due to its low viscosity, is appropriate only for use with embedded traffic markers.
  - ❖ Type IV - Standard Set Epoxy for Blade Deflecting-Type Plowable Markers.

Hot Bitumen:

- Used for the installation Permanent Raised Markers on asphalt surfaces only
- Used for the installation Temporary Raised Markers on non-final and final pavement surfaces
- Hot Bitumen must meet the NCDOT Standard Specification Section 1081-3.

Pressure Sensitive

- Used for the installation Temporary Raised Markers on non-final and final pavement surfaces
- Used for small permanent installations
- As supplied by the manufacturer.

Class 2: Molten Thermoplastic and Profiled Marking Installation

OVERVIEW

Thermoplastic

- A long-life pavement marking material that is a blend of solid ingredients (resins, pigments and fillers) that become molten when heated and then become solid after cooling.
- Lasts approximately 5-7 years on center lines, 8-10 years on edge lines.
- Normal curing times are between 3 and 10 minutes.
- Encourage use on asphalt pavements.
- Performs best in non-snowplow areas.
- Best for asphalt marking.

Approved products
https://apps.ncdot.gov/vendor/approvedproducts/

SPECIFICATIONS

Material Specifications for Thermoplastic Pavement Markings:
Division 10, Section 1087 of the NCDOT Standard Specifications

- The thermoplastic material must be applied at temperatures between 400°F & 440°F (204°C& 226.5°C).
- Maximum storage life is one year from the date of shipment from the manufacturer to the contractor or the project.
- Section 106-3 – Material Certifications
  Type 3 Material Certification and Type 4 Material Certification is required **BEFORE** marking begins. The best time is at the preconstruction meeting.

  Type 3 Certification – Manufacturer's Certification
  A manufacturer's certification shall be a certified statement that the material actually shipped to the project was manufactured by production processes which are periodically and routinely inspected to assure conformance to specification requirements.

  Type 4 – Certified Test Reports:
  A certified test report shall be a certified report of test conducted by an approved independent testing laboratory on samples taken from same heat or lot number as the material actually shipped to the project. The report shall identify the heat or lot number.

INSTALLATION METHODS AND PROCEDURES

Pavement Marking General Requirements for **TIP Projects**:
Division 12, Section 1205 of the NCDOT Standard Specifications

- For full-control-of-access multi-lane roadway (4 or more total lanes) and ramps, including Interstates, replace all markings including symbols by end of each workday's operation if lane is opened to traffic.
- For all other multi-lane (3 or more lanes) and ramps, replace center lines, lane lines, railroad symbols, and school symbols by end of each workday's operation if lane is open to traffic. Replace edge lines, gore lines and other symbols within 3 days.
- For 2 lane, 2 way roads, replace center lines, railroad symbols, and school symbols within 5 days and edge lines and all other symbols within 15 days.
- Edge line thickness is 90 mils.
- Center line and lane line thickness are 120 mils. This will change to 90 mils with Special Provision.
- Initial Retroreflectivity (within 30 days of placement under traffic) requirements as measured with a LTL 2000, a LTL-X, or an approved mobile retroreflectometer:
  - Standard Bead
    - White 375 mcd/lux/m2
    - Yellow 250 mcd/lux/m2
  - Highly Reflective Media
    - White 800 mcd/lux/m2
    - Yellow 600 mcd/lux/m2

- Thermoplastic with Highly Reflective Media requires a Special Provision.

- Do not apply pavement marking materials over a longitudinal joint.

Pavement Marking General Requirements for **Resurfacing**:

- For full-control-of-access multi-lane roadway (4 or more total lanes) and ramps, including Interstates, replace all markings including symbols by end of each workday's operation if lane is opened to traffic.
- For all other multi-lane (3 or more lanes) and ramps, replace center lines, lane lines, stop bars, railroad symbols, and school symbols by end of each workday's operation if lane is opened to traffic. Replace edge lines, gore lines and other symbols within 3 days.
- For 2 lane, 2 way roads, replace center lines, stop bars, railroad symbols, and school symbols within 5 days and edge lines and all other symbols within **30 days**.
- Edge line thickness is 90 mils.
- Center line and lane line thickness are 120 mils. This will change to 90 mils with Special Provision.
- Initial Retroreflectivity (within 30 days of placement under traffic) requirements as measured with a LTL 2000, a LTL-X, or an approved mobile retroreflectometer:
  - Standard Bead
    - White 375 mcd/lux/m2
    - Yellow 250 mcd/lux/m2

  - Highly Reflective Media
    - White 800 mcd/lux/m2
    - Yellow 600 mcd/lux/m2

- Thermoplastic with Highly Reflective Media requires a Special Provision.
- Do not apply pavement marking materials over a longitudinal joint.

Weather Limitations and Seasonal Limitations: Division 12, Section 1205-3(C)(3) of the NCDOT Standard Specifications

- For all installations, check the forecast and current weather conditions and make sure they meet or exceed the manufacturer's recommendations. The bond between the marking material and the pavement is affected by the weather. As a rule, marking materials (or the primers or adhesives used with the marking materials) set slower at cooler temperatures. Because temperature affects curing time and could affect bonding, it should be a consideration when applying different types of materials.
- Air and pavement temperature must be 50°F (10°C) or higher and rising before applying thermoplastic pavement markings.
- Do not apply thermoplastic pavement markings between the dates specified below:
  - **East of I-95:**
    December 15 to March 16
  - **East of I-77 and including I-95:**
    November 30 to April 1
  - **West of and including I-77:**
    November 15 to April 16

Pre-marking and Layout
Division 12, Section 1205-3(E) of the NCDOT Standard Specifications

- Premark each installation of pavement marking materials prior to application on new pavement and when required to replace pavement marking, except when existing markings are visible.
- Get the premarking inspected and approved **BEFORE** placing the pavement marking materials.
- When resurfacing, re-establish the new pavement markings using the record of existing markings in conjunction with the *2018 Roadway Standard Drawings*. Unless otherwise directed by the engineer, new pavement markings not meeting the current standards should be updated to the *2018 Roadway Standard Drawings.* Have existing or proposed "passing zones" reviewed by the engineer before installation. Submit the record of the existing pavement markings seven calendar days before the obliteration of any pavement markings.

Application Temperature of Material

- Thermoplastic requires:
  - ❖ constant application temperature within a specific range
  - ❖ no more than four hours of continuous heating
  - ❖ a minimum surface temperature, which must be determined at a location in the shade (if present).
- When material temperature is too low the following can occur:
  - ❖ No adhesion
  - ❖ Crumbly edges and line gaps
  - ❖ Line cracks immediately or in future
  - ❖ Crumbly edges or rough line surface
- When material is overheated the following can occur:
  - ❖ Roughened, pitted lines
  - ❖ Gas bubbles
  - ❖ Line swollen, skewed and/or rounded
  - ❖ Line cracks immediately or in future
  - ❖ Crumbly edges or rough line surface

Application Speed

- As a rule, the striper should travel at a speed of 3-5 MPH. This will assist in assuring that the material is applied in a way that results in the specified thickness and width. In addition, markings will bond more securely to the surface.

Surface Preparation:
Division 12, Section 1205-3(F) of the NCDOT Standard Specifications

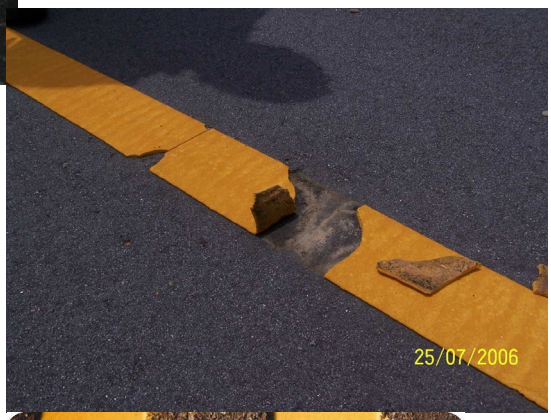
- A strong bond between the marking material and the pavement surface is one of the most critical factors in obtaining a successful installation.
- Make sure that all pavements are free of grease, oil, mud, dust, dirt, grass, loose gravel and other deleterious material, prior to applying pavement markings.
- Prepare the pavement surface a minimum of 2 inches (51mm) wider than the pavement markings to be placed, such that an additional 1 inch (25.4 mm) of prepared area is on both sides of the pavement markings after they are applied.
- Apply primer sealer to concrete pavement surfaces before applying pavement marking material.
- When surface preparation operations are completed, vacuum the pavement surface clean to remove residue or debris.

Moisture Testing Procedures
Division 12, Section 1205 of the NCDOT Construction Manual – Inspection of In-Place Pavement Marking Material (Pre-Installation Inspection Procedures)

Some materials are sensitive to the amount of humidity. Remember that moisture can affect bonding. Use either a Plastic Wrap Test or Felt Paper Test (Thermoplastic on Asphalt Only) to check for moisture.

Thickness Measurement Procedure
Division 12, Section 1205 of the NCDOT Construction Manual – Inspection of In-Place Pavement Marking Material (Installation Inspection Procedures)

In order to get the longest life out of a pavement marking line, the material must be the proper thickness. Use a taper thickness gauge to measure the thickness of the thermoplastic material.

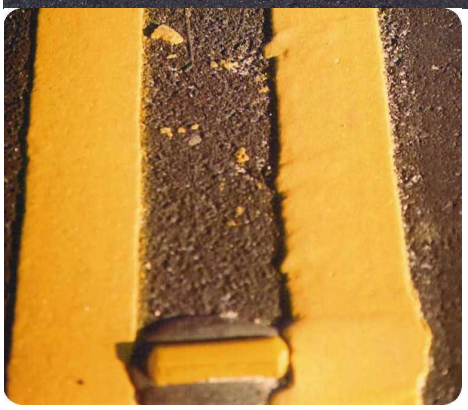


Bond Testing Procedures
Division 12, Section 1205 of the NCDOT Construction Manual – Inspection of In-Place Pavement Marking Material (Installation Inspection Procedures)

Bond is very important to the life of pavement marking lines. Check bond of a thermoplastic that is still pliable with a knife or screwdriver to see if there is asphalt bonded underneath the marking. Check the bond of cured thermoplastic with a knife or screwdriver to see if the marking can be “popped” off the pavement.

Some things that could cause de-bonding are:

- Moisture and/or oils on Pavement
- Dirt on Pavement
- Material Temperature
- Air and/or Pavement Temperature
- Improper Material
- Improper Installation



PROFILED PAVEMENT MARKING OVERVIEW

Profiled Pavement Markings

Protruded Thermoplastic

Rumble Stripes

Profiled Markings

- Markings with undulating or "raised" profiles to provide auditory, vibratory and visual cues to the driver
- Used to provide better "wet-night" visibility
- Used to provide "rumbles" to alert drivers when veering from travel lanes
- Can be used as a roadway safety enhancement to warn of roadside hazards (i.e., canals, narrowed lanes)
- Can be used in "high crash" locations to make drivers more alert
- Needs an Engineering Study before installation

Approved products

- Must be approved by the Signing and Delineation Unit
- Any approved Thermo or Polyurea may be used in the rumble stripe application

https://apps.ncdot.gov/vendor/approvedproducts/

SPECIFICATIONS FOR PROFILED PAVEMENT MARKING

Material Specifications for Profiled Pavement Marking

- Protruded Thermoplastic Profiled Marking requires Special Provision (see end of Chapter)
- Thermoplastic: Furnish a Type 3 and Type 4 Material Certification in accordance with Article 106-3 **BEFORE** placing markings.
- Polyurea: Per Special Provision, furnish a Type 2 and Type 3 Material Certification in accordance with Article 106-3 **BEFORE** placing markings.

Type 2 Certification – Typical Certified Mill Test Report
A typical certified mill test report shall be a certified report of tests conducted by the manufacturer on samples taken from a lot which is typical of the material actually shipped to the project, but which may or may not be from the lot shipped.

Type 3 Certification – Manufacturer's Certification
A manufacturer's certification shall be a certified statement that the material actually shipped to the project was manufactured by production processes which are periodically and routinely inspected to assure conformance to specification requirements.

Type 4 – Certified Test Reports:
A certified test report shall be a certified report of test conducted by an approved independent testing laboratory on samples taken from same heat or lot number as the material actually shipped to the project. The report shall identify the heat or lot number.

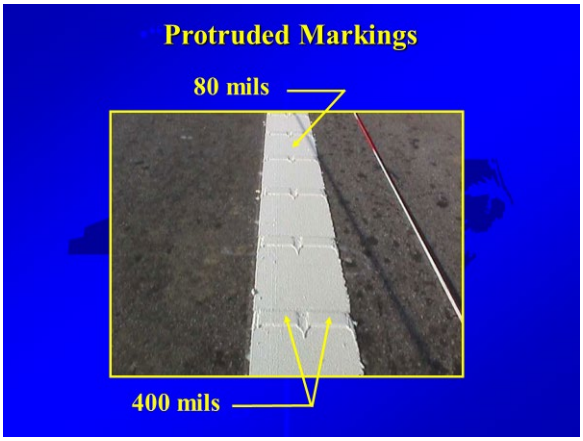
INSTALLATION METHODS AND PROCEDURES FOR PROFILED PAVEMENT MARKING

Factors To Consider When Installing Profiled Pavement Marking

Application Issues

Protruded

- The air and pavement temperatures should be 50 degrees F and rising.
- The line widths are normally 8" and 12" due to the width of the 'hills'. Typically the 'valleys' are 80 mils thick while the 'hills' are 400 mils thick.
- Can be any profile as long as it meets specs
- Check for the following:
  - ❖ No adhesion
  - ❖ Crumbly edges and line gaps
  - ❖ Line cracks immediately or in the future
  - ❖ Rough line surface
  - ❖ Air bubbles
  - ❖ Line swollen, skewed or rounded



Rumble Stripes

- Thermoplastic - The air and pavement temperatures should be 50 degrees F and rising.
- Polyurea -The air and pavement temperatures should be 40 degrees F and rising.
- The line widths can be standard 4" widths or wide line applications
- It is very important to make sure the pavement surface and all "indentations" in the pavement are properly cleaned and free of moisture prior to installation

Application Speed

Profiled Thermoplastic Material
As a rule, the striper should travel at a speed of 1-2 MPH (depending on line width). This will assist in assuring that the material is applied in the specified thickness and width. In addition, markings will bond securely to the surface.

Rumble Stripes
As a rule, the striper should travel at a speed of 3-8 MPH (depending on line width and material). This will assist in assuring that the material is in the specified thickness and width. In addition, the markings bond securely to the surface.

Moisture Testing Procedures Division 12, Section 1205 of the NCDOT Construction Manual – Inspection of In-Place Pavement Marking Material (Pre-Installation Inspection Procedures)

Some materials are sensitive to the amount of humidity. Remember that moisture can affect bonding. Use either a Plastic Wrap Test or Felt Paper Test (Thermoplastic on Asphalt Only) to check for moisture.

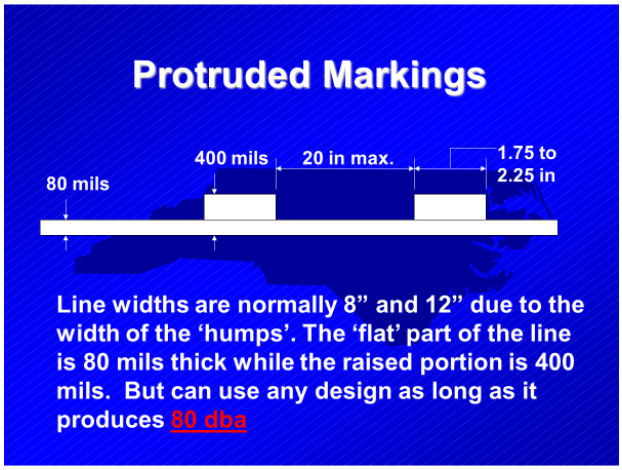
Bond Testing Procedures
Division 12, Section 1205 of the NCDOT Construction Manual – Inspection of In-Place Pavement Marking Material (Installation Inspection Procedures)

Profiled Thermoplastic
Bond is very important to the life of pavement marking lines. Check bond of a thermoplastic that is still pliable with a knife or screwdriver to see if when marking is "peeled" off the pavement, there is asphalt bonded underneath the marking. Check the bond of a cured thermoplastic with a knife or screwdriver to see if the marking can be "popped" off the pavement.

Rumble Stripes
All pavement marking material should be well bonded to the pavement surface after it has "cured". Check with a knife or screwdriver to see if the marking can be "flaked" off the pavement.

Thickness Measurement Procedure
Division 12, Section 1205 of the NCDOT Construction Manual – Inspection of In-Place Pavement Marking Material (Installation Inspection Procedures)

Protruded Thermoplastic
Typically uses 80 mils in the valleys and 400 mils in the hills as measured by a taper thickness gauge. Can use different profiles as long as it can produce 80 dba.



Rumble Stripes
Thermoplastic uses 90 mils extruded on Edge line and 120 mils extruded on Center line. Center line will change to 90 mils with Special Provision.

Polyurea will have a dry film thickness 20 mil or 30 mil depending what is specified in the contract.

Uses for Profiled Pavement Markings

- Rumble Stripes are used on roadways with existing rumble strips to provide better "wet night" visibility.
- Either profiled marking could be used on any roadway to provide an audible and physical warning to alert motorists when they are veering from the travel lane
- Either profiled marking could be used where there are conditions on or near the roadway that would be considered hazardous (i.e., canals, narrowed lanes, etc.)
- Both provide long life durability and wet night retroreflectivity

Class 3: Polyurea and Pavement Marking Tapes Installation

POLYUREA OVERVIEW

- Polyurea is a long life pavement marking material
- NC only uses 2 part systems
- "No track" time is based on manufacturing specification
- Last approximately 5 years on high volume roadways and 8 years on low volume roadways
- Used on all concrete pavement
- Used on roadways (including asphalt) with high volume and high snowplow use

Approved products
https://apps.ncdot.gov/vendor/approvedproducts/

SPECIFICATIONS FOR POLYUREA

Material Specifications for Polyurea: Division 10, Section 1087 of the NCDOT Standard Specifications

Per Special Provision, furnish a Type 2 and Type 3 Material Certification in accordance with Article 106-3 **BEFORE** placing markings.

Type 2 Certification – Typical Certified Mill Test Report
A typical certified mill test report shall be a certified report of tests conducted by the manufacturer on samples taken from a lot which is typical of the material actually shipped to the project, but which may or may not be from the lot shipped.

Type 3 Certification – Manufacturer's Certification

A manufacturer's certification shall be a certified statement that the material actually shipped to the project was manufactured by production processes which are periodically and routinely inspected to assure conformance to specification requirements.

INSTALLATION METHODS AND PROCEDURES FOR POLYUREA

Factors to Consider When Installing Polyurea Division 12, Section 1205 of the NCDOT Standard Specifications

- It is very important to make sure the pavement surface is properly cleaned and free of moisture prior to installing polyurea material.
- Air and pavement temperatures should be 40° F and rising.
- Although curing compound is not used on bridge decks, the bridge decks **MUST** still be prepped to remove any surface laitance and debris.
- Ensure proper mixing of the Polyurea material. When material is not mixed properly, the following can occur:
  - ❖ No adhesion
  - ❖ Crumbly edges
  - ❖ Have large dark gray areas
  - ❖ Flaking
  - ❖ Will not cure or harden
- Initial Retroreflectivity requirements, **changed with Special Provision included in all new polyurea projects**, measured with an approved mobile retroreflectometer:
  - ❖ White 375 mcd/lux/m2
  - ❖ Yellow 250 mcd/lux/m2

- In general, do not apply polyurea between November 15 and the following February 28. If no weather treatments have been applied and the polyurea manufacturer's

specifications allow, the product may be able to be applied within these dates.

- Do not use for symbols, characters, stop bars and diagonals.

Application Speed

- As a rule, the striper should travel at a speed of 3-8 MPH (depending on line width). This will assist in assuring that the material is applied in the specified thickness and width. In addition, markings will bond more securely to the surface.

Moisture Testing Procedures
Division 12, Section 1205 of the NCDOT Construction Manual – Inspection of In-Place Pavement Marking Material (Pre-Installation Inspection Procedures)

Some materials are sensitive to the amount of humidity. Remember that moisture can affect bonding. Use Plastic Wrap Test to check for moisture.

Bond Testing Procedures
Division 12, Section 1205 of the NCDOT Construction Manual – Inspection of In-Place Pavement Marking Material (Installation Inspection Procedures)

Bond is very important to the life of pavement marking lines. The polyurea material should be well bonded to the pavement surface after it has "cured" (see manufacturer's recommendations). Check with a knife or screwdriver to see if the marking can be "flaked" off the pavement.

Thickness Measurement Procedure
Division 12, Section 1205 of the NCDOT Construction Manual – Inspection of In-Place Pavement Marking Material (Installation Inspection Procedures)

In order to get the longest life out of a pavement marking line, the material must be the proper thickness. Measure the thickness of the polyurea material while it's still "wet" and without beads. The required "dry film" thickness on concrete and asphalt surfaces is 30 mils as measured by a wet film thickness gauge so a little more than 30 mils wet should be applied.

Benefits of Using Polyurea Pavement Markings

- Preferred markings for concrete pavement due to color retention, bonding and durability.
- Better durability than standard traffic paints
- Better long-term performance on highways that receive multiple snowplowing activities due to its lower profile.
- Installation in cooler temperatures.

TAPES (COLD APPLIED PLASTIC) OVERVIEW

- Permanent Tapes can be used on concrete and asphalt surfaces.
- Temporary (Removable) Tapes are usually used in short term work zone applications (traffic shifts, interim layers of pavement, etc.) when paint is not as viable an option.

Approved products
https://apps.ncdot.gov/vendor/approvedproducts/

TYPE OF PAVEMENT MARKING TAPES AND SPECIFICATION REQUIREMENTS

Material Specifications for Tape Pavement Markings: Division 10, Section 1087 of the NCDOT Standard Specifications

Type I – Permanent Standard Tape

White	400 mcd/lux/m2
Yellow	300 mcd/lux/m2

Typically, a two (2) year life cycle permanent tape used on roadways with an ADT of 5000 or less.

Type 2 – Permanent High Performance Tape

White	500 mcd/lux/m2
Yellow	300 mcd/lux/m2

Material may come as one piece with a black border with yellow or white in the center. Typically, a five (5) year permanent tape used on roadways with an ADT greater than 5000.

Type 3 - Permanent Wet Reflective High Performance Tape:

White:	500 mcd/lux/m2 – Dry 250 mdc/lux/m2 – Wet
Yellow:	300 mcd/lux/m2 – Dry 200 mcd/lux/m2 – Wet

Wet reflective tape shall meet the above retroreflective values both wet and dry.

Type 4– Removable Tape:

White	700 mcd/lux/m2
Yellow	400 mcd/lux/m2

Removable tape that is usually used in work zones for temporary traffic shifts.

Material Certifications for Tape Pavement Markings: Division 1, Section 106 of the NCDOT Standard Specifications

Removable Tape

Furnish a Type 3 Material Certification in accordance with Article 106-3 **BEFORE** placing markings.

Type 3 Certification – Manufacturer's Certification
A manufacturer's certification shall be a certified statement that the material actually shipped to the project was manufactured by production processes which are periodically and routinely inspected to assure conformance to specification requirements.

Cold Applied Plastics (Permanent Tape)

Furnish a Type 2 Material Certification and a Type 3 Material Certification in accordance with Article 106-3 **BEFORE** placing markings.

Type 2 Certification – Typical Certified Mill Test Report
A typical certified mill test report shall be a certified report of tests conducted by the manufacturer on samples taken from a lot which is typical of the material actually

shipped to the project, but which may or may not be from the lot shipped.

Type 3 Certification – Manufacturer's Certification
A manufacturer's certification shall be a certified statement that the material actually shipped to the project was manufactured by production processes which are periodically and routinely inspected to assure conformance to specification requirements.

PRE-INSTALLATION REQUIREMENTS AND TESTING PROCEDURES

Temperature and Moisture Testing Procedures Division 12, Section 1205 of the NCDOT Construction Manual – Inspection of In-Place Pavement Marking Material (Pre-Installation Inspection Procedures)

Temporary & Permanent (Cold Applied Plastics)

- Installation ambient air temperature and surface temperatures depend on manufacturer. Check manufacturer's specifications.
- Should pass moisture test using plastic wrap method.
- Remove any curing compound and/or surface laitance before placing tapes.
- Remove existing markings according to manufacturer's specification.
- See Manufacturer's specification before applying a primer sealer to pavement.
- Have premarking approved by engineer prior to placing markings.
- Tape should be cut 1 inch on either sided of lateral joints

Remember that moisture can affect bonding. Ensure there is no moisture in the last 24 hours. Refer to the Construction Manual for proper moisture testing procedures.

Surface shall be free of grease, oil, mud, dust, dirt, grass, loose gravel and other deleterious material, prior to applying Tape.

POST-INSTALLATION PROCEDURES AND INSPECTION METHODS

Bond Testing Procedures Division 12, Section 1205 of the NCDOT Construction Manual – Inspection of In-Place Pavement Marking Material (Installation Inspection Procedures)

Bond is very important to the life of pavement marking lines. The cold applied plastic should be well bonded to the pavement surface (see manufacturer's recommendations). Check to see if the marking can be removed from the pavement after the adhesive has had time to cure.

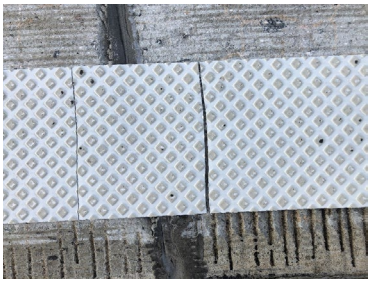
Thickness Measurement Procedure Division 12, Section 1205 of the NCDOT Construction Manual – Inspection of In-Place Pavement Marking Material (Installation Inspection Procedures)

In order to get the longest life out of a pavement marking line, the material must be the proper thickness. Since tapes are not "manufactured" on site, the thickness of this material should not vary. The required thickness of tapes is between 15 and 90 mils.

Uses for Removable and Permanent Tapes

Removable Tapes are used in construction zones and between layers of pavement when the pavement will be open to traffic during construction.

Cold Applied Plastics (Permanent) are used for permanent applications such as bridge concrete pavements, symbols, characters, etc.



Class 4: Traffic Control for Pavement Marking Installation

OVERVIEW

Planning and Preparation

- Identify the work to be performed and the equipment/methods that will be used to accomplish the work.
- Know the location of the work
  - ❖ Storage of Materials
  - ❖ Ingress/Egress of Equipment Issues
- Create and get familiar with your own traffic control plan or get to know the pre-prepared traffic control plan.
- Check to ensure you have the traffic control devices needed to implement the plan and that they are in good condition.
- Hold a tailgate meeting to discuss and get input on working the plan.
- Regulatory and Legal Issues.
- Know protocol when discrepancies arise

Traffic Control for Pavement Marking

- Mobile operations – moves intermittently or stopped up to 5 minutes.
- Moving Operation Caravan – Moving at least 3 miles per hour continuously.
- Lane Closures – you install.
- Lane Closures – inside other's work zones.

Devices

- Personal Protective Equipment (PPE)
- Stop/Slow Paddle
- Flashing Lights on Vehicles
- Portable Signs
- Cones & Drums
- Impact Attenuators
- Electronic Signs

Advanced or Special Situations

- High Speed Roadways
- High Volumes
- Commuter Traffic
- 6 or more lane roadways
- Night Work

Work Zone Qualification and Training Requirements

- Work Zone Traffic Control Supervisor became a requirement on July 1, 2011
- Work Zone Installer is a requirement after July 1, 2021
- Work Zone Flagger became a requirement on July 1, 2010
- Every member of the crew installing, maintaining, or removing traffic control must be flagger certified, at minimum, even if flagging is not part of the traffic control. This requirement became effective on 7/1/2021.

PLANNING AND PREPARATION

Identify the work to be performed and the equipment/methods that will be used to accomplish the work

- Knowing exactly what work you will perform and how you will accomplish the work allows you to provide the most adequate method of performing that work safely.

Visit the site

- Be familiar with the site where you are going to work. What kind of development is in the area? Do you have factories, schools, shopping centers, rock quarries, etc. that may create large volumes of traffic or debris that might adversely affect your production or damage your lines?
- What kind of road is it…two-way, two-lane, one way, 4 lanes or more divided, center turn lane, Interstate?
- What kinds of vehicles use this road…heavy trucks, wide loads such as mobile homes or farming equipment, cars only, bicycles, pedestrians?
- What is the general speed of the traffic?
- What about your equipment? Are there plenty of places to enter and exit the roadway?
- Can you store your materials safely near the work site if needed?
- What are the traffic volumes like? Do a 5-minute count and multiply by 12 to get a quick feel for the vehicles per hour on the road.
- After the site visit, you may need to alter your work equipment selection.

Review the provided Traffic Control Plan or prepare your own Traffic Control Plan

- If a Traffic Control Plan has been provided for your work, review it carefully to ensure that it will provide you adequate safety protection for your work operation and the site conditions.
- **Never alter your work operation to fit a prepared Traffic Control Plan that does not adequately provide safety protection for the site conditions. Alter the Traffic Control Plan to fit the site conditions.**
- When preparing your own Traffic Control Plan, it should be designed based on the operation to be performed, the equipment to be used, and the site conditions.
- Ensure you have on hand or can rent/buy the proper Traffic Control devices to install the traffic control plan adequately. Make sure these devices are in good condition. A good alternative to owning or buying all the devices you will need for every traffic control situation you may encounter is to use a reputable firm that specializes in traffic control installations.

Tailgate Meetings

- Hold Tailgate Meetings at the beginning of each day to discuss the traffic control and/or safety procedures to be used for that day. It is critically important that every crewmember understands the traffic control "Big Picture" and their role in creating that "Big Picture".
- Hold additional tailgate meetings if you change the type of work you are performing and need different traffic control and/or safety procedures.
- Fill out a Tailgate Meeting form each day to document your work activities.

Regulatory and Legal Issues

- The Occupational Safety and Health Administration (OSHA) can inspect your workers PPE and your work zone without prior notice. That inspection could also result in a monetary fine. Each person on the crew will need to know their specific task as it relates to work zone safety and the Traffic Control Plan you are using at the time of the inspection. This is one very good reason why tailgate meetings are so important.
- Tort Liability comes into play when something you do damages property or injures someone. In most cases in the Pavement Marking Industry, this involves vehicles getting paint on them. Proactive action may all but eliminate this problem: Proper signing such as "Wet Paint" and/or "Stay Off Line" with down arrows are good choices. Record the license number or at least the color and make of the vehicle(s) that destroy your lines and report them to the local Police or Sheriff. Report these incidents to your office as soon as they occur so folks will know what may be coming their way.

DEVICES

Personal Protective Equipment (PPE)

- Use gloves, eye protection, long sleeves, and long pants to protect your skin while handling hot or caustic material.
- Flaggers must wear high-visibility safety apparel that meets the Performance Class 2 or higher requirements of ANSI/ISEA 107-2010 or the equivalent revision. For nighttime flagging operations, Performance Class 3 safety apparel is required. This requirement began with the January 2018 edition of the NCDOT Standards and Specifications for Roads and Structures.
- All others should wear high-visibility safety apparel that meets the Performance Class 2 or 3 requirements of ANSI/ISEA 107-2004 or the equivalent revision. A person designated by the employer to be responsible for worker safety shall make the selection of the appropriate class of garment. This is effective with the 2009 edition of the MUTCD.in. As of Jan. 18 use the most current version of the MUTCD.

Stop/Slow paddles

- Must be 6' - 7' from the pavement surface to the bottom of the sign on a staff/pole.
- Must be 24" minimum width.

Flashing Lights on Vehicles

- Use warning lights with at least 50% being amber in color attached to the vehicle as high as possible and in a manner such that they are not obscured by equipment or supplies.
- Vehicle hazard signals or lights may be used to supplement this requirement.
- This requirement applies to all work vehicles and equipment NOT inside a lane closure or behind barrier.
- This requirement does NOT apply to dump trucks, but is encouraged. (Effective date 7-1-2012)

Portable Signs

- Must be NCHRP 350 or MASH tested and NCDOT approved.
- Vertical distances above the edge of pavement to the bottom of the sign are 1' for 2 lane, 2 way and 5' for multilane highways.
- Do not use aluminum signs; only roll-up or approved composite (i.e. alpolic) on projects Let January 2005 and after.
- Do not use mesh signs on projects Let January 2002 and after.
- Remember the signs tell the story to the motorist. What action do you want the motorist to take to stay out of your work zone? Messages such as "Men Working" or "Utility Work" tell the driver nothing really. The clean signs standing tall get the attention. The torn sign (often faded mesh) with mud on it flopping in the breeze (such as most of the "Log Trucks Entering Highway" signs) get no respect and therefore no attention or action from the motorist.

Cones, Drums & Skinny-Drums

- Cones
  - ❖ Use Orange Cones 28" or greater in height. Reflectorized collars are required for work between dusk and dawn. As a good rule of thumb, If you begin **before 9 AM or work after 3 PM**, use cones with reflectorized collars.
  - ❖ Use 36" minimum height cones on Freeways and Interstates. Cones are not allowed at night on facilities with speed limits above 55 mph.
  - ❖ Tar and "tack coat" are not retroreflectorized so don't use cones with it on them in a work zone.
  - ❖ Travel speeds above 45 MPH generally will require some type of ballast for cones such as double stacking.
- Skinny-drums
  - ❖ For facilities with speed limits below 45 mph, skinny-drums shall be placed at 20 feet in the taper and 40 feet in tangent sections.
  - ❖ For facilities with speed limits of 45 mph or higher, drums shall be used in the taper spaced in accordance with Article 1130-3 of the Standard Specifications and skinny drums shall be spaced at 80 feet in the tangent sections.
  - ❖ Cannot be used at night on control of access facilities or facilities with speed limits greater than 55 mph.
  - ❖ Cannot be used in tapers on multilane roadways
- When using identifying marks on devices, place the marks on a non-retroreflectorized surface.
- Use the base and ballast types (including the appropriate weights) designed specifically for your device. Crashes may result from improper installation of devices.
- Do not mix cones, skinny drums, and drums in lane closure tapers or in lane closure tangents, unless directed by the TMP or the Engineer.
- Regularly inspect devices to ensure a bright, uniform, accurate message is being sent to the motorist. Dirty, crushed and/or, misaligned (crooked) devices only send confusing messages to the motorist.

Truck Mounted Impact Attenuator (TMA)

- Use the appropriate NCHRP Test Level for the speed on your road. Test Level II for 45 MPH or less and Test Level III for 50 MPH and above.
- Remember to add the Roll-Ahead distances to your work space needs when using a TMA for stationary operations
- Remember to increase the Roll-Ahead distances provided by the TMA manufacturer when using a TMA in a moving caravan.
- Always use a TMA on an Interstate or freeway roadway.
- If the work train is long, you may use more than one TMA.

Electronic Signs

- Flashing Arrow Board (FAB)
  - ❖ Use “4 Corner Flash” for Caution Mode.
  - ❖ Use “Flashing Full Arrows” to indicate merge left or right.
  - ❖ Use “Caution” Mode when on the shoulder and/or on 2 lane, 2 way roadways.
  - ❖ Place FAB in “full power” mode during daylight hours and dimmed mode in Nighttime hours.
  - ❖ Type C FABs are required when speeds are great then 45 MPH.
- Changeable Message Sign (CMS)
  - ❖ Use messages that require the driver to take action such as “Left Lane Closed”, “Left Lane Narrows”, or “Merge Right”.
  - ❖ Place CMS well beyond the last vehicle in the queue (back-up).
  - ❖ Use messages that are clear and understandable with standard abbreviations.

TRAFFIC CONTROL FOR PAVEMENT MARKING

Mobile Operations – Moves intermittently or is stopped up to 5 minutes (If you need further assistance, contact the Work Zone Traffic Control Section at (919) 814-5000.

- Do not involve flaggers (use lane closures)
- May be used for Raised (Stick-on) and Snowplowable marker installations and repairs to symbols.
- Best used in lower volume, lower speed locations.
- Vehicles should be well delineated (marked) and lighted during the night.
- If operation is stopped for longer than 15 minutes, use lane closure.
- Flaggers in lane closures without cones or drums may be used.

Moving Operation Caravan – Moving at least 3 miles per hour

- Do not involve flaggers (use lane closures)
- May be used with Paint, Long line Thermoplastic, Polyurea, some Stick-on Markers and line removal operations
- Ensure caravan contains proper number of work vehicles to provide the dry times needed for the material being placed.
- **DO NOT stretch the distance between work vehicles** as this only tempts motorist to weave between your work vehicles increasing the opportunity for crashes and your Tort Liability risk.
- Accurate advance warning is critical for this traffic control especially on Interstates and freeways.
- Truck mounted CMS are required for moving operations on Multilane Roadways and Interstates
- Ground mounted CMS are required for moving operations on Interstates

Lane Closures – You Install

- May be used with all types of pavement marking and marker installations.
- Lay the lane closure out to suit the site conditions. Begin with the layout from the place the work will be performed.
- Install the devices beginning with the first device that will be seen by the motorist.
- Use TMA with your operation on Interstates and freeways.

Lane Closures – Inside Existing Work Zones

- May be used with all types of pavement marking and marker installation.
- Use TMA with your operation on Interstates and freeways.
- Remember to review existing Traffic Control setup and adjust your signs, FAB, and other devices as needed when inside an existing work zone.

ADVANCED OR SPECIAL SITUATIONS

For all these situations it is best to get the help of a specialist in the Traffic Control field. A company that specializes in this work as discussed previously is a good idea. Remember the Work Zone Traffic Control Section is always a good resource (919) 814-5000.

High Speed Roadways

- The closing speeds of vehicles to your slow moving equipment is much greater on Interstates and other High Speed Roadways where motorists regularly travel 10 to 20 MPH over the posted speed limit.
- CMS signs are required on Interstates and are highly recommended on other high-speed roadways. Remember to constantly remind the motorist where you are and what you want them to do with messages such as "Slow Moving Vehicle in Lt Lane", "Move Right".
- Full radio communication between all vehicles in the work train is essential.
- All crew members should know exactly what their job is in the work train and what is expected of all other crew members to provide maximum safety to the entire work train and the motoring public. Daily tailgate meetings should include a discussion of how yesterday's operations went and what can be done to improve upon it.

High Volume

- The same considerations that are used with high-speed situations apply to high volume situations, especially where high speeds exist.
- Consider doing the work at off-peak travel times especially in or near large cities.
- Increase the number of vehicles in your work train to achieve the required "no track" drying times.
- Consider using lane closures to achieve properly "cured" pavement marking, as "uncured" marking can have the glass beads mashed into the line and ruin retroreflectivity.

Commuter Traffic

- The same considerations that are used with high speed and high volume situations apply to commuter traffic, especially where high speed and high volume are present in and near large cities.
- Commuters tend to believe they "know the way". Electronic sign usage should be increased on roadways such as I-40 in Wake Co and I-77 in Charlotte.

6 or more lane roadways

- The center lane(s) of a 6 or 8 lane or greater width roadway presents special challenges when using a moving operation for placement of pavement markings. All the points above should be considered when dealing with 6 or more travel lanes.
- A good rule of thumb is to work with the Work Zone Traffic Control Section personnel to ensure you have the best possible plan for your situation. A reputable traffic control installation firm can also be of assistance when dealing with these special situations.

Night Work

- Lighting will be required for this work. Ensure your lighting plan has been reviewed and approved by the appropriate authority. The more visible you are to the approaching motorist the easier it will be for them to avoid your work area. This is especially true when working on a skip line next to traffic. The better lit your work area is the better you can tell if you are placing the material properly.
- Lighting for night work should illuminate your work area and not be blinding to the motorist.
- A good rule of thumb is to work with the Traffic Control Section personnel to ensure you have the best possible plan for your situation. A reputable traffic control installation firm can also be of assistance when dealing with these special situations.

Conflicts Before and During Operation

- If a conflict comes up between you and the prime regarding layout or traffic control, the Engineer should be involved.
- If there is a major change in the field layout or operation, a new plan sheet should be provided unless the Engineer approves it.
- Do not leave an unsafe situation. Immediately contact the prime and/or Engineer so they can work with you to find a solution.
- If there is a conflict between the field and plans, contact the **Engineer.**

WORK ZONE QUALIFICATION AND TRAINING REQUIREMENTS

These requirements apply to anyone working inside the Right of Way of a NCDOT Highway System including, but not limited to, NCDOT State Forces, Contractors, and Encroachers

Work Zone Flagger:
Any person performing the functions of a work zone flagger.

NEW REQUIREMENT EFFECTIVE 7/1/2021:
Every member of the crew responsible for setup, installation, maintenance, or removal of traffic control devices shall be trained and certified as a work zone flagger, even if flagging is not being performed as part of the traffic control.

Work Zone Installer:
At least one member of every crew responsible for setup, installation, maintenance, and removal of traffic control devices within any highway right of way shall be trained and certified as a Work Zone Installer. The certified Work Zone Installer should serve as crew leader and shall be on site and directing the installation and removal of temporary traffic control.

Work Zone Traffic Control Supervisor:
A person assigned to a project that oversees and is responsible for all the traffic control measures used on that project.

- Each course will teach current North Carolina specifications and roadway standards and any other requirements of the NCDOT.
- All required OJT is considered to be WZTC related experience and, if necessary, can be obtained under the direct supervision of a person already qualified in that category.
- The Work Zone Traffic Control Section will maintain a list of approved training sources.

Implementation Dates
- WZTC Flagger – July 1, 2010
- WZTC Installer – July 1, 2021
- WZTC Supervisor – July 1, 2011

Work Zone Education Verification App:
The Department has launched a training records database, named the Work Zone Education Verification App (WZ-EVA) to allow our inspectors and resident engineers to quickly verify training credentials of work zone flaggers, installers, and supervisors in the field. Once an individual completes an approved training course, approved trainers will be required to upload training certifications to WZ-EVA and issue official wallet cards which are generated by the WZ-EVA system. NCDOT will not provide printed wallet cards except for workers with Virginia or South Carolina certifications to be issued one time for a single year period.

Effective 7/1/2022, work zone flagger, installer, and supervisor certifications will not be recognized by NCDOT inspectors and resident engineers unless they are entered into the WZ-EVA system. Contact your training provider to ensure your training credentials have been uploaded to the system.

For WZTC Training Information, go to the following website-
https://connect.ncdot.gov/projects/WZTC/Pages/Training.aspx

Class 5: Inspection Procedures, Troubleshooting and Glass Beads

OVERVIEW

Inspection Procedures

- Check for proper paperwork, proper installation equipment, proper traffic control, pavement moisture, ambient and pavement temperature, and wind conditions before placement.
- **Pavement markings should be inspected for bond, color, bead embedment, and workmanship immediately after placement. DON'T WAIT UNTILL ALL THE MARKINGS HAVE BEEN INSTALLED.**
- Collect initial pavement marking line retroreflectivity no later than 30 days after placement. Two (2) weeks after placement is the optimal time to check retroreflectivity, but can be checked anytime in the first 30 days opened to traffic.

SPECIFICATIONS

Material Specifications for Glass Beads Section 1087.

Type 3 Certification – Manufacturer's Certification:
A manufacturer's certification shall be a certified statement that the material actually shipped to the project was manufactured by production processes which are periodically and routinely inspected to assure conformance to specification requirements.

Type 4 – Certified Test Reports:
A certified test report shall be a certified report of test conducted by an approved independent testing laboratory on samples taken from same heat or lot number as the material actually shipped to the project. The report shall identify the heat or lot number.

INSPECTION METHODS AND PROCEDURES

Pre-Installation Procedures: Division 12, Section 1205 of the NCDOT Construction Manual – Inspection of In-Place Pavement Marking Material (Pre-Installation Inspection Procedures)

Pre-Installation Inspection Procedures

- Material Certification (This should be handed to the Engineer weeks prior to operation.
  -Type 3 (Paint) or Type 3 and 4
- Moisture
  -Plastic Wrap Test
    - ✓ Also known as Saran Wrap Test
    - ✓ 12”X12” square clear plastic wrap in sunny spot
    - ✓ Attach to surface on all four sides with duct tape
    - ✓ Wait 3-5 minutes and check for moisture on backside of wrap
  -Felt Paper Test
    - ✓ Only used when putting thermoplastic on asphalt
    - ✓ 12”X12” square of felt paper on asphalt
    - ✓ Apply material directly onto paper
    - ✓ Wait for 10 seconds and check for moisture on backside of paper
- Application temperature (Air and Surface)
  -Thermo 50 degrees F and rising
  -Paint 40 degrees F and rising
  -Polyurea 40 degrees F and rising
  -Heated-In-Place Thermo 40 degrees F and rising
  -Epoxy 40 degrees F and rising
- Wind
  -Difficult to apply beads uniformly
  -May cause lines to have fuzzy edges
- Pre-marking and Layout
  -Section 1205-3 (E) of Standard Specifications
- No Passing Zones
  -Replace marking in the same patterns as before unless changes are noted
  -Changes in no passing zones should be made by an engineer or designate
- Location of Paving Joints
- Retroreflectometer Calibration (see RETROREFLECTOMETERS in Class 5 material)

Installation Inspection Procedures: Division 12, Section 1205 of the NCDOT Construction Manual – Inspection of In-Place Pavement Marking Material (Installation Inspection Procedures)

Installation Inspection Procedures

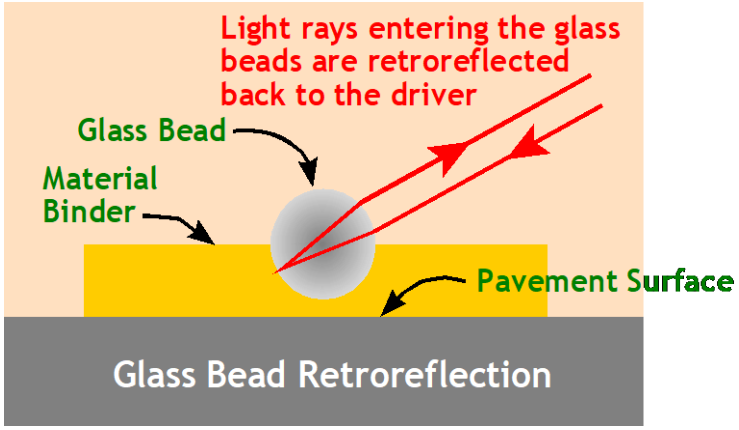
- Check marking color, bead distribution, retro, lateral deviation and width during application.
- Beads
  -Bead embedment
- Bond
  -Chisel Test (Thermo)
- Thickness
  -Wet Film Thickness Gauge
  -Taper Gauge (Thermo)
- Width
- Color
- Workmanship
  -Lateral Deviation
- Location of Retroreflectivity Readings
  -Beginning/Middle/End
- Cracks
  -Long Line – 2 transverse cracks/ft
  -Skip Lines – 2 transverse cracks/ft
  -Stop Bars – 1 transverse crack/ft
  -Symbols & Letters – 2 cracks
  -Word Messages – If 2 or more letters fail as above, the whole word fails.

Post-Installation Inspection Procedures

- Inspected in 1000 ft. sections
- Retroreflectivity – 30 day readings
- **12 month observation period**
- Bond

GLASS BEADS

Factors To Consider When Applying Glass Beads: Division 12, Section 1205 of the NCDOT Construction Manual



Glass Beads

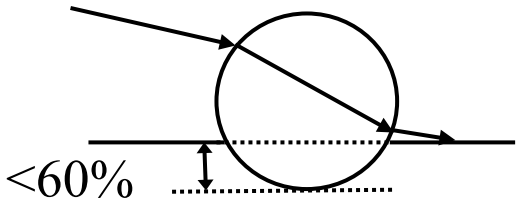
- Definition of Retroreflectivity.
- Glass Beads allow pavement markings to be retro-reflective.
- Glass Beads can be intermixed into some pavement marking material and/or dropped on the top of pavement marking.
- NC Standard Glass Beads are made from recycled glass.
- Both intermix and drop-on beads are 80% round.
- Glass Beads used in pavement marking have a moisture proof coating to keep the beads from clogging in the guns and an additional coating to help it embed into the pavement marking material.
- Beads are applied at the following rates:
  - 6 pounds per gallon for Paint
  - 7 pounds per 100 square feet for Thermoplastic
  - 25 pounds of standard beads per gallon for Polyurea
  - 8 pounds of Highly Reflective Elements per gallon for Polyurea
- Most penalties are caused by NOT installing the appropriate amount of glass beads/highly reflective elements.

Drop-on Glass Beads

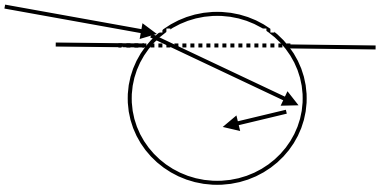
- Use an automatic high pressurized bead dispenser or a pressurized mechanical feed attached to the pavement marking equipment for long-line pavement marking installation.
- Locate bead applicator at the proper distance behind the application of pavement marking material to provide the proper amount of retroreflectivity.
- Use a gravitational method when using hand-liner equipment to install symbols, characters or stop bars.

Bead Embedment

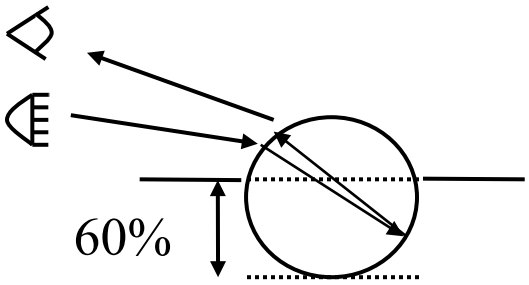
- Beads provide the best retroreflection when there is 40% of the bead exposed above the marking and 60% embedded in the marking.
- Proper bead coatings are essential for proper embedment.



Under Embeded



Over Embeded



Optimal Embedment

Bead Coverage

- Beads provide the best retroreflection when they are spread out evenly.

- Putting too many beads on the marking (also known as flooding the line) can actually decrease the retroreflectivity of the line.

Class 6: Heated-In-Place Thermoplastic and Retroreflectometers

OVERVIEW

Heated-In-Place Thermoplastic

- A preformed thermoplastic which has already been manufactured to its final shape and thickness.
- Durable pavement marking used for stop bars, symbols and characters.
- NC uses only preformed thermoplastic that is heated from the top down to the pavement surface, requiring no preheating of the pavement.
- 125 mil thickness (120 mil thickness **in place**) for center lines, skip lines, transverse bands, mini-skip lines, characters, and crosswalk lines.
- 95 mil thickness (90 mil thickness **in place**) for edge lines, gore lines, diagonals, and symbols.
- 240 mil in place thickness for in lane rumble strips (may be placed in two lifts).
- Can be installed on both asphalt and concrete.
- Use sealer on old asphalt or any type of concrete.
- Road surface must be clean and dry.

Retroreflectometers

- Calibrate the LTL-X:
  - ❖ Before the start of work each day at the work site
  - ❖ If the LTL-X has not been used for 30 minutes or more
  - ❖ Once every 2 hours if the LTL-X is being used continuously all day
- Check the condition of the instrument before and after every use.
- **Have instruments serviced by the manufacturer every year.**

Approved products listing

- https://apps.ncdot.gov/vendor/approvedproducts/

HEATED-IN-PLACE THERMOPLASTIC

- A preformed thermoplastic which has already been manufactured to its final shape and thickness
- Durable pavement marking used for stop bars, symbols and characters
- NCDOT uses only preformed thermoplastic that is heated from the top down to the pavement surface requiring no preheating of the pavement
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SPECIFICATIONS FOR HEATED-IN-PLACE THERMOPLASTIC

Application Equipment for Heated-in-Place Thermoplastic:
Section 1205 of the NCDOT Standard Specifications

Apply Heated-in-Place Thermoplastic using a propane heat gun and other materials such as an infrared temperature gauge as recommended by the manufacturer.

MEASUREMENT INSTRUCTIONS FOR HEATED-IN-PLACE THERMOPLASTIC

Normally, each package of heated-in-place thermoplastic comes with installation instructions. To ensure a successful installation, these instructions should be followed exactly.

When applying on concrete, make sure there is a sufficient supply of the approved sealer, if required by the manufacturer.

Each package of heated-in-place thermoplastic has been assembled to allow a step by step layout of the marking starting from the top of the package. Each package is labeled for ease of identification and contains a drawing, which illustrates proper layout.

Do not store packs of heated-in-place thermoplastic on top of the hot asphalt before or during the application process.

Clean the Surface

- Use a powered blower or compressed air.
- Use a broom if blower is unavailable (not as effective as blower).
- Remove all old tapes, excessive amounts of paint, oxidized thermoplastic, and salt or deicers with a pressure washer.

Applying on Salt, Deicers, or Curing Compounds

- Heated-in-place thermoplastic cannot be applied on top of salt, deicers or concrete curing compounds because they will interfere with the bonding process.
- If salt, deicers, or curing compounds have been used, then you must wait until 2 or 3 heavy rainfalls have washed the chemicals off the pavement prior to placing the material.
- Road salts and deicers can also be removed by pressure washing the surface prior to applying heated-in-place thermoplastic.

Applying on Existing Paint or Tape

- Heated-in-place thermoplastic should not be applied on top of a heavy coat of paint or tape. Paint or tape will act as a barrier between the marking and the bitumen in the asphalt.

Applying on Existing Thermoplastic, Chip Seal, or Seal Coats

- Heated-in-place thermoplastic can be applied on top of existing thermoplastic, chip seal, and some seal coats provided these materials are well bonded to the road surface.

Applying on New, Existing Thermoplastic

- When applying heated-in-place thermoplastic on top of new, existing thermoplastic scrape off any thermoplastic that is loose and then remove moisture. The old thermoplastic surface must be clean.

Applying on Old, Existing Thermoplastic

- Take particular care when applying heated-in-place thermoplastic over old thermoplastic because the old thermoplastic may have oxidized material on the surface.
- Under normal traffic conditions, this oxidized material is continually worn away.
- In gore areas or other places where the marking does not receive much traffic, this oxidized layer remains on top of the marking and will form a barrier between the existing material and any new marking installed on top.
- When installing heated-in-place thermoplastic on top of old thermoplastic, heat the old thermoplastic first and scrape off the bulk of the material with a shovel.

- Place and heat the new marking on top of the freshly exposed old thermoplastic.
- Heat the new marking thoroughly and make sure that the indents on the material close.
- You will achieve the best bond possible if the fresh exposed old thermoplastic is molten when the new layer is positioned and heated.
- When working with oxidized thermoplastic, the top layer must be removed prior to applying heated-in-place thermoplastic.

Applying on Concrete Surfaces

- A sealer must be applied to assure adequate bonding between the heated-in-place thermoplastic and concrete road surface.
- Sealers seal the surface to prevent the upward migration of moisture through the concrete.
- Sealers bond to the very fine dust particles which are always present in concrete.
- Sealers provide an interface between the concrete surface and the heated-in-place thermoplastic, forming a bond between the two.
- It is important to make sure the pavement surface is dry before applying the sealer because surface moisture will prevent a good bond.
- Humidity and fluctuating temperatures have an effect on the strength of the sealer's bond because they leave an invisible film of moisture on the surface.
- During high humidity, water may condense on the sealer as it dries since the sealer is solvent based.
- If the sealer feels damp when you test to see if it is dry, leave it for a couple more minutes or heat the area very quickly before applying heated-in-place thermoplastic.
- Do not begin the heated-in-place thermoplastic application process before the sealer film is tack free most of the sealer solutions are flammable.
- Heat the area to remove moisture just as you would for an asphalt application.
- Be very careful not to overheat as spalling can occur and concrete particles may be ejected.
- Sealers can be applied with a paint roller or sprayed.
- Apply the sealer to the entire area to be marked, and make sure it gets down into the grooves and cracks in the concrete.
- Avoid applying excessive amounts of sealer in crevices, grooves, etc. because the solvent will not readily evaporate and may burn when the heated-in-place thermoplastic is heated.

Remove Moisture

- It is very important that all surface moisture is removed prior to applying heated-in-place thermoplastic on the pavement.
- Even if it hasn't rained for several days, moisture may be present on the pavement due to humidity, morning dew or condensation from automobile air conditioning units.
- If moisture is not removed, heated-in-place thermoplastic will not bond properly to the pavement and your marking will fail.
- If you do install heated-in-place thermoplastic shortly after precipitation has occurred, it is recommended you dry the surface, position the material and heat one section at a time. This will help prevent areas which you have already dried form reabsorbing moisture from the air of surrounding road surfaces.
- Use heat gun to remove moisture from the roadway.
- Look for a "dark shadow" around the area being heated to indicate moisture has been removed.

Layout the material

- Make sure the layout and position is correct before heating material.
- Avoid leaving gaps by making sure the individual pieces touch each other.

Heat the material

- Consult with manufacturer's instructions on installation.
- Move your heat gun flame in a pattern so the entire area is evenly heated.
- Heat gun strokes should be approximately 2 feet wide in a slow, even motion.
- Keep the nozzle of the heat gun approximately 2-6 inches from the material.
- Wind conditions may dictate that the heat gun nozzle be held closer to the material.
- Look at the color, gaps, seams, edges or other indicator indentations in the material to

insure the material has been heated enough.
- Additional heating is not necessary and may cause the surface beads to sink, resulting in low retroreflectivity

Do the chisel test
- After the marking has cooled down, you must perform a chisel test to assure a proper bond has been achieved before removing your traffic control measures.
- Do the chisel test on an area of the material where the visual signs show the least.
- When you pull the material back, a portion of the underlying asphalt should also lift with the marking, indicating that sufficient bond has been achieved.
- If portions of the asphalt are not embedded on the heated-in-place thermoplastic, you have not applied enough heat.
- Simply reheat the material and repeat the chisel test until the asphalt lifts with the material.
- Do not leave the project site until you have established that sufficient bonding has taken place.
- Attempting to reheat the marking at a later time will fail because moisture will accumulate between the marking and the pavement due to natural condensation and rainwater.
- When performing the chisel test on material applied on concrete, seldom will you see the pavement separating as it might on asphalt.
- You should see a thin layer of the heated-in-place thermoplastic material adhering to the concrete.

Allow to Cool
- All materials should be allowed to cool until they are firm to the touch before allowing traffic to run over them.
- During warm weather, it may take longer for the material to cool down
- Applying water on the markings will shorten the cooling process.

Uses for Heated-in-Place Pavement Markings

- Long life marking
- High ADT roadways
- Non-Snowplow Areas
- Crisp, Neat Stop Bars, Symbols and Characters
- Installation in cooler temperatures

RETROREFLECTOMETERS

Beginning of Day Check
- Check the optic window for dust or dirt; Clean if necessary.
- Check that the calibration date on the Red Field Block is not more than one (1) week old; If so, do a calibration transfer.
- Make sure the battery is fully charged (Full charge takes eight (2) hours).
- Make sure data log has enough space for your new readings.

Zero Procedure

- Press the CALIBRATION button. Mount the calibration unit underneath the front end of the instrument.
- This is done by tilting the instrument slightly backward and then placing the unit. Make sure that the pins on the side of the unit fit into the holes in the LTL-X.
- Press the OK button to start zero calibration. During calibration the lamp will flash a number of times.

Reference calibration

- Now the instrument is ready for the next step and the display will tell you to rotate the calibration unit.

- Again, it is important that the pins on the side of the unit fit into the holes in the LTL-X.

- Check and if necessary, correct the calibration value shown in the display so it matches the value stamped on the calibration unit.
- Press the OK button to finish the calibration.
- The calibration procedure is now done.
- Press the **Print** button.
- Remove the calibration unit and store it properly.
- Press OK to return to the measurement display.

Checking the Calibration

- Place the Red Field calibration block in the calibration position.
- Press the RL button.
- Make sure that RL value on the display matches the RL value on the calibration block +/- 1 mcd/lux/m^2.
- Recalibrate if necessary.
- Remove the calibration block and place back in its storage place.

Retroreflectivity Reading Procedure

- Place the LTL on the marking straight down making sure that the LTL covers the marking as much as possible.
- Press the **RL** button to take a reading.
- Moving the LTL on the marking must be done by lifting the LTL straight up; do not slide the machine - this can cause damage to the optic window.

End of Day Check

- Check the optic window for dust or dirt; Clean if necessary.
- Check that the calibration date on the Red Field block is not more than one week old; If so, do a calibration transfer.
- Make sure the battery is fully charged (Full charge takes eight (2) hours).
- Make sure data log has enough space for your new readings.

Cleaning

- **Do not clean the black block – it is your traceable standard. Only the manufacturer can certify it.**
- Clean the Red Block ceramic and light trap with window/glass cleaner & a lint-free cloth. After cleaning, a calibration transfer must be performed.
- Clean the optic window with window/glass cleaner & a lint-free cloth.