

**APPLICATION SPECIFICATION
CONVENTIONAL PAVEMENT MARKING MATERIALS
3 MINUTE DRY ALKYD AND HIGH SOLIDS LATEX**

Values stated in the International System of Units SI apply only to projects to be constructed in Metric units of measure. Values stated in inch-pound units (in parenthesis) apply only to projects to be constructed in English units of measure.

Materials

The traffic marking paint shall be yellow or white in color and shall conform to the attached Mn/DOT Specification. ALL MATERIALS shall be free of lead, cadmium, mercury, hexavalent chromium and other toxic heavy metals as defined by the United States Environmental Protection Agency.

The material shall be marked as follows:

- | | |
|-------------------------|----------------------|
| 1. Manufacturer's Name | 4. Color of Material |
| 2. Place of Manufacture | 5. Batch Number |
| 3. Date of Manufacture | |

Only material manufactured by a Mn/DOT approved manufacturer will be allowed for use on Mn/DOT projects. The following manufacturers are approved to supply material:

Beads
Potters, Inc.

Quality Paint
Vogel Paints, Inc.
Linear Dynamics, Inc.
Centerline Industries, Inc.
Sherwin Williams, Inc.

A sample from each batch shall be submitted to the Mn/DOT Laboratory for inspection and testing at least 15 days prior to use in the field.

Equipment

Application equipment for permanent markings shall consist of a machine of the spray type capable of applying the material under pressure at a controlled temperature through nozzles equipped with remotely controlled cutoff mechanisms and suitable line guides that will produce clean cut lines and prevent excessive material drift. The marking material shall be applied with truck-mounted traveling units properly equipped to apply the paint stripes as required. Where two or more lines are to be applied closely spaced, the

machine shall be equipped to apply those stripes simultaneously. For application of broken lines, the spray unit shall include an automatic feed control device capable of being set to produce the specified stripe to gap ratio. The truck equipment shall be capable of accumulating the length applied by each gun individually each day. Only material application shall activate the length accumulators. The read out shall be digital and not externally adjustable.

Vehicles in the striping train shall be deployed and equipped with traffic control devices as set forth in the "Field Manual" of the *Minnesota Manual on Uniform Traffic Control Devices*. Additionally, the shadow vehicle shall be equipped with a truck-mounted attenuator on high speed (SPEED LIMIT 65 kmph (40 mph) and greater), high volume (ADT 1500 and greater) highways.

The equipment shall also be capable of applying glass beads by a pressurized system. All guns on the spray carriage shall be in full view of the operators during the spraying operation.

Application

The Engineer will place necessary "spotting" at appropriate points to provide horizontal control for longitudinal striping, determine starting and cutoff points and provide inspection of all work. Broken line intervals will not be marked. The Contractor shall cooperate with inspection personnel and take appropriate actions to assure quality pavement marking installations.

Pavement markings shall only be applied when the air temperature is at least 10 C (50 F) unless the manufacturer, in writing, authorizes a lower temperature. Markings shall not be applied when the wind or other conditions cause a film of dust to be deposited on the pavement surface after cleaning and before the marking material can be applied. No striping operations will be permitted between sundown and sunrise without written permission from the Engineer.

At the time of applying the marking material, the application area shall be free of contamination. The contractor shall clean the roadway surface prior to the line application in a manner and to the extent required by the Engineer.

The filling of tanks, pouring of materials or cleaning of equipment shall not be performed on unprotected pavement surfaces unless adequate provisions are made to prevent spillage of the material. Waste material, spent solvents and cleaning materials shall be properly stored and disposed of in accordance with all federal, state and local laws, regulations and ordinances.

Glass beads shall be applied immediately after application of a paint line at a rate of 960 g/L (8 lbs./gal.). Beads shall be evenly distributed on pavement. All material shall be placed in a workmanlike manner, which shall result in a clearly defined line that has been adequately reflectorized with glass beads.

All pavement striping shall be 100 mm (4 in.) wide, unless otherwise specified, and broken line shall be in lengths of 2 m (6.56 ft.) separated by a gap of 8 m (26.25 ft.) for a 10 m (32.81 ft.) cycle length. All pavement striping shall be a minimum of 380 μ m thick (wet thickness) and the thickness shall be uniform across the width of the line.

A tolerance of 6 mm ($\frac{1}{4}$ in.) over or under the specified width will be allowed for striping provided the variation is gradual and does not detract from the general appearance. Broken line segments may vary up to 75 mm (3 in.) from the specified lengths provided the over and under variations are reasonably compensatory. Alignment deviations from the control guides shall not exceed 50 mm (2 in.). Material shall not be placed over a longitudinal joint. Establishment of application tolerances shall not relieve the contractor of his responsibility to comply as closely as possible with the planned dimensions.

Application for the marking material shall be such as to provide uniform film thickness throughout the coverage area. Stripe ends shall be clean cut and square, with a minimum of material beyond the cutoff.

Acceptance/Rejection of Pavement Markings

Acceptance or rejection of pavement markings will be based on thickness and width of material placed as determined by field measurements and yield calculations. Visual observations will determine whether adhesion, chipping and color of the in-place pavement markings is acceptable. The minimum acceptable initial retroreflectivity, as determined in the attached METHOD OF MEASUREMENT FOR DETERMINING AVERAGE RETROREFLECTIVITY shall equal or exceed 275 mcd/m²/lux for white and 180 mcd/m²/lux for yellow material, respectively.

All retroreflectivity readings and data analysis will be provided by Mn/DOT at no cost to the Contractor. Mn/DOT reserves the right to:

- make daytime and/or nighttime visual inspections with or without the presence of the Contractor's representative, mainly to locate obvious or suspect areas of deficiency,
- determine retroreflectivity of symbols, legends and lines wider than 200 mm (8 in.) using a portable unit only, and
- accept initial retroreflectivity based on random sampling by color of all markings if computed averages exceed the specified minimum values.

Reduction in Payment

A reduction in pay shall be made for reduced thickness, retroreflectivity and width. Thickness and retroreflectivity shall be computed by random measuring. Thickness shall be computed by the following formula:

$$\text{Thickness (micrometers)} = \frac{\text{Liters} \times 0.001 \text{ meters}^3 \times 10^{-3}}{\text{Length (meters)} \times \text{Width (meters)}}$$

Use 3.785 liters x gallons if paint is metered in gallons.

Example: A 380 micrometers thick paint line requires a liter of material for every 25.8 m of 100 mm wide line.

The equation in English units is:

$$\text{Thickness (inches)} = \frac{\text{Gallons} \times 231 \text{ cubic inches}}{\text{Length (inches)} \times \text{Width (inches)}}$$

And, 1 mil = 0.001 of an inch.

A 15 mil thick 4 inch wide line yields 320 feet per gallon.

Correction of Defects

All pavement markings not conforming to the requirements of the Contract shall be removed and replaced or otherwise repaired to the satisfaction of the Engineer. Removal of unacceptable work shall be accomplished with suitable blasting or grinding equipment unless other means are approved by the Engineer.

Where yield computations show a deficiency in material usage of not more than 20 percent, the Engineer may require satisfactory repair or may accept the work at a reduced unit price which is in direct proportion to the percent of the deficiency. Where the deficiency in material usage exceeds 20 percent, the Engineer may require removal and replacement or otherwise corrected to the satisfaction of the Engineer.

If the Engineer requires removal and replacement of a deficient line, message or symbol, the contractor shall remove, by an approved process, at least 90% of the marking material without excessive scarring the existing pavement. The removal width shall be approximately 25 mm (1 in.) wider all around the deficient marking.

Where initial reflectivity readings fall below the minimum acceptable levels by not more than 20%, the Engineer may require satisfactory repair or may accept the work at a reduced unit price which is in direct proportion to the percent of the deficiency. Where the deficiency in retroreflectivity exceeds 20 percent, i.e., less than 220 mcd/m²/lux for white and 145 mcd/m²/lux for yellow, the Engineer may require removal and replacement or otherwise corrected to his satisfaction.

If this process has to be repeated on several projects with either the same Contractor, subcontractor and/or manufacturer(s), Mn/DOT will take corrective action. This corrective action will be a two step process:

Step 1 Pavement marking contractor/manufacturer(s) will be considered not approved for Mn/DOT projects, except to bring workmanship/product back into compliance.

Step 2 If the first step cannot be attained, the pavement marking contractor/manufacturer(s) will not be allowed to bid on Mn/DOT projects and/or will be removed from product lists.

METHOD OF MEASUREMENT FOR DETERMINING AVERAGE RETROREFLECTIVITY

Measurements shall be taken with either a portable or mobile retroreflectometer conforming to 30-meter geometry which is defined as: the entrance angle (the angle between the illumination axis and the retroreflector axis) shall fall between 88.50 and 88.76 and the observation angle (the angle between the illumination axis and the observation axis) shall fall between 1.0 and 1.05 ; and, the co-viewing angle (the complement of the entrance angle) shall fall between 2.29 and 2.50 .

The following methodology will be used to evaluate retroreflectivity performance of in-service longitudinal line pavement markings:

LENGTH AND NUMBER OF TEST SEGMENTS^a PER ROADWAY^b PER LINE TYPE^c

Length of Roadway	Number of Test Segments	Length of Test Segments
1.5 km (1 mi.)	1	300 m (0.2 mi.)
Greater than or 1.5 km (1 mi.)	1 per 1.5 km (1 mi.)	300 m (0.2 mi.)

- a TEST SEGMENTS-- Areas of a roadway chosen for measuring retroreflectivity of the line types.
- b ROADWAY--As used here, means that portion of a street or highway ordinarily used for vehicular traffic. In the event a street or highway includes two or more separate roadways, the term roadway shall refer to each roadway separately.
- c LINE TYPE-- Longitudinal lines of the same color and function. For example, white and yellow edge lines are each a line type.

Measurements in Test Segments

PORTABLE RETROREFLECTOMETER

1. Take a minimum of 10 readings in each test segment per line type.
2. On broken lines (skip striping), take no more than two readings per stripe, with readings 0.5 m (20 in.) from ends of marking.
3. For solid lines, divide test segment into ten areas of 30 m (100 ft.); space readings a minimum of 10 m (32.81 ft.) and a maximum of 30 m (100 ft.) apart.
4. For 10 percent of each message type, take 5 readings on each message line; for 10 percent of each symbol type, take 5 readings on each symbol.
5. Upon completion of the evaluation, regardless of the results, additional test segments may be ordered by the Engineer.

MOBILE RETROREFLECTOMETER

1. Calibration of the instruments shall be in accordance with the manufacturer's instructions.
2. Retroreflectivity shall be measured at a minimum rate of 10 percent of each roadway length by line type.
3. Should another mobile unit be available, the maximum acceptable deviation for measurements made by the two different instruments of the same manufacturer and for the same roadway length shall be $\pm 10\%$.
4. Repeatability for the given mobile unit shall be $\pm 6\%$.
5. Upon completion of the evaluation, regardless of the results, additional test segments may be ordered by the Engineer.

MISCELLANEOUS CONTROLS

1. Take measurements on a dry, clean roadway.
2. Collect data in direction of traffic flow.
3. Measurement units are $\text{mcd/m}^2/\text{lux}$.
4. Wait at least two (2) weeks from date of placement of the markings before taking initial readings.
5. Randomly select test segments unless night reviews or other knowledge supersedes a random selection process.
6. The Engineer may request additional readings or test segments.
7. Measure each line type separately.
8. In the event LASERLUX is not available, the Engineer may require the use of the portable retroreflectometer or establish an alternative evaluation plan.

Contents of Retroreflectivity Report

The Report shall consist of:

State Project number.

Trunk Highway number.

Test date.

Geographical location of the test site(s), including distance from the nearest permanent site identification, such as a reference point.

Identification of the pavement marking material tested: type, color, age, and transverse location on the road.

Identification of the retroreflectometer.

Remarks concerning the overall condition of the lines, messages and symbols such as carryover of asphalt, uneven distribution of beads, etc.

Average of the readings for each test segment with one standard deviation calculated.

Average of the readings for each type of message and symbol.