



**INDIANA DEPARTMENT OF TRANSPORTATION
DIVISION OF MATERIALS AND TESTS**

**MEASUREMENT OF RETRO-REFLECTIVE
PAVEMENT MARKING MATERIALS
ITM No. 931-23**

1.0 SCOPE.

- 1.1** This test method covers the measurement and acceptance of retro-reflectivity on pavement markings using portable hand-operated and mobile 30-meter geometry instruments.
- 1.2** The purpose of this test method is to assure that adequate retro-reflectivity of pavement markings is provided by newly applied markings for the driver of a vehicle and to assure that the retro-reflectivity is maintained throughout the warranty period.
- 1.3** Newly applied pavement markings are those which have been applied between 14 to 30 days before testing and from which all excess glass spheres have been removed. (Excess glass spheres contribute to erroneous readings directly after application and are generally not present a few days after application). Warranty periods will begin with the substantial completion date for the contract as defined in 101.59, but not prior to November 1 of the calendar year in which the last pavement markings were installed.
- 1.4** Retro-reflectivity measurements are required to be taken by an operator trained and certified by the authorized representative of the manufacturer of the retro-reflectometer. The portable retro-reflectometer operator certification shall be valid until January 31 of odd numbered years. The Engineer will verify operator certification on the INDOT website.
- 1.5** This ITM may involve hazardous materials, operations, and equipment and may not address all of the safety problems associated with the use of the test method. The user of the ITM is responsible for establishing appropriate safety and health practices and determining the applicability of regulatory limitations prior to use.

2.0 REFERENCES.

2.1 ASTM Standards.

- E 1710 Standard Test Method for Measurement of Retroreflective Pavement Marking Materials with (CEN)-Prescribed Geometry Using a Portable Retroreflectometer

2.2 ITM Standards.

802 Random Sampling

3.0 TERMINOLOGY. Definitions for terms and abbreviations will be in accordance with the Department's Standard Specifications, Section 101 and the following:

3.1 Section. For newly applied markings, the application of each color of pavement marking completed by one application crew in one day. For warranty testing, a section is defined as the application of each color of pavement marking completed in accordance with the contract requirements.

3.2 Segment. For newly applied markings, a portion equal to one third of the pavement marking application of a day. For warranty testing, a segment is defined as a portion equal to one third of the pavement marking application of a section.

3.3 Sampling Zone. A location within each segment that retro-reflectivity readings are taken when using a portable retro-reflectometer

3.4 CEN Geometry. The geometry of instrument measurement specified by CEN, based on a viewing distance of 30m from an arbitrary passenger vehicle with an eye height of 1.2m and a single headlight mounting height of 0.65m in the same vertical plane and a pavement stripe directly ahead of the headlight.

3.5 Retro-reflectivity. A standard of measure for pavement markings. The units for these measurements are millicandelas per square meter per lux.

3.6 Event Codes. A list of codes indicating problems with measurements

3.7 MRDC. Mobile Reflectivity Data Collection

4.0 SIGNIFICANCE AND USE. This ITM is used to determine retro-reflective properties of pavement marking materials containing retroreflecting beads, such as traffic stripes and surface symbols, using a portable or mobile retro-reflectometer that may be placed on the road delineation to measure the retro-reflection at a prescribed geometry.

5.0 APPARATUS.

5.1 Retro-reflectometer, Delta Model LTL-X, LTL3000, LTL3500, RoadVista Model StripeMaster 3, Stripemaster II or Stripemaster II Touch, in accordance with ASTM E 1710. The measurement geometry will be 88.76° for the entrance angle β_1 , 0° for β_2 , and 1.05° for the observation angle. The aperture angles for both the source and receiver will not exceed 0.33° .

A factory calibration shall be performed on the retro-reflectometer at a minimum of once per calendar year. A copy of the calibration shall be provided to the Engineer prior to the start of work. Comparison measurements with an INDOT reflectometer may be made by the Contractor at an INDOT location.

- 5.2** Mobile Retro-Reflectometer. A self-propelled, mobile retro-reflectometer with video and mapping capabilities certified by the manufacturer or manufacturer authorized representative. The mobile retro-reflectometer Certification Program shall be used. The mobile retro-reflectometer will have a measurement geometry of 88.76° for the entrance angle β_1 , 0° for β_2 , and 1.05° for the observation angle. The aperture angles for both the source and receiver will not exceed 0.33° .

A factory calibration shall be performed on the mobile retro-reflectometer at a minimum of once per calendar year. A copy of the calibration shall be provided to the Engineer prior to the start of work. Comparison measurements with an INDOT mobile retro-reflectometer may be made by the Contractor at an INDOT location.

- 6.0** **PORTABLE RETRO-REFLECTOMETER SAMPLING.** Each sampling zone for retro-reflectivity measurement will be determined as follows:

6.1 **Longitudinal Lines.**

- 6.1.1** Two lane highways. Divide the length of newly applied pavement marking application completed in a single day's work by three to establish the length of each segment containing a sampling zone. For the warranty testing, test the yellow centerline in each of the three sampling zones and test both white edgelines separately in each of the three sampling zones. The lane lines for turn lanes may be combined with a white edge line if they were applied on the same day. See the testing diagrams in ITM 802 for additional information.
- 6.1.2** Multilane undivided highways. Divide the length of newly applied pavement marking application completed in a single day's work by three to establish the length of each segment containing a sampling zone. For the warranty testing, test the yellow centerline or two way left-turn lane markings in each of the three sampling zones. Test the white edgeline and lane line(s) for both directions of traffic in each of the three sampling zones. See the testing diagrams in ITM 802 for additional information.
- 6.1.3** All other highways. Divide the length of newly applied pavement marking application completed in a single day's work by three to establish the length of each segment containing a sampling zone. For the warranty testing, test the yellow edgelines in both directions of traffic in each of the three sampling zones. Test the white edgeline and lane line(s) in both directions of traffic in each of the three sampling zones. See the testing diagrams in ITM 802 for additional information.

6.1.4 In each segment, the Engineer will randomly generate a point to the nearest tenth of a mile to begin taking measurements of the sampling zone area in accordance with ITM 802.

6.2 Letters, Symbols, and Transverse Lines.

6.2.1 Each letter, symbol, or transverse line is considered a sampling zone area.

7.0 PROCEDURE FOR PORTABLE RETRO-REFLECTOMETER.

7.1 Use the manufacturer's instructions for operation of the portable retro-reflectometer.

7.1.1 Ambient temperature shall be not less than 40°F

7.1.2 The surface of the marking shall be clean and dry

7.1.3 Transporting the instrument from an air conditioned area to the test site may result in fogging of mirrors in the instrument. If there is any doubt concerning the calibration or the readings are not constant, allow the instrument to reach ambient conditions and recalibrate with the instrument standard.

7.1.4 Turn on the retro-reflectometer, and allow the device to reach equilibrium following the manufacturer's instructions.

7.1.5 Subsequent to standardization, an internal or secondary reference surface such as diffuse white or retro-reflecting surface is used to maintain the standardization of the instrument during brief periods of transport to the test site area.

7.2 Zero and calibrate the hand-operated instrument. Print the zero and calibration readings at the beginning of the day's work. Recalibrate the instrument every 2h when taking readings. Print the zero and calibration readings each time these operations are performed. The instrument zero and calibration are to be in accordance with the instrument manufacturers written instructions.

7.3 All measurements obtained in the sampling areas listed as follows will be made in the direction of traffic flow, except as noted in 7.4.2.

7.4 Longitudinal Lines.

7.4.1 Make the first measurement at the beginning of the sampling zone and make 16 retro-reflectivity measurements within each sampling zone. If any portion of the sampling zone is unsafe for taking measurements, move forward to the first point which may be inspected safely and begin

the sampling zone there. Do not move the sampling zone simply for convenience. A change in the starting point of one sampling zone will not change the starting point of the subsequent sampling zone. If a valid measurement is not attainable at a location within the sampling zone due to a pothole, grass, obvious tracking, etc., move forward in the sampling zone to the first available location for a valid measurement and resume the subsequent measurements within that sampling zone.

- 7.4.2 When a sampling zone contains only skip lines for evaluation, measure each skip line at two evenly spaced locations on the line. For measurements of skip lines with two-way traffic, one measurement on each line shall be taken in one direction and the other measurement on the same line shall be taken in the opposite direction. For measurements of skip lines with one-way traffic, the two measurements on each line shall be taken in the direction of the traffic flow.
- 7.4.3 When a sampling zone contains centerline with a skip line and a solid line, measure each skip line once and measure the solid line at the same station. Measurements are taken in the direction of the traffic flow for each line and represent two of the required 16 measurements.
- 7.4.4 When a sampling zone contains centerline with two solid lines, measure each line at the same station at 15 ft intervals. Measurements are taken in the direction of the traffic flow for each line and represent two of the required 16 measurements.
- 7.4.5 When a sampling zone contains edge lines, or a combination of edge and lane lines, each line shall have 16 measurements taken in the direction of the traffic flow.

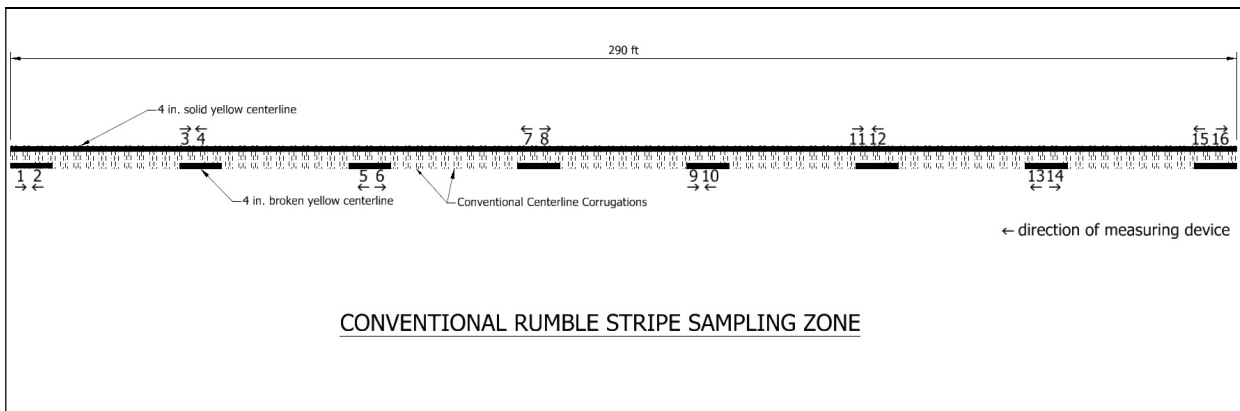
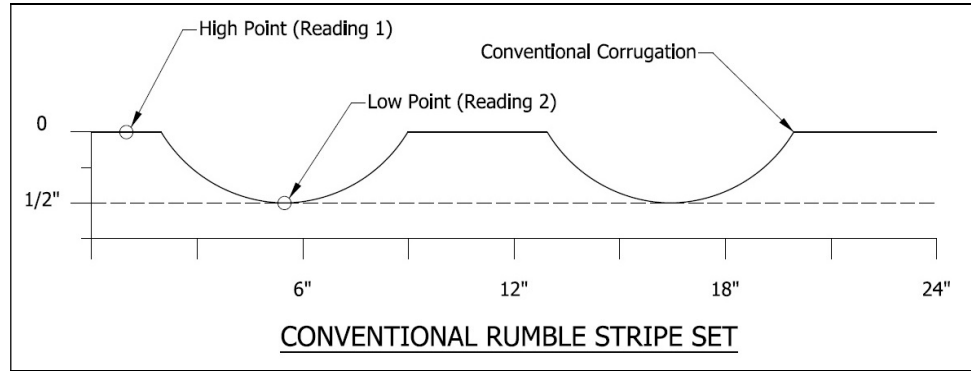
7.5 Letters, Symbols and Transverse Lines.

- 7.5.1 Make a minimum of ten random measurements on each letter, symbol, or transverse line which is 8 ft tall or wide. For a letter, symbol, or transverse line less than 8 ft tall or wide, five random measurements are made.

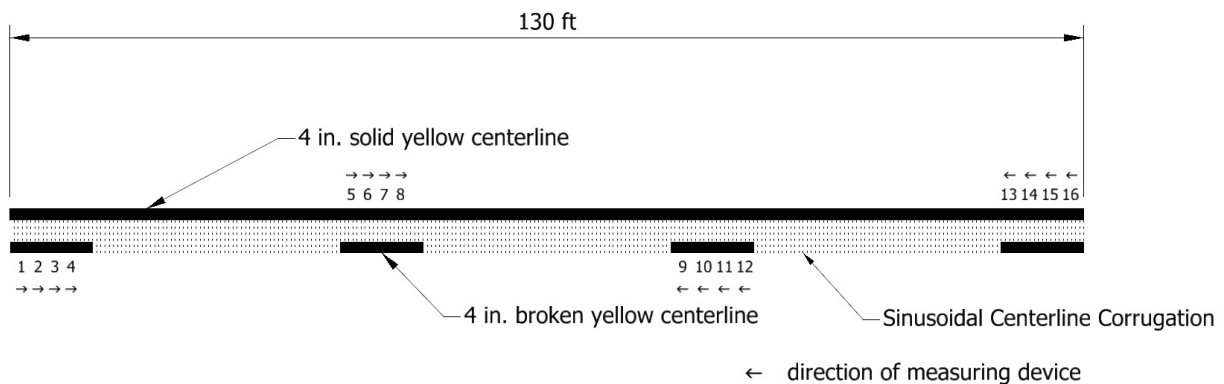
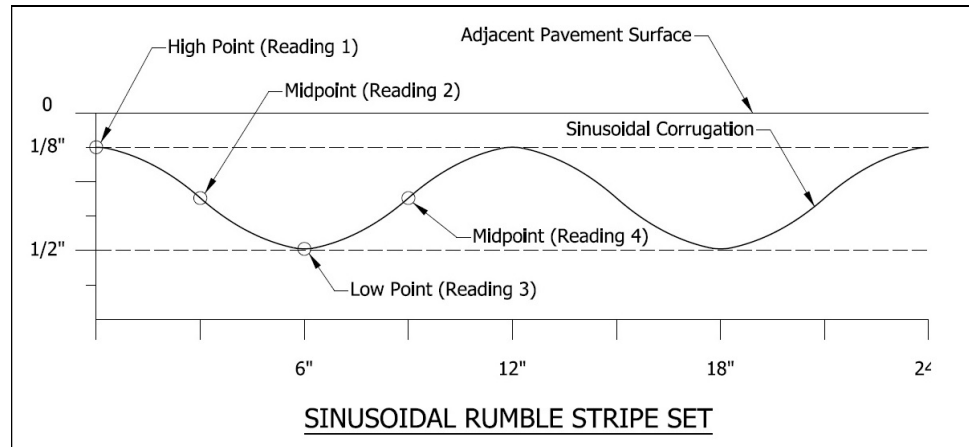
7.6 Rumble Stripes

- 7.6.1 When measuring longitudinal lines placed within a conventional pavement corrugation, the 16 measurements shall be taken in 8 sets. The sets shall be 40 ft apart and each set shall consist of 2 measurements, the first at the pavement surface, and the second at the low point of the corrugation as shown in the diagram below. For measurement of lines with two-way traffic, four of the measurements shall be taken at both the high and low point of the corrugation for both directions of traffic. For

double solid or one solid and one skip centerlines, these measurements shall be evenly split between the two lines. Add 10% as a standard adjustment factor to each of the 16 measurements and calculate the average retro-reflectivity reading.



7.6.2 When measuring longitudinal lines placed within a sinusoidal corrugation, the 16 measurements shall be taken in 4 sets. The sets shall be 40 ft apart and each set shall consist of 4 measurements, the first at the high point of the sinusoidal corrugation, the second at the midpoint between the high point and the low point, the third at the low point of the sinusoidal corrugation, and the fourth at the midpoint between the low point and the next high point, as shown in the diagram below. For measurement of lines with two-way traffic, two of the measurements shall be taken at the high and low point and each midpoint of the set for both directions of traffic. For double solid or one solid and one skip centerlines, these measurements shall be evenly split between the two lines. Add 20% as a standard adjustment factor to each of the 16 measurements and calculate the average retro-reflectivity reading.



SINUSOIDAL RUMBLE STRIPE SAMPLING ZONE

8.0 PROCEDURE FOR MOBILE RETRO-REFLECTOMETER

- 8.1 Use the manufacturer written instructions for operation of the mobile retro-reflectometer.
- 8.2 The MRDC shall be obtained for pavement markings on roadways as shown in the plans or as designated by the Engineer.
- 8.3 The MRDC shall be collected on a dry pavement and when the ambient air temperature is greater than 40°F.
- 8.4 For the purpose of evaluating retro-reflectivity, data obtained through evaluation according to Section 808 will be evaluated separately for each section.
- 8.5 The calibration of the mobile retro-reflectometer shall be verified. The verification measurements at the beginning of the work shall be recorded for each day. Verification of the calibration of the instrument shall be done as necessary when taking readings. Verification measurements shall be reported each time these operations are performed.

- 8.6** The Department will provide the Contractor operating the mobile retro-reflectometer with the routes for evaluation. The routes evaluated will represent all of the longitudinal line segments completed in a section of striping. Data shall be collected in the direction of the traffic flow. On non-divided highways, the centerline markings shall be measured in both directions of traffic flow.
- 8.7** A set of field comparison readings with the portable retro-reflectometer shall be obtained at least once every four hours while conducting MRDC. A minimum of twenty readings, distributed over the interval measured, shall be obtained. The average portable retro-reflectometer reading shall be listed next to the mobile retro-reflectometer average reading for that interval with the reported MRDC data. Approval shall be requested from the Engineer to obtain a field comparison on a separate roadway when measuring a roadway where portable retro-reflectometer readings are difficult to obtain. The portable retro-reflectometer printout of all the readings taken for the field comparison check shall be submitted with the corresponding MRDC data. The mobile average reading is required to be within a $\pm 15\%$ range of the portable average readings. The off-location field comparison readings and the new MRDC shall be provided at no additional cost to the Department.

The Engineer may take readings with a Department portable retro-reflectometer to ensure accuracy at any time. The Department Construction Division will take comparison portable readings and serve as the referee if there is a significant difference between the Engineer portable readings and the Contractor mobile and portable readings. Field comparison readings shall be obtained on a flat and straight roadway when possible.

- 8.8** Periodic field checks at pre-measured locations shall be done. When requested by the Engineer, the mobile unit readings shall be reported to the Engineer immediately after obtaining the average retro-reflectivity value for a designated pre-measured test location. The Engineer will have taken portable retro-reflectivity measurements at the test location within 10 days of the test. The test location will not include pavement markings less than 30 days old. If the measured mobile average does not fall within $\pm 15\%$ of the pre-measured portable average, further calibration and comparison measurements may be required before any further MRDC is allowed. The results of the field check shall be submitted with the MRDC report for that day.
- 8.9** All MRDC shall be documented by county and roadway or as directed by the Engineer
- 8.10** All raw data collected, video and maps shall be documented
- 8.11** A high-quality DVD showing the markings as they are measured shall be documented

8.12 The data file and video shall contain the following information:

8.12.1 Preliminary Documentation Sample. A sample data file, video, and map of MRDC data in the required format shall be submitted 10 working days prior to beginning the work. The format shall meet specification requirements and be approved by the Engineer before any work may begin.

8.12.2 Initial Documentation Review and Approval. The Department will review documentation submitted for the first day of MRDC. If the documentation does not meet specification requirements, further MRDC will not be allowed until the deficiencies are corrected. The Department will inform the Contractor no later than five working days after submittal of the documentation if the first day of MRDC does not meet specification requirements. Time charges will continue unless otherwise directed by the Engineer.

9.0 CALCULATIONS.

9.1 Calculate the average for each sampling zone, segment, and section as follows:

$$\text{Average } (\bar{x}): \quad \bar{x} = \sum_{i=1}^n \frac{x_i}{n}$$

Where: n = the number of measurements within each measurement sampling zone

10.0 REPORT. A final report shall be submitted in the format specified by the Engineer to the Department District Traffic Engineer within one calendar week after the service is complete.

10.1 Portable Reflectivity Report. The report for portable retro-reflectometer shall include the following items:

10.1.1 Test date and time

10.1.2 Date and time of application of the pavement marking, or date of final acceptance of the contract and contract number for 180 day warranty testing

10.1.3 Color of and type of pavement marking

10.1.4 For newly applied pavement markings, manufacture and product name or number of each material used

- 10.1.5 The location road, route number, reference points, direction of traffic, line identification, and other designated information
 - 10.1.6 All measurements reported in millicandelas per square meter per lux for each sampling zone of each traffic direction for each longitudinal lane marking or each letter, symbol, and transverse line
 - 10.1.7 The average for each sampling zone, segment, and section
 - 10.1.8 The serial number and date of last factory calibration for the retro-reflectometer
 - 10.1.9 Each of the zero and calibration readings
 - 10.1.10 The field reading tape printout
- 10.2 Mobile Reflectivity Final Report.** A final report in the format specified by the Engineer shall be submitted to the Department District Traffic Engineer within one calendar week after the service is complete. The final report is required to contain a list of the problems encountered and the locations where problems occurred during MRDC. The mobile reflectivity final report shall include the following:
- 10.2.1 The Record of Verification of the Instrument Calibration.** A record of the verification of calibration measurements at the beginning of each day of work and each time the verification of calibration measurements is performed.
 - 10.2.2 Data Files.** Data files shall include the following:
 - a) Date
 - b) District Number
 - c) County
 - d) Route number with reference markers or other reference information provided by the Engineer to indicate the location of beginning and data collection points on that roadway
 - e) Cardinal direction
 - f) Line type, single solid, single broken, double solid, etc
 - g) Type of marking material
 - h) Line color
 - i) File name corresponding to video
 - j) Data for each centerline listed separately
 - k) Average reading taken for each 0.1 mi. interval or designated by the Engineer
 - l) Accurate GPS coordinates within 20 ft for each interval
 - m) Color-coding for each interval indicating passing or failing, unless

otherwise directed by the Engineer. Passing and failing thresholds will be provided by the Engineer.

- n) Graphical representation of the MRDC y-axis showing retro-reflectivity and x-axis showing intervals corresponding with each data file
- o) Distance in miles driven while measuring the pavement markings
- p) Event codes pre-approved by the Engineer indicating problems with measurement
- q) Portable retro-reflectometer field check average reading and corresponding mobile average reading for that interval when applicable
- r) Upper validation threshold may be included separately with the raw data but is required to be clearly identified with the data collected using that threshold.

10.2.3 Map in Electronic Format. A map in an electronic format with each MRDC submission that includes the following information:

- a) Data
- b) District number
- c) Color-coded one mile intervals or interval length designated by the Engineer for passing or failing retro-reflectivity values or retro-reflectivity threshold values provided by the Engineer
- d) Percentage of passing and failing intervals

10.2.4 Video. A high-quality DVD with the following information:

- a) Labeled with date and corresponding data file name
- b) District number
- c) County
- d) Route number with reference markers or other designated reference information to indicate the location of beginning and end collection points on that roadway
- e) Retro-reflectivity values presented on the same screen with the following information
- f) Date
- g) Location
- h) Starting and ending mileage
- i) Total miles
- j) Retro-reflectivity readings; and Upper validation thresholds may be included separately with the raw data but must be clearly identified with the data collected using that threshold.

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