AHTD TRC TRANSPORTATION RESEARCH COMMITTEE

TRC0403

# Establishing a Statewide Pavement Markings Management System

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Final Report

2007

# Establishing a Statewide

# Pavement Markings Management System

**ARKANSAS STATE HIGHWAY AND TRANSPORTATION DEPARTMENT**

**Ron Strickland**

**PLANNING AND RESEARCH DIVISION**

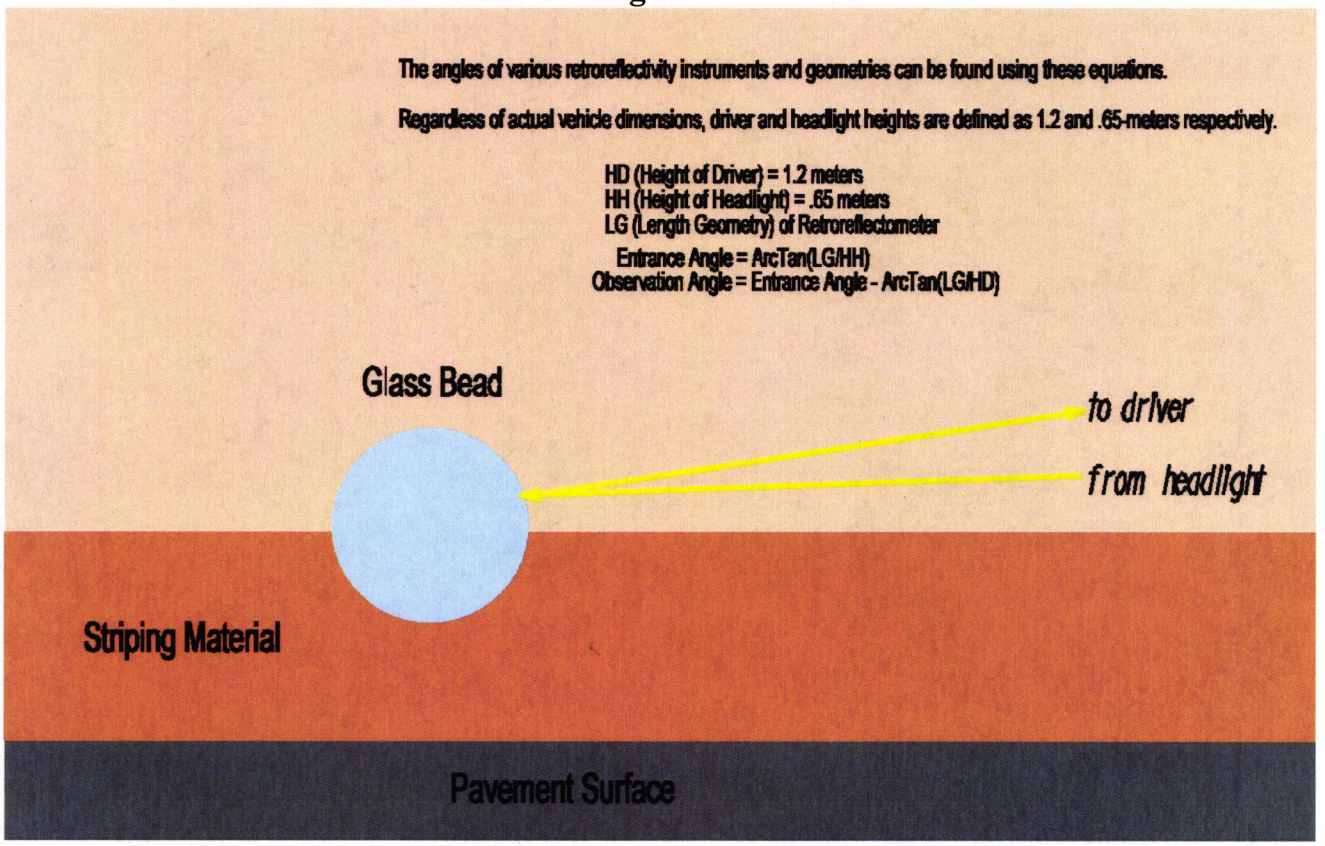
**March 2007**

# Introduction

By design, pavement markings are almost universally used as the primary method of providing motorists with all relevant information pertaining to appropriate lane usage and vehicle maneuvers. Consequently, in order to perform effectively, pavement markings must remain clearly visible to drivers regardless of conditions. Quick to realize the safety benefits achieved by enhancing the marking's visibility and thus its effectiveness, all dimly lighted and Interstate pavement markings are currently required by FHWA (Federal Highway Administration) to be capable of reflecting light back toward its origin (retroreflective luminescence or RL) by the use of tiny glass beads embedded in the marking surface. Most noticeable at night when illuminated by a vehicle's headlights, this feature can significantly aid driver's comprehension and reaction times when determining safe driving maneuvers in critical situations.

The national standard for measuring retroreflectivity by the American Society for Testing and Materials (ASTM) currently requires the use of a 30-meter geometry instrument. (Figure 1) It should be noted that RL measurements taken using one geometry cannot be readily converted to another geometry. As a result, the method of measurement must be stated with the reading.

**Figure 1**



Due to the thousands of miles of roadways within the state, a large portion of roadway maintenance funds must be reserved annually for pavement marking maintenance. Consequently, in an effort to attain the most benefit from these funds, highway agencies have come to use measurable characteristics such as durability, installation costs and, more recently, retroreflectivity levels as primary criteria when evaluating pavement markings.

Efforts by Congress are now underway for the FHWA to establish a minimum acceptable RL level (expressed in millicandelas (mcd/lux/$m^2$)) as a requisite for marking replacement. However, related research studies indicate any forthcoming specification(s) should also consider the roadway speed limit, road class, color of line, and presence or absence of roadway lighting all of which further diffuses the issue of determining an unqualified minimum acceptable RL value. Another related difficulty is that rainfall accumulations on roadway surfaces can severely reduce marking visibility and RL levels.

## Wet Weather RL Levels

ASTM describes two Standard Test Methods for the measurement of pavement markings under wet conditions based on the use of 30-meter geometry retroreflectometers. One method (Standard Condition of Wetness) describes flooding by a sprayer or bucket method and waiting 45 seconds before the RL measurement is taken. The other method (Condition of Continuous Wetness) describes continuously wetting the pavement marking with a sprayer while measuring with the retroreflectometer. In practice, these test methods are both labor and time intensive and the procedures must be adhered to closely to be able to achieve repetitive results. As with dry readings, a host of roadway surface variables can deny consistent testing results.

No clear test method is described for measuring or quantifying the benefits claimed by manufacturers for raised marking materials designed to project above accumulated surface water levels under wet or rainy road conditions. Past efforts to quantify the safety benefits of raised markings have been by the method of comparing vehicle crash rates. However, many factors can influence the marking's performance over its lifetime meaning the overall safety benefits of marking materials should also be considered when establishing FHWA mandatory replacement guidelines. See Durability factors.

## Specification Implementation Issues

In the course of enacting regulations for a minimum RL marking level, AASHTO (American Association of State Highway and Transportation Officials) recognizes that it is desirable to maintain an adequate level of retroreflectivity for both traffic signs and pavement markings. Further, AASHTO recommends that Congress reconsider the requirement of putting such information in the Manual of Uniform Traffic Control Devices (MUTCD) due to Tort Liability issues. Otherwise, responsible agencies may be burdened without a reasonable transitional period to take adequate compliance measures. To avoid this, AASHTO proposes the Congressional mandate should be changed to allow agencies to establish a marking management system for providing for reasonably maintained nighttime visibility of traffic control devices through one or more of the following methods:

- Nighttime inspections
- Sign and markings management system
- Sign Life Analysis
- Other methods as appropriate.

Nighttime inspections are routine in many existing sign and marking maintenance programs for visually and systematically insuring maximum reflectivity results chiefly by verifying both the pavement marking condition and the correct alignment of road signs to the roadway.

A sign and markings management system would track the service life of sign and pavement markings by storing information relating to installations, inventory, retroreflectivity, specific action steps, costs, and suppliers in a database.

Maximizing highway markings and sign usage through specific performance measurements.

Typically, all state highway organizations have the necessary trained crews and equipment for maintaining pavement markings and signs to an appropriate level adequate for public safety.

## Related Studies

In October 2003, a report titled *3M™ Stamark™ Liquid Pavement Marking* (LPM) *Series 1200* was prepared by the Department where 3M and Gulfline product evaluations were conducted at three test locations: I-40 (Interstate-rural) and US 70B (principle arterial-urban) with new asphalt pavement and new concrete bridge decks and approach slabs; and US 67 (principle arterial-rural) with new asphalt pavement. Two other locations were later added at Pratt Road just west of I-530 and Highway 167 south of Batesville. At that time, all RL test readings were collected from manufacturer's representatives on location while using a 30-meter geometry test instrument. For control purposes and in order to maintain the integrity of future anticipated comparisons, the Department purchased a 30-meter portable retroreflectometer (a second was purchased a year later). See Appendix A. All data collected at that time was intended to formulate a basis for evaluations. No conclusive results were obtained following the product evaluations however the Department determined many factors could have an impact on retroreflectivity values. See Durability factors.

## Current Performance

The FHWA currently has no minimum RL level specification for determining mandatory marking replacement. This anticipated requirement is largely due to section 406(a) of the 1993 Department of Transportation Appropriations Act, which requires the Manual on Uniform Traffic Control Devices (MUTCD) to specify minimum RL values for in-service pavement markings (FHWA 1998). Pending enactment, efforts are under way for the Department to develop an appropriate plan to measure RL values on the nearly 16,367 miles of state-maintained highways on a yearly cycle. With each additional pavement marking evaluation, information regarding replacement dates and the durability (lifetime) can be accumulated to form a database for a statewide pavement marking management system.

In order to evaluate the statewide performance of existing striping, a Precision Scan mobile test vehicle was contracted to collect RL data over a test route that went west from Little Rock to Fort Smith to Rogers to Harrison and back to Conway. See Figure 2. Due to test constraints, only one line of pavement striping could be scanned for each pass along a highway so either centerline (US Highways) or right edgeline (Interstates) measurements were collected.

## Durability Factors

The following four groupings* are factors that can have an influence on the RL readings taken from roadway surfaces. The first three groupings describe before, during and after installation, respectively, and the last group pertains to the actual measurement process. Note - The grouped items are not listed in order of importance or influence.

1) Factors that can influence the product lifetime (RL durability) before actual application.
- Quality of paint (chemical composition)
- Quality of binder (chemical composition)
- Quality of glass beads (roundness, hardness and refractive index)
- Roadway surface preparation
- Roadway surface type (asphalt, asphalt-cement, concrete)
- Marking location on roadway (outside or inside marking)
- Roadway alignment
- Lane widths

2) Factors that can influence the product lifetime (RL durability) at time of application.
- Adequate quantity or number of glass beads per linear foot (LF)
- Applied thickness adequate for type surface and traffic volume
- Temperatures of ambient air, roadway surface, and striping material
- Adequate time to dry before applying traffic

3) Factors that decrease product lifetime after application (RL durability).
(Barring installations outside manufacturers specifications or recommendations)
- Number of Vehicles per Day (VPDs)
- Volume of heavy trucks
- Exposure time (i.e. age)
- Sun and chemical bleaching
- Winter snow removal (all methods: plow, chemicals, etc.)

4) Factors that can influence RL measurement during testing.
- Instrument calibration
- Stripe centered in test window
- Wet or dry surface (Dew or moisture/No dew or no moisture)
- Washed or unwashed (No road grime/Road grime)
- Un-level pavement at test point

*Note-Applies to both White or Yellow marking types

Subsequently, a number of readings should be taken to form an adequate basis for determining the general condition of the retroreflectivity of a given section of highway.

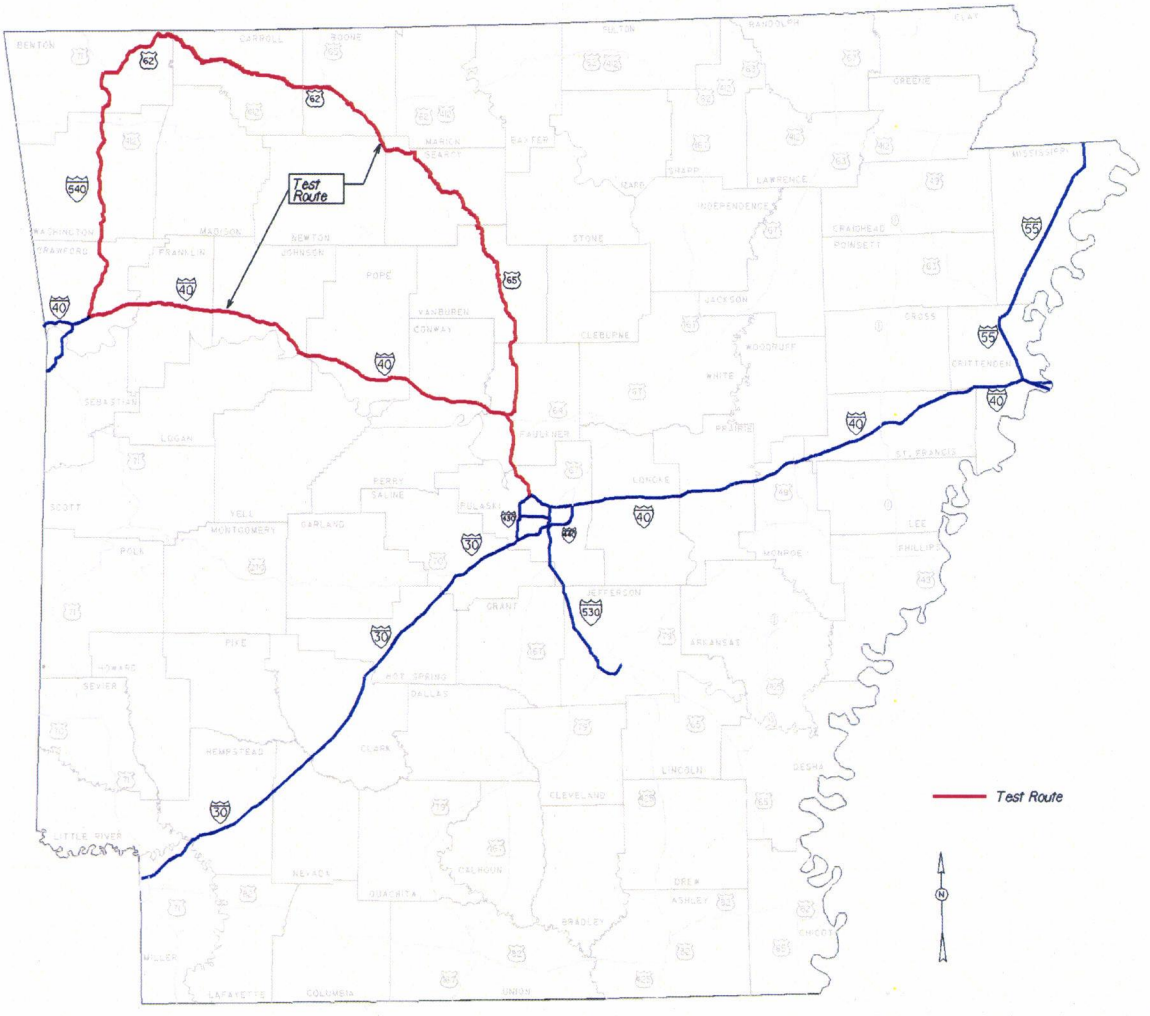
Notably of interest, a unique combination of factors can also contribute to increased RL readings after initial installations. 3M microcrystalline beads and other oversize beads are

bigger and heavier than the average glass beads and as the beads are dropped onto the wet marking material, it is believed to exhibit a tendency to roll slightly due to its roundness and forward velocity of the marking vehicle creating a thin covering of marking material over a portion of the beads as evidenced by abnormally low initial RL readings. Subsequent tire traffic eventually wears off this thin overcoat exposing more of the bead thus allowing for higher reflectivity measurements. This behavior has not been found with the much denser thermoplastic materials.

## Precision Scan Route and Equipment

Figure 2 below indicates the test route in red through northwest Arkansas that includes sections of Interstates 40 and 540 and Highways 62 and 65. Typically, mobile retroreflectometers are mounted inches off the road surface requiring daily cleaning and calibration checks performed against a handheld retroreflectometer and or a test strip having known RL characteristics.

**Figure 2**



Precision Scan collected readings during October/November 2004 and November 2005. The percent RL change over this one-year period for test loop sections through Northwest Arkansas are shown in Table 2.

**Table 2**

| County | Route | Dir | Line | From | To | 2005 ADT | RL Avg 2005 | RL Avg 2004 | % RL Change | Log miles |
|---|---|---|---|---|---|---|---|---|---|---|
| Benton | US 62 | East | Yellow Center 1 | Jct I-540 | Jct AR 94 | 29400 | 168 | 229 | -26.6% | 2.9 |
| Benton | US 62 | East | Yellow Center 2 | Jct AR 94 | End of Center Turn Lane | 17100 | 172 | 188 | -8.5% | 5.0 |
| Benton | US 62 | East | Yellow Center 3 | End of Center Turn Lane | Carroll County Line | 4800 | 176 | 152 | 15.8% | 15.7 |
| Boone | US 62 | East | Yellow Center | Carroll County Line | Jct US 65 | 7900 | 136 | 325 | -58.2% | 6.7 |
| Boone | US 65 | South | Yellow Center 4 | Jct US 62 | Mile Marker 20.5 | 18000 | 173 | 317 | -45.4% | 1.8 |
| Boone | US 65 | South | Yellow Center 5 | Mile Marker 20.5 | Mile Marker 22.2 | 19800 | 95 | 160 | -40.6% | 4.6 |
| Boone | US 65 | South | Yellow Center 1 | Mile Marker 0.00 (Harrison) | Jct US 65 Business | 18000 | 90 | 151 | -40.4% | 5.5 |
| Boone | US 65 | South | Yellow Center 2 | Jct US 65 Business | Mile Marker 6.2 | 15200 | 160 | 265 | -39.6% | 4.8 |
| Boone | US 65 | South | Yellow Center 3 | Mile Marker 6.2 | Newton County Line | 7900 | 127 | 146 | -13.0% | 1.7 |
| Carroll | US 62 | East | Yellow Center 3 | Mile Marker 0.00 | Mile Marker 7.5 | 7700 | 138 | 245 | -43.7% | 4.2 |
| Carroll | US 62 | East | Yellow Center 1 | Benton County Line | Mile Marker 4.3 | 2100 | 199 | 112 | 77.7% | 7.9 |
| Carroll | US 62 | East | Yellow Center 2 | Mile Marker 4.3 | Mile Marker 12.3 | 3100 | 206 | 299 | -31.1% | 7.5 |
| Carroll | US 62 | East | Yellow Center 4 | Mile Marker 7.5 | Mile Marker 9.5 | 8000 | 91 | 118 | -22.9% | 2.0 |
| Carroll | US 62 | East | Yellow Center 5 | Mile Marker 9.7 | Mile Marker 12.0 | 12400 | 216 | 250 | -13.6% | 2.3 |
| Carroll | US 62 | East | Yellow Center 6 | Mile Marker 0.00 (Berryville) | Boone County Line | 6700 | 175 | 260 | -32.7% | 17.3 |
| Conway, Pope | I-40 | West | White Edge 3 | Mile Marker 113 | Mile Marker 83.5 (Hwy 331) | 27500 | 203 | 184 | 10.3% | 29.5 |
| Crawford, Washington | I-540 | North | White Edge 1 | Jct I-40 | Mile Marker 50.6 | 18500 | 174 | 177 | -1.7% | 30.6 |
| Faulkner | US 65 | South | Yellow Center 1 | Van Buren County Line | Mile Marker 3.5 | 8400 | 150 | 147 | 2.0% | 3.6 |
| Faulkner | US 65 | South | Yellow Center 2 | Mile Marker 3.5 | Mile Marker 7.2 | 8700 | 150 | 154 | -2.6% | 3.7 |
| Faulkner | US 65 | South | Yellow Center 3 | Mile Marker 7.2 | Mile Marker 10.2 | 16300 | 85 | 151 | -43.7% | 3.0 |
| lkner | US 65 | South | Yellow Center 4 | Mile Marker 10.2 | Mile Marker 13.1 | 23000 | 116 | 132 | -12.1% | 2.9 |
| lkner | US 65 | South | Yellow Center 5 | Mile Marker 13.1 | Jct I-40 | 23900 | 240 | 133 | 80.5% | 6.3 |
| Faulkner, Conway | I-40 | West | White Edge 2 | Mile Marker 135.7 (AR 89) | Mile Marker 113 | 39800 | 229 | 237 | -3.4% | 22.7 |
| Faulkner, Pulaski | I-40 | East | White Edge | Mile Marker 135.8 | Mile Marker 141.7 | 61600 | 149 | 119 | 25.2% | 5.9 |
| Franklin, Crawford | I-40 | West | White Edge 9 | Mile Marker 37 | Jct I-540 (Exit 12) | 22500 | 179 | 186 | -3.8% | 24.9 |
| Johnson | I-40 | West | White Edge 6 | Mile Marker 71.4 (John. Co. Line) | Mile Marker 59.7 | 23600 | 186 | 251 | -25.9% | 11.7 |
| Johnson | I-40 | West | White Edge 7 | Mile Marker 59.7 | Mile Marker 47.5 | 21900 | 167 | 161 | 3.7% | 12.3 |
| Johnson, Franklin | I-40 | West | White Edge 8 | Mile Marker 47.5 | Mile Marker 37 | 22000 | 217 | 332 | -34.6% | 10.3 |
| Newton | US 65 | South | Yellow Center | Boone County Line | Searcy County Line | 7100 | 131 | 184 | -28.8% | 3.0 |
| Pope | I-40 | West | White Edge 4 | Mile Marker 83.5 | Mile Marker 76.8 | 26400 | 56 | 64 | -12.5% | 6.7 |
| Pope | I-40 | West | White Edge 5 | Mile Marker 76.8 | Mile Marker 71.4 | 23500 | 183 | 175 | 4.6% | 5.4 |
| Pulaski, Faulkner | I-40 | West | White Edge 1 | Mile Marker 146.7 (West of I-430) | Mile Marker 135.7 (AR 89) | 62200 | 155 | 101 | 53.5% | 11.2 |
| Searcy | US 65 | South | Yellow Center 1 | Newton County Line (0.00) | Buffalo River (15.4) | 5300 | 104 | 162 | -35.8% | 15.4 |
| Searcy | US 65 | South | Yellow Center 2 | Buffalo River (0.00) | Mile Marker 3.1 | 4400 | 102 | 147 | -30.6% | 3.1 |
| Searcy | US 65 | South | Yellow Center 3 | Mile Marker 3.1 | Mile Marker 3.6 | 4400 | 81 | 106 | -23.6% | 0.5 |
| Searcy | US 65 | South | Yellow Center 4 | Mile Marker 3.6 | Mile Marker 4.1 | 4400 | 88 | 115 | -23.5% | 0.5 |
| Searcy | US 65 | South | Yellow Center 5 | Mile Marker 4.1 | Mile Marker 4.7 | 4400 | 117 | 141 | -17.0% | 0.6 |
| Searcy | US 65 | South | Yellow Center 6 | Mile Marker 4.7 | Mile Marker 9.0 | 5500 | 99 | 226 | -56.2% | 4.3 |
| Searcy | US 65 | South | Yellow Center 7 | Mile Marker 9.0 | Mile Marker 10.6 | 6500 | 57 | 40 | 42.5% | 1.6 |
| Searcy | US 65 | South | Yellow Center 8 | Marshall (0.00) | Mile Marker 0.5 | 9600 | 47 | 44 | 6.8% | 0.5 |
| Searcy | US 65 | South | Yellow Center 9 | Mile Marker 0.5 | Mile Marker 1.6 | 6600 | 76 | 118 | -35.6% | 1.1 |
| Searcy | US 65 | South | Yellow Center 10 | Mile Marker 1.6 | Van Buren Co. Line (10.6) | 5700 | 149 | 163 | -8.6% | 9.0 |
| Van Buren | US 65 | South | Yellow Center 1 | Searcy County Line (0.00) | Mile Marker 6.5 | 5600 | 181 | 142 | 27.5% | 6.5 |
| Van Buren | US 65 | South | Yellow Center 2 | Mile Marker 6.5 | Mile Marker 7.8 | 6000 | 95 | 99 | -4.0% | 1.3 |
| Van Buren | US 65 | South | Yellow Center 3 | Mile Marker 7.9 | Mile Marker 15.9 | 6400 | 156 | 131 | 19.1% | 7.9 |
| Van Buren | US 65 | South | Yellow Center 4 | Clinton (0.00) | Mile Marker 4.1 | 14600 | 159 | 94 | 69.1% | 4.1 |
| Buren | US 65 | South | Yellow Center 5 | Mile Marker 4.1 | Mile Marker 14.9 | 8800 | 163 | 141 | 15.6% | 10.8 |
| Buren | US 65 | South | Yellow Center 6 | Mile Marker 14.9 | Mile Marker 16.0 | 7900 | 156 | 227 | -31.3% | 1.2 |
| van Buren | US 65 | South | Yellow Center 7 | Mile Marker 16.0 | Faulkner Co. Line (18.2) | 8600 | 154 | 130 | 18.5% | 2.2 |
| Washington | I-540 | North | White Edge 2 | Mile Marker 50.6 | Mile Marker 61.1 | 21200 | 167 | 224 | -25.4% | 10.5 |
| Washington, Benton | I-540 | North | White Edge 3 | Mile Marker 61.1 | US 62 | 56800 | 158 | 255 | -38.0% | 24.8 |

In an effort to determine the durability of the current paint markings installed on the test route, existing Department maintenance records were neither sufficient nor complete from date of original installation. Visual inspections of supposedly unimproved sections along the test route failed to provide any additional information. As a result, a durability analysis of the original markings proved inconclusive. Recent installations included with the 2005 but not the 2004 test data may be included in an RL database but fall outside the reach of this project. In general, the Precision Scan test route consisted of Gulfline raised pavement markings (edgelines) on Interstates and flat thermoplastic or water-based (centerlines) on US Highways.

Table 3 shows the 12-month change in number and percentage of test route section miles showing RL levels below 100. Within this period, an additional 17.4-miles (4.5%) of striping tested have had RL levels drop below 100. Bearing in mind only one marking (either centerline or edgeline) was tested along the test route, it is conceivable the tested line performed well and the untested ones were in need of replacement or vice versa. Only one westbound Interstate section pending reconstruction west of Russellville fell below an RL level of 100.

It should be noted that rainfall was recorded within 2-weeks prior to both the 2005 and 2004 Precision Scan tests. It was not possible to determine the amount of rainfall at each location or to what extent the presence or absence of surface residues may have affected test route results.

**Table 3**

| Year | Miles (RL < 100) | Percentage of Miles (RL < 100) |
|---|---|---|
| 2005 | 31.6 | 8.1 |
| 2004 | 14.2 | 3.6 |
| **Annual Increase** | **17.4** | **4.5** |

ASTM is currently specifying minimum acceptable RL values for new installations at 250 (White) and 175 (Yellow). Most manufacturers' specifications if properly applied should readily meet these minimum RL specifications. See Appendix B for new installations and warranties.

## Conclusion

The Department currently relies on visual inspection for managing pavement marking condition and replacement. The Department currently has no database for the systematic monitoring or scheduling of maintenance or replacement of pavement marking RL levels on a statewide basis. Depending on the measures necessary to meet pending FHWA compliance regarding RL levels:

1. The Department should consider including specifications regarding minimum RL levels for new installations and warranty periods (as measured by 30-meter geometry),
2. The Department should hold manufacturers and contractors to task to meet contract specifications for both temporary and permanent pavement markings,
3. The Department should have available the means and equipment required to perform the work necessary for determining new installation and warranty compliance.

The Department should formulate a systematic statewide method for collecting and evaluating data on both new and existing pavement striping, such that the Department can adequately provide for continued public safety by:

4. Determining statewide needs to effectively plan for meeting anticipated compliance levels by means of a database system containing all relevant data for evaluating highway RL levels,
5. Managing a scheduled monitoring and maintenance program within a statewide budget,
6. Effectively evaluating pavement marking products that exhibit superior performance with regards to a range of durability factors,
7. Matching pavement striping to road surface characteristics and conditions to achieve the greatest costs benefits.

A database containing simply RL information is not adequate for developing an effective pavement marking management system. All relevant factors impacting the serviceability and durability of pavement markings must be included in order to make comprehensive decisions regarding the management and placement of pavement markings.

## Recommendations

There are several recommendations that should be included on related issues that fell outside the scope of this study.

1. Several 30-meter retroreflectometer manufacturers use different type light sources and receivers producing dissimilar test results. To avoid contention, the Department must specify that all RL warrantees be capable of meeting minimum levels "as measured by Department equipment"-currently a Delta model LTL-X.
2. Standardized guidelines describing the Department's methods and procedures for all newly installed pavement marking RL testing must be established (i.e. number of tests, minimum number of failing measurements or averaged level) per linear line length.
3. All manufacturers' installation specifications for new marking installations must be checked and recorded by Department personnel regarding marking thicknesses, ambient temperatures and moisture, etc. for future referencing.

An ongoing effort is needed to continue the progress made to date by the Department. Thus far, approximately 97.5% of the state's highways have no collected RL data available and recommendations for continuing the task include:

1. An additional year of test route testing collected to further efforts for evaluating long term data on known markings over these highway sections.
2. The Department has no mobile RL collection equipment for accomplishing the task of collecting statewide RL data. Until this changes, it is recommended the Department initiate plans for collecting data from all new pavement marking installations using Department Construction and Striping Crews respectively.
3. Individual RL retroreflectometers must be made available for each District's use.
4. Periodic statewide inspections of old markings may not be possible using handheld equipment alone without enlisting assistance from Area Maintenance personnel.
5. Data collection will remain manpower intensive and it is recommended that additional funding be sought through the Highway Safety Improvement Program (HSIP).

# *Appendix A*

*Pavement Marking Test Sites*

Precision Scan also contracted to collect RL data from selected highways and test locations involving 3M and Gulfline pavement marking products. See Related Studies. Precision Scan's method of acquiring RL data consisted of taking approximately 52 reading for every tenth of a mile measured and averaging these results over each 0.1-mi distance traveled. These data logs were segmented by roadway features such as mileposts or intersections rather than highway logmile. Included were Pratt Road, University Avenue, Interstate 40 and Highway 167 south of Batesville. Averaged pavement markings readings from the Pratt Road, University Avenue, and Interstate 40 test locations are shown below. Note-An inspection station and exit ramps on this segment of I-40 were repainted in 2005.

**Table 1A**

| County | Route | Product | Line | From | To | Mileage | 2005 Avg. RL | 2004 Avg. RL |
|---|---|---|---|---|---|---|---|---|
| Pulaski | Pratt Road | 3M | Yellow Center | Jct I-530 | Arch Street | 2.4 | 495 | 532 |
| Pulaski | US 70 Business | 3M | Yellow Center | On Fourche Creek Bridge | After Fourche Creek Bridge | 0.1 | 328 | 348 |
| Pulaski, Faulkner | I-40 | Gulfline | White Edge 1 | Mile Marker 146.7 (West of I-430) | Mile Marker 135.7 (AR 89) | 11.2 | 155 | 101 |

Precision Scan also collected test readings from the Highway 167 Batesville location. The averaged readings for 2.6-miles south and 2.3-miles north of the Salado Bridge on Highway 167 south of Batesville are also furnished for comparison.

**Table 2A**

| Direction | Line | From | To | Avg. RL (2005) | Avg. RL (2004) |
|---|---|---|---|---|---|
| South | White Skip 1 | Mile Marker 6.02 | Mile Marker 3.36 | 239 | 468 |
| South | White Edge 1 | Mile Marker 6.02 | Mile Marker 3.36 | 160 | 294 |
| North | White Edge 1 | Mile Marker 3.36 | Mile Marker 6.02 | 103 | 210 |
| North | White Skip 1 | Mile Marker 3.36 | Mile Marker 6.02 | 269 | 530 |
| **3M Averages White** | | | | **192.75** | **375.5** |
| South | Yellow Center 1 | Mile Marker 6.02 | Mile Marker 3.36 | 441 | 571 |
| North | Yellow Center 1 | Mile Marker 3.36 | Mile Marker 6.02 | 433 | 610 |
| **3M Averages Yellow** | | | | **437** | **590.5** |
| North | White Edge 2 | Mile Marker 6.07 | Mile Marker 8.40 | 270 | 268 |
| North | White Skip 2 | Mile Marker 6.07 | Mile Marker 8.40 | 274 | 326 |
| South | White Edge 2 | Mile Marker 8.40 | Mile Marker 6.07 | 245 | 234 |
| South | White Skip 2 | Mile Marker 8.40 | Mile Marker 6.07 | 228 | 287 |
| **Gulfline Averages White** | | | | **254.25** | **278.75** |
| North | Yellow Center 2 | Mile Marker 6.07 | Mile Marker 8.40 | 165 | 193 |
| South | Yellow Center 2 | Mile Marker 8.40 | Mile Marker 6.07 | 144 | 134 |
| **Gulfline Averages Yellow** | | | | **154.5** | **163.5** |

The averaged line readings shown below were taken at the bridge ends by Precision Scan to compare to the recordings taken from the Department's 30-meter retroreflectometer. The percentage of error was also calculated to shown the disparity between the Department and Precision Scan's collected 5 months later. The results indicated very little difference between contracted data and the Department data. Note that if an additional 5-months wear was deducted from the 2004 Department data shown in Table 3-A, the percentages of error should have decreased for three of the four results.

**Table 3-A**

**Precision Scan Data and Comparisons**

| 3M @ Salado Bridge (Mile Marker 6.02) | White (2005) | Yellow (2005) | White (2004) | Yellow (2004) |
|---|---|---|---|---|
| 5 IND 167 SOUTH WE 1 | 258 | | 344 | |
| 5 IND 167 NORTH WE 1 | 134 | | 369 | |
| 5 IND 167 SOUTH WS 1 | 231 | | 667 | |
| 5 IND 167 NORTH WS 1 | 272 | | 666 | |
| 5 IND 167 SOUTH YC 1 | | 637 | | 738 |
| 5 IND 167 NORTH YC 1 | | 395 | | 634 |
| Precision Scan Averaged Data | 224 | 516 | 512 | 686 |
| Department Averaged Data | | | 523 | 711 |
| Percentage of Error | | | -2.2% | -3.6% |
| | | | | |
| Gulfline @ Salado Bridge (Mile Marker 6.07) | | | | |
| 5 IND 167 SOUTH WE 2 | 280 | | 187 | |
| 5 IND 167 NORTH WE 2 | 288 | | 294 | |
| 5 IND 167 SOUTH WS 2 | 240 | | 255 | |
| 5 IND 167 NORTH WS 2 | 219 | | 360 | |
| 5 IND 167 SOUTH YC 2 | | 137 | | 135 |
| 5 IND 167 NORTH YC 2 | | 163 | | 198 |
| Precision Scan Averaged Data | 257 | 150 | 274 | 167 |
| Department Averaged Data | | | 294 | 162 |
| Percentage of Error | | | -6.7% | 2.8% |

WE-White Edgeline, WS-White Skipline, YC-Yellow Centerline

Further test site monitoring could provide additional insight when specifying 3M or Gulfline pavement marking products for a specific roadway surface or condition.

# *Appendix B*

*LPM and Gulfline Specifications*

# ARKANSAS STATE HIGHWAY COMMISSION
## CHANGE ORDER

Job Name Pleasant Plains-Co. Rd. 6(S) Route & Section Rt.167, Sec. 17
Job No. 005963 FAP No. NH-0032(14) County Independence Change Order No. 14
Changes between Station Entire Project and Station

APPROVED COPIES MAILED 10-16-03

TO: Contr. Surety R.E. D.E.

**Description of Change:**
(1) Add the items "Profiled Thermoplastic Pavement Marking White (4")", "Profiled Thermoplastic Pavement Marking Yellow (4")", "Retroreflective Liquid Pavement Marking White (4")", and "Retroreflective Liquid Pavement Marking Yellow (4")" and install same in lieu of planned "Thermoplastic Pavement Marking White (4")" and "Thermoplastic Pavement Marking Yellow (4")" in accordance with attached Special Provisions.
(2) Install and pay for Construction Pavement Markings on Final Surface.
(3) Add fourteen (14) Working Days to Contract.
Cumulative Time: 275+30 (C.O. #3 )+14 (C.O. # 14) = 319 Working Days.

**Reason for Change:** To evaluate and compare the effectiveness of "Profiled Thermoplastic Pavement Marking" and "Retroreflective Liquid Pavement Marking".
**NOTE: THE UNIT PRICE FOR "PROFILED THERMOPLASTIC PAVEMENT MRKS. WHITE (4")" , "PROFILED THERMOPLASTIC PAVEMENT MRKS. YELLOW (4")", "RETROREFLECTIVE LIQUID PAVEMENT MRKS. WHITE (4")", AND RETROREFLECTIVE PAVEMENT MRKS. YELLOW (4") HAS BEEN AGREED TO AND WILL BE ESTABLISHED BY SUPPLEMENTAL AGREEMENT.**
Attachment: Contractor's Correspondence; SP "Profiled Thermoplastic Pavement Marking"; SP "Retroreflective Liquid Pavement Marking"; SP "Coordination of Durable Pavement Markings".

**SUMMARY**

| Item No. | Item | Unit | Unit Price | PRESENT Quantity | PRESENT Amount | REVISED Quantity | REVISED Amount |
|---|---|---|---|---|---|---|---|
| SS & 719 | Profiled Thermoplastic Pavement | L.F. | 1.14 | 0.00 | 0.00 | 35830.00 | 40846.20 |
| | Marking White (4") | | | | | | |
| SS & 719 | Profiled Thermoplastic Pavement | L.F. | 1.14 | 0.00 | 0.00 | 35830.00 | 40846.20 |
| | Marking Yellow (4") | | | | | | |
| SS & 719 | Thermoplastic Pavement Marking White (4") | L.F. | 0.27 | 71660.00 | 19348.20 | 0.00 | 0.00 |
| SS & 719 | Thermoplastic Pavement Marking Yellow (4") | L.F. | 0.27 | 71660.00 | 19348.20 | 0.00 | 0.00 |
| SP | Retroreflective Liquid Pvmt. Mrks. White (4") | L.F. | 1.26 | 0.00 | 0.00 | 35830.00 | 45145.80 |
| SP | Retroreflective Liquid Pvmt. Mrks. Yellow (4") | L.F. | 1.26 | 0.00 | 0.00 | 35830.00 | 45145.80 |
| 604 | Construction Pavement Markings | L.F. | 0.07 | 0.00 | 0.00 | 71660.00 | 5016.20 |
| | | | | Totals: $ | 38696.40 | $ | 177000.20 |

**Overrun** $ 138303.80

**Recommended** 10-9-03
for District Engineer

**APPROVED** 10-15-03
Construction Engineer

**Authorized** 10-15-03
Assistant Chief Engineer

**Requested** 10-09-03
Resident Engineer

**Atlas Asphalt, Inc.**

*Batesville Division*
P.O. Drawer 2236
Batesville, AR 72503

870-251-2371
Fax 870-251-1241



October 7, 2003

Mr. Tim Dunlap
Resident Engineer
P. O. Box 2073
Batesville, AR 72503

Re: AHTD Job No. 005963
FAP No. NH-0032(14)
Independence County

Dear Mr. Dunlap:

Atlas Asphalt request a change order for the following:

| | | | | | |
|---|---|---|---|---|---|
| SS&719 | Profiled Thermoplastic Pavement Marking White (4") | L.F. | $1.14 | 35,830.00 | $40,846.20 |
| SS&719 | Profiled Thermoplastic Pavement Marking Yellow (4") | L.F. | $1.14 | 35,830.00 | $40,846.20 |
| SP | Retroreflective Liquid Pvmt. Mrks. White (4") | L.F. | $1.26 | 35,833.00 | $45.149.58 |
| SP | Retroreflective Liquid Pvmt. Mrks. | L.F. | $1.26 | 35,833.00 | $45,149.58 |

Atlas Asphalt, Inc. is also requesting fourteen (14) working days over and above that allowed by the specifications due to overrun.
Atlas Asphalt, Inc. certifies the unit prices indicated are in compliance with Section 109.04 of the 1996 Standard Specifications.

Respectfully,

David Shetron
Assistant for Operations

DS/ch

**ARKANSAS STATE HIGHWAY AND TRANSPORTATION DEPARTMENT**
**SPECIAL PROVISION**
**JOB NO. 005963**
**LIQUID PAVEMENT MARKING**

1. **Description.** This item shall consist of furnishing and installing at locations shown on the plans or as directed, retroreflective liquid pavement markings as specified in accordance with these special provisions. The liquid marking material shall be applied by spray method onto asphaltic cement concrete and Portland cement concrete surfaces. Following an application of composite reflective elements and glass beads, and upon curing, the resulting marking shall be an adherent reflectorized stripe of the specified thickness and width that is capable of resisting deformation by traffic.

   The markings are to be placed under existing traffic conditions. The work shall comply with the MUTCD except as modified by these specifications.

2. **Materials.** The Material Supplier shall furnish materials that meet the following specifications.

   The markings shall be comprised of a polyurea coating adhered to the pavement surface, and reflective media adhered to the polyurea coating. The polyurea coating shall consist of a mixture of high-quality resins, curing agent, and pigments. The reflective media shall consist of glass beads and composite reflective elements. The composite reflective elements shall contain microcrystalline ceramic beads bonded to an opacified ceramic core.

   **A. Polyurea**

   **1. Composition Requirements:**

   1.1 The polyurea coating shall be formed by the reaction of two components (Part A and Part B).

   1.2 The Part A component shall be composed of secondary amines, pigments and fillers as needed to meet performance requirements of this specification. The Part B component shall be a polyisocyanate polymer capable of reacting with Part A to form a polyurea coating. The Part B composition shall be > 95% resin. Part A composition shall conform to Table 1.

Table 1
Part A Composition

| Component | Composition by weight | |
|---|---|---|
| | White | Yellow |
| Resin | 50% min | 50% min |
| Titanium Dioxide* | 18.5% min | 5% min |
| Organic Yellow Pigment | N/A | 4% min |
| Reinforcing Filler | 35% max | 35% max |

* Titanium dioxide shall meet ASTM D467-Type IV (Rutile grade – 80% min $TiO_2$)

**ARKANSAS STATE HIGHWAY AND TRANSPORTATION DEPARTMENT**
**SPECIAL PROVISION**
**JOB NO. 005963**
**LIQUID PAVEMENT MARKING**

1.3 The two components shall be formulated such that proper cure occurs when they are mixed at a volumetric ratio of 3:1 (3 volumes of Part A and 1 volume of Part B).

1.4 The Part A and Part B components shall not contain appreciable amounts of volatile diluents. The polyurea coating shall be essentially a 100% solids product.

1.5 The polyurea coating materials shall be manufactured without the use of lead chromate pigments or other similar, lead-containing chemicals.

## 2. Properties

2.1 **Color:** The preformed markings shall consist of white and yellow films with pigments selected and blended to conform to standard highway colors. When tested according to ASTM E1347 a test specimen without beads or reflective elements created by combining 3 volumes of Part A with 1 volume of Part B and having a thickness of 15 ± 1 mils shall meet the following color requirements:

White – cap Y of 75% minimum and a reasonable match to Federal Test Standard 595A-17778

Yellow – cap Y of 45% minimum and shall fall within the limits of FHWA Yellow Color Tolerance Chart, PR color #1 and shall be a reasonable match to Federal Standard No. 595A-13538.

2.2 **Color and Weathering Resistance:** The mixed polyurea compound, both white and yellow, when applied to a 3" x 6" aluminum panels s at 15±1 mil in thickness with no glass beads or elements and exposed for 500 hours in a Q.U.V. Environmental Testing Chamber, as described in ASTM-G154, Cycle #1, shall conform to the following minimum requirements. The color of the white polyurea system shall not be darker than Federal Standard No. 595A-17778. The color of the yellow polyurea system shall be reasonably close to Federal Standard No. 595A-13538.

2.3 **Track-Free Time (Laboratory):** When tested in accordance with ASTM D 711, the polyurea marking material shall reach a track-free condition in 5 minutes or less for a 15 mil thickness. This test shall be performed with AASHTO Type 1 beads coated at a rate of 0.099 pounds per square foot. The track-free time shall not increase substantially with decreasing temperature.

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LIQUID PAVEMENT MARKING

2.4 **Adhesion to Concrete:** The polyurea coating, when tested according to ACI Method 503, shall have such a high degree of adhesion to the specified concrete surface that there shall be a 100% concrete failure in the performance of this test. The prepared specimens shall be conditioned at room temperature (75° ± 2° F) for a minimum of 24 hours and maximum of 72 hours prior to the performance of the tests indicated.

2.5 **Adhesion to Asphalt:** The polyurea coating, when tested according to ACI Method 503, shall have such a high degree of adhesion to the specified asphalt surface that there shall be a 100% asphalt failure in the performance of this test. The prepared specimens shall be conditioned at room temperature (75° ± 2° F) for a minimum of 24 hours and maximum of 72 hours prior to the performance of the tests indicated.

**B. Reflective Media:**

The reflective media shall be made up of reflective elements and glass beads for drop-on application and shall conform to the following requirements:

**1. Glass Beads:**

The required glass beads shall be a 60/40 blend (60% sinkers and 40% floaters) of AASHTO M 247 Type I gradation 1.5 index glass beads. The glass beads shall have a minimum of 70% Rounds as measured according to ASTM D1155. Crush Resistance shall be measured according to the procedures of ASTM D1213 and shall have a minimum crush resistance of 30 pounds for beads retained on a US #40 Mesh sieve. The beads shall be treated for adhesion and moisture resistance.

Acid Resistance: A sample of glass beads supplied by the manufacturer shall show resistance to corrosion of their surface after exposure to a 1% solution (by weight) of sulfuric acid. The 1% acid solution shall be made by adding 5.7cc of concentrated acid into 1000cc of distilled water. CAUTION: Always add the concentrated acid into the water, not the reverse. The test shall be performed as follows:

Take a 1" x 2" sample, adhere it to the bottom of a glass tray and place just enough acid solution to completely immerse the sample. Cover the tray with a piece of glass to prevent evaporation and allow the sample to be exposed for 24 hours under these conditions. Then decant the acid solution (do not rinse, touch, or otherwise disturb the bead surfaces) and dry the sample while adhered to the glass tray in a 150°F (66° C) oven for

approximately 15 minutes. Microscopic examination (20X) shall show not more than 15% of the beads having a formation of very distinct opaque white (corroded) layer on their entire surface.

**2. Composite Reflective Elements:**

The composite reflective elements shall be composed of a titania opacified ceramic core having clear and/or yellow tinted microcrystalline ceramic beads embedded to the outer surface.

Index of Refraction - All microcrystalline ceramic beads bonded to reflective elements shall have a minimum index of refraction of 1.8 when tested using the liquid oil immersion method.

2.1 Testing Procedure For Refractive Index of Beads by Liquid Immersion

2.1.1 Equipment Required:
2.1.1.1 Microscope (minimum 100X magnification).
2.1.1.2 Light Source - preferably sodium light or other monochromatic source, but not absolutely essential.
2.1.1.3 Refractive Index Liquids. (Available from R.P. Cargille Laboratories, Inc., Cedar Grove, NJ.)
2.1.1.4 Microscope Slide and Slide Cover.
2.1.1.5 Mortar and Pestle.

2.1.2 Procedure:

2.1.2.1 Using the mortar and pestle, crush a few representative beads and place a few of these crushed particles on a microscope slide.

2.1.2.2 Place a drop of a refractive index liquid, with an index as close to that of the crushed particles as can be estimated, on the particles.

2.1.2.3 Cover the slide with a microscope slide cover and view the crushed particles by transmitted light normal to the slide surface (illuminated from the bottom).

2.1.2.4 Adjust the microscope mirror to allow a minimum light intensity for viewing. This is particularly important if sodium light is not used.

2.1.2.5 Bring a relatively flat and transparent particle into focus.

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**JOB NO. 005963**
**LIQUID PAVEMENT MARKING**

2.1.2.6 By slightly raising and lowering the objective (microscope tube), look for one or both of the following:

Becke Line - This light line will appear to move either into the particle or away from it. In general, if the objective is raised, the line will move toward the material of higher refractive index; if the objective is lowered, the line will move toward the material of lower index.

2.1.2.7 Variation in Particle Brightness - When raising the objective from a sharp focus, the particle will appear to get brighter or darker than the surrounding field. If it becomes brighter, the particles have a higher refractive index than the liquid. If it becomes darker, the glass has a lower refractive index than the liquid. In both cases, the opposite will be true if the objective is lowered.

2.1.2.8 This test can be used to confirm that the beads are above or below a specified index. It can also be used to give an accurate determination of the index (+ or - 0.001). This is done by using several refractive index liquids until a match or near match of indices occurs. The index of the glass will equal that of the liquid when no Becke line and no variation in bead brightness observed.

The size and quality of the beads shall be such that the performance requirements for the retroreflective material shall be met.

Gradation of the reflective elements shall be less than 5% retained on a #8 US Standard sieve and more than 90% retained on a #35 US Standard sieve.

Acid Resistance: A sample of microcrystalline ceramic reflective elements supplied by the manufacturer, shall show resistance to corrosion of their surface after exposure to a 1% solution (by weight) of sulfuric acid. The 1% acid solution shall be made by adding 5.7cc of concentrated acid into 1000cc of distilled water. CAUTION: Always add the concentrated acid into the water, not the reverse.

Place 10g of the beads in a 100ml beaker and cover with 30 to 40ml of the 1 weight percent sulfuric acid solution. Cover the beaker to prevent evaporation and allow the sample to be exposed for 24 hours under these conditions. Then decant the acid solution, rinse the beads with fresh DI water and dry the sample in a 150° F (66° C) oven for approximately 15

minutes or until the sample is dry. Microscopic examination (20X) shall show no more than 15% of the beads having a formation of a very distinct opaque white (corroded) layer on their entire surface.

**C. Finished Markings**

Because of normal variances in road surfaces, application processes, and measurement, the properties of markings made from the materials specified herein will vary from one installation to the next. When the materials are applied according to the specifications in Section III, they shall be capable of forming markings with the following reproducibility of properties:

1. **On-the-Road Track-Free Time:** When installed at 77° F and at a wet film thickness of 15±1 mils, the markings shall reach a no-track condition in less than 3 minutes. Track-free shall be considered as the condition where no visual deposition of the polyurea marking to the pavement surface is observed when viewed from a distance of 50 feet, after a free-rolling traveling vehicle's tires have passed over the line. The track-free time shall not increase substantially with decreasing temperature.

2. **Skid Resistance:** The average initial skid resistance shall be 45 BPN or greater when tested according to ASTM E303.

3. **Reflectance:** The initial retroreflectance averaged over many installations shall be at least 700 [(mcd(ft-2)(fc-1] for white and 500 [(mcd(ft-2)(fc-1] for yellow. The standard deviation of initial retroreflectance for many installations shall be no more than 130 [(mcd(ft-2)(fc-1] for both white and yellow. Measurements shall be made according to ASTM E1710 using a portable pavement marking reflectometer with 30 meter measurement geometry.

   The initial retroreflectance of a single installation shall be the average value determined according to the measurement and sampling procedures outlined in ASTM D 6359, using a 30-meter retroreflectometer. The 30-meter retroreflectometer shall measure the coefficient of retroreflected luminance, RL, at an observation angle of 1.05 degrees and an entrance angle of 88.76 degrees. RL shall be expressed in units of millicandelas per square foot per foot-candle [(mcd(ft-2)(fc-1]. The metric equivalent shall be expressed in units of millicandelas per square meter per lux [mcd(m-2)(lux-1].

   Initial performance of pavement markings shall be measured within 7 days after application.

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**LIQUID PAVEMENT MARKING**

3. **Construction Requirements:** The markings shall be applied in accordance with the manufacturer's installation instructions. Marking configurations shall be in accordance with the "Manual on Uniform Traffic Control Devices".

The reflectorized pavement markings shall be placed only on properly prepared surfaces and at the widths and patterns designed on the contract plans. Marking operations shall not begin until applicable surface preparation work is completed and approved by the Engineer.

The pavement markings shall be applied at a minimum uniform wet thickness of 20 mils. Reflective elements and glass beads shall be applied at a rate specified by the manufacturer.

**A supplier's representative must be present at the time the markings are applied to ensure that the markings are placed in accordance with this specification and the manufacturer's recommended procedures.**

A. **Appplication Equipment:** The equipment shall be capable of producing markings that meet the specifications contained herein using the materials specified in Section 2 Materials.

1. The equipment shall be a mobile, truck mounted and self-contained pavement marking machine with a minimum resin tank capacity of 60 gallons Part A materials.

2. The equipment shall be designed to maintain a uniform rate of speed at increasing or decreasing road grades.

3. The equipment shall be capable of air-blasting the pavement, spraying the mixed polyurea components, and dropping the reflective elements and glass beads in a single pass.

4. The equipment shall be capable of proportioning (3 volumes of Parts A to every 1 volume Part B) and mixing the liquid components continuously to ensure proper cure.

5. The equipment shall be capable of heating and maintaining the heated temperature of the liquid components to enable proper mixing and spraying of the material.

At any time throughout the duration of the project, the Contractor shall provide free access to his application equipment for inspection by the Engineer, his authorized representative, or a materials representative.

**ARKANSAS STATE HIGHWAY AND TRANSPORTATION DEPARTMENT**
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**LIQUID PAVEMENT MARKING**

**B. Application:** The markings shall be applied by a manufacturer certified contractor in accordance with the manufacturer's installation instructions. Marking configurations shall be in accordance with the "Manual on Uniform Traffic Control Devices."

1. **Moisture:** The markings shall only be applied during conditions of dry weather and when the pavement surface is dry and free of moisture.

2. **Air Temperature:** The markings shall only be applied when road and air temperatures are above 40 degrees F.

3. **Surface Preparation:** Marking operations shall not begin until applicable surface preparation work is completed and approved by the Engineer.

   3.1 Prior to applying the markings, the contractor shall remove any remaining existing markings to expose a minimum of 80% of the pavement surface.
   3.2 Prior to applying the markings, the contractor shall remove all curing compounds on new Portland cement concrete surfaces.
   3.3 Prior to applying the markings, the contractor shall remove all dirt, sand, dust, oil, grease and any other contaminants from the road surface.
   3.4 Application over temporary paint is acceptable provided the following conditions are met:
   3.4.1 Temporary paint shall be a water-based material, with no more than 4 pounds of glass beads per gallon of paint placed on its surface.
   3.4.2 Temporary paint shall be applied at a dry mil thickness of approximately 8 mils or less.
   3.4.3 If Temporary paint is greater than approximately 8 mils, Temporary Line needs to be removed.

4. **Dimensions:** The reflectorized pavement markings shall be placed only on properly prepared surfaces and at the widths and patterns as designated on the contract plans. The markings shall be applied in accordance with the "Manual on Uniform Traffic Control Devices" and in accordance with the Engineer's plans.

5. **Other Restrictions:** The Engineer and/or Contractor shall determine further restrictions and requirements of weather and

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**LIQUID PAVEMENT MARKING**

pavement conditions necessary to meet the all other application specifications and produce markings that perform to the satisfaction of the Engineer.

6. **Binder Thickness:** The polyurea binder (mixed Part A and Part B) coating shall be applied at rates to achieve minimum uniform wet thicknesses as follows:

| Surface Type | Recommended Liquid Pavement Marking Thickness (1 inch=1000 mils) and Rates of Application[1] |
|---|---|
| All New and Existing Pavement Types | 20 mils (240 4-inch lineal feet per gallon) |

[1] Application rates calculated using a conversion of 231 cubic inches per US liquid gallon.

7. **Reflective Media Application:** The contractor shall ensure that the beads and elements are properly set in the polyurea coating so that their exposed portions are free of polyurea coating material. The specified reflective media shall be dropped at rates to achieve the following coating weights:

| Units | Glass Beads | Composite Reflective Elements |
|---|---|---|
| Pounds per 4-inch linear foot | 0.026 lbs/4-inch lf | 0.011 lbs/4-inch lf |
| Grams per 4-inch linear foot | 12 grams per 4-inch lf | 5 grams per 4-inch lf |
| Pounds per gallon - **20 mils, 240 theoretical feet per gallon** | 6.4 lbs/gal | 2.65 lbs/gal |
| Pounds per gallon - **25 mils, 190 theoretical feet per gallon** | 5.0 lbs/gal | 2.1 lbs/gal |

8. **Volumetric Proportioning:** The contractor shall ensure proper proportioning (3 volumes of Part A and to every 1 volume of

Part B) and mixing of the polyurea components so that the markings are adequately hardened throughout and are free of soft or uncured material. Typically, such areas will darken over time from dirt and tire residue.

9. **Overspray:** The contractor shall ensure the polyurea coating does not exhibit excessive overspray.

10. **Adhesion:** The contractor shall ensure that the polyurea coating is well adhered to the road surface, and that the beads and elements are well adhered to the binder.

11. **Marking Performance:** The typical average initial retroreflectance of the markings shall be 900 [$(mcd(ft^{-2})(fc^{-1}]$ for white and 700 [$(mcd(ft^{-2})(fc^{-1}]$ for yellow. Retained retroreflectance of the markings after 48 months shall be 100 [$(mcd(ft^{-2})(fc^{-1}]$ for both white and yellow.

The average initial retroreflectance shall be determined according to the measurement and sampling procedures outlined in ASTM D 6359, using a 30 meter retroreflectometer. The 30 meter retroreflectometer shall measure the coefficient of retroreflected luminance, $R_L$, at an observation angle of 1.05 degrees and an entrance angle of 88.76 degrees. $R_L$ shall be expressed in units of millicandelas per square foot per foot-candle [$(mcd(ft^{-2})(fc^{-1}]$. The metric equivalent shall be expressed in units of millicandelas per square meter per lux [$mcd(m^{-2})(lux^{-1}]$.

Initial performance of pavement markings shall be measured within 7 days after application.

## C. Inspection and Testing

During the application of the polyurea material, the Engineer may request the following tests to verify application to the parameters required in this specification.

1. **Binder thickness:** During appropriate locations along the alignment of the project site, the Engineer may obtain a sample of polyurea material applied onto a test card or silicone coated paper for the purposes of checking for proper binder thickness. The polyurea material shall be applied without reflective elements or glass beads. Upon cure of the binder material, the binder thickness shall be verified by the Engineer to meet the requirements of Section "Application Conditions – Binder Thickness" in this

specification. The Contractor shall provide to the Engineer the application speed of the equipment during the time of the sample.

2. **Reflective Media:** When required by the Engineer, the Contractor shall demonstrate to the Engineer the proper calibration of reflective elements and glass beads compared with the manufacturers requirement. The calibration shall be conducted with a graduated cylinder or other similar device. Reflective elements or glass beads shall be collected from the reflective element and glass bead guns for a timed period. The volume of the reflective elements and glass beads collected shall be measured and compared with the manufacturer's requirements

3. **Application Cards:** The Contractor shall provide to the Engineer at least one completed Application Card with typical binder and reflective media applied onto the surface. This Application Card will serve as a record of the project application conditions and settings. Application Cards are available from the manufacturer.

4. **Sampling:** The state and supplier will coordinate sampling of materials used on the project either at the time of receipt at the applicators warehouse or at the plant of manufacture.

**D. Rework:**

1. When markings are found to be non-conforming under Section II, the material supplier shall provide replacement materials at no cost.

2. When markings are found to be non-conforming under Section III, the contractor shall bear full responsibility for all repair work and associated costs, including purchase of replacement materials.

3. When the fault of non-conformance with the specification is indeterminate or in dispute, the materials supplier shall provide replacement materials and the contractor shall repair the markings, both at no cost to the Engineer and/or Agency.

**4. Method of Measurement.** The liquid pavement markings will be measured by the linear foot (meter) of line of a width specified complete-in-place. Removal of construction and permanent pavement markings will be measured and paid for under Section 604.

**ARKANSAS STATE HIGHWAY AND TRANSPORTATION DEPARTMENT**
**SPECIAL PROVISION**
**JOB NO. 005963**
**LIQUID PAVEMENT MARKING**

5. **Basis of Payment.** Work completed and accepted and measured as provided above will be paid for at the contract unit price bid per linear foot (meter) for Liquid Pavement Marking of a color and width specified, which price shall be full compensation for furnishing and placing all materials, and for all materials, labor, tools, equipment and incidentals necessary to complete the work.

Payment will be made under:

| **Pay Item** | **Pay Unit** |
|---|---|
| Liquid Pavement Marking (Color, Width) | Linear Foot (Meter ) |

7/2/98
4/1/99
4/6/00
9/15/00
4/11/03
10/6/03

**ARKANSAS STATE HIGHWAY AND TRANSPORTATION DEPARTMENT**
**SPECIAL PROVISION**
**JOB 005963**
**SPECIFICATIONS FOR INVERTED PROFILE PAVEMENT MARKING**

## A. Description

This section shall cover the work of furnishing all materials and placing the inverted profile thermoplastic traffic marking that is hot applied to the pavement surface. (as specified in accordance with this special provision and the Standard Specifications for Highway Construction, Arkansas State Highway and Transportation Department, Edition of 2003, Section 719). This pavement marking shall be formed during application with an inverted profile that will rapidly drain water from the highway surface. This rapid draining shall allow the traffic stripe to be highly reflective in heavy rain. This special provision supersedes certain items in the Standard Specifications for Highway Construction.

This Inverted Profile Pavement Marking System shall be composed of three (3) items: A thermoplastic marking compound, a double drop glass bead system, and special equipment capable of producing the inverted profile pavement marking. This type of pavement marking shall be designated as Profiled Thermoplastic Pavement Marking.

## B. Sampling and Testing

Sampling and testing shall be in accordance with the Arkansas State Highway and Transportation Department's sampling and testing procedures.

## C. Materials

**1. Description.** This provision covers machine applied Alkyd/Maleic thermoplastic pavement marking material with both intermixed and drop-on glass beads for use in the Inverted Profile Pavement Marking.

**2. Thermoplastic Material.** The thermoplastic material used for hot Alkyd/Maleic applications shall consist of homogeneously mixed pigments, fillers, resins and glass beads and shall be available in both white and yellow.

The thermoplastic material shall be free of contaminates and shall be dry blended from 100% virgin stock, using no reprocessed materials. The thermoplastic material, while on the roadway surface, and at any natural ambient temperature, shall exist in a hard solid state with cold ductility that permits normal movement with the road surface without chipping and/or cracking.

The material shall meet the minimum requirements specified herein including, but not limited to, composition, physical characteristics, etc. The physical and chemical properties contained in this specification shall apply regardless of the type of formulation used. The pigment, beads and fillers shall be free from all skins, dirt and foreign objects.

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**SPECIFICATIONS FOR INVERTED PROFILE PAVEMENT MARKING**

The thermoplastic material upon heating shall not exude fumes which are toxic, or injurious to persons or property.

The thermoplastic material shall not deteriorate or discolor when held at the application temperature for periods of time up to four (4) hours, or upon reheating to the application temperature for a period of time not to exceed four (4) hours.

The thermoplastic material shall be readily applicable at temperatures between 400° and 430°F (204° and 221°C), from the approved equipment, to produce pavement markings of the required type and thickness above the pavement surface as described elsewhere in this specification.

## D. Composition

The pigment, beads, resin and fillers shall be a uniform blend. The material shall be free from all skins, dirt, and foreign objects and shall comply with requirements according to Table I.

**Table I Composition**

| Component | Composition By Weight | |
|---|---|---|
| | White | Yellow |
| Binder | 18% Min. | 18% Min. |
| Glass Beads (Intermixed) - Class B | 40% Min. | 40% Min. |
| Titanium Dioxide (For White Material Only) | 10% Min. | N/A |
| Yellow Pigment (For Yellow Material Only) | N/A | 5% Min. |
| Calcium Carbonate & Inert Filler | 31% Max. | 41% Max. |

NOTE "A": The amount of calcium carbonate and inert fillers shall be at the option of the manufacturer, providing all other requirements of the specifications are met.

### Other Ingredients

Titanium Dioxide shall meet ASTM D 476 - Type II, (Rutile grade - 92% Min. Titanium content).

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**SPECIAL PROVISION**
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**SPECIFICATIONS FOR INVERTED PROFILE PAVEMENT MARKING**

## GLASS BEADS - INTERMIXED AND DROP-ON

The glass beads used in formulating the thermoplastic compound or dropped on the thermoplastic shall be smooth, clear and free from any air inclusions and scratches that might affect their function as a retro-reflective media, and shall have the characteristics listed as follows:

### E. Intermix Glass Beads

**Class B** glass beads shall make up a minimum of 40% of the thermoplastic compound, by weight. These beads shall meet all requirements of ASTM D 1155 with 70% true spheres; the +20 sieve shall be tested visually.

All Class B glass beads shall be coated with an adhesion promoting coating which shall also provide moisture resistance as tested by AASHTO M-247.

### Size Distribution

The gradation of Class B glass beads shall have the following size distribution.

| US Standard Sieve Size (Microns) | % Passing |
|---|---|
| 16 | 99 - 100 |
| 20 | 75 - 100 |
| 30 | 55 - 95 |
| 50 | 10 - 35 |
| 100 | 0 - 5 |

### F. Drop-On Glass Beads

Drop-on glass beads shall be separated into the two (2) following classes:

**Class A** drop-on glass beads shall be used in the first bead coat and shall exhibit the following characteristics:

1. **Color and Clarity.** The glass beads shall be colorless and clear and shall be free of carbon residues.
2. **Index of Refraction.** The index of refraction shall be 1.50 or higher.
3. **Roundness.** The glass beads shall have a minimum of 80% rounds per screen for the two highest sieve quantities (determined visually) and no more than 3

percent angular particles per screen (visual). The remaining sieve fractions shall be no less than 75% rounds (determined visually, per aspect ratio using microfiche reader). (Angulars are defined as particles with sharp edges).

4. **Air Inclusions.** The glass beads may contain a maximum of 10% air inclusions.
5. **Specific Gravity.** The specific gravity of the glass beads shall be a minimum of 2.50.
6. **Gradation.** The gradation of Class A glass beads shall be as follows:

| US Standard Sieve Size (Microns) | | % Retained |
|---|---|---|
| 12 | (1680) | 0 |
| 14 | (1400) | 0 - 5 |
| 16 | (1190) | 0 - 20 |
| 18 | (1000) | 0 - 80 |
| 20 | (840) | 10 - 80 |
| 30 | (595) | 0 - 50 |
| Pan | | 0 - 10 |

All Class A beads shall be coated with an adhesion promoting coating which shall also provide moisture resistance as tested by AASHTO M-247.

**Class B** drop-on glass beads shall be used in the second bead coat and shall comply with ASTM D 1155; the +20 portion shall be tested visually and shall have an adhesion promoting coating which shall also provide moisture resistance as tested by AASHTO M-247. Not more than 30% of the glass spheres shall be irregular or fused spheroids. At least 70% of the beads shall be true spheres. (ASTM D-1155, Procedure B).

1. **Gradation.** The gradation of Class B glass beads shall be as follows:

| US Standard Sieve Size | % Passing |
|---|---|
| 16 | 99 -100 |
| 20 | 75 - 100 |
| 30 | 55 - 95 |
| 50 | 10 - 35 |
| 100 | 0 - 5 |

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## G. Physical Characteristics

**(1) Color.** The thermoplastic pavement marking material shall meet the following requirements for daylight reflectance and color when tested using a standard color difference meter (0° - 45°) ICE, Illuminate C and a magnesium oxide standard or an approved secondary standard. (ASTM E1347 and I.T.E. spec. section 4.3.1)

**White** - Daylight reflectance at 45° - 0° of 75% minimum and match federal test standard number 595a, (Color 17886).

**Yellow** - Daylight reflectance at 45° - 0° of 45% minimum and match federal test standard number 595a, (Color 13538), which shall fall within the limits of FHWA highway color tolerance chart, PR color #1.

**Chromaticity.** Coordinates x and y shall fall in an area bordered bythese coordinates:

| | | | | |
|---|---|---|---|---|
| X | 0.470 | 0.510 | 0.490 | 0.537 |
| Y | 0.455 | 0.489 | 0.432 | 0.462 |

**(2) Reflectivity.** The initial reflectance for the in-place marking shall have the minimum reflectance values shown as follows, as obtained with a retroreflectometer using 30-meter geometry:

Dry Night: **White** - 450 mcd/m²/lux **Yellow** - 350 mcd/m²/lux

**(3) Retained Reflectivity.** The thermoplastic pavement marking material shall retain the minimum reflectance value of 150 mcd/m²/lux for at least four years after placement. Failure to meet this requirement shall require the manufacturer to replace the portion of the material shown to be below these minimums. The manufacturer shall supply a written warranty indicating the terms of this requirement.

**(4) Yellowness Index.** The white thermoplastic material shall not exceed a yellowness index of 0.15 (I.T.E. spec. section 4.3.8.)

**(5) Cracking Resistance at Low Temperature.** The thermoplastic pavement marking material shall be 100% passing. (AASHTO T-250 and I.T.E. spec. section 4.3.4.)

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**(6) Impact Resistance.** The impact resistance of the thermoplastic pavement marking material shall be a minimum of 10-inch pounds [1.13joule(j)]. (I.T.E. spec. section 4.3.5.)

**(7) Softening Point.** The thermoplastic material shall have a softening point of 102.5° ± 9.5°C (215° ± 15° F), (ASTM D-36).

**(8) Drying Time.** When applied at a temperature of 412° ± 12.5°F (211° ± 7°C) and at a thickness of 0.140 in. (4.7mm), the thermoplastic material shall set to bear traffic in not more than two (2) minutes when the air temperature is 50°F (11°C) and not more than 10 minutes when the air temperature is 90°F (32°C) .

**(9) Profilability.** The thermoplastic pavement marking material shall be formulated so that when applied at a temperature of between 400° and 430°F/204° and 221 C°, the individual profiles shall be a minimum of .140 in./3.556 mm when measured at the highest point of the profile and shall not excessively run back together.

**(10) Flashpoint.** The thermoplastic material shall have a flashpoint not less than 475°F (246°C). ASTM D-92 "Flash and Fire Points by Cleveland Open Cup")

**(11) Indention Resistance.** After 15 seconds with the sample panels and Shore Durometer (Ty-A2) reading 90°F (32°C), and applying a 5lb. (2 kg) load, the reading shall not be less than 45. (ASTM D-2240)

**(12) Flowability.** After heating the thermoplastic material for four (4) hours ± 5 minutes at 425° ± 3°F (218° ± 2° C) and testing for flowability, the white thermoplastic shall have a maximum percent residue of 22 and the yellow thermoplastic shall have a maximum residue of 24 percent. (I.T.E. spec., section 4.3.7.)

**(13) Extended Heating.** After heating and stirring the thermoplastic material for 8.5 hours at 425° ± 3°F (218°± 2°C) and testing for flowability, the thermoplastic shall have a maximum residue of 28 percent.

**(14) Storage Life.** The thermoplastic material shall meet the requirements of this specification for a period of one (1) year. The thermoplastic must also melt uniformly with no evidence of skins or unmelted particles for the one year period. Any material not meeting the above requirements shall be replaced by the manufacturer.

**(15) Packaging and Marking.** The thermoplastic material shall be packaged in suitable containers to which it will not adhere during shipment and storage. The bags of

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thermoplastic material shall be approximately 22 x 14 x 4 in. (560 x 350 x 100 mm) and shall weigh approximately 50 pounds (23 kg.). Each container label shall designate the color, manufacturer's name, batch number and date of manufacture. Each batch manufactured shall have its own separate number. The label shall warn the user that the material shall be heated to 400° to 430°F (204° to 221° C) during application.

The Contractor shall assume all costs resulting from the use of patented materials, equipment, devices or processes used on, or incorporated in the work, agrees to indemnify and save harmless the purchaser and his duly authorized representatives from all suits at law, or action of every nature for or on account of the use of any patented materials, equipment, devices, or processes.

## H. Construction Methods

1. The application equipment shall be specially designed for placing hot thermoplastic material in a hot molten state on the pavement surface utilizing a pressure type application method. The hot thermoplastic Inverted Profile pavement marking shall be formed by a thermoplastic die that is allowed to travel along in proximity with the road surface. The die is pulled forward by a special linkage that will allow it to automatically level itself as to float and remain parallel with the road surface. The top of the die shall be enclosed and provide entry means for the hot molten thermoplastic to enter the die cavity. The bottom of the die shall contain a moveable door that is remote controlled so as to start or stop the flow of thermoplastic on to the pavement surface. When the moveable door is open, thermoplastic can flow through the die and will apply a thermoplastic line that will be formed rearward of the advancing die. The road surface shall be at the bottom of the die enclosure. Thermoplastic shall be fed to the die under pressure through flexible oil-jacketed stainless steel hoses. The thermoplastic die shall be formed from a single solid block of steel that is oil-jacketed on four (4) sides in order to keep the die hot at all times.

The thermoplastic die shall incorporate within the same housing a special curtain coater, low pressure drop-on type glass bead gun, (Bead Coat #1). The pressure die and curtain coat bead gun shall be a single unit that is oil-jacketed on four (4) sides and is formed from a single solid block of steel. This glass bead gun shall dispense glass beads onto the hot thermoplastic line from a height of approximately one (1) in. (25mm) above the road surface. The point at which the glass beads strike the surface of the pavement marking shall be approximately 3in. (75mm) behind the strike point of the thermoplastic itself. This reflective bead coat #1 shall utilize Class A glass beads as specified in the "Drop-On Glass Bead" Section (F), and shall provide a surface coating of 50% of the thermoplastic pavement marking surface. Of this 50% surface coverage, at least 50% of the beads will be embedded to a depth of 60% of their diameter.

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A second curtain coater, low pressure drop-on type glass bead gun capable of applying a continuous sheet or ribbon of glass beads shall follow at an interval of approximately ten (10) inches (250 mm) behind the first bead gun. This second glass bead gun shall apply bead coat #2 which will form a continuous drop-on coat of Class B glass beads immediately in front of the pavement marking profiling device. This second curtain coat of glass beads shall have a low impact speed so that they are not forced into the pavement marking under pressure.

A special rotatable wheel pavement marking profiling device shall be located approximately eight (8) inches (200mm) behind bead gun #2. This rotatable wheel device shall be approximately seven (7) inches (175mm) in diameter and shall have a plurality of spaced projections located around it circumference. The pavement marking profiling device shall be wider than the pavement marking being applied in order that the pavement marking shall be adequately covered. The projections on the portable pavement marking device shall have an angular pavement marking profiling surface set at an angle to the pavement surface. The rotatable pavement marking profile device shall be mounted with an automatic leveling device to the same carriage assembly as the thermoplastic gun. Using rollers to place grooves in the traffic marking utilizing a separate vehicle or grooves that are not pressed within one (1) second of thermoplastic material application will not be allowed under this specification. To insure that no hot thermoplastic adheres to the wheel as it rotates and profiles the marking, a small air atomized water jet shall apply a thin mist of water to the rotatable profile wheel. No water puddles greater than 1/4 inch / 6mm in diameter shall be allowed to accumulate on the pavement surface in proximity to the freshly placed pavement marking.

All parts of the thermoplastic holding tank including manifolds, hoses, pipes, dies, etc., shall be oil-jacketed to insure accurate temperature control. The thermoplastic material shall be preheated in kettles designed specifically for that purpose. Each kettle of preheated thermoplastic material shall be properly mixed and heated to the correct application temperature. The preheated material shall then be fed to the thermoplastic gun for application.

1. The striper unit shall be truck mounted with kettle capacity to hold 2000 lbs.(907 kg.), of thermoplastic and shall have the capacity to contain enough glass beads and water to apply one full kettle of thermoplastic.

2. All new asphalt surfaces shall have a minimum cure period of 14 days prior to installing the inverted profile pavement marking, unless otherwise approved by the engineer.

3. All pavement areas to be marked shall be thoroughly cleaned using equipment capable of cleaning without damaging the surface. This will include, but not be limited to all vegetation, loose soil, oils, and other debris. Installation of the inverted profiled pavement marking shall follow as closely as practical after the surface has been cleaned.

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4. Where so shown on the plans or directed, the existing pavement marking shall be removed by grinding.

When placing inverted profile pavement marking on existing asphalt pavement that has more than one existing light coat of striping material, the existing marking shall be removed to the point that 80% of the pavement surface is visible.

When placing inverted profile pavement marking on Portland Cement Concrete no curing compound shall be marked over. Existing pavement markings shall be ground to the point that 80% of the pavement surface is visible.

Removal of existing pavement marking will be paid for as a separate item of work.

Where unsatisfactory inverted profile pavement marking performed by the Contractor must be removed and replaced in compliance with these specifications, the Contractor shall use the removal method described above. No payment will be made for removal or replacement of the Contractor's unsatisfactory marking.

5. When placing inverted profile pavement marking, no striping shall be permitted when the surface temperature is less than 60°F (16° C). A non-contact infrared pyrometer shall be supplied by the Contractor for use by the engineer for temperature verification). To prevent the rapid cooling of the freshly placed marking, no striping shall be performed when there is moisture on the pavement surface or when winds exceed 12 mph (19 km/Hr). After hard rains, even though no moisture is visible, Portland Cement Concrete and asphalt surfaces can hold water. When unseen moisture is suspected to be present, a moisture test shall be performed. The test shall be as follows:

(A) Place a piece of tar paper on the pavement surface.
(B) Pour 1/2 gallon (1.9 L) of thermoplastic onto the paper.
(C) After two (2) minutes, lift the paper and inspect to see if moisture has been drawn from the pavement.
(D) If moisture is present, do not proceed with Inverted Profile pavement marking until the surface is moisture free.

Documentation of weather and pavement conditions shall be maintained by the Contractor and supplied to the Engineer on the approved AHTD form.

6. The thermoplastic material shall be preheated and thoroughly mixed at an application of between 400°F (204° C). minimum and 430°F (221° C). maximum. A digital thermometer, complete with a 24 inch probe, shall be supplied to the Engineer by the Contractor for temperature verification.

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When measured at the highest point of the profile, the cold thickness of the in place thermoplastic pavement marking shall be a minimum of .140 inch (3.55mm) for inverted profile markings. The thickness of the thermoplastic in the bottom of the profiles shall range from 0.025 - 0.050 inch (0.635 – 1.27mm). The individual profiles shall be located transversely across the pavement marking at interval of approximately one (1) inch (25mm). The bottoms of these intervals shall be between 3/32 and 5/16 inch (2.38 and 7.94mm) wide. In order to drain water and to reflect light, it is normal for the top surface of the inverted profiles to be irregular. The rate of thermoplastic application for inverted profile thermoplastic pavement marking shall be approximately 2,500 lb. per mile (1,134 kg/km) for a 4 inch (100mm) solid pavement marking and there shall be appropriate adjustments for skip markings or various line widths.

The glass bead application rate for Class A glass beads (bead coat #1) shall be approximately 500 pounds per mile (141 kg/km) of 4 inch (100mm) solid pavement marking. There shall be appropriate adjustments for skip markings or various line widths.

The glass bead application rate for Class B glass beads (bead coat #2) shall be approximately 500 pounds per mile (141 kg/km) of 4 inch (100mm) solid pavement marking. There shall be appropriate adjustments for skip markings or various line widths.

The thickness of the pavement marking materials shall be verified periodically [at least every 1/4 mile (400m)] and any thickness more than 5% under the designated thickness shall be reworked. A consistent, un-corrected underrun will not be allowed and the Contractor will be required to install the specified minimum thickness of .140 in (3.55mm). A wet film thickness checker, such as a GulfLine Model 140W, shall be provided to the engineer.

Also a cold thickness checker, such as a GulfLine Model 140C, shall be provided to the Engineer by the Contractor for film thickness verification.

When installing thermoplastic inverted profile pavement marking over more than one existing painted stripe on old oxidized asphalt, on all concrete surfaces, or on asphalt surfaces when surface temperatures are below 70°F (21°C)., a two component epoxy primer sealer shall be used and installed as recommended in writing by the thermoplastic material manufacturer. The epoxy primer sealer shall be EX255/EX256 as manufactured by Crown Paint Company of Oklahoma City, OK., or approved equal.

If an alternate epoxy primer sealer to the Crown Paint EX255/EX266 is used, the Contractor shall supply a mill analysis and proof of adequate performance of the alternate when used with thermoplastic inverted profile pavement markings.

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## I. Measurement

This item will be measured by the linear foot (meter). Where double stripes are placed, each pavement marking will be measured separately.

## J. Inspection Procedure for In-Place Inverted Profile Thermoplastic Pavement Markings

### Purpose

To provide supervising AHTD personnel with a procedure for insuring compliance with various item in the performance specifications for in-place inverted profile thermoplastic pavement marking. **A supplier's representative must be present at the time of the application of the markings to ensure that the markings are placed in accordance with this specification and the manufacturer's recommended procedures.**

### Apparatus

(1) Measuring tape or ruler
(2) A 30-meter retroreflectometer complying with ASTM E 1710
(3) Magnifying glass
(4) GulfLine Model 140C (Cold Thickness Checker)
(5) GulfLine Model 140W (Wet Thickness Checker)
(6) Non-Contact Infrared Pyrometer
(7) Digital Thermometer with 24 in. (600mm) Probe
(8) Electronic Digital Wind Speed Indicator

### Procedure - Line Selection

Periodic random inspection stations shall be selected by the Engineer throughout the project. Measurements of the pavement marking thickness, width, apparent bond strength and retroreflectivity shall be taken. In a given three (3) foot (1 meter) section, several reflectance readings will be taken and averaged to yield a net reading. (See attached retained retro-reflectivity warranty)

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## Procedure - Thickness

After the striper unit has passed a given point by a distance of 40 ft. (12 m), use a GulfLine Model 140W Line Thickness Checker to test the pavement marking thickness. Place the checker over the pavement marking so that the two end flats rest on the road surface on either side of the marking. Slide the checker forward along the pavement marking for about a 6 in. (150 mm) distance. The middle flat of the checker should make a slight indention in the highest point of the pavement marking. From this, you can accurately estimate the wet film thickness of the pavement marking.

After the pavement marking is allowed to completely cool, the marking thickness can be accurately measured by placing the GulfLine Model 140C Thickness Tester over the marking in the same manner as the wet test. Rest the checker pad that is connected to the dial indicator on the highest point of the pavement marking. From time to time test the calibration of the checker by placing it on a flat surface. The dial indicator can be rotated so as to set a zero (0) reading on a flat surface.

Note: The minimum required in-place thickness of the inverted profile pavement marking shall be .140 inches (140 mils) [3.556 mm] as measured at the highest point of the marking.

## Procedure - Width

Measure the pavement marking width across the marking at the bottom of the inverted profile. The line width should be four (4) inches (Range of 3 7/8" to 4 3/8") [100mm (98 – 110 mm)].

## Procedure - Retroreflectivity

Use the 30-meter retroreflectometer to measure the retroreflectivity at random locations. See "Physical Characteristics", (2) (Reflectivity). Also, see the operation manual distributed with this device for detailed instructions on usage. (Within seven (7) days of application - see attached retained retroreflectivity warranty.)

## Procedure - General

BEADS - 50% of the glass beads should be embedded to approximately 60% of their diameter to insure proper adherence to the thermoplastic marking material and provide maximum initial retroreflectivity. Shallow embedment allows the beads to debond and deep embedment reduces retroreflectivity. Use a magnifying glass to view bead embedment.

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BONDING - The thermoplastic inverted profile pavement marking shall be properly bonded to the pavement surface. This can be checked with a knife or screw driver while the material is still pliable. If the material is properly bonded, it should bring up some asphalt with it. When completely cured, it should be almost impossible to get a knife or screwdriver blade between the marking and the roadway.

## K. Warranty

Longitudinal markings, designated as Profiled Thermoplastic Permanent Marking shall meet the minimum performance level of 150 millicandelas/$m^2$/lux under dry pavement conditions, (white or yellow) for a period of 48 months from the date of installation when exposed to normal roadway conditions and regardless of average daily traffic. Failure to meet this requirement shall result in the total replacement of the portion of the material shown to be below these minimums.

Adequacy will be determined by an average brightness reading over a zone minimum marking length of 300 LF (90m) using the 30-meter reflectometer. The zone of measurement referred to includes: 1) Center lines 2) Edge lines and 3) Skip Lines.

The measurement procedure for this warranty will entail a visual night inspection by a Supplier representative and a Department representative to identify areas of the installation which appear to be below the specified minimum warranted reflectance value. All reflectance measurement should be made on a clean dry surface at a minimum temperature of 40°F (4°C).

Measurement intervals for installations with areas less than, or equal to, three miles which appear to be below the minimum specifications, should be made at a minimum of three (3) check points for each zone. These should include the start point, approximately mid-point and the end point.

Measurements for installations with areas greater than three (3) miles (5 km) which appear to be below the minimum specifications, should be made at the start point and end point of the areas in questions with additional measurements spaced at three (3) mile (5km) intervals between the start and end points.

The number of measurements at each check point for each zone will be as follows:

(A) Skip Lines: Eighteen measurements distributed over 6 skip lines, should be made at each check point.

(B) Center Lines and/or edge lines: Eighteen (18) measurements should be made and the measurements should be distributed over 300 LF (90 m)continuous stripe.

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(C) If the pavement markings are more than 6 in. (150mm) wide, the cross sections should be determined by one third (1/3) of the measurements on the right edge, one third (1/3) of the measurements on the axis and one third (1/3) of the measurements on the left edge.

In addition, the reflectance values at each check point shall be averaged by zone to determine conformance to the minimum reflective values. Also, evidence of failure to follow the supplier's recommended application procedures will void this warranty.

## L. Payment

The work performed and materials furnished in accordance with this item and measured as provided under "Measurement" will be paid for as "Profiled Thermoplastic Pavement Marking" of the various colors, widths, and thickness specified. This price shall be full compensation for furnishing all materials, for application of pavement markings, and for all other labor, tools, equipment and incidentals necessary to complete the work, except as shown below. No compensation will be paid for additional work performed and materials furnished resulting from failure to comply with the manufacturers written warranty. This will include materials, application of markings, labor, tools, equipment, traffic control and incidentals necessary to complete the work.

Surface preparation, and/or pavement marking removal when shown on the plan, will be paid for under a separate pay item.

Payment will be made under:

| **Pay Item** | **Pay Unit** |
|---|---|
| Profiled Thermoplastic Pavement Marking White (_____in. / mm) | Linear Foot / Meter |
| Profiled Thermoplastic Pavement Marking Yellow (_____in. / mm) | Linear Foot / Meter |

# ARKANSAS STATE HIGHWAY AND TRANSPORTATION DEPARTMENT

## SPECIAL PROVISION

## JOB 005963

## COORDINATION OF DURABLE PAVEMENT MARKINGS

**Section 604 Traffic Control Devices in Construction Zones** of the Standard Specifications for Highway Construction, Edition of 1996, is hereby amended as follows:

**Subsection 604.02(d)(1)** is hereby deleted and the following substituted therefor:

(1) Asphalt Surfaces. Only painted markings complying with the waterborne acrylic emulsion polymer paints specified in Section 718 may be used, except that the glass beads shall be placed on the surface of the wet paint in the amount of not more than 0.5 kg/L (4 pounds per gallon) and not less than 0.3 kg/L (3 pounds per gallon). Markings shall be yellow for centerlines and inside edge lines, white for lane lines and outside edge lines, and have straight, unbroken edges.

**Subsection 604.03(f) Pavement Markings** is hereby expanded as follows:

When both Inverted Profile Pavement Marking and Liquid Pavement Marking are planned to be placed on the same project, either marking may be placed first. The placement of the second marking shall begin within fourteen (14) calendar days after the placement of the first marking is complete. (Day 1 of the 14-day period is the first day that it becomes practical and possible to place the other marking.)