Montana Department of Transportation
Research Programs
November 2018

EXPERIMENTAL PROJECTS FINAL REPORT

3M WET REFLECTIVE CERAMIC ELEMENTS AND POTTERS VISIMAX PLUS: NEW BEAD TECHNOLOGY FOR ADDED RETROREFLECTIVITY IN ALL WEATHER PAVEMENT MARKINGS

Location:	US 310/US 212 (N4) Approximate Reference Point 43-53, Counties Carbon and Yellowstone Counties
Project Name:	Rockvale - Laurel
Project Number:	HSIP 4-1(63)43
Experimental Project No.	MT-12-12
Type of Project:	Pavement Markings Retroreflectivity
Principal Investigator:	Craig Abernathy: Experimental Project Manager (ExPM)
Date of Installation:	September 2013
Date of Inspection:	July 2018

Description

Evaluate the effectiveness of 3M Ceramic Elements and Potters VISIMAX Plus when blended with conventional MDT Type 2 glass beads in highway pavement markings.

These elements are claimed to provide increased retro-reflectivity during wet conditions allowing states to recess a 20 mil thick striping in a 60 mil deep grind resulting in an increased durability during plowing seasons. The increased retro-reflectivity during wet conditions is also being evaluated to determine their effectiveness as safety treatments.

1. 3M Elements wet-reflective dualoptic beads (1.9 and 2.4 reflective-index bead blend) are microcrystalline ceramic beads embedded on a center core to provide added reflectivity for pavement markings under wet and rainy conditions. The 3M system combines standard glass beads with the ceramic elements blend to maintain optimal visibility as described by the manufacturer.

2. The Potters VISIMAX Plus incorporates three to four times the diameters of conventional beads with high-clarity glass to allow for maximum retroreflectivity in wet conditions. Thousands of high-index beads form the outer VISIMAX shell as described by the manufacturer.

Additional technical information on the products being tested may be found at:

Potters VISIMAX:

http://www.pottersbeads.com/hs/NorthAmerica/Products/VISIMAXVISIMAXPLUSHwySafetyMarkingSpheres.aspx

3M Elements:

http://multimedia.3m.com/mws/mediawebserver?mwsId=66666UgxGCuNyXTtoxMVlxT_EVtQEcuZgVs6EVs6E666666--&fn=Elements%20flyer.pdf

Experimental Design

Beads used on the project was a blend consisting of 3M wet reflective elements and MDT Type 2 glass beads, a blend consisting of VISIMAX Plus and MDT Type 2 glass beads, and a control segment of 2 miles using MDT's standard application rate of Type 2 glass beads. The beads will be applied to 20 mil thick epoxy striping placed in a 60 mil +/- 5 mill groove.

The blend ratio of retro-reflective elements to MDT Type 2 glass beads was established based on supplier recommendations. The project will entail line striping of the centerline (non-recessed); which will have rumble strips, recessed fog line, and passing lines.

The blend incorporating the 3M reflective elements will be placed from reference point (RP) 42.9 to 46.9, MDT Type 2 glass beads will be placed from RP 46.9 to 48.9 and serve as a control section, and the blend incorporating the VISIMAX Plus will be placed from RP 48.9 to 52.9 on N-4 (US 310/US 212).

The following is a detailed breakout of the test and control sections:

RP 42.9 to RP 46.9 (4 miles/6.4km)	6 lbs. per gallon 3M Wet Reflective Elements
	20 lbs. per gallon Type 2 Glass Beads in accordance with Section 620
RP 46.9 to RP 48.9 (2 miles/3.2km)	**Control Section**: 25 lbs. per gallon Type 2 Glass Beads in accordance with Section 620
RP 48.9 to RP 52.9 (4 miles/6.4km)	10 lbs. per gallon VISIMAX Plus
	10 lbs. per gallon Type 2 Glass Beads in accordance with Section 620

Evaluation Procedures

Research will document the installation for best practice and any constructions concerns germane to the performance of the striping placement. Initial retroreflectivity readings will establish a baseline for ongoing comparisons. Semi-annual inspections will report on markings integrity and any other measurable outcomes.

Additional site inspections may supplement the semi-annual visits based on need. Monitor and report on long-term performance. Documentation of actual nighttime wet-rainy/dry conditions will supplement the reporting. Before and after safety data will be added to the report as that becomes available.

Construction Documentation: Will include information specific to the installation events of the pavement markings.

Post Documentation: Will entail semi-annual inspections of the marking durability as well as documented retro-readings of the project sections.

The purpose of an experimental features report is to document the phases and events of any given project to gain the reader an understanding of the overall activities required to install or incorporate the research element into an active construction or maintenance project. This report also establishes a baseline for defining performance for any given feature under actual service conditions to determine its relative merits.

Evaluation Schedule

Research will monitor performance for a minimum period of five years annually, with every year up to ten years (informally). This is in accordance with the Department's "Experimental Project Procedures". Delivery of a construction/installation report, interim, annual or semi-annual reports is required as well as a final project report (responsibility of Research).

2013:	Installation/Construction Report
2014-2017:	Semi-Annual Inspections/ Annual Evaluation Reports
2018:	Final Evaluation/Final Report

Initial Remarks

This report attempts to capture the pertinent elements of the installation events to give the reader an understanding on how these new pavement marking components function. This report also establishes a baseline of documentation for use in determining future performance of the striping project. As noted earlier semi-annual site evaluations will be added annually to the construction report. This report and other information may be found at: http://www.mdt.mt.gov/research/projects/bead_technology.shtml

District staff connected with the project reported no concerns or issues regarding the applications of all three sections which may affect future performance. The grinding phase as well as the markings placement was competently installed.

Although subjective, District personnel as well as Research staff, on-site inspections during nighttime dry and wet conditions; noticed increased retroreflectivity with the two test sections as compared to the control. Current consensus (directly after installation of the striping project) categorized the 3M and Visamax products as comparable in added illumination and acceptable contrast with the adjacent pavement.

Note on page ten (10) only the 3M test section is portrayed in this report during nighttime wet conditions. Due to increase traffic and safety concerns the VISIMAX section was reviewed while active driving but was not digitally captured. An attempt will be made to add that information in future site inspections if possible.

The retroreflective measurement readings were taken after the striping was completed during wet pavement conditions. In early November additional retro-readings were taken during dry pavement conditions; it was reported due to a recent weather event deicer was present on the surface and may affect these readings. See page eleven (11) for those results. See page twenty-eight (28) for project layout location diagram.

Note that in 2015 reconstruct projects decreased the linear distance of the test sections 1 & 3. This has been noted on the project location diagram.

Site Visit March 2015: Project Update

All project test and control sections white lines placed in the 60 mil groove are in undamaged shape with no appreciable visible distress due to environmental factors or from snow plow activities. As predicted the yellow center lines have received distress from snow plows as seen in images contained in this report. Retro readings were conducted in October 2014.

Site Visit April 2016: Project Update

All project test and control sections white lines placed in the 60 mil grooved recess are in appropriate shape with no appreciable visible distress due to environmental factors or from snow plow activities. The grooved pavement, to date, has allowed the white markings to remain in good visible condition.

As noted in the report, the 3M and Visimax sections have lost a proportion of bead elements from the binder. Either from inadequate embedment, environmental factors, vehicle tire impact; or successive plow passes may be wearing the pavement surface to a point where top contact with the recessed stripe is now beginning to take place.

Visually, it appears the yellow center lines have been reapplied as seen in images contained in this report.

Site Visit April 2017: Project Update

Same as reported in 2016.

Site Visit July 2018: Project Update

Same as reported in 2017.

Since retroreflectivity readings for the project sections were initially taken after application (2013) and once in 2014; with no additional testing, no conclusion may be made to the long-term retroreflectivity efficacy on any of the project sections.

By recessing the white stripe (fog line) in a 60mil groove not only protected the investment of the beads but extended the life of the stripe. Where the centerline striping needed to be reapplied this was not the case with the white stripe,

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The following are representative images and descriptions of the applied treatments:

September/October 2013: Pages 7-11
Initial Retroreflectivity: Page 12
April of 2014: Pages 14-18
March 2015: Pages 19-22
April 2016: Pages 23-28
May 2017: Page 29
July 2018: Pages 30-31

Pre and Post Installation Images

🡸 Representative image taken in July of 2013 prior to new pavement markings application. View north.

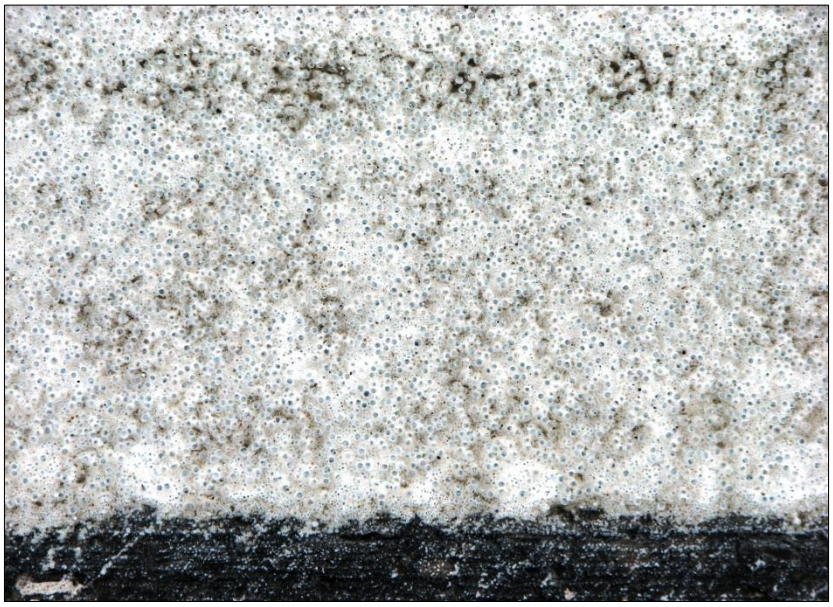
🡸 Representative image taken in September of 2013 after pavement markings application, showing added centerline and shoulder rumble strips. View north.

September 2013 – Project images taken during wet conditions

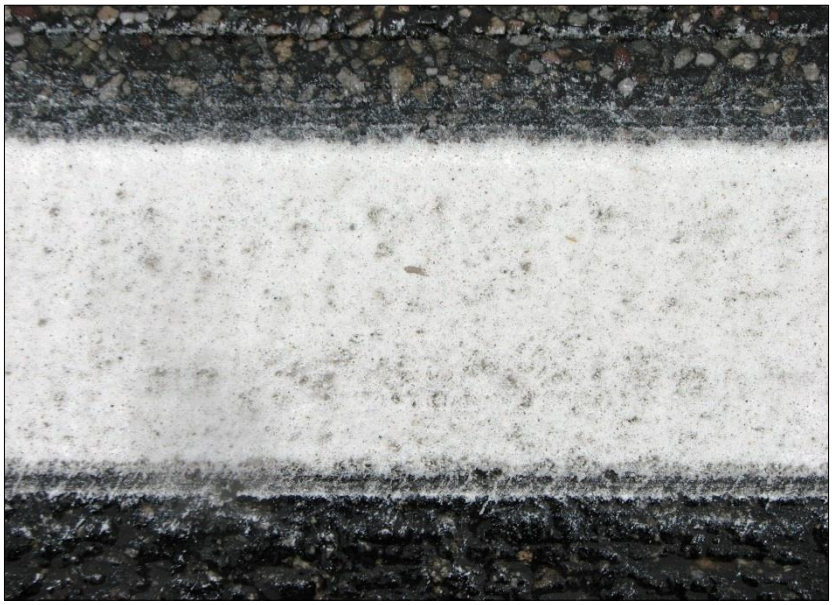
🡐 Beginning of VISIMAX PLUS pavement markings at reference point 53 looking south.

🡐 Beginning of Control (Type 2) pavement markings at reference point 49 looking south.

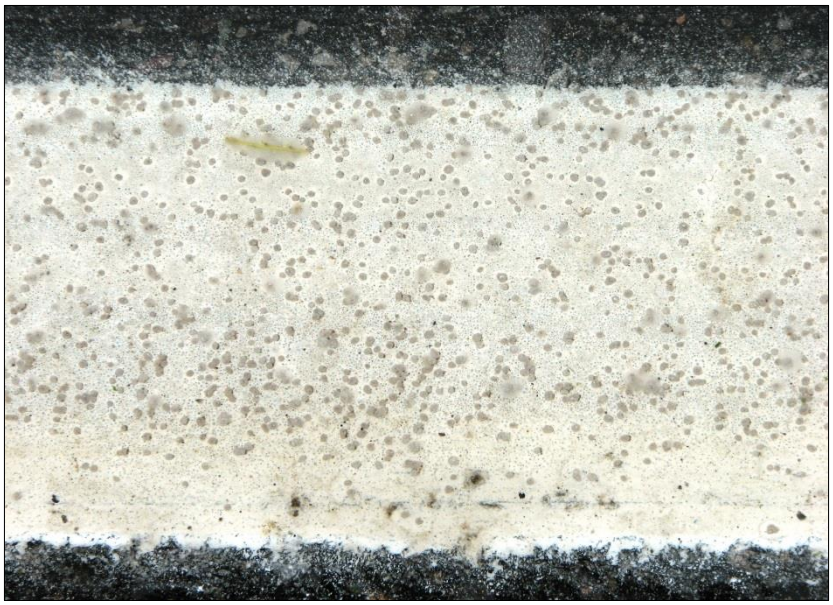
🡐 Beginning of 3M Wet Reflective Elements pavement markings at reference point 47 looking south.



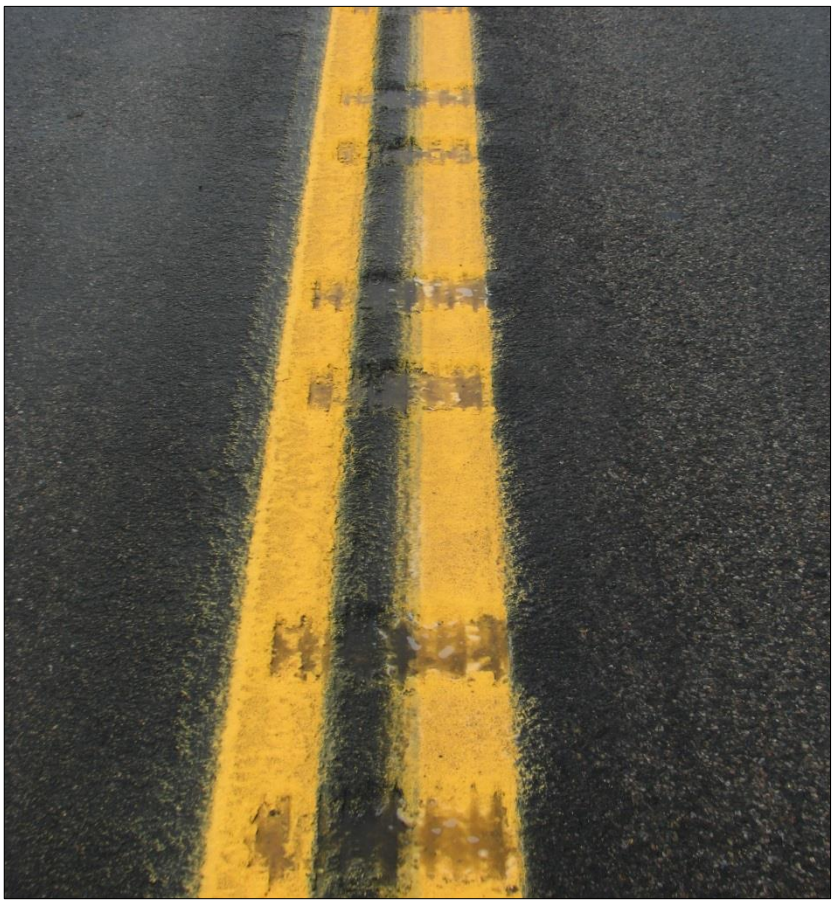
🡸 Close-up of the VISIMAX PLUS white pigmented pavement markings.



🡸 Close-up of the Control (Type 2) white pigmented pavement markings.



🡸 Close-up of the 3M Wet Reflective Elements white pigmented pavement markings.



🡐 Representative image of no-passing stripes placed over center-line rumble strips (wet condition).

🡐 Representative image (taken in mid-October 2013) of no-passing lane stripes placed over center-line rumble strips (dry condition).

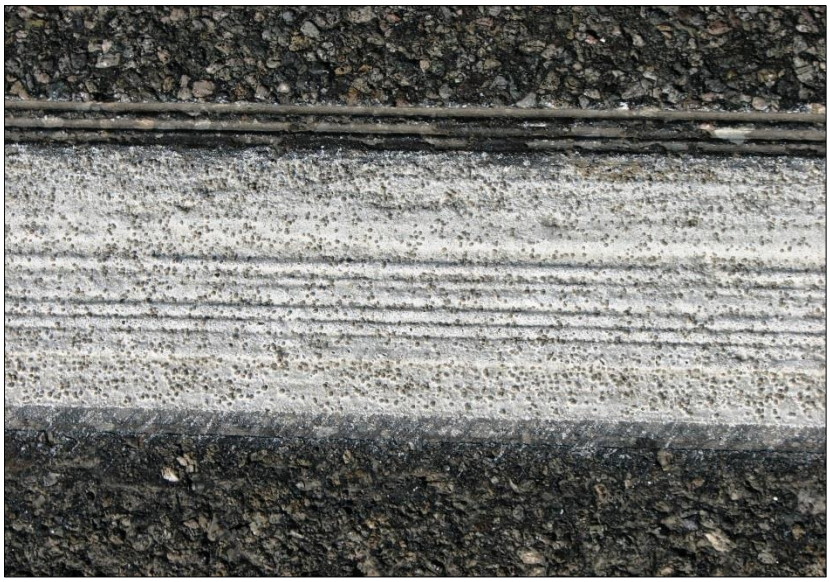
Note that centerline striping did not receive a 60 mil recess groove treatment.

October 2013 – Project images taken during dry conditions

🡐 Close-up of the VISIMAX PLUS white pigmented pavement markings.

Note that (for the most part) the pavement stripe falls well within the parameters of the 60 mil recessed groove; which should aid in the durability of the stripe. This is indicative of all three (3) sections on the project.

🡐 Close-up of the Control (Type 2) white pigmented pavement markings.



🡐 Close-up of the 3M Wet Reflective Elements white pigmented pavement markings.

September 2013: Documentation during wet and nighttime conditions

🡅 This is the transition of the 3M striping and control section at approximately RP 47 (yellow arrow); view east. It was actively raining at the time. 🡇 The image below is the transition of the conventional striping and 3M striping at approximately RP 43.

Although difficult to see in these images; during actual field observation, the difference in luminosity and contrast between the 3M and control section was apparent under wet, nighttime conditions.

Retroreflectivity Readings Collected during Dry and Wet Conditions - 2013

Milepost	SB September-Wet Shoulder	SB November-Dry Shoulder	NB September-Wet Shoulder	NB November-Dry Shoulder
52-Visamax	392	178	382	175
50-Visamax	454	242	535	293
48-Control	**221**	**235**	**359**	**241**
47-Control	**394**	**290**	**334**	**238**
46-3M	325	223	614	231
44-3M	752	305	713	308

Milepost	September-Wet Center	November-Dry Center
52-Visamax	397	192
50-Visamax	349	203
48-Control	**336**	**225**
47-Control	**319**	**221**
46-3M	357	258
44-3M	563	306

Retroreflectivity Readings Collected during Dry Conditions - 2014

Milepost	SB October Shoulder	Center	NB October Shoulder
52-Visamax	Under Construction		
50-Visamax	225	135	166
48-Control	**230**	**167**	**232**
47-Control	**290**	**120**	**228**
46-3M	290	206	290
44-3M	328	221	254

Note: The District used a handheld retro gun; Potters model MX 30. Retro-readings were taken approximately at two locations per section.

Supplemental

↑ This image taken on October 15, 2013 of the centerline markings is showing distress of debonding of the striping binder to the pavement surface commonly associated with snow plow damage or some other type of metal to binder contact.

District Maintenance staff reported in November they are noticing more of this kind of distress and since it is not in a milled groove is expected to increase over time.

Site Inspection April 2014 – 3M Elements Section

🡸 Beginning of the 3M section at reference point 43; view east.

🡸 Close-up of 3M Elements marking.

This image is representative of the overall condition of the stripe on the project.

Potters VISIMAX PLUS Section

🡐 Beginning of the Visamax section at reference point 49; view east.

🡐 Close-up of Visamax marking.

This image is representative of the overall condition of the stripe on the project.

Type II Control Section

🡐 Beginning of the Type II control section at reference point 47; view east.

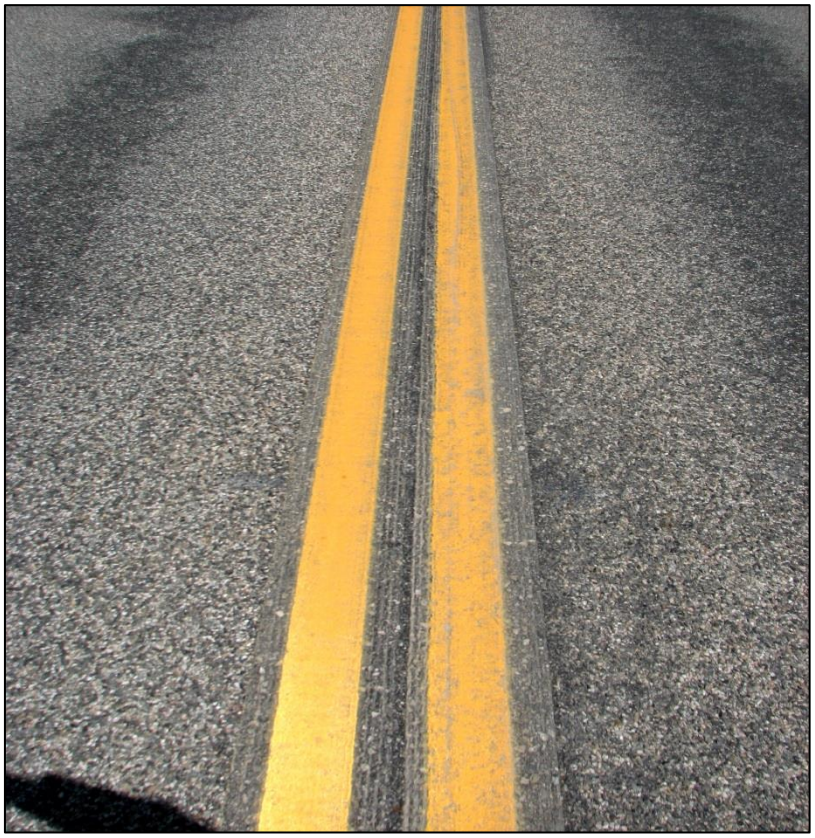
🡐 Close-up of Type II marking.

This image is representative of the overall condition of the stripe on the project.

Yellow Centerline Documentation – April 2014

🡸🡻 Images representative of the general condition of the stripe over rumble strip on the project.

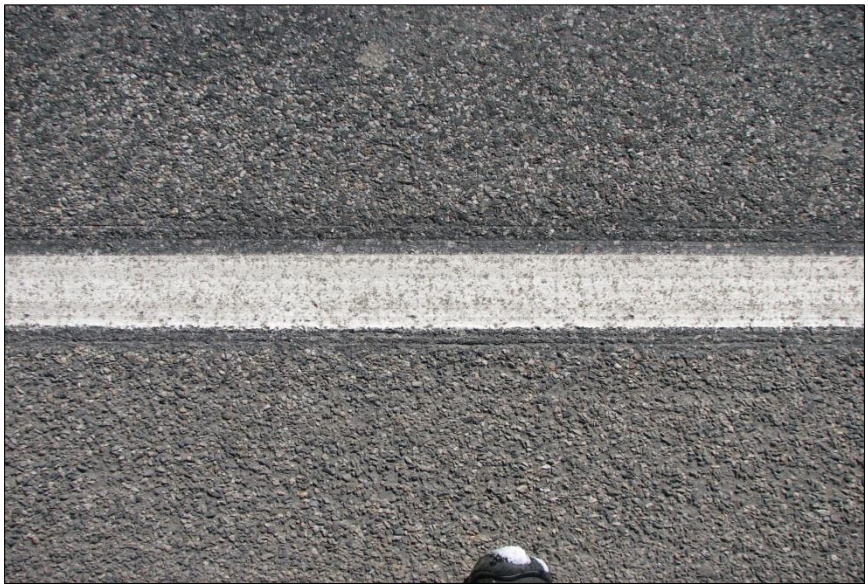
Loss of binder to pavement due to assumed snow plow passes.



🡸 There was a small linear section of no-passing zone that received a 60 mil grind within the 3M Element section. As seen in the 2014 inspection, the stripe is in good condition.

Site Inspection March 2015 – 3M Elements Section

🡐 Overview of 3M Elements section; view west near mile point 47.



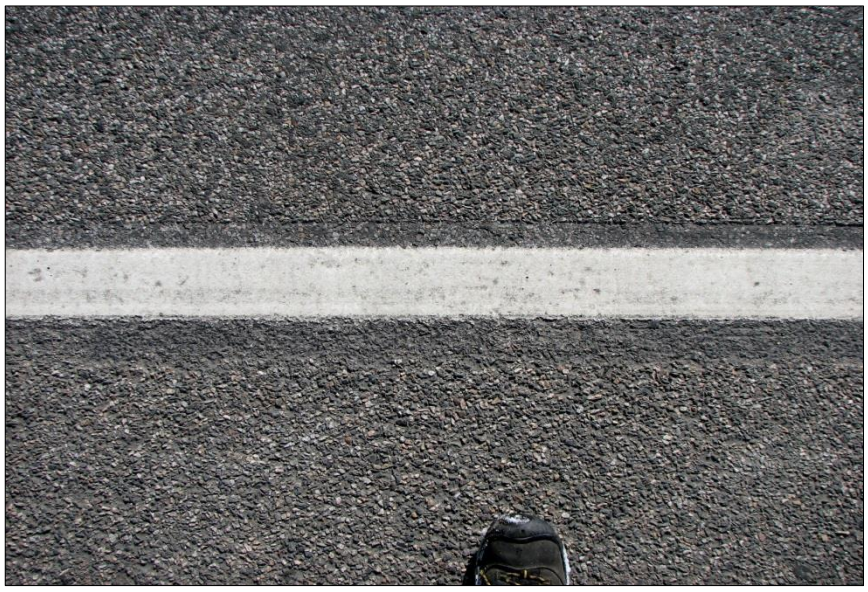
🡐 Close-up of 3M Elements marking.

This image is representative of the overall condition of the stripe on the project.

🡐 Additional close-up of 3M Elements marking.

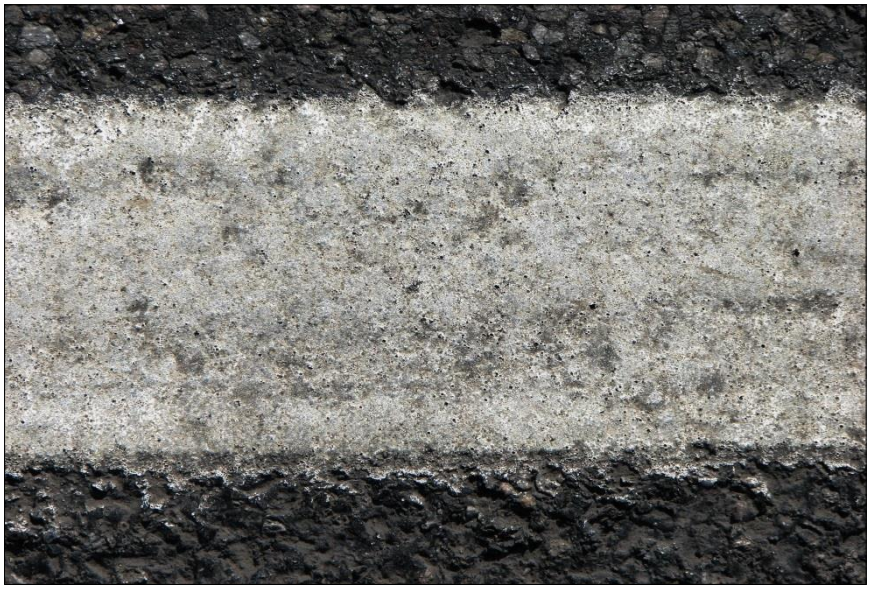
Type II Control Section

🡐 Overview of Type II Control section; view west near mile point 49.



🡐 Close-up of Type II marking.

This image is representative of the overall condition of the stripe on the project.



🡐 Additional close-up of Type II marking.

VISIMAX PLUS Section

🡐 Overview of VISIMAX PLUS section; view west near mile point 50.

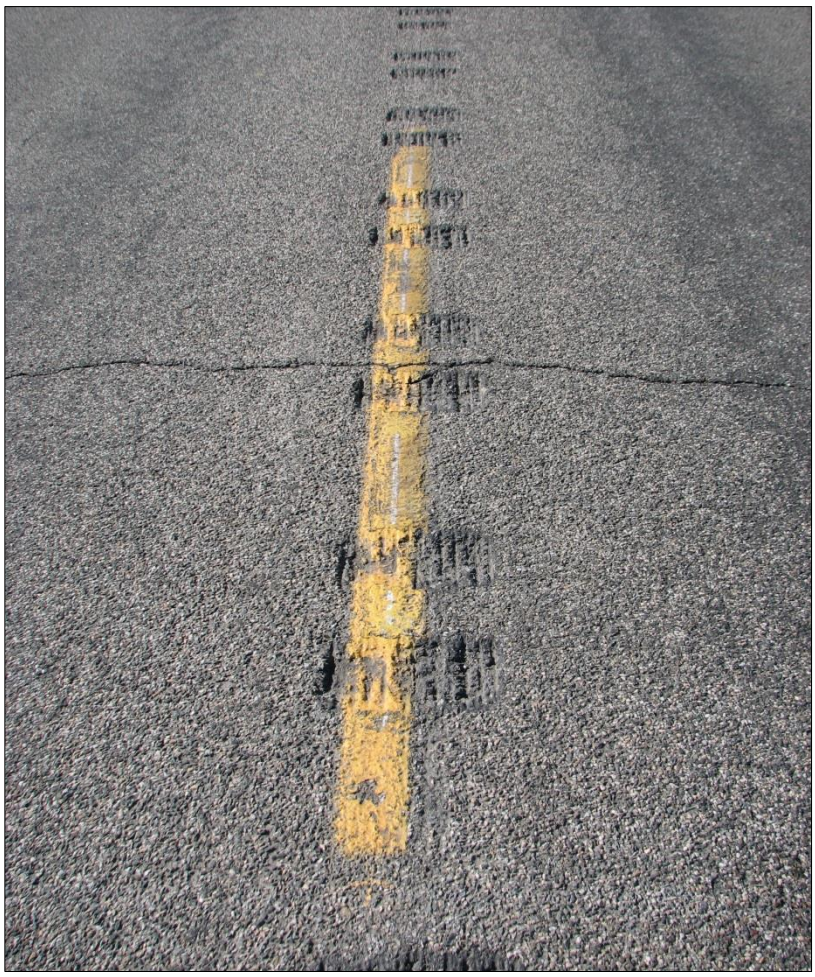
🡐 Close-up of VISIMAX PLUS marking.

This image is representative of the overall condition of the stripe on the project.

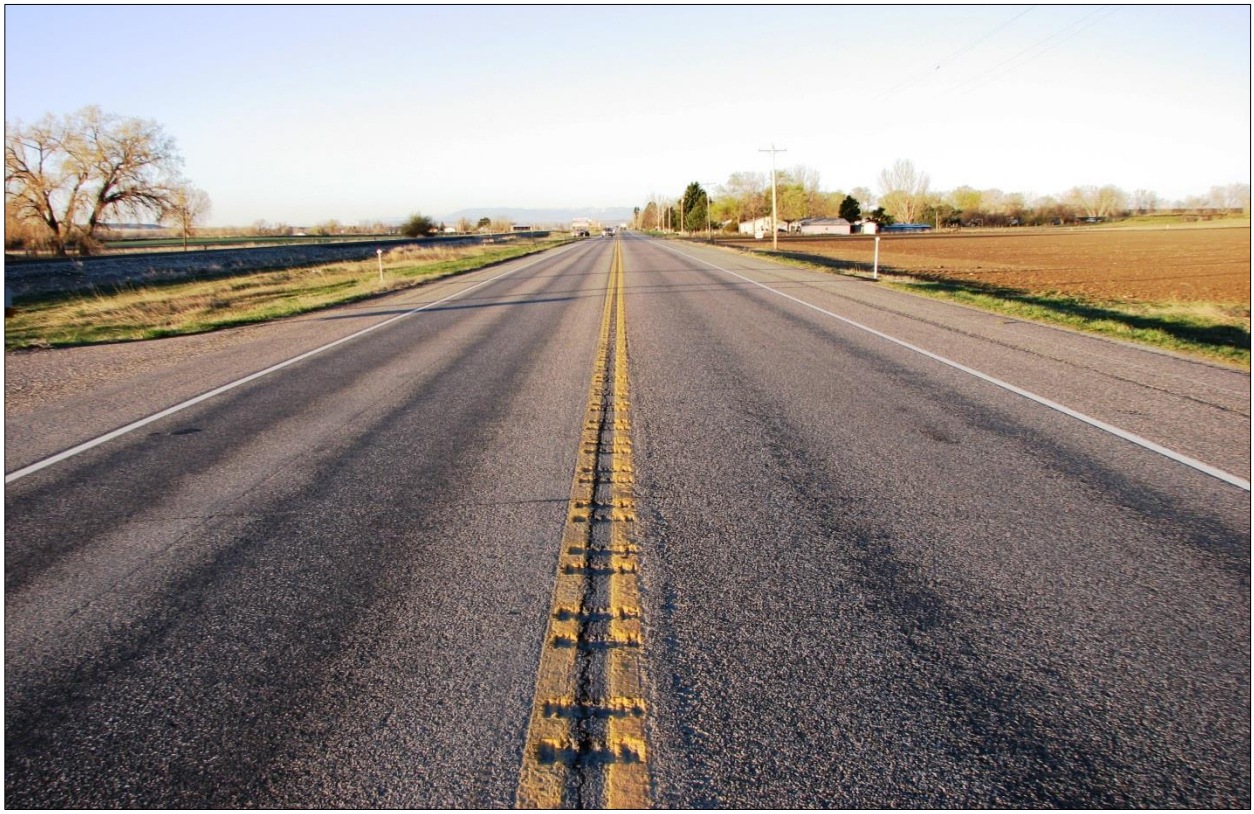
🡐 Additional close-up of VISIMAX PLUS marking.

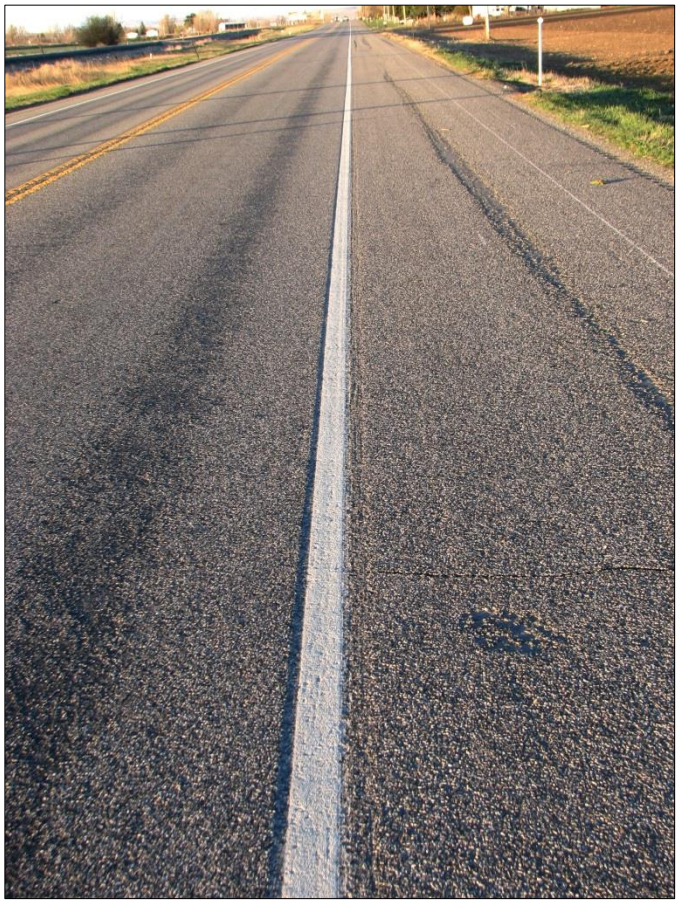
Yellow Centerline Documentation – March 2015

🡸🡻 Images representative of the general condition of the stripe over rumble strip on the project.



Site inspection April 2016: Visamax Section





🡅 Overview of Visamax Plus section, view south: Approximate mile post 52.

🡸 Representative image of the condition of white stripe indicative of the entire section.

The applied 60 mil grind depth, to date, appears to protect the stripe from plow pass damage as compared to the un-milled centerline stripes.

🡅🡇 Several close-ups of the Potters Visamax 50/50 blend with type II beads. Visually, it appears a small proportion of the larger bead spheres have debonded from the binder; either from inadequate embedment, environmental factors, vehicle tire impact; or successive plow passes may be wearing the pavement surface to a point where top contact with the recessed stripe is now beginning to take place.

Type II Control Section

🡅 Overview of Type II control section, view south: Approximate mile post 49.

🡄 Representative condition of the white stripe indicative of the entire section.

The applied 60 mil grind depth, to date, appears to protect the stripe from plow pass damage as compared to the un-milled centerline stripes.

🡅🡇 Several close-ups of the type II bead section.

3M Elements Section

🡅 Overview of 3M Elements section, view south: Approximate mile post 47.

🡄 Representative image of the condition of white stripe indicative of the entire section.

The applied 60 mil grind depth, to date, appears to protect the stripe from plow pass damage as compared to the un-milled centerline stripes.

Several close-ups of the 3M Elements 30% blend with type 2 beads. Visually, it appears a proportion of the larger bead elements have debonded from the binder; either from inadequate embedment, environmental factors, vehicle tire impact; or successive plow passes may be wearing the pavement surface to a point where top contact with the recessed stripe is now beginning to take place.

May 2017 Site Inspection

🡅 Representative image of project pavement marking condition; approximate reference point 51, view west.

All project sections (visually) were in the same condition as reported in 2016. Recessed fog line (white stripe) was in good shape, intact throughout the entire length of the project.

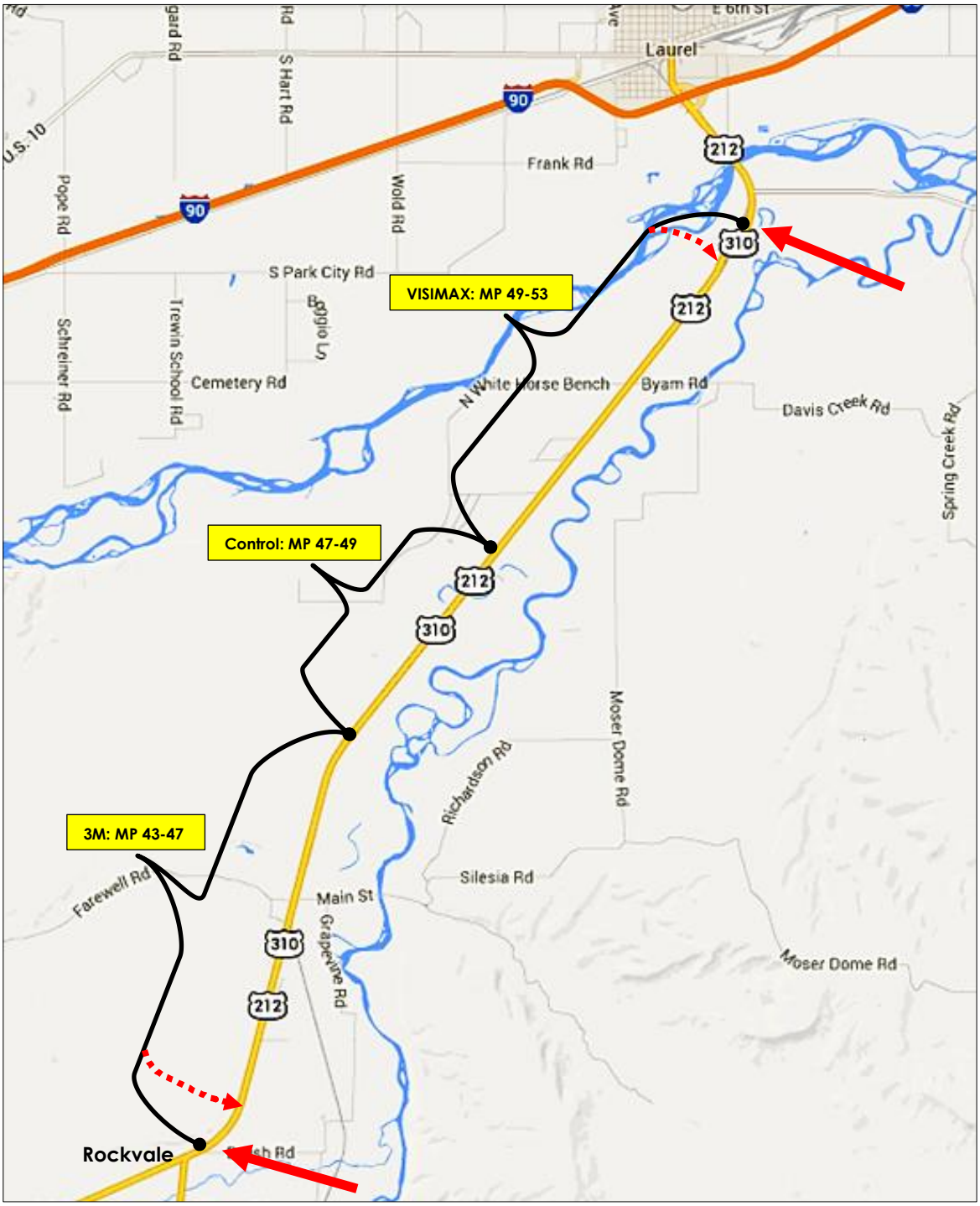
July 2018 Site Inspection

🡅 Representative image of project pavement marking condition; approximate location Carbon/Yellowstone County line (view south).

All project sections (visually) were in the same condition as reported in 2017. Recessed fog line (white stripe) was in good shape, intact throughout the entire length of the project sections.

🡄 Representative image of fog line condition on project.

🡅 Representative image of 60mil recessed fog line stripe. This has kept the stripe (on all sections) intact since installation in 2013.



***Project Sections Layout**

Section 1: 3M Wet Reflective Elements – Mile Point 42.9-46.9
Section 2: Control: Type 2 Glass Beads – Mile Point 46.9-48.9
Section 3: VISIMAX Plus – Mile Point 48.9- 52.9

Project length change due to Reconstruct - 2015

*All values are approximate, not to scale.

Disclaimer

The use of a product and/or procedure in the course of an evaluation does not constitute an endorsement by the Department nor does it imply a commitment to purchase, recommend, or specify the product/procedure in the future.

Data resulting from the project is public information and will not be considered privileged. The MDT may, at its discretion, release all information developed during and after the in-service evaluation.