

Transportation Safety Division

3M[™] Connected Roads All Weather Elements

Product Bulletin CR AWE for California January 2022

Replaces Product Bulletin CR AWE for California Dated May 2020

1 Description

3M[™] Connected Roads All Weather Elements ("**Elements**") have been designed for use on roadways and highways, primarily as long line pavement markings. They can be used in either new marking applications or as parts of maintenance marking applications. Elements, when used with compatible binders, form markings that are highly visible, day and night, under both dry and wet weather conditions.

 Table 1. 3M Connected Roads All Weather Elements product family.

	Series Names	
30	50	90
31	51	91
30M	50M	70M
31M	51M	71M
30E	50E	70E
31E	51E	71E

January 2022

2 Composite Optic Construction

Elements consist of an outer layer of microcrystalline ceramic beads partially embedded into composite cores to provide optimal performance under dry and/or wet conditions.

3 Specifications

3.1 Retroreflectivity

Elements, when tested according to the methods below, shall have the minimum wet and dry cup brightness values presented in Table 2.

Property/test method	Series 30,	Series 50,	Series 90,
	30E, 30M	50E, 50M	70E, 70M
Dry Cup Brightness	White: 11.1	White: 7.4	White: 1.8
R _A , cd/lx/m ²	Yellow: 5.9	Yellow: 4.6	Yellow: 1.1
Wet Cup Brightness	White: 0.8	White: 2.4	White: 4.2
R _A , cd/lx/m ²	Yellow: 0.6	Yellow: 1.2	Yellow: 2.1

Table 2. Minimum initial coefficients of retroreflection [cd/lx/m²].

3.2 Retroreflectivity Measurements

3.2.1 Equipment and Supplies

- 8 to 24 ounce (200 to 800 mL) glass jar and lid
- No. 30 US mesh 8" (200 mm) sieve or close equivalent
- Sieve pan
- Sieve lid
- 400 mL glass beaker
- Glass stir rod or metal spatula
- Large glass or plastic funnel (greater than 5 in. / 130 mm top opening)
- Balance, accurate to 0.1 gram
- Metal or plastic sample weighing pans
- Concentrated Simple Green[®] All Purpose Cleaner
- Drying oven, set to 150 °F (65 °C)
- Sample cups Glass petri dishes, approximately 2 to 4 in. (50–100 mm) diameter and at least ½ in. (12 mm) high
- RoadVista[®] 932 retroreflectometer or equivalent conforming to CIE Publication 054.2-2001 and/or ASTM E1709, capable of pointing nearly vertically down onto a sample resting on a horizontal surface with -4.0° entrance angle and 0.2° observation angle
- Wash bottle with water and soap solution 200:1 water to pH neutral household dish-washing detergent (5 g/L)

3.2.2 Sample Preparation

- 1. Collect a representative sample of Elements.
- 2. Measure out 100 grams of sample using balance.
- 3. Place 100 grams sample of Elements in clean glass jar and screw on lid.
- 4. Shake vigorously by hand for one minute to remove fines.
- 5. Attach sieve pan to bottom of sieve.
- 6. Empty jar contents onto the sieve.
- 7. Place lid on sieve, then swirl and shake sieve and contents for 30 seconds.
- 8. Remove sieve pan and lid and discard pan contents.
- 9. Transfer sieve contents into a clean 400 mL glass beaker, using funnel if necessary.
- 10. Pour or spray Simple Green[®] over the Elements until Elements are barely submerged.
- 11. Swiftly stir submerged Elements with glass rod or spatula for 20 seconds and let stand for 20 minutes. Fill the beaker to at least half way with clean water, then stir for 20 seconds.

- 12. Decant as much liquid from the beaker as possible without pouring out Elements.
- 13. Refill beaker containing Elements to at least half way with clean water, stir for 20 seconds, then decant as much liquid as possible. Repeat until rinse water is clean and clear (3–5 times).
- 14. Pour the Elements from the beaker onto the sieve, to remove any excess water, and spread them out evenly on the sieve screen to form a thin layer. Rinse the Elements in the sieve tray with clean water to remove any remaining debris and cleaning solution. Tilt the sieve slightly to allow excess retained water to run out of the sieve.
- 15. Place the sieve with Elements in the 150 °F (65 °C) drying oven and leave until thoroughly dry (allow at least 30 minutes).
- 16. Remove sieve and Elements from the oven and allow to cool to room temperature.
- 17. Transfer enough of the cooled Elements from the sieve to a glass petri dish, using a funnel if necessary, to form an even layer of Elements about 1/4 in. (6 mm) deep.

3.2.3 Dry Cup Brightness Test Procedure

- 1. Calibrate retroreflectometer according to manufacturer's recommendations.
- 2. Use manufacturer-supplied stabilizing devices to ensure proper alignment of retroreflectometer with the sample in the petri dish.
- 3. Set the retroreflectometer to take measurements using -4.0° entrance angle and 0.2° observation angle.
- 4. Place the dish and sample on a flat, level surface.
- 5. Carefully rest the instrument on the rim of the petri dish with its measurement area positioned over the Elements.
- 6. Take a measurement and record the R_A value in cd/lx/m².
- 7. Repeat the procedure for 2 more samples from each batch or lot and report values as the averages of the three samples.

3.2.4 Wet Cup Brightness Test Procedure

- 1. Calibrate retroreflectometer according to manufacturer's recommendations.
- 2. Use manufacturer-supplied stabilizing devices to ensure proper alignment of retroreflectometer with the sample in the petri dish.
- 3. Set the retroreflectometer to take measurements using -4.0° entrance angle and 0.2° observation angle.
- 4. Place the dish and sample on a flat, level surface.
- 5. Using the wash bottle, gently flood and cover the Elements in the petri dish with the soap and water solution. Manually press down any Elements that float to ensure a smooth, even liquid surface above the Elements, across the entire petri dish.
- 6. Carefully rest the instrument on the rim of the petri dish with its measurement area positioned over the Elements.
- 7. Take a measurement and record the R_A value in cd/lx/m².
- 8. Repeat the procedure for 2 more samples from each batch or lot and report values as the averages of the three samples.

3.3 Gradation

The gradation of Elements shall meet or be within the limits in Table 3.

 Table 3. Element gradation.

US Mesh	Micron	Mass Percent of Elements Passing ASTM D1921
10	2000	95–100
14	1410	0-40
20	850	0–5

4 Elements Use and Binder Compatibility

Table 4 presents the general compatibilities of Elements with several common pavement marking binders.

Binder	Target Thickness, final dry/cured (mils, 0.001")	Elements series for majority dry reflectivity with some wet reflectivity	Elements series for balanced wet and dry reflectivity	Elements series for high wet reflectivity
High build water-borne paint	18–25+	30	50	90
Thermoplastic	≥90	30	50	90
3M LPM 5000	18–25+	30	50	90
Epoxy and Polyurea (excluding LPM 5000)	18–25+	30E	50E	70E
Methyl Methacrylate (MMA)	20–150+	30M	50M	70M

 Table 4. General compatibilities of 3M Connected Roads All Weather Elements.

4.1 Reflective Elements for High Build Waterborne Paint

Elements Series 30, 50, and 90 are generally compatible with paints formulated with Dow[®] FASTRACK[™] HD21-A binder. Since formulations may vary, users should test for ultimate compatibility and performance. Markings should be applied at a target wet thickness of at least 25 mils (0.025 inches).

4.2 Reflective Elements for Thermoplastic Markings

Elements Series 30, 50, and 90 are generally compatible with formulations based on alkyd and hydrocarbon binders with a target thickness greater than 90 mils. At a minimum, these materials should meet AASHTO M249 specifications. Since formulations may vary, users should test for ultimate compatibility and performance.

4.3 Reflective Elements for Epoxy and Polyurea Markings

Elements Series 30E, 50E, and 70E are generally compatible with formulations of epoxy and polyurea pavement markings. Since formulations may vary, users should test for ultimate compatibility and performance.

4.4 Reflective Elements for 3M LPM 5000 Markings

Elements Series 30, 50, and 90 are compatible with 3M LPM 5000 markings. Please see <u>3M Product Bulletin</u> <u>3M LPM 5000</u> for further information.

4.5 Reflective Elements for Methyl Methacrylate (MMA) Markings

Elements Series 30M, 50M, and 70M are generally compatible with MMA pavement markings. Since formulations may vary, users should test for ultimate compatibility and performance.

5 Installation

5.1 Weather and Pavement Conditions

Elements should be applied according to the manufacturers' application guidelines for the appropriate binders.

5.2 Installation Equipment

Elements must be installed using a double-drop Element/bead delivery system. The Elements must be installed as the first drop of the two drop system and at a truck speed of no greater than 8 mph to minimize loss, prevent rolling, and ensure adequate sink. Contact 3M Technical Service at 1-800-553-1380 for additional information on modifying existing equipment.

5.3 Binder Thickness

Elements should be applied at target binder thicknesses according to the guidelines presented in Table 4. Contact 3M Technical Service for product recommendations and additional application information and restrictions.

5.4 Placement of Elements and Beads

Elements and accompanying second drop beads should be applied to pavement marking binders such that the Elements and beads do not roll, thus ensuring that their exposed portions are free of binder material. Elements and beads should be embedded (sunk) into binders to a depth of approximately 50% of their diameter. Undersinking the Elements and beads will result in their premature loss and the optical failure of the marking. Oversinking the Elements will result in low dry and wet brightnesses.

5.5 **Typical Properties**

Typical initial retroreflectance values are shown in Table 5. Some variance should be expected across applications, and all values represent initial properties unless otherwise noted.

Property/test method	Series 30, 30E, 30M	Series 50, 50E, 50M	Series 90, 70E, 70M
Retroreflectivity, Dry Average	White: 825	White: 700	White: 500
ASTM E1710	Yellow: 625	Yellow: 525	Yellow: 375
Retroreflectivity, Wet Recovery Average	White: 150	White: 275	White: 375
ASTM E2177	Yellow: 125	Yellow: 225	Yellow: 300
Retroreflectivity, Wet Continuous Average	White: 100	White: 200	White: 275
ASTM E2832	Yellow: 75	Yellow: 150	Yellow: 225

 Table 5. Typical average initial coefficients of retroreflected luminance^a [mcd/m²/lx].

a. Typical retroreflectivity results represent average performance for smooth pavement surfaces. Results may vary due to differences in pavement type and surface roughness. Initial readings taken of "M" or "E" Elements must be performed after the treatment has been cleaned off of the Elements. Increased Elements drop rate may be necessary to compensate for increased surface area characteristic of rough pavement surfaces. Wet retroreflectivity testing of markings applied in grooved or recessed surfaces is difficult since water pools in recesses. In such cases, consider installing sections of pavement markings for testing on either a smooth section of the pavement surface, or on rigid panels (50 mil aluminum). If markings are applied to panels, allow them to cure, then move them carefully for retroreflectivity testing - make sure to protect the optics when transporting.

Elements with "E" and "M" designations have been treated to prevent them from over-sinking into the binder and to slow the wicking of the binder onto the Elements. This treatment causes a temporary reduction in retroreflectivity that is regained after exposure to weather and vehicle traffic. Retroreflectivity recovery may take up to 5 weeks, depending on the weather and vehicle traffic levels. Data presented in Table 5 were, therefore, taken after the treatment was cleaned off. Similarly, users should take initial retroreflectivity readings on E and M type Elements after the treatment has been cleaned off by exposure to weather and vehicle traffic. However, if spot checks are required for markings containing "E" or "M" Elements at the time of application, they should only be performed upon fully hardened markings and after the treatment has been manually cleaned off of the Elements. To remove the treatment, soak the line section to be measured with Concentrated Simple Green[®] All Purpose Cleaner. Let stand for 2 minutes, then rinse clean with water. Blot the line with a clean, dry cotton towel to remove excess water and allow to dry completely before performing dry or wet retroreflectivity tests.

Table 6 show typical properties for markings made with Elements.

 Table 6. Other typical properties of 3M Connected Roads All Weather Elements.

Property	Test Method	Expected Result
Index of refraction of ceramic beads	ASTM E1967-98	1.89 for Dry, 2.4 for Wet
Acid resistance of glass	24-hr exposure of microcrystalline ceramic beads to 1% solution (by weight) sulfuric acid	No more than 15% of beads showing distinct opaque surface upon microscopic examination

5.6 Traffic Marking Binder Material

The marking binder shall be of quality and type as designated by governing agency. The quality binder shall be thoroughly mixed, homogeneous, and applied to the road surface per manufacturer's specifications.

5.7 3M Connected Roads All Weather Elements

Elements must be installed using the double-drop Element/bead delivery system. The Elements must be installed as the first drop of the double-drop system. The Elements shall be of the color of the traffic marking binder. Elements types shall also be chosen for each binder type according to the criteria described in Table 4. The typical gradation for Elements is shown in Table 3. Contact 3M application engineering for additional installation questions.

5.8 3M Connected Roads All Weather Elements Application Rates

Minimum Elements application rates for smooth or densely-packed pavement surfaces are presented in Table 7. The application rates stated provide good initial retroreflectivity and match the longevity, or restripe frequency, of most pavement marking binder systems to which the Elements are installed. More heavily traveled roads will require greater quantities of Elements to achieve similar longevities.

Rough pavement surfaces (open-graded mixes, large stone mixes, etc.) can have up to 50% more surface area than smooth surfaces. As a result, rough pavement surfaces require greater quantities of marking materials (binder, Elements, and beads) than smooth surfaces to achieve similar coverages.

Units	Minimum for Durable Markings on Smooth Surface	Minimum for Temporary Markings on Smooth Surface
Pounds per 4-inch lineal foot	0.018	0.009
Pounds per mile, 4-inch width	93	46.5
Grams per 4-inch lineal foot	8	4
Grams per square foot	24	12
Grams per square meter	260	130
Pounds per gallon - 20 mils ~240 ft/gal	4.2	2.1
Pounds per gallon - 25 mils ~ 190 ft/gal	3.4	1.7
Pounds/100 Sq ft	5.3	2.6
Element count per square inch, average	35-40	18–20

Table 7. 3M Connected Roads All Weather Elements application rates.

5.9 Second Drop Glass Beads

A second drop of glass beads is necessary to improve physical characteristics, durabilities of finished markings, and assure expected track-free times. Glass beads usually provide some measure of increased visibility during dry conditions as well.

Many different glass bead gradations are currently used for pavement markings. Table 8 presents glass bead gradations appropriate for application to paint, polyurea, epoxy, 3M LPM 5000, MMA, and thermoplastic. The gradation of the second drop must meet or be within the limits in Table 8.

Common bead types with liquid pavement markings Bead gradations - mass percent passing (ASTM D1214)					
US Mesh	Microns	AASHTO M247 Type 1	Missouri Specification Type P ^a	FP03 718.19 Type 3	18/50 (Utah) Performance Specification
12	1700			100	
14	1410			95–100	
16	1180	100		80-95	
18	1000			10-40	65-80
20	850	95–100	90–97	0–5	
25	710			0-2	
30	600	75–95	60-87		0–30
40	425				
50	300	15–35	0–15		0–5
70	212		0–5		
80	180				
100	150	0–5			

Table 8. Typical gradations of second drop glass beads.

a. A minimum of 15% of the total weight shall be from direct melt glass. All +30 US mesh beads shall be 85% minimum rounds and have a minimum crush strength of 30 lbs. in accordance with ASTM D1213.

Typical glass bead application rate ranges are shown in Table 9.

Table 9. Typical glass bead application rates.

Binder Type Units	High Build Waterborne Paint	Polyurea / 3M LPM 5000	Epoxy ^a	ММА	Thermoplastic
Pounds per 4" lineal foot	0.026-0.053	0.033-0.053	0.05-0.0917	0.033-0.053	0.033-0.053
Grams per 4" lineal foot	12-24	15–24	22.7-41.6	15–24	15–24
Pounds per gallon - 20 mils ~240 ft/gal	6.4–12.8	8.0–12.8	12–22		
Pounds per gallon - 25 mils ~ 190 ft/gal	5.1–10.2	6.4–10.2	9.5–17.4		
Pounds/100 Sq ft	7.94–15.87	9.92–15.87	15–27.5	9.92–15.87	9.92–15.87
Preferred bead type	Missouri Type P or 18/50 (Utah)		18/50 (Utah) or FP	-3 #718.19 Type 3	

a. Bead drop rate may be adjusted to achieve adequate track-free time.

5.10 Quality of Second Drop Glass Beads

The required glass beads shall have an index of refraction of 1.5 when tested by the immersion method at 25 °C (77 °F). The glass beads shall be surface treated for optimal performance with the liquid binder traffic marking. The glass beads shall have a minimum of 70% rounds as measured according to ASTM D1155. The surfaces of the glass beads shall be free of pits and scratches. The glass beads retained on a #40 U.S. mesh sieve (425 microns) shall have a minimum crush strength of 30 pounds, in accordance with ASTM D1213.

6 Storage

For best results, store Elements, covered and off the ground, in a cool (40–100 °F, 4–38 °C), dry area, indoors or outdoors. Use Elements within one year of receipt. Follow binder and glass bead manufacturers' instructions for storage.

7 Health and Safety Information

Read all health hazard, precautionary, and first aid statements found in the Safety Data Sheet (SDS) and/or product labels of chemicals prior to handling or use. Refer to SDSs for information regarding volatile organic compound (VOC) contents of chemical products. Consult local regulations and authorities for possible restrictions on product VOC content and/or VOC emissions.

8 Quality Policy and Warranty Information

8.1 3M Basic Product Warranty

3M has no control over application methods or the quality of the surface to which materials are applied. Therefore, 3M's warranty for Elements shall be limited to the quality of materials supplied.

Elements are warranted ("**Basic Warranty**") to be free of defects in materials and manufacture at the time of shipment and to meet the specifications stated in this product bulletin. If the Elements are proven not to have met the Basic Warranty on their shipment date, then a buyer's exclusive remedy, and 3M's sole obligation, at 3M's option, will be refund or replacement of the Elements.

8.2 Disclaimer

THE 3M WARRANTY IS MADE IN LIEU OF ALL OTHER WARRANTIES OR CONDITIONS, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTY OR CONDITION OF MERCHANTABILITY, OR FITNESS FOR A PARTICULAR PURPOSE, OR ANY IMPLIED WARRANTY ARISING OUT OF A COURSE OF DEALING OR OF PERFORMANCE, CUSTOM, OR USAGE OF TRADE.

8.3 Limitation of Liability

Except for the limited remedy stated above, and except where prohibited by law, 3M will not be liable for any loss or damage arising from the use of or the inability to use the Elements or any 3M product, whether direct, indirect, special, incidental, or consequential damages (including but not limited to lost profits, business, or revenue in any way), regardless of the legal theory asserted including warranty, contract, negligence, or strict liability. Before using, the user shall determine the suitability of Elements for his/her intended use and the user assumes all risk and liability whatsoever in connection therewith.

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9 Other Product Information

Always confirm that you have the most current version of the applicable product bulletin, information folder, or other product information from 3M's Website at <u>http://www.3M.com/roadsafety</u>.

10 Literature References

<u>3M IF 5.22</u>	All Weather Paint Application Guidelines for Elements and Glass Beads on a High-Build Waterborne Traffic Marking Paint
3M IE 5 23	3M™ Connected Roads All Weather Elements Application Guidelines for 3M Connected
<u>51VI IF 5.25</u>	Roads All Weather Elements
<u>3M IF 5.24</u>	3M™ All Weather Thermoplastic Pavement Markings Application Guidelines
<u>3M IF 5.28</u>	Liquid Pavement Marking Application Guidelines Series 5000

3M PB AWPAll Weather Paint3M PB AWTAll Weather Thermoplastic3M PB LPM 50003M™ Liquid Pavement Marking Series 5000

ASTM Test Methods are available from ASTM International, West Conshohocken, PA.

For Information or Assistance Call: 1-800-553-1380 In Canada Call: 1-800-3M HELPS (1-800-364-3577)

Internet:

http://www.3M.com/roadsafety

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