

**(b) Optical Performance**

Test the reflector for specific intensity as described below:

Form a 1" diameter flat pad using #3 coarse steel wool per Federal Specification FF-W-1825. Place the steel wool pad on the reflector lens. Apply a load of 50 lb and rub the entire lens surface 100 times. Do not abrade the red lens of the Type 3 and Type 4 bi-directional units.

Locate the reflector to be tested with the center of the reflecting face at a distance of 5 ft from a uniformly bright light source having an effective diameter of 0.2".

The photocell must be an angular ring 0.37" I.D. x 0.47" O.D. Shield it to eliminate stray light. The distance from light source center to the center of the photoactive area shall be 0.2". If a test distance of other than 5 ft is used, modify the source and receiver in the same proportion as the test distance.

After abrading the lens surface using the above steel wool abrasion procedure, the specific intensity of each crystal reflecting surface at 0.2 degrees observation angle must not be less than the following when the incident light is parallel to the base of the reflector.

<b>TABLE 1086-1 MINIMUM SPECIFIC INTENSITY (candle/footcandle/unit marker)</b>		
<b>Color</b>	<b>Horizontal Entrance Angle</b>	
	<b>0 Degrees</b>	<b>20 Degrees</b>
Crystal	3.00	1.20
Yellow	1.80	0.72
Red	0.75	0.30

**(D) Properties**

All optical and physical properties for snowplowable pavement markers shall conform to ASTM D4383.

**(E) Epoxy Adhesive**

The epoxy adhesive shall meet the requirements of Section 1081. Mix the epoxy adhesive rapidly by a 2 component type automatic metering, mixing and extrusion apparatus.

**(F) Material Certification**

Furnish a Type 2 material certification in accordance with Article 106-3 for all raised snowplowable markers before use.

## **SECTION 1087 PAVEMENT MARKINGS**

**1087-1 GENERAL**

Yellow and white pavement markings shall be retroreflective. Black pavement markings shall be matte, non-retroreflective.

The material manufacturer has the option of formulating the pavement marking material according to his own specifications; however, the manufacturer shall meet all the minimum requirements specified herein.

All pavement marking materials, pigments, beads and resins shall be free from all skins, dirt and foreign objects.

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1 Use pavement marking materials capable of being fabricated into pavement markings of  
2 specified dimensions and adhering to asphalt and Portland cement concrete pavements when  
3 applied in accordance with their manufacturer’s recommendation.

4 Pavement marking materials upon heating shall not exude fumes, which are toxic, or injurious  
5 to persons or property.

6 Homogeneously mix all pavement marking materials.

7 **1087-2 COMPOSITION**

8 **(A) Paint Composition**

9 Pavement marking paint shall be a ready mixed type paint product conforming to Federal  
10 Specification FP03 with spraying consistency suitable for use as a retroreflective  
11 pavement marking. Glass beads are dropped by suitable pressurized means into the wet  
12 paint as it is applied to the pavement.

13 **(B) Removable Tape Composition**

14 Removable tape pavement marking shall be composed of materials as specified by their  
15 manufacturer.

16 Use removable tape markings capable of conforming to pavement contours, breaks,  
17 faults, etc. through the action of traffic at normal pavement temperatures. The tape shall  
18 have resealing characteristics such that it is capable of fusing with itself and previously  
19 applied marking tape of the same composition under normal conditions of use. The  
20 removable tape markings shall be patchable.

21 Use removable tape markings capable of adhering to the pavement by  
22 a pressure-sensitive pre-coated adhesive or as directed by the manufacturer.

23 **(C) Thermoplastic Composition**

24 Use thermoplastic alkyd/maleic pavement markings composed of the materials in  
25 Table 1087-1.

<b>TABLE 1087-1 PHYSICAL PROPERTIES OF THERMOPLASTIC ALKYD/MALEIC PAVEMENT MARKINGS</b>	
<b>Component</b>	<b>By Weight</b>
Alkyd/Maleic Binder	18.0% Min
Glass Beads (Premixed)	30.0% Min
Titanium Dioxide Pigment (ASTM D476 Type 2)	10.0% Min.
Yellow Pigment (For Yellow Marking Only) Silica Encapsulated Lead Chromate Pigment	4.0% Min.

26 Use white thermoplastic that does not contain anatase titanium dioxide pigment.

27 Provide yellow thermoplastic that contains only heat resistant silica encapsulated lead  
28 chromate pigment. The lead chromate pigment shall contain at least 60% lead chromate.

29 Calcium carbonate and inert fillers may be as opted by the manufacturer, providing all  
30 other qualifications are met.

31 The total silica content used in the formulation of the thermoplastic shall be the premixed  
32 glass beads. Uniformly disperse the pigment, beads, and filler in the binder.

1 The Alkyd/maleic binder shall consist of a mixture of synthetic resins (at least one  
 2 synthetic resin shall be solid at room temperature) and a high boiling point plasticizers.  
 3 At least 1/2 of the binder composition shall be 100% maleic-modified glycerol of resin  
 4 and be no less than 15% by weight of the entire material formulation. The binder shall  
 5 contain no petroleum hydrocarbon resins. Use resins/rosins that are maleic-modified  
 6 glycerol esters.

7 The thermoplastic material shall be free of contaminates and be homogeneously dry-  
 8 blended or hot mixed from 100% virgin stock using no reprocessed materials, (excluding  
 9 the requirement to use reprocessed glass).

10 The thermoplastic material shall not deteriorate or discolor when held at the application  
 11 temperatures for at least 4 hours or upon repeated reheating (at least 4 times).

12 The color, viscosity and chemical properties versus temperature characteristics of the  
 13 thermoplastic material shall remain constant for up to 4 hours at the application  
 14 temperature and be the same from batch to batch.

15 The thermoplastic material shall be readily applicable at temperatures between 400°F and  
 16 440°F from the approved equipment to produce lines and symbols of the required above  
 17 the pavement thickness.

#### 18 **(D) Cold Applied Plastic Composition**

19 The cold applied plastic pavement marking shall consist of a mixture of high quality  
 20 polymeric materials, pigments and glass beads distributed throughout its base cross-  
 21 sectional area, with a reflective layer of beads bonded to the top surface.

22 The cold applied plastic markings shall adhere to the pavement by a pressure-sensitive  
 23 pre-coated adhesive.

24 The cold applied plastic shall conform to pavement contours, breaks, faults, etc. through  
 25 the action of traffic at normal pavement temperatures. The film shall have resealing  
 26 characteristics such that it is capable of fusing with itself and previously applied marking  
 27 tape of the same composition under normal conditions of use. The cold applied plastic  
 28 pavement marking shall be patchable.

#### 29 **1087-3 COLOR**

30 All pavement markings, without drop-on beads, shall visually match the color chips that  
 31 correspond to the Federal Standard Number 595b for the following colors:

Crystal: Color No. 17886 (White)

Yellow: Color No. 13538

Black: Color No. 37038

#### 32 **1087-4 GLASS BEADS**

##### 33 **(A) Composition**

34 The silica content of the glass beads shall be at least 60%.

35 Manufacture the beads from 100% recycled non-pigmented glass from a composition  
 36 designed to be highly resistant to traffic wear and to the effects of weathering. All  
 37 standard intermix and drop-on glass beads shall be manufactured using 100% North  
 38 American recycled glass cullet.

39 Glass beads shall have no more than 75 ppm of arsenic as determined by the United  
 40 States Environmental Protection Agency Method 6010B in conjunction with the United  
 41 States Environmental Protection Agency Method 3052 modified.

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### 1 (B) Physical Characteristics

2 Use glass beads that are colorless, clean, transparent and free from milkiness, excessive  
3 air bubbles, skins and foreign objects. Use glass beads with a minimum refractive index  
4 of 1.50 when tested by the liquid immersion method at 77°F ± 9°F in accordance with  
5 ASTM D1214 using the Becke Line Method or an equivalent method. Use glass beads  
6 that are spherical in shape and essentially free of sharp angular particles or particles  
7 showing surface scarring or scratching.

8 All intermixed and drop-on glass beads shall comply with NCGS § 136-30.2.

### 9 (C) Gradation & Roundness

10 Use drop-on and intermixed glass beads in all pavement markings with at least 80% true  
11 spheres when tested in accordance with ASTM D1155. Drop-on and intermixed glass  
12 beads used on any pavement markings shall meet Table 1087-2.

Sieve Size	Gradation Requirements	
	Minimum	Maximum
Passing #20	100%	--
Retained on #30	5%	10%
Retained on #50	40%	80%
Retained on #80	15%	40%
Passing #80	0%	5%
Retained on #200	0%	5%

### 13 (D) Chemical Resistance

14 Conduct the following chemical resistance test on all glass beads:

15 Place 3 to 5 g portions of the same glass bead batch to be tested in 3 separate glass  
16 beakers or 3 porcelain dishes. Cover one sample with distilled water, cover the second  
17 sample with 3N solution of sulfuric acid and cover the third sample with 50% solution of  
18 sodium sulfides. After one hour of immersion, examine the glass bead samples  
19 microscopically for evidence of darkening or frosting. All 3 samples shall show no  
20 evidence of darkening or frosting.

### 21 (E) Moisture Resistance

22 Conduct the following moisture resistance test on drop-on glass beads:

23 Place a 2 lb minimum sample of glass beads in a clean, washed cotton bag with a thread  
24 count of 50 warp, 50 woof. Immerse the bag containing the sample in a container of  
25 water for 30 seconds or until the water covers the spheres, whichever is longer. Remove  
26 the bag from water and force excess water from the sample by squeezing the bag.  
27 Suspend the bag and allow to drain for 2 hours at room temperature 70°F to 72°F. Then  
28 mix the sample in the bag by shaking thoroughly. Transfer the sample slowly to a clean  
29 dry glass funnel having a stem of 4" in length with 1/4" inside diameter. The entire  
30 sample shall flow freely through the funnel without stoppage. When first introduced in  
31 the funnel, if the spheres clog, it is permissible to lightly tap the funnel to start the flow.

### 32 1087-5 PACKAGING FOR SHIPMENT

33 Deliver all pavement marking and glass bead materials to the project in suitable containers  
34 packaged by the manufacturer. Clearly and adequately mark each material container to  
35 indicate the material, color, date of manufacture, process, batch or lot number, manufacturer's  
36 name and location, temperature application range, shelf life and include the MSDS.

1 Thermoplastic pavement marking materials shall be in block or granular form packaged in  
 2 either suitable corrugated containers or thermal degradable plastic bags to which it will not  
 3 adhere during shipment or storage.

4 Package glass beads in moisture resistant packaging.

5 **1087-6 STORAGE LIFE**

6 All pavement marking materials shall meet this Specification for one year from the date of  
 7 shipment from the manufacturer to the Contractor, or the project when stored properly by the  
 8 manufacturer's recommendation. Replace any pavement marking materials not meeting these  
 9 Specifications.

10 **1087-7 TESTS TO BE PERFORMED**

11 When independent test laboratory tests are required, perform them on samples taken by  
 12 an agency certified by the Department from the same process, batch or lot number as the  
 13 material shipped to the project. The test reports shall contain the lot number. Use  
 14 Department approved independent test laboratories.

15 Perform the following tests on thermoplastic pavement marking materials, intermixed glass  
 16 beads and drop-on glass beads unless prescribed otherwise by the Engineer:

17 **(A) Intermixed and Drop-on Glass Beads**

18 Use X-ray Fluorescence for the normal sampling procedure for intermixed and drop-on  
 19 beads, without crushing, to check for any levels of arsenic. If any arsenic is detected, the  
 20 sample shall be crushed and repeat the test using X-ray Fluorescence. If the test detects  
 21 more than 75 ppm arsenic, perform tests as determined by the United States  
 22 Environmental Protection Agency Method 6010B and 3052 modified. Drop-on glass  
 23 beads or pavement markings containing glass beads with more than 75 ppm arsenic shall  
 24 not be approved for use.

25 **(B) Thermoplastic Pavement Marking Material Composition**

26 (1) % Binder tested in accordance with ASTM D4797.

27 (2) % Titanium Dioxide Pigment tested in accordance with ASTM D3720 or D4764.

28 (3) % Lead Chromate Pigment tested in accordance with D4797.

29 (4) % Glass Beads tested in accordance with ASTM D4797.

30 Except ash, use a 100 gram sample rather than a 10 gram sample to allow for testing of  
 31 gradation and percent of rounds. Provide the results of sieve analysis and % rounds.

32 **(C) Flash Point**

33 The thermoplastic shall have a flashpoint of no less than 500°F when tested in  
 34 accordance with ASTM D92 COC.

35 **(D) Requirements**

36 The thermoplastic material after heating for  $240 \pm 5$  minutes at  $425 \pm 3^\circ\text{F}$  and cooled to  
 37  $77 \pm 3^\circ\text{F}$  shall meet the following:

38 (1) Color

39 (a) White

40 Daylight reflectance  $2^\circ$  Standard observer and CIE illuminant

41 Using XYZ scale D65/10° - 80% minimum

42 ASTM E1349

43 Yellowness Index - The white thermoplastic shall not exceed a yellowness index  
 44 of 0.12

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- 1 (b) Yellow
- 2 Daylight reflectance at 2° Standard observer and CIE illuminant
- 3 Using XYZ scale D65/10° - 45% minimum =Y
- 4 ASTM E1349
- 5 (2) Bond Strength
- 6 The bond strength shall be 200 psi or greater in accordance with ASTM D4796.
- 7 (3) Cracking Resistance at Low Temperatures
- 8 After applying a 4", 125 mil draw-down to concrete blocks and cooling to 15 ± 3°F,
- 9 the material shall show no cracks at an observation distance of 12".
- 10 (4) Specific Gravity
- 11 The specific gravity shall be 1.95-2.20 in accordance with ASTM D792.
- 12 (5) Softening Point
- 13 The softening point shall be 215 ± 15°F in accordance with ASTM D36.
- 14 (6) Drying Time
- 15 When applied at a thickness of 125 mils, the material shall set to bear traffic in no
- 16 more than 2 minutes when air and substrate temperature is 50°F ± 3°F (and no more
- 17 than 10 minutes when the air and substrate temperature is 90°F ± 3°F when applied
- 18 at temperature of 412.5 ± 12.5°F in accordance with AASHTO T 250.
- 19 (7) Alkyd Binder Determination
- 20 The thermoplastic material shall immediately dissolve in diacetone alcohol. Slow
- 21 dissolution is evidence of the presence of hydrocarbon binder components.
- 22 (8) Indentation Resistance
- 23 The Shore Type A2 Durometer with a 4.41 lb load applied shall be between 40 and
- 24 75 units after 15 seconds at 115°F in accordance with ASTM D2240.

**1087-8 MATERIAL CERTIFICATION**

26 Furnish the following pavement marking material certifications in accordance with  
27 Article 106-3:

Glass Beads	Type 3 Material Certification and Type 4 Material Certification
Paint	Type 3 Material Certification
Removable Tape	Type 3 Material Certification
Thermoplastic	Type 3 Material Certification and Type 4 Material Certification
Cold Applied Plastic	Type 2 Material Certification and Type 3 Material Certification
Polyurea	Type 3 Material Certification

**SECTION 1088  
DELINEATORS**

**1088-1 REFLECTIVE UNIT REQUIREMENTS FOR DELINEATORS**

**(A) Definition**

- 32 Refer to ASTM D4956.
- 33 Define “entrance angle” as the angle at the reflector between direction of light incident on
- 34 it and direction of reflector axis.