



OFFICE MEMORANDUM

DATE: March 28, 1979

TO: K. A. Allemeier
Engineer of Testing and Research

FROM: M. H. Janson

SUBJECT: Astro Optics Delineators
Research Project 78 NM-559, Research Report No. R-1110

This is in response to D. E. Orne's October 12, 1978 request to test the subject delineators. According to the memo, the delineators had been received through the New Materials Committee. One type of delineator was submitted to the Committee in September by Jerry Bracy, District Manager for the R. E. Dietz Company, and a representative of Astro Optics Corporation.

On October 26, 1978, John Sweeney, Vice President of Roadway Specialties, Incorporated, submitted three additional delineator types, and also indicated that he represented Astro Optics.

Optical tests and water seal tests were requested in Mr. Orne's memo. Photometric tests showed that the delineators did meet the manufacturer's claims but the water seal tests showed that the manufacturer had difficulty in obtaining a satisfactory seal.

The Laboratory had received the following crystal and yellow delineators for evaluation:

- 1) Astro Optics Model 001, for center mounting on delineator posts,
- 2) Astro Optics Model B-1, for mounting on concrete barriers,
- 3) Astro Optics Model GR-1, similar to B-1 but fitted for mounting in guardrails,
- 4) Astro Optics Model CM-1, for mounting on raised curbs.

After learning of the water seal test failures, A. P. Schueler, President of Astro Optics Corporation contacted the Laboratory. It was claimed that the samples were prototypes and had been submitted in error by Mr. Sweeney. On December 19, 1978, claimed production samples were submitted by J. Kennedy of Astro Optics and their representative J. Bracy.

The delineators as noted above were evaluated in the Laboratory by conducting photometric, color, seal, and heat or warping tests. Materials used in delineator fabrication were also identified. Results of the tests show that the manufacturer can produce satisfactory delineators if quality control is improved.

Astro Optics Model 001 Center Mount Delineator

These delineators are intended for edge of roadway or ramp delineation as a replacement for center mount delineators presently used. Two units, one crystal and one yellow, were evaluated (Fig. 1). Color of the yellow delineator is near the green limit but does conform with specified requirements as shown in Figure 2. The figure shows an outline of the specified SAE color space and the chromaticity coordinates obtained from measurements on a 0.25-in. thick disc molded from pieces of the delineator.

The seal between the front face and the back face was satisfactory. The delineators showed no evidence of water intake after being submerged in water in a pressurized container at 2.5 psi for 15 minutes. Results from a heat test which subjected the delineators to a 125 F temperature for four hours showed little or no effect on the photometric performance of the delineators.

The delineator face material was identified as an acrylic plastic and the support backing was identified as ABS plastic.

Considering intended use, the Model 001 delineators conform with MDOT specific luminance requirements for center mount delineators. Comparison of photometric test values for the yellow and crystal delineators showed that the delineators had approximately equal reflective intensities. Crystal delineators were expected to have approximately a 1.6 greater reflective intensity than the yellow. Improved quality control is indicated. From an approximate 400-ft driver sight condition and beyond, Model 001 and center mount delineators provide an approximately equivalent reflective intensity performance in an entrance angle range of -45 degrees to +25 degrees. However, under these sight conditions, the Model 001 delineators exceed the performance of center mount delineators at +30 degree (traffic side) entrance angles and maintain a useful retroreflective range to +50 degrees. For sight distance viewing conditions less than 300 ft, and at -30 to +50 degree entrance angles, the Model 001 delineators have either a slightly greater reflective intensity than Type 3 (3M High Intensity) reflective sheeting (10 sq in.) delineators or an equivalent reflective intensity. At -5 to -30 degree entrance angles, the Type 3 delineators provide a greater reflective intensity than the Model 001 delineators.

The above comparisons are based on a photometric 0 degree entrance angle that is normal with respect to the face of the delineator and a mounting orientation angle of 90 degrees or normal to a driver's line of sight. Entrance angle and orientation angle geometries are shown in Figure 3.

Required performance at entrance angles greater than +20 degrees is usually limited to sight distances less than 400 ft and to horizontal curves, ramps, and reduced speed areas. Delineation in such areas might be improved by installing the Model 001 delineators. For sight distances beyond 500 ft the Model 001 delineators would provide a reflective intensity performance equivalent to currently used 3-in. center mount delineators. Tables 1 and 2 show specific luminance values for 90, 60, and 45 degree

mounting geometries. Values are also shown for center mount delineators and reflective sheeting. The values can be used for delineator reflective intensity comparisons for sight distances of at least 400 ft.

NOTE: It must be understood that the specific luminance values are similar to efficiency values and can only be used for comparing various types of delineators. The values at the various orientation or entrance angles of a given delineator cannot be compared to show field performance. The values are not equivalent to brightness as seen by a driver. For example, the crystal delineator specific luminance value at the 10-degree entrance angle is 80 percent of the 0 degree value but in the field, headlight illumination available at 10 degrees is only about 10 percent of the 0-degree illumination, and, therefore, a comparison for field performance could show that at 10 degrees the brightness is about 8 percent of the brightness at 0 degrees. Comparisons of data under similar viewing and lighting conditions can show, for example, that at 40 degrees the Model 001 delineators would appear brighter than a center mount delineator, but human eye response would render the comparison somewhat less than the approximately six times difference shown by the specific luminance values.

Astro Optics Model B-1 and GR-1 Delineators

These delineators are intended for barrier wall or guardrail installation. Two units of each model as shown in Figure 4, one crystal and one yellow were evaluated. Color of the yellow delineators is near the green limit as noted above. One of the units, Laboratory No. 78 RD-282, showed evidence of water intake after being submerged in water at 2.5 psi for 15 minutes.

Results from the heat test showed little or no effect on the photometric performance of the delineators.

Comparison of photometric test values for the yellow B-1 and GR-1 delineators showed that the GR-1 delineator had approximately twice the reflective intensity of the B-1 delineator. Approximately equal values as found for the crystal delineators were expected. Improved quality control is indicated.

The delineator face material was an acrylic plastic and the support backing was identified as ABS plastic.

The Model B-1 delineator was designed specifically for barrier wall installation and the support backing as modified for the Model GR-1 delineator was designed for guardrail installation. Fastening is accomplished with adhesives. Comparing the photometric performance of one of these delineators mounted or oriented parallel to the traffic flow and a guardrail washer delineator oriented perpendicular to the traffic flow shows that:

- 1) For an approximate viewing distance of 400 ft and beyond the B-1 and GR-1 delineators have a slightly better reflective intensity performance at entrance angles of -10 to +30 degrees. The B-1 and GR-1 delineators have a useful retroreflective range to +75 degrees (traffic side).

2) For sight distances of less than 300 ft, the B-1 and GR-1 have reflective intensity characteristics approximately equivalent to reflective sheeting delineators at entrance angles of -10 to +45 degrees but again the B-1 and GR-1 exceed the reflective intensity characteristics of reflective sheeting and have a useful retroreflective range to +75 degrees.

Tables 3 and 4 show specific luminance values for barrier wall or guardrail mounting geometries at 0 degree and 30 degree orientations. The values can be used for delineator reflective intensity comparisons for sight distances of at least 400 ft. It should be noted that the 0 degree mounting geometry would result in the larger face of the delineator fastened to the wall or parallel with the driver's sight in a straight roadway section.

Astro Optics Model CM-1 Delineators

These units are designed for raised curb or obstacle delineation. Two units as shown in Figure 5, one crystal and one yellow were evaluated. Test results on color, seal, and resistance to warping were satisfactory. Photometry test results for short range viewing conditions are shown in Table 5.

Recommendations

Model 001 Center Mount Delineators - It is recommended that the delineators be evaluated in the field as a replacement for 3-in. center mount delineators currently used. Installation in ramp, horizontal curve, and low speed areas should be considered.

Model GR-1 Guardrail and B-1 Barrier Wall Delineators - Guardrail installations should be considered for evaluation but a barrier wall installation is especially recommended because of the delineators low profile. The delineator would protrude about 1 in. from the wall. Astro Optics has recently reinforced the protruding wing of the delineator as shown in Figure 4.

If protrusion from the wall is not an important consideration, then the use of either two center mount delineators or two pieces of Type 3 sheeting, mounted as shown in Figure 6, can be recommended for barrier wall delineation. The alternative is suggested on the basis of center mount delineator or sheeting delineator performance as summarized in Tables 3 and 4 and on the assumption that delineators installed as shown in the figure would cost about the same as one Astro Optics delineator.

Model CM-1 Delineator - A field evaluation of these markers is recommended for installations such as raised curbs in safety islands, exit gores and tops of barrier walls or guardrail posts.

Optical performance characteristics for limited viewing distance delineators such as the Model B-1 and GR-1 delineators are recommended as shown in Table 6.

TABLE 6
OPTICAL PERFORMANCE OF LIMITED
VIEWING DISTANCE DELINEATORS*

Color	Specific Luminance, Candlepower Per Footcandle Per Unit At 0.2 Degree Divergence Angle		
	Entrance Angle, degrees		
	0	+20	+60
Crystal	25	25	25
Yellow	15	15	15

* Oriented per manufacturer's recommendations.

TESTING AND RESEARCH DIVISION

Marvin H. Jensen

Supervisor - Spectrochemistry and
Photometry Unit

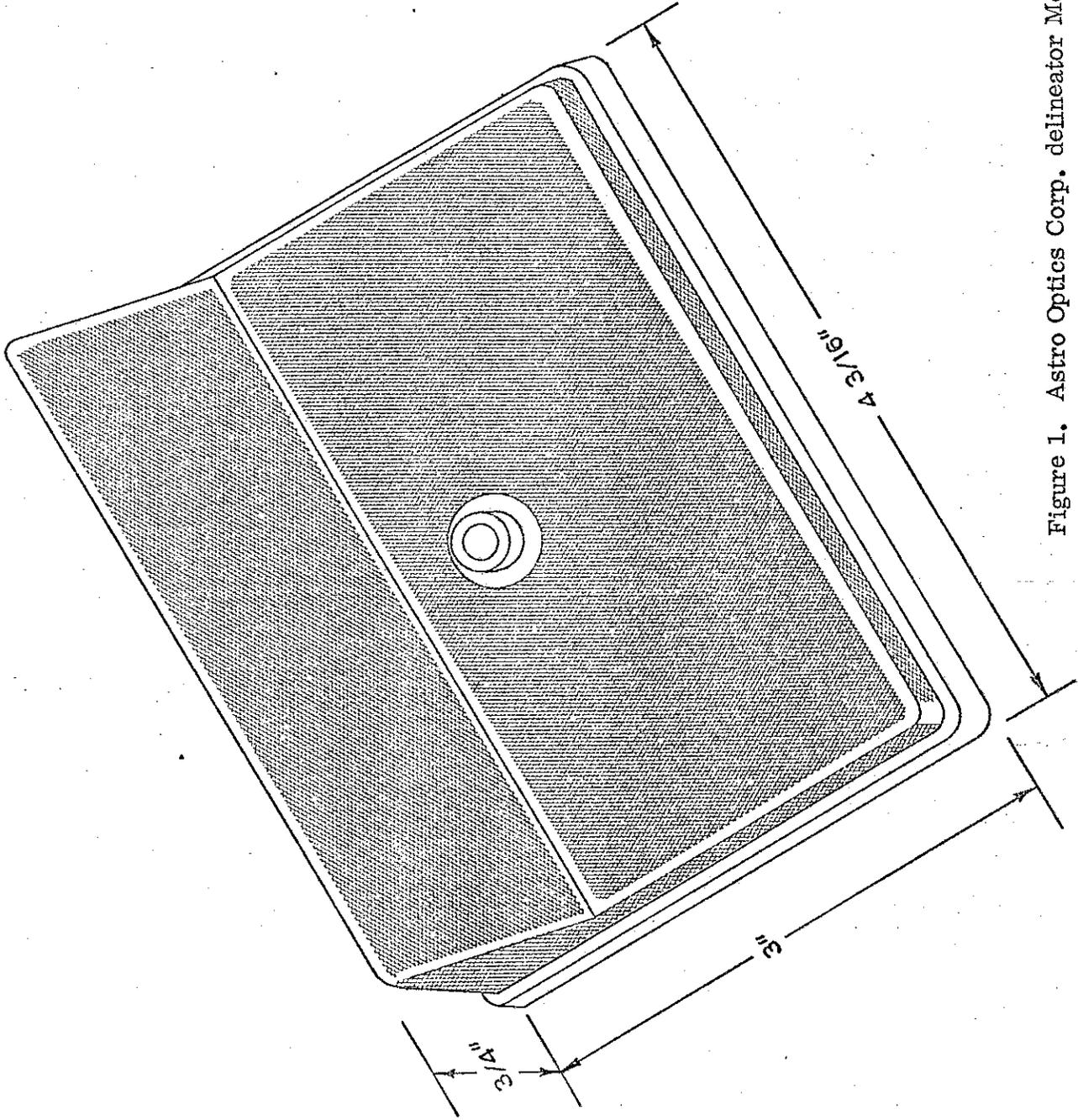


Figure 1. Astro Optics Corp. delineator Model 001.

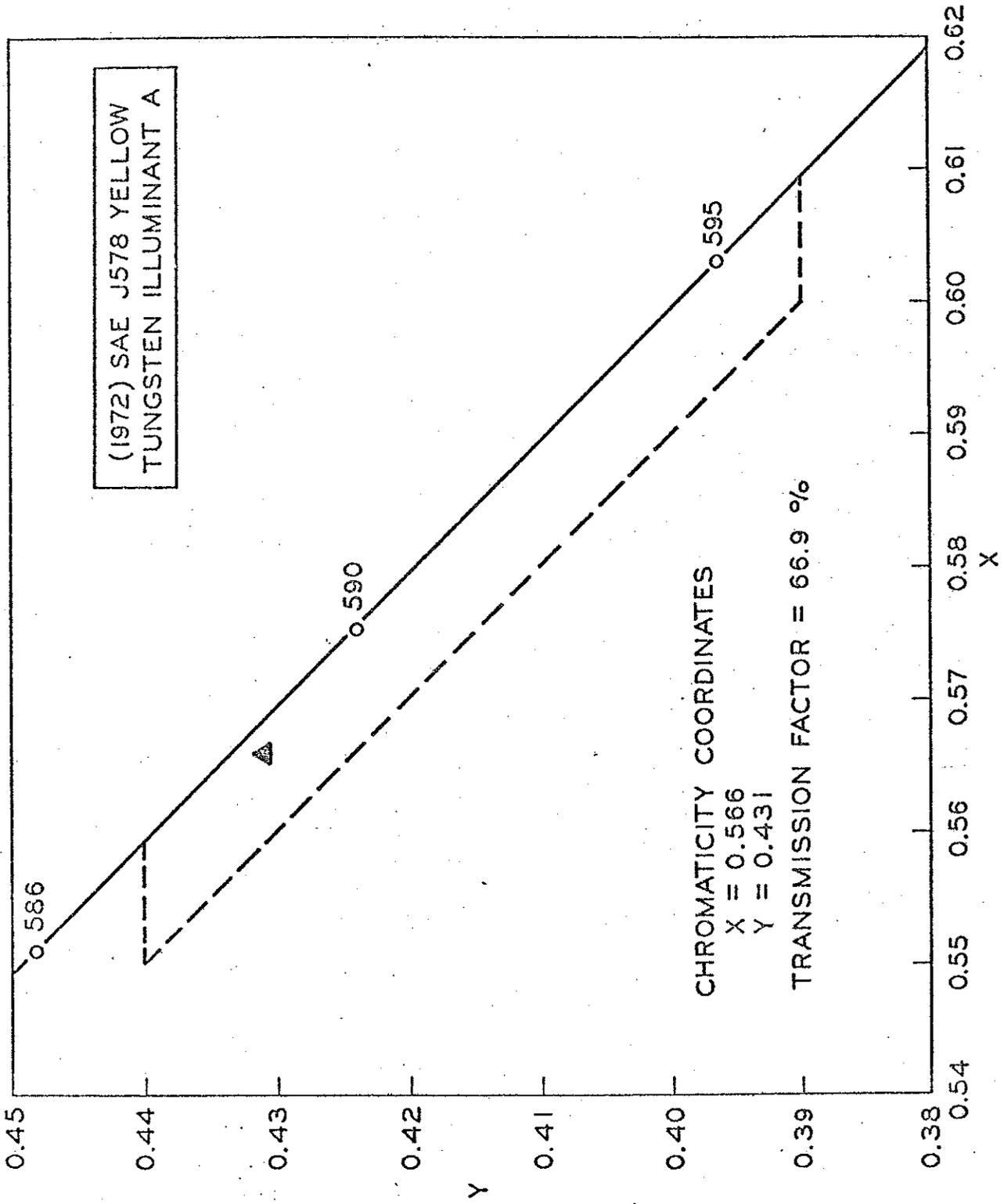


Figure 2. Astro Optics delineator, yellow, Laboratory No. 78 RD-284.

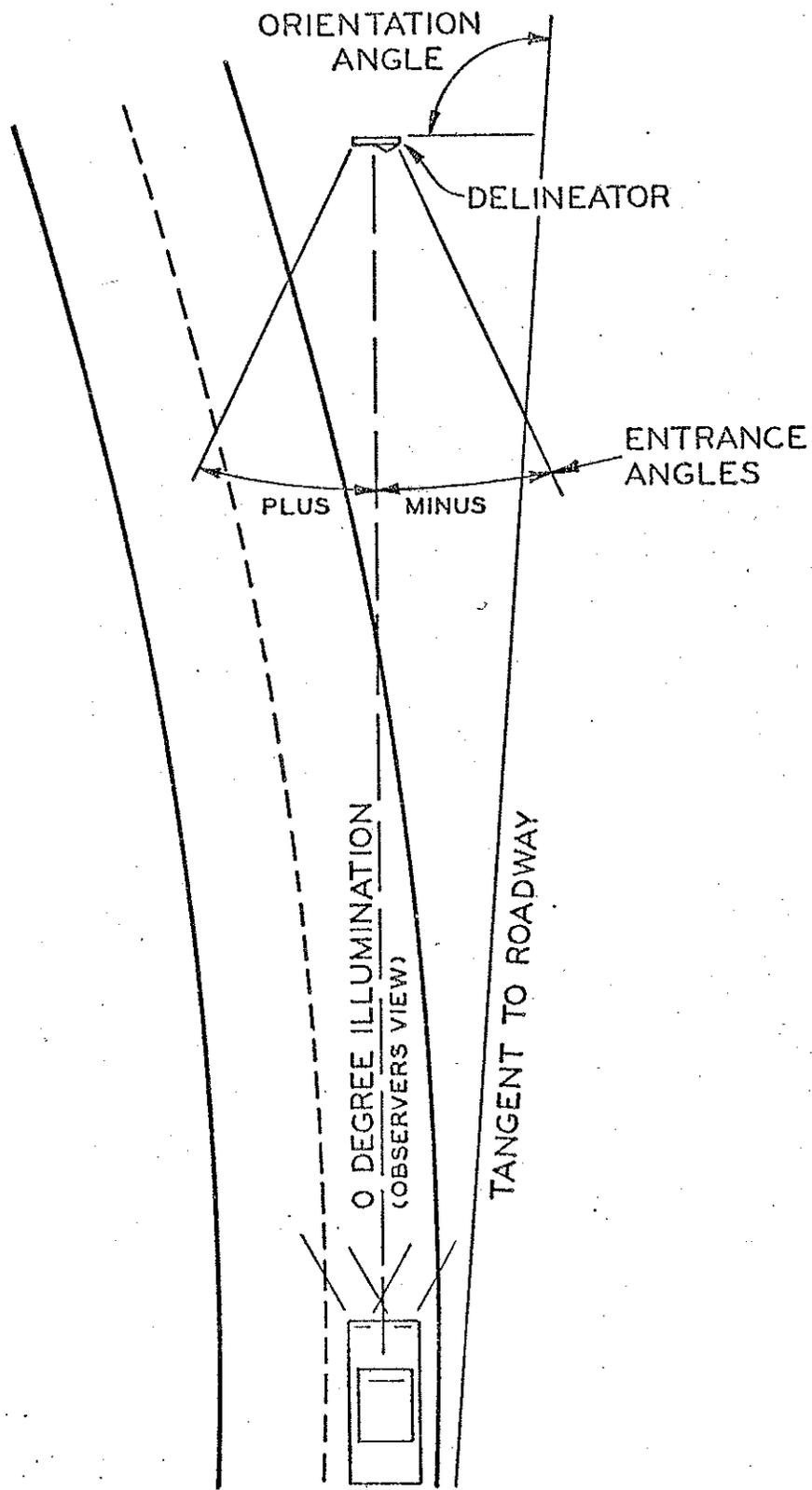


Figure 3. Delineator entrance angle and orientation angle geometries.

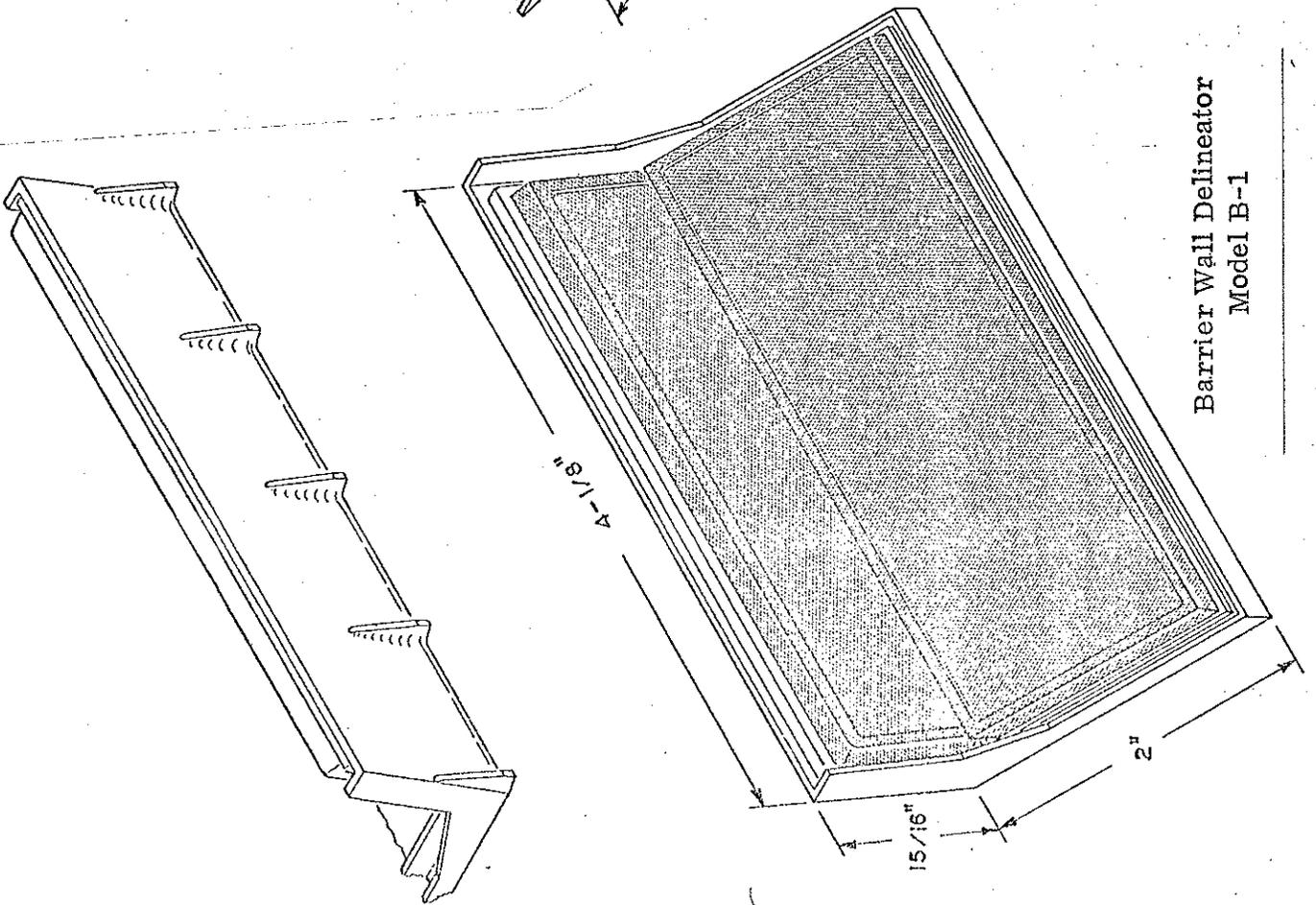
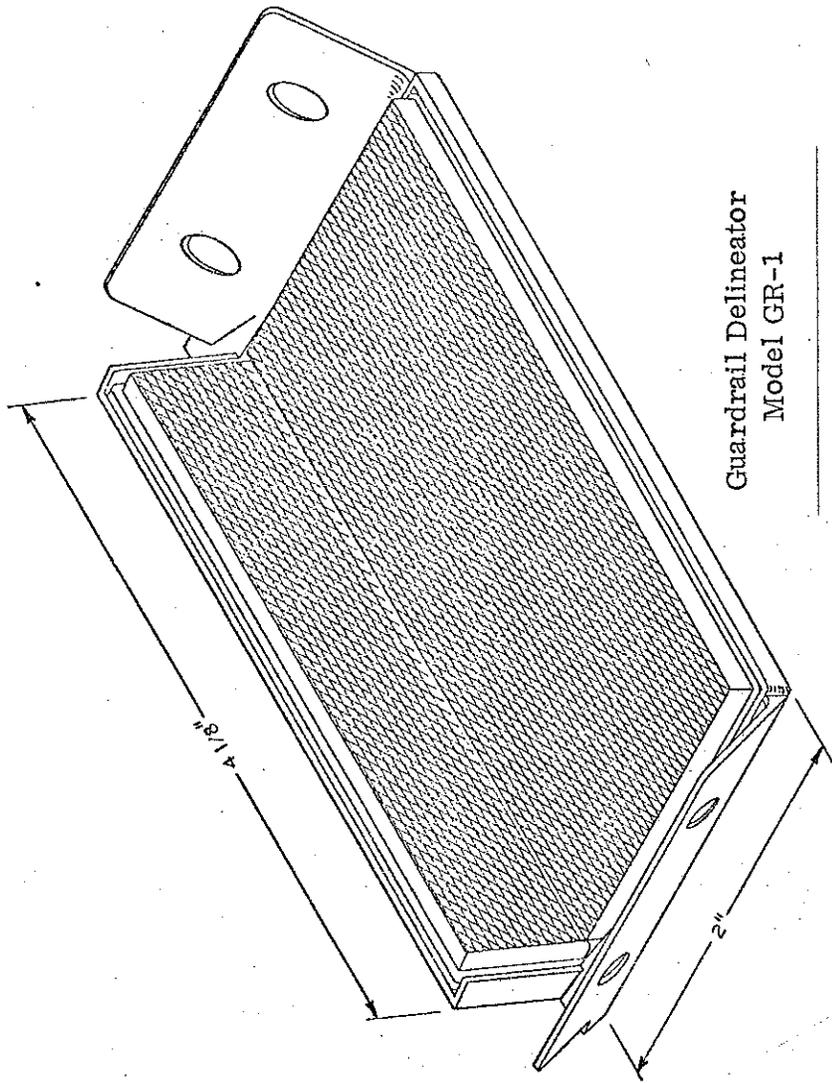


Figure 4. Astro Optics Corp. delineators.

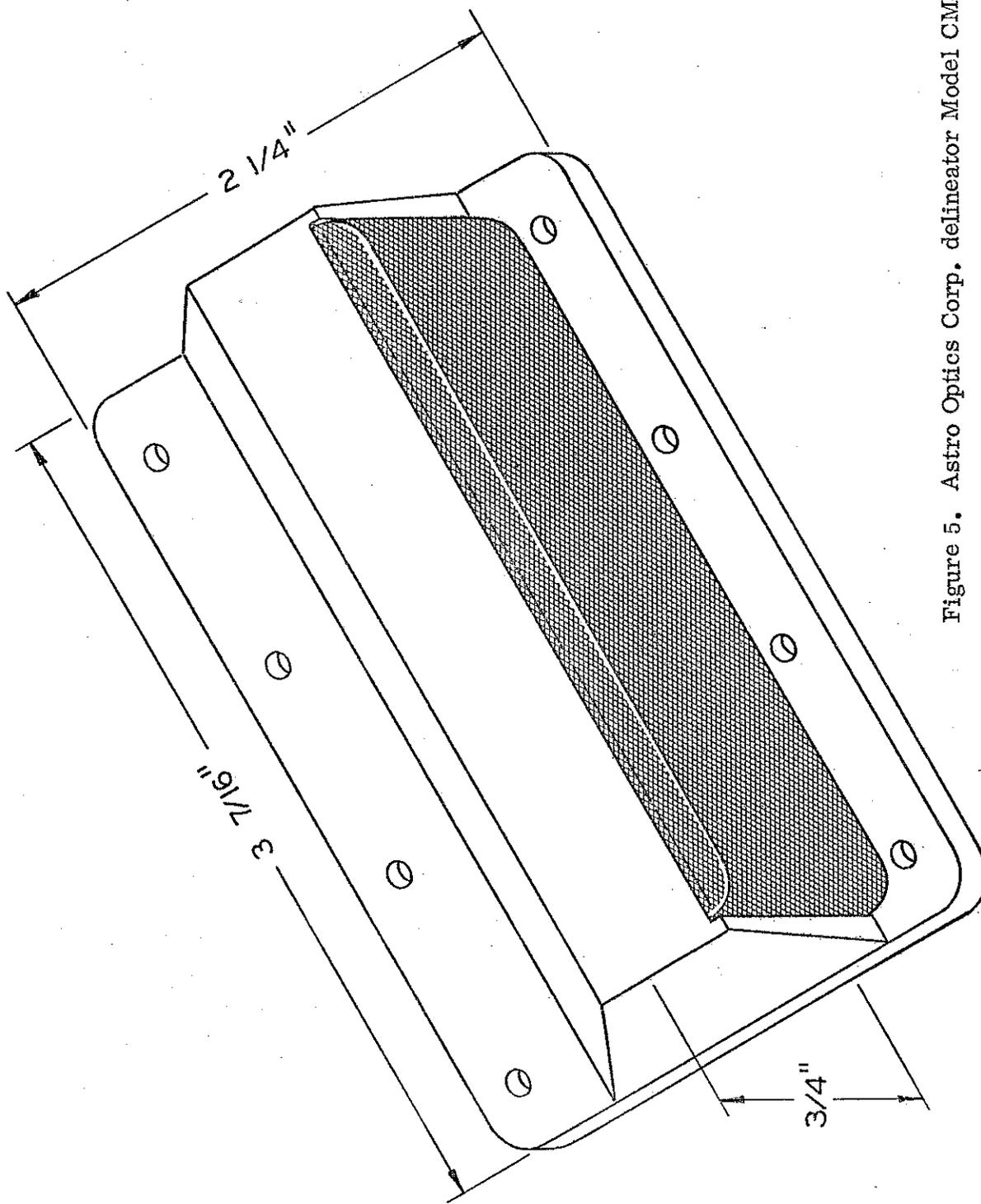


Figure 5. Astro Optics Corp. delineator Model CM-1.

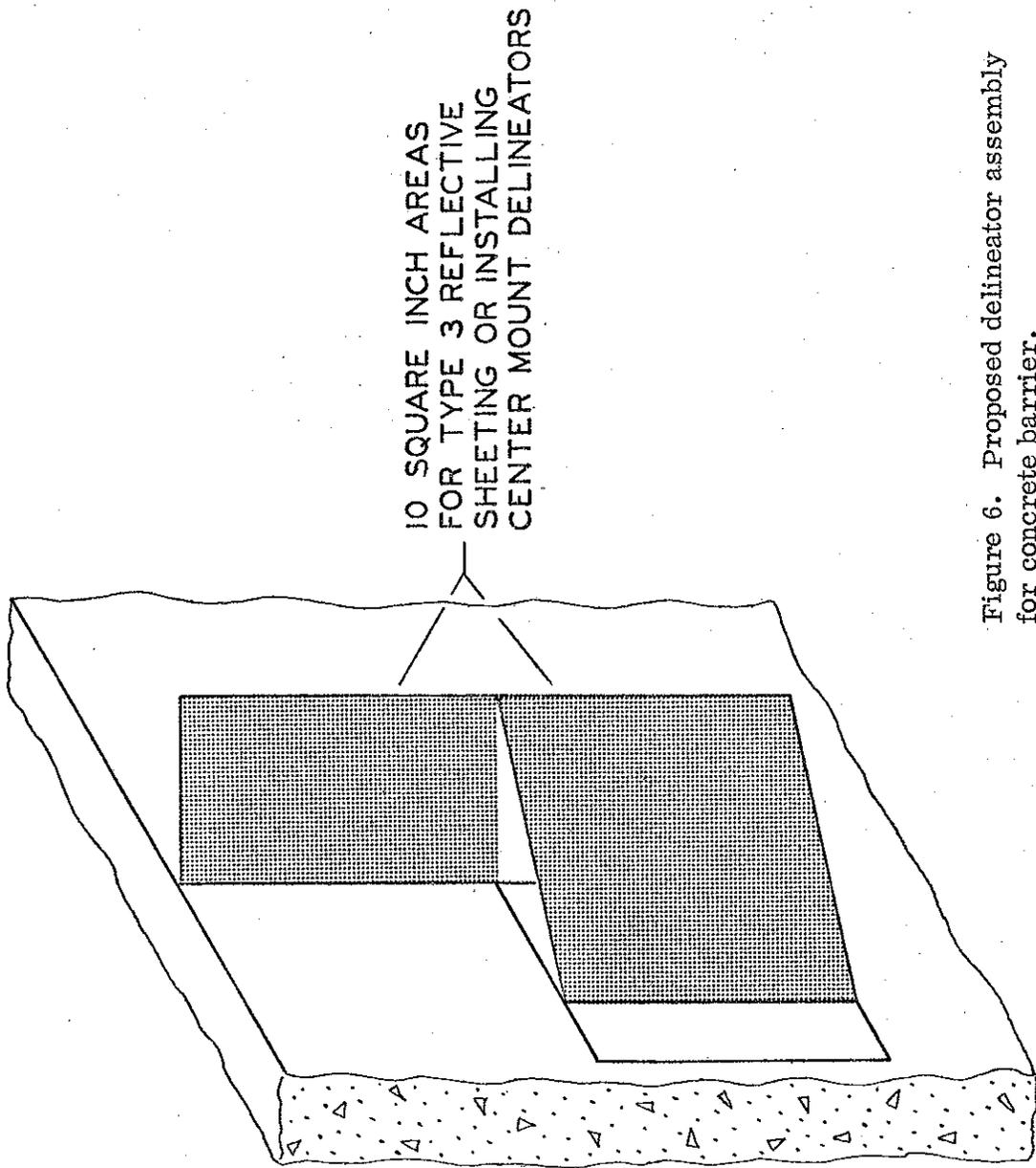


Figure 6. Proposed delineator assembly
for concrete barrier.

Table 1

Specific Luminance of Astro Optics Model 001, Crystal Delineators

Delineator Identification and Mounting Orientation	Specific Luminance cp/ftc/unit at 0.2 Deg Divergence																					
	Entrance Angles																					
	70	60	50	40	30	25	20	15	10	5	0	5	10	15	20	25	30	40	50	60	70	
90 Degree Orientation Astro Optics, Model 001 Laboratory No. 78 RD-285	0.4	2.1	19.2	35.8	55.0	61.8	72.1	104.4	119.1	130.3	138.7	130.0	112.3	95.0	67.8	38.3	25.1	8.0	0.9			
MDOT Specification, 3 inch centermount							42.0				84.0				42.0							
Centermount, 3 inch	----	0.2	0.8	5.7	25.6	49.5	97.2	131.4	150.0	161.0	165.8	161.0	150.0	131.4	96.3	48.2	25.1	5.7	0.8	0.2		
Reflective Sheeting, Type 3, 10 sq in.	0.1	1.0	4.4	10.0	15.8	18.1	19.8	20.8	21.4	21.7	22.3	21.9	21.5	21.2	20.3	18.7	16.4	10.3	4.2	0.9	0.1	
60 Degree Orientation Astro Optics, Model 601 Laboratory No. 78 RD-285	35.8	55.0	72.1	119.1	138.7	130.0	112.3	95.0	67.8	38.3	25.1	15.4	8.0	3.4	0.9							
Centermount, 3 inch	5.7	25.6	97.2	150.0	165.8	161.0	150.0	131.4	95.3	48.2	25.1	13.0	5.7	2.2	0.8	1.0	0.2	----	----	----	----	
Reflective Sheeting, Type 3, 10 sq in.	10.0	15.8	21.4	22.3	21.9	21.5	21.2	20.3	20.3	18.7	16.4	13.6	10.3	6.9	4.2	2.1	0.9	0.1	----	----	----	
45 Degree Orientation Astro Optics, Model 001 Laboratory No. 78 RD-285	61.8	104.4	130.3	130.0	95.0	67.8	38.3	25.1	15.4	8.0	3.4	0.9										
Centermount, 3 inch	49.5	131.4	161.0	161.0	131.4	96.3	48.2	25.1	13.0	5.7	2.2	0.8	1.0	0.2								
Reflective Sheeting, Type 3, 10 sq in.	18.1	20.8	21.7	21.9	21.2	20.3	18.7	16.4	13.6	10.3	6.9	4.2	2.1	0.9	0.3	0.1						
30 Degree and 0 Degree Orientations Not Practical																						
Two Delineators one at 90 degrees and one at 45 degrees																						
Centermount, 3 inch	49.5	131.6	161.5	166.7	157.0	145.8	145.4	156.5	163.0	166.7	168.0	161.8	151.0	131.6	96.3	48.2	25.1	5.7	0.8	0.2		
Reflective Sheeting, Type 3, 10 sq in.	18.2	21.8	26.1	31.9	37.0	38.4	38.5	37.2	35.0	32.0	29.2	26.1	23.6	22.1	20.6	18.8	16.4	10.3	4.2	0.9	0.1	

Table 2

Specific Luminance of Astro Optics Model 001 Yellow Delineators

Delineator Identification and Mounting Orientation	Specific Luminance cp/lc/unit at 0.2 Deg Divergence																								
	Entrance Angles																								
	70	60	50	40	30	25	20	15	10	5	0	5	10	15	20	25	30	40	50	60	70 ^r				
90 Degree Orientation Astro Optics, Model 001 Laboratory No. 78 RD-284	0.5	1.9	13.1	24.9	39.1	44.5	56.7	83.3	93.7	105.9	123.1	106.3	89.6	76.1	48.4	28.5	19.2	6.0	0.4						
MIDOT Specification, 3 inch centermount						25.0					50.0				25.0										
Centermount, 3 inch	----	----	0.2	2.3	11.1	21.8	44.0	59.2	67.7	74.5	77.2	74.9	72.4	59.2	43.3	21.2	11.0	2.2	0.2	----					
Reflective Sheeting, Type 3, 10 sq in.	0.1	1.2	4.8	10.5	15.3	16.6	17.4	17.8	18.0	18.1	18.7	18.1	18.0	17.8	17.4	16.6	15.3	10.5	4.8	1.2	0.1				
60 Degree Orientation Astro Optics, Model 001 Laboratory No. 78 RD-284	24.9	39.1	56.7	83.7	123.1	106.3	89.6	76.1	48.4	28.5	19.2	12.0	6.0	2.0	0.4										
Centermount, 3 inch	2.3	11.1	44.0	67.7	77.2	74.9	72.4	59.2	43.3	21.2	11.0	5.2	2.2	0.8	0.2	0.3									
Reflective Sheeting, Type 3, 10 sq in.	9.9	14.3	17.2	18.0	18.7	18.1	18.0	17.8	17.4	16.6	15.3	13.3	10.5	7.6	4.8	2.6	1.2	0.1							
45 Degree Orientation Astro Optics, Model 001 Laboratory No. 78 RD-284	44.5	83.3	105.9	106.3	76.1	48.4	28.5	19.2	12.0	6.0	2.0	0.4													
Centermount, 3 inch	21.8	59.2	74.5	74.9	59.2	43.3	21.2	11.0	5.2	2.2	0.8	0.2	0.3												
Reflective Sheeting, Type 3, 10 sq in.	16.2	17.7	18.1	18.1	17.8	17.4	16.6	15.3	13.3	10.5	7.6	4.8	2.6	1.2	0.5	0.1									
30 Degree and 0 Degree Orientations Not Practical																									
Two Delineators One at 90 degrees and one at 45 degrees																									
Centermount, 3 inch	21.8	59.2	74.7	77.2	70.3	65.1	65.2	70.2	72.9	76.7	78.0	75.1	72.7	59.2	43.3	21.2	11.0	2.2	0.2	----					
Reflective Sheeting, Type 3, 10 sq in.	16.3	18.9	22.9	23.6	33.1	34.0	34.0	34.1	31.3	28.6	26.3	22.9	20.6	19.0	17.9	16.7	15.3	10.5	4.8	1.2	0.1				

Table 3

Specific Lumiance of Astro Optics Model B-1 and GR-1 Crystal Delineators

Delineator Identification Mounting Orientation	Specific Lumiance ep/ftc/unit at 0.2 Deg Divergence																					
	Enhance Angles																					
	70	60	50	40	30	25	20	15	10	5	0	5	10	15	20	25	30	40	50	60	70	
90, 60, and 45 Degree Orientations Not Practical.																						
30 Degree Orientation Astro Optics, Model B-1 Laboratory No. 78 RD-283				42.0	51.4	54.9	54.7	46.7	37.3	31.2	44.1	44.6	41.3	42.4	44.8	42.8	33.2	4.1				
0 Degree Orientation Astro Optics, Model B-1 Laboratory No. 78 RD-283	42.0	51.4	54.7	37.3	44.1	44.6	41.3	42.4	44.6	42.8	33.2	17.9	4.1	-----								
30 Degree Orientation Astro Optics, Model GR-1 Laboratory No. 78 RD-287				37.7	46.3	48.4	50.3	46.5	37.5	32.2	38.8	40.7	38.6	38.8	42.2	38.8	32.4					
0 Degree Orientation Astro Optics, Model GR-1 Laboratory No. 78 RD-287	37.7	46.3	50.3	37.5	38.8	40.7	38.6	38.8	42.2	38.8	32.4	18.2	4.9	-----								
MDO Specification, 3 inch Centermount				42.0			9.7				84.0											
Reflective Sheeting (10 sq in.)							9.7				17.4											
Centermount Delineator and Reflective Sheeting Delineator 30 Degree and 0 Degree Orientations Not Practical.																						
90 Degree Orientation for Comparison Reflective Sheeting Type 3, 10 sq in.	0.1	1.0	4.4	10.0	15.8	18.1	19.8	20.8	21.4	21.7	22.3	21.9	21.5	21.2	20.3	18.7	16.4	10.3	4.2	0.9	0.1	
Two Delineators One at 90 Degrees and one at 45 Degrees																						
Centermount, 3 inch	49.5	131.6	161.8	166.7	157.0	145.8	145.4	156.5	163.0	166.7	168.0	161.8	151.0	131.6	96.3	48.2	25.1	5.7	0.8	0.2	---	
Reflective Sheeting, Type 3, 10 sq in.	18.2	21.8	26.1	31.9	37.0	38.4	38.5	37.2	35.0	32.0	29.2	26.1	23.6	22.1	20.6	18.8	16.4	10.3	4.2	0.9	0.1	

Table 4

Specific Luminance of Astro Optics Model B-1 and GR-1 Yellow Delineators

Delineator Identification and Mounting Orientation	Specific Luminance cp/ft ² /unit at 0.2 Deg Divergence																					
	Entrance Angles																					
	70	60	50	40	30	25	20	15	10	5	0	5	10	15	20	25	30	40	50	60	70	
30 Degree Orientation Astro Optics, Model B-1 Laboratory No. 78 RD-282			12.3	12.3	13.8	15.3	16.7	18.2	19.8	11.6	10.9	15.3	15.7	15.2	15.3	13.9	12.1	4.0	-----	-----	-----	---
0 Degree Orientation Astro Optics, Model B-1 Laboratory No. 78 RD-282	12.3	13.8	16.7	13.8	10.9	15.3	15.7	15.2	15.3	15.9	12.1	9.0	4.0	0.5								
30 Degree Orientation Astro Optics, Model GR-1 Laboratory No. 78 RD-286	30.9	40.2	43.2	34.3	25.0	30.2	29.1	29.8	33.0	28.0	25.9	12.6	4.9	-----								
0 Degree Orientation Astro Optics Model GR-1 Laboratory No. 78 RD-286	30.9	40.2	43.2	34.3	25.0	30.2	29.1	29.8	33.0	28.0	25.9	12.6	4.9	-----								
M/DOT Specification, 3 inch centermount						25.0					50.0											25.0
Reflective Sheeting (10 sq in.)						5.6					10.4											5.6
90 Degree Orientation for Comparison																						
Reflective Sheeting, Type 3, 10 sq in.	0.1	1.2	4.8	10.5	15.3	16.6	17.4	17.8	19.0	18.1	16.7	18.1	18.0	17.8	17.4	16.6	15.3	10.5	4.8	1.2	0.1	
Two Delineators One at 50 Degrees and one at 45 Degrees																						
Centermount, 3 inch	21.8	55.2	74.7	77.2	70.3	65.1	65.2	70.2	72.9	76.7	78.0	75.1	72.7	59.2	42.3	21.2	11.0	2.2	0.2			
Reflective Sheeting, Type 3, 10 sq in.	16.3	18.9	22.9	28.6	33.1	34.0	34.0	34.1	31.3	28.6	26.3	22.9	20.6	19.0	17.9	16.7	15.3	10.5	4.8	1.2	0.1	

90, 60 and 45 Degree Orientations Not Practical.

Centermount Delineator And Reflective Sheeting Delineator 30 Degree and 0 Degree Orientation Not Practical

Table 5

Specific Luminance of Astro Optics Model CM-1 Delineators

Delineator Identification and Mounting Orientation	Specific Luminance cp./ftc./unit at 0.5 Deg Divergence																					
	Entrance Angles																					
	70	60	50	40	30	25	20	15	10	5	0	5	10	15	20	25	30	40	50	60	70	
Crystal Curb Marker, Laboratory No. 78 RD-289					1.0	1.3	2.3	4.0	4.2	4.9	4.7	5.1	4.9	4.2	2.2	1.3	0.7					
Yellow Curb Marker, Laboratory No. 78 RD-288					0.7	1.1	2.1	3.8	4.3	4.8	4.9	5.2	4.5	3.7	2.0	1.3	0.7					