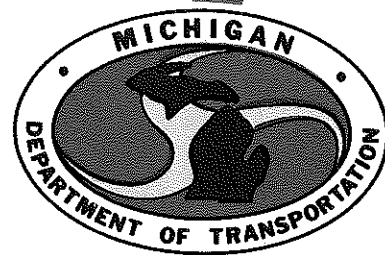


LEGIBILITY AND VISIBILITY OF
RETROREFLECTIVE SIGN MATERIALS



MATERIALS and TECHNOLOGY DIVISION

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RETROREFLECTIVE SIGN MATERIALS

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Research Laboratory Section
Materials and Technology Division
Research Project 76 TI-345
Research Report No. R-1304

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Lansing, January 1990

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SUMMARY

The purpose of this study was to investigate the relative effectiveness of major retroreflective sign materials. Three white legend materials (demountable characters with reflector buttons, Type III encapsulated lens high intensity retroreflective sheeting, and Type II enclosed lens engineering grade retroreflective sheeting) and three green background materials (Type III sheeting, Type II sheeting, and non-reflective paint) were used in various combinations of legend and background. A group of 11 observers were driven through a test area where both an overhead and a roadside sign were displayed with the legend/background combinations, and the observers rated the combinations for legibility and visibility under both day and nighttime conditions.

Results

- 1) Demountable characters with reflector buttons were the preferred legend material for night and day.
- 2) Type III and Type II sheeting were equally preferred background materials for the above legend material.
- 3) Type III legend on Type II background was the favored sheeting-on-sheeting sign combination.

Recommendations

- 1) The Department should further investigate the use of demountable characters with reflector buttons as a legend material for signs.
- 2) The Materials and Technology Division should institute a follow-up investigation on the effectiveness of signing combinations, including newly available signing materials and a broader spectrum of observers.

INTRODUCTION

Background

Because of renewed interest in sign performance and reflectivity of various sign materials, unpublished data gathered in 1976 are now presented in this report. These data were gathered as a response to a request from the Department's Committee for Investigating Sign Visibility. Its purpose was to investigate the relative effectiveness of the major retroreflective sign materials. Legibility and visibility of various combinations of sign materials were evaluated by observers from various Divisions of the Department, all of whom had experience in the field of traffic signing. The Committee was later dissolved and interest in the study results waned.

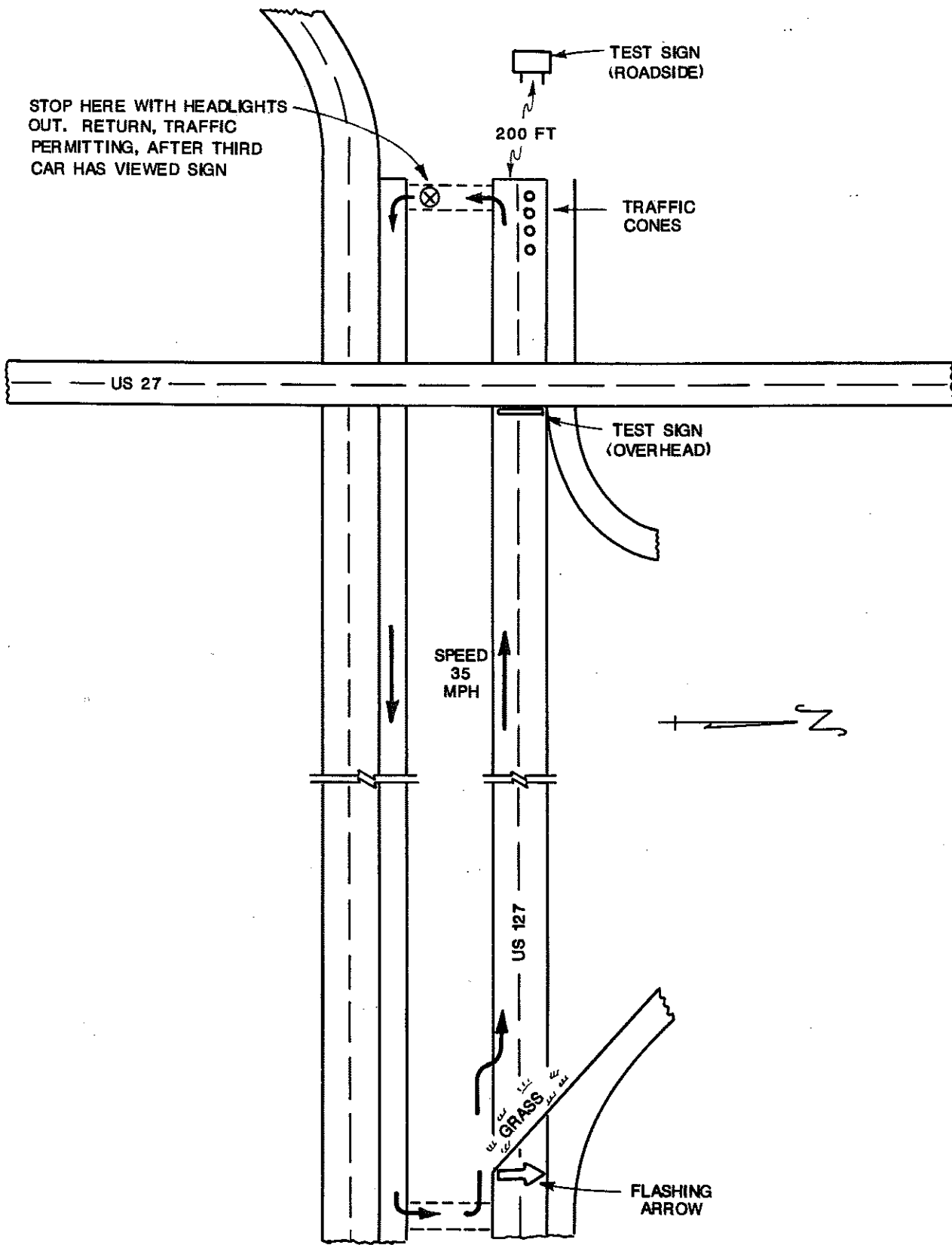


Figure 1. US 127 test site.

Three white legend materials were used in this study: 1) Demountable characters with reflector buttons (DMC/R), 2) Type III encapsulated lens high intensity retroreflective sheeting, and 3) Type II enclosed engineering grade retroreflective sheeting. Three green background materials were used: 1) Type III sheeting, as above, 2) Type II sheeting, as above, and 3) Non-reflective paint (NRP). Sheeting type designations are per the Michigan 1984 Standard Specifications for Construction, and FHWA Standard Specifications for Construction of Roads and Bridges on Federal Projects, FP-85.

Evaluation Procedure

A test site was located on an unopened section of US 127 at the US 27 overpass north of Lansing. The rural lighting environment was dark and favorable for good sign legibility and visibility. Overhead test signs were mounted near the overpass on a raised platform and roadside test signs were mounted 200 ft beyond the end of the pavement, and 500 ft beyond the overhead sign (Fig. 1). The bottom height of the overhead sign was 20 ft. The bottom height of the roadside sign was 7 ft and its left edge was 12 ft to the right of the travelled lane edge. The roadside sign was visible but not legible to observers while they viewed the overhead sign. The observer cars travelled in the left lane of US 127, and did not pass the roadside sign, but turned left 200 ft in front of it.

There were two types of signs presented to the observers in a series of 13 pairs of overhead and roadside mountings. The first group of 12 sign pairs was used in a "sequential comparison" evaluation. The 13th pair of signs was used in a "simultaneous comparison" evaluation. Each pair was presented once to each observer on one circuit of the test site. The sequential presentation displayed one pair at a time to observers; in the simultaneous presentation legend and background combinations were shown at the same time, on one sign face, to the observers.

The rationale for conducting both sequential and simultaneous sign comparisons was that:

- 1) The sequential comparison technique allowed several full-sized signs with legend to be compared; however, this means of comparison relied to a considerable extent on observer memory.
- 2) The simultaneous comparison sign technique removed the reliance on memory, but reduced the observer sensitivity to the legibility and visibility differences between individual sign material combinations;
- 3) Thus, a combination of the two techniques should yield a better balance than a single technique.

Sequential Comparison Evaluation

The substrate of the 12 pairs of signs for the sequential comparison test was 4 ft by 2-1/2 ft by 5/8 in. plywood. Four sign pairs were painted

with non-reflective green paint, four sign pairs had Type II green reflective sheeting, and four sign pairs had Type III green reflective sheeting backgrounds.

For each type of background there was a 10 in. high, three-letter legend made of either Type II white reflective sheeting, Type III white reflective sheeting, or demountable characters with reflector buttons (DMC/R). The letters were Series E style. The DMC/R were Series E letters cut from 0.04 in. aluminum, painted white with reflectors glued into the letters (Fig. 2). In addition, three signs had Series D demountable characters with plastic reflectors. Series D and E are designations for configuration

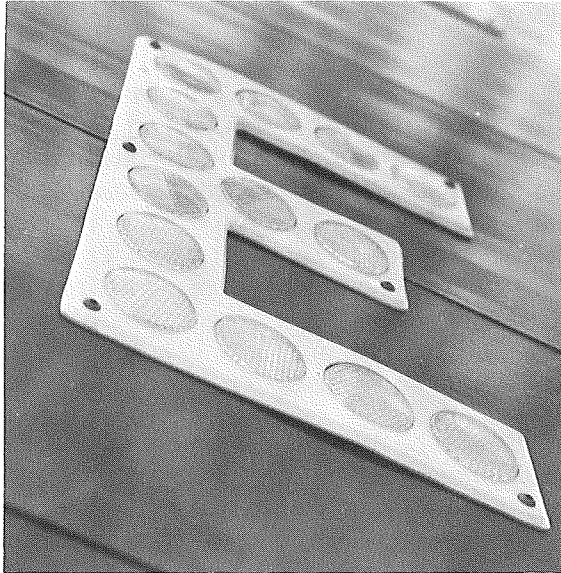


Figure 2. DMC/R (demountable character with reflector button) Series E legend letter.

of sign letters: height, width, stroke, and pattern. Essentially, Series E Modified letters exhibit broader strokes and smaller gaps between letter segments than Series D. Standards for letter sizes and patterns are given in the Federal Highway Administration's Standard Alphabets for Highway Signs and Pavement Markings (1977).

Each sign had a border of the same reflective material as the three-letter legend. The legend was one of several three-letter words (ARE, DEN, ONE, RAT, RED, SAD, SOD, SON, TAR AND TON). These words were determined by an indoor photometric range study to be of approximately equal inherent legibility (Michigan Department of Transportation Research Report No. R-581, August 1966).

Table 1 lists the various sign combinations.

Observers were instructed to instantaneously evaluate each sign for visibility and legibility separately according to the four-point rating scale on the bottom of the data sheet used in the sequential comparison (Fig. 3). The rating scale attributed the following points for performance: Excellent, 4; Good, 3; Fair, 2; and Poor, 1.

TABLE 1

Legend	Sequential Sign Background
Type II white sheeting (Series E)	Type II green sheeting
Type III white sheeting (Series E)	Type II green sheeting
DMC/R (Series E)	Type II green sheeting
DMC/R (Series D)	Type II green sheeting
Type II white sheeting (Series E)	Type III green sheeting
Type III white sheeting (Series E)	Type III green sheeting
DMC/R (Series E)	Type III green sheeting
DMC/R (Series D)	Type III green sheeting
Type II white sheeting (Series E)	Non-reflective green paint
Type III white sheeting (Series E)	Non-reflective green paint
DMC/R (Series E)	Non-reflective green paint
DMC/R (Series D)	Non-reflective green paint

Simultaneous Comparison Signs

The simultaneous comparison signs were the 13th pair of roadside and overhead signs presented to the observers. They were constructed of a 4 ft by 5-1/2 ft by 5/8 in. plywood with three types of background material. The top third of the sign had green Type III reflective sheeting, the middle third had non-reflective green paint, and the bottom third had Type II green reflective sheeting. Each third of the sign contained three 10-in., Series E, capital letter Es of the three legend materials (Fig. 4).

The observers were instructed to rank each of the nine combinations of legend and background material from 1 through 9, with 9 being most desirable. The observers were asked to base their ranking on how well each combination of legend and background exhibited both good legibility and good visibility as compared with the other combinations.

Observers

The observers consisted of members of the Traffic and Safety, Maintenance, and M&T Divisions, and the Research Laboratory. Eight of them were members of the Committee for Investigating Sign Visibility. All eleven observers viewed the overhead signs and the roadside signs either on the nights of November 9 and 22, 1976 and five observers also viewed the roadside signs in the daytime on November 16. On November 9 the weather was cold and clear, on November 16 it was cold and bright with some cloud cover, and on November 22 it was cold with light blowing snow.

Since motorists normally use low beam headlights, the tests also used low beams which had been aimed using SAE visual aiming recommendations

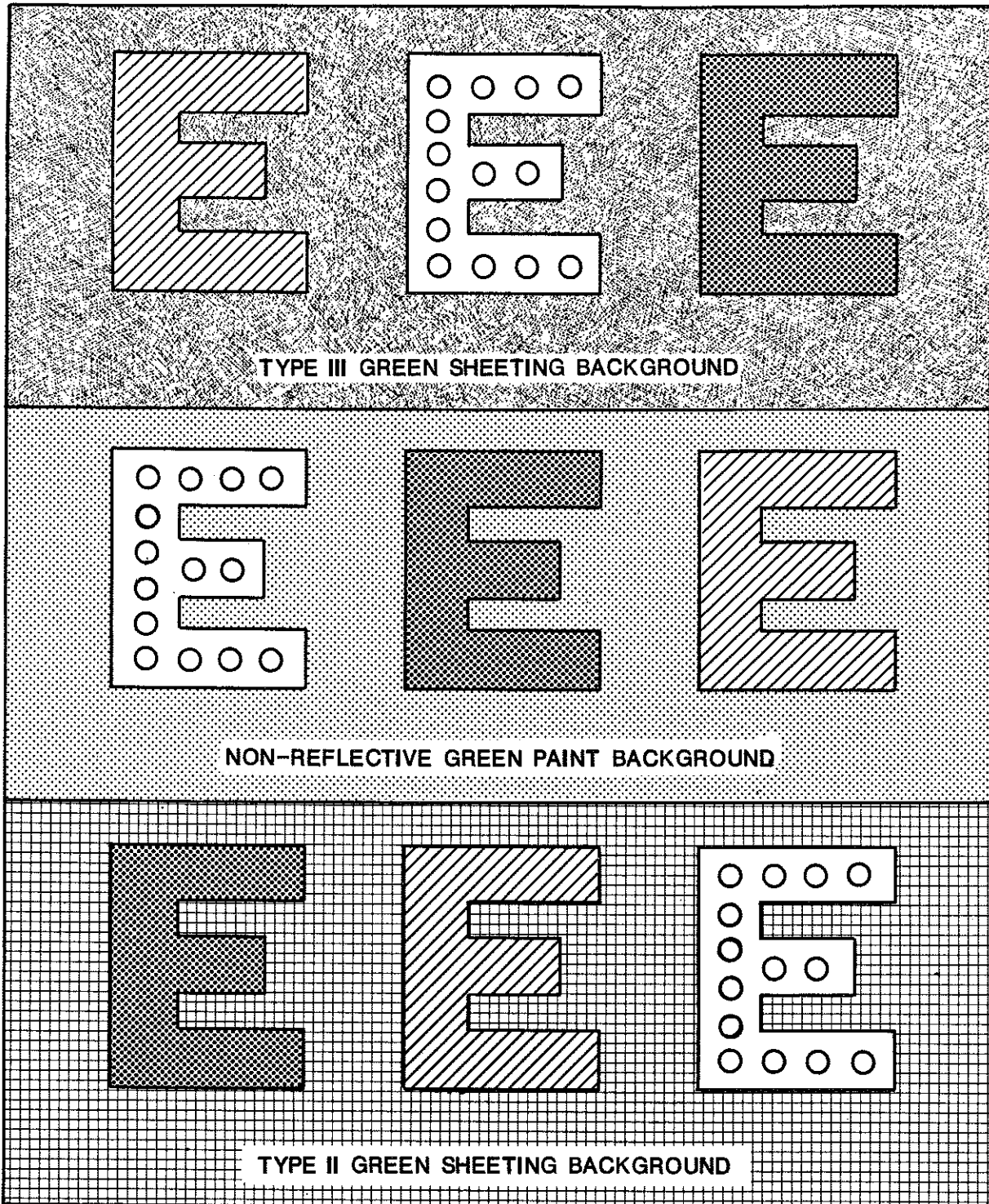
SEQUENTIAL SIGN EVALUATION

OBSERVER _____ DATE _____

OVERHEAD SIGN		SIGN NO.	ROADSIDE SIGN	
Visibility	Legibility		Visibility	Legibility
<input type="checkbox"/>	<input type="checkbox"/>	A	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	B	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	C	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	D	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	E	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	F	<input type="checkbox"/>	<input type="checkbox"/>

RANKING: 4=EXCELLENT
3=GOOD
2=FAIR
1=POOR

Figure 3. Rating data sheet.



LEGEND:  DMC/R  TYPE III WHITE SHEETING  TYPE II WHITE SHEETING

Figure 4. A simultaneous comparison sign.

(Standard J599C). During the aiming procedure the vehicles had two adults in the front seat and full gasoline tanks to simulate a typically loaded automobile, as used during the sign observations.

Luminance Measurements

The day and night luminance (brightness) of each signing material was measured on the various signs by means of a Pritchard telephotometer mounted at the driver eye position in an observer vehicle. The nighttime luminance was measured at 300 ft and 600 ft from the sign and the daytime luminances at 1000 ft. The luminance at midday with a nearly cloudless sky, and at night illuminated by headlamps are listed in Table 2.

Table 2 shows that white Type II sheeting and demountable characters had the greatest daytime luminance. Close examination of the materials verified the brightness order of the daytime legends. White Type II sheeting appeared much whiter than the grayish white Type III sheeting. The glass beads in the Type III sheeting were much darker than the beads in the Type II sheeting. The demountable characters were painted with white enamel which had a high reflectance.

TABLE 2
LUMINANCE OF SIGN MATERIALS

Material	Luminance, in foot-Lamberts				
	Day	Night			
	1,000 ft	Roadside		Overhead	
		300 ft.	600 ft	300 ft	600 ft
White Type II Engineering Grade Reflective Sheeting	2,470	2.61	2.73	0.79	0.62
White Demountable Characters with Reflector Buttons	2,270	5.89	5.48	1.68	2.66
White Type III High Intensity Reflective Sheeting	1,620	4.55	3.53	1.47	0.85
Green Type III High Intensity Reflective Sheeting	365	0.50	0.74	0.19	0.23
Green Type II Engineering Grade Reflective Sheeting	320	0.45	0.70	0.17	0.19
Green Non-Reflective Paint	185	*	*	*	*

*Non-detectable

RESULTS

Simultaneous Sign Comparison

Table 3 shows the average of observer ratings for the simultaneous sign comparison and the resulting rankings. The rankings are based on 9 as highest ranking, 8 next highest, etc., down to a ranking of 1 as lowest ranking. Individual observer ratings are listed in Appendix A. The simultaneous ratings and rankings are listed in Appendix B for nighttime overhead, nighttime roadside, and daytime roadside signs.

The DMC/R legends on all three backgrounds were rated much higher than any other sign combinations. Type III legend on Type II background, the favored sheeting on sheeting sign, ranked below all three DMC/R signs.

TABLE 3

Legend	Background	Simultaneous		Sequential	
		Rating	Rank ¹	Rating ²	Rank
DMC/R	Type III	7.7	8	3.2	9
DMC/R	Type II	8.2	9	3.0	8
DMC/R	NRP	7.2	7	2.9	7
Type III	Type III	3.3	3	2.7	4
Type III	Type II	5.2	6	2.8	6
Type III	NRP	4.5	5	2.5	2
Type II	Type III	2.4	1	2.6	3
Type II	Type II	3.4	4	2.7	5
Type II	NRP	3.2	2	2.4	1

¹Rank #9 = Highest

²Average of visibility and legibility ratings

Sequential Sign Comparison

Table 3 also shows the average sequential ratings and rankings. (Individual observer ratings are listed in Appendix C for nighttime roadside and overhead, daytime roadside and for legibility and visibility. Appendix D lists average observer ratings for each type of sign. The ratings shown are averages of the legibility and visibility ratings.) While the sequential ratings are based on 4 as the maximum possible, the rank order in Table 3 is based on 9 being the highest rated sign combination on the basis of both legibility and visibility ratings.

Again, the DMC/R legend ranked highest, and Type III on Type II finished fourth.

On the simultaneous comparison, DMC/R on Type II rated highest. On the sequential comparison, DMC/R on Type III rated highest. Further study is needed to evaluate the better background sheeting for DMC/R legend. (Type IIA, super engineering grade and diamond grade sheeting should also be evaluated as legend and background in a follow-up study).

Overall Ranking of Sign Combinations

Table 4 shows the final observer ratings and resulting ranking of all legend and background material combinations based on combined simultaneous and sequential observer ratings listed in descending order. In order to facilitate the combined ranking the 4-point sequential ratings were first converted to the 9-point simultaneous rating scale, by multiplying the sequential ratings by a factor of 2.25.

TABLE 4
FINAL RANK ORDER OF LEGEND
AND BACKGROUND COMBINATIONS

Legend	Background	Average of Sequential and Simultaneous Ratings	Rank
DMC/R	Type III	7.5	9
DMC/R	Type II	7.5	9
DMC/R	NRP	6.9	7
Type III	Type II	5.7	6
Type III	NRP	5.1	5
Type II	Type II	4.7	4
Type III	Type III	4.6	3
Type II	NRP	4.3	2
Type II	Type III	4.2	1

TABLE 5
COMPARISON OF SERIES D AND SERIES E STYLES
OF LEGEND FOR DEMOUNTABLE CHARACTERS
(Average of Legibility and Visibility, 4-Point Rating Scale)

Legend/ Background Combination	Nighttime				Daytime	
	Roadside Sign		Overhead Sign		Roadside Sign	
	Series D	Series E	Series D	Series E	Series D	Series E
Demountable Characters/ Type III	3.1	3.5	2.6	2.8	3.5	3.4
Demountable Characters/ Type II	3.0	3.1	2.4	2.5	3.0	3.4
Demountable Characters/ Non-Reflective Paint	3.2	3.0	2.4	2.7	3.4	3.1

Note that in Table 4 the two top-ranked legend and background combinations DMC/R on Type III and on Type II, were equally rated by observers. Since Type II is cheaper, it could be preferred.

Series E Modified Legend vs. Series D Legend

Table 5 below shows that Series E Modified legend was rated higher by observers with the exception of the roadside sign with non-reflective paint (NRP) background. Individual observer ratings of letter styles are listed in Appendix E. As noted previously, the Series E Modified letters exhibit broader strokes and smaller gaps between letter segments than Series D. Broader strokes are better able to resist the negative effects of halation of bright backgrounds. Halation causes a bright area to appear greater than its true size against a very dark background such as NRP. Brighter backgrounds would cause letter strokes to appear narrower than they would appear with less bright or NRP backgrounds. Therefore, broader stroke letters such as the Series E Modified may have a legibility advantage over the narrower stroke Series D where the background is reflectorized.

Contrast Ratio

There are some indications in the literature that contrast ratio affects sign legibility (see, for example, Sivak and Olson, "Optimal and Minimal Luminance Characteristics," TRB 1027, 1985). Contrast ratios of each sign type were computed from sign luminances (listed in Table 2) and Table 6 shows the sign materials ranked according to decreasing legibility compared with their corresponding contrast ratios.

For nighttime the greater legibility was associated by the greater contrast ratios with the exception of the infinite ratios. Legend luminance also influenced the ranking Sivak and Olson, cited earlier, found that nighttime legibility declined above approximately 12:1. (The infinite ratios

TABLE 6
CONTRAST RATIO COMPARED WITH LEGIBILITY

Night Roadside					Day Roadside			
Legend	Background	Average Rank Legibility	Contrast Ratio*		Legend	Background	Legibility Rank	Contrast Ratio
			300 ft	600 ft				
DMC/R	Type III	9	12	7	DMC/R	Type III	9	6
DMC/R	Type II	8#	13	8	DMC/R	NRP	9	12
Type III	Type II	8#	10	5	Type II	Type III	9	7
DMC/R	NRP	6	*	*	DMC/R	Type II	6	7
Type III	Type III	5#	9	5	Type III	Type III	5	4
Type II	Type II	5#	6	4	Type II	NRP	4	13
Type II	NRP	5#	*	*	Type III	Type II	3	5
Type III	NRP	2	*	*	Type III	NRP	3	9
Type II	Type III	1	5	4	Type II	Type II	1	8

#Represents ties in observer ratings
*Ratio equals infinity

were ranked relatively low by observers.) The daytime contrast ratios had little or no correlation with legibility. The sign luminance was so great that contrast ratio may not have been a major factor because other factors such as color contrast and legend size and shape, at these luminance levels become more important. This agrees with previous research showing a positive relationship between greater nighttime legibility and higher contrast ratios. Thus the ratio of legend to background reflectivities should be designed to approximately a 12:1 ratio for maximum nighttime legibility. This ratio would imply the use of DMC/R with Type II or III reflective sheeting or Type III sheeting legend on Type II sheeting background.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

1) The four combinations of legend and background materials that stood out as most legible and visible for roadside and overhead guide signs night and day were (in decreasing order of observer preference):

- a. White demountable characters with reflector buttons on green Type III encapsulated lens high intensity reflective sheeting rated equally with,
- b. White demountable characters with reflector buttons on Type II enclosed lens engineering grade reflective sheeting.
- c. White demountable characters with reflector buttons on non-reflective green enamel paint.
- d. White Type III encapsulated bead high intensity reflective sheeting on green Type II enclosed lens engineering grade reflective sheeting.

2) Type II enclosed lens engineering grade sheeting legend ranked low in observer preference.

3) In general, observers preferred letter Series E Modified over Series D; however, if non-reflective backgrounds are to be used, observers preferred Series D for roadside signs.

Recommendations

1) Since this study has shown that observers prefer DMC/R legend for optimum visibility and legibility, serious consideration by MDOT should be given to its implementation on guide signs in areas where there is a high ambient illumination or complex visual backgrounds, such as in urban areas.

2) The Materials and Technology Division should conduct a follow-up study with observers representing the driving age population. The study should include the newer reflective materials such as microprismatic sheeting and Type IIA super engineering grade.

APPENDICES

APPENDIX A

INDIVIDUAL OBSERVER RATINGS- SIMULTANEOUS COMPARISONS

Observer	Test Type	Date 1976	DMC/R (Legend)			Type III (Legend)			Type II (Legend)		
			III (Background)	II	NRP	III (Background)	II	NRP	III (Background)	II	NRP
R. Addy	NR	1/22	7	9	8	5	6	4	1	2	3
	NO	"	7	9	8	5	6	4	1	2	3
V. Andrews	NR	1/22	8	7	9	4	6	5	2	1	3
	NO	"	8	9	6	3	7	5	2	1	4
M. Janson	NR	11/9	8	7	9	3	5	6	1	2	4
	NO	"	7	9	8	4	5	6	1	2	3
	DR	1/16	8	9	6	1	4	7	5	3	2
J. Kanillopoolos	NR	11/9	8	9	7	5	6	4	2	3	1
	NO	"	8	9	7	4	6	5	1	3	2
	DR	1/16	9	7	8	1	2	4	3	5	6
S. Lingeman	NR	11/9	8	6	9	3	5	7	1	4	2
	NO	"	7	9	8	6	4	5	1	2	3
F. Rieger	NR	11/9	6	8	9	4	3	7	1	2	5
	NO	"	6	9	8	4	7	5	1	2	3
R. Rigotti	NR	11/9	8	9	7	5	6	3	1	4	2
	NO	"	8	9	7	4	5	3	1	6	2
	DR	1/16	9	8	6	4	3	2	5	7	1
W. Roth	NR	1/22	7	9	6	4	8	5	1	2	3
	NO	"	8	9	6	5	7	4	2	1	3
G. Skinner	NR	11/9	9	7	8	4	5	6	1	2	3
	NO	"	8	9	6	5	7	4	2	1	3
	DR	1/16	9	5	3	1	7	2	8	6	4
G. Smith	NR	11/9	7	8	9	4	5	6	1	2	3
	NO	"	6	8	9	3	5	7	1	2	4
	DR	1/16	6	9	8	1	4	2	3	7	5
J. Truax	NR	1/22	7	9	8	4	6	5	1	2	3
	NO	"	8	9	6	4	7	5	1	2	3

DMC/R=Demountable Characters with Reflectors NRP=Non Reflective Green Paint

NR=Nighttime Roadside NO=Nighttime Overhead DR=Daytime Roadside

APPENDIX B

SUMMARY OF SIMULTANEOUS SIGN COMPARISON RESULTS

Legend	Background	Overall Ratings		Overhead Nighttime		Roadside Nighttime		Roadside Daytime		Nighttime Average	
		Rank	Avg.	Rank	Avg.	Rank	Avg.	Rank	Avg.	Rank	Avg.
DMC/R	TYPE II	9	8.3	9	8.9	8	8.0	8	7.6	9	8.5
DMC/R	TYPE III	8	7.6	8	7.4	7	7.5	9	8.2	7	7.5
DMC/R	NRP	7	7.4	7	7.2	9	8.1	7	6.2	8	7.6
TYPE III	TYPE II	6	5.4	6	6.0	6	5.5	4	4.0	6	5.8
TYPE III	NRP	5	4.7	5	4.8	5	5.3	2	3.4	5	5.0
TYPE III	TYPE III	4	3.7	4	4.3	4	4.1	1	1.6	4	4.2
TYPE II	NRP	3	3.1	3	3.0	3	2.9	3	3.6	3	3.0
TYPE II	TYPE II	2	2.9	2	2.2	2	2.4	6	5.6	2	2.3
TYPE II	TYPE III	1	1.9	1	1.3	1	1.2	5	4.8	1	1.2

Highest Ranking = 9

APPENDIX C

INDIVIDUAL OBSERVER RATINGS - SEQUENTIAL COMPARISON

Observer	Test Type	Date 1976	DMC/R (Legend)						Type III (Legend)						Type II (Legend)					
			(Background Sheeting)						(Background Sheeting)						(Background Sheeting)					
			III Vis	III Leg	II Vis	II Leg	NRP Vis	NRP Leg	III Vis	III Leg	II Vis	II Leg	NRP Vis	NRP Leg	III Vis	III Leg	II Vis	II Leg	NRP Vis	NRP Leg
R. Addy	NR	11/22	4	3	4	2	4	2	3	3	3	4	3	2	3	2	3	3	3	3
	NO		4	2	4	4	3	3	3	2	4	3	2	3	3	1	3	3	2	3
V. Andrews	NR	11/22	3	2	2	2	2	1	3	3	3	3	2	1	2	1	3	3	3	2
	NO	"	3	2	2	1	2	3	3	2	3	3	3	3	2	1	3	3	2	2
M. Janson	NR	11/9	4	4	4	4	4	3	3	2	4	3	4	3	3	2	3	2	3	4
	NO	"	3	4	3	2	3	4	2	3	3	2	3	3	3	1	2	2	1	2
	DR	11/16	3	2	4	3	2	3	2	3	1	2	3	2	3	3	3	2	3	3
J. Kanilopoulos	NR	11/9	4	3	4	3	4	2	3	3	4	3	4	2	4	2	3	2	3	3
	NO	"	2	2	3	3	3	3	2	2	3	3	3	3	2	2	2	2	1	2
	DR	11/16	4	4	4	3	4	4	4	3	3	2	3	3	4	4	4	3	3	3
S. Lingeman	NR	11/9	3	4	3	4	4	4	3	3	3	4	3	4	3	4	3	4	2	3
	NO	"	4	3	2	2	2	2	2	2	2	2	2	2	1	1	2	3	1	1
F. Rieger	NR	11/9	4	3	4	3	3	4	3	2	3	2	4	2	3	2	4	3	4	3
	NO	"	4	3	3	2	3	3	3	3	3	3	3	4	2	1	3	2	2	3
R. Rigotti	NR	11/9	4	4	4	3	4	4	4	4	4	3	3	2	4	3	4	3	4	3
	NO	"	3	3	3	2	3	2	2	2	3	3	3	3	3	2	3	2	2	2
	DR	11/16	4	4	4	3	4	3	4	3	4	2	3	2	4	3	4	2	3	2
W. Roth	NR	11/22	4	3	1	2	2	3	3	2	2	3	2	3	1	3	3	2	1	2
	NO	"	2	2	1	2	2	3	1	2	2	3	2	3	2	2	3	2	2	2
G. Skinner	NR	11/9	4	3	2	3	1	3	3	3	4	2	1	3	4	2	4	4	1	3
	NO	"	1	3	2	3	1	2	2	3	2	3	1	3	4	2	2	3	1	2
	DR	11/16	2	3	3	3	1	3	2	2	2	3	1	3	3	4	2	2	1	2
G. Smith	NR	11/9	3	3	4	4	3	4	3	2	3	3	3	4	3	2	3	2	3	3
	NO	"	3	3	2	3	3	4	1	2	3	3	1	2	1	1	3	2	1	2
	DR	11/16	4	4	4	3	3	4	3	3	2	2	2	1	3	3	1	1	3	3
J. Truax	NR	11/22	4	4	4	3	3	2	3	4	3	3	3	3	3	3	4	3	2	2
	NO	"	3	2	3	2	2	2	1	1	4	3	1	1	1	1	3	3	2	2

DMC/R=Demountable Characters with Reflectors NRP=Non Reflective Green Paint

NR=Nighttime Roadside NO=Nighttime Overhead DR=Daytime Roadside Vis=Visibility Leg=Legability

APPENDIX D

SUMMARY OF SEQUENTIAL SIGN COMPARISON RESULTS

Legend	Background	Overall Ratings		Overhead Nighttime		Roadside Nighttime		Roadside Daytime		Nighttime Average	
		Rank	Avg.	Rank	Avg.	Rank	Avg.	Rank	Avg.	Rank	Avg.
DMC/R	TYPE III	9	3.2	8	2.8	9	3.5	9	3.4	9	3.1
DMC/R	TYPE II	8	2.9	4	2.5	8	3.1	9	3.4	5	2.8
DMC/R	NRP	7	2.9	7	2.6	5	3.0	6	3.1	7	2.8
TYPE III	TYPE II	7	2.9	9	2.9	8	3.1	2	2.3	8	3.0
TYPE II	TYPE II	5	2.7	6	2.6	6	3.1	3	2.4	7	2.8
TYPE III	TYPE III	4	2.6	3	2.1	4	3.0	5	2.9	3	2.5
TYPE III	NRP	3	2.6	5	2.5	3	2.8	2	2.3	4	2.6
TYPE II	TYPE III	2	2.4	1	1.8	1	2.7	9	3.4	1	2.2
TYPE II	NRP	1	2.3	2	1.8	2	2.7	4	2.6	2	2.3

Highest Ranking = 9

APPENDIX E
 SERIES "D" LETTERS vs SERIES "E" MODIFIED LETTERS
 INDIVIDUAL OBSERVER RATINGS - SEQUENTIAL COMPARISON

Observer	Test Type	Date 1976	DMC/R - SERIES E (Modified)						DMC/R - SERIES D					
			(Background Sheeting)						(Background Sheeting)					
			III Vis	III Leg	II Vis	II Leg	NRP Vis	NRP Leg	III Vis	III Leg	II Vis	II Leg	NRP Vis	NRP Leg
R. Addy	NR	1/22	4	3	4	2	4	2	4	3	3	1	3	4
	NO		4	2	4	4	3	3	3	3	4	3	2	3
V. Andrews	NR	1/22	3	2	2	2	2	1	3	2	3	3	3	2
	NO	"	3	2	2	1	2	3	3	2	2	2	2	1
M. Janson	NR	11/9	4	4	4	4	4	3	4	3	4	4	4	3
	NO	"	3	4	3	2	3	4	3	3	3	2	2	3
	DR	1/16	3	2	4	3	2	3	4	3	2	3	3	3
J. Kanillopoulos	NR	11/9	4	3	4	3	4	2	4	2	4	3	4	3
	NO	"	2	2	3	3	3	3	3	3	2	3	3	2
	DR	1/16	4	4	4	3	4	4	4	4	3	3	4	4
S. Lingeman	NR	11/9	3	4	3	4	4	4	3	3	3	4	4	4
	NO	"	4	3	2	2	2	2	2	2	2	2	4	4
F. Rieger	NR	11/9	4	3	4	3	3	4	3	3	3	3	4	4
	NO	"	4	3	3	2	3	3	3	2	3	4	3	3
R. Rigotti	NR	11/9	4	4	4	3	4	4	3	2	3	3	4	3
	NO	"	3	3	3	2	3	2	4	3	2	3	3	3
	DR	1/16	4	4	4	3	4	3	4	3	3	3	4	3
W. Roth	NR	1/22	4	3	1	2	2	3	2	3	2	2	2	3
	NO	"	2	2	1	2	2	3	1	2	1	2	1	2
G. Skinner	NR	11/9	4	3	2	3	1	3	3	3	1	3	2	2
	NO	"	1	3	2	3	1	2	2	3	1	3	2	2
	DR	1/16	2	3	3	3	1	3	3	2	3	3	2	3
G. Smith	NR	11/9	3	3	4	4	3	4	4	4	3	4	3	3
	NO	"	3	3	2	3	3	4	3	4	1	3	2	4
	DR	1/16	4	4	4	3	3	4	4	4	3	4	4	4
J. Truax	NR	1/22	4	4	4	3	3	2	4	4	4	4	3	4
	NO	"	3	2	3	2	2	2	3	2	3	2	2	2

DMC/R=Demountable Characters with Reflectors NRP=Non Reflective Green Paint
 NR=Nighttime Roadside NO=Nighttime Overhead DR=Daytime Roadside Vis=Visibility Leg=Legability