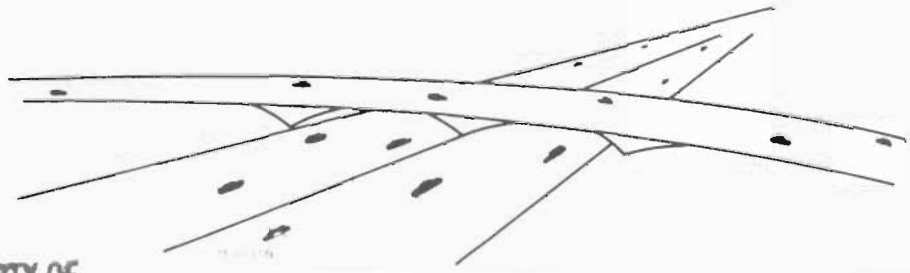

DEPARTMENTAL RESEARCH

Report Number 270-1

EVALUATION OF MATERIALS FOR SHOULDER-MOUNTED SIGNS AND SIGN MAINTENANCE MANAGEMENT

STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION

Duplicate Dept. Sect. B

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16. Abstract

Contrast Ratio, specific intensity of legend over the specific intensity of the background, is a convenient method of expressing reflectorized characteristics of a shoulder mounted sign that can be related to the functionality of a sign at night.

Night legibility distance of signs with reflectorized legend and reflectorized background vary as a function of the contrast ratio. Signs with reflectorized backgrounds of red, green, and blue with reflectorized legend were studied on the roadway. It was determined that variance in legibility distance at night, due to color variation, was insignificant when compared to contrast ratio.

Night legibility distance of signs with opaque legend and reflectorized backgrounds of yellow, orange, and white was found to vary as a function of background specific intensity.

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Evaluation of Materials for Shoulder-Mounted Signs and Sign Maintenance Management

Research Report Number 270-1

Research Project 1-9-80-270

by
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Conducted by
Materials & Tests Division and Houston Urban Office
In cooperation with the
Transportation and Planning Division
Texas State Department of Highways and Public Transportation

August 1983

The opinions expressed herein are those of the author and are not necessarily those of the Texas State Department of Highways and Public Transportation.

The report does not constitute a standard, specification or regulation.

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Table of Contents

Summary

Shoulder mounted signs with reflectorized and opaque legends with reflectorized backgrounds have been studied on the roadway in rural areas and on urban freeways with fixed roadway illumination. Included in the study were signs with white reflectorized legend and reflectorized backgrounds of green, blue and red and signs with opaque legend with reflectorized backgrounds of white, orange and yellow.

It has been determined that night legibility distance of signs with reflectorized legend and background varies with the driver. However, the night legibility distance for most drivers varies as a function of Contrast Ratio (specific intensity of the legend over the specific intensity of the background). Night legibility distance for most drivers (those who do not have serious night vision impairment) increases as the "Contrast Ratio" increases up to 15. Night legibility distance then remains fairly constant for higher contrast ratios.

The only deviation found from this characteristic trend was for signs with legend S.I. (specific intensity) greater than 237 (button removable copy) when viewing with headlights on high beam; in this case, legibility distance was maximum at contrast ratios below 5. At a contrast ratio of about 12, the legibility distance for low beam and high beam was equal. At higher contrast ratios, the legibility distance for low beam exceeded the legibility distance for high beam by approximately 5 percent. These characteristics are a result of halo effect.

Signs with S.I. legends above 237 with contrast ratios below 5 on high beams and signs with S.I. legends from 100 to 120 with contrast ratios from 9 to 15 on high beams produce the greatest legibility distances and are equal in legibility distance. On low beams, signs with legend S.I. above 100 with contrast ratios above 10, yield the greatest legibility distances, about 5 to 6 percent lower than the optimum signs for high beams.

Signs constructed with background S.I. equivalent to Texas State Department of Highways and Public Transportation Departmental Materials Specification D-9-8300, Flat Surface Sheeting, Type A and legends meeting Type E of D-9-8300 or D-9-8400 produce overall best legibility performance. Signs produced with materials of other types produce higher target values in some cases, but shorter legibility distances.

Legibility distance of signs with opaque legend and reflective background increases rapidly to a background S.I. of around 45. Thereafter the rate of increase in legibility distance slowly decreases to a maximum legibility distance at a background S.I. of 110 to 120 and then the legibility distance decreases, due to the halo effect.

Implementation

In order for the Department to realize the optimum return from the monies expended on this project, the following specifications have been adopted for state wide use.

Item 634 Plywood Signs (Type A)
Item 636 Aluminum Signs (Type A)
Item 638 Aluminum Railroad Crossbuck Sign Panel Assembly
Item 644 Conformable Sheeting Reflectorized Signs

of the 1982 Standard Specifications for Construction of Highway, Streets and Bridges and the following Departmental Material Specifications.

D-9-8300 Flat Surface Reflective Sheeting
D-9-8400 Reflectorized Removable Legend

I. Subject:

Evaluation of Materials for Shoulder-Mounted Signs and Sign Maintenance Management.

II. Purpose:

The objects of this study are:

1. Determine minimum and maximum reflective requirements for optimum legibility of signs utilizing reflective legend and background. Determine these requirements for both engineer-grade and high specific intensity sheeting.
2. Determine need, if any, and where high specific intensity sheeting should be utilized for shoulder-mounted signs, such as crossbucks, yield, and stop signs. Evaluate high specific intensity and engineer-grade sheeting for construction signs and barricades. Determine if, when, and where high specific intensity sheeting should be used.
3. Develop a sign maintenance program that will yield the optimum cost-effective functional life of signs.
4. Develop a sign management program that will allow the Department to determine realistic expenditures for signing.
5. Revise or develop specifications and guidelines commensurate with the above objectives.
6. Assist Districts and other Divisions with implementation.

Objectives 3 and 4 were deleted from the study. Objective 2 was not specifically addressed due to termination of the project.

III. Conclusions and Recommendations:

Signs of optimum functionality can be produced from reflective materials available in a competitive market. Type A (Engineer Grade) and Type B (Super Engineer Grade) sheeting, as specified in Departmental Material Specification D-9-8300, Flat Surface Reflective Sheeting, produce signs with satisfactory legibility distance. Type C (High Specific Intensity) sheeting produces signs of higher target value but less legibility distance. The use of Type C reflective sheeting is only recommended in those few locations where target value is of extreme importance and legibility is of minor importance. The use of Type A sheeting is recommended for all shoulder mounted signs.

Sheeting with specific intensity from 110 to 120 produces the optimum legibility distance for signs with opaque legends. Signs with reflectorized legend and background exhibit optimum legibility distance when the specific intensity of the legend is from 140 to 200 footcandles per footcandle per square foot and the background specific intensity is 7 to 11 percent of the legend specific intensity.

Specifications and test procedures have been developed, recommended and adopted for statewide use.

IV. Materials:

Reflectorized sheeting materials of various grades and reflective levels produced by five different manufacturers have been evaluated. Acrylic plastic reflectors for removable sign legend produced by two companies have been evaluated.

V. Equipment:

Brightness of reflective sheeting materials used in this study was determined with a Tektronix J-16 Light Meter utilizing a J-6511 probe. For uniformity in comparing data, all data was converted to Specific Intensity, footcandles per footcandle per square foot.

Specific Intensity of acrylic plastic reflectors was measured per unit instead of per square foot.
An Atlas Weatherometer was utilized for accelerated testing of reflective sheeting materials. A test fence facing south at 45° atop a five story building at the Department Camp Hubbard Complex in Austin, Texas was utilized for accelerated weathering in conjunction with the weatherometer.

Color was determined with a Gardner Color Difference Meter, XL20. Infrared characteristics were determined with a Perkin-Elmer 521 Grating Infrared Spectrophotometer.

VI. Procedure for Data:

Performance data, such as durability with respect to reflectivity and color retention, was determined in the weatherometer and on the test fence.

Legibility distances were determined on actual roadways. One roadway was a rural two lane roadway. The other was a six lane controlled access roadway with fixed roadway illumination. The legibility studies were carried out under actual road conditions; no attempt was made to alter traffic in any manner.

Screens were obtained utilizing uniform dot patterns that allowed reduction in the reflective intensity of the sheeting at 30, 50 and 70 percent. By utilizing these screens and white opaque screen ink and selecting sheeting at various reflective levels, sign backgrounds and legends were produced at various levels of reflectivity.
Sheeting legend was made by cutting letters from aluminum and then putting white reflective sheeting of various reflective levels on the letter blank. Background sign panels were made of the various colors and reflective levels. The legend was fitted with studs on the back to match pre-drilled holes in the sign panels. This allowed the rapid change of text on a sign.

To eliminate legibility of legend by recognition as near as possible, the words Olton, Alton, Elton, Eldon and Aldon were selected. All letters were six inch series D capitols. Observers were instructed by the recorder to drive the course between 40 and 50 miles per hour and read the legend on each sign. As the observer read the sign, the recorder activated a distance measuring device (DMI) and then deactivated it when the sign was passed. If the observer read the sign correctly the recorder recorded the legibility distance. If the sign was misread, the legibility distance was not recorded; this also eliminated any remaining chance of legibility by recognition.

A similar situation was divised for signs with opaque legend and reflective backgrounds.

Both female and male observers were utilized who ranged in age from eighteen to the mid-fifties. Some of the observers wore glasses. At least one observer had night vision impairment. A total of 99 observers participated in both the rural and urban study.

All legibility studies were conducted at night during the summer months. When a test run was scheduled, it was carried out regardless of weather. Therefore, tests were conducted during clear and rainy weather. However, no extreme heavy rains were encountered.

VII. Discussion:

Ever since man has used some manner of path or road as a common travel way to get from one place to another, he has used some method of marking the way and/or destination. Early signs were either crudely carved in wood or painted on wood. Roads eventually became a convenience pattern and with this convenience, signing that was usually paint on board. Man eventually learned to reflectorize signs for better night visibility and legibility. The first reflectorized signs were glass spheres embedded in paint. Ever since then, there has been a continuing effort to produce materials of higher brightness for sign reflectorization.

For the last ten or more years, producers of reflective materials have geared their efforts toward brightness and durability with little thought given to the actual needs of the motorist. Most users went along with brightness because that was something readily apparent as one viewed two or more signs of varying brightness. As this trend progressed, users began to notice that, even though signs of higher brightness had better target value, legibility or functionality may be impaired. With such thoughts in mind, it was decided to do a research study to determine the legibility of signs commonly used on the roadway.

At that time, 1977, the most commonly used sign was black legend on a white reflectorized background; and initial studies were conducted on this type of sign. Signs were made with white reflectorized backgrounds of varying intensity levels, using dot pattern screens that allowed reductions in intensity of 30, 50 and 70 percent. Background specific intensity (S.I.) ranged from 20 to 130 candlepower per foot-candle per square foot. Five legends (7 inch series C letters) were used; ELSA, EDNA, EULA, 2383 and 2838. The study was conducted on a two lane rural road using 57 observers (Figure 1). Legibility distance for a sign of any given S.I. varied from observer to observer. However, the legibility distance, with respect to varying S.I. for all observers, exhibited the same characteristic. That is, as the S.I. increased from the low of 20, the legibility distance increased rapidly to an S.I. of around 45 or 50. Thereafter, the rate of increase in legibility distance diminished with increased S.I. Legibility distance peaked at an S.I. of about 110. At an S.I. above 110, the legibility distance actually decreased. This was true for almost all observers. The reason for this characteristic is that the background gets so bright that it begins to "halo" the text. The only way to overcome the effect of the higher brightness or S.I., is to use larger letters with a wider stroke, which in turn means the sign must be larger. Therefore, it is not feasible to utilize reflective sheeting with an S.I. over 120 for shoulder mounted signs with white reflectorized backgrounds and black legends (Figure 2).

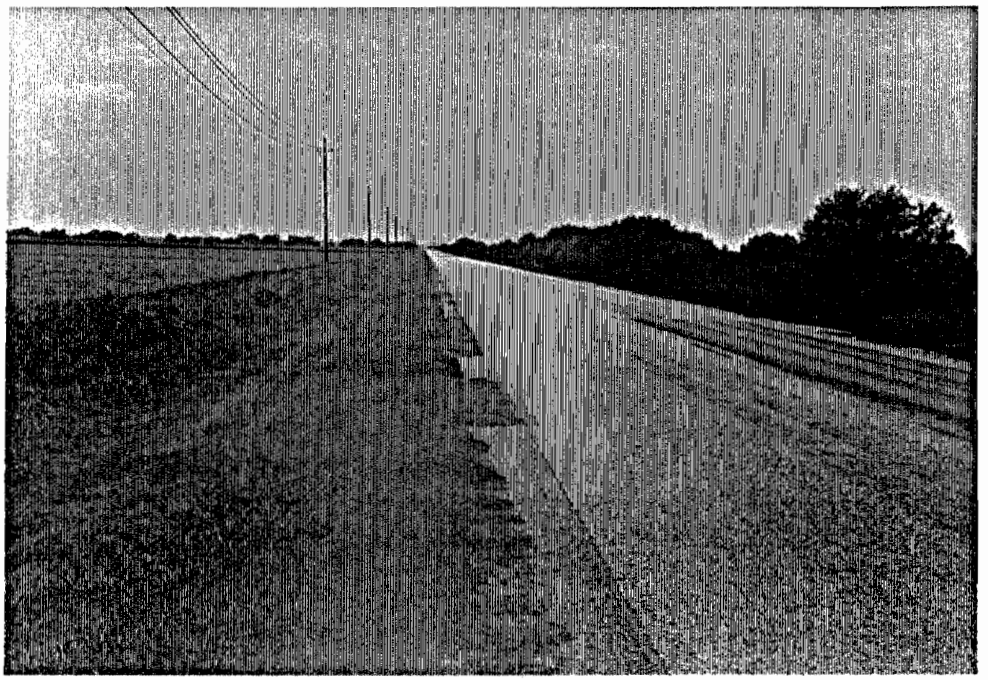


Figure 1

Rural Test Location

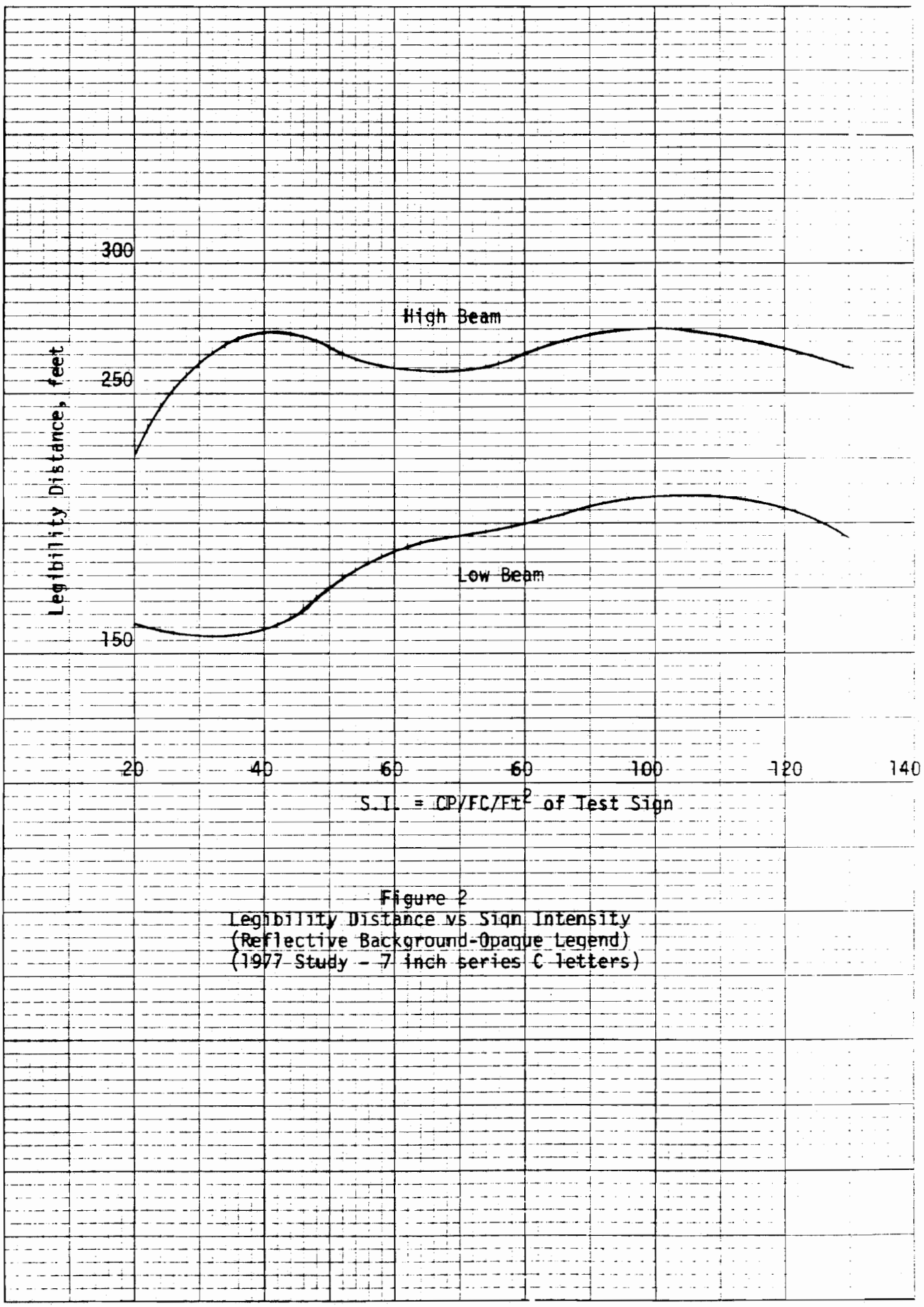


Figure 2
Legibility Distance vs Sign Intensity
(Reflective Background-Opaque Legend)
(1977 Study - 7 inch series C letters)

To further check the legibility distance with respect to varying S.I., two signs of different S.I. were placed on the same support. The same characteristic of legibility distance with respect to varying S.I., as stated above, was observed.

Based on the information gained from the 1977 study, a study was undertaken in 1980 to determine legibility distance as a function of S.I. for signs with reflectorized legend and background. Signs were studied with white legend and green, blue and red backgrounds.

There are two ways to consider reflectivity of signs that utilize reflective background and legend. One is to determine brightness of the entire sign and express the legend brightness as a percent of the total brightness. Using this method, it is difficult to conceive the actual or relative brightness of either the legend or background, because it is dependent on the actual area of each. The second method is to express the relationship of the background and legend as "contrast ratio", S.I. of legend divided by the S.I. of the background per unit area. Under this method, one does not know the exact S.I. of either the legend or background, but does know that the legend is so many times as bright as the background. The contrast ratio method was chosen to express characteristics of signs studied. By choosing this method, signs of any background S.I. could be studied with varying legend S.I. Data could then be isolated easily by background S.I. and compared to signs of other background S.I.

Under this portion of the research, legibility was studied on a two lane rural road and a six lane controlled access roadway with fixed roadway illumination (Figure 3). Most observers participated in the studies on both types of roadway. A majority of the studies were conducted using green background and white legend. Backgrounds of red and blue were studied sufficiently to determine that color variation was not a main criteria in legibility of reflectorized signs. A main criteria was considered as something that noticeably changed legibility distance when all other characteristics of any two or more signs remained constant or were of the same measured value, such as letter size and S.I. As anticipated from the initial study, legibility distance for a given size letter varied as a function of contrast ratio. Here again, legibility distance varied from observer to observer for any given sign. However, as the contrast ratio was increased from 2 to approximately 50, the legibility distance of most drivers followed the same general trend.

Figure 3

Urban Test Location

Consider a sign with a background S.I. of about 15. As the legend S.I. increases from about 60 to about 250, the legibility distance increases until a legend S.I. of approximately 170 is obtained, and then decreases as the legend S.I. is increased (Figure 4). Analysis of Figure 4 shows that, as the background S.I. drops from 58, the legibility distance increases rapidly to an S.I. of about 15 on high beams.

If legibility distance is plotted against contrast ratio (Figure 5) at constant legend S.I., the effect of halo can be realized. The legend with an S.I. of 237, High Specific Intensity Sheeting, on high beams begin to halo with backgrounds of S.I. less than 40 (contrast ratio of 6). Once the background S.I. drops below about 13 (contrast ratio about 20), the halo effect remains almost constant. On the other hand, if one observes the same signs with low beams, it is apparent that the halo effect is not encountered until the background S.I. drops to about 15 (contrast ratio of 16) and is constant for lower background S.I.'s.

No significant effect was observed with legend S.I. of 102 and the maximum legibility distance was achieved. This is in agreement with results obtained on the black legend on white reflectorized background study.

A study of Figure 5 shows that the rate of change in legibility distance is less between contrast ratios of 9 and 14. This suggests that signs with good legibility characteristics can be produced over a relatively wide range of reflectivity.

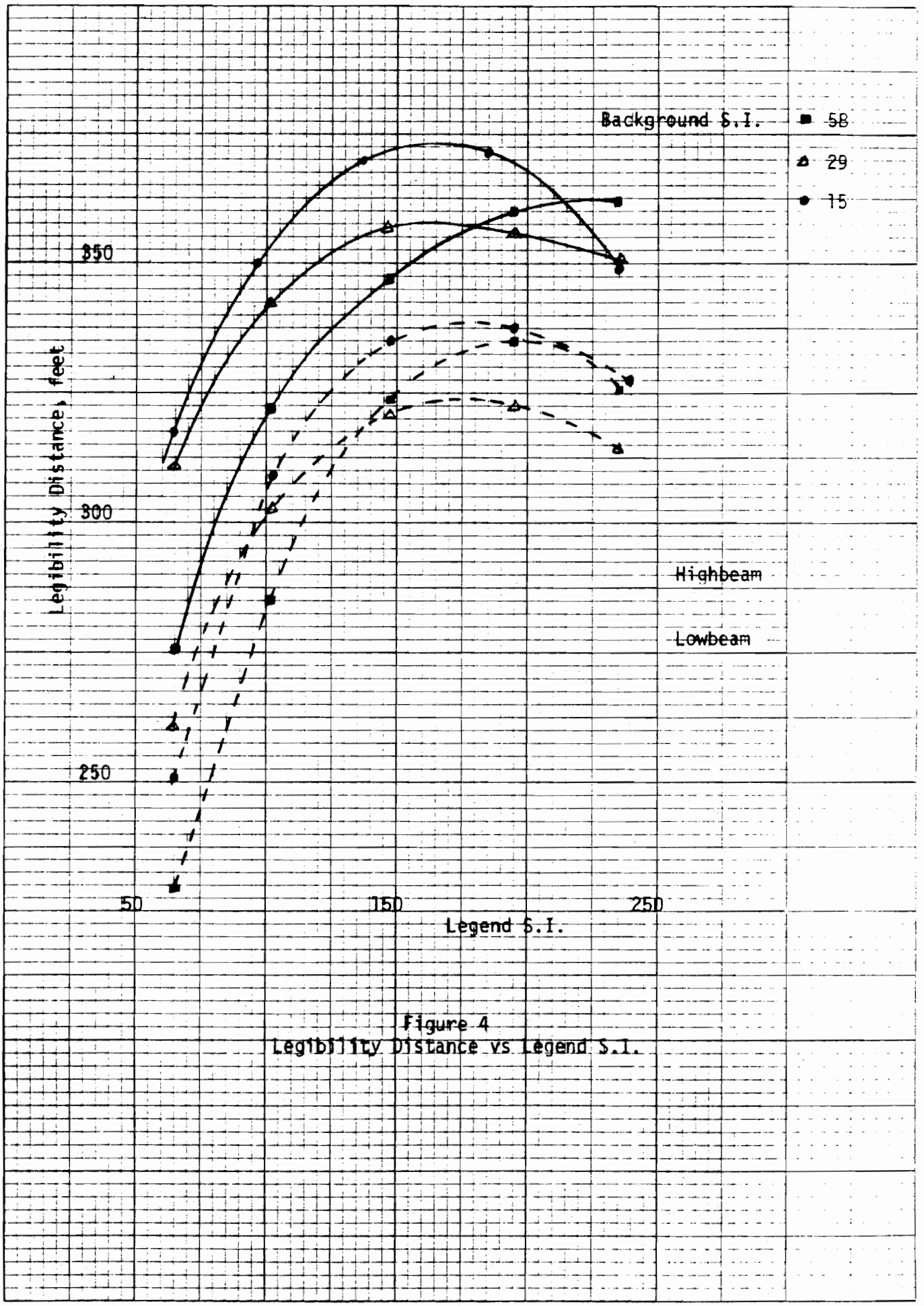


Figure 4
Legibility Distance vs Legend S.I.

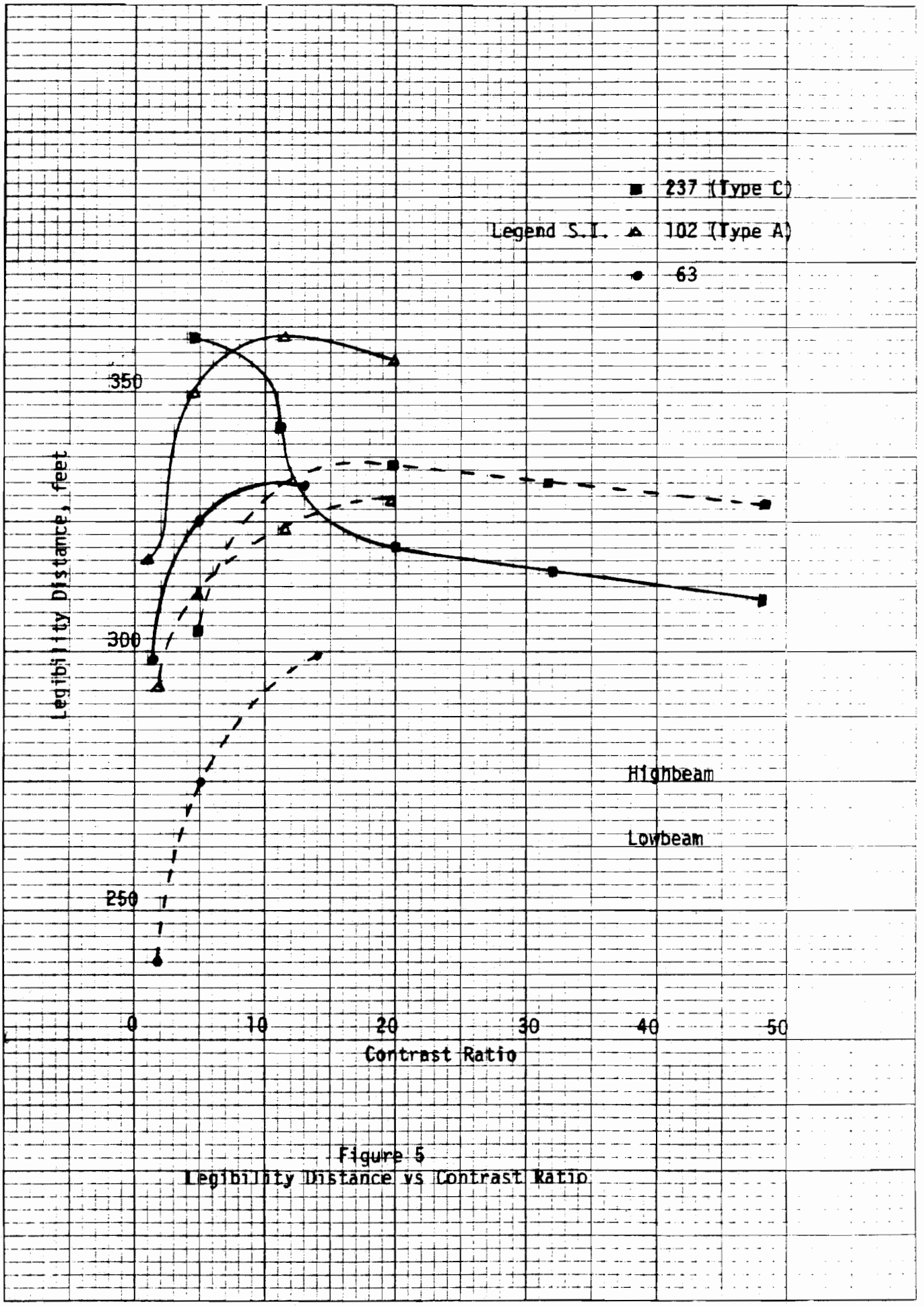


Figure 5
Legibility Distance vs Contrast Ratio

If one considers the data from both studies, one finds that legibility of reflectorized signs is dependent on reflectivity difference, the same as nonreflectorized signs are dependent on color difference. For instance, consider black legend on a white background, nonreflectorized, and consider gray as a shade of black. Then, as the darkness of gray is increased to pure black, the legibility will increase, such that it could be said that maximum contrast in color produces maximum legibility. This same characteristic would be true for signs with reflectorized background and legend, if it were not for the "halo" effect. All data shows that, as the contrast between legend and background reflectivity increased, so did the legibility distance, to some point, for each observer, and then it began to decrease. All observers who were questioned, commented that the legends of higher reflectivity began to "halo". Some even noted that, briefly, legends of high brightness could be read before the halo effect was encountered. In normal signing of roadways, the halo effect can be eliminated by increasing the letter size sufficiently to offset the halo effect due to the brightness of automobile headlights. An effort was made to check the halo effect of button removable copy, by replacing the buttons with buttons of the next smaller size. Limited tests were conducted because the buttons were still so bright that the halo effect dominated.

In all of the studies performed, best legibility distances were achieved for 6 and 7 inch legend when the predominant S.I., background or legend was around 100 to 110. Ten inch button removable copy yielded comparable legibility distances to 6 inch reflectorized legend of 100 S.I. with a background S.I. of 10 and the 7 inch opaque legend with 100 S.I. background. Total measured luminance for each legend with button removable copy was slightly higher than total measured luminance for each legend with high specific intensity sheeting.

Typical legibility distance data is contained in Appendix A and B. Specifications developed as a result of this study and previous work on signing materials are contained in Appendix C.

APPENDIX A

Typical Data for 1977 Study

DATA SHEET

#14. SCHULTZ

Observer: LINDA ~~SCHULTZ~~ Date: 14 JUNE 77

Car: CHEVY (124A) Speed: 30 MPH

Position of Observer: (Driver) or Passenger

Headlights: High Beam or (Low Beam)

Remarks: AGE = EARLY 20'S ; SKY WAS PARTLY CLOUDY

[NEW SIGN = 2383]

Run Number	Sign Identification	Message Read	Distance	Actual Message	Approx. S.I.
1.	3 BLANK	2333	150	2383	130
2.	3 AB	2838	175	2838	85
3.	1 BLANK	EDNA	300	EDNA	60
4.	1 AB	2333	175	2383	45
5.	1 HE	EDNA	150	EDNA	15
6.	2 AC	EVLA	225	EULA	60
7.	3 BC	2383	125	2383	70
8.	4 BLANK	ELSA	125	ELSA	100
9.	1 HD	2383	175	2383	20
10.	4 AC	2333	175	2838	70
11.	5 HA	EULA	225	EULA	35
12.	2 AD	2333	175	2383	65

DATA SHEET

#9.

Observer: MICKEY COCHRAN Date: 7 JUNE 77

Car: CHEVY CHEVELLE (71 124A) Speed: 30 MPH

Position of Observer: (Driver) or Passenger

Headlights: High Beam or (Low Beam)

Remarks: VISION CORRECTED WITH GLASSES. --- SKY CLEAR
AGE= MID 30's

[KEY SIGN = EDNA]

Run Number	Sign Identification	Message Read	Distance	Actual Message	Approx. S.I.
1	3 AA	ELSA	100	ELSA	80
2	2 BE	EDNA	150	EDNA	50
3	4 AE	EULA	100	EULA	70
4	5 BLANK	EDNA	100	EDNA	130
5	2 BA	2838	100	2838	50
6	1 HD	2383	75	2383	20
7	1 BD	EDNA	125	EDNA	35
8	2 AC	EULA	125	EULA	60
9	3 AD	EDNA	150	EDNA	80
10	1 HA	ELSA	150	ELSA	20
11	1 BLANK	EDNA	150	EDNA	60
12	1 HE	EDNA	75	EDNA	15

38

DATA SHEET

Observer: CAROL SANDBERG Date: 7-28-77

Car: 124A Speed: 30 MPH

Position of Observer: Driver or Passenger

Headlights: High Beam or Low Beam

Remarks: AGE 18 NO GLASSES

Run Number	Sign Identification	Message Read	Distance	Actual Message	Appr S.I
1.	4 BLANK	ELSA	200	ELSA	10(
2.	1 BB	EULA	250	EULA	40
3.	3 AD	EDNA	200	EDNA	80
4.	1 HD	2383	150	2383	20
5.	2 AC	EULA	200	EULA	60
6.	1 BC	ELSA	225	ELSA	40
7.	3 BLANK	2383	150	2383	130

DATA SHEET

Observer: (6) HERB SMART Date: 2 JUNE 77

Car: FORD TORINO (#196A) Speed: 30 MPH

Position of Observer: (Driver) or Passenger

Headlights: High Beam or Low Beam ((A) or (B))

Remarks: * INDICATES ONCOMING HEADLIGHTS.

PARTLY CLOUDY; FULL MOON ; AGE = LATE 30's

GLASSES

Run Number	Sign Identification	Message Read	Distance	Actual Message	Approx. S.I.
1(B)	2 AC	EULA ✓	300	EULA	60
2(B)	3 BLANK	2383	175	2383	130
3(B)	3 HD	2838 ✓	125	2838	30
4(B)	1 BB	EULA ✓	150	EULA	40
* 5(B)	4 BLANK	ELSA ✓	175	ELSA	100
6(B)	3 AD	EDNA ✓	250	EDNA	80
7(B)	1 HD	283 X	125	2383	20
8(B)	4 AC	2838	150	2838	70
9(A)	4 BLANK	ELSA	250	ELSA	100
10(A)	2 AC	EULA	225	EULA	60
11(A)	4 AC	2338 X	175	2838	70
12(A)	1 HD	2383	200	2383	20

APPENDIX B

Typical Data for 1980 Study

Location
FM 973
Rural

Sign Set Up

Background Color Red Date 5-13-81

Intensities

Sign #1 SI-6 #21 #2 SI-13 #22 #3 SI-45 #7 #4 SI-21 #23 #5 SI-3 #6

Legend Color White

Intensity of Legend on Sign

Run #1

Sign #1 SI-237 Olton #2 SI-228 Elton #3 SI-102 Alton #4 SI-72.5 Eldon #5 SI-204 Oldan

Run #2

Sign #1 SI-63.8 Aldon #2 Olton #3 Elton #4 Alton #5 Eldon

Run #3

Sign #1 Oldan #2 Aldon #3 Olton #4 Elton #5 Alton

Run #4

Sign #1 Eldon #2 Oldan #3 Aldon #4 Olton #5 Elton

Run #5

Sign #1 Alton #2 Eldon #3 Oldan #4 Aldon #5 Olton

Run #6

Sign #1 Elton #2 Alton #3 Eldon #4 Oldan #5 Aldon

Driver Terri Cloud Age 25 Gender F Glasses No

Date 5-13-81 Car Make & Yr 1980 Fairmont Weather Clear ☐ Rain ☐

Run #	Headlights Low Beam	Headlights High Beam	Message
Sign # 1	340 ft	247 ft	Olton
1	310 ft	342 ft	Aldon
2	282 ft	233 ft	Oldon
3			
Sign # 2	326 ft	229 ft	Elton
1	285 ft	291 ft	Olton
2	329 ft	331 ft	Aldon
3			
Sign # 3	322 ft	304 ft	Alton
1	358 ft	315 ft	Elton
2	296 ft	344 ft	Olton
3			
Sign # 4	271 ft	396 ft	Eldon
1	276 ft	334 ft	Alton
2	308 ft	303 ft	Elton
3			
Sign # 5	250 ft	305 ft	Oldon
1	261 ft	317 ft	Eldon
2	232 ft	302 ft	Alton
3			

Driver Terri Cloud Age 25 Gender F Glasses No

Date 5-13-81 Car Make & Yr 1980 Fairmont Weather Clear ☑ Rain ☐

Run # 4, 5, 6

	Headlights Low Beam	Headlights High Beam	Message
Sign # 1	315 ft	295 ft	Eldon
	269 ft	309 ft	Alton
	296 ft	334 ft	Elton
Sign # 2	238 ft	281 ft	Oldan
	241 ft	288 ft	Eldon
	234 ft	304 ft	Alton
Sign # 3	228 ft	243 ft	Aldon
	265 ft	283 ft	Oldan
	213 ft	309 ft	Eldon
Sign # 4	326 ft	400 ft	Olton
	241 ft	322 ft	Aldon
	216 ft	312 ft	Oldon
Sign # 5	341 ft	294 ft	Elton
	224 ft	225 ft	Olton
	139 ft	259 ft	Aldon

Driver Lee Mottern Age 26 Gender F Glasses Yes

Date 5-13-81 Car Make & Yr 1981 LeBaron Weather Clear ☑ Rain ☐

Run #	Headlights Low Beam	Headlights High Beam	Message
Sign # 1	444 ft	414 ft	Olton
1	486 ft	439 ft	Alton
2	401 ft	381 ft	Olden
Sign # 2	445 ft	408 ft	Elton
1	472 ft	480 ft	Olton
2	373 ft	443 ft	Aldon
Sign # 3	372 ft	426 ft	Alton
1	408 ft	506 ft	Elton
2	416 ft	381 ft	Olton
Sign # 4	358 ft	361 ft	Eldon
1	394 ft	492 ft	Alton
2	467 ft	370 ft	Elton
Sign # 5	374 ft	455 ft	Oldon
1	302 ft	427 ft	Eldon
2	357 ft	431 ft	Alton

Driver Lee Mattern Age 26 Gender F Glasses Yes

Date 5-13-81 Car Make & Yr 1981 LeBaron Weather Clear ☑ Rain ☐

Run # 4 5 6

	Headlights Low Beam	Headlights High Beam	Message
Sign # 1	358 ft	420 ft	Eldon
	422 ft	510 ft	Alton
	413 ft	410 ft	Elton
Sign # 2	396 ft	400 ft	Oldan
	326 ft	412 ft	Eldon
	452 ft	437 ft	Alton
Sign # 3	176 ft	392 ft	Aldon
	345 ft	485 ft	Oldan
	286 ft	322 ft	Eldon
Sign # 4	323 ft	428 ft	Olton
	329 ft	387 ft	Aldon
	441 ft	421 ft	Oldan
Sign # 5	362 ft	461 ft	Elton
	411 ft	441 ft	Olton
	289 ft	356 ft	Aldon

Driver Larry Worden Age 31 Gender M Glasses No

Date 5-13-81 Car Make & yr 1981 LeBaron Weather Clear ☑ Rain ☐

Run # 1 / 2 / 3

	Headlights Low Beam	Headlights High Beam	Message
Sign # 1	420 ft	536 ft	Olton
	401 ft	482 ft	Aldon
	435 ft	407 ft	Oldan
Sign # 2	414 ft	503 ft	Elton
	573 ft	460 ft	Olton
	358 ft	453 ft	Aldon
Sign # 3	260 ft	251 ft	Alton
	473 ft	524 ft	Elton
	452 ft	450 ft	Olton
Sign # 4	306 ft	388 ft	Eldon
	339 ft	433 ft	Alton
	446 ft	476 ft	Elton
Sign # 5	356 ft	464 ft	Oldan
	277 ft	382 ft	Eldon
	353 ft	340 ft	Alton

Driver Larry Worden Age 31 Gender M Glasses No

Date 5-13-81 Car Make & Yr 1981 LeBaron Weather Clear ☑ Rain ☐

Run # 4 5 6

	Headlights Low Beam	Headlights High Beam	Message
Sign # 1	406 ft	411 ft	Eldon
	527 ft	343 ft	Alton
	446 ft	346 ft	Elton
Sign # 2	428 ft	395 ft	Oldan
	423 ft	310 ft	Eldon
	422 ft	421 ft	Alton
Sign # 3	245 ft	234 ft	Aldon
	439 ft	367 ft	Oldan
	228 ft	270 ft	Eldon
Sign # 4	376 ft	451 ft	Olton
	425 ft	298 ft	Aldon
	413 ft	422 ft	Oldan
Sign # 5	434 ft	558 ft	Elton
	422 ft	481 ft	Olton
	198 ft	335 ft	Aldon

Driver Paul D. Pennybacker Age 22 Gender M Glasses Yes

Date 5-13-81 Car Make & Yr 1980 Fairmont Weather Clear ☒ Rain ☐

Run # 1 2 3

	Headlights Low Beam	Headlights High Beam	Message
Sign # 1	293 ft	269 ft	Olton
	324 ft	426 ft	Aldon
	282 ft	358 ft	Oldan
Sign # 2	328 ft	365 ft	Elton
	203 ft	252 ft	Olton
	198 ft	281 ft	Aldon
Sign # 3	238 ft	254 ft	Alton
	246 ft	284 ft	Elton
	243 ft	362 ft	Olton
Sign # 4	146 ft	201 ft	Eldon
	204 ft	283 ft	Alton
	276 ft	445 ft	Elton
Sign # 5	239 ft	257 ft	Oldan
	157 ft	206 ft	Eldon
	208 ft	277 ft	Alton

Driver Paul D. Pennybacker Age 22 Gender M Glasses Yes

Date 5-13-81 Car Make & Yr 1980 Fairmont Weather Clear ☐ Rain ☐

Run # 4, 5, 6

	Headlights Low Beam	Headlights High Beam	Message
Sign # 1	269 ft	363 ft	Eldon
	246 ft	226 ft	Alton
	338 ft	396 ft	Elton
Sign # 2	195 ft	360 ft	Oldan
	171 ft	297 ft	Eldon
	268 ft	334 ft	Alton
Sign # 3	148 ft	181 ft	Aldon
	197 ft	309 ft	Oldan
	119 ft	171 ft	Eldon
Sign # 4	295 ft	416 ft	Olton
	143 ft	185 ft	Aldon
	265 ft	362 ft	Oldan
Sign # 5	308 ft	321 ft	Elton
	206 ft	362 ft	Olton
	159 ft	153 ft	Aldon

Location
LOOP 1 (MOPAC)
URBAN

Sign Set Up

Background Color Blue Date 9-8-81

Intensities

		SI-6.3		SI-3.0		SI-35.7		SI 28.6	SI-11
Sign #1	#22	#2	#8	#3	#10	#4	#9	#5	#30

Legend Color White

Intensity of Legend on Sign

Run #1

		SI-237		SI-11[illegible]		SI-204		SI-72.5		SI-228
Sign #1	Olton	#2	Alton	#3	Olden	#4	Elden	#5	Elton

Run #2

		SI 63.8							
Sign #1	Alden	#2	Olton	#3	Alton	#4	Olden	#5	Elden

Run #3

Sign #1	Elton	#2	Alden	#3	Olton	#4	Alton	#5	Olden

Run #4

Sign #1	Elden	#2	Elton	#3	Alden	#4	Olton	#5	Alton

Run #5

Sign #1	Olde[illegible]	#2	Elden	#3	Elton	#4	Alden	#5	Olton

Run #6

Sign #1	Alton	#2	Elden	#3	Elden	#4	Elton	#5	Alden

Driver Linda Ball Age 27 Gender F Glasses Yes

Date 9-8-81 Car Make, Yr 1981 LeBaron Weather Clear ☒ Rain ☐

Headlights Low Beam

	Run # 1		Run # 4	
	2		5	
	3	Message	6	Message
Sign # 1	403 ft	Olton	275 ft	Eldon
	438 ft	Aldon	450 ft	Oldan
	522 ft	Elton	497 ft	Alton
Sign # 2	503 ft	Alton	528 ft	Elton
	396 ft	Olton	467 ft	Eldon
	389 ft	Aldon	422 ft	Oldan
Sign # 3	574 ft	Oldan	472 ft	Aldon
	461 ft	Alton	560 ft	Elton
	514 ft	Olton	440 ft	Eldon
Sign # 4	449 ft	Eldon	418 ft	Olton
	456 ft	Oldan	359 ft	Aldon
	456 ft	Alton	597 ft	Alton (Elton)
Sign # 5	530 ft	Elton	568 ft	Alton
	429 ft	Eldon	504 ft	Olton
	452 ft	Oldan	387 ft	Aldon

Driver Clarence Stark Age 45 Gender M Glasses No

Date 9-8-81 Car Make & Yr 1980 Fairmont Weather Clear ☒ Rain ☐

Headlights Low Beam

	Run # 1		Message	Run # 4		Message
	2			5		
	3			6		
Sign # 1	448	ft	Olton	418	ft	Eldon
	407	ft	Aldon	342	ft	Oldan
	381	ft	Elton	343	ft	Alton
Sign # 2	373	ft	Alton	355	ft	Elton
	452	ft	Olton	406	ft	Eldon
	327	ft	Aldon	396	ft	Oldan
Sign # 3	279	ft	Oldan	350	ft	Aldon
	387	ft	Alton	364	ft	Elton
	358	ft	Olton	284	ft	Eldon
Sign # 4	331	ft	Eldon	346	ft	Olton
	447	ft	Oldan	284	ft	Aldon
	338	ft	Alton	354	ft	Elton
Sign # 5	501	ft	Elton	300	ft	Alton
	205	ft	Eldon	341	ft	Olton
	373	ft	Oldan	370	ft	Aldon

Driver Terri Cloud Age 26 Gender F Glasses N

Date 9-8-81 Car Make & Yr 1981 LaBaron Weather Clear ☐ Rain ☐

	Run # 1		Run # 4	
Headlights Low Beam	2		5	
	3	Message	6	Message
Sign # 1	349 ft	Olton	433 ft	Eldon
	363 ft	Aldon	343 ft	Oldan
	493 ft	Elton	390 ft	Alton
Sign # 2	339 ft	Alton	393 ft	Elton (Olton
	265 ft	Olton	320 ft	Eldon
	327 ft	Aldon	253 ft	Oldan
Sign # 3	330 ft	Oldan	255 ft	Aldon
	318 ft	Alton	396 ft	Elton
	373 ft	Olton	321 ft	Eldon
Sign # 4	313 ft	Eldon	355 ft	Olton
	343 ft	Oldan	316 ft	Aldon
	374 ft	Alton	289 ft	Alton (Elto
Sign # 5	366 ft	Elton	303 ft	Alton
	313 ft	Eldon	309 ft	Olton
	331 ft	Oldan	319 ft	Aldon

Driver Gary Whiteley Age 32 Gender M Glasses Yes

Date 9-8-81 Car Make & Yr 1980 Fairmont Weather Clear ☐ Rain ☐

	Run # 1		Run # 4	
Headlights Low Beam	2		5	
	3	Message	6	Message
Sign # 1	341 ft	Olton	340 ft	Eldon
	366 ft	Aldon	273 ft	Oldan
	409 ft	Elton	376 ft	Alton
Sign # 2	446 ft	Alton	327 ft	Elton
	377 ft	Olton	337 ft	Eldon
	363 ft	Aldon	334 ft	Oldan
Sign # 3	371 ft	Oldan	314 ft	Aldon
	425 ft	Alton	368 ft	Elton
	378 ft	Olton	290 ft	Eldon
Sign # 4	401 ft	Eldon	308 ft	Olton
	321 ft	Oldan	358 ft	Aldon
	374 ft	Alton	411 ft	Elton
Sign # 5	419 ft	Elton	354 ft	Alton
	339 ft	Eldon	373 ft	Olton
	364 ft	Oldan	381 ft	Aldon

APPENDIX C

Specifications

Adopted by the Texas State Department of Highways and Public Transportation, September 1, 1982.

ITEM 634

PLYWOOD SIGNS (Type A)

634.1. **Description.** This item shall govern for plywood signs having sign blanks made from high density plastic-faced plywood and having sign faces reflectorized with flat surface reflective sheeting.

634.2. **Materials.** Copies of Departmental Material Specifications are available from the State Department of Highways and Public Transportation, Materials and Tests Division, 38th and Jackson St., Austin, Texas, 78703.

(1) **Sign Blanks.** Sign blanks shall be in accordance with Departmental Specification, D-9-7100, "Plywood Sign Blanks".

Sign faces are not acceptable if the variation of the surface in any direction exceeds an amount equal to 1/8-inch per foot of defect in width or height as the case may be. Any vertical or horizontal misalignment between panel faces shall not be greater than 1/16-inch.

(2) **Sign Face Reflectorization.** Sign faces shall be reflectorized with flat surface reflective sheeting and shall be of the color shown on the plans. The sheeting shall be of the same manufacture for all signs of the same classification throughout the project and shall be in accordance with Departmental Specification D-9-8300, "Flat Surface Reflective Sheeting", Type A.

(3) **Sign Message.** The sign message shall be of the size, type and color shown on the plans.

(a) Screen processing ink approved by the Department's Material and Test Division shall be used for sign messages applied to sign faces by the screen process. Messages shall have clean, sharp edges with no runs or sags and shall be of sufficient thickness to completely cover the background material. Screen inks shall conform to Departmental Specification D-9-8300, "Flat Surface Reflective Sheeting".

(b) Reflectorized removable legend specified on the plans for various signs shall conform with Departmental Specification, D-9-8400, "Reflectorized Removable Legend".

(c) Reflectorized sheeting legend, specified on the plans for various signs, shall be made from material conforming to Departmental Specification D-9-8300, "Flat Surface Reflective Sheeting".

(d) When sheet aluminum signs are required as a part of the message, they shall conform with the plans and with the Item, "Aluminum Signs (Type A)".

(4) **Hardware.** All bolts, nuts, washers, lock washers, and other hardware used in making the signs which are not specifically covered on the plans shall be galvanized steel, stainless steel or aluminum in conformance with Departmental Specification D-9-7120, "Sign Hardware". Dissimilar metals shall be so selected or insulated as to prevent corrosion.

(5) **Sign Post Connections.** All sign post or support connections shall be capable of developing the full strength of the sign and they shall be stainless steel, galvanized steel, or aluminum, in conformance with Departmental Specification D-9-7120, "Sign Hardware". Dissimilar metals shall be so selected or insulated as to prevent corrosion.

634.3. **Fabrication.**

(1) **Working Drawings.** Prior to fabrication the Contractor shall submit for approval of the Engineer five prints of the working drawing for each sign using removable reflectorized legend, except that when there are two or more signs of identical design, a working drawing for only one of the signs need be submitted. The working drawings shall show the details of the panels, frames, wind beams, stiffeners, joint backing plates, splices, if any, fasteners, brackets, sign post or support connections, and methods of attaching legend to the sign face. In addition, the working drawing shall show letter height and interline spacing of the legend in sufficient detail to check against the plans.

(2) Sign blanks shall be cut to the proper size and shape shown on the plans for the various signs. Thickness of the sign blanks shall be as shown on the plans. Unless otherwise shown on the plans, no panel shall have a face dimension less than 2'-0". Signs 4' x 8' or smaller in either dimension shall be of one-piece construction.

(3) All sign blanks or sign panel fabrication, including cutting, drilling, and edge routing shall be completed prior to application of reflective materials.

(4) Reflective Sheeting shall be applied to sign faces in conformance with the recommended procedures of the manufacturer of the sheeting.

Whenever a sign face is comprised of two or more panels, the reflective sheeting on adjacent panels must be matched carefully for color to provide uniform appearance and brilliance both day and night. Because one roll of sheeting may be sufficient to cover several panels, each panel shall be

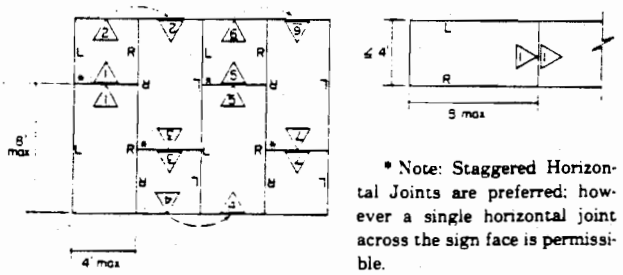
match-marked consecutively as sheeting is applied from any one sheeting roll. Panels shall then be assembled consecutively as shown below to construct the completed sign:

TYPICAL ASSEMBLY

△1 — Matchmarks

L — Left edge of sheeting as it comes off the roll.

R — Right edge of sheeting as it comes off the roll.



* Note: Staggered Horizontal Joints are preferred; however a single horizontal joint across the sign face is permissible.

Nonconformance with this assembly procedure may result in non-uniform shading and an undesirable contrast between adjacent widths of applied sheeting which will not be acceptable. When splicing of sheeting is necessary, the number of splices shall be held to a minimum consistent with the sheeting widths furnished by the manufacturer. The minimum dimension for any one piece of sheeting material shall be 1'-0".

(5) **Cutting, Handling and Storing Sign Blanks and Panels.** High density exterior type plywood panels may be fabricated with standard woodworking equipment. Precaution shall be taken to prevent overlay surfaces from coming in contact with any substance which would inhibit adhesion of reflective sheeting. Fabrication of all plywood signs shall be accomplished in a uniform and workmanlike manner.

(6) Sign identification decals shall be coded and attached to the sign panels after fabrication as specified in the plans.

634.4. Erection.

(1) Prior to erection, all bolt heads and hardware showing on sign faces shall be covered with reflective sheeting or painted similar in color to the sign face.

(2) Completed sign blanks and panels shall be handled and stored in such manner that corners, edges and faces are not damaged. Any mars, scratches or other damage to the sign faces which are not visible when viewed, as outlined in the Department's *MANUAL OF TESTING PROCEDURES*, at a distance of fifty feet, shall be acceptable. Finished sign faces shall be stored off the ground in a vertical position and protected from the weather until properly erected.

(3) Sign identification decals shall be coded after erection as specified in the plans.

634.5. Cleaning. The signs shall be cleaned prior to inspection. The signs shall be washed with a cleaning solution acceptable to the manufacturer of the sign coating to remove all grease, oil, dirt, smears, streaks, finger marks, and other foreign particles prior to shop inspection and prior to final inspection, after erection.

634.6. Sampling and Testing. Sampling and testing will be in accordance with the Department's *MANUAL OF TESTING PROCEDURES*.

634.6. Measurement. Plywood Signs (Type A) will be measured by the square foot. Measurement will be made to the nearest 0.01 square foot of the area of the vertical front face of the signs erected as determined from the plans and the specifications with no deductions for rounding off corners. No measurement will be made for area in excess of this minimum area.

634.8. Payment. Payment for Plywood Signs (Type A) shall be made at the unit price bid per square foot for "Plywood Signs (Type A)" as specified, which price shall be full compensation for furnishing the high density sign blanks and/or panels; fabrication of the blanks and/or panels; furnishing and application of reflective sheeting to the faces of blanks and/or panels; application of message to the sign faces as required by the plans; furnishing and fabrication of frames, wind beams, stiffeners, and/or joint backing strips that are required; furnishing all bolts, rivets, screws, fasteners, clamps, brackets and sign post or support connections; assembling and erecting the signs, washing and cleaning the signs after erection; and all other labor, materials, and incidentals necessary to provide signs complete and attached to the sign posts or supports.

Adopted by the Texas State Department of Highways and Public Transportation, September 1, 1982.

ITEM 636

ALUMINUM SIGNS (Type A)

636.1. **Description.** This item shall govern for aluminum signs which are of one piece construction made from sheet aluminum, and which have the face side reflectorized.

636.2. **Materials.** Copies of Departmental Material Specifications are available from the State Department of Highways and Public Transportation, Materials and Tests Division, 38th and Jackson St., Austin, Texas, 78703.

(1) **Sign Blanks.** Sheet aluminum sign blanks shall conform with Departmental Specification D-9-7110, "Aluminum Sign Blanks", and shall be of the thickness shown on the plans.

(2) **Sign Face Reflectorization.** Sign face reflectorization shall be of the color shown on the plans.

Flat surface reflective sheeting shall be used for reflectorization of sign faces with messages applied by the screen process, using process ink, in conformance with the plans. Flat surface reflective sheeting shall be of the same manufacture for all signs of the same classification throughout the project.

Flat surface reflective sheeting shall conform with Departmental Specification D-9-8300, "Flat Surface Reflective Sheeting", Type A.

(3) **Hardware for Attaching Aluminum Signs (Type A) to Guide Signs.** Attachments of Aluminum Signs (Type A) to guide signs as a part of the guide sign message shall be made by screws of stainless steel, galvanized steel, or aluminum, in conformance with Departmental Specification D-9-7120, "Sign Hardware". Dissimilar metals shall be so selected or insulated as to prevent corrosion.

When required by the plans, aluminum hardware used for signs located in coastal and heavy industrial atmospheres shall be given a dichromate sealed finish conforming with the requirements of Departmental Specification D-9-7120, "Sign Hardware".

636.3. **Fabrication.**

(1) **Cutting and Handling.** Sign blanks shall be cut to the proper size and shape as shown on the plans, shall be free of buckles, warps, burrs, dents, cockles, and other defects resulting from fabrication, and shall be essentially a plane surface.

The sign blanks shall not be handled except by device or clean canvas gloves between all cleaning operations and the application of the reflective material. There shall be no opportunity for the blanks to come in contact with grease, oils, or contaminants prior to the application of the reflective material.

(2) **Application of Reflective Sheeting to Sign Faces.** Sheeting shall be applied to sign faces in conformance with the recommended procedures of the manufacturer of the sheeting. When splicing of sheeting is necessary, the number of splices shall be held to a minimum consistent with the sheeting widths furnished by the manufacturer, and the minimum dimension for any one piece of sheeting shall be 1'-0".

(3) **Sign Message.** Sign messages shall be the size and color shown on the plans. Screen processing ink approved by the Department's Materials and Tests Division shall be used for sign messages applied to sign faces by the screen process. Messages shall have clean, sharp edges with no runs or sags and shall be of sufficient thickness to completely cover the background material. Screen inks shall conform to Departmental Specification D-9-8300, "Flat Surface Reflective Sheeting".

636.4. **Sign Identification Decals.** Sign identification decals shall be affixed to each independently mounted sign panel and coded after fabrication and after erection as specified in the plans.

636.5. **Sign Post Connections.** Sign post connections shall conform with the designs shown on the plans.

636.6. **Cleaning.** The signs shall be cleaned prior to inspection. The signs shall be washed with a cleaning solution acceptable to the manufacturer of the sign coating to remove all grease, oil, dirt, smears, streaks, finger marks, and other foreign particles prior to shop inspection and prior to final inspection, after erection.

636.7. Sampling and Testing will be in accordance with the Department's *MANUAL OF TESTING PROCEDURES*.

Adopted by the Texas State Department of Highways and Public Transportation, September 1, 1982.

ITEM 638

ALUMINUM RAILROAD

CROSSBUCK SIGN PANEL ASSEMBLY

638.1. **Description.** This item shall govern for railroad crossbuck sign panel assemblies which are made from aluminum and which have the face side reflectorized.

638.2. **Materials.** Copies of Departmental Material Specifications are available from the State Department of Highways and Public Transportation, Materials and Tests Division, 38th and Jackson St., Austin, Texas, 78703.

(1) **Sign Panels.** Extruded aluminum railroad crossbuck sign panels and sheet aluminum supplemental track number signs shall be of the thickness shown on the plans and shall conform with Departmental Specification D-9-7110, "Aluminum Sign Blanks".

Panels shall be dimensioned as shown in the plans.

(2) **Sign Face Reflectorization.** Sign face reflectorization shall be of the color shown on the plans.

Flat surface reflective sheeting shall be used for reflectorization of sign panels and shall conform with Departmental Specification D-9-8300, "Flat Surface Reflective Sheeting", Type C. All sheeting shall be of the same manufacture for all railroad crossbuck assemblies on this project.

(3) **Sign Support Connections and Hardware.** Sign support connections shall be as shown on the plans and shall conform with Departmental Specification D-9-7120, "Sign Hardware".

All bolts, nuts, washers, lock washers, fasteners, and other hardware used in making the signs which are not specifically covered on the plans shall be galvanized steel, stainless steel, or aluminum, subject to the condition that dissimilar metals shall be so selected or insulated as to prevent corrosion.

638.3. **Fabrication.**

(1) **Cutting and Handling.** All fabrication of sign panels including cutting and drilling or punching of holes shall be completed prior to metal degreasing and application of the reflective material.

The sign panels shall not be handled except by device or clean canvas gloves between all cleaning operations and the application of the reflective material. There shall be no opportunity for the panels to come in contact with grease, oils, or contaminants prior to the application of the reflective material.

(2) **Application of Reflective Sheeting to Sign Faces.** Reflective sheeting shall be applied without splices to the sign faces in conformance with the recommended procedures of the manufacturer of the reflective sheeting.

(3) **Sign Message.** The sign message shall be of the size, type and color shown on the plans. Processing ink used in applying the message shall be approved by the Department's Materials and Tests Division. The message shall have clean, sharp edges with no runs or sags and shall be of sufficient thickness to completely cover the background material. Screen inks shall conform to Departmental Specification D-9-8300, "Flat Surface Reflective Sheeting".

638.4. **Cleaning.** The signs shall be cleaned prior to inspection. The signs shall be washed with a cleaning solution acceptable to the manufacturer of the sign coating to remove all grease, oil, dirt, smears, streaks, finger marks, and other foreign particles prior to shop inspection and prior to final inspection, after erection.

638.5. **Sampling and Testing.** Sampling and testing will be in accordance with the Department's *MANUAL OF TESTING PROCEDURES*.

638.6. **Measurement.** Aluminum Railroad Crossbuck Sign Panel Assembly will be measured by each two-panel crossbuck assembly and supplemental track number sign when required, complete and attached to the sign supports.

638.7. **Payment.** Work performed and materials furnished as prescribed by this item, measured as prescribed under "Measurement", shall be paid for at the unit price bid per sign for "Aluminum Railroad Crossbuck Sign Panel Assembly", which price shall be full compensation for furnishing aluminum sign panels; fabrication of the panels; treatment of the sign panels required by this specification; furnishing and applying reflective sheeting to the sign panels; screening of the message as required by the plans; furnishing the sign post connectors; washing and cleaning of the signs after erection; and furnishing all other materials, labor and incidentals necessary to provide signs completed and attached to the sign supports.

636.8. **Measurement.** Aluminum Signs (Type A) will be measured by the square foot. Measurement will be made to the nearest 0.01 square foot of the area of the vertical front face of the signs erected as determined from the plans and specifications, with no deductions for rounding off corners, and no measurement will be made for area in excess of this minimum area.

636.9. **Payment.** Payment for Aluminum Signs (Type A) shall be made at the unit price bid per square foot for "Aluminum Signs (Type A)" which price shall be full compensation for furnishing sheet aluminum sign blanks; fabrication of the sign blanks, treatment of the sign blanks required by this specification; furnishing and applying reflective sheeting to the sign faces; screening of messages as required by the plans; furnishing the sign connections; washing and cleaning the signs after erection; and furnishing all other materials, labor and incidentals necessary to provide signs completed and attached to the sign support or guide sign as specified on the plans.

Adopted by the Texas State Department of Highways and Public Transportation, September 1, 1982.

ITEM 644

CONFORMABLE SHEETING REFLECTORIZED SIGNS

644.1. **Description.** This item shall govern for the furnishing and installation of signs made solely of reflective sheeting which has a pressure-sensitive adhesive backing that allows the sign to be affixed to such surfaces as are shown in the plans.

644.2. **Materials.** Copies of Departmental Material Specifications are available from the State Department of Highways and Public Transportation, Materials and Tests Division, 38th and Jackson St., Austin, Texas, 78703.

The reflective sheeting shall be capable of being applied to and used on rough, porous surfaces such as concrete, asphalt, steel, brick, and wood for the purpose of posting overhead clearances for bridges. The material must be a product suitable for use in these exposure conditions and must conform to Departmental Specification D-9-8300, "Flat Surface Reflective Sheeting", Type D.

644.3. **Fabrication.** The message as shown on the plans shall be screened on the reflective sheeting in accordance with the sheeting producer's recommended practices utilizing screen inks approved by the Department. Screen inks shall conform to Departmental Specification D-9-8300, "Flat Surface Reflective Sheeting".

644.4. **Installation.** Signs will be installed as shown on the plans or as directed by the Engineer. Before application, the surface must be prepared to the satisfaction of the Engineer in accordance with the manufacturer's instructions.

Whenever the sign is applied over expansion joints, deep cracks or seams, it is to be slit to avoid tearing or lifting. Any applied sign that has wrinkles, air pockets, ragged edges, tears or bends shall be removed and replaced at the sole cost of the Contractor. The installation as a whole shall be carried out in conformance with requirements herein stated and with details and dimensions shown in the plans. Upon completion, the work shall present a neat and workmanlike appearance.

644.5. **Sampling and Testing.** Sampling and testing will be in accordance with the Department's *MANUAL OF TESTING PROCEDURES.*

644.6. **Measurement.** Conformable Sheeting Reflectorized Signs will be measured to the nearest 0.01 square foot of material in place. No deductions for rounding off sign radii corners will be made.

644.7. **Payment.** The materials furnished and work performed as prescribed by this item, measured as provided under "Measurement" shall be paid for at the unit price bid for "Conformable Sheeting Reflectorized Signs" which price shall be full compensation for furnishing all labor, tools, equipment, and incidentals necessary to fabricate and install the signs and to otherwise complete the work.

STATE DEPARTMENT OF HIGHWAYS
AND
PUBLIC TRANSPORTATION

Departmental Materials Specification: D-9-8400
Reflectorized Removable Legend

I. Description: This specification shall govern for the materials, composition, quality, sampling and testing of reflectorized removable legend, as specified hereinafter.

II. Bidder's and/or Supplier's Requirements: All prospective bidders, suppliers, contractors, sign fabricators, and/or coaters are hereby notified that the materials utilized to coat the frames for the reflectorized removable legend shall be either polyvinylidene flouride plastic-thermosetting or thermosetting polyester prequalified under Departmental Specification D-9-8500, "Non-reflective Background Coatings."

III. Payment:

A. Procurement by the State: Payment for all materials governed by this specification will be in accordance with the provisions of the purchase order awarded by the State.

B. Contract: All materials governed by this specification utilized in the manufacture or production of sign faces, sign panels, and/or completed signs, shall be considered as subsidiary to the signs on which they are used.

IV. Sampling and Testing: Sampling and testing shall be in accordance with the State Department of Highways and Public Transportation, Materials and Tests Division Manual of Testing Procedures. Costs of sampling and testing are normally borne by the Department. However, the costs of sampling and testing of materials failing to conform with the requirements of this specification shall be borne by the contractor or supplier. Costs of sampling and testing of failing material shall be assessed at the rate established by the Materials and Tests Engineer, and in effect at the time of testing. Amounts due the Department for conducting such tests will be deducted from monthly or final estimates on contracts or from partial or final payments on direct purchases by the State.

V. Material Requirements:

A. General Requirements: This specification covers the general and specific requirements of reflectorized removable legend which shall consist of acrylic-plastic reflectors supported by embossed-aluminum frames. All reflectorized removable legend supplied on any one contract project shall be of the same manufacture.

B. Embossed Aluminum Frames: The aluminum frames design shall be the Federal Highway Administration's Standard Alphabet for Highway Signs, modified to accommodate the required reflectors. The frames shall be fabricated from 0.040 inch aluminum sheet conforming to the requirements of ASTM Specification B209 alloy 3003. The size and spacing of the holes for reflectors in the frames shall be such as to afford maximum night and day legibility and visibility to the finished figure.

C. Coatings: The fabricated frames shall be coated with either a Class A or Class B coating meeting the requirements of Departmental Specification D-9-8500, "Non-Reflective Background Coatings", except that the thickness of the Class A coating shall be 2.0 to 8.0 mils. The color of the coating shall be white, unless specified otherwise.

D. Acrylic-Plastic Reflectors: The reflectors shall be acrylic plastic and shall consist of a clear and transparent plastic face, herein referred to as the lens, and back material attached to the lens around the entire perimeter to form a homogeneous unit permanently sealed against dust, water and air. The reflectors shall be colorless. The lens shall consist of a smooth front surface free from projection or indentations other than for identification and a rear surface bearing a prismatic configuration such that it will effect internal reflection of light. The manufacturer's name or trade mark shall be moulded legibly into the face or back of the lens.

Reflectors shall be designed for installation as an integral part of the frame or otherwise securely affixed to the frame to prevent their displacement in handling or service. Frames in which reflectors are assembled by means of tape are unacceptable.

1. Optical Performance: The specific intensity of the reflectors shall equal or exceed the following minumum values:

Entrance Angle Degrees	Divergence Angle Degrees	Specific Intensity Cp./Sq. Foot/Foot-Candl
0	1/10	2000
20	1/10	800
0	1/3	1000
20	1/3	400

2. Seal Test: The reflectors shall comply with the requirements listed in Test Method Tex-845-B.

3. Heat-Resistance Test: The reflectors shall comply with the requirements listed in Test Method Tex-846-B.