Approved September 19, 1988
Date

MINUTES OF THE House COMMITTEE ON Transportation.

The meeting was called to order by Rex Crowell at
Chairperson

1:30 ~~a.m.~~/p.m. on March 28, 1988 in room 519-S of the Capitol.

All members were present except: Representative Charles Laird

Committee staff present:
Bruce Kinzie, Revisor of Statutes
Hank Avila, Legislative Research
Donna Mulligan, Committee Secretary

Conferees appearing before the committee:
Secretary Horace B. Edwards, Kansas Department of Transportation
Dr. Hugh McGee, Bellomo-McGee, Inc.
Representative Jim Lowther
Major David Hornbaker, Kansas Highway Patrol
Mr. Pat Barnes, Kansas Motor Car Dealers Association
Ms. D. Jeanne Kutzley, Office of the Attorney General

The meeting was called to order by Chairman Crowell, and the first order of business was a presentation by the Kansas Department of Transportation concerning the reflectorized sheeting study.

Secretary Horace B. Edwards, Kansas Department of Transportation, spoke to the Committee regarding the reflectorized sheeting study. (See Attachment 1) He said the firm of Bellomo-McGee, Inc., was selected from a group of four qualified consultants to conduct a study on reflectorized sheeting.

Dr. Hugh McGee, Bellomo-McGee, Inc., testified concerning the reflective sheeting study which was conducted. (See Attachment 2)

The next order of business was a hearing on HB-3104 concerning increasing fees charged for certain vehicle inspections and disposition of those fees.

Representative Jim Lowther briefed the Committee on the contents of HB-3104, and said the extra money from the fee increase would be added to the budget of the Highway Patrol.

Major David Hornbaker, Kansas Highway Patrol, testified in support of HB-3104 and said the VIN inspection program serves as a deterrent to stolen vehicles being brought into Kansas.

Mr. Pat Barnes, Kansas Motor Car Dealers Association, testified in opposition to HB-3104. (See Attachment 3)

Mr. Barnes said with HB-3104, the VIN inspection fund essentially becomes a law enforcement tax, which is a significant departure from the policy recognized for generations whereby general taxes and revenue fund general services which are enjoyed by all.

The hearing on HB-3104 was concluded.

MINUTES OF THE House COMMITTEE ON Transportation,

room 519-S Statehouse, at 1:30 xx.m./p.m. on March 28, 1988

The next order of business was a hearing on SB-462 concerning odometer rollbacks.

Bruce Kinzie briefed the Committee on the contents of the bill.

Ms. D. Jeanne Kutzley, Office of the Attorney General, testified in support of SB-462. (See Attachment 4)

She said under SB-462, the consumer will have a remedy against a "supplier" if they purchase a vehicle with a rolled back odometer. Ms. Kutzley explained that in SB-462 the word "supplier" is defined as 1) a licensed motor vehicle dealer; or 2) any person or business which purchases, sells or exchanges 5 or more motor vehicles in any one calendar year; or 3) any person or business which in the ordinary course of business purchases, sells or exchanges motor vehicles.

Ms. Kutzley stated this definition means that those sellers most likely to have knowledge of the rollback will be held responsible.

Major David Hornbaker, Kansas Highway Patrol, testified in support of SB-462. (See Attachment 5)

He said odometer fraud in the United States is a widespread crime, with annual potential monetary losses estimated at $5 billion. He said passage of SB-462 will allow law enforcement to at least have a chance in the apprehension and prosecution of odometer fraud perpetrators.

Mr. Pat Barnes, Kansas Motor Car Dealers Association, testified in support of SB-462. (See Attachment 6)

The hearing on SB-462 ended.

Rex Crowell

Rex Crowell, Chairman

REFLECTIVE SHEETING STUDY

For

KANSAS DEPARTMENT OF TRANSPORTATION

Prepared By

BELLOMO-McGEE, INC.

901 Follin Lane, Suite 220

Vienna, Virginia 22180

(703) 255-3312

BMI

February 1988

Attach. 1

BELLOMO-McGEE, INC.

BMI

February 3, 1987
Ref: BMI-J-246

Mr. Mark T. Roberts, P.E.
Chief, Bureau of Design
Kansas Department of Transportation
Docking State Office Building
Topeka, Kansas 66612-1568

Re: Reflective Sheeting Study, 106-K-3178-01

Dear Mr. Roberts:

Bellomo-McGee, Inc. (BMI) has completed the study of reflective sign sheeting use in Kansas, and submits the final report herewith. This report was prepared to satisfy the 1987 Kansas Senate Bill Number 142, which mandated a study of the use of reflectorized sign sheeting on state roadways.

BMI evaluated the use of reflectorized sheeting for permanent road signs and for temporary signs and devices used in highway work zone areas. The specific objectives of the study included determination of appropriate sheeting type, cost justifications for use of the sheeting, and justification of sheeting use considering safety issues. This report presents the pertinent findings and conclusions from the study, and offers recommendations for policy changes.

BMI appreciated the opportunity to participate in this independent assessment of KDOT's signing practices.

Sincerely,

BELLOMO-McGEE, INC.

Hugh W. McGee

Hugh W. McGee, Ph.D., P.E.
Principal

HUGH W. McGEE SR. LICENSED 10912 KANSAS PROFESSIONAL ENGINEER

901 Follin Lane, Suite 220, Vienna, Virginia 22180 (703) 255-3312

REFLECTIVE SHEETING STUDY

Prepared for:

KANSAS DEPARTMENT OF TRANSPORTATION

Prepared by:

BELLOMO-McGEE, INC.
901 Follin Lane, Suite 220
Vienna, Virginia 22180

FEBRUARY 1988

TABLE OF CONTENTS

	Page
LIST OF EXHIBITS	ii
EXECUTIVE SUMMARY	S-1
1. INTRODUCTION	1
1.1 Background	1
1.2 Study Objectives	2
1.3 Methodology	3
1.4 Report Organization	4
2. TYPES OF REFLECTIVE SHEETING	5
3. LITERATURE REVIEW	12
3.1 Performance	12
3.2 Safety Issues	24
3.3 Sheeting Economics	27
4. SURVEY RESULTS	31
4.1 State Questionnaire Results	31
4.2 Fabricator Interviews	51
5. ECONOMIC ANALYSIS	54
5.1 Sign Cost and Benefit Variables	54
5.2 Methods of Economic Analysis	59
5.3 Economic Analysis Models	63
6. SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS	89
6.1 Summary of Findings	89
6.2 Conclusions	91
6.3 Recommendations	92
REFERENCES	94
APPENDIX A Questionnaire Sent to States	97
APPENDIX B Policies of Three States on the Use of High Performance Sheeting	104
APPENDIX C Names of Persons and Companies Contacted Concerning Construction Zone Signs/Devices	112
APPENDIX D Cost Data	114

LIST OF EXHIBITS

EXHIBIT		PAGE
S-1	Economic Analysis Procedure	S-7
S-2	Cost Comparison Summary	S-9
1	Principles of Retroreflection	6
2	Comparison of Reflective Sheeting Specifications	8
3	Known Manufacturers of Various Sheeting Types	10
4	Typical Guaranteed Minimum SIA Values	11
5	Stop Sign Minimum SIA Values	14
6	Construction Zone Signs Minimum SIA Values	15
7	Warning Signs Minimum SIA Values	16
8	Overhead Guide Signs Minimum SIA Values	18
9	Guidelines for Sheeting Type Selection	19
10	Results of States' Use of Reflective Sheeting	33
11	Economic Analysis Procedure	61
12	Service Life Sensitivity - Overhead Guide Signs	66
13	Interest Rate Sensitivity - Overhead Guide Sings	68
14	Overhead Guide Signs Annual Cost Summary	71
15	Service Life Sensitivity - Post Mounted Signs	73
16	Ground Mounted Signs - Annual Cost Summary	74
17	Effects of Vandalism - Post Mounted Signs	77
18	Typical Construction Zone Project	80
19	Construction Zone Devices Bid Averages (1981 - 1987)	81
20	Construction Work Zone Cost Analysis	83

1. EXECUTIVE SUMMARY

1.1 INTRODUCTION

Bellomo-McGee, Inc. (BMI) was engaged to conduct an independent assessment of the sign retroreflective sheeting practices of the Kansas Department of Transportation (KDOT). KDOT currently specifies two types of retroreflective sheeting for signs -- Type I or regular performance and Type 2 or high performance. Their policy is to use the brighter, but more expensive, high performance sheeting for overhead guide signs, critical regulatory signs such as STOP and YIELD signs and for all devices used in highway work zones. This practice, especially that of requiring high performance sheeting for work zone devices, has come under scrutiny by the State Legislative Post Audit Committee. Furthermore, the 1987 Kansas Senate Bill Number 142 mandated that the Secretary of Transportation conduct a study on the use of reflectorized sheeting on State road signs.

This section presents the Executive Summary of the Sheeting Study prepared by Bellomo-McGee, Inc. for the Kansas Department of Transportation dated February 1988. The Executive Summary includes the study objectives and approach, followed by specific key findings, conclusions, and recommendations.

2. STUDY BACKGROUND

2.1 Objectives

Survey States

Survey the other 49 states in regard to usage of engineering grade and high performance grade reflective sheeting in construction work zones and for general signing.

Economic Analysis

Produce an economic evaluation of engineering grade versus high performance grade reflective sheeting in regard to construction work zones and for general signing. This task shall include relative durabilities of the two types of sheeting, initial cost of the sheetings, life cycle costs, and any other cost differentials involved with application and performance.

Safety Issues

Study and report on safety factors involved in the use of engineering grade versus high performance grade reflective sheeting as they are involved with the problems of construction work zones, and general signing areas.

Signing Practices and Procedures

Compare Kansas Department of Transportation practices regarding reflective sheeting usage, specifications, and test procedures with the general practices in other states.

2.2 Approach

Questionnaire Survey

A questionnaire was sent to 49 states and the District of Columbia. The questionnaire focused on the States' practices and their experiences with retroreflective sheeting. The responses from the questionnaire survey became the basis for recommended changes in KDOT signing policies, and provided economic data for the cost evaluation.

Telephone Survey

A phone survey of several suppliers of traffic control devices for highway work zones was made to get information on their experience with different types of sheeting.

Literature Review

A review of relevant literature was performed to isolate key factors needed to complete this study. Also, contacts were made with pertinent agencies and institutions to learn of on-going signing research. From these sources, information on safety issues, economic considerations, and performance standards was obtained and subsequently utilized.

Economic Models

Using data obtained from KDOT, the national survey, and the literature review, economic assessment models were generated to analyze the comparative costs and benefits of high performance and engineering grade sheeting. The economic evaluation independently assessed construction zone signing, general signing areas, and vandalism and accident reduction impacts as related to the sheeting utilization decision.

3. SURVEY RESULTS

3.1 Sheeting Use

Approximately 67 percent of the responding states, including Kansas, use high performance sheeting for background and copy on freeway guide signs. About half of the respondents, including Kansas, use engineering grade sheeting for guide signs on conventional roadways.

In considering regulatory signs, the majority (62 percent) of the respondents, including Kansas, use high performance sheeting for the right-of-way series, i.e., STOP and YIELD signs. For the movement series regulatory signs about 46 percent of the respondents including Kansas use high performance sheeting. The movement series consists of turning, alignment, exclusion, and one-way signs.

Considering warning signs (yellow signs) about 58 percent of respondents, including Kansas, use high performance sheeting to some extent. Also in construction zone areas about 60 percent of respondents, including Kansas, use high performance sheeting on signs and devices.

3.2 Construction Work Zones

With the fatality rate substantially higher in construction work zones as compared to general areas, special consideration of safety is required. Approximately 77 percent of the respondents, including Kansas, stated that they use steady-burn or flashing lights on devices in construction work zones. Of these respondents most stated that the use of lights is independent of sheeting type, however several states inferred that the use of lights may be unnecessary with high performance sheeting.

3.3 Selected Responses

The following table summarizes other key responses from the questionnaire survey:

Issues	Average of All Respondents	KDOT
Service Life (years)		
- engineering grade	8	10
- high performance	11	15
Sheeting warranty (years)		
- engineering grade	7	7
- high performance	10	10
Initial Cost ($/S.F.)		
- engineering grade	0.66	0.59
- high performance	3.07	3.05

Many states used the warranty period as the service life; hence, the average represents an conservative estimate.

The sheeting specification L-S-300C is utilized by 50 percent of the responding states including Kansas.

4. SHEETING SELECTION

The proper means of selecting sheeting type considers the reflective intensity (or brightness) necessary to provide adequate detection and recognition distance for the motorist. In the circumstances where either sheeting type (engineering grade or high performance) provides adequate reflective intensity than economic comparisons and isolation of other benefits are appropriate.

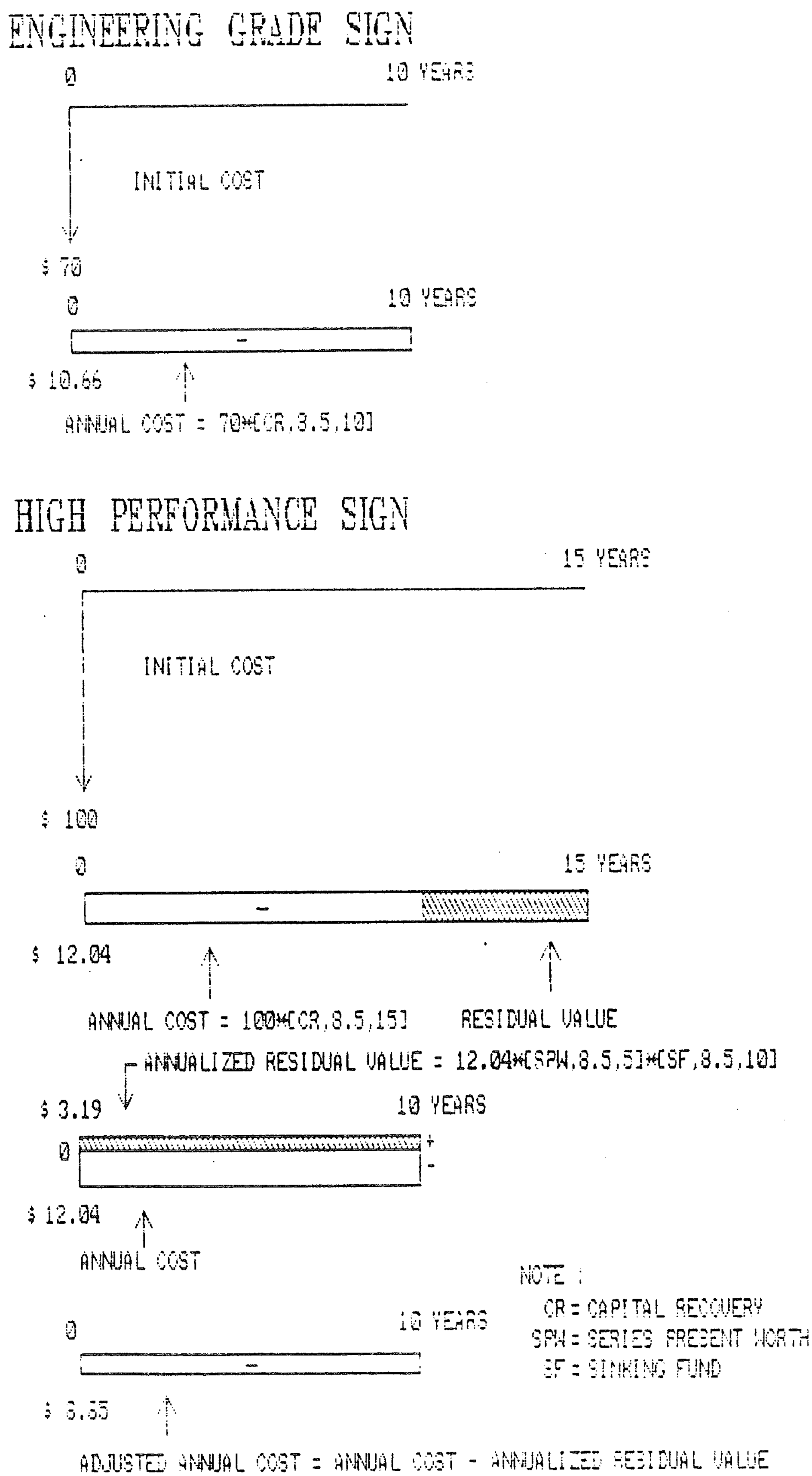
4.1 Reflective Intensity

From the literature review of pertinent studies the higher reflective intensity provided by high performance sheeting is required for certain signing applications, including the following:

- Overhead guide signs for all situations except for low ambient light areas (rural dark locations) and with 3 or fewer words on the sign.
- All warning signs (yellow) except in low ambient light (rural) situations and low speeds (less than 35 mph).
- STOP and YIELD signs for all high speed (greater than 50 mph) and medium to high ambient (suburban and urban locations) light situations.
- Construction work zone signs and devices on situations involving high speed, high ambient light, restricted geometrics and lane change maneuvers.

4.2 Economics

An economic analysis was conducted for permanent signs (overhead and post mounted) and construction zone signs and devices. The methodology used to perform this analysis is presented on Exhibit S-1. The life cycle costs analysis method for permanent signs calculates the Equivalent Uniform Annual Cost (EUAC) for each alternative. The longer life of high performance sheeting is credited as a residual value and subtracted from the EUAC for each alternative.



BMI

ECONOMIC ANALYSIS PROCEDURE

Exhibit
S-1

Since sign replacement in construction zones is more a factor of damage and mishandling than sheeting deterioration, this analysis was conducted based on a project-day cost basis. The construction zone analysis was conducted for signs and channelizing devices with and without steady-burn or flashing lights. A summary of the cost comparison analyses performed for each sign type is found in Exhibit S-2.

From this analysis high performance sheeting is cost effective when used on overhead and ground-mounted signs. In construction zones because of the short service life, engineering grade is more cost effective when using steady-burn and flashing lights. However, if the need for lights is eliminated with use of high performance substantial savings are generated. Elimination of the lights when using engineering grade sheeting is not recommended.

For all analyses an interest rate of 8.5 percent was assumed. A sensitivity analysis of the annual costs versus varying interest rates was conducted. Not until a rate of 15.5 percent is achieved does high performance sheeting fail to be more cost effective. Also, a sensitivity analysis was conducted for variations in service life assuming a 10 year life for engineering grade sheeting. Considering overhead guide signs, the high performance sheeting must provide 2.8 (12.8 years total) additional years of service to be cost effective. If high performance sheeting service life is less than 12.8 years, engineering grade is more cost effective.

	ENGINEERING GRADE	HIGH PERFORMANCE
OVERHEAD GUIDE SIGNS*		
• New	$144.96	$116.73
• Overlay	$102.41	$ 92.06
GROUND MOUNTED SIGNS*	$ 7.70	$ 5.83
CONSTRUCTION WORK ZONE**		
• With Lights	$281.60	$287.56
• Without Lights	N/A	$104.56

* Annual Cost/Sign/Year
** All Devices Per Project Day

BMI

COST COMPARISON SUMMARY

Exhibit S-2

4.3 Benefits

From the literature review no direct evidence of actual accident rate or severity reduction was found resulting from the use of high performance sheeting. However, many researchers and agencies addressing the issue conclude that, although difficult to quantify, there are safety benefits attributable to high performance sheeting. Considering an average nighttime construction zone accident cost of approximately $25,000 a reduction in relatively few accidents would out weigh the additional cost of high performance sheeting. An approximate 5 percent reduction in nighttime construction zone accidents would justify the higher cost of high performance sheeting on construction zone signs and devices.

Other benefits of high performance sheeting found through this study are:

- less need for external illumination of overhead signs,
- less need for steady-burn or flashing lights in construction zones,
- provision of a brighter sign for a larger period of time.

5. CONCLUSIONS

The principal conclusions to be drawn from the findings are as follows:

- KDOT's current practice for use of high performance sheeting for permanent signing is entirely appropriate given the benefits of the brighter sheeting. As long as the sign life is not substantially shortened by damage, high performance sheeting is more cost effective compared to engineering grade sheeting.

- KDOT's current practice for use of high performance sheeting for construction zone devices is also entirely appropriate. Although slightly more expensive than engineering grade, it provides the motorist devices which are brighter and therefore more likely to be detected. Also, in certain situations, its use can defer the need for steady-burn or flashing lights.

6. RECOMMENDATIONS

The following recommendations are offered to KDOT regarding their reflective sheeting policy and practices.

1. KDOT should adopt the specifications contained in Federal Highway Administration FP-85 that deal with reflective sheeting. This would permit the use of super-engineering grade sheeting, a mid-priced enclosed-lens sheeting brighter than the regular performance type. (KDOT should also review for adoption the soon-to-be-approved ASTM specification on reflective sheeting.)

2. KDOT should adopt a specification for maintained retroreflection of devices used in highway work zones. A standard similar to that in FP-85 (Sec. 635.03) is recommended. This standard specifies that reflective sheeting on signs, drums, barricades and other devices shall be maintained to a level of not less than 75 percent of the minimum SIA values required for Type II sheeting (enclosed lens, engineering grade) and 50 percent of the minimum SIA value required for Type III sheeting (high performance, encapsulated lens).

3. Investigate and establish a policy on the need for steady-burn lights for channelizing devices made with high performance sheeting for use in highway work zones.

4. Investigate and establish a policy on the need for illumination of overhead guide signs made of high performance sheeting.

5. Expedite the implementation of a sign inventory system which, among other purposes, would provide a data base on sign life.

1. INTRODUCTION

1.1 Background

Highway signs, delineators, markers and traffic control devices are visible at night primarily because they are fabricated with reflective material. This material is typically retroreflective sheeting consisting of either microsize glass beads or prismatic lenses. The properties of these materials are such that light from a vehicle striking the surface of the device will be returned back to the driver of the vehicle. The amount of light returned varies with type of retroreflective material used and the relative location of the device to the driver and the vehicle headlights.

Currently the Kansas Department of Transportation (KDOT) recognizes, through their specifications, two types of retroreflective material. Type I, commonly referred to as engineering grade, is an enclosed lens sheeting. Type II, commonly referred to as high performance, is an encapsulated lens sheeting. Type II sheeting is a brighter, longer lasting sheeting than Type I, but is up to five times more expensive to purchase.

KDOT's policy is to require high performance sheeting for all devices used in highway work zones. Furthermore, they are using high performance sheeting for overhead guide signs and critical regulatory signs such as STOP and YIELD signs. This practice, especially that of requiring high performance sheeting for work zone devices, has come under scrutiny by the State Legislative Post Audit Committee. Furthermore, the 1987 Kansas Senate Bill Number 142 mandated that the Secretary of Transportation conduct a study on the use of reflectorized sheeting on State road signs.

In October, 1987, Bellomo-McGee, Inc. was retained to conduct an independent study. This report presents the results of that effort.

1.2 Study Objectives

The general stated objective was to "...study the use of reflectorized sheeting on State road signs which is to include the types of sheeting used, cost justifications for use of such sheeting, safety factors justifying such use and other factors deemed pertinent to the use of reflectorized sheeting." From this general directive, five specific tasks were directed by KDOT, namely:

Task 1 - Survey the other 49 states in regard to usage of engineering grade and high performance grade reflective sheeting in construction work zones and for general signing.

Task 2 - Produce an economic evaluation of engineering grade versus high performance grade reflective sheeting in regard to construction work zones and for general signing. This task shall include relative durabilities of the two types of sheeting, initial cost of the sheetings, life cycle costs, and any other cost differentials involved with application and performance.

Task 3 - Study and report on safety factors involved in the use of engineering grade versus high performance grade reflective sheeting as they are involved with the problems of construction work zones.

Task 4 - Study and report on the safety factors involved in the use of engineering grade versus high performance grade reflective sheeting as they are involved with general signing, especially regulatory and warning signs and some critical types of guide signs.

Task 5 - Compare Kansas Department of Transportation practices regarding reflective sheeting usage, specifications, and test procedures with the general practice in other states.

1.3 Methodology

To meet the objectives of the study, BMI conducted the following activities.

1. A questionnaire was sent to 49 states and the District of Columbia. The questionnaire focused on the States' practices and their experiences with retroreflective sheeting. The responses from the questionnaire survey became the basis for recommended changes in KDOT signing policies, and provided economic data for the cost evaluation.

2. A phone survey of several suppliers of traffic control devices for highway work zones was made to get information on their experience with different types of sheeting.

3. A review of relevant literature was performed to isolate key factors needed to complete this study. Also, contacts were made with pertinent agencies and institutions to learn of on-going signing research. From these sources, information on safety issues, economic considerations, and performance standards was obtained and subsequently utilized.

4. Using data obtained from KDOT, the national survey, and the literature review, economic assessment models were generated to analyze the comparative costs and benefits of high performance and engineering grade sheeting. The economic evaluation independently assessed construction zone signing, general signing areas, and vandalism and accident reduction impacts as related to the sheeting utilization decision.

1.4 Report Organization

The remainder of this report is organized into five (5) chapters. Chapter 2 presents a background discussion of the reflective sheeting types. The discussion of the pertinent findings from the literature review is presented in Chapter 3. The review of the questionnaire presenting KDOT versus the collective states' responses is located in Chapter 4. The economic analysis of high performance and engineering grade sheeting is presented in Chapter 5. Finally, the conclusions and recommendations resulting from the study are presented in Chapter 6. References may be found at the end of Chapter 6. Finally, there are four appendices which provide additional information.

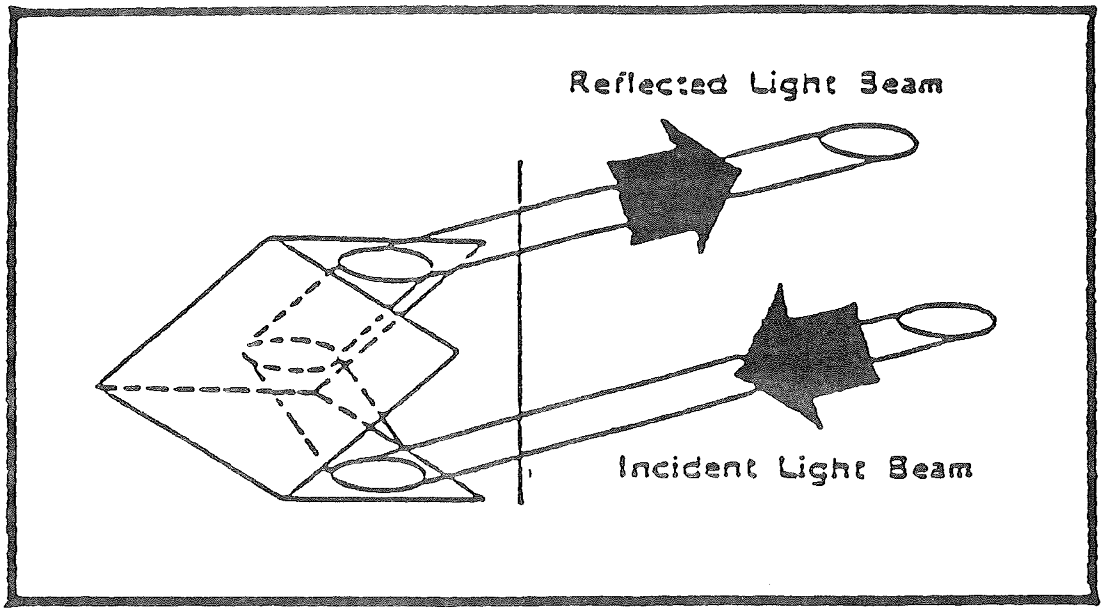
2. TYPES OF REFLECTIVE SHEETING

The current specification(1) of the Kansas Department of Transportation acknowledges two types of reflective sheeting -- Type I, Regular Performance and Type II, High Performance. An overview of the characteristics of these sheetings and others in use is presented in order to better understand the subsequent discussions.

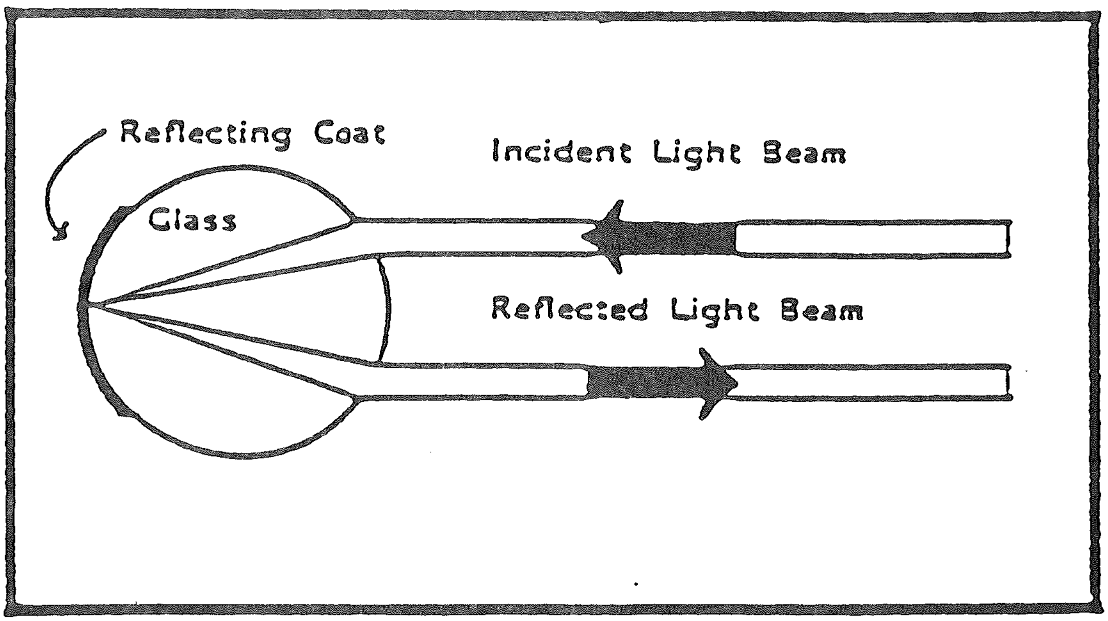
Two principles followed to achieve retroreflectivity for roadway signs and devices are spherical lens and prismatic retroreflection. Prismatic, also known as cube-corner, retroreflection is achieved through total internal reflection. Spherical lens retroreflection is achieved through a combination of a glass bead and a reflecting surface. These principals are illustrated in Exhibit 1.

Retroreflective sheeting is merely flexible sheets of variable width consisting of countless micro cube-corners or beads enclosed in a weather resistant transparent plastic film. Most sheeting being used today is glass bead sheeting, which is either enclosed lens glass bead sheeting or encapsulated lens glass bead sheeting. The primary distinction between the two types is that the encapsulated lens sheeting has an air space between the beads and the plastic film which makes it more reflective.

The Type I, Regular Performance sheeting, in the Kansas specification is the enclosed-lens type sheeting. It is also known as engineering grade sheeting in the industry. The Type II - High Performance sheeting is the encapsulated lens sheeting or "some other reflective system that will comply with all



Cube-Corner (Prismatic) Retroreflection



Spherical Retroreflection

BMI

PRINCIPLES OF RETROREFLECTION

Exhibit 1

applicable provisions of this specification", which could be the prismatic lens sheeting.

There are at least three "national" specifications for reflective sheeting:

1. Federal Specification L-S-300C, a General Services Administration specification.
2. Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects (FP-85).
3. M268 - Retroreflective Sheeting for Traffic Control by the American Association of State Highway Officials.

Kansas's specifications are based on Federal Specification L-S-300C.

One of the key properties of reflective sheeting is its ability to return light. The technical term is the ratio of luminance or the coefficient of retroreflection and is defined as the amount of light reflected from a retroreflective material compared to the amount of light falling on the sign material. The measure of the ratio of luminance in the various specifications (i.e., FP-85 (FHWA), L-S-300C, AASHTO M268-84) is the specific intensity per unit area (SIA) or reflective intensity, typically expressed in terms of candelas per footcandle per square foot. Exhibit 2 compares the values of intensity for the three most common specifications mentioned previously. The reflective intensity values are minimum acceptable standards for utilization of new sign sheeting. This measure insures the initial reflective performance but does not specify an in-field performance measure.

Specification	Engineering Grade (E.G.)	High Performance (H.P.)
L-S-300C	Type I	Type II
AASHTO M268-84I	Type II	Type IIIA
FP-85	Type II	Type IIIA

Minimum Specific Intensity Per Unit Area (SIA)
0.2 Observation Angle
-4 Entrance Angle

Sheeting Color	L-S-300C		AASHTO		FP-85	
	E.G.	H.P.	E.G.	H.P.	E.G.	H.P.
White	80	250	70	250	70	250
Red	18	45	14.5	45	14.5	45
Orange	30	100	25	100	25	100
Brown	2.5	-	1	-	2	-
Yellow	50	170	50	170	50	170
Green	12	45	9	45	9	45
Blue	6	20	4	20	4	20

Note: Kansas follows L-S-300C.

BMI COMPARISON OF REFLECTIVE SHEETING SPECIFICATIONS **Exhibit 2**

Specifications have evolved around the development of new sheetings by manufacturers. The most recent FHWA specification in FP-85 includes a Type II-A enclosed-lens sheeting which is known as super-engineering grade. It also has a Type III-B which is the aforementioned prismatic lens high performance sheeting and a Type IV which is a high performance vinyl sheeting of low durability that is used for reflective white collars around orange cones and for "fold-up" temporary signs. The American Society of Testing Materials (ASTM) is developing a specification which will have six types of reflective sheeting.

Exhibit 3 lists by type the known manufacturers of reflective highway sign sheeting. The specific sheetings do not necessarily meet all the specifications.

While the initial measure of retroreflectance (i.e., SIA, Reflective Intensity, Coefficient of Retroreflection) insures the delivered quality and performance of the sheeting, this does not guarantee longevity of the material. Periodic measurements of retroreflectance are needed to determine the extent of useful life remaining. Also, minimum standards not only for the delivered product, but for the in-service product as well should be followed. These measurements of in-service performance can and should be related to the manufacturer warranties. The values in Exhibit 4 represent the retroreflectance levels typically guaranteed by manufacturers. These values represent 80 percent of the initial retroreflectance values in Exhibit 2.

Sheeting Type (as per FP-85)

Type II	Type IIA	Type IIIA	Type IIIB
Avery/Fasson	Seibulite	Seibulite	Stimsonite
Seibulite	Kiwalite (Sakai Trading)	3M	Reflexite*
3M			
Kiwalite (Sakai Trading)			
American Decal (Adcolite)			

Note:

Type II = Engineering Grade

Type IIA = Super Engineering Grade

Type IIIA = High Performance Grade

Type IIIB = High Performance Grade (Prismatic)

* Construction Work Zone Devices Only

BMI

KNOWN MANUFACTURERS
OF VARIOUS SHEETING TYPES

Exhibit 3

Minimum SIA
0.2 Observation Angle
-4 Entrance Angle

Sheeting Color	Engineering Grade Seven Years (except as noted)	High Performance Seven Years	High Performance Ten Years
White	40	212	200
Red	5*	38	36
Orange	10**	-	-
Brown	0.5**	10	9
Yellow	20	144	136
Green	3	38	36
Blue	2	17	16

* 6 year performance
** 5 year performance

BMI

TYPICAL GUARANTEED
MINIMUM SIA VALUES

Exhibit
4

3. LITERATURE REVIEW

This chapter presents findings of the literature review undertaken to assess the characteristics of high performance and engineering grade sheetings as pertains to visibility, safety and economics. The performance, safety and economic ingredients of sign sheeting are interconnected and the selection of sheeting type on any one characteristic is inappropriate. The performance levels directly affect the service life, which is the major factor in the cost-benefit analysis. The monetary benefits of improved roadway safety, while difficult to quantify, also need consideration in the economic analysis.

3.1 Performance

3.1.1 Required Luminance

A key factor in deciding which type of sheeting to use is the level of luminance provided by the sheeting in comparison to the driver's visibility needs. In other words, how bright does the sign need to be?

Currently there are no national standards for minimum levels of luminance. However, there has been some recent research which addresses this issue.

A 1987 study of nighttime conspicuity of highway signs by Dr. Paul Olson(2) of the University of Michigan has resulted in recommendations for minimum SIA values for various sign types. The SIA values are presented based on area complexity and the required stopping distance for various speeds. The complexity refers to the background (ambient) light levels in the immediate vicinity of the signing location. The complexity is typically described as low, medium and high corresponding to rural, suburban and urban areas, respectively. Exhibit 5 presents the SIA values recommended for 30" x 30" red STOP signs. Referring to the SIA values for red presented previously in Exhibit 2, engineering grade would be sufficient for low speeds and low complexity areas. SIA values provided by high performance sheeting are required for most situations. And, when there are high speed and high complexity areas, supplemental warning signs are warranted in addition to the higher SIA requirement.

From the same study, considering orange construction zone signs, Olson derives the values presented in Exhibit 6 for minimum SIA. The distances shown are those required to make a lane change.

Comparison of these values to those found in Exhibits 2 and 4 show that a single engineering grade sign is rarely acceptable, even for low complexity areas. The high performance sheeting levels of SIA satisfy the minimums in low speed areas with low and medium complexity, which typically occur in construction zones. However, where higher speeds and complexity areas occur, more signage is required.

Exhibit 7 presents minimum SIA values for warning (yellow) signs by speed, area complexity, and decision choices as determined by Olson. Here, the engineering grade sheeting is sufficient in low-complexity areas. This finding is consistent with the guidelines for warning signs presented by Mace et al.(3) in 1985. Mace found that engineering grade (Type II) sheeting

Recommended Minimum SIA Values for a STOP Sign

Speed (mph)	Stopping Distance (feet)	Area Complexity High	Medium	Low
65	569	*	*	150
60	484	*	*	71
55	407	*	155	30
50	337	170	63	14
45	272	70	25	8
40	215	30	11	4
35	164	16	5	3
30	121	8	3	2

* Supplemental Warning Required

Source: Olson (2)

BMI

STOP SIGN MINIMUM SIA VALUES

Exhibit 5

RECOMMENDED MINIMUM SIA VALUES FOR A CONSTRUCTION ZONE SIGN (ORANGE) REQUIRING A LANE CHANGE

	Traffic Volume							
	Light to Medium				Medium to Heavy			
	Required Distance	Area Complexity			Required Distance	Area Complexity		
Speed (mph)	(feet)	High	Medium	Low	(feet)	High	Medium	Low
≥ 45		*	*	*		*	*	*
40	469	*	*	170	575	*	*	*
35	411	*	425	95	503	*	*	240
30	352	*	230	51	431	*	*	114
25	293	280	98	28	359	*	250	57

* Advance warning sign required.

Source: Olson (2)

Recommended Minimum SIA Values for Warning Signs (Yellow)

	Area Complexity						
	Low		Medium			High	
	Number of Choices		Number of Choices			Number of Choices	
Speed (mph)	0-3	3 or more	0-1	2-3	3 or more	0-1	2 or more
65	15	31	15	86	630	230	*
60	15	25	15	63	414	173	1115
55	15	21	15	52	276	144	750
50	15	17	15	38	180	110	520
45	15	15	15	29	126	80	345
40	15	15	15	23	80	63	230
35	15	15	15	17	52	52	150
30	15	15	15	15	35	38	100

*Supplementary devices required.

Source: Olson (2)

BMI

WARNING SIGNS
MINIMUM SIA VALUES

Exhibit 7

degraded to an SIA value of approximately 18 (similar to the value at seven years from Exhibit 4) was adequate in the low-complexity areas. From the Olson and Mace studies, engineering grade sheeting would be adequate for medium-complexity areas also, at speeds approaching 50 mph. After this point, the levels of luminance provided by high performance (Type III) sheeting are required.

From the SIA values in Exhibit 8 for overhead guide signs (green), Olson found that engineering grade sheeting was adequate in low-complexity areas with three or fewer words. Olson used a study by Mitchell and Forbes(4) on reading times of words on guide signs versus speed as a determinant of minimum SIA in these instances. He suggested that where engineering grade was insufficient, higher luminance level reflective sheeting or multiple signs are required.

The research by Olson and Mace has isolated by speed, complexity, etc. the instances where engineering grade and high performance sheeting are appropriate for roadway signs. Their research has shown that in very limited applications, typically low speed, low complexity areas, engineering grade sheeting is acceptable. This finding is consistent with the reflective sheeting selection guidelines found in "Retroreflectivity of Roadway Sings for Adequate Visibility: A Guide"(5) which are excerpted in Exhibit 9.

Recommended Minimum SIA Values for Overhead Guide Signs (Green)

	Area Complexity								
	Low			Medium			High		
Speed	Words on Sign			Words on Sign			Words on Sign		
(mph)	3	6	9	3	6	9	3	6	9
70	8	15	27	13	31	70	35	82	200
60	8	13	22	12	25	54	32	70	150
50	7	11	17	11	20	37	28	54	100
40	7	9	13	10	15	25	25	40	68
30	6	8	10	8	12	17	22	33	46

Sign placement is 20 feet high over a 24 foot roadway.

Source: Olson (2)

"....some general guidelines that are offered for the selection of sheeting type based on the visibility requirements discussed. These are:

1. Type II sheeting provides adequate levels of retroreflectivity for all permanent signs in many situations.

2. Type IIA, Type IIIA or Type IIIB sheeting is desirable for regulatory signs, e.g., STOP, YIELD, etc. in high speed areas (45 mph, 72 kph or greater) requiring a driver reaction in advance of the sign.

3. Either Type IIA, Type IIIA or Type IIIB sheeting is desirable for all critical signs (regulatory, warning or guide) in any visually complex situation, e.g., dense urban or suburban area with competing light sources, or where signs would be unexpected.

4. Type IIIA or IIIB sheeting is desirable for all signs placed on the left side of a two-way road (e.g., NO PASSING ZONE pennant).

5. For those signs which require wide angular viewing, such as the DO NOT ENTER or WRONG WAY sign at a ramp terminus or signs on a freeway curved ramp, Type IIA or IIIA sheeting is suggested.

6. For work zone traffic control devices, Type IIIA or IIIB sheeting is desirable for advance warning signing, other critical signs and other "stand alone" retroreflectorized devices. The level of retroreflectivity afforded by Type IIA sheeting is adequate for channelization devices, provided the devices are kept clean, because several devices are visible at one time. (For durability purposes, Type IIIA reboundable sheeting may be required.)

NOTE: Type II = Engineering Grade

Type IIA = Super Engineering Grade

Type IIIA = High Performance, Encapsulated Bead

Type IIIB = High Performance, Prismatic

Source: McGee and Mace(5)

BMI GUIDELINES FOR SHEETING TYPE SELECTION

Exhibit 9

3.1.2 Legibility

The purpose of highway signs is to transmit a message to the driver in order that an appropriate action can be completed. Much study has been undertaken to analyze background contrast ratios, minimum acceptable luminance values, optimum letter size, etc., all of which affect the legibility of highway signs. The sign legibility or distance at which the sign message or symbol is distinguishable is the determining factor in evaluating the effectiveness of the information transmission.

Forbes(6) described legibility as the distance for reading a sign given an unlimited observation time. Based on previous research, Woltman(7) presented factors affecting legibility distances; these being letter height, width, spacing, contrast and brightness. All interact and influence each other in affecting the sign legibility.

Contrast between background and legend has a major effect on legibility. Borton(8) presented evidence based on previous research by Forbes that legibility distance increased with the introduction of increased legend-background contrast. Borton reported that a luminance ratio of 5 to 1, which from field observation is typical for high performance sheeting, is by Forbes the optimum for increasing legibility distance. This finding is collaborated by the standards in the FP-85(9), which also states a value in the range of 5:1 for contrast.

Colomb and Michaut(10) reported on studies addressing the effect of increased sign illuminance (brightness) on legibility distance. It was determined that legibility distance increases of 15 percent were possible with a sheeting having SIA values 3 times those of regular sheetings with letter height and series held constant. This comparison is directly applicable to the characteristics of high performance and engineering grade sheetings. It is suggested in a recent FHWA report(5) that with letter height and contrast held constant that the luminance (brightness) of the retroreflective material (sheeting) determines the legibility index.

Studies by Allen(11) were conducted to determine optimum luminance of signs. It was found in that study that optimum luminance in areas without ambient lighting is approximately 10 Foot Lamberts (Ft-L). Based on actual field measurements by Youngblood and Woltman(12) of reflected luminance of highway signs, Robertson(13) concluded that encapsulated lens (high performance) sheeting conforms to the 10 Foot-Lamberts luminance value found by Allen at distances of 300-900 feet. Also, Robertson suggested that enclosed lens (engineering grade) sheeting failed to meet the 10 Foot-Lamberts standard at any distance. Suggestions by some, including the 1978 Wisconsin DOT study(14), contend that high intensity sheeting is overpowering or too bright, ultimately reducing legibility distance. However, Robertson presented luminance readings of high performance sheeting signs by Youngblood and Woltman and the State of Louisiana which were consistently well below 100 Foot-Lamberts. The 100 Foot-Lamberts value is typically the point where halation begins.

The studies of contrast and brightness affecting sign legibility presented in this chapter have suggested that high performance sheeting is necessary in many signing applications. The engineering grade sheeting fails to provide minimum luminance and contrast values for optimum legibility distance.

3.1.3 Sign Illumination

In considering legibility of overhead signs, the issue of external illumination must be discussed. Until the introduction and acceptance of high performance sheeting, most overhead guide signs were constructed with engineering grade sheeting (some with reflector button for the message) with external illumination. The illumination was necessary in most areas (urban and rural) since the reflective properties of engineering grade sheeting were not sufficient given the location of the signs (typically 20 feet above the pavement). Recently (since the mid-1970's) agencies have implemented and researched overhead signs with high performance sheeting without external illumination, as a means of reducing signing costs. The results of the research and field experience are discussed in the following paragraphs.

In an FHWA Notice(15) it was suggested that encapsulated lens sheeting (high performance) provided sufficient target value and legibility on rural roadways with constant grade, tangent, unobstructed view for 1,200 feet. This report assumed a savings for illuminated engineering grade sign replacement with high performance sign of $175 per sign per year. Where high performance sheeting signs are appropriate in new construction areas, a savings of $8,500 per sign could be realized. This report did emphasize that in urban areas external sign lighting should not be eliminated except where an engineering study of human factors, target value, and legibility distances has determined that signs can perform satisfactorily without lighting. Also, each location should receive an onsite nighttime evaluation to determine whether external illumination can be eliminated.

A study by Woods and Rowan(16) found that under high beam conditions, encapsulated lens sheeting (high performance) had a 5 percent greater legibility distance than an illuminated engineering grade sign. Considering low beam legibility, the encapsulated lens sheeting had a 19 percent less legibility distance, but was still within acceptable limits. They concluded that encapsulated lens sheeting was usable for overhead guide signs on freeway type roadways with minimum 1,200 feet tangent lengths.

The results of a study by Van Norren(17),(18) were similar to those of Woods and Rowan. Van Norren suggested that in rural roadways without curves, non-illuminated signs are satisfactory.

As a result of this research, numerous agencies have determined guidelines and specifications addressing the elimination of overhead sign external illumination. One such directive is the 1984 Ohio DOT Application Standard which states:

"In rural areas, external sign lighting may be eliminated at:

1. The first Advance Guide (GB) sign (e.g., 1-mile sign) at a local exit.
2. The 2 mile and 1 mile Advance Guide signs at a freeway to freeway interchange.

3. The 1/2 mile or Next Right Advance Guide sign on tangent roadways having a constant grade approach for at least 1,200 feet without overpasses or overhead sign structures prior to the sign."

A 1987 Minnesota DOT report(19) on illumination of overhead guide signs concluded that non-illuminated overhead guide signs are adequate on straight roadways with low ambient lighting.

The previous discussion on overhead signs supports the practice of eliminating illumination of overhead signs in certain roadway circumstances (tangent section, low ambient lighting, etc.). However, most research and subsequent specification agree that external illumination is necessary in high complexity areas and urban areas with high levels of ambient light. The monetary savings of eliminating lighting structures and power usage more than offsets the higher cost of high performance sheeting.

3.2 Safety Issues

One of the benefits attributed to high performance sheeting is the added margin of safety resulting from the brighter sign. This section presents specific concerns of highway safety as related to signing and sign brightness (reflectivity).

3.2.1 General Signing Areas

As reported by Paniati, Mace, and Hostetter(20), nighttime fatalities account for approximately 60% of all fatalities nationally. They also reported that based on data presented by the National Safety Council the nighttime death rate per 100 million vehicle miles is over three times that of the daytime rate (5.08 vs 1.61 deaths per 100 million vehicle miles, respectively). In Kansas the experience is similar, with a disproportionate amount of nighttime fatalities occurring.

A report by the Urban Traffic Engineers Council(UTEC)(21) cited a Seattle study which determined that a 26% increase in nighttime right-angle accidents occurred at their 15-year-old stop signs. They attributed the increase in accidents directly to the loss of nighttime reflectivity. According to a manual(22) prepared by Missouri State Highway Commission for FHWA, estimated nighttime accident reduction of 10% is possible with sign upgrading. While this estimate does not distinguish the specific meaning of upgrade, reflective properties is an obvious component.

In a FHWA report(23) on highway safety, a study location experienced a 30% reduction in fatal accidents after signing improvements were implemented. In a Pennsylvania study(24) of highway tort liability where fatalities or serious injuries occurred, deficient signing was cited most often as the accident cause (41%). Sign improvements include such things as increased brightness, additional signs, more appropriate message, etc. These studies have concluded that highway signing is a key ingredient in improving highway safety. The 1984 FHWA report also concluded that traffic sign improvements have the highest investment return of all improvement types.

As the average age of the general public grows older, consideration of the needs of decreasing visual acuity is required. A study by Sivak(25) determined that older drivers required nearly 70 percent more legibility distance than younger drivers at night. As discussed previously, the legibility distance is a product of sign brightness and contrast. Brighter signs were recommended as safety countermeasures at a 1985 workshop(26) on older drivers' needs. The workshop also concluded that establishment of minimum levels of brightness and reflectivity concerning highway signs and devices is suggested.

3.2.2 Construction Work Zones

In Kansas work zones nearly 67% of all fatalities occur at night, according to the 1987 data. High performance sheeting has been required in construction work zones since March, 1986 in Kansas. A comparison of nighttime accidents from 1985 to 1987 shows a marked decrease from 379 to 274 accidents, respectively. This reduction accounts for most of the decrease in total work zone accidents from 989 in 1985 to 850 in 1987. While factors such as exposure rates were not considered in this comparison, a trend has seemingly been established. Further monitoring of work zone accidents is required to further justify attributing accident reduction to high performance sheeting.

Approximately 35 percent of 1986 Kansas accidents involved a fatality or personal injury, according to the Kansas accidents report(27). Comparatively, in construction work zones of the total number of accidents, nearly 55% involved a fatality or personal injury. This marked contrast in accident severity underlines the need for additional improvement in work zone motorist directives. A recent summary report of work zone accidents(28) issued by the American Association of State Highway and Transportation Officials (AASHTO) concluded that approximately half of fixed object accidents in work zones occur in darkness. They also concluded that fixed object accidents result in injuries and fatalities more often than vehicle-vehicle collisions. This report recommended that since 70 percent of all work zone accidents occur in daylight but more than 50 percent of fatalities occur at night, work zones should be critically reviewed considering motorist guidance during dark time periods.

3.3 Sheeting Economics

The following is a review of other state agencies' attempts to perform economic analyses of engineering grade versus high performance sheeting utilization.

3.3.1 Cost-Benefit Analysis

In an economic analysis completed by the Pennsylvania Department of Transportation(29), a comparison was made of the cost of signs including materials and labor. Service life was assumed as 8 years and 15 years for engineering grade and high performance, respectively. This analysis which was conducted for overhead guide signs concluded that the high performance sheeting was more cost effective than engineering grade based on average annual costs.

In an economic analysis done by the Florida DOT(30), expected service life of 14 years for engineering grade sheeting and 10 years for high performance sheeting was used. The annual cost of engineering grade sign was significantly lower than the annual cost of high performance sign. This was due to the higher initial cost of high performance sign and the shorter expected service life. Circumstances of weather, sun exposure and poor quality high performance sheeting create an atypical situation in Florida.

The results of the economic analysis by the Michigan DOT(8) indicated a lower annual cost per square foot for signs fabricated with high performance sheeting by Michigan's central sign shop. The expected service life of engineering grade was assumed as 7 years and high performance was 12 years.

An Economic analysis by North Carolina Department of Highways(31) also indicated a lower annual cost per square foot for signs fabricated with high performance sheeting.

Economic analysis based on extensive research in Virginia(32) considered the in-place cost of sign per square foot for an engineering grade and high performance sign. Based on the expected service life of 7 years for engineering grade sign and 10 years for high performance sign, the annual cost of high performance signs per square foot was lower. It was concluded that the use of high intensity sheeting was cost effective.

The Idaho DOT(33) prepared a study in 1977 that considered life expectancies of the signs as opposed to sheeting life. While this is an appropriate and desirable method, the data needed for such a calculation is typically unobtainable. According to the Idaho study the sign life expectancy was 5.0 and 5.9 years for engineering grade and high performance, respectively.

Under this scenario the difference in square foot cost was only $0.04 ($0.57/s.f. engineering grade and $0.61/s.f. high performance). This study also did not assign monetary benefits to increased sign reflectivity.

The majority of above mentioned studies resulted in the finding that high performance sheeting was more cost effective.

3.3.2 Non-Monetary Benefits

The FHWA report(15) cited previously suggested other benefits of using encapsulated (high performance) sheeting such as reduced maintenance. The reduction in required maintenance could reduce worker and motorist exposure to the hazards of work areas. Since work maintenance areas typically require lane closures, the level of service to the public could be improved with the use of high performance sheeting. The effects of adverse weather and power failures could be mitigated with the introduction of high performance sheeting signs.

The Minnesota DOT in its overhead sign illumination practices review(19) stated the following:

> "Although immeasurable with respect to accidents or accident potential, the safety afforded the public by utilizing H.I. [high intensity/performance] sheeting, in lieu of painted background may well offset the additional expenditure of $26,000 annually."

Numerous state DOT's and researchers have referred to the safety benefits of the brighter high performance sheeting. The results of the safety benefits would be reduced accident rates and severity. Reduction in accidents certainly has a monetary value but the quantification of such is difficult, with extensive research and data collection at controlled before and after sites.

Considering lighting (flashing, steady-burn) on construction zone channelization devices, discussion with officials of the Texas State Department of Highways and the Mississippi State Highway Department at the 1988 TRB Human Factors Workshop - Work Zone Safety Session was conducted. These gentlemen felt that channelization drums with high performance sheeting do not require lights in work zones. According to them, the brightness of the high performance sheeting was sufficient as an attention-getting device. They suggested that high performance signs do require more care in handling and fabrication, and a strict routine of cleaning and maintenance is required to insure adequate reflectivity. Once the contractors conformed to the additional care needed with high performance sheeting, it has performed well in work zones. For curved and non-tangent sections (as with overhead signing) the channelizing devices tend to lie beyond the motorist angle of viewing, therefore additional conspicuity provided by the lights may be required.

4. SURVEY RESULTS

This chapter presents the findings from the questionnaire survey of the states and the phone survey of several suppliers and fabricators of work zone traffic control devices.

4.1 State Questionnaire Results

A questionnaire was prepared by BMI and sent by KDOT to the chief transportation official at 49 states and the District of Columbia. Forty-one states including Kansas completed the questionnaire, which represents an 80% response. The emphasis of the questionnaire was to determine the type of sign sheeting material utilized, the sheeting specifications and testing, service life of engineering grade and high performance sheeting, and comparative cost data. (A copy of the questionnaire is located in Appendix A of this report.)

This section is structured with the specific question (from the questionnaire) listed, followed by the Kansas DOT response, then the collective response of the other states. Following each question and set of responses is a discussion of the findings and subsequent significance. The results are grouped into the following four related areas of concern:

1. Sign material and utilization
2. Specifications and Testing of Material
3. Service Life
4. Cost

4.1.1 Sign Material and Utilization

QUESTION 1 - What is your policy regarding the use of different sheeting grades for the following types of signs and channelization devices:

a) Freeway guide signs
b) Conventional road guide signs
c) Regulatory signs
d) Warning signs
e) Construction zone signs
f) Sheeting used on barricades
g) Channelization devices

KDOT and Others' Response:

Exhibit 10 shows KDOT's response, (indicated by an "X") and the number of other state responses* for each of the sign types and sheeting types. Since some states use more than one type of sheeting, certain rows add to a value greater than the number of respondents.

Discussion: For freeway guide signs, a large majority of the states use high performance sheeting for the copy, (i.e., the legend, symbol and border), and/or the background. The KDOT response for freeway guide signs was demountable high performance copy on high performance sheeting, which was the second choice of all respondents.

---

* NOTE: Throughout this chapter where Kansas' response is marked by an "X", the corresponding number of other state responses does not include Kansas.

BACKGROUND/LEGEND MATERIAL

Sign Type	Button Copy On		Demountable E.G. Copy On		Demountable H.P. Copy On		Direct Applied Copy Using	
	E.G. Sheeting	H.P. Sheeting	E.G. Sheeting	H.P. Sheeting	E.G. Sheeting	H.P. Sheeting	E.G. Sheeting	H.P. Sheeting
a. Freeway Guide Signs	7	10	1	2	7	13X	7	20
b. Conventional Road Guide Signs	3	1	2	0	3	3	22X	17
c. Regulatory Signs	Not Applicable							
1. Right of Way Series							15	21X
2. Speed Series							21X	15
3. Movement Series							21	15X
4. Parking Series							23X	10
5. Pedestrian Series							20X	15
6. Miscellaneous Series							22X	14
d. Warning Signs							20X	22X
e. Construction Zone Signs							18	23X
f. Barricades & Channelizing Devices							18	23X

"X" - denotes KDOT Response
(00) - denotes number of states responding

Note: Since multiple sheeting and copy types are used for some sign types, certain rows add to a value greater than the number of respondents.

BMI RESULTS OF STATES' USE OF REFLECTIVE SHEETING

Exhibit 10

For conventional road guide signs, KDOT agreed with nearly all respondents as to utilizing direct applied copy. A slight majority (22 vs 17), including KDOT, utilize engineering grade sheeting for this sign type.

Practically all smaller post-mounted signs for regulatory and warning messages and construction zone devices use the direct applied copy technique. For the regulatory sign series, high performance sheeting is the choice of the majority of the states only for the right-of-way series, i.e. the STOP and YIELD signs. Kansas is with the majority. The need for the additional brightness for these critical signs is the reason for using high performance sheeting. Kansas concurs with the majority of states in all other regulatory sign series except for the movement series, i.e. turning, alignment, exclusion and one-way signs. Here, Kansas agrees with 15 other states that high performance sheeting is the better material.

For warning signs there is only a slight majority of the states favoring high performance sheeting. KDOT responded to utilizing both types of sheeting for the warning signs as per their specification. Some states have indicated that they will use engineering grade for warning signs in rural areas, especially if they are likely to be vandalized.

Considering construction zone signs, barricades, and channelizing devices, 23 of the 41 respondents, including KDOT, use high performance sheeting with direct applied copy. This majority preference for high performance most likely reflects the general opinion that work zones are particularly dangerous and require brighter devices.

The KDOT practices as to sheeting and copy type are very consistent with the standards of the responding states. The KDOT responses were typically aligned with the majority in all sign type instances.

QUESTION 2 - For all of the instances that you used high performance sheeting in question #1, explain why.

KDOT Response: Primarily for safety during nighttime driving for guide, warning, and construction work zone signs.

Others' Response: The 33 states that responded expressed that increased safety, higher visibility, and longer service life and durability are the reasons for using high performance sheeting.

Discussion: The higher reflective performance and longer service life were deciding factors in utilizing high performance sheeting over engineering grade. Numerous states as well as KDOT expressed that high performance sheeting is selected when hazardous situations or potential safety problems are realized. Apparently the states that use the high performance sheeting have decided that it is worth the additional initial cost for a greater margin of safety.

QUESTION 3 - In question #2, if accidents or accident rates were a determining factor in using high performance sheeting, how much change in accident frequency was experienced after the utilization of high performance sheeting for each sign type?

KDOT Response: No statistics reported.

Others' Response: No statistics reported.

Discussion: Although accident reduction is purported to be a significant benefit of using high performance sheeting, no state has quantified or even attempted to quantify any change in accidents. The contributing factors for this situation are the detailed accident information required and the need for appropriate controlled before and after site locations.

QUESTION 4 - Do you use lights on signs or channelizing devices in construction zones?

KDOT Response: Steady burning: yes Flashing: yes

Others' Response: Steady burning: 28 Yes, 9 No

Flashing: 30 Yes, 6 No

Discussion: The "lights" in question were the Type A and B, flashing warning lights and Type C steady-burn lights noted in the Manual on Uniform Traffic Control Devices (Sec. 6E-5). Based on the above responses, the vast majority of states, including Kansas, use both type of lights in construction work zones. This does not mean, however, that they are used in every project. Typically, when used, flashing lights will be used for the advance signs and other devices when placed separately on or off the roadway, and steady burn lights will be used for channelizing devices arrayed throughout the work zone.

QUESTION 5 - If you answered "yes" to question #4, does your policy change with the type of sign sheeting used (engineering grade vs high performance)? Please explain.

KDOT Response: Currently, the policy is to use lights regardless of the sheeting type. However, KDOT is considering changing their lighting policy to not use these lights on drums and barricades when high performance sheeting is used.

Others' Response: Based upon the 33 responses to this question, it appears that the policy decision to use steady-burn or flashing lights in construction work zones does not change with sheeting type. The need for lights is based on an evaluation of each location independent of sheeting type. However, some respondents stated that when high performance sheeting is used, the lights are not used on the construction zone devices. Other respondents considered criteria such as; geometrics, ambient lighting, volumes, and project type in determining the lighting requirements. One respondent stated that high performance sheeting is used for all construction devices and flashing lights for the advance warning signs only.

Discussion: The use of lights on construction zone devices tends to be independent of sheeting type. However, it seems that the practice of not using lights on barricades, drums, etc. when these are fabricated with high performance sheeting is being considered and experimented with by more states.

Major items to consider in this decision are:

a. Regular maintenance and cleaning of signs is mandatory. Dirt build-up and damage is prevalent in construction areas requiring frequent inspection.
b. When a light becomes inoperable, the usefulness is completely lost, and its visibility is provided solely by the sheeting.
c. High performance sheeting, is susceptible to damage and resultant loss of reflectivity.

Further discussion of this topic follows in the next section with the results of the construction zone signing contractor interviews.

QUESTION 6 - Considering sheeting type, do you provide external illumination in any case for:

	Engineering Grade		High Performance	
	Yes	No	Yes	No
Roadside Signs	1	32X	1	29X
Overhead Signs	19X	16	17X	13

"X" - denotes KDOT Response
(00) - denotes number of states responding

QUESTION 7 - If you responded "yes" to any of the above, please describe your sign illumination policy.

KDOT and Others' Response: The table above provides a summary of the responses and shows that only one state illuminates roadside signs, but a majority of the states illuminate their overhead signs regardless of the sheeting type. However, the practice of not illuminating overhead signs with high performance sheeting is becoming more prevalent. Kansas's policy is to illuminate overhead signs with engineering grade and "some" high performance grade signs.

Other selected responses included:

1. Overhead signs are illuminated at high volume freeway interchanges.
2. Overhead signs are illuminated if they are not visible for 1200 feet (this follows the FHWA policy).
3. Overhead signs are not illuminated in rural areas, but illumination is required in urban areas.
4. Need for illumination is determined based on independent study for each individual sign based on location, geometrics, traffic volumes, etc.
5. Roadside signs are illuminated at only high accident and hazardous locations.

4.1.2 Specifications and Testing of Sheeting Material

QUESTION 1 - With regard to reflectance levels (i.e., Specific Intensity Per Unit Area), does your agency follow any of the following specifications:

- L-S-300C
- FP 85 (FHWA)
- AASHTO M268-84

KDOT and Others' Response: KDOT's specification for reflective intensity is adapted from L-S-300C. The responses from the other states are as follows:

	Responses
L-S-300C	20
FP 85 (FHWA)	13
AASHTO M268-84	6

Discussion: All the states responding follow one of the three "national" standards, although some have modified the standard to meet their specific needs. Since FHWA's FP-85 is relatively new, many states have not yet revised their specifications to correspond to it.

QUESTION 2 - Do you have different photometric or material requirements for:

KDOT and Others' Response:

		Responses	
		Yes	No
a.	Overhead as compared with roadside sign installations?	5	34X
b.	Signs placed on different classes of highway or where different traffic volumes are encountered?	6	33X
c.	Different types of signs (guide, warning, regulatory)?	14	25X
d.	Signs or devices in construction zones?	14	25X

QUESTION 3 - If your answer to any of the above was "Yes", please describe the specifications.

KDOT Response: No response because they responded "No" to the above question.

Discussion: The response to these two questions somewhat reflected the response to the very first question on their use of reflective sheeting.

None of the states explicitly state that a certain level of reflectivity is required for certain types of signs or situations. However, several states do specify that certain types of sheeting, usually high performance, i.e. encapsulated lens, is to be used for certain signs or situations. Appendix B includes specifications on the use of high performance sheeting from some of the respondents. Based on these responses it is a common practice to use high performance sheeting on freeway guide signs, regulatory signs with red background, warning signs at critical locations outside metro areas, especially the chevron road alignment sign and construction zone signs. For construction zones, high performance sheeting is used for all permanent signs and engineering grade sheeting is used for barrels and barricades because engineering grade sheeting can apparently resist abrasion and rough handling better than high performance sheeting.

QUESTION 4 - Has your agency conducted research to set desirable photometric specifications for signing material? If "Yes", please provide a copy or a dated reference.

KDOT Response: No

Others' Response: 2-Yes, 37-No

Discussion: One state referenced a study by Allen and Smith(34) for the Highway Research Board regarding luminance requirements for overhead signs. The other state has set photometric standards for "Brown" engineering grade sheeting that differ from the typical specification values.

4.1.3 Service Life

QUESTION 1 - From your records or experience, what is the life expectancy of each sign sheeting used?

KDOT and Others' Response:

Type of Sheeting	Average Life Expectancy Kansas	Midwest*	All Respondents
Engineering Grade	10	8.2	7.9
High Performance	15	12.1	11.0

* Includes states with assumed similar weather, climatic conditions, geography, population densities, etc. as Kansas.

Discussion: Based on the responses the service life appears to be affected by the climatic conditions. States experiencing intense sunlight and high moisture conditions (e.g., Florida, Hawaii, Alabama, etc.) indicate life expectancy lower than the average. Since climate is an influencing factor, states in the Midwest in proximity to Kansas were grouped to establish an average service life appropriate to that area. Thus, the table above shows the service life reported by Kansas, other Midwest states, and all respondents. An important point about the reported service life of high performance sheeting is that many of the responses, including Kansas, represent a guess, because in many cases the sheeting has not been in place for the full life. In other words there is not enough history to establish a reliable estimate of service life for high performance sheeting. It is noted that Kansas's response for service life is higher than the average for both engineering grade and high performance.

QUESTION 2 - Does the type of sheeting copy affect the life of the sign sheeting?

KDOT Response: No

Others' Response: Only 6 of 37 respondents answered "Yes" to this question. One state stated that after removing button copy, rust stains are apparent. This state has subsequently discontinued the use of button copy.

Discussion: From this survey, no consistent tendencies of copy affecting sign sheeting are apparent. Intuitively, even if copy had an impact on service life, no appreciable differences between sheeting types would be realized.

QUESTION 3 - What manufacturer warranties do you have for each sheeting type?

KDOT and Others' Response:

	Warranty		
Type of Sheeting	Kansas	Midwest	All Respondents
Engineering grade	7	7.0	6.9
High performance	10	10.4	10.1
Orange sheeting	3	3.0	3.0

Discussion: The warranties for sign sheeting are extremely consistent throughout the responding states. The only states with shorter warranties than the 10 and 7 years are Florida, Hawaii and California, which interestingly are the states with the lower life expectancy estimates. Some states such as Wyoming, New Mexico and Virginia responded with slightly longer (12-15 years) high performance warranties than the 10 year norm. Orange-colored sheeting typically has a 3 year warranty.

QUESTION 4 - Do any of the following factors affect the life expectancy of a sign sheeting?

KDOT and Others' Response:

		High Performance		Engineering Grade	
		Yes	No	Yes	No
a.	Differences in weather conditions the jurisdiction.	12X	23	13X	22
b.	Directional orientation of the sign	25X	12	28	10
c.	Color of the sheeting (white, orange, black, yellow, etc.)	20X	16	21X	16

QUESTION 5 - If "Yes" to any part in Question 4, please give specific information and estimated life expectancy changes.

KDOT Response:

a. Engineering grade sheeting is affected by moisture more than high performance sheeting.

b. South and west oriented signs have 25% less service life.

c. Orange color sheeting deteriorates faster with an expected life reduction of 50%.

Others' Response: The majority of the respondents stated that south facing signs deteriorate faster than other orientations. The orange color sheeting signs fade faster than other colors. The reduction in expected life due to these factors was not quantified by any respondent.

Discussion: As is evident from the responses and known from the literature, the service life of the sheeting is dependent upon general weather conditions, and especially the orientation of the sign towards the sun. Also, orange sheeting has a much shorter service life than other colors. However, of importance to the cost analysis is that these conditions affected both engineering grade and high performance grade.

QUESTION 6 - Please estimate the percent of your highway signs that are vandalized each year.

KDOT Response: Approximately 12% of signs are vandalized each year.

Others' Response: The average of the 31 responses was approximately 12% of the total signs vandalized per year.

Discussion: Many states, including Kansas, added comments such as; "estimate", "no data kept", etc. beside their response. During interviews of KDOT officials, they expressed that limited vandalism/sign replacement information is kept. Apparently, most state highway departments have not been able, due to manpower and monetary constraints, to record such data. While the 12% vandalism rate is significant, a more meaningful statistic for the cost analysis is the average life of a sign. Unfortunately, no good data exists for this factor.

QUESTION 7 - Of the total signs vandalized each year, please estimate the percent by region.

KDOT Response: 58% Rural Areas

42% Urban Areas

Others' Response: (25 responses)

55% Rural Areas
22% Suburban Areas
23% Urban Areas

Discussion: Kansas concurs with other states in that vandalism is more prevalent in rural areas. The states were also asked to provide a distribution by roadway class. Only one state responded and stated vandalism on Interstate highways is minimal.

4.1.4 Cost

QUESTION 1 - What is the most recent cost of sign sheeting in terms of dollars per square foot?

KDOT and Others' Response:

	Cost $$ per Square Foot		
Sheeting Type	Kansas	Midwest	All Respondents
Engineering grade	0.59*	0.66	0.66
High Performance	3.05*	3.04	3.07

*KDOT Response in the questionnaire was $0.62 and $2.93 respectively per square foot. However, since that time, updated values were obtained.

Discussion: Kansas' cost for engineering grade sheeting is approximately 10% less than the average of all respondents' cost. The cost for high performance sheeting is in line with the national averages. The cost of super engineering grade sheeting from a total of 2 respondents was $1.80 per square foot. The range of values for engineering grade sheeting cost was from $0.59 to $0.88 per square foot. The range of values for high performance sheeting cost (excluding a particular state which has unique circumstances due to climatic conditions) was from $2.71 to $3.75 per square foot.

QUESTION 2 - Has your agency prepared a cost-benefit analysis of high performance versus engineering grade sheeting?

KDOT Response: No

Others' Response: 3-Yes, 38-No

Discussion: The three states (VA, NC, and FL) which have prepared cost-benefit analyses considered the initial sign sheeting cost, expected service life, and interest rates to calculate an annualized cost for both engineering grade and high performance sheeting. The results of their studies were discussed in the Literature Review chapter.

QUESTION 3 - With regard to maintenance of highway signs, does the type of sheeting (engineering grade versus high performance) affect the maintenance costs?

KDOT Response: Yes

Others' Response: 21 Yes, 20 No

QUESTION 4 - If you answered "Yes" to question #3, what was the difference in maintenance costs ($ per sign per year) and why was there a difference (cleaning, frequency of maintenance, etc.)?

KDOT Response: If considering cleaning of signs only (not sign replacement), high performance sheeting signs require less cleaning, resulting in maintenance cost savings.

Others' Response: Based on the responses received from the other states, there is no difference in maintenance cost for the two types of sheeting if only the cleaning and frequency of cleaning are considered.

Discussion: Disregarding the replacement of signs, the maintenance cost involved with high performance sheeting signs is less than engineering grade. Due to the greater reflective performance of high performance sheeting, more dirt, moisture, etc. can be "accepted" on the sign surface before cleaning is required. Also, it has been suggested that dirt and moisture has a tendency to "slide off" high performance sheeting easier than engineering grade sheeting.

QUESTION 5 - How often do you inspect your highway signs?

KDOT Response: Daily

Others' Response:

Inspection Period	Number of Responses: Engineering Grade	High Performance
1 day	2	1
1 week	1	1
1 month	3	3
3 months	1	1
6 months	3	4
1 year	15	13
2 years	1	1
3 years	1	1
5 years	1	0
Random	7	6

Discussion: KDOT directs its maintenance crews to inspect signs continuously (daily) and it conducts yearly nighttime inspections. The majority of the states inspect signs yearly, but as indicated by the list above there is a wide variation.

QUESTION 6 -If your inspection period differs from engineering grade sheeting signs to high performance sheeting signs, explain the reasons for the difference.

KDOT Response: None

Others' Response: None

Discussion: Considering the lack of response to this question, it can be assumed that the inspection period does not vary given the sheeting type, or actual inspection periods are random and not based on set policy.

QUESTION 7 - Is there an appreciable difference between engineering grade and high performance sheeting signs considering handling, storage, and fabrication charges?

KDOT and Others' Response:

	Yes	No	High Performance Cost Difference KDOT	High Performance Cost Difference All Respondents
Handling	8X	27	+$0.16/sign	+$0.23/sign
Storage	4	30X		No Responses
Fabrication	17	18X	+$0.40/sign	+$2.31/sign

"X" - denotes KDOT Response
(00) - denotes Number of States Responding

Discussion: There were only 2 responses to the handling cost difference portion of this question. From the KDOT response, an additional handling cost is incurred when using high performance sheeting due to the packing material requirements, specifically protective slip sheets placed between finished signs. No respondents quantified any additional storage costs generated by the use of high performance sheeting, although 4 responded as such. The fabrication of high performance sheeting signs requires approximately $0.40 additional cost, according to KDOT, for the manufacturer's recommended clear coating of stop signs only. An additional cost is introduced in some instances by the method of high performance sheeting application. Seven states quantified the additional fabrication cost with a range from $0.40 to $8.00 per sign for high performance sheeting signs.

4.2 Fabricator Interviews

In order to get the insights of suppliers as to their experience with the two sheeting types, interviews of numerous companies with work zone experience were conducted. The names/companies contacted (see Appendix C) were obtained from the American Traffic Safety Services Association, Inc. (ATSSA). The interviewees have experience with the fabrication, placement, or distribution of work zone signs and devices.

An open ended interview technique was used to obtain information on the comparative service life, durability, fabrication, lighting, costs, and general impressions of engineering grade and high performance sheeting. The differences in opinion to an extent can be attributed to the interviewers inherent biases. The topics discussed are presented with a summary of the responses.

Service Life

The majority of the interviewees responded that sign damage due to mishandling by crews, vehicle collision, and hurled objects significantly reduces the service life of all sheeting in construction work zones. Contrary to circumstances in general signing areas, sign replacement rarely becomes an issue of sheeting reflectivity deterioration. Beyond the agreement on the sign damage, the responses for service life were inconsistent. The upper limit for expected life is approximately 3 years (however, one respondent stated a service life for engineering grade of 8-9 years), with disagreement on which sheeting type would provide that value.

On the lower end the minimum expected service life is approximately 6 months with both sheetings providing that length of service dependent on the interviewee. From the vast range of service lives attributed to either sheeting type, neither sheeting type is clearly superior considering this issue.

Durability

The durability of the sign sheeting is directly related to the service life in work zone areas. A key issue in selecting a type of sheeting is the amount or severity of damage possible before sign or device replacement is required. Some respondents, considering damage caused by the sun, weather and moisture, stated that high performance is as durable as engineering grade. However, scratches and damage caused by flying or moving objects deteriorate high performance to a greater extent than engineering grade, as per most respondents. As in the responses to service life, the comments pertaining to durability were not consistent by type of sheeting. One respondent suggested that moisture penetrates between the high performance sheeting and the panels, creating a peeling problem. The actual fabrication process could create such a condition, but speculation without field inspection is unwarranted.

Fabrication

According to certain respondents, the fabrication costs of signs or devices, namely application of the sheeting, are greater when using high performance sheeting. Other respondents stated that there was no difference in fabrication costs beyond the initial sheeting material costs. Some respondents stated that high performance sheeting was more difficult to handle and fabricate, while others stated the converse. It can be concluded that heat activated application methods for high performance sheeting introduce increased fabrication costs from the additional cooling cycle required and the slip sheet (i.e., a thin paper material used to separate high performance sheeting panels during storage) used in the process.

Use of Steady-Burn or Flashing Lights

While most construction zone specifications suggest the lighting (steady-burn or flashing) of channelizing devices, certain respondents suggested that elimination of the lights is possible with the use of high performance sheeting. The remaining respondents stated that the lights are needed for depth perception and attention getting, therefore elimination is not possible due to the increase in reflective intensity. The issue becomes whether increased reflective intensity serves as an attention-getting device or not.

Other Selected Comments

To further emphasize the disagreement currently realized in regards to the better sheeting type for work zone devices, consider the following statements from the interviews:

- High intensity is the best product on the market.
- Added visibility of high intensity justifies the additional cost.
- High intensity sheeting devices do not need lights.
- There is no substitute for lights on devices.
- High intensity is a waste of taxpayers' money.
- "Old" high intensity sheeting is a poor product.
- Moisture penetrates between high intensity sheeting and the panel backing material.

Clearly there was no consensus of opinion by those interviewed.

5. ECONOMIC ANALYSIS

This chapter presents the economic analysis of high performance versus engineering grade sheeting as used on highway signs and work zone devices in Kansas. In completing this analysis an attempt to isolate all possible items with cost differences between the sheeting types was made. Section 5.1 lists the items considered for utilization in the subsequent economic models. The items or variables considered pertinent or significant were quantified in terms of dollars per sign or square feet of sheeting. The values applied to each variable were determined from KDOT data, the questionnaire responses, previous research, and engineering judgement. Section 5.2 describes the economic methods used and the structure of the cost comparison models. Section 5.3 presents the results of cost analysis for each model developed.

5.1 Sign Cost and Benefit Variables

5.1.1 Sign Costs

Previous economic analysis of sign sheeting have considered the service life and initial costs. These items are arguably the key ingredients in any assessment of sign sheeting; however, to introduce more refinement and detail, an in-depth study to isolate additional cost variables was performed. Once these cost and benefit variables were established, an effort was made to quantify them in usable terms.

While researching the sign sheeting topic, it became apparent that differing signing types and conditions (overhead guide signs, construction zone signs, roadside signs) required separate analysis. One type or grade of sheeting does not seem appropriate for global use; therefore, recommendations considering sign location and purpose are required. The following are the cost variables isolated for the subsequent economic models.

There are numerous cost components associated with fabrication, storage, handling, transportation, installation and maintenance of roadway signs. An economic comparison based solely on the cost of sign sheeting material would not be adequate in deciding what materials to use. The fabrication costs include the cost of blanks, sheeting, labor, overhead, etc. Storage costs are the costs incurred in the storage of signs prior to use. Handling costs include the cost of slip sheeting, packing and crating of signs prior to shipment from the fabrication shop. Transportation costs include the cost of transporting the sign from the shop to the field for installation. Installation costs include the cost of hardware, field labor, traffic control, etc. required to place the sign. The maintenance costs are incurred throughout the life of the sign, including such items as inspection, cleaning, overlay, etc. For any given sign, fabrication cost will depend on the type of blank used (steel or aluminum), type of sheeting, size of the sign, and application procedure.

According to data received from KDOT, high performance sheeting STOP signs cost approximately $0.40/sign more to fabricate than engineering grade because of clear coating. All other signs have comparable fabrication costs, excluding initial material costs. The average difference in fabrication costs based on the questionnaire responses received from the other states is $2.31/sign. Since there is a significant discrepancy in fabrication cost differences between the two sheetings considering the responses from KDOT and other states, the price of a finished sign was obtained and used in the economic analysis. The price list of finished signs manufactured by the Kansas Correctional Industries was obtained from KDOT. It should be considered that the finished sign prices for engineering and high performance sheeting reflect an overhead cost based on a fixed percentage of total sign cost. Since a sign produced with high performance sheeting has a higher initial cost, the overhead charges are also higher. There seems to be no basis for additional overhead costs when producing high performance signs. Since this analysis includes this apparent inflation of costs it is assumed that the high performance sign prices are conservative in nature.

As discussed earlier, storage costs are the costs incurred in the storage of new signs. KDOT indicated that there is no difference in the storage costs for engineering grade sheeting and high performance sheeting signs. To this item on the questionnaire, 30 responded that there is no difference in storage costs between the two. Therefore, this cost component was not considered in the economic analysis.

Handling costs include the cost of slipsheeting, packing and crating prior to the actual shipment. KDOT response indicated that the handling charges are \$0.16/sign higher for high performance sheeting signs than for engineering grade sheeting signs. Responses from other states also indicated higher handling charges for high performance sheeting signs. The average value of the difference in handling charges is \$0.23/sign. The handling cost differences are included in the completed sign prices furnished by KDOT. Based on discussion with KDOT engineers there is no appreciable difference in transportation and installation costs for signs with engineering grade sheeting or high performance sheeting. Therefore these cost components were not considered in the economic analysis.

Maintenance of highway signs includes inspection, cleaning, overlaying, etc. From the sheeting questionnaire responses, the telephone interviews of fabricators and certain research, high performance signs seem to require less cleaning than engineering grade signs due to the higher retroreflective performance and the "slippery" qualities of the sheeting face. Apparently road film, dirt, and moisture are transported off high performance sheeting better than engineering grade sheeting. However, the need for cleaning road signs is typically not determined under a regimented policy or schedule but by casual, visual inspection. Therefore, quantifying any sign cleaning cost savings created by high performance sheeting is inappropriate at this time. At such time that cleaning policies are scheduled on a per sign or district basis, "real" dollar savings can be realized. Inspection of signs for retroreflective performance is also considered maintenance. From the questionnaire results, the average inspection period for high performance is only slightly longer than engineering grade. Since the inspection for retroreflection is similar to the cleaning in that few states utilize a strict scheduled policy, real cost savings are difficult to isolate.

Numerous states, referring to the maintenance costs, isolated the initial replacement or rehabilitation costs incurred when using high performance sheeting. In this analysis, the replacement of signs is included in the service life estimate and not realized as an actual maintenance cost.

In addition to the direct costs discussed above, there are other external costs due to vandalism which effect the economic analysis. The effect of vandalism on the costs is discussed later in this chapter.

The economic analysis of sign sheeting includes cost (presented previously) and the incremental benefits attributed to the better, higher performance sheeting. The comparative benefits of different sign sheetings are both difficult to isolate and quantify. The benefits associated with high performance sheeting, some of which are difficult to isolate and quantify include: increased effective life, removal of work zone and/or overhead sign illumination, improved user service, and greater margin of safety. These benefits are all related to the increased retroreflective performance of the high performance sheeting. The logic and assumptions in quantifying benefits are presented in Section 5.3 of this chapter.

High performance sheeting has been assigned an effective service life (void of vandalism, accident knockdowns, etc.) of approximately 15 years, while engineering grade is assumed to be 10 years.

Based on KDOT responses to the questionnaire on sign sheeting, all guide signs with engineering grade sheeting are illuminated. Based on the instances where replacement of engineering grade sheeting signs with high performance sheeting signs eliminates the need for external illumination there will be a saving in initial installation, cost of lighting and the annual cost of illumination. As discussed in the literature review chapter, site selection of locations for non-illumination considering high performance sheeting usage is vital. Any policy concerning this issue should be flexible and responsive to specific locations.

Studies of motorist choice have concluded that high performance sheeting is preferable to engineering grade sheeting in many signing applications. It can be assumed that the higher reflectance values of high performance provide the motorist with greater reaction and decision times for necessary maneuvers. One specific study(35) in Pennsylvania indicated that motorists favored high performance sheeting background for overhead signs.

Without controlled test locations and specific accident information, accident reduction based on higher reflectivity is difficult to assume. Intuitively, there are safety benefits (accident reduction) associated with the utilization of high performance sheeting and this study presents a basis for quantifying the impacts considering the cost of "typical" accidents. The monetary benefits to the users are determined in terms of cost savings per accident reduction. However, reasonable assumptions of accident reduction are necessary and directly affect the reliability of such an analysis

5.2 Methods of Economic Analysis

The objective of economic analysis is to compare the future streams of costs and benefits in such a way that for a specific future period of time that the analysis will disclose the most economical design. The six most common methods for performing economic analysis are:

1. Equivalent uniform annual cost method
2. Present worth of costs method

3. Equivalent uniform annual net return method

4. Net present value method

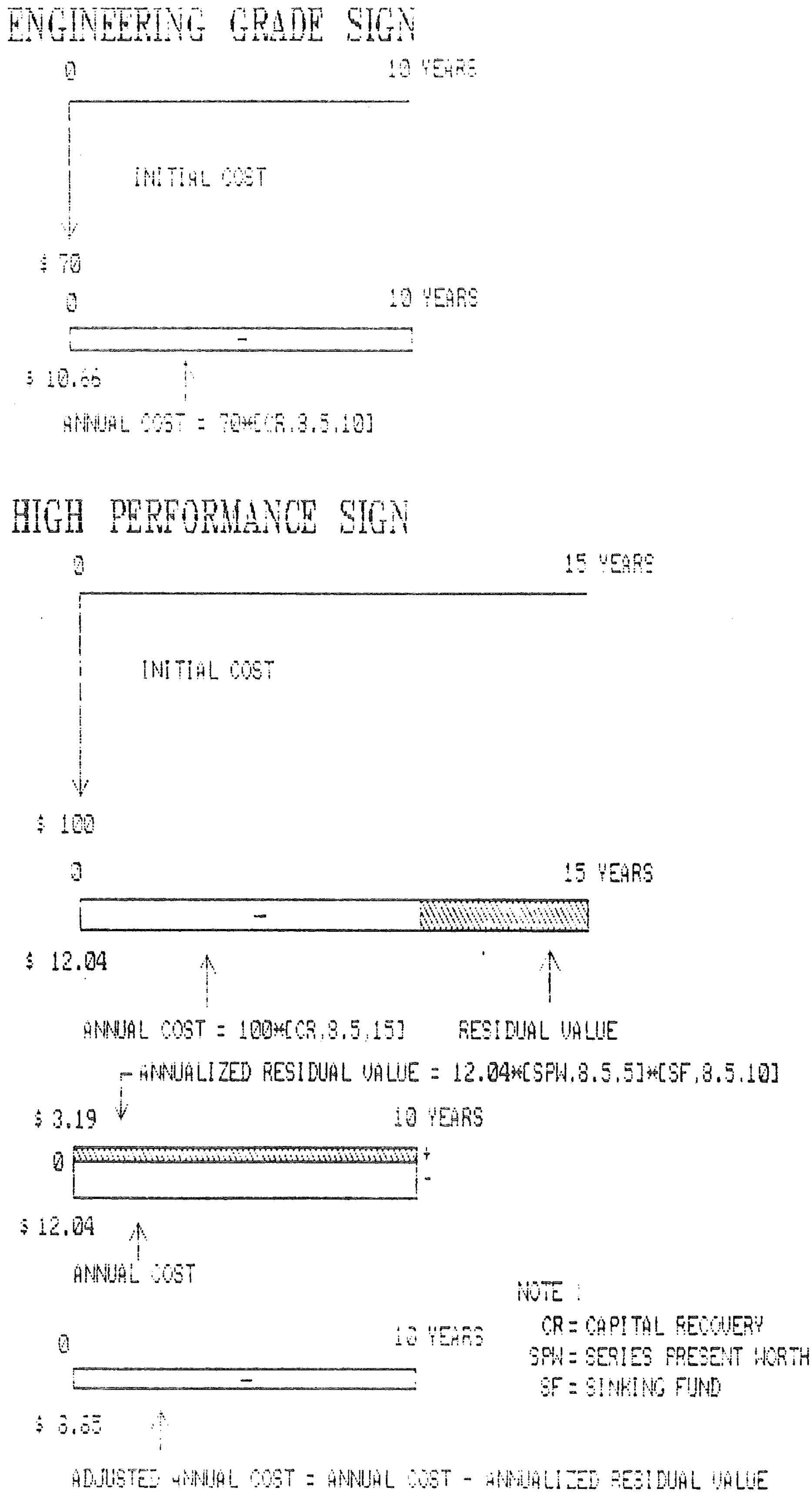
5. Benefit/cost ratio method

6. Rate of return method

Since the concept of annual costs is most commonly used, the method of equivalent uniform annual costs was selected for the economic analysis. Thorough discussions of this method are presented in economic texts written by Winfrey(36), and Barish and Kaplan(37). In this method, the annual cost of a capital investment to be recovered in "n" years, considering interest rates, is found by multiplying its first cost by the appropriate capital recovery factor (CRF). The uniform amount so determined, if charged at the end of each year for the assumed useful life, will exactly repay the initial investment with interest.

One of the principal difficulties of any engineering economic analysis involving alternatives concerns the problems of unequal service life. The adjustment procedure to equalize the analysis periods between the alternatives assumes an analysis period equal to the shorter lived alternative and allows a terminal value for the remainder of the life of the longer lived alternative. This is shown in Exhibit 11.

One method of adjusting (36,37) for the terminal value is the reduction of equivalent uniform annual cost by the value of the number of years of service remaining. The desirable alternative is the one resulting in the lowest annual cost. The analysis produces arithmetic answers in terms of dollars per sign per year, the magnitude of which depends upon engineering judgement



ENGINEERING GRADE SIGN
0
10 YEARS
INITIAL COST
$ 70
0
10 YEARS
$ 10.66
ANNUAL COST = 70*[CR,8.5,10]
HIGH PERFORMANCE SIGN
0
15 YEARS
INITIAL COST
$ 100
0
15 YEARS
$ 12.04
ANNUAL COST = 100*[CR,8.5,15]
RESIDUAL VALUE
ANNUALIZED RESIDUAL VALUE = 12.04*[SPW,8.5,5]*[SF,8.5,10]
$ 3.19
10 YEARS
0
+
-
$ 12.04
ANNUAL COST
NOTE :
CR = CAPITAL RECOVERY
SPW = SERIES PRESENT WORTH
SF = SINKING FUND
0
10 YEARS
$ 8.85
ADJUSTED ANNUAL COST = ANNUAL COST - ANNUALIZED RESIDUAL VALUE

in selecting factors and estimating the future. Two critical factors are the time value of money and the period of analysis. The sensitivity of each of these factors in controlling the results should be understood.

Economic comparisons are performed based on the cost information supplied by KDOT, including 1) cost of materials, 2) cost of labor, 3) installation costs, and 4) cost of traffic control. Comparison of annual costs was conducted for the expected service life of sign sheeting. KDOT response to the sign sheeting questionnaire indicated an expected service life of 15 years for high performance sheeting and 10 years for engineering grade sheeting. The 10 year service life for engineering grade seems to be the upper limit according to the literature and was subsequently utilized. Even though experience with high performance sheeting is limited, many agencies and researchers expected a service life of 15-20 years. Given these estimates the lower limit of 15 years was used in this analysis. The information on handling, storage, fabrication, etc. cost differences obtained from the questionnaire were not isolated in this analysis. However, the total sign cost data include these differences. The development of this method is as follows:

Let:

TC	=	Total Cost including cost of materials, labor, installation and traffic control.
EUAC	=	Equivalent Uniform Annual Cost
i	=	Time value of money or interest rate
n	=	Service life of sheeting
CRF	=	Capital Recovery Factor = $\frac{i(1+i)^n}{(1+i)^n - 1}$

Then:

EUAC = TC x CRF

5.3 Economic Analysis Models

Economic models were developed to analyze comparative costs of engineering grade and high performance sheeting signs for permanent and construction zone signing. In considering permanent (general) signing, separate analyses were conducted for overhead guide signs and ground mounted signs. The analysis of construction zones was performed on a per-typical-project basis, as opposed to the permanent signing per sign basis. This approach is warranted since the service life of signs in construction zones is short and variable due to damage.

5.3.1 Permanent Signing

This section presents the analysis of permanent highway signs (i.e. overhead guide signs and ground mounted signs). The analysis of overhead guide signs assumes new construction and overlay of an existing structure. A sensitivity analysis of service life and interest rates is presented for overhead signs also. For ground mounted signs, analysis of new devices only is prepared assuming that overlaying is not an advantageous alternative. Since ground mounted signs are typically exposed to high vandalism rates, an analysis considering this is presented.

A. Annual Cost Comparison for Overhead Guide Signs

1. New Guide Signs

This analysis is performed assuming a 15' x 10' new overhead sign installation. The costs supplied by KDOT of this particular sign considering both sheeting types are detailed below (the specific breakdown of hourly rates, materials, etc. is provided in Appendix D):

Item	Engineering Grade	High Performance
Materials	$695.00	$1,064.00
Labor	74.00	74.00
Installation	113.00	113.00
Traffic Control	70.00	70.00
TOTAL COST	$952.00	$1,321.00

Economic Analysis Variables:

- Expected Service Life of Engineering Grade Sign = 10 years
- Expected Service Life of High Performance Sign = 15 years
- Interest Rate = 8.5%

Equivalent Uniform Annual Costs:

Engineering Grade

$EUAC_{E.G.}$ = $951.00 * [CRF,8.5,10]

= $951.00 * 0.152408

= $144.96/sign/year

High Performance

$EUAC_{H.P.}$ = $1320.00 * [CRF,8.5,15]

= $1320.00 * 0.120420

= $158.95/sign/year

At this point, no benefit of longer service life of high performance sheeting has been accounted for. At the tenth (10th) year of service the high performance sheeting still has a worth for the additional expected 5 years. This worth is termed Series Present Worth (SPW) and is calculated below:

SPW = $158.95 [CRF,8.5,5]

= $158.95 * 3.940642

= $626.36/sign

Where SF = Sinking Fund Factor

SPW value annualized

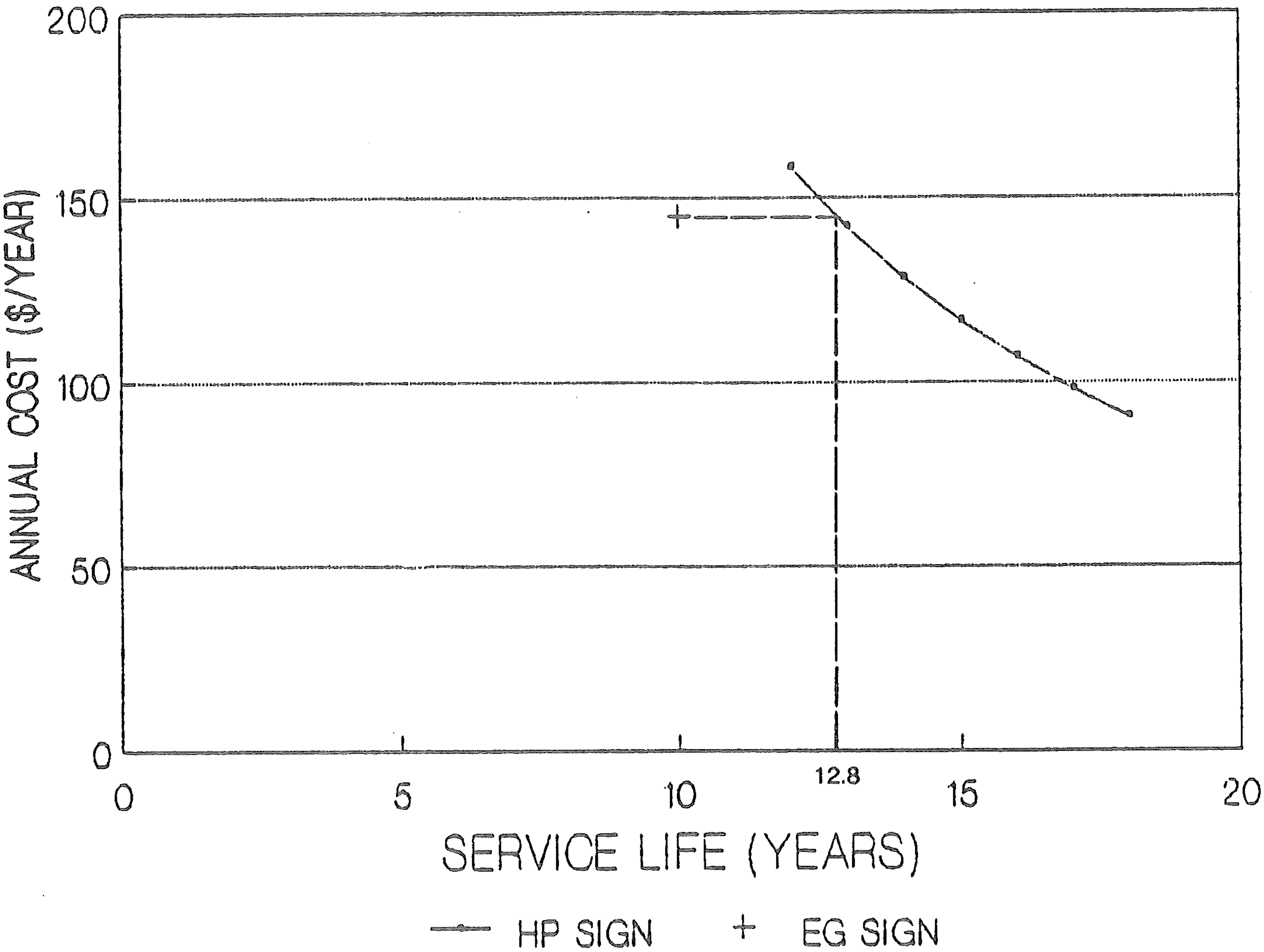
= $626.36 [SF,8.5,10]

= $626.36 * 0.067408

= $ 42.22/sign/year

The Adjusted Equivalent Uniform Annual Cost for the high performance sign over 10 years is therefore $158.95 - 42.22 = <u>$116.73/sign/year</u> compared to the $144.96 cost for engineering grade sheeting.

A sensitivity analysis was performed to determine the effect of service life on annual cost. Engineering grade sheeting has been used for many years with an upper value life expectancy of 10 years. Assuming engineering grade life of 10 years to be fixed, the life expectancy of high performance sheeting was varied from 12 to 18 years. Using an interest rate of 8.5%, the annual cost for high performance sign for different service lives is shown graphically in Exhibit 12.



BMI

SERVICE LIFE SENSITIVITY - OVERHEAD GUIDE SIGNS

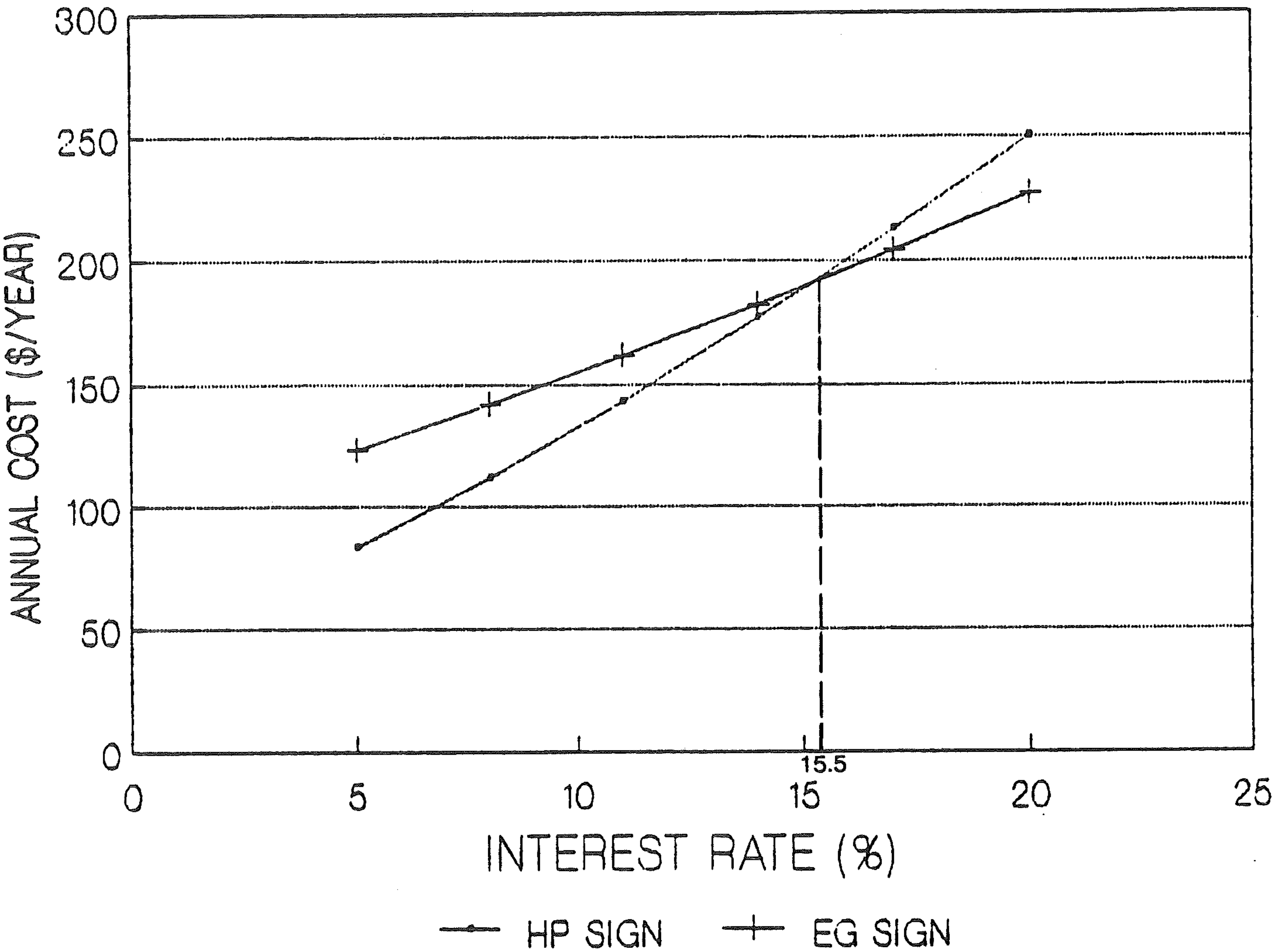
Exhibit 12

Exhibit 12 shows that the annual cost for high performance sign is highly sensitive to the expected service life. For high performance sheeting service life of less than 13 years, the annual cost of high performance sign exceeds the annual cost of engineering grade sign. The yearly difference of 2.8 years (say 3) is the additional life of high performance sheeting required to insure its cost effectiveness.

A sensitivity analysis was conducted to determine the effect of interest rates on annual cost of engineering grade and high performance signs. Assuming a 15 year and 10 year service life for high performance and engineering grade respectively, the annual costs of an overhead guide sign are shown graphically in Exhibit 13. The graph shows that for lower interest rates the annual cost of high performance sign is lower than annual cost of engineering grade sign. At a 15-1/2 percent interest rate, the annual cost of engineering grade sign and high performance sign are the same. For interest rates higher than 15-1/2 percent, the annual cost of high performance sign is higher than engineering grade sign. When interest rates cannot be predicted with certainty, sensitivity analysis can help determine the effect on annual cost.

2. Overlaying Existing Guide Signs

Overlaying of signs is a major maintenance expense incurred each year. Therefore, comparisons of cost for overlaying signs with 0.04 aluminum overlay was performed. The cost components include 1) cost of materials, 2) cost of labor, 3) installation costs, and 4) cost of traffic control. Comparison of annual cost for the overlay procedure is done for the expected



BMI

INTEREST RATE SENSITIVITY -
OVERHEAD GUIDE SIGNS

Exhibit
13

service life of the sign sheeting. This assumes that the overlay lasts as long as a new sign sheeting and that the sign structure (i.e. posts, hardware, etc.) lasts 20-30 years. For this analysis both of these assumptions are reasonable. Again, the basis of comparison is the EUAC of the two sheetings. The total costs supplied by KDOT of overlaying a 15' x 10' overhead guide sign are as follows (see Appendix D for specific cost breakdowns):

Item	Engineering Grade	High Performance
Materials & Labor	$434.00	$803.00
Installation	150.00	150.00
Traffic Control	87.00	87.00
TOTAL COST	$671.00	$1,040.00

Equivalent Uniform Annual Costs:

Engineering Grade

$EUAC_{E.G.}$ = $671.00 * [CRF,8.5,10]
= $671.00 * 0.152408
= $102.41/sign/year

High Performance

$EUAC_{H.P.}$ = $1,040.00 * [CRF,8.5,15]
= $1,040.00 * 0.120420
= $ 125.35/sign/year

At this point, no benefit of longer service life of high performance has been accounted for. To do so the following calculations are made:

SPW = $125.35 [SPW,8.5,5]
= $125.35 * 3.940642
= $493.95/sign/year

SPW annualized
= $493.95 [SF,8.5,10]
= $493.95 * 0.067408
= $ 33.29/sign/year

The Adjusted Equivalent Uniform Annual Cost of high performance overlay over 10 years is then $125.35 - 33.29 = $92.06/sign/year, again lower than the engineering grade cost of $107.41.

Exhibit 14 summarizes the cost comparison for overhead guide signs. As noted, high performance sheeting is cost effective for this type of sign.

B. Annual Cost Comparison for a New Ground Mounted Warning Sign

From price information provided by KDOT, the costs of a typical 30"x30" warning sign are as follows:

Item	Engineering Grade	High Performance
Materials & Labor	$26.38	$41.75
Installation	6.59	6.59
Traffic Control	17.56	17.56
TOTAL COST	$50.53	$65.90

Economic Analysis Variables:

- Expected Service Life of Engineering Grade Sign = 10 years
- Expected Service Life of High Performance Sign = 15 years
- Interest Rate = 8.5%

New Overhead Guide Sign

	Engineering Grade	High Performance
EUAC/sign/year =	$144.96	$158.95
Annual worth of additional service life/sign/year =	-	$42.22
Adjusted EUAC/sign/year =	$144.96	$116.73

Overlay Overhead Guide Sign

	Engineering Grade	High Performance
EUAC =	$102.41	$125.35
Annual worth of additional service life/sign/year =	-	$ 33.29
Adjusted EUAC =	$102.41	$ 92.06

Equivalent Uniform Annual Costs:

Engineering Grade

$EUAC_{E.G.}$ = \$50.53 * [CRF,8.5,10]

= \$50.53 * 0.152408

= \$ 7.70/sign/year

High Performance

$EUAC_{H.P.}$ = \$65.90 * [CRF,8.5,15]

= \$65.90 * 0.120420

= \$ 7.93/sign/year

SPW = \$ 7.93 [SPW,8.5,5]

= \$ 7.93 * 3.940642

= \$31.24/sign/year

SPW Annualized

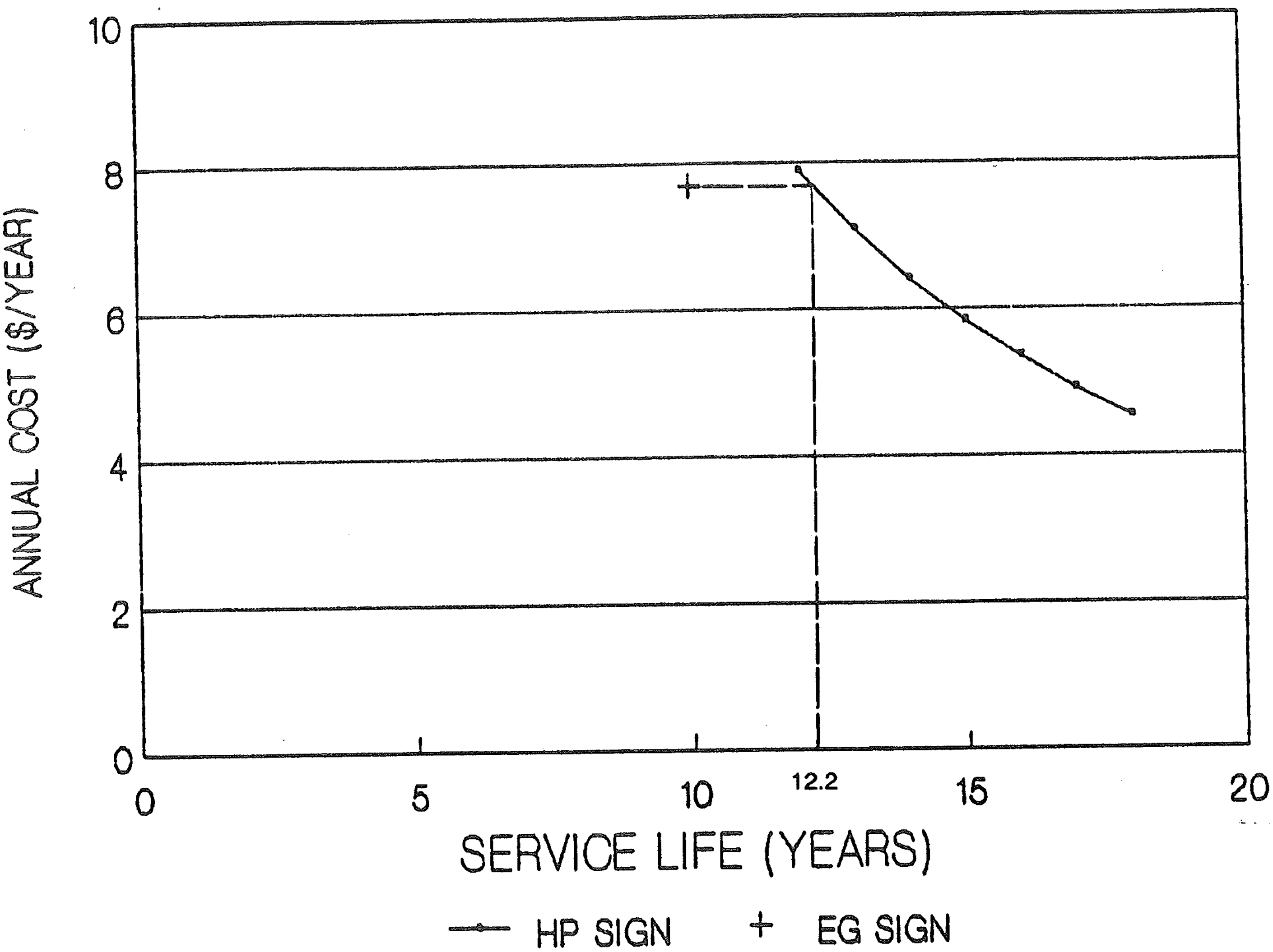
= \$31.24 [SF,8.5,10]

= \$31.24 * 0.067408

= \$ 2.10/sign/year

Adjusted Equivalent Uniform Annual Cost of high performance sign over 10 years is \$7.93 - 2.10 = \$5.83/sign/year.

As with overhead signs, a sensitivity analysis was performed of the effects of service life. Assuming an engineering grade service life of 10 years, the high performance needs 2.2 additional years of service to be cost effective. This analysis is presented in Exhibit 15. Exhibit 16 presents a summary of this sign type analysis. On the basis of sheeting service life, initial costs, and interest rates, the high performance sheeting signs are more cost effective. This result is consistent with prior attempts by Virginia DOT and others to economically analyze sign sheeting.



BMI

SERVICE LIFE SENSITIVITY -
POST MOUNTED SIGNS

Exhibit
15

	Engineering Grade	High Performance
EUAC =	$7.70	$7.93
Annual worth of additional service life/sign/year =	-	$2.10
Adjusted EUAC =	$7.70	$5.83

BMI

GROUND MOUNTED SIGNS -
ANNUAL COST SUMMARY

Exhibit 16

Vandalism

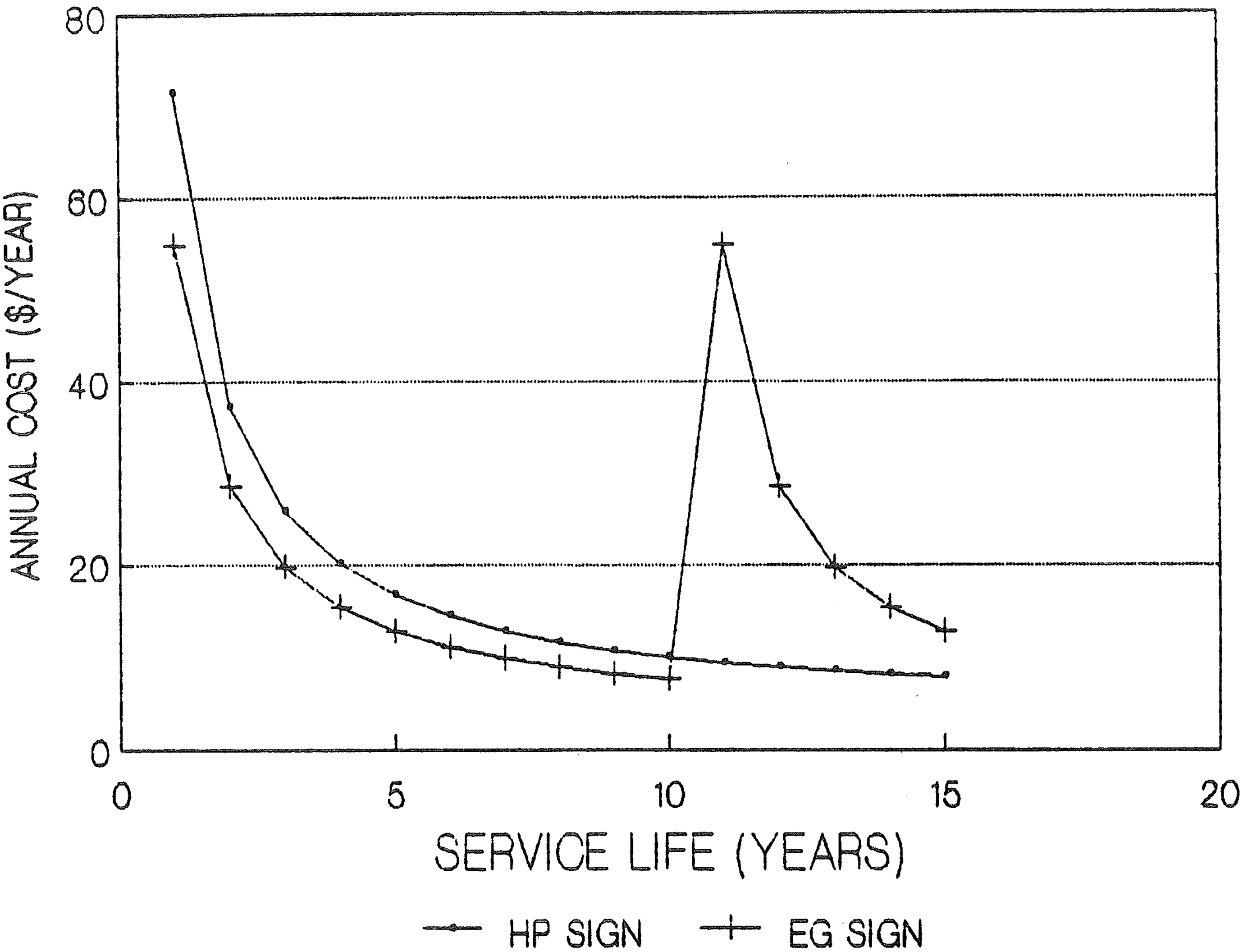
Another critical item in the analysis of ground mounted signs is vandalism. Vandalism accounts for 30 percent of total sign maintenance costs each year, according to Ross(38). While this is a significant expenditure, the necessary signing information required to perform monetary analysis is lacking. The FHWA report states that most highway agencies are void of sign inventories, making estimates of vandalism costs difficult.

In this model a comparison is made of the annual cost of an engineering grade ground mounted sign and a high performance ground mounted sign, taking into account the effect of vandalism. The effect of vandalism can be reflected in terms of reduction in service life. Sensitivity analysis of annual cost is performed with respect to service life. It is assumed that a high performance sign which fails and is replaced after being in place for 15 years has given its full measure of service. Similarly, an engineering grade sign which fails and is replaced after being in place for 10 years has given its full measure of service. If a sign was replaced at some earlier date due to vandalism, the age at replacement would represent the service life with the annual costs calculated for that service life. According to an FHWA report(39), freeway guide signs are not as frequently subjected to vandalism as post mounted ground signs due to their location and the increased lighting typically present. Therefore, annual cost comparisons are made for ground mounted warning signs only.

The appropriate method to analyze the impacts of vandalism is the sign service life rather than sheeting service life. Items such as vandalism, obsolescence of signing, accidents, etc. lessen the effective service life of a sign to some extent. However, the reduction in service life due to vandalism is difficult to quantify, since much detailed information is required (placement year, cause of replacement, extent of damage, etc.). Vandalism rates, according to the questionnaire responses, are strictly estimates. Also, the degree and type of vandalism is variable dependent upon class of roadway, area type, and type of sign. Therefore, a system-wide sheeting selection policy seems inappropriate based on vandalism rates. This issue is better suited to analysis on a sign by sign basis. Where no choice in sheeting type is available, the vandalism issue does not affect the selection decision.

The cost analysis and curves in Exhibit 17 give guidance based on expected (or previous experience) service life for a sign, where the choice of sheeting is available. When the circumstances are such that sheeting type is a real choice, the curve in Exhibit 17 shows that any sign with an expected service life less than 10 years should use engineering grade sheeting. Beyond 10 years, due to the engineering grade sheeting replacement cost, the sign should be produced with high performance sheeting. In dealing with vandalism each sign should be considered individually based on:

- location (urban vs rural)
- class of roadway
- engineering criteria
- proximity to colleges, schools, etc.
- proximity to hunting areas
- message of the signs
- frequency of vandalism



BMI

EFFECTS OF VANDALISM
POST MOUNTED SIGNS

Exhibit
17

Total Cost including materials, labor, installation, and traffic control for a ground mounted high performance warning sign = $65.90, and for engineering grade sign = $50.53. Since the annual costs are computed for the same service life for engineering grade and high performance sign, no adjustment is necessary to compare the alternatives.

After 10 years the engineering grade sign has given its full measure of service and requires replacement. Therefore, the engineering grade annual cost due to vandalism for the eleventh year of service equals the annual cost for service in the first year. This analysis shows that where the expected service life of a sign due to vandalism does not exceed 10 years, engineering grade reflective sheeting should be used. Again, this is only true where a choice between engineering grade and high performance sheeting is available. There are locations where better attention value, legibility at night and other traffic engineering requirements will dictate the use of high performance sheeting. Therefore one point should remain paramount in any interpretation of the findings, namely that the most important function of a sign is to get the message to the driver.

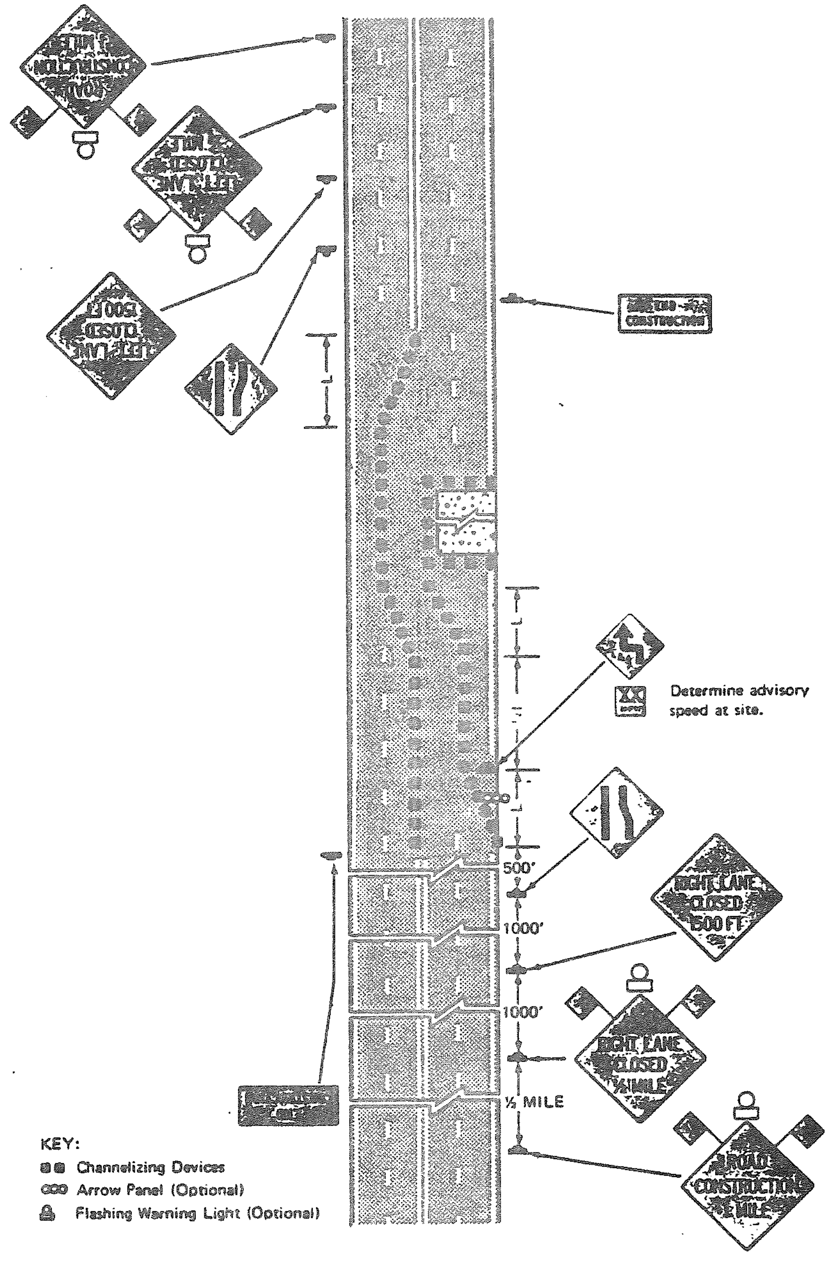
5.3.2 Construction Zone Signing

From interviews with KDOT and others with construction zone experience, it was determined that an economic analysis using the service life of the sheeting was inappropriate. Typically, signs in construction work zones require replacement due to damage or mishandling. In these areas, replacement rarely is necessary due to loss of reflectivity. The economic analysis was performed using a typical work zone project with a lane closure, as shown on Exhibit 18. Based on interview responses, the service lives of engineering grade sheeting signs and high performance sheeting signs were assumed to be 3 years and 2 years, respectively.

The cost items were obtained from bid price summary sheets supplied by KDOT. Exhibit 19 presents those items considered and their average yearly cost per day since 1981. The cost of devices increased in 1986, the year in which high performance sheeting was introduced in work zones. However, the prices for 1987 have returned to the levels experienced prior to the switch to high performance sheeting. No conclusions can be drawn from these bid prices. Work zone signs and devices are bid items on most construction projects in Kansas. The contractor has the responsibility for providing all traffic control and channelizing devices and charges a dollar amount per day per item (rent) accordingly.

Since the current KDOT policy is to use high performance sheeting in construction work zones, assumptions for the rent price of devices with engineering grade sheeting were made. Applying the differences in annual costs of highway signs from previous models, a corresponding daily unit cost was determined assuming 250 project days per year. From this calculation, the daily rent price of work zone signs and devices using engineering grade sheeting is approximately $0.06 less than high performance. The 1987 bid prices obtained from KDOT reflects the use of high performance sheeting. The calculated $0.06 was subtracted from these values to arrive at assumed engineering grade costs. The cost comparison assumes three scenarios:

- High performance sheeting on all signs/devices, and lights on drums.
- Engineering grade sheeting on all signs/devices, and lights on drums.
- High performance sheeting on all signs/devices, and no lights on drums.



Source: Manual on Uniform Traffic Control Devices (MUTCD)

BMI TYPICAL CONSTRUCTION ZONE PROJECT **Exhibit 18**

CONTRACT BID AVERAGES FOR YEARS 1981 - 1987

Item Code	Item Description	Units	Year: Average of Years 1981-1984	1985(1)	1986(2)	1987(3)
025331	CONST SIGNS (0-9.25)	EADA	0.32	0.38	0.47	0.32
025332	CONST SIGNS (9.26-16.25)	EADA	0.49	0.70	0.86	0.67
025333	CONST SIGNS (16.25-OVER)	EADA	1.43	0.95	1.49	1.07
025334	CONST BAR (TP I OR II)	EADA	0.58	0.62	0.90	0.57
024335	CONST BAR (TP II 4-8LF)	EADA	1.90	1.70	2.45	2.74
024336	CONST BAR (TP III 9-14LF)	EADA	1.70	1.84	1.97	1.90
024337	CONST WNG LT (TP B)	EADA	1.65	1.68	1.75	1.43
024338	REF DRUM	EADA	0.74	0.80	0.86	0.76

(1) Engineering Grade Sheeting

(2) 3 Months Engineering Grade and 9 Months High Performance Sheeting

(3) High Performance Sheeting

Notes: EADA = Each Day

Prices are cost per day per device

Item Codes and Descriptions are from KDOT Yearly Bid Average Summary

Source: KDOT

Certain studies and interviews presented in the Literature Review and Survey Results chapters have expressed the possibility of eliminating lights on construction zone devices with the introduction of high performance sheeting. The interviews of fabricators and installers of these devices resulted in a mixed reaction; some felt that lights were not required when using high performance, and others felt that lights are always necessary regardless of sheeting type. Exhibit 20 presents the results of this comparison. As shown, for the devices having reflective sheeting, the use of high performance sheeting results in an additional $6.00 (approximately) per project-day. However, if the lights were removed from the channelizing drums, a savings of approximately $175.00 per project-day results. The above computations indicate that it is economical to use engineering grade sheeting on construction zone signs and drums if lights are also used. However, the difference in costs is nominal. In addition to the costs, other benefits such as higher attention value and higher legibility at night of the high performance sheeting should be considered. Elimination of the lights where high performance sheeting is used reduces costs by almost half. Before removal of the lights on channelizing devices, the criteria concerning non-curved sections, periodic maintenance, and the other guidelines presented in the previous discussions should be considered.

5.3.3 Other Cost Benefit Items

Benefits attributed to high performance sheeting concerning illumination, higher brightness and accident reduction are presented in this section.

Item	Quantity	H.P.	E.G.	Other Items	H.P.	E.G.	H.P., No Lights
Signs							
o 48"x48"	6	0.67	0.61		4.02	3.66	4.02
o 36"x36"	2	0.32	0.26		0.64	0.52	0.64
o 30"x30"	2	0.32	0.26		0.64	0.52	0.64
o 18"x18"	2	0.32	0.26		0.64	0.52	0.64
o 60"x24"	2	0.67	0.61		1.34	1.22	1.34
Reflectorized Drums	128	0.76	0.72		97.28	92.16	97.28
Flashing Light on drums	128			1.43	183.00	183.00	-
TOTAL PER PROJECT DAY					287.56	281.60	104.56

BMI

CONSTRUCTION WORK ZONE
COST ANALYSIS

Exhibit 20

A. Elimination of Overhead Guide Sign Illumination

From the detailed information presented in the Literature Review chapter, certain overhead guide sign locations do not warrant illumination. As discussed, this determination should be made based on engineering design review on a case by case basis. Where elimination of the illumination is appropriate, the following analysis of cost savings is applicable.

Based on the data obtained from KDOT, an average initial cost of illumination is $2,200/structure with an annual operation cost of $500/structure. The analysis is prepared for a new location and existing location with the lights turned off.

New Sign Location

Annual cost of structure assuming service life of the structure is 30 years

is = $2,200 * [A/P,8.5%,30] [where A/P = Capital Recovery]

= $2,200 * 0.093051

= $ 204.71/year

Annual cost of illumination including the initial cost of structure and operation cost per year = $204.71 + $500 = $704.71 The $704.71 per sign per year therefore represents the possible savings by using high performance sheeting.

Turning Off Lights

The savings of \$500/structure/year (annual operation costs) is experienced in locations where turning the lights off is determined appropriate.

KDOT's response to the signing questionnaire indicated that all engineering grade overhead signs are illuminated. Therefore, by eliminating lighting at a new signing location, an annual savings of \$704.71 per sign is experienced. Since the decision to eliminate illumination should be based on a location by location engineering study considering the guidelines presented in the Literature Review chapter, the total annual savings is unquantifiable. Once locations are isolated apply the appropriate savings per sign values to the number of locations not needing illumination (new or existing). Potential locations for this benefit are the guide signs in rural areas, typically on the states' two lane system. From previously discussed research, some overhead guide signs in rural areas do not require illumination. Also, research has also shown that in urban areas with low and medium complexity, high performance sheeting guide signs provide sufficient legibility. Only in urban, high complexity areas where background ambient lighting is prevalent are illuminated guide signs needed. Therefore, in those areas that non-illuminated high performance sheeting signs are satisfactory, substantial monetary savings can be realized.

B. Higher Brightness

Most researchers and agencies agree that providing increased sign brightness is advantageous (within certain upper limits) and desirable if it is cost effective. An attempt to quantify the higher brightness of high performance over engineering grade sheeting was performed by Cottrell(40). The underlying assumption in this analysis is that all additional brightness (measured in candlepower/foot-candle/square foot = 1 lumen) is beneficial to and usable by the motorist. The following analysis utilizes Cottrell's methodology:

Consider:

C = Cost per lumen per year of service life

IC = Initial cost of sheeting per square foot

L_n = Average luminance of new material (from specifications)

L_o = Average luminance at end of useful life (from manufacturer warranties)

SL = Effective service life (warranty life)

Then:

$$C = \frac{IC}{\frac{L_n + L_o}{2} \times SL} \qquad \text{[For each sheeting type]}$$

Engineering Grade (white sheeting, L-S-300C specification)

$$C = \frac{0.59}{\frac{80 + 40}{2} \times 7}$$

C = 0.281 cents per lumen

High Performance (white sheeting, LS-300C specification)

$$C = \frac{3.05}{\frac{250 + 200}{2} \times 10}$$

C = 0.135 cents per lumen

As shown from this calculation, the cost for providing 1 lumen of light is significantly less for high performance sheeting. While this analysis does not consider if all additional brightness is usable, it does provide a basis for higher reflectivity cost-benefits.

C. Accident Reduction

Reasonably, the increased reflectivity and sign visibility of high performance sheeting should reduce accident rates and severity. Any reduction in accidents creates a dramatic cost savings to the users and the controlling agencies. The difficulty posed in quantifying this benefit of high performance sheeting is the lack of data isolating sign brightness as contributing to accident reduction. The following methodology can be applied if and when controlled before and after studies determine the actual magnitude or number of accidents reduced after implementation of "brighter" signs. Certain studies in the Literature Review chapter have given accident reduction information based on signing upgrades.

Recent studies by Rollins and McFarland(41) isolate accident cost by severity and location. These values are as follows:

Total Accident Costs by Severity and Area

Area	Fatal	Injury	Property Damage Only
Rural	$883,137	$10,644	$1,298
Urban	$826,856	$8,745	$1,519

As shown, rural accidents tend to have higher costs resulting from increased severity.

These accident costs were applied to KDOT work zone accident data for 1985, since 1985 data summarizes accidents by area type (i.e., urban, rural). It was determined that for this analysis, nighttime work zone locations have an immediate need for improvement. A quote from the Kansas Interim Proposal No. 33 supports this notion:

> "We know that over 50 percent of work zone fatalities occur at night, and the most common collision involves a vehicle and a fixed object such as a roadside barrier or barricade. This should tell us something about the need for adequate delineation at night."

The average costs per accident in work zones, assuming the accident costs above and the severity breakdown from KDOT accident records, are as follows:

Average Cost per Accident in Construction Zones

Urban Night	Rural Night
\$19,731	\$30,808

An accident cost/benefit analysis was performed using the per project-day costs of \$287.56 and \$281.60 previously calculated for high performance and engineering grade construction signs and devices respectively. Assuming 200 days per project and 300 total projects statewide per year, the additional cost of providing high performance sheeting with lights would be approximately \$350,000 per year. If the use of high performance sheeting reduced nighttime construction zone accidents by approximately 15 (or 5% of the approximate 300 nighttime accidents) the extra cost of high performance sheeting would be justified. While unquantifiable a reduction in accident severity, which greatly influences the average accident cost, could result from the use of high performance sheeting as well.

6. SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

This final chapter provides a summary of findings, conclusions and recommendations relevant to the main objective of the study.

6.1 Summary of Findings

The following statements present the summary of findings.

1. Kansas Practices vs Other States

   a. Kansas agrees with the majority of the states in the following practices:

      - Use of high performance sheeting for freeway guide signs.
      - Use of engineering grade sheeting for guide signs on conventional roads.
      - Use of high performance sheeting for construction zone signs and channelizing devices.

   b. For regulatory signs, Kansas:

      - agrees with the majority of states in using high performance sheeting for right-of-way signs, i.e., STOP and YIELD signs.
      - agrees with the majority in using engineering grade for all other regulatory signs except the movement series, i.e., turning, alignment, exclusion and one-way signs.
      - is in the minority in their use of high performance sheeting for the movement series signs.

   c. Kansas's use of high performance sheeting for warning signs is dependent upon specific sign type and situation, which is consistent with most other states.

d. Kansas's practice on using steady-burn or flashing lights on construction signs and channelizing devices is consistent with the majority of the states and is independent of sheeting type.

e. Kansas is consistent with the majority of the states in requiring external illumination of overhead guide signs with high performance sheeting. However, more states, including Kansas, are experimenting with elimination of illumination when using high performance sheeting.

f. Kansas aligns with the majority of states in following Federal Specification L-S-300C for establishing minimum reflectance levels.

2. Sheeting Reflectance Levels

Based on the best available studies of minimum luminance requirements to meet drivers' needs, high performance sheeting is suggested for the following conditions:

- All STOP and YIELD signs except where speeds are low (below 35 mph) and the ambient light is low.
- For critical warning signs in medium and high ambient light areas.
- For guide signs in medium and high complexity areas.
- For construction work zone signs and channelization devices.

3. Safety Benefits of High Performance Sheeting

The safety benefits of the brighter high performance sheeting can only be inferred because there is no conclusive study relating accident reduction to sign brightness.

4. **Sheeting Economics**

The life cycle cost comparison of high performance and engineering grade sheeting has shown that high performance sheeting is more cost effective provided the full service life of the sheeting is realized. When signs have to be replaced due to vandalism, knockdowns, etc., engineering grade is more cost effective.

The use of high performance sheeting can result in additional monetary benefits due to:

a. Elimination of external illumination of overhead guide signs where appropriate.

b. Elimination of steady-burn lights on channelizing devices, where appropriate.

c. Potential reduction in accident frequency and severity.

6.2 Conclusions

The principal conclusions to be drawn from the findings are as follows:

- KDOT's current practice for use of high performance sheeting for permanent signing is entirely appropriate given the benefits of the brighter sheeting. As long as the sign life is not substantially shortened by damage, high performance sheeting is more cost effective compared to engineering grade sheeting.

- KDOT's current practice for use of high performance sheeting for construction zone devices is also entirely appropriate. Although slightly more expensive than engineering grade, it provides the motorist devices which are brighter and therefore more likely to be detected. Also, in certain situations, its use can defer the need for steady-burn or flashing lights.

6.3 Recommendations

The following recommendations are offered to KDOT regarding their reflective sheeting policy and practices.

1. KDOT should adopt the specifications contained in FP-85 that deal with reflective sheeting. This would permit the use of super-engineering grade sheeting. (KDOT should also review for adoption the soon-to-be-approved ASTM specification on reflective sheeting.)

2. KDOT should adopt a specification for maintained retroreflection of devices used in highway work zones. A standard similar to that in FP-85 (Sec. 635.03) is recommended. This standard specifies that reflective sheeting on signs, drums, barricades and other devices shall be maintained to a level of not less than 75 percent of the minimum SIA values required for Type II sheeting (enclosed lens, engineering grade) and 50 percent of the minimum SIA value required for Type III sheeting (high performance, encapsulated lens).

3. Investigate and establish a policy on the need for steady-burn lights for channelizing devices made with high performance sheeting for use in highway work zones.

4. Investigate and establish a policy on the need for illumination of overhead guide signs made of high performance sheeting.

5. Expedite the implementation of a sign inventory system which, among other purposes, would provide a data base on sign life.

REFERENCES

(1) Kansas Department of Transportation, Special Provision to the Standard Specifications Edition of 1980, Subsection 2201, Reflective Sheeting, 80P-185-R3.

(2) Olson, P. "Minimum Requirements for Adequate Nighttime Conspicuity of Highway Signs", University of Michigan Transportation Research Institute, 1987 (unpublished).

(3) Mace, D.J., King, R.B., and Dauber, G.W. Sign luminance requirements for various background complexities. Institute for Research. State College, PA FHWA/RD-85/056, September 1985.

(4) Mitchell, A. and Forbes, T.W. "Design of Sign Letter Size.", Proceedings, American Society of Civil Engineers, New York, NY Vol. 68, 1942.

(5) McGee, H.W. and Mace, D.L., "Retroreflectivity of Roadway Signs for Adequate Visibility: A Guide", FHWA/DF-88/001, 1987.

(6) Forbes, T.W. "A Method for Analysis of the Effectiveness of Highway Signs", Journal of Applied Psychology, Vol. 23, 1939

(7) Woltman, H.L. "Review of Visibility Factors in Roadway Signing, Special Report 134", Highway Research Board, 1973.

(8) Borton, W. L., "Evaluation of Sign Face and Legend Materials for Overhead Signs", Michigan DOT, 1982.

(9) Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects, FP-85, U.S. Department of Transportation, Federal Highway Administration.

(10) Colomb, M., and Michaut, G., "Retroreflective Road Signs: Visibility at Night", Transportation Research Record 1093.

(11) Allen, T.M., "Night Legibility Distances of Highway Signs", HRB Bulletin 191, 1958.

(12) Youngblood, W.P., and Woltman, H.L., "A Brightness Inventory of Contemporary Signing Materials for Guide Signs", HRR No. 377, HRB, 1971.

(13) Robertson, R.N., "Use of High Intensity Reflective Materials in Highway Signing", VHRC 73-R6, Virginia Highway Research Council, 1973.

(14) Information found in the Kansas Post Audit Report, April 1986.

(15) "Encapsulated Lens (High Intensity) Reflective Sheeting Sign Material", FHWA Notice N5040.17, FHWA, June 15, 1976.

(16) Woods, D.L. and Rowan, N.J., "Overhead Signs Without External Illumination", TRB Research Record 611, 1976.

(17) Van Norren, D., "Overhead Signs Without External Illuminations Part I: Literature and Review and Calculation.", Institute for Perception Report No. IZF, 1978-C20., 1978.

(18) Van Norren, D., "Overhead Signs Without External Illuminations Part II: Experiments on Legibility Distance." Institute for Perception Report No. IZF 1978-C28., 1978.

(19) Hajjiri, S.A. and Michalopoulos, P.G., "Review of Current Practices for Illumination and Reflectorization of Overhead Guide Signs", Minnesota DOT, MN/RC-87/02, 1987.

(20) Paniati, J.F., Mace, D.J., and Hostetter, R.S., "A Sign Management System to Maintain Sign Visibility at Night", Public Roads, March 1987.

(21) Van Gelder, William, "UTEC Forum: A Look at Signing", ITE Journal, June 1982.

(22) "Manual on Identification, Analysis and Correction of High Accident Locations", FHWA, 1982.

(23) "The 1984 Annual Report on Highway Safety Improvement Programs", FHWA, 1984.

(24) Gittings, G.L., "Tort Liability in the Pennsylvania DOT", Proceedings of the Conference on the Effectiveness of Highway Safety Improvements, March 1985.

(25) Sivak, M. et al, "Effect of Driver's Age on Nighttime Legibility of Highway Signs", Michigan Safety Research Institute, 1979.

(26) "Summary of Findings and Recommendations: Workshop on Highway Mobility and Safety of Older Drivers and Pedestrians", June 1985.

(27) "Kansas Standard Summary of Motor Vehicle Traffic Accidents", Accident Analysis Section - Bureau of Rural and Urban Development, KDOT, 1986.

(28) "Summary Report on Work Zone Accidents", AASHTO, July 1987.

(29) Information supplied by the Pennsylvania Department of Transportation.

(30) Information supplied by the Florida Department of Transportation.

(31) Information supplied by the North Carolina Department of Highways.

(32) Information supplied by the Virginia Department of Highways.

(33) Information supplied by the Idaho Department of Transportation.

(34) Allen, T.M., Smith, G.M. et al., "Luminance Requirements for Illuminated Signs", Record 179, Highway Research Board, 1967.

References Cont'd

(35) "A Limited Evaluation of Reflective and Non-reflective Background for Overhead Signs", PA DOT Research Project No. 75-19.

(36) Winfrey, R., "Economic Analysis for Highways", International Textbook Company, Scranton, PA, 1969.

(37) Barish, N.N., Kaplan, S., "Economic Analysis for Engineering and Managerial Decision Making", McGraw-Hill, 1978.

(38) H.E. Ross, J.L. Buffington, G.D. Weaver, and D.L. Schafer, "State of the Practice in Supports for Small Highway Signs", U.S. Department of Transportation, Federal Highway Administration, Technology Sharing Report 80-222, 1980.

(39) Perkins, D., "Countermeasures for Sign Vandalism", Report No. FHWA-IP-86-7, FHWA, September 1986.

(40) Cottrell, B.H.Jr., "Comparative Analysis of Reflective Sheeting", VHTRC82-R22, Virginia Highway Transportation Research Council, 1981.

(41) Rollins, J.B. and McFarland, W.F., "Costs of Motor Vehicle Accidents and Injuries", The Texas Transportation Institute, for Transportation Research Board presentation, 1986.

APPENDIX A

QUESTIONNAIRE SENT TO STATES

SIGN SHEETING QUESTIONNAIRE

In completing this questionnaire, please consider the following definitions:

E.G. = Engineering Grade Sheeting = Type II & IIA in FP-85.

H.P. = High Performance Grade Sheeting = Type III in FP-85.

FP-85, Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects, 1985

A. SIGN MATERIAL AND UTILIZATION

1. What is your policy regarding the use of different sheeting grades for the following types of signs and channelization devices?

(Respond by marking "X" in the appropriate column for each type of sign listed.)

SIGN TYPE	Button Copy on		Demountable Copy E.G. Copy on		Demountable Copy H.P. Copy on		Direct Applied Copy Using	
	E.G. Sheeting	H.P. Sheeting	E.G. Sheeting	H.P. Sheeting	E.G. Sheeting	H.P. Sheeting	E.G. Sheeting	H.P. Sheeting
a. Freeway Guide Signs	___	___	___	___	___	___	___	___
b. Conventional Road Guide Signs	___	___	___	___	___	___	___	___
c. Regulatory Signs								
1- Right-of-way series	___	___	___	___	___	___	___	___
2- Speed series	___	___	___	___	___	___	___	___
3- Movement series	___	___	___	___	___	___	___	___
4- Parking series	___	___	___	___	___	___	___	___
5- Pedestrian series	___	___	___	___	___	___	___	___
6- Miscellaneous series	___	___	___	___	___	___	___	___
d. Warning Signs	___	___	___	___	___	___	___	___
e. Construction Zone Signs	___	___	___	___	___	___	___	___

f. Sheeting used on Barricades & Channelizing Devices E.G.___ H.P.___

Other, explain ____

2. For all of the instances that you used H.P. sheeting in question #1, explain why. (Attach extra sheets if necessary.)

____

____

____

____

3. In question #2, if accidents or accident rates were a determining factor in using H.P. sheeting, how much change in accident frequency was experienced after the utilization of H.P. sheeting began for each sign type (regulatory, warning, etcetera)?

____

____

____

____

4. Do you use lights on signs or channelizing devices in construction zones?

Steady-burning: Yes ___ No ___ Flashing: Yes ___ No ___

5. If you answered "yes" to question #4, does your policy change with the type of sign sheeting used (E.G. vs. H.P.)? Please explain.

____

____

____

____

6. Considering sheeting type, do you provide external illumination in any cases for:

	E.G.		H.P.	
	Yes	No	Yes	No
Roadside signs	___	___	___	___
Overhead signs	___	___	___	___

If you responded "yes" to any of the above, please describe your sign illuminating policy.

____

____

____

B. SPECIFICATIONS AND TESTING OF SHEETING MATERIAL

1. With regard to reflectance levels (i.e., Specific Intensity Per Unit Area), does your agency follow any of the following specifications:

   a. L-S-300C ____
   b. FP 85 (FHWA) ____
   c. AASHTO M268-84 ____

If not, please indicate what is used or provide a copy of your specifications. ________________

____

2. Do you have different photometric or material requirements for:

	Yes	No
a. Overhead as compared with roadside sign installations?	___	___
b. Signs placed on different classes of highway or where different traffic volumes are encountered?	___	___
c. Different types of signs (guide, warning, regulatory)?	___	___
d. Signs or devices in construction zones?	___	___

If your answer to any of the above was "yes", please describe the specifications. ________________

____

____

____

3. Has your agency conducted research to set desirable photometric specifications for signing material? (If "yes", please provide a copy or a dated reference.) Yes ___ No ___

C. SERVICE LIFE

1. From your records or experience, what is the life expectancy of each sign sheeting used?

   High Performance ____ years

   Engingeering Grade ____ years

   Other, specify ______ ____ years

2. Does the type of sheeting copy affect the life of the sign sheeting? Yes ___ No ___

If yes, please list type of copy and sheeting used and explanation of conditions. ________________

____

____

3. What manufacturer warranties do you have for each sheeting type?

High Performance ______ years

Engineering Grade ______ years

Other, specify __________ ______ years

4. Do any of the following factors affect the life expectancy of sign sheeting?

	High Performance Yes	High Performance No	Engineering Grade Yes	Engineering Grade No
a. Differences in weather conditions within the jurisdiction.	___	___	___	___
b. Directional orientation of the sign.	___	___	___	___
c. Color of the sheeting (white, orange, black, yellow, etc.)	___	___	___	___

If "yes" to any part, please give specific information and estimated life expectancy changes. ______________________________

____

____

5. Please estimate the percent of your highway signs that are vandalized each year.

_____% of sign total.

6. Of the total signs vandalized each year, please estimate the percent by region.

_____% rural areas
_____% suburban areas
_____% urban areas

If percent by roadway class is known, please include this information.

____

____

____

D. COST

1. What is the most recent cost of sign sheeting in terms of dollars per square foot?

	Cost ($/sq. ft.)	Year	Supplier Name
High Performance	________	___	________
Engineering Grade	________	___	________
Other, specify ______	________	___	________

2. Has your agency prepared a cost-benefit analysis of High Performance vs. Engineering Grade sheeting? Yes ___ No ___

If yes, please attach a copy of the analysis or at least describe the method. ____

____

____

3. With regard to maintenance of highway signs, does the type of sheeting (E.G. vs. H.P.) affect the maintenance costs? Yes ___ No ___

4. If you answered "yes" to question #3, what was the difference in maintenance costs and why was there a difference? (cleaning, frequency of maintenance, etcetera) $_______/sign/year.

____

____

____

5. How often do you inspect your highway signs?

	E.G.	H.P.
Inspection period	___	___

6. If your inspection period differs from E.G. sheeting signs to H.P. sheeting signs, explain the reasons for the difference.

____

____

____

7. Is there an appreciable difference between E.G. sheeting and H.P. sheeting signs considering handling, storage and fabrication charges?

	Yes	No	High Performance Cost Difference (+ or −)
Handling	___	___	$ __________/sign
Storage	___	___	$ __________/sign
Fabrication	___	___	$ __________/sign

Do you want a summary of the questionnaire results? Yes ___ No ___

Name: ______________________________

Title: ______________________________

Department: ______________________________

State: ______________________________

Address: ______________________________

____

____

Please return the questionnaire to:

Dr. Hugh McGee
Bellomo-McGee, Inc.
901 Follin Lane, Suite 220
Vienna, Virginia 22180

APPENDIX B

Policies of Three States on the Use of High Performance Sheeting

MINNESOTA DEPARTMENT OF TRANSPORTATION
Technical Services and Operations Divisions
Technical Memorandum No. 86-6-T-4
April 15, 1986

To: Distribution 57, I and J

From: Gene Ofstead, Assistant Commissioner
Technical Services

L. F. McNamara, Assistant Commissioner
Operations

Subject: Reflective Sheeting
Policy for Mn/DOT - 1986

INTRODUCTION

On July 20, 1983, a committee was appointed by Deputy Commissioner R. J. McDonald to review, evaluate and make recommendations on Mn/DOT's existing reflective sheeting policy. The committee was charged to determine usable service life and to make economic analysis of each sheeting type. The committee's "Reflective Sheeting Report" was dated November 17, 1983. A summary of the report's recommendations was sent to each District Engineer by R. J. McDonald's memorandum dated August 28, 1984.

The purpose of this technical memorandum is to establish a policy that incorporates and supercedes previous policies on Mn/DOT's use of Retroreflective Sheeting. This technical memorandum also provides an implementation schedule so all Mn/DOT maintenance areas can comply with this policy in a timely manner.

RETROREFLECTIVE SHEETING POLICY

For Mn/DOT operations the following signs shall use Encapsulated Lens (High Intensity) Retroreflective Sheeting, Mn/DOT Specification 3352.2A2b - "Standard No. 2" (herein referred to as encapsulated lens reflective sheeting):

1. **Regulatory Signs**

    a. "STOP" (R1-1).
    b. "YIELD" (R1-2).
    c. "4-WAY" (R1-3).
    d. "ALL WAY" (R1-4).
    e. "DO NOT ENTER" (R5-1).
    f. "WRONG WAY" (R5-1a).
    g. Overhead, non-illuminated.

Externally illuminated guide signs will continue to have painted backgrounds with encapsulated lens legend and borders (Spec. 3352.2A2b).

EXCEPTIONS TO USE OF ENCAPSULATED LENS SHEETING

The following are exceptions to the above stated use of encapsulatd lens reflective sheeting. The following signs may use enclosed lens (Mn/DOT Specification 3352.2A2a) sheeting:

1. Minor green guide signs such as those naming lakes, rivers, streams, boundaries of cities and counties, and mileposts.
2. Orange signs used for daytime operations not directly related to construction or maintenance of the roadway or shoulders. Examples of these operations are: portable weigh scales, safety checks, survey crews, testing operations, mowing, signal and lighting repair, etc.
3. Vehicle mounted fluorescent orange signs used for daytime moving and mobile operations.
4. The standard "STOP"/"SLOW" flaggers paddle.

The following signs may use roll-up prismatic reflectorized sheeting (specifications will be issued):

1. Orange signs used for daytime <u>maintenance</u> operations.

IMPLEMENTATION SCHEDULE

Implementation of the reflective sheeting policy will be as provided below:

1. Construction/Maintenance Work Zones

   a. Encapsulated lens reflective sheeting will be required, as detailed herein, in all construction contracts bid after October 1, 1986 or on projects that specify a Starting Date ater January 1, 1987.

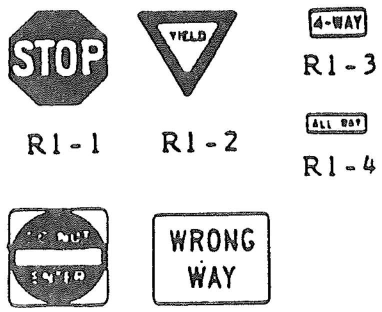
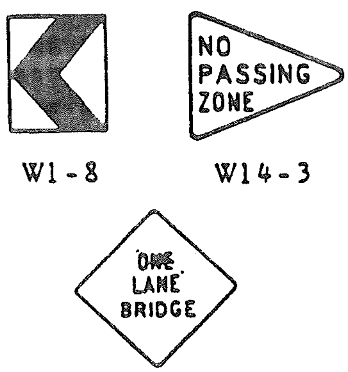
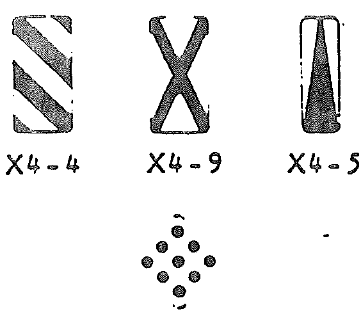
   b. Maintenance operations and other on-the-roadway support activities shall use devices with encapsulated lens sheeting, as detailed herein, by April 1, 1987.

2. Inplace signs on all trunk highways.

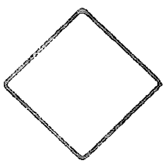
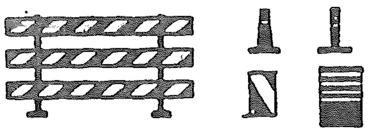
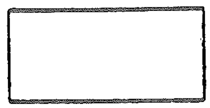
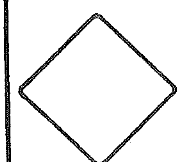
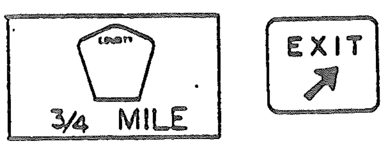
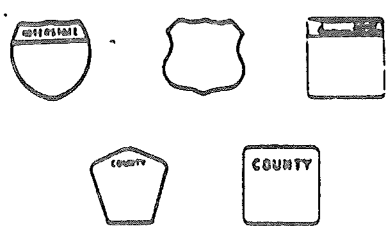
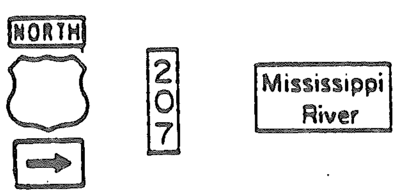
   During the next three construction seasons, signing contracts will be awarded to bring signs in each district into conformance with the sheeting policy herein.

   Each maintenance area is charged with implementing recurring sign maintenance in accordance with the policy. A recurring maintenance schedule shall be developed using 10 and 14 year cycles for enclosed and encapsulated lens sheeting, respectively. In order to monitor the performance of the reflective qualities of inplace signs each

ATTACHMENT
ENCAPSULATED LENS REFLECTIVE SHEETING POLICY
Mn/DOT - 1986
Technical Memorandum No. 86-6-T-4

SIGN TYPE	REFLECTIVE SHEETING Mn/DOT SPECIFICATION 3352.2A2		REMARKS
	STANDARD No. 2 ENCAPSULATED LENS (HIGH INTENSITY)	STANDARD No. 1 ENCLOSED LENS (ENGINEER GRADE)	
REGULATORY SIGNS	 R1-1 R1-2 R1-3 R1-4 R5-1 R5-1a	All other regulatory signs except as noted in "Remarks".	All overhead, nonilluminated regulator signs shall use encapsulated lens reflective sheeting.
WARNING SIGNS	 W1-8 W14-3 W5-3	All other warning signs except as noted in "Remarks".	All overhead, nonilluminated warning signs shall use encapsulated lens reflective sheeting.
OBJECT MARKERS	 X4-4 X4-9 X4-5 X4-2	See Remarks	All object markers made with reflective sheeting shall use encapsulated lens reflective sheeting
DELINEATORS	 Type IA Type IVA	See Remarks	All delineators made wit reflective sheeting sha use encapsulated lens reflective sheeting.

ATTACHMENT
ENCAPSULATED LENS REFLECTIVE SHEETING POLICY
Mn/DOT - 1986
Technical Memorandum No. 86-6-T-4

SIGN TYPE	REFLECTIVE SHEETING Mn/DOT SPECIFICATION 3352.2A2 STANDARD No. 2 ENCAPSULATED LENS (HIGH INTENSITY)	 STANDARD No. 1 ENCLOSED LENS (ENGINEER GRADE)	REMARKS
CONSTRUCTION AND MAINTENANCE SIGNS AND CHANNELIZERS	 All black legend on orange background warning and guide signs, except as noted in remarks.  BARRICADES CHANNELIZERS All reflectorized orange and orange/white traffic control devices except as noted in remarks.	 Vehicle mounted fluorescent orange signs used for mobile and moving operations. See Remarks  Black legend on orange background signs not related to construction or maintenance of the roadway or shoulder.	All other signs and traffic control devices used in highway work zones shall conform to the provisions of this policy. Refer to the policy tex for exceptions on the use of encapsulated ler reflective sheeting.
GUIDE SIGNS	 All legends, borders and demountable symbols used on guide signs, including route marker overlays. 	 All blue and brown guide signs may use enclosed lens background with encapsulated lens legend.  All independent route marker assemblies, minor green guide signs and mile markers.	Illuminated signs may have painted backgroun with encapsulated lens legends and borders. Refer to the policy te for all details and exceptions.

AS 64-1
April 18, 1984

APPLICATION STANDARD

OHIO DEPARTMENT OF TRANSPORTATION

USE OF TYPE G

REFLECTIVE SHEETING

The purpose of this Application Standard is to establish a policy on use of Type G reflective sheeting (Item 730.19 of the ODOT Construction and Material Specifications) and the elimination ofexternal sign lighting.

I. Sign Reflectorization with Type G Sheeting

On freeways, Type G reflective sheeting shall be used on all signs in the following categories:

- mainline and ramp signs, delineators, and object markers
- entrance ramp approach signs
- construction or maintenance work zone signs, object markers, delineators, and channelizing devices

On all other highways, Type G reflective sheeting shall be used on the following signs:

- overhead guide signs
- overhead permanent regulatory or warning signs (e.g. R-23, R-26A, W-40, W-54A, W-55)
- Stop signs (R-1)
- Multi-way signs (R-1a, 1b)
- Yield signs (R-2)
- Wrong Way signs (R-41a)
- Do Not Enter signs (R-41b)
- One Way signs (R-43, 44)
- Chevron Alignment signs (W-33)
- Bridge End Markers (X-6)
- Construction or Maintenance work zone signs and channelizing devices
- Delineators
- Route Shields (M-1C,2C,5C)

Implementation of this policy shall occur as new signs of the above types are required or existing signs exceed their service life and are replaced or re-furbished.

II. Elimination of External Sign Lighting

Where guide signs are reflectorized with Type G reflective sheeting, the elimination of external sign lighting shall be governed by the following criteria.

Note: Type G sheeting is High Performance Encapsulated Lens Sheeting.

In rural areas, external sign lighting may be eliminated at:

1. the first Advance Guide (GB) sign (e.g. 1 Mile sign) at a local exit.
2. the 2 Mile and 1 Mile Advance Guide signs at a freeway to freeway interchange.
3. the 1/2 Mile or Next Right Advance Guide sign on tangent roadways having a constant grade approach for at least 1,200 feet without overpasses or overhead sign structures prior to the sign.

In urban areas, external sign lighting should not be eliminated except where an engineering study of human factors, target value, and legibility distances has determined that signs can be expected to perform satisfactorily without lighting. The potential effect of adverse weather conditions should be included in the evaluation where feasible.

Diagrammatic signs, signing for lane drop situations, left exit signing, and entrance direction signing at the entrance ramp shall retain external sign lighting in both rural and urban areas.

Where two or more signs occupy an overhead sign structure, the need to retain lighting on one sign shall cause retention of lighting on all signs on the structure.

The condition(s) leading to a decision to eliminate external sign lighting shall be documented.

Bernard B. Hurst

Bernard B. Hurst,
Assistant Director

Type A Signs

Series	Description	Reason*	Remarks
R1-1	Stop	R	
R1-2	Yield	R	
R1-4	All Way	R	
R2-1	Speed Limit	D	48" x 60" Only
R2-I102	Minimum 45	D	48" x 36" Only
R5-1	Do Not Enter	D	
R5-9	Wrong Way	D	
R13-I100	Trucks Over 8 Ton Must Weigh	D	
W1-8	Chevron	R	
W3-1	Stop Ahead	R	
W3-2	Yield Ahead	R	
W4-1	Right & Left Merge	D	
W4-3	Right & Left Added Lane	D	
W13-3	Ramp Speed	D	
W14-3	No Passing Zone	R	
M1-1	Interstate Shields	D	
M1-2	Business Loop	D	
M1-4a	U.S. Shields	D	
M1-I100a	Illinois Shields	D	
M2-1	Jct	D	Green & Blue Only
M3-1	North	D	Green & Blue Only
M3-2	East	D	Green & Blue Only
M3-3	South	D	Green & Blue Only
M3-4	West	D	Green & Blue Only
M4-I100	Toll	D	Blue Only
M4-5	To	D	Green & Blue Only
M4-7	Temporary	D	Green & Blue Only
M5-1 & 2	Arrows	D	Green & Blue Only
M6-1 thru 7	Arrows	D	Green & Blue Only
D8-1	Weigh Station ____ Mile	D	
D8-3	Weigh Station Arrow	D	
D9-2	Hospital Symbol	D	48" x 48" Only
D9-6	Handicap Symbol	D	22" x 22" No Margin Only
D9-I101	State Police Headquarters Arrow	D	
D9-I102	State Police Headquarters ____ Mile	D	
D9-I105	Exit	D	
Type 1	Diamond	R	Red Only
	Freeway Panels (Background & Legend)	D	All Except Brown

*Reason: R = Reflectivity Justification
D = Durability Justification

Note: Type A signs are high performance, encapsulated lens sheeting.

APPENDIX C

Names of Persons and Companies Contacted Concerning Construction Zone Signs/Devices

APPENDIX C

Names of Persons and Companies Contacted

Concerning Construction Zone Signs/Devices

James L. Heaton, V.P.
Advance Barricades & Signing, Inc.
Jupiter, Florida

Dale Blalock
Traffic Control Products of Mississippi, Inc.
Jackson, Mississippi

Warren Spivey, President
Spivey Rentals, Inc.
Hampton, Virginia

Vince Blanco, President
Akron Safety Lite & Equipment Company
Akron, Ohio

Fred Johnson, President
Lectric-lites Company, Inc.
Fort Worth, Texas

Rick Bowman, President
A-1 Rental Sales and Service, Inc.
Pueblo, Colorado

B. D. Kanan, President
Contractor's Traffic Protection Company, Inc.
Kansas City, Kansas

APPENDIX D

COST DATA

Replacement Cost of Signs

A. 15' x 10' Overhead Guide Sign (typical)

1. New sign manufactured with aluminum structural panels and high performance grade reflective sheeting:

Materials:

Structural Panels, 150 sq ft @ $3.25 =	$487.50
Background Sheeting, 150 sq ft @ $3.05 =	$457.50
Copy with Sheeting, 20 sq ft @ $4.05 =	$ 81.00
Fasteners, 64 post clips @ $0.55 =	$ 35.20
15 Panel Bolts, nuts, washers @ $0.16 =	$ 2.40
SUBTOTAL	$1,063.60

Labor: Sign Shop Worker, 8 hours @ $9.22 =	$ 73.76
SUBTOTAL	$ 73.76

Installation:

Labor - 2 Laborers, 3 hours each @ $8.78 =	$ 52.68
Labor - 1 Supervisor, 3 hours @ $9.68 =	$ 29.04
Equipment - 3/4 Ton Truck, 3 hours @ $0.38 =	$ 1.14
Equipment - Hydraulic Derrick Truck 3 hours @ $10.00 =	$ 30.00
SUBTOTAL	$112.86

Traffic Control:

Labor - 2 Laborers 4 hours each @ $8.78 = (Including 1 hour for set-up; signs are on hand - no material cost.)	$ 70.24
SUBTOTAL	$70.24

TOTAL	**$1,320.46**

2. Overlay existing sign with 0.040" aluminum sheeted with high performance grade reflective sheeting:

Materials:

Overlay, 150 sq ft furnished by Kansas Correctional Institute @ $4.93 =	$739.50
Copy, 20 sq ft @ $3.05 =	$ 61.00
3/16" Rivets, 150 @ $0.02 =	$ 3.00
SUBTOTAL	$803.50

Labor - None, included in overlay cost in Materials above.

Installation:

Labor - 2 Laborers 4 hours each @ $8.78 =	$ 70.24
Labor - 1 Supervisor 4 hours @ $9.68 =	$38.72
Equipment - 3/4 Ton Truck, 4 hours @ $0.38 =	$ 1.52
Equipment - Hydraulic Derrick Truck, 4 hours @ $10.00 =	$ 40.00
SUBTOTAL	$150.48

Traffic Control:

Labor - 2 Laborers 5 hours each @ $8.78 = (Includes 1 hour for set-up; signs are on hand - no material cost.)	$ 87.80
SUBTOTAL	$ 87.80

TOTAL	$1,041.78

B. 30"x30" ground mounted warning sign, aluminum substrate sheeted with high performance grade reflective sheeting:

Materials:

1 each 30" sign manufactured and delivered from Kansas Correctional Institute @ $41.75 =	$ 41.75
SUBTOTAL	$ 41.75

Labor - None, included in material cost above.

Installation:

Labor - 2 Laborers 1/4 hour each @ $8.78 =	$ 4.39
Equipment - 3/4 Ton Truck 1/4 hour @ $8.78 =	$ 2.20
SUBTOTAL	$ 6.59

Traffic Control:

Labor - 2 Laborers 1 hour each @ $8.78 = (1/2 hour each remove & install)	$ 17.56
SUBTOTAL	$ 17.56

TOTAL	**$ 65.90**

Note: Kansas current contract cost of engineering grade reflective sheeting is $0.59 per square foot.

End of Attach 1

Bellomo-McGee, Inc.

Bellomo-McGee, Inc. (BMI) is a professional services firm, specializing in traffic and transportation engineering, transportation planning and management services. The firm is headquartered at 901 Follin Lane in Vienna, Virginia. The staff of experienced professionals and support personnel number 20.

BMI is unusual in that the firm conducts a substantial amount of research in addition to its practice of engineering. The combination enables the application of state-of-the-art traffic engineering practices and the latest research findings to real-world situations. BMI has conducted research for the Federal Highway Administration (FHWA) on large trucks, rural roads, geometric design standards, bridge and highway drainage and air quality; and for the National Cooperative Highway Research Program (NCHRP) on signs and markings. BMI clients include federal agencies, state and local governments, local developers, attorneys and major companies. The principals and senior staff have been nationally recognized for their contributions to the field of transportation.

Particularly relevant capabilities and experience leading to the firm's selection to perform the KDOT Reflective Sheeting Study include:

> BMI has experience and capabilities in both research and engineering consulting services. They are familiar with research methods (i.e., evaluations, statistics, sampling, surveys, performance measures, etc.) and state-of-the-art literature. From their engineering projects with state and local agencies, they are familiar with sign design and specifications and the practical aspects of signing.
>
> They recently prepared for the Federal Highway Administration a report on "Reflectivity of Highway Signs for Adequate Visibility". It is a comprehensive document on reflective sheeting which demonstrates their knowledge of the subject matter.
>
> They have begun a project for the National Cooperative Highway Research Program which deals with highway signing. It is entitled, "Sign Evaluation and Replacement Program: Policies and Criteria for Expressways and Freeways". It will result in a synthesis of information from all states on different techniques and methods used for lighting, refurbishing and replacing of signs and supports, planning, programming and cost-benefit.
>
> They have conducted several economic analyses. One in particular is the anlaysis of the use of 8-inch vs. 4-inch edgelines, which they are conducting for the FHWA. They developed an economic model, which includes safety, to establish whether different widths of edgelines are justifiable compared to the standard 4-inch edgeline.

Attach. 2

They have conducted studies for state legislative actions and are aware of their special needs regarding conclusive findings, justifiable recommendations, and timely reporting with clear and understandable graphs, charts, etc. For example, in Virginia, BMI undertook a study which was presented to the State Legislature on statewide analysis of the cost responsibility for various vehicle classes and functional systems. The study results were graphically rendered and presented to the State Finance Committee at a recorded public hearing. The testimony resulted in positive changes to the eventual legislation that was prepared.

Date: 3-22-88
Prepared by: KDOT Staff
Source: Prequalification Capabilities Summary - BMI

PRESENTATION TO TRANSPORTATION COMMITTEE

OF

KANSAS HOUSE OF REPRESENTATIVES

ON

REFLECTIVE SHEETING STUDY

FOR

KANSAS DEPARTMENT OF TRANSPORTATION

BY:

HUGH W. McGEE, P.E.
BELLOMO-McGEE, INC.
VIENNA, VIRGINIA

BMI

MARCH 28, 1988

TWO TYPES OF REFLECTIVE SHEETING PER KDOT SPECIFICATIONS

GRADE	TYPE	UNIT COST ($/SF)	SIA LUMINANCE LEVEL (WHITE)
I. REGULAR OR ENGINEERING GRADE	ENCLOSED LENS BEAD	0.60	70
II. HIGH PERFORMANCE	ENCAPSULATED LENS BEAD	3.05	250

STUDY APPROACH

1. QUESTIONNAIRE SURVEY OF 50 STATES
2. TELEPHONE SURVEY OF CONSTRUCTION ZONE DEVICE SUPPLIERS
3. LITERATURE REVIEW OF PERTINENT RESEARCH
4. DEVELOPMENT OF ECONOMIC MODELS

OBJECTIVES OF STUDY

1. SURVEY OTHER STATES
2. CONDUCT ECONOMIC EVALUATION ENGINEERING GRADE VERSUS HIGH PERFORMANCE SHEETING
3. EVALUATE SAFETY FACTORS RELATED TO USE OF BOTH SHEETINGS
4. COMPARE KDOT PRACTICES AND SPECIFICATIONS TO OTHER STATES

FOCUS

1. GENERAL SIGNING
2. CONSTRUCTION WORK ZONE SIGNS AND DEVICES
3. ENGINEERING GRADE VERSUS HIGH PERFORMANCE

STATE SURVEY RESULTS

SHEETING USE

GUIDE SIGNS

- MAJORITY OF STATES (67%), INCLUDING KANSAS, USE HIGH PERFORMANCE FOR BACKGROUND AND COPY FOR FREEWAY SIGNS

- SMALL MAJORITY (51%), INCLUDING KANSAS, USE ENGINEERING GRADE FOR CONVENTIONAL ROADS

REGULATORY

- MAJORITY (62%), INCLUDING KANSAS, USE HIGH PERFORMANCE FOR R.O.W. SERIES (STOP, YIELD)

- 46%, INCLUDING KANSAS, USE HIGH PERFORMANCE FOR MOVEMENT SERIES (I.E., TURN RESTRICTIONS, ONE-WAY SIGNS.)

WARNING

- MAJORITY (58%), INCLUDING KANSAS, USE HIGH PERFORMANCE

CONSTRUCTION SIGNS AND DEVICES

- MAJORITY (60%), INCLUDING KANSAS, USE HIGH PERFORMANCE

STATE SURVEY RESULTS

USE OF LIGHTS ON WORK ZONE DEVICES

- 77 %, INCLUDING KDOT USE STEADY BURN AND FLASHING LIGHTS
- USE OF LIGHTS INDEPENDENT OF SHEETING TYPE, ALTHOUGH SEVERAL STATES FEEL LIGHTS UNNECESSARY WITH HIGH PERFORMANCE SHEETING

CRITERIA FOR SELECTION OF SHEETING TYPE

1. MINIMUM/DESIRABLE REFLECTIVE INTENSITY
2. ECONOMICS
3. BENEFITS

REQUIRED REFLECTIVE INTENSITY

STUDIES SUGGEST HIGH PERFORMANCE IS NEEDED FOR:

1. OVERHEAD GUIDE SIGNS FOR ALL SITUATIONS EXCEPT FOR LOW AMBIENT LIGHT AREAS AND WITH 3 OR FEWER WORDS ON SIGN

2. WARNING SIGNS FOR ALL BUT LOW AMBIENT LIGHT SITUATIONS AND LOW SPEEDS (<35 MPH)

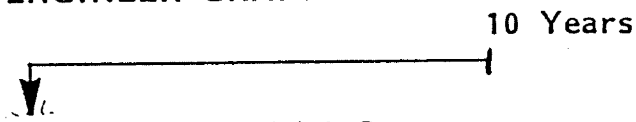
3. STOP AND YIELD SIGNS FOR ALL HIGH SPEED (>50 MPH) AND MEDIUM TO HIGH AMBIENT LIGHT SITUATION, REGARDLESS OF SPEEDS.

4. WORK ZONE DEVICES AT SITUATIONS INVOLVING EITHER OF HIGH SPEED, HIGH AMBIENT LIGHT, RESTRICTED GEOMETIRCS AND LANE CHANGE MANEUVERS.

ECONOMIC ANALYSIS METHODOLOGY

I. FOR PERMANENT SIGNS

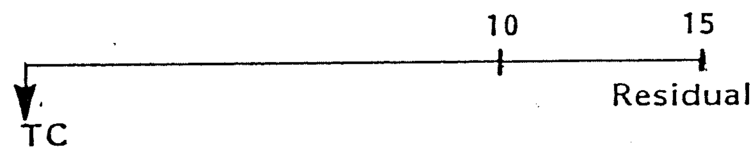
- ENGINEER GRADE



TC = Total Initial Cost

EUAC = TC x CRF

- HIGH PERFORMANCE



ADJUSTED EUAC = $EUAC_{15}$ − ANNUALIZED RESIDUAL VALUE

$$= (TC \times CRF_{15}) - (EUAC_{15} \times SPW_5 \times SF_{10})$$

WHERE EUAC = Equivalent Uniform Annual Cost
CRF = Capital Recovery Factor
SPW = Series Present Worth
SF = Sinking Fund Factor

II. FOR WORK ZONES

- COMPARATIVE COSTS BASED ON PER PROJECT DAY COSTS

COST COMPARISON SUMMARY

	ENGINEERING GRADE	HIGH PERFORMANCE
OVERHEAD GUIDE SIGNS *		
• New	$144.96	$116.73
• Overlay	$102.41	$ 92.06
GROUND MOUNTED SIGNS *	$ 7.70	$ 5.83
CONSTRUCTION WORK ZONE **		
• With Lights	$281.60	$287.56
• Without Lights	N/A	$104.56

* Annual Cost/Sign/Year

** All Devices Per Project Day

SAFETY BENEFITS OF HIGH PERFORMANCE SHEETING

1. NO DIRECT EVIDENCE OF ACCIDENT SAVINGS WITH HIGH PERFORMANCE SHEETING

2. REDUCTION IN RELATIVELY FEW ACCIDENTS IN WORK ZONES WOULD OUTWEIGH ADDITIONAL COST OF HIGH PERFORMANCE SHEETING

OTHER BENEFITS OF HIGH PERFORMANCE SHEETING

1. LESS NEED FOR EXTERNAL ILLUMINATION OF OVERHEAD SIGNS

2. LESS NEED FOR STEADY-BURN OR FLASHING LIGHTS IN WORK ZONES

3. BRIGHTER SIGN FOR LONGER PERIOD OF TIME

RECOMMENDATIONS

1. ADOPT SPECIFICATIONS IN FP-85
2. ADOPT A MAINTAINED REFLECTIVE INTENSITY SPECIFICATION FOR WORK ZONE DEVICES PER FP-85
3. EVALUATE NEED FOR STEADY-BURN LIGHTS FOR CHANNELIZING DEVICES IN HIGHWAY WORK ZONES
4. EVALUATE NEED FOR EXTERNAL ILLUMINATION OF OVERHEAD GUIDE SIGNS USING HIGH PERFORMANCE SHEETING
5. DEVELOP SIGN INVENTORY SYSTEM -- DATA BASE FOR SIGN AND SHEETING LIFE

Statement Before The

HOUSE COMMITTEE ON TRANSPORTATION

By The

KANSAS MOTOR CAR DEALERS ASSOCIATION

Monday, March 28, 1988

Re: HB3104

Mr. Chairman and Members of the Committee, I am Pat Barnes, legislative counsel for the Kansas Motor Car Dealers Association. Our trade association represents most of the franchised new car and new truck dealers in Kansas.

Today we appear before you in opposition of HB3104 which would increase the fee for VIN inspections on vehicles brought into Kansas from outside its boarders from $10 per hour for such inspections to $12 per hour. Under HB3104 the Kansas Highway Patrol and its designees currently carry out VIN inspections in this state. Under the current system, $9 out of every $10 is given to any designee carrying out inspections and $1 is retained by the Kansas Highway Patrol. Those of you who were around when the VIN inspection system was originally mandated will recall that the idea behind the charge was only to off-set the cost of the program, not provide a revenue raising source of funding for state programs in the same way that tax revenues do.

This bill represents additional cost to Kansas consumers

Attach. 3

and dealers. If a VIN inspection takes more than one hour because of difficulties with the numbers found, or not found, or because of some other irregularity about the vehicle (such as an odometer roll back) the minimum fee of $10 is not charged, but the hourly rate continues. In other words, if it takes several hours to do a VIN inspection, then the inspection is billed at the rate of $10 per hour under the present system. With this bill it would go up to $12 per hour. Under the present system the inspector gets paid a fee of $10 no matter what amount of time less than one hour is expended in doing the inspection. If it takes 10 minutes, then the fee is still $10.

This cost may not represent much on a per car basis, but when an individual brings a number of cars across the state line and titles them in Kansas, the cost begins to add up. Particularly, dealers will obtain mass inspections of cars in order to save their customers the burden and additional inconvenience of obtaining their own inspections following the purchase of the car. As such, when 200 or more cars are brought by a dealer to a location throughout the course of a year for inspection, the cost is significant. This is a cost which must be passed on to consumers overall either on a per car basis, or through overhead costs.

It seems this inspection fund may be getting beyond the original intent of the law, which was to help off-set VIN inspection costs. It essentially proposes a $2 hike in VIN fees so an additional appropriation of $3 per inspection can be given to the Highway Patrol for general funding purposes. The designees would still continue to receive the windfall of $9 per hour for each inspection. With this bill the VIN inspection fund essentially becomes a law enforcement tax, which is a significant departure from the policy recognized for generations whereby general taxes and revenue fund general services which are enjoyed by all.

Thank you for providing the opportunity for KMCDA to present their views on this bill. We oppose this bill and urge you to vote against it.

STATE OF KANSAS

OFFICE OF THE ATTORNEY GENERAL

2ND FLOOR, KANSAS JUDICIAL CENTER, TOPEKA 66612-1597

ROBERT T. STEPHAN
ATTORNEY GENERAL

MAIN PHONE: (913) 296-2215
CONSUMER PROTECTION: 296-3751

TESTIMONY OF D. JEANNE KUTZLEY
ASSISTANT ATTORNEY GENERAL, CONSUMER PROTECTION DIVISION
BEFORE THE HOUSE TRANSPORTATION COMMITTEE
ON S.B. 462

March 28, 1988

Mr. Chairman & Members of the Committee:

Attorney General Stephan strongly supports legislation which would provide a remedy to consumers who buy cars with rolled back odometers.

As you are aware, cars with rolled back odometers create enormous problems for the consumers who buy them unaware of the true mileage. These cars often require costly repairs the consumers did not anticipate. Consumers are cheated of years of dependable transportation. The value of the car is distorted because of the false mileage. S.B. 462 will provide consumers a remedy.

Under S.B. 462, the consumer will have a remedy against a "supplier." "Supplier" is defined in this act as (1) a licensed motor vehicle dealer; or (2) any person or business which purchases, sells or exchanges 5 or more motor vehicles in any one calendar year; or (3) any person or business which in the ordinary course of business purchases, sells or exchanges motor vehicles. This definition means that those

Attach. 4

sellers most likely to be engaged in rolling back odometers and most likely to have knowledge of the rollback will be held responsible. However, it also means that an individual or business who is an unwitting intermediate purchaser would not be held responsible.

The sale of the rolled back car would be voidable at the consumer's request. But the consumer is not required to void the sale.

If the consumer requested the sale be voided, the consumer could recover damages under the following formula. the consumer would recover the greater of 1) the purchase price before trade-in allowance less set off or 2) the purchase price before trade-in allowance plus verified repairs less set off. An example of a consumer's recovery for an intermediate car is as follows:

Purchase Price (before trade-in)	$10,000
Set-off (20,000 miles at 27¢ per mile)	5,400
Consumer's Recovery	$ 4,600

OR

Purchase Price (before trade-in)	$10,000
Repairs	+ 3,000
Set-off (20,000 miles at 27¢ per mile)	5,400
Consumer's Recovery	$ 7,600

In no case would the consumer's recovery exceed the purchase price of the vehicle before trade-in allowance. There will be some cases where the consumer has incurred great expense in repairing the car. The consumer should be entitled to recover those repair expenses. However, to avoid a situation where that recovery becomes excessive, recovery is limited by the phrase "not to exceed the purchase price of the vehicle before trade-in allowance." That will put a cap on the recovery available. The Attorney General would have enforcement powers and consumers would be allowed to bring private actions. If the consumer brings a private action, he or she can recover the damages defined above or the $2,000 per violation civil penalties listed in the bill, whichever is greater. In addition, the consumer could recover reasonable attorney fees.

These remedies do not supplant any available under the federal odometer law. Due to potential conflicts with federal agencies, the Attorney General's Office does not enforce federal law.

A defense is available to suppliers. A supplier can avoid all liability under this act merely by advising the consumer at the time of purchase whether or not the supplier has done a title search on the motor vehicle.

There is a great deal of difficulty in pursuing any remedy against auto auctions or against out of state roll back sellers. The Attorney General does not have jurisdiction, adequate staff nor the budget to pursue these interstate cases in great numbers. With no additional staff, the Consumer Protection Division could enforce this bill. At present, the division does work on similar cases and pursue them as far as possible. However, the case often hits a dead end when the ultimate roll back company is out of state or possibly has disappeared by the time they can be found.

Thank you for allowing us an opportunity to testify. Attorney General Stephan strongly supports this bill and firmly believes this is necessary to protect Kansas consumers.

SUMMARY OF TESTIMONY

HOUSE TRANSPORTATION COMMITTEE

SENATE BILL 462

PRESENTED BY

MAJOR DAVID HORNBAKER

KANSAS HIGHWAY PATROL

MARCH 28, 1988

The Kansas Highway Patrol appears in support of Senate Bill 462. This bill is essentially House Bill 2524 introduced during the 1987 Legislative Session. That particular piece of legislation was introduced at the request of the Kansas Highway Patrol.

Odometer fraud in the United States is a widespread crime, with annual potential monetary losses estimated at $5 billion.

Odometer fraud is a "hidden" crime that secretes itself within a myriad of title transactions, odometer statements, duplicate titles and countless other "paper trails", making it difficult if not impossible to determine the true criminal.

The proposed change in SB 462 will allow law enforcement to at least have a decent chance in the apprehension and prosecution of odometer fraud perpetrators.

The Special Committee on Transportation heard testimony from many conferees representing both the enforcement and industry side concerning motor vehicles.

This bill is the result of those hearings and of the conferees. We totally support the Committee's recommendations and ask favorable consideration of SB 462.

Statement Before the

HOUSE COMMITTEE ON TRANSPORTATION

by the

KANSAS MOTOR CAR DEALERS ASSOCIATION

Monday, March 28, 1988

RE: PROPOSAL #32 & SB462

Mr. Chairman and Members of the Committee, I am Pat Barnes, legislative counsel for the Kansas Motor Car Dealers Association, trade association representing most franchised new car and new truck dealers in Kansas. We support SB462 dealing with odometer fraud.

Thank you for the opportunity to appear before you today to share our thoughts with you regarding the $3 billion per year fraud called odometer tampering.

KMCDA and the franchised dealers of Kansas have long been involved in efforts to curtail odometer tampering. KMCDA was active in supporting legislation requiring odometer disclosure in Kansas many years ago, prior to the federal law. In the past, KMCDA actively worked with the Kansas Congressional Delegation to secure passage of amendments to the Federal Odometer Act. In 1984, we were a very vocal supporter of the bill which increased the penalty for odometer tampering in Kansas from a misdemeanor to a Class "E" felony.

Attach. 6

Before going further, I would like to provide you with some background on what a dealer must do with regard to odometer certification.

I have attached a copy of the required federal odometer statement which must be completed each and every time a vehicle ownership change occurs. When you go to your local dealer and trade vehicles, federal law requires that you, as the transferor, certify to the transferee the odometer reading on the vehicle being sold. At the same time, the dealer, as the transferor of the new vehicle, must provide you with an odometer certification for the new vehicle. When the dealer then sells your trade-in, either at retail or at wholesale, he must provide an odometer certification to that purchaser. Federal law also requires the transferor to retain a copy of the odometer certification for a minimum of four years.

You will notice on the Odometer Statement there are two certifications which the transferor must make when completing this form. For the first certification, the transferor must certify:

1. The mileage on the odometer is the actual mileage, or,

2. The mileage is in excess of the 99,999 mechanical odometer, or

3. That the mileage is <u>not</u> the actual mileage of the vehicle.

The transferor must next certify that:

1. The transferor did not alter, set back, or disconnect the odometer and has no knowledge of

anyone else doing so; or

2. The odometer was repaired or replaced while in the transferor's possession and that the mileage is identical to the mileage prior to the service; or

3. The odometer was repaired or replaced and the mileage was reset to "zero." (When checking that box, the transferor must also state the mileage before the repair.)

I would also note that when an odometer is repaired/replaced and reset to zero, the law requires that a sticker be affixed to the left door post stating the mileage prior to the repair/replacement, and the date of the service.

I have used the word "transferor" rather than dealer, in my explanation above. This is because federal law requires all transferors of vehicles, not just dealers, to give the odometer statement.

The franchised dealers of Kansas, and nationally, are extremely concerned about the growth in odometer tampering. Thousands of vehicles are bought and sold daily across the country, and it has reached the point that neither an individual or dealer really knows what he is getting when purchasing or trading for a vehicle. Those involved in this fraud are very good at what they do, and they know not only how to spin the odometer, but how to clean the car and wash the title to make it virtually impossible to tell that there are more miles on the vehicle than what shows on the odometer.

Usually we hear about the new or used vehicle dealers who get caught, and tend to believe that the entire problem lies within the automobile industry itself. But, dealers are victims, too. Sometimes they are victims of other dealers, and sometimes they are victims of customers. What dealer would have had any reason to suspect that a very clean, three year old car with just over 20,000 miles was anything but a good, low mileage vehicle? A St. Louis dealer didn't and traded for it. Luckily, one of his mechanics discovered an inspection certificate in the vehicle which showed that the vehicle had accrued over 51,000 miles two years prior. The dealer sued the customer, and a jury awarded the dealer $2,900 plus attorney fees, and with treble damages in Missouri, the award amounted to nearly $11,000. The minister who had spun the odometer may still be paying off the penalty. In 1986 an Overland Park, KS, dealer traded for a late model foreign car. Everything appeared to be in order until, through another dealership, he discovered mileage on the vehicle had been set back 20,000 miles. The customer repurchased the vehicle from the dealer.

The franchised dealers wish there was an easy solution to this problem, but unfortunately, there is not. In our opinion, Kansas does not have the problem that other states have, but we cannot afford to be complacent for two reasons. First, odometer tampering does occur in Kansas, and that must be stopped. Secondly, if we become complacent, the problem in

Kansas will grow. Odometer tampering will not go away by itself.

In closing, Mr. Chairman and Members of the Committee, I would issue one word of caution. During your deliberations be extremely careful not to make criminals out of honest citizens and business persons. Remember that many people this very day own vehicles that have been spun, and they don't know it, and might never know it. This is the idea behind the civil penalty sections of SB462 which were originally proposed by the attorney general and are now contained in SB462. Under this section of the law, commencing at page 3 of the bill, a dealer rolling an odometer would face civil penalties, but one who did not violate the law and who disclosed no title search was done on the vehicle would not. The main idea behind the disclosure of no title search is to notify the consumer no tracing has been done on the mileage history of the vehicle. (Title searches are not presently readily available and are time consuming. The average dealer does not have the means available to do them, and they aren't economically feasible for business purposes.) We want to catch those who know they are doing wrong, but we don't want to unfairly persecute those who didn't even know that anything wrong had been done.

Mr. Chairman and Members of the Committee, the Kansas Motor Car Dealers Association wants to rid the automobile industry of this fraud. However, we don't want the blame placed upon us for the sake of convenience. We think SB462 is an acceptable reflection of what the law should be in Kansas.

Thank you for your time, and I would be happy to respond to questions.

Reorder From: Kansas Motor Car Dealers Assn. – 717 Merchants National Bank Building – Topeka, Kansas 66612

101374

UNALTERABLE CARBONLESS PAPER · NO CARBON IS REQUIRED

ODOMETER (MILEAGE) STATEMENT

(FEDERAL REGULATIONS REQUIRE YOU TO STATE THE ODOMETER MILEAGE UPON TRANSFER OF OWNERSHIP. AN INACCURATE OR UNTRUTHFUL STATEMENT MAY MAKE YOU LIABLE FOR DAMAGES TO YOUR TRANSFEREE, FOR ATTORNEY FEES, AND FOR CIVIL OR CRIMINAL PENALTIES, PURSUANT TO SECTIONS 409, 412, AND 413 OF THE MOTOR VEHICLE INFORMATION AND COST SAVINGS ACT OF 1972 (PUB. L. 92-513, AS AMENDED BY PUB. L. 94-364)) AND APPLICABLE STATE LAWS.

I, ____________________ , STATE THAT THE ODOMETER
TRANSFEROR'S NAME · SELLER · PRINT

MILEAGE ON THE VEHICLE DESCRIBED BELOW NOW READS ____________________ MILES/KILOMETERS.
ODOMETER READING

CHECK ONE BOX ONLY:

☐ (1) I HEREBY CERTIFY THAT TO THE BEST OF MY KNOWLEDGE THE ODOMETER READING AS STATED ABOVE REFLECTS THE ACTUAL MILEAGE OF THE VEHICLE DESCRIBED BELOW.

☐ (2) I HEREBY CERTIFY THAT TO THE BEST OF MY KNOWLEDGE THE ODOMETER READING AS STATED ABOVE REFLECTS THE AMOUNT OF MILEAGE IN EXCESS OF DESIGNED MECHANICAL ODOMETER LIMIT OF 99,999 MILES/KILOMETERS OF THE VEHICLE DESCRIBED BELOW.

☐ (3) I HEREBY CERTIFY THAT TO THE BEST OF MY KNOWLEDGE THE ODOMETER READING AS STATED ABOVE IS NOT THE ACTUAL MILEAGE OF VEHICLE DESCRIBED BELOW AND SHOULD NOT BE RELIED UPON.

MAKE		MODEL	BODY TYPE
VEHICLE IDENTIFICATION NO.		YEAR	DEALER STOCK NO.

CHECK ONE BOX ONLY:

☐ (1) I HEREBY CERTIFY THAT THE ODOMETER OF SAID VEHICLE WAS NOT ALTERED, SET BACK OR DISCONNECTED WHILE IN MY POSSESSION, AND I HAVE NO KNOWLEDGE OF ANYONE ELSE DOING SO.

☐ (2) I HEREBY CERTIFY THAT THE ODOMETER WAS ALTERED FOR REPAIR OR REPLACEMENT PURPOSES WHILE IN MY POSSESSION, AND THAT THE MILEAGE REGISTERED ON THE REPAIRED OR REPLACEMENT ODOMETER WAS IDENTICAL TO THAT BEFORE SUCH SERVICE.

☐ (3) I HEREBY CERTIFY THAT THE REPAIRED OR REPLACEMENT ODOMETER WAS INCAPABLE OF REGISTERING THE SAME MILEAGE, THAT IT WAS RESET TO ZERO, AND THAT THE MILEAGE ON THE ORIGINAL ODOMETER OR THE ODOMETER BEFORE REPAIR WAS ____________ MILES/KILOMETERS.

TRANSFEROR'S STREET ADDRESS (SELLER)		
CITY	STATE	ZIP CODE
DATE OF STATEMENT	TRANSFEROR'S SIGNATURE (SELLER) X	

TRANSFEREE'S NAME (BUYER)		
STREET ADDRESS		
CITY	STATE	ZIP CODE

I, X ____________________ HEREBY CERTIFY THAT I HAVE RECEIVED A COPY OF THE ABOVE ODOMETER (MILEAGE) STATEMENT.
TRANSFEREE'S SIGNATURE · BUYER

580.6 REV. 8/80

ORIGINAL – TRANSFEREE (BUYER)