



# LIGHT USE STUDY FOR VERTICAL CHANNELIZATION DEVICES

## Final Report 554

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16. Abstract <p>Although the Manual on Uniform Traffic Control Devices (MUTCD) does not require the use of warning lights on channelization devices, the Arizona Department of Transportation (ADOT) has historically required their use on all traffic control devices used at nighttime construction zones. This report documents research done for ADOT on the use of steady-burn warning lights on vertical panels in roadway construction zones. Specific tasks included a review of the requirements and policies of the departments of transportation of other states regarding the use of flashing warning lights on traffic control devices, a review of ADOT's construction zone requirements, a search for relevant research, reviews of construction zone accident reports and incident logs, and interviews with ADOT field construction staff regarding the past performance of the Ultra Panels (Type III sheeting) with and without steady-burn warning lights.</p> <p>The literature search found sources that support this requirement and other sources that state it is unnecessary. Two of the thirty-four transportation agencies that responded to the survey reported that they had requirements for steady-burn lights similar to Arizona requirements: the Alberta (Canada) Ministry of Transportation and the Illinois Department of Transportation (for roadways with traffic levels over 2,500 vehicles per day). The Ultra Panel, a type of vertical panel, has been successfully used without warning lights on three highway construction projects in Arizona. ADOT field construction staff associated with these projects strongly supported the use of these vertical panels without warning lights. A review of accident records and incident reports did not reveal any significant deficiencies associated with the vertical panels used without warning lights.</p>					
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## SI\* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS					APPROXIMATE CONVERSIONS FROM SI UNITS				
Symbol	When You Know	Multiply By	To Find	Symbol	Symbol	When You Know	Multiply By	To Find	Symbol
<b><u>LENGTH</u></b>					<b><u>LENGTH</u></b>				
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ft	Feet	0.305	Meters	m	M	Meters	3.28	feet	ft
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mi	Miles	1.61	Kilometers	km	Km	Kilometers	0.621	miles	mi
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in <sup>2</sup>	square inches	645.2	square millimeters	mm <sup>2</sup>	mm <sup>2</sup>	Square millimeters	0.0016	square inches	in <sup>2</sup>
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yd <sup>2</sup>	square yards	0.836	square meters	m <sup>2</sup>	m <sup>2</sup>	Square meters	1.195	square yards	yd <sup>2</sup>
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fl oz	Fluid ounces	29.57	Milliliters	mL	mL	Milliliters	0.034	fluid ounces	fl oz
gal	Gallons	3.785	Liters	L	L	Liters	0.264	gallons	gal
ft <sup>3</sup>	cubic feet	0.028	cubic meters	m <sup>3</sup>	m <sup>3</sup>	Cubic meters	35.315	cubic feet	ft <sup>3</sup>
yd <sup>3</sup>	cubic yards	0.765	cubic meters	m <sup>3</sup>	m <sup>3</sup>	Cubic meters	1.308	cubic yards	yd <sup>3</sup>
NOTE: Volumes greater than 1000L shall be shown in m <sup>3</sup> .									
<b><u>MASS</u></b>					<b><u>MASS</u></b>				
oz	Ounces	28.35	Grams	g	G	Grams	0.035	ounces	oz
lb	Pounds	0.454	Kilograms	kg	Kg	Kilograms	2.205	pounds	lb
T	Short tons (2000lb)	0.907	megagrams (or "metric ton")	mg (or "t")	Mg	megagrams (or "metric ton")	1.102	short tons (2000lb)	T
<b><u>TEMPERATURE (exact)</u></b>					<b><u>TEMPERATURE (exact)</u></b>				
°F	Fahrenheit temperature	5(F-32)/9 or (F-32)/1.8	Celsius temperature	°C	°C	Celsius temperature	1.8C + 32	Fahrenheit temperature	°F
<b><u>ILLUMINATION</u></b>					<b><u>ILLUMINATION</u></b>				
fc	Foot candles	10.76	Lux	lx	Lx	Lux	0.0929	foot-candles	fc
fl	foot-Lamberts	3.426	candela/m <sup>2</sup>	cd/m <sup>2</sup>	cd/m <sup>2</sup>	candela/m <sup>2</sup>	0.2919	foot-Lamberts	fl
<b><u>FORCE AND PRESSURE OR STRESS</u></b>					<b><u>FORCE AND PRESSURE OR STRESS</u></b>				
lbf	Poundforce	4.45	Newtons	N	N	Newtons	0.225	poundforce	lbf
lbf/in <sup>2</sup>	poundforce per square inch	6.89	Kilopascals	kPa	kPa	Kilopascals	0.145	poundforce per square inch	lbf/in <sup>2</sup>

SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380

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## **ABBREVIATIONS**

ADOT	Arizona Department of Transportation
ATSSA	American Traffic Safety Services Association
DOT	Department of Transportation
DPS	Department of Public Safety
FHWA	Federal Highway Administration
HOV	High Occupancy Vehicle
MUTCD	Manual on Uniform Traffic Control Devices
NCHRP	National Cooperative Highway Research Program
OPS	Office of Operations
SPR	State Planning and Research
TAC	Technical Advisory Committee
TCS	Traffic Control Supplement
TRB	Transportation Research Board
TTI	Texas Transportation Institute
VES	Vision Enhancement Systems
UV	Ultraviolet

# EXECUTIVE SUMMARY

## INTRODUCTION

This report documents a research study for the Arizona Department of Transportation (ADOT) on the use of steady-burn warning lights on vertical panels in roadway construction zones. While the *Manual on Uniform Traffic Control Devices* (MUTCD)<sup>(1,2)</sup> does not require the use of warning lights on channelization devices for nighttime roadway construction, ADOT has historically made this a requirement. The ADOT Traffic Control Supplement (TCS) to the MUTCD requires the use of warning lights on all traffic control devices used for nighttime construction work.<sup>(3)</sup> In June 2002, ADOT adopted a revision to this supplement that dropped the requirement for the use of warning lights on roadways that are continuously lighted.<sup>(4)</sup>

Specific work efforts for this project included a search for relevant research or reports, a review of the requirements and policies set by the departments of transportation of other states regarding the use of steady-burn warning lights on traffic control devices, a review of ADOT's construction zone requirements, a review of construction zone accident reports and incident logs on three projects that used Ultra Panels (Type III sheeting) without warning lights, and interviews with key ADOT field construction staff regarding the past performance of vertical panels with and without steady-burn warning lights.

## LITERATURE SEARCH

The State of Arizona requires the use of warning lights on all traffic control channelization devices for nighttime construction work. The literature search found some research that supported the use of traffic control devices without steady-burn warning lights, which is similar to the reported practices of most of the states that were surveyed. In contrast, other literature sources were found that strongly encouraged the use of steady-burn warning lights. It is important to note that all of the literature found suggests that there are instances when using warning lights with traffic channelization devices is warranted and prudent.

NCHRP Report 236 was finalized in 1981 and concluded that steady-burn warning lights provided more guidance to motorists at night than reflectorized devices without lights.<sup>(5)</sup> This report recommended the use of warning lights and Type III reflective sheeting on traffic control channelization devices. Other reports were found in support of the use of steady-burn warning lights on traffic channelizing devices, including *Warning Devices Type "C" Steady-Burn Lights* prepared by the Institute of Vehicular Safety in 1992,<sup>(6)</sup> *Steady-Burn Warning Lights* prepared by KLD Associates in 1992,<sup>(7)</sup> and a Michigan Department of Transportation internal memo written in 1989.<sup>(8)</sup>

Two other reports, TTI 01-2293<sup>(9)</sup> and NCHRP 476<sup>(10)</sup> present a different viewpoint, concluding that steady-burn warning lights used at night did not enhance driver performance when attached to channelizing devices equipped with high intensity sheeting. Advances in vision enhancement systems<sup>(11)</sup> and headlights<sup>(12)</sup> can enhance a driver's ability to see and locate hazards, but research was not found to clarify how these affect a driver's ability to read traffic signs. No research was found that discussed how changes in headlight technology, primarily changes in the type of light produced by the headlight, affect the retroreflectivity of reflective sheeting.

The development of the Ultra Panel, a new type of vertical panel, has led to continuing discussions in the traffic control industry of whether or not steady-burn warning lights should be required on traffic control devices. The Ultra Panel has a handle which makes it easy to maneuver. It is hollow, which makes it stackable, and made of plastic which makes it relatively lightweight. It has a recessed area for reflective sheeting that is larger than areas on standard vertical panels. It has a wider base for greater stability and greater resistance to wind forces. ADOT construction forces that have used the Ultra Panel have been highly impressed by its performance.

The 3M Company, one of the largest manufacturers of reflective sheeting, was contacted to obtain information regarding the retroreflectivity of their sheeting products and the use of steady-burn warning lights. The 3M Company's official position is to support the use of steady-burn warning lights on traffic channelizing devices. The 3M Company has written letters to several state transportation departments, including those of Arizona, Florida, and Michigan, encouraging these agencies to use or continue the use of warning lights on traffic control devices. The literature search found a review of the negative effect of dew on retroreflective sheeting, as reported by the 3M Corporation.<sup>(13)</sup>

## **SURVEY OF STATE DEPARTMENTS OF TRANSPORTATION**

A survey of the transportation departments of other states was conducted to determine these agencies' requirements for temporary barricading and the use of warning lights on temporary barricades. Thirty-three states and one Canadian province responded to the survey. Twenty-three of the thirty-four responding agencies reported that they use vertical panels, with nineteen of these agencies using the vertical panels at night. The Alberta Transportation Department was the only agency that reported requiring steady-burn warning lights on channelization devices. The Illinois Department of Transportation requires warning lights on any roadway with an average daily traffic level over 2,500 vehicles per day. The presence or amount of ambient lighting does not appear to be a factor in determining whether steady-burn warning lights on channelizing devices are required.

Most of the agencies that responded to the survey indicated a minimum requirement of Type III (high intensity) reflective sheeting, with Type I and Type IV as other choices for minimum requirements. The minimum type of required retroreflective sheeting does not appear to be influenced by the presence or lack of ambient lighting.

Only three of the responding agencies stated that they had conducted any research regarding the requirements for steady-burn warning lights. Only the Wisconsin Department of Transportation has documented its study, which resulted in upgrading channelizing device retroreflective sheeting to high intensity (Type III) and omitting the requirement for steady-burn warning lights except in tapers. The significant results of this survey are presented in Table 1.

**Table 1 - Results of Survey of State Transportation Departments**

<b>Question</b> <b>Does your agency allow the use of ...</b>	<b>Yes</b>	<b>No</b>	<b>Sometimes</b>	<b>No Response</b>
Traffic Cones during the day?	34	0	0	0
Traffic Cones during the night?	21	13	0	0
Type I Barricades during the day?	14	20	0	0
Type I Barricades during the night?	11	23	0	0
Type II Barricades during the day?	19	15	0	0
Type II Barricades during the night?	17	17	0	0
Vertical Panel during the day?	22	12	0	0
Vertical Panel during the night?	19	15	0	0
Traffic Drums during the day?	34	0	0	0
Traffic Drums during the night?	34	0	0	0
<b>In areas with established ambient lighting, does your agency require the use of ...</b>	<b>Yes</b>	<b>No</b>	<b>Sometimes</b>	<b>No Response</b>
Steady-burn warning lights with Type I Barricades?	0	26	4	4
Steady-burn warning lights with Type II Barricades?	1	26	5	2
Steady-burn warning lights with Vertical Panels?	0	27	3	4
Steady-burn warning lights with Const. Zone Signs?	2	26	5	1

### **USE OF ULTRA PANEL**

Vertical panels without warning lights have been used on three highway construction projects in Arizona. These three projects were design-build projects, namely I-17 from Thomas Road to Peoria Avenue in Phoenix, US 60 from I-10 to Val Vista Drive in the eastern part of the Phoenix metropolitan area, and SR 68 from Bullhead City to Golden Valley in rural Mohave County. The Ultra Panel, a type of vertical panel, was first used on the I-17 project and was subsequently the predominant traffic channelization device used on the US 60 and SR 68 projects. ADOT field construction staff associated with

these projects were in strong support of the use of the Ultra Panels (Type III sheeting) without warning lights and would recommend their use on future projects.

## **PROJECT REVIEWS**

A review of accident records, traffic control logs, and interviews with ADOT staff for the three identified construction projects did not reveal any significant deficiencies associated with the use of the Ultra Panels without steady-burn warning lights.

In contrast to ADOT staff with experience using the Ultra Panels without warning lights, ADOT construction staff with experience only using channelizing devices with warning lights were not as supportive as their counterparts. These individuals felt that traffic channelizing devices, and specifically vertical panels, benefit from the use of warning lights. Several of these individuals thought that the warning lights should be used during daylight hours as well. In interviews, representatives of ADOT construction offices throughout the state indicated a clear preference for using vertical panels over both traffic cones and Type II barricades.

A review of accident reports occurring in construction zones associated with these three projects did not reveal any mention of motorists reporting problems seeing the Ultra Panels or understanding the construction zone traffic control. Forty-four accidents on I-17 and four on US 60 that involved a vehicle striking a vertical panel or barricade were reviewed. Due to the limited number of construction-related accidents on SR 68, all forty-four accidents on this route were reviewed. None of the accident reports that were reviewed indicated that motorists expressed a problem seeing the Ultra Panels or other traffic control devices. None of the reported accidents on SR 68 involved a motorist colliding with a traffic channelizing device.

An informal survey of Department of Public Safety (DPS) Officers assigned to monitor the Phoenix freeway system indicated that these officers were supportive of the use of the Ultra Panels without warning lights. They felt that the addition of the warning lights to the Ultra Panel did not significantly improve drivers' ability to see the Ultra Panels. It is important to note that both sections of I-17 and US 60 in the Phoenix area have very high levels of ambient lighting.

## **ATSSA POSITION**

The American Traffic Safety Service Association (ATSSA), an international trade association representing companies and individuals in the traffic control and roadway safety industry, supports the use of steady-burn warning lights on traffic channelization devices used for nighttime road closures. The Arizona Chapter of ATSSA echoes this position and has expressed their preference for the use of warning lights to ADOT on numerous occasions, including at various ADOT and ATSSA partnering sessions. ATSSA strongly supports the use of warning lights for the safety of their personnel and also the safety of workers in construction zones and the motoring public.

## 1.0 INTRODUCTION

The Arizona Department of Transportation (ADOT) has historically required the use of warning lights on all traffic control devices used for lane closures and channelization at nighttime construction zones. Recently, three design-build construction projects used the Ultra Panel, a type of vertical panel channelization device, without warning lights. The success of these three projects has fueled interest within ADOT to consider revisions to the ADOT policy requiring warning lights on channelization devices. The specific attributes of the Ultra Panel that appealed to ADOT staff include:

- The handle at the top of the Ultra Panel improves the maneuverability of the device and makes it easier to be set up quickly.
- The hollow feature allows the Ultra Panel (without a warning light) to be stacked so that more devices can potentially be carried on a truck.
- The design makes it easier to add sandbags for extra weight to an Ultra Panel than to a Type II Barricade.
- The highly reflective Type III sheeting used on the Ultra Panel makes this device very visible and easily seen by motorists.

ADOT staff felt that the use of the Ultra Panel allowed the contractor's staff to set up faster and carry more devices on a truck, which increased the amount of work time available to the contractor.

In June 2002, ADOT adopted a revision to the State's supplement to the Manual on Uniform Traffic Control Devices (MUTCD) that dropped the requirement for the use of warning lights on roadways that are continuously lighted.

The first approved use of the Ultra Panel without the steady-burn warning light was on the I-17 design-build project, from Thomas Road to Peoria Avenue. In January 1999, ADOT approved Change Order Number One on this project which approved the contractor's request to use the Ultra Panel (or approved equal) manufactured by Bent Manufacturing, Inc., without the use of a Type C steady-burn light. The change order approved the Ultra Panel as a substitute for Type II barricades for channelization purposes only. The letter also indicated that appropriate barricading with Type A flashing lights would continue to remain a traffic control requirement when delineating or identifying a roadway hazard.<sup>(14)</sup>

Justification for the change order was "This product meets the approval of NCHRP 350 and will increase the speed and safety of traffic control set-ups and take-downs on I-17. The product has a Type III high-intensity reflective sheeting surface of at least 270 square inches, which meets the minimum reflective area required by current specification."

Following the success of this project, ADOT decided to use the Ultra Panel without warning lights as the predominant traffic control channelizing device on two subsequent design-build projects, the US 60 and SR 68 projects.

The MUTCD, published by the Federal Highway Administration (FHWA), does not require the use of warning lights on channelization devices for nighttime roadway construction. This manual does suggest instances where the warning lights would be useful and should be considered for use.

ADOT contracted DMJM+HARRIS, a national civil and transportation engineering firm, to conduct a research study on the use of flashing warning lights on vertical panels in roadway construction zones. The purpose of this research project was to provide information and documentation to ADOT on the use of vertical panels and warning lights. Specific work efforts included in this research project were:

- Search for relevant research, documentation, or reports. This work effort included an extensive search of internet sites and web pages. Several reports were found that discussed the use of warning lights, as well as other reports that addressed ancillary issues.
- Review of the requirements and policies of the transportation departments of other states regarding the use of traffic channelizing devices, the use of steady-burn warning lights on traffic control devices, and minimum requirements for retroreflective sheeting. This included the development and distribution of a survey to state transportation departments to solicit this information. Thirty-three states and one Canadian province responded to the survey.
- Review of ADOT's current work zone requirements, ADOT's supplement to the MUTCD, and how the ADOT requirements and supplement relate to the requirements included in the MUTCD. This review also included a discussion of MUTCD requirements for vertical panels and warning lights.
- Review of work zone related accident reports, project incident reports, and project traffic control logs that were kept on the three ADOT construction projects that used the Ultra Panel without warning lights.
- Interviews with key ADOT field construction staff regarding the past performance of the Ultra Panels and other traffic channelizing devices with and without steady-burn warning lights. These interviews included representatives of the three ADOT design build projects as well as staff from other ADOT construction offices.

A detailed description of these tasks and their results is presented in the following sections of this report.

## **2.0 LITERATURE SEARCH**

One task in evaluating the need for warning lights on traffic control channelization devices, and specifically on vertical panels, was to conduct a literature search for relevant information and past studies or tests on this subject. Although an extensive search was conducted using the internet only a few articles or reports specifically addressing this issue were found. Many papers, reports, and articles on somewhat related topics were found and copies of many of these articles were requested. Unfortunately, most of these studies did not prove to be applicable to this research project. Some of these studies may be of interest to the reader of this report and so are listed in the bibliography.

Many report abstracts, explaining the purpose and content of the reports, were collected and reviewed to help determine the reports' applicability. Copies of reports thought to be relevant were obtained and reviewed. Several of these reports originally appeared to address issues regarding the need for warning lights on channelization devices. After reviewing these reports, they were found to contain no particular information useful to this study and will not be mentioned further.

Many other potential sources of information were researched. The local American Traffic Safety Services Association (ATSSA) chapter provided a significant amount of literature. Some of the reports that were found that are of significant value to this report are summarized in the following sections. These sources have been grouped into three categories: "Articles Supporting the Use of Steady-Burn Lights," "Articles Not Supporting the Use of Steady-Burn Lights," and "Articles on Related Topics."

### **2.1 ARTICLES SUPPORTING THE USE OF STEADY-BURN LIGHTS**

Five articles were found that support the use of steady-burn warning lights on vertical channelization devices. These articles come from an array of sources: the NCHRP, a private institute, a private sector engineering firm, the State of Michigan, and the 3M Company. These articles are discussed in the following sections.

#### **2.1.1 NCHRP Report 236**

One report that proved to be useful was prepared for the National Cooperative Highway Research Program (NCHRP), sponsored by the Transportation Research Board (TRB).<sup>(5)</sup> This report, *Evaluation of Traffic Controls for Highway Work Zones* (NCHRP Report 236), was completed in 1981 and provided valuable background literature for this research project. The objective of this research study was to evaluate different types of traffic control channelizing devices and to develop recommendations as to how these devices should be used.

A second phase of the study included the analysis of traffic channelizing devices using improved reflectorization (Type III sheeting) and attached lighting. The

conclusions of the report stated that steady-burn warning lights provide additional delineation of a channelization system during the night. They enhance conspicuity considerably, particularly on horizontal and vertical curves. The report concluded that steady-burn warning lights should be used to supplement retroreflective sheeting on traffic control devices for nighttime road closures.

### **2.1.2 Institute of Vehicular Safety**

In 1992 the Institute of Vehicular Safety, based in Columbus Ohio, published the report titled *Warning Devices Type "C" Steady-Burn Lights* in response to the Ohio Department of Transportation's decision to drop their requirement for the use of steady-burn warning lights on all traffic control devices. The report includes a discussion on the needs of older drivers versus the needs of younger drivers. It states, "Many older drivers have more difficulty managing the demands of modern traffic than the average younger driver. For example, many older drivers do not have sufficient time or distance to respond to visual clues – particularly under conditions of low illumination – because they cannot see as well as younger drivers. Therefore any reduction is dangerous."

The report concluded that "the removal of Type "C" steady-burn lights has not been proven to enhance the mobility of older drivers." The report also concludes "no one has stated construction zones are safer without steady-burn Type "C" warning lights."<sup>(15)</sup>

### **2.1.3 KLD Associates Report**

In 1992, KLD Associates, based in New York, prepared a report for the American Traffic Services Association (ATSSA) titled *Steady-Burn Warning Lights*. The report included a literature search and a summary of field observations of drivers as they negotiated construction zones using devices with and without steady-burn warning lights. The report reached four conclusions:

- (1) "Steady-burn warning lights are generally effective in positively influencing driver behavior. Specifically, for distances exceeding 1200 feet, steady-burn lights produced a higher percentage of correct responses, for all device and lighting configurations, than did devices with no lights."
- (2) "The rate of decline in driver responses was far more pronounced at distances exceeding 1000 feet, for devices with no lights than for devices with Type 'C' lighting."
- (3) "For all lighting treatments (full, alternate, none) and lane closure configurations (left, right) the older drivers (age 55+ years) recorded significantly less accurate responses than did the younger (under age 55) drivers."
- (4) "The recommended deployments of Type 'C' warning lights are more effective than no lights, in stimulating correct responses by older drivers."<sup>(16)</sup>

Following the conclusions, this report makes two recommendations that relate to this research project:

(1) “The deployment of Type ‘C’ steady-burn warning lights on alternate channelizing devices (reflective drums or panels) used for left lane closures will significantly improve the decision making performance of all driver age groups over the entire range of approach distances up to 2,000 feet as compared with no deployment of lights. Deployment of Type ‘C’ steady-burn warning lights on all devices did not perform as well as the alternate deployment of lights over the same range of distances. Thus, deployment of lights on alternate devices is strongly recommended for left lane closures in the interest of traffic safety.”

(2) “For many traffic environments, there is no advantage gained in deploying Type ‘C’ steady-burn warning lights on reflective channelizing devices used for right lane closures. Thus, there is no basis for recommending the general deployment of these warning lights for right lane closures. However, in environments characterized by high-speed operations, compromised visibility due to inclement weather and/or complex maneuvers caused by the work zone configuration, the literature suggests that the deployment of Type ‘C’ warning lights should be considered on all channelizing devices used for right lane closures.”<sup>(17)</sup>

#### **2.1.4 Michigan Department of Transportation**

In 1989 the chairman of the State of Michigan’s Construction Zone Review Team wrote an internal memo stressing the need for the State of Michigan to continue the use of steady-burn warning lights on traffic channelization devices:

“In 1986 we encountered a line of mud splattered barrels, caused by intermittent rains, along an excavated area of the Lodge. These barrels were almost totally non-reflective and were nearly invisible on that dark night, but the lights in the barrels were almost 100 percent working and provided a visible safe line of delineation. This single experience pointed out the value of barrel lights on any project where barrel reflectivity might be lost for even one night due to sudden unexpected mud splatter conditions. Since that time and because of that experience the team has tended to support the continued use of steady-burn lights on barrels used for channelization. This year (1989) we encountered a long barrel string with approximately ninety percent of the lights inoperative. We felt this stretch of road was more difficult to negotiate than other areas of the same job with fully operative lights on the barrel string.”<sup>(8)</sup>

#### **2.1.5 3M Company**

The consultant contacted the 3M Company’s Traffic Control Materials Group in St. Paul, Minnesota. The 3M Company is one of the largest manufacturers of reflective sheeting, and its Traffic Materials Group is responsible for developing and marketing many of the past advances in reflective sheeting.

The 3M National Sales Manager addresses the subject of warning lights on work zone traffic control devices in a letter to ADOT dated March 22, 2002. The letter mentions a

1995 memo to the Michigan Department of Transportation on the same subject. The letter to ADOT states:

“It has always been 3M’s position that every generation of technology adds incrementally to the driving environment. In that respect, we feel that lights add another critical layer of protection and performance to work zone devices. For night performance, the use of high brightness sheeting along with the use of lights creates a commanding work zone, with a clear and unambiguous guidance.... We urge you (ADOT) to continue the use of lights on devices, and to explore additional options that may help to improve safety with work zone devices.... We join the Arizona ATSSA Chapter and other industry members in our support of lights on work zone devices. We are hopeful that you continue your current practice, and continue to look for other incremental safety enhancements for devices on your roads.”<sup>(18)</sup>

## **2.2 ARTICLES NOT SUPPORTING THE USE OF STEADY-BURN LIGHTS**

Three articles were found that support the use of vertical channelization devices without steady-burn warning lights. Two reports were sponsored by the TRB and the third report is from the State of Wisconsin. NCHRP Report 476, sponsored by the TRB, attempted to establish guidelines for nighttime construction traffic control and is discussed in some detail in this report. All three articles are discussed in the following sections.

### **2.2.1 TTI Report 01-2293**

The Texas Transportation Institute (TTI) has performed several studies regarding traffic control devices, including TTI Report 01-2293 *Sequential Warning Light Systems for Work Zone Lane Closures*. This report addressed the use of different light patterns and tested construction lane closures with and without warning lights. One of the findings of this study stated “No differences were found among the three warning light systems studied and the two base treatments (no lights and steady-burn lights) in terms of subject performance. Specifically, all five treatments encouraged subjects to leave the closed lane without causing confusion.”<sup>(19)</sup>

### **2.2.2 NCHRP 476**

NCHRP Report 476 *Guidelines for Design and Operation of Nighttime Traffic Control for Highway Maintenance and Construction* was finalized in 2002. The report – as stated in the Foreword – “presents guidelines to assist highway agencies in developing and implementing a plan for night work that will provide for public and worker safety and satisfy the community while minimizing waste and other problems associated with the supply of materials and capable workers.”<sup>(10)</sup> This report contained a compilation of previous articles and reports on the topic of this research project.

The report states “Channelizing devices are required to form the closure taper and buffer spaces and to provide delineation throughout the temporary traffic control zone. To accommodate the added visibility requirements of night work, channelizing devices

that are larger and more visible than those used in comparable daytime applications are desirable.”<sup>(20)</sup>

The report discusses traffic control devices for routing of pedestrians: “Retroreflectorized traffic control devices are of little value to pedestrians. Type C warning lights may be used to delineate pedestrian pathways, and Type A warning lights may be used to mark isolated hazards if sufficient lighting has not been provided. It is important that these warning devices not create a distraction to motorists.”<sup>(21)</sup> The authors cited the *Traffic Control Device Handbook* (1983), published by the Federal Highway Administration, U.S. Department of Transportation, Washington D.C. as a reference for this statement. <sup>(22)</sup>

Chapter two of this report discusses the design requirements for various traffic control devices. The introduction to this chapter includes a statement that is at the heart of the issue discussed in this report. It states:

“Because of reduced visibility and the increase in the number of impaired drivers, as well as the need to set up and remove most of the devices on a nightly basis, night work zones present special considerations in terms of channelizing and guidance devices. Enhanced channelization and guidance is essential to protect workers and the public from intrusions into work spaces or other areas not intended for travel. Devices that must be set up and removed nightly should be selected, with consideration of ease of handling as well as visibility and other traffic control characteristics. The space available in some activity areas may require that the width of the channelizing devices selected be kept as narrow as possible to provide adequate space for travel lanes and the work space. Previous research established that increasing the amount of reflective material improved driver performance at night in terms of speed reduction, detection distance, and lane changing behavior.”<sup>(23)</sup>

The authors cited S.A Ahmed’s report on the subject of the amount of sheeting versus driver performance. <sup>(24)</sup>

NCHRP Report 476 provides a good introduction and description of the use of vertical panels:

“Vertical panels provide good visibility and are suitable for lane closure tapers. Vertical panels, especially the 30-cm (12-inch) wide version, provide similar advantages to drums for night use. Although vertical panels are narrower than drums are, their height is the same and the 30-cm (12-inch) panels include more reflective sheeting per side than the drum panels include. When used in closely spaced arrays, vertical panels are thought to be equivalent to drums. Their relatively compact size facilitates handling, and when equipped with a weighted base, they are easy to place on the roadway and are stable under traffic-induced winds. Because vertical panels are a two-dimensional device, they are less appropriate than drums for use at intersections, driveways, and other locations where they must be visible over a wide range of approach angles.”<sup>(25)</sup>

Consideration of the retroreflectivity of the traffic control channelization device may be important in the discussion of whether or not that device needs to be equipped with a warning light. NCHRP Report 476 addresses retroreflectivity stating:

“For effective visibility and detection, it is essential for all channelizing devices to be equipped with retroreflective materials at night. The MUTCD describes the required area and pattern of reflectivity for all channelizing devices, and those requirements have been accepted as providing good visibility. However, there are no accepted guidelines on the level of brightness of the retroreflective sheeting needed to provide acceptable performance. Research has shown that brighter sheeting increases the recognition and detection distance of channelizing devices.... however, considering initial cost and durability, the brightest sheetings were not found to be most cost-effective. When closely spaced, large devices are used to define the travel lane through the work area, the added brightness of the premium grades of reflective sheeting does not appear to offer any advantage, provided the devices are kept in good condition. The smaller tubular devices, and perhaps cones, should benefit most from better retroreflectivity. For individual or small groups of devices used to mark isolated hazards, especially on dark roadways with high approach speeds, increased target value provides more assurance that drivers will recognize and avoid the hazard. In such cases, consideration should be given to the use of type II or III sheeting. However, for closely spaced devices used to define travel lane, there is no consensus that these premium materials provide any advantage over engineering-grade sheeting.”<sup>(26)</sup>

The authors again cited S.A. Ahmed for his report on this subject <sup>(24)</sup> and the American Society of Testing and Materials.<sup>(27)</sup>

With respect to the use of warning lights, NCHRP Report 476 states that “Both flashing and steady-burn warning lights may be used to improve the detection and visibility of channelizing devices.”<sup>(28)</sup>

Later in a following section of the report the authors discuss the use of flashing warning lights on traffic control devices. They state:

“Flashing lights are generally considered to be effective for attracting driver attention. When channelizing devices are used to mark isolated hazards or features, the addition of flashing lights may improve the likelihood of being noticed by drivers, and this effect may be greater at night when drivers are drowsy or otherwise impaired. Increased driver attention at the start of tapers is especially important, and flashing lights on the first two devices may help to ensure detection by approaching drivers. Likewise, flashing lights should be provided on barricades at road and ramp closures to improve driver attention to the barricades. Flashing devices are not to be used in longitudinal displays because they provide to drivers a potentially confusing pattern that may obscure the actual vehicle path.”<sup>(29)</sup>

In the section on steady-burn warning lights the report discussed the use of steady-burn warning lights in similar detail. This section of NCHRP Report 476 is especially relevant to this project. This section reads:

“Steady-burn lights are intended to define the edge of the travel path. Because the brightness and size of the light is overpowered by large reflectorized channelization devices, the value of steady-burn lights to supplement large retroreflectorized channelizing devices is questionable. Studies in Ohio concluded that these lights did not enhance driver performance when attached to channelizing devices equipped with high intensity sheeting. Considering the large device size and close spacing recommended by these guidelines and the experience of states such as New York and Iowa, it is doubtful that steady-burn lights on channelizing devices will provide any value in night work zones. In addition to the questionable value for visibility, earlier research has shown that lights attached to channelizing devices may break windshields when impacted and may increase the risk of the channelizing device being thrown on impact rather than pushed down by the impacting vehicle.”<sup>(30)</sup>

The authors cited four individual references for the above statements. <sup>(31,32,33, and 34)</sup>

The next section of the NCHRP Report 476 discussed the attachment of the lights to barricades. The report states:

“When the decision is made to use lights on channelizing devices, it is essential that the attachment is sufficiently strong to resist impact forces. Lights torn loose from a channelizing device present a greater risk of windshield breakage or becoming a potentially lethal projectile. Batteries used to power warning lights, especially the heavy-duty batteries used with Type B lights, present a risk in terms of broken windshields and passenger compartment intrusion and may present a risk to workers if dislodged on impact. The preferred mounting, especially for heavy-duty batteries, is at ground level to eliminate the risk of windshield contact and being thrown into the work space. The lightweight batteries used in Type A lights may be attached directly to the barricade or channelizing device. However, it is essential for the attachment to be secure to reduce the risk of becoming dislodged on impact and to discourage theft by vandals.”<sup>(35)</sup>

This may be a historical concern, since traffic control channelization devices with warning lights that are in use today have met the crash testing guidelines established in NCHRP Report 350.<sup>(36)</sup>

This report next included a discussion of work zone signs and the retroreflectivity of warning signs. This section of the report reads as follows:

“If not severely degraded, Type I material (also referred to as engineering grade) provides sufficient sign detection and recognition for standard 48-inch signs in all but very complex visual backgrounds. However, because the service life of this material is relatively short and high speeds and complex areas may require greater retroreflectivity for conspicuity, more reflective materials should be used. Considering service life and the need for greater conspicuity, a high intensity material such as Type III (also referred to as prismatic) or a material of greater retroreflectivity should be used for all warning signs except when standard sized signs are used on low-speed, low-volume roads. The fluorescent material often used today will satisfy this requirement. Painted sign panels are not to be used, and flexible panels (i.e. rollup signs) should be avoided if possible.”<sup>(37)</sup>

### **2.2.3 Wisconsin Department of Transportation**

Responding to the survey on other state transportation departments traffic control device usage and polices, the Wisconsin Department of Transportation reported preparing a study that documented their review of sign sheeting and the use of steady-burn warning lights. Although several other states reported conducting similar studies, Wisconsin was the only state DOT that documented their analysis with a written report.

The report *Construction Workzone Reflective Sheeting Study, Final Report* was completed in August 1989. The introduction to this report states “In 1988, the Wisconsin Department of Transportation developed and carried out a research project designed to give preliminary information on which reflective sheeting materials were most effective for use in construction zones.” The conclusions of this report recommended the use of high intensity sheeting on traffic barrels. This report also concluded that “A benefit of this study was discovering the potential safety hazards of yellow warning lights traditionally used on construction zone barrels. Eliminating the use of warning lights would increase worker and driver safety in work zones. The high intensity sheeting on barrels is reflective enough that, according to the field review team, it out performs the yellow warning lights. For this reason the lights could be omitted, lowering the cost of maintaining the barrels.”<sup>(38)</sup> It is important to note that this test was conducted on traffic drums, and not on vertical panels - the results may or may not be the same.

## **2.3 ARTICLES ON RELATED TOPICS**

Several articles were found that discuss issues related to the use of steady-burn warning lights on vertical channelization devices and drivers’ ability to see traffic channelizing devices, but do not provide recommendations or guidance on their use. These include articles on the new Ultra Panel, the effect of dew on sign sheeting reflectivity, advances in headlight technology, advancements in vision enhancement systems for vehicle drivers, and two future TRB projects that may discuss or analyze the use of steady-burn warning lights. These articles are discussed in the following sections.

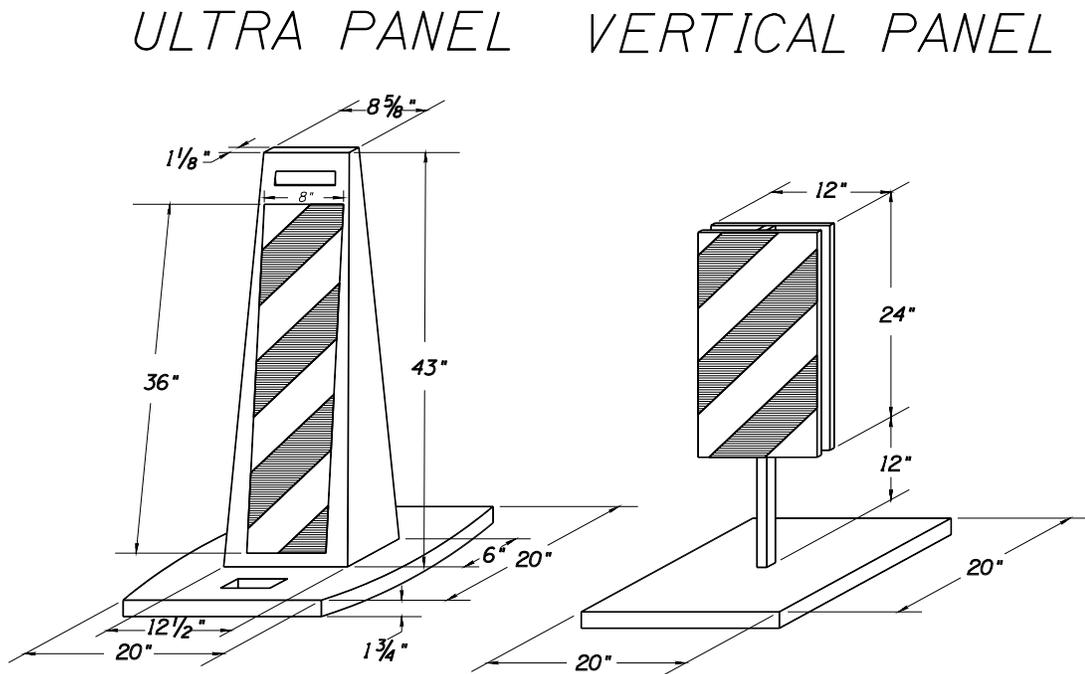
### **2.3.1 Ultra Panels**

The amount of retroreflective sheeting that is installed on a traffic control device may enter into the consideration of whether or not that device should be equipped with a warning light for use in nighttime construction zones. A new type of vertical panel has been developed by the Bent Manufacturing Company. This vertical panel, called the Ultra Panel, is constructed of low density polyethylene. Its hollow design allows it to be fully stackable, with or without the rubber base attached. It has a wide base for greater stability and greater resistance to wind forces, although it does require the use of sand bags when used in areas of extreme wind or high speed truck traffic. A large arch carrying handle allows easy gripping of the Ultra Panel. The panel contains a recessed sheeting area that can accommodate a maximum of 288 square inches of retroreflective sheeting, which is more that the minimum of 270 square inches required by the MUTCD. Some of the reflective sheeting is less than twelve inches above the pavement. This panel

can be used with or without a warning light, although when equipped with a warning light the Ultra Panel loses its ability to be stackable. <sup>(39)</sup>

The differences between a typical vertical panel and the Ultra Panel are shown schematically in Figure 1 below.

**Figure 1 – Ultra Panel**



### 2.3.2 Dew Effect on Retroreflective Performance

As previously mentioned the 3M Company is the leading developer of retroreflective sign sheeting materials. 3M has conducted a significant amount of research on the reflectivity of their products when they are covered with dew. One memo, written in 1993, addresses this topic:

“Dew formation on the surface of signs does cause a reduction in retroreflective performance. This phenomenon is the subject of significant research here in our laboratory. Part of that research involves monitoring the performance of all classes of retroreflective sheeting at our outdoor dew deck. At this facility we continually monitor, using a scanning video camera and retroreflectometer, full size sign panels for changes in brightness during ‘real world’ dew events. From this work, we know that all retroreflective sheetings undergo equivalent reductions of retroreflective performance in dew conditions. These reductions can be severe. Loss of up to 80% of the coefficient of retroreflection at the test geometry of 0.2 degree observation angle and 4 degree entrance angle is not uncommon.”<sup>(13)</sup>

One interesting note is that dew and moisture are different. A follow-up telephone call to 3M yielded the information that a sign covered with dew may lose its retroreflectivity, but a sign that is covered with water maintains its retroreflectivity.

### **2.3.3 Advancements in Headlights**

Recent advances in vehicle headlights may also have some impact on the driver's nighttime vision and ability to detect traffic control devices and pavement markings. A study *Ultraviolet Headlamp Technology for Nighttime Enhancement of Roadway Markings and Pedestrians* was originally presented in the Journal of the Transportation Research Board. This report discussed the impacts of adding supplemental ultraviolet (UV) headlights to increase nighttime visibility. This study cited extensive research conducted in Sweden and the United States. The results of the field study indicated that pavement markings could be observed thirty percent farther with UV headlights than with standard headlights, and pedestrians could be observed approximately ninety percent further with the addition of the UV headlights. Study subjects consistently evaluated the use of the UV headlights as beneficial. This study did not specifically address the effects of the UV headlights on sign sheeting retroreflectivity.<sup>(12)</sup>

The company, Bright Solutions, Inc., claims that glass and plastic headlight lenses become yellow and cloudy as they age, reducing the amount of light that passes through the lens. The company claims that cleaning headlights with their product can restore the headlight to its original performance – often improving the performance of the headlight and the driver's nighttime visibility by as much as ninety-five percent.<sup>(40)</sup>

No other research was found on the subject of different types of headlights, different manufacturer headlights, and how these affect the driver's ability to see traffic signs or traffic control devices at night.

### **2.3.4 Vision Enhancement Systems**

Similar to the recent advancements in headlight technologies, another consideration regarding the use of warning lights on traffic control devices is the advancement in vision enhancement systems and the assistance they provide to drivers. A study presented in the Journal of the Transportation Research Board, *Human Factors Related to Use of Vision Enhancement Systems*, discussed the impacts of vision enhancement systems (VES). Although there are several types of VES, the concept is the same. A video screen, either mounted in the dashboard or projected onto the windshield of the vehicle, details the vehicle path and potential obstacles.

This was a small study, conducted with eight participants, with some interesting results. The study found that older drivers were less willing to use and depend on the VES than the younger drivers. The results of the study suggested that although the VES system provided advanced indication of an object in the roadway at a greater distance than what low-beam headlights could provide, this information was often not detected by

the driver. Drivers using a VES system did detect roadway curves at a greater distance than those using low-beam headlights without a VES system. <sup>(11)</sup>

### **2.3.5 NCHRP Project 3-69**

Project 3-69 was recently initiated through the NCHRP and results of this study have not been released. The objective of the study is to develop a methodology that assists designers in developing appropriate design and traffic control recommendations for the safe and efficient movement of traffic through construction zones on high-speed highways. The study overview states that it will identify the problems associated with the design and traffic control treatments in construction zones. It is anticipated that the use of warning lights and vertical panels will be two of the topics addressed in this report.

### **2.3.6 NCHRP Project 22-18**

Project 22-18 is an active research project funded by the NCHRP and being conducted by Texas A & M Research Foundation. The objective of this project is to test the crash capabilities of various traffic control devices to determine whether or not they meet the criteria established in NCHRP Report 350. It is not clear whether or not this study will address the use of warning lights on the various traffic control devices being tested.

## **2.4 SUMMARY**

The literature search did not locate a report that presented a scientific analysis of drivers' ability to see traffic control devices equipped with steady-burn warning lights versus their ability to see traffic control devices without warning lights. Several reports were found that discussed driver behavior responding to traffic control devices with warning lights and those without warning lights. The following discussion presents a brief summary and overview of the various reports and documents discussed earlier in this report resulting from the literature search conducted for this study.

- NCHRP Report 236 recommends the use of steady-burn warning lights on channelization devices used in nighttime construction zones with Type III sheeting. <sup>(5)</sup>
- A report prepared by the Institute of Vehicular Safety addresses the needs of older drivers and the benefit that the warning lights provide these drivers. This report fully supports and stresses the need for the use of steady-burn warning lights on traffic channelizing devices. <sup>(6)</sup>
- A report prepared for ATSSA by KLD Associates concluded that Type "C" steady-burn warning lights should be considered on all channelizing devices used in work zones experiencing high-speed traffic, poor visibility, inclement weather, or locations requiring complex maneuvers. <sup>(7)</sup>

- In 1989 the chairman of the State of Michigan's Construction Zone Review Team wrote an internal memo stressing the need for the Michigan Department of Transportation to continue the use of steady-burn warning lights on traffic channelization devices.<sup>(8)</sup>
- The 3M Corporation has written letters to the States of Arizona, Florida, and Michigan encouraging the use of warning lights on traffic control devices. These letters state 3M's official position supporting the use of steady-burn warning lights on traffic channelizing devices.<sup>(18)</sup>
- TTI Report 01-2293<sup>(9)</sup> and NCHRP Report 476<sup>(10)</sup> state that brighter sign sheeting increases the recognition and detection of traffic control devices sufficiently so that steady-burn warning lights are not needed on these devices.
- All of the reports suggested that flashing warning lights be used to mark hazards or dangerous locations, and that there may be instances where the use of steady-burn warning lights may be beneficial and their use should be considered.
- NCHRP 476 suggests a minimum sign reflectivity of Type III (also referred to as prismatic) for all traffic control signs. Type IV and Type V sheetings were also recommended for use, but the higher sign visibility resulting from these sheetings may not be off-set by their considerably higher costs.
- NCHRP 476 states that the warning lights and the batteries used to power them may present a risk of broken windshields and potentially lethal flying objects if the light or battery were to become detached from the traffic control device during a collision. In contrast to this statement, traffic control devices with warning lights in use today have passed the crash testing requirements represented in NCHRP 350.
- The new Ultra Panels, a type of vertical panel, can provide more reflective sheeting area than typical vertical panels, although this additional sheeting is typically less than twelve inches above the roadway. These Ultra Panels are hollow, which makes them stackable, lighter, and equipped with a handle that makes them potentially easier to use in construction zones.<sup>(39)</sup>
- Recent developments in vision enhancement systems<sup>(11)</sup> and headlights<sup>(12,40)</sup> may improve driver ability to see traffic control devices, although nothing definitive was found on this subject.

The bibliography of related reading at the end of this report lists the reports, articles, websites and other documents that were obtained or investigated during the course of this study but were not mentioned or discussed in the literature section of this report. Many discuss other topics related to the use of steady-burn warning lights and traffic control issues and may be of interest to the reader.

### 3.0 SURVEY OF STATE DEPARTMENTS OF TRANSPORTATION

Arizona is not the only state that has dealt with the issue of requiring or not requiring the use of steady-burn warning lights on vertical panels that are used to channelize traffic. In an effort to obtain other state department of transportation requirements, a brief survey regarding the use of traffic control devices and warning lights to channelize traffic in work zones was developed. A draft survey was prepared and distributed to the project Technical Advisory Committee (TAC) for review and comment. A final survey was developed that incorporated the review comments of the TAC.

Representatives of ADOT's Traffic Group posted this survey on an internet site and invited the transportation departments of other states to participate in the survey. ADOT called many of the states to obtain their input into the survey process. In all, thirty-three states and one Canadian province responded to the survey. Appendix A contains a more detailed listing of the agencies that responded to the survey. Following is a listing in alphabetical order of the states and province that responded to the survey:

- Alaska
- Alberta, Canada
- Colorado
- Connecticut
- Idaho
- Illinois
- Indiana
- Iowa
- Kansas
- Maryland
- Massachusetts
- Michigan
- Minnesota
- Mississippi
- Missouri
- Nebraska
- Nevada
- New Hampshire
- New Mexico
- New York
- North Carolina
- North Dakota
- Oregon
- Pennsylvania
- South Carolina
- South Dakota
- Tennessee
- Texas
- Utah
- Virginia
- Washington
- West Virginia
- Wisconsin
- Wyoming

The results of the eight-question survey are summarized on the following pages:

### 3.1 SURVEY QUESTION NUMBER ONE

The first question asked if the agency allowed the use of various traffic control devices to channelize traffic in construction zones in their jurisdiction. The intent of this question was to establish whether or not each agency allowed the use of vertical panels or other traffic control devices. The question as presented in the survey is shown below with the results tabulated in Table 2.

**Question #1.** Does your agency allow the use of the following traffic control devices to channelize traffic in construction zones in your jurisdiction?

	During Day Hours	During Night Hours	Requirements _____
Traffic Cones	<input type="checkbox"/>	<input type="checkbox"/>	Requirements _____
Type I Barricades	<input type="checkbox"/>	<input type="checkbox"/>	Requirements _____
Type II Barricades	<input type="checkbox"/>	<input type="checkbox"/>	Requirements _____
Vertical Panels	<input type="checkbox"/>	<input type="checkbox"/>	Requirements _____
Traffic Drums	<input type="checkbox"/>	<input type="checkbox"/>	Requirements _____

**Table 2 – Question #1 Survey Results**

Device	Allowed (Day)	Allowed (Night)	Total Responses
Traffic Cones	34	21	34
Type I Barricades	14	11	34
Type II Barricades	19	17	34
Vertical Panel	22	19	34
Traffic Drums	34	34	34

Several interesting observations can be made from the responses to this question. With the exception of traffic cones, most of the traffic control devices that were allowed to be used during daylight hours were allowed during night hours.

Some of the comments regarding this question were:

- The DOTs for the states of Alaska, Connecticut, Illinois, Michigan, Mississippi, Missouri, North Carolina, Oregon, South Carolina, Washington, Wyoming and the Province of Alberta all reported that they do not use vertical panels during the day or night. The Michigan, Washington, and Alberta DOTs indicated on the survey form that they do not allow the use of vertical panels but later in the comments responded that they do use vertical panels, but on a very limited basis.
- The DOTs for the states of Colorado, Idaho, Iowa, Indiana, Kansas, Maryland, Minnesota, Nebraska, Nevada, New Hampshire, New Mexico, New York, North

Dakota, Pennsylvania, Tennessee, Utah, Virginia, West Virginia, and Wisconsin all reported that they use vertical panels for both daylight and nighttime construction projects.

- The Massachusetts, South Dakota, and Texas DOTs reported that they use vertical panels during the day but not during the night.
- The DOTs for the states of Connecticut, Michigan, Mississippi, Missouri, North Carolina, Oregon, Washington, and Wyoming all reported that they do not use Type I barricades, Type II barricades or vertical panels as channelizing devices. Drums and cones are their preferred traffic control devices for channelizing traffic.
- The Idaho DOT reported that it may not use Type II barricades in the future.
- There does not appear to be a pattern as to which state DOTs use vertical panels and which do not. Nor does there appear to be a pattern as to why some DOTs prefer one type of traffic control device and others prefer different devices.

### 3.2 SURVEY QUESTION NUMBER TWO

The second question determined which agencies require steady-burn warning lights on each of the different types of traffic control devices. The question as presented in the survey is shown below with the results tabulated in Table 3.

**Question #2.** In areas with established ambient lighting, does your agency require steady-burn warning lights?

On Type I Barricades	___	Yes	___	No	___	Sometimes
On Type II Barricades	___	Yes	___	No	___	Sometimes
On Vertical Panels	___	Yes	___	No	___	Sometimes
On Construction Zone Signs	___	Yes	___	No	___	Sometimes

**Table 3 – Question #2 Survey Results**

Device	Yes	No	Sometimes	No Response	Total Responses
Type I Barricades	0	26	4	4	34
Type II Barricades	1	26	5	2	34
Vertical Panels	0	27	3	4	34
Const. Zone Signs	2	26	5	1	34

Some general observations regarding these survey responses are:

- None of the state DOTs that responded to the survey reported requiring steady-burn warning lights on channelization devices. Alberta, Canada was the only agency that reported requiring warning lights on traffic control devices for channelizing devices, which were Type II barricades. The State of Illinois DOT indicated a requirement for steady-burn warning lights on all roadways with an average daily traffic level over 2,500 vehicles per day.
- The Alberta Canada DOT reported that they are currently developing standards for the use of warning lights on channelization devices in urban areas with high levels of ambient lighting.
- The DOTs of Iowa and Oregon reported dropping requirements for warning lights due to the advances in reflective sheeting. Oregon cited problems with the lights working/not working and the dynamics involved when the device with the light and battery pack is struck as a reason for no longer requiring warning lights.
- Many of the state DOTs reported using the steady-burn warning lights for special circumstances but that steady-burn warning lights are not routinely required. Most of these agencies require flashing warning lights to be used in tapers and special situations.

### 3.3 SURVEY QUESTION NUMBER THREE

The third question addressed the same issue as Question Two except that it seeks the agency requirement, if one is established, on the use of steady-burn lights in areas without ambient lighting. The question as presented in the survey is shown below with the results tabulated in Table 4.

**Question #3.** In areas without established ambient lighting, does your agency require steady-burn warning lights?

On Type I Barricades                    \_\_\_ Yes        \_\_\_ No        \_\_\_ Sometimes  
 On Type II Barricades                   \_\_\_ Yes        \_\_\_ No        \_\_\_ Sometimes  
 On Vertical Panels                        \_\_\_ Yes        \_\_\_ No        \_\_\_ Sometimes  
 On Construction Zone Signs           \_\_\_ Yes        \_\_\_ No        \_\_\_ Sometimes

**Table 4– Question #3 Survey Results**

Device	Yes	No	Sometimes	No Response	Total Responses
Type I Barricades	0	26	4	4	34
Type II Barricades	1	26	5	2	34
Vertical Panels	0	26	3	5	34
Const. Zone Signs	3	26	4	1	34

The survey responses and comments for Question Three were the same as for Question Two. This is surprising in that this is interpreted to mean that either the level of ambient lighting has little impact on the requirement for steady-burn warning lights, or that there are many difficulties associated with developing two sets of standards for traffic control devices.

### 3.4 SURVEY QUESTION NUMBER FOUR

The fourth question of the survey determined the agencies' minimum reflective sheeting requirement for channelization devices used in areas that contain ambient light. The question as presented in the survey is shown below with the results tabulated in Table 5.

**Question #4.** In areas with established ambient lighting, what does your agency require as a minimum type of reflective sheeting to be used on channelization devices in construction areas in your jurisdiction?

On Traffic Cones	Requirements _____
On Type I Barricades	Requirements _____
On Type II Barricades	Requirements _____
On Vertical Panels	Requirements _____
On Traffic Drums	Requirements _____

**Table 5 – Question #4 Survey Results**

Device	Not Used	Type I	Type II	Type III	Type IV	Total Responses
Traffic Cones	6	3	0	21	4	34
Type I Barricades	12	3	0	15	4	34
Type II Barricades	9	3	0	17	5	34
Vertical Panel	9	3*	0	18	5*	34
Traffic Drums	0	3	0	25	6	34

\* The State of Michigan DOT reported two different requirements for vertical panels - diamond grade (Type IV) for freeways and high impact projects, and engineer's grade (Type I) for all other situations.

Some of the comments and general observations regarding this question are:

- The Oregon DOT reported that it does not differentiate between day and night work with respect to minimum reflectivity on traffic control devices for consistency among traffic control devices, and for ease in contract pricing, documentation, and inspection.
- The Illinois DOT reported that they are converting to fluorescent orange on drums, so the type of sheeting will change to prismatic. Other state DOTs reported that they are currently reviewing their sheeting requirements.

### 3.5 SURVEY QUESTION NUMBER FIVE

Question Five is similar to Question Four except that it asks for the type of sheeting required in areas without established ambient lighting. The question as presented in the survey is shown below with the results tabulated in Table 6.

**Question #5.** In areas without established ambient lighting, what does your agency require as a minimum type of reflective sheeting to be used on channelization devices in construction areas in your jurisdiction?

On Traffic Cones Requirements \_\_\_\_\_  
 On Type I Barricades Requirements \_\_\_\_\_  
 On Type II Barricades Requirements \_\_\_\_\_  
 On Vertical Panels Requirements \_\_\_\_\_  
 On Traffic Drums Requirements \_\_\_\_\_

**Table 6 – Question #5 Survey Results**

Device	Not Used	Type I	Type II	Type III	Type IV	Total Responses
Traffic Cones	6	3	0	21	4	34
Type I Barricades	12	3	0	15	4	34
Type II Barricades	9	3	0	17	5	34
Vertical Panel	9	3*	0	18	5*	34
Traffic Drums	0	3	0	25	6	34

\* The State of Michigan DOT reported two different requirements for vertical panels - diamond grade (Type IV) for freeways and high impact projects, and engineer's grade (Type I) for all other situations.

The responses to Question Five were similar to Question Four, signifying that the agencies that responded do not differentiate sheeting requirements between projects in areas with ambient lighting from those projects in areas without ambient lighting. As pointed out by the Oregon DOT, it may be very time consuming to develop different criteria for ambient and non-ambient lighted areas and then verify and enforce these different requirements.

### 3.6 SURVEY QUESTION NUMBER SIX

Question Six asked if the agency has performed any type of research or studies related to the use of traffic control devices without steady-burn warning lights in lighted or unlighted construction zones. The intent of this question was to find agencies that have completed research so that copies of their reports could be requested. The question as presented in the survey is shown below with the results tabulated in Table 7.

**Question #6.** Has your agency conducted any research or study regarding the use of traffic control devices without steady-burn warning lights in construction zones in lighted or unlighted areas?

\_\_\_ Yes      \_\_\_ No

**Table 7 – Question #6 Survey Results**

Yes	No	No Response	Total Responses
3	30	1	34

Some general observations regarding these survey responses are:

- The Connecticut DOT has recently adopted a new policy for warning lights on drums. The first three drums in succession will have Type I warning lights – flashers – the rest of the drums will remain unlit.
- The Wisconsin DOT performed a study in 1988-89. This study resulted in upgrading channelizing device reflective sheeting to high intensity and omitting warning lights, except in tapers. A copy of this report was requested and evaluated. This report was discussed in detail in the literature search section of this report. <sup>(38)</sup>
- The Illinois DOT responded that they had performed some unscientific research regarding the use of reflective discs rather than lights. The reflective disc were constructed of plywood and covered with reflective sheeting. It was stated that these discs were not effective in fog or rain. No official report has been prepared by Illinois regarding their review. They did not adopt the use of the reflective discs.
- The Iowa, Michigan, Washington, and Maryland DOTs commented that they have performed field reviews or unscientific experimentation on various projects including the visibility of traffic control devices. They reported making observations showing adequate levels of delineation, retroreflectorization and positive guidance without the use of steady-burn warning lights. These studies and results were not compiled into a written report documenting the study and results.

### **3.7 SURVEY QUESTION NUMBER SEVEN**

Question Seven of the survey offered the responding agency an opportunity to add any general comments regarding warning lights and traffic control devices. Of the thirty-four DOTs that responded, several agencies used this opportunity to provide additional input. These responses were:

- Connecticut Department of Transportation: “We do not use construction barricades as channelizing devices, but Type III construction barricades are used for temporary road closures with Type III Reflective Sheeting.”
- Illinois Department of Transportation: “Lights seem like an expense that could be cut, but I believe they are the most effective in poor conditions when other devices fail to provide adequate delineation, i.e. fog, rain, snow, etc...”
- Iowa Department of Transportation: “We use Type “A” and Type “B” warning lights to draw attention to selected signs and barricades.”
- North Carolina Department of Transportation: “We require 5” to 6” Stripes (Type 1 Sheeting) on all drums.”
- New York Department of Transportation: “Steady-burn lights are not required on devices with reflective sheeting.”
- Texas Department of Transportation: “The type of sheeting and type of device is not dependant on ambient lighting.”

### **3.8 SURVEY QUESTION NUMBER EIGHT**

Question Eight simply asked the agency if they would like a copy of the final results of the survey. All of the agencies that responded to the survey have requested a copy. The response to this question was anticipated and included to encourage agencies to respond to the survey. The consultant will send the final survey results to all agencies that requested a copy.

### **3.9 PREVIOUS SURVEY**

An earlier survey of state agencies was conducted regarding the requirements of steady-burn warning lights on traffic channelizing devices. All fifty states and the District of Columbia were included in this survey, the results of which are several years old. This survey was conducted by Bob’s Barricades, Inc., a traffic control and barricading company.

This earlier survey conducted by Bob’s Barricades, Inc., reported that in addition to the Arizona, Alaska, Florida, Hawaii, Massachusetts, Michigan, New Hampshire,

Oklahoma, Vermont, and Washington, D.C., require the use of steady-burn warning lights on channelization devices. As a part of this research project being conducted for ADOT, the Alaska, Massachusetts, Michigan, and New Hampshire DOTs indicated that they do not require the use of steady-burn warning lights. The other states, namely Florida, Hawaii, Oklahoma, and Vermont did not respond to the survey conducted as a part of this project for ADOT.

Several states, including Louisiana, New Mexico, Pennsylvania, South Carolina, and Wisconsin responded to this previous survey conducted by Bob's Barricades, Inc., indicating that they use the steady-burn warning lights in tapers only while Idaho, Minnesota, Montana, Nevada, and Rhode Island responded to this previous survey conducted by Bob's Barricades, Inc., that they sometimes require the use of the steady-burn warning lights.

### **3.10 SUMMARY**

The following list summarizes several general observations that can be made based on the survey responses. A total of thirty-four transportation departments, representing thirty-three states and one province, responded to the surveys. It was learned that:

- Of the thirty-four responses to the survey, twenty-two (sixty-five percent) agencies use vertical panels to channelize traffic in daytime construction zones and nineteen (fifty-six percent) use vertical panels to channelize traffic in nighttime construction zones.
- Traffic drums and cones appear to be the preferred traffic control methods. All of the state DOT agencies reported that they used drums at night, and twenty-one (sixty-two percent) reported using cones at night – second only to the drums.
- With the exception of the Province of Alberta, no agency reported that they required the use of steady-burn warning lights on traffic control devices to channelize traffic. The Alberta DOT uses Type II barricades and drums with warning lights, but does not use vertical panels or Type I barricades.
- Requirements for steady-burn warning lights or the minimum required retroreflective sheeting do not vary between areas with established ambient lighting and areas without established ambient lighting.
- Type III sheeting was most often cited as the minimum level of retroreflective sheeting on channelization devices required by the state DOT agencies that responded to the survey.
- Only the State of Wisconsin has prepared a final report that documented their previous study of the relationship between reflective sheeting and the use of warning lights on traffic control devices.<sup>(38)</sup>

## **4.0 REVIEW OF MUTCD & ADOT SUPPLEMENT**

Arizona, like many other states in the country, has adopted a supplement to the Manual of Uniform Traffic Control Devices (MUTCD). This supplement, The ADOT Traffic Control Supplement (TCS), is intended to augment the MUTCD and not replace it. As it states in the introduction to the supplement, “The supplement is intended to enhance, amplify, and reinforce the MUTCD and to establish uniform policies for the application of traffic control devices on State of Arizona roadways.... It is not the intent of this document to repeat the standards and guidelines already established in the MUTCD, but rather to provide additional information which is applicable specifically to the practices, policies, and procedures currently being implemented in the State of Arizona.”<sup>(3)</sup>

### **4.1 ADOT TRAFFIC CONTROL SUPPLEMENT**

The *Arizona Department of Transportation Traffic Control Supplement 1996* specifically addresses traffic control requirements and guidelines for construction zones and construction activities in Arizona.<sup>(3)</sup> It supplements items covered in Part VI of the MUTCD. This supplement addresses the use of warning lights on vertical panels. It states “A flashing warning light shall be placed on each end of each type III barricade whenever the type III barricade will remain in place overnight or whenever the barricade is set during early morning hours or construction extends into the late evening hours. Steady burning lights shall be placed on every vertical panel, type I and II barricade and drum during these same periods” (Section 6F-5a).

The important word in the above paragraph is the word “shall.” The MUTCD in section 1A-5 defines shall as “a mandatory condition. Where certain requirements in the design or application of the device are described with the word ‘shall’ stipulation, it is mandatory when an installation is made that these requirements be met.”

In June 2002, ADOT adopted a revision to the ADOT TCS, revising section 6F-5a to include the sentence “The exception to this standard is for sections of roadway that are continuously lighted where neither type of warning light will be required for channelizing devices.”<sup>(4)</sup>

### **4.2 MUTCD – 1988 EDITION**

The 1988 edition of the MUTCD,<sup>(1)</sup> section 6C-5, states that “for nighttime use, it is desirable to place flashing warning lights on vertical panels when they are used singly and steady burn warning lights on vertical panels when they are used in a series for channelization.” This clearly leaves the use of warning lights at the discretion of the engineer.

In 1993, the FHWA adopted Revision 3 (September 3, 1993) to Part VI of the 1988 edition of the MUTCD,<sup>(1)</sup> which established a *may* condition for the use of warning lights on channelization devices in construction areas. The MUTCD defines *may* as “a permissive condition. No requirement for the design or application is intended.”<sup>(41)</sup>

### **4.3 MUTCD – MILLENNIUM EDITION**

The requirement for using warning lights on vertical panels presented in the 1988 Edition of the MUTCD is similar to the requirement presented in the Millennium Edition of the MUTCD, which is the newest version of the MUTCD.<sup>(2)</sup> The Millennium Edition of the MUTCD is being adopted by the various State Transportation Departments and has not yet been adopted by the State of Arizona, which still operates under the 1988 Edition of the MUTCD and adopted supplements.<sup>(1)</sup>

The Millennium Edition of the MUTCD states that “Warning lights may be added to channelizing devices in areas of frequent fog, snow, or severe roadway curvature, or where visual distractions are present” (Section 6F.55). The manual also states that these optional warning lights “shall flash when placed on channelizing devices used alone or in a cluster to warn of a condition. Warning lights placed on channelizing devices used in a series to channelize road users shall be steady-burn” (Section 6F.55). The word “may” is used, similar to the 1988 Edition, indicating a permissive condition and not a requirement.<sup>(2)</sup>

The MUTCD states that “the function of channelizing devices is to warn road users of conditions created by work activities in or near the roadway and to guide road users. Channelizing devices include cones, tubular markers, vertical panels, drums, barricades, and temporary raised islands. Channelizing devices provide for smooth and gradual motor vehicle traffic flow from one lane to another, onto a bypass or detour, or into a narrower traveled way. They are also used to separate motor vehicle traffic from the work space, pavement drop-offs, pedestrian or bicycle paths, or opposing directions of motor vehicle traffic” (Section 6F.55).

It also states that “The lightweight and portability of warning lights are advantages that make these devices useful as supplements to the retroreflectorization on signs and channelizing devices. The flashing lights are effective in attracting road users’ attention.... Type ‘A’ Low-Intensity flashing warning lights and Type ‘C’ steady-burn warning lights shall be maintained so as to be capable of being visible on a clear night from a distance of 900 m (3,000 ft)” (Section 6F.72).

### **4.4 SUMMARY**

ADOT has adopted the 1988 edition of the MUTCD and the 1993 revision to Part 6 which allow, but do not require, the use of steady-burn warning lights on vertical panels used to channelize traffic in construction zones.<sup>(1)</sup> ADOT has adopted a supplement to the MUTCD which requires the use of steady-burn warning lights on channelizing

devices used to channelize traffic in construction zones. In June 2002, ADOT adopted a revision to the TCS dropping the requirement for warning lights on channelizing devices for stretches of roadway that are continuously lighted.

The updated version titled the Millennium Edition of the MUTCD also does not require the use of steady-burn warning lights on channelizing devices in construction zones. The Arizona DOT has not yet adopted the Millennium Edition of the MUTCD.

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## 5.0 FIELD REVIEWS AND INTERVIEWS

Another important source of information to consider when evaluating the use of warning lights and traffic control devices in construction zones is the review of police accident reports, ADOT incident reports, and ADOT traffic control logs. Three freeway / highway routes which have been subjected to lane closures within the past couple of years were selected for review. All three of these projects were design-build projects where the contractor requested to use the Ultra Panels without the warning lights. These three construction projects were identified as good representative projects to evaluate the use of vertical panels without warning lights in nighttime construction zones. These projects were:

- A design-build project to add auxiliary lanes, HOV lanes, and noise walls to seven miles of I-17 in central Phoenix. The project extended from Thomas Road to Peoria Avenue and was a culmination of earlier projects that constructed these improvements south of this project. Construction began in February 1999 and was concluded in September 2000. This stretch of I-17 had an average daily traffic level of approximately 200,000 vehicles per day. I-17 had very good established lighting prior to the start of this construction project.
- A design-build project in Phoenix to widen US 60 to five lanes and a HOV lane between I-10 and Gilbert Road, and to widen US 60 to four lanes and a HOV lane between Gilbert Road and Val Vista Drive. The project also included auxiliary lanes, sound walls, landscaping, and freeway management system improvements. This project began in July 2001 and is scheduled to be completed in July 2003. This project initially had a contract amount of 184.2 million dollars, the largest in state history. US 60 carries average daily traffic levels of 140,000 to 190,000 vehicles per day. This project area also had good established lighting prior to the start of construction.
- A design-build project to build 13.5 miles of four-lane divided highway in Mohave County, a rural portion of northwestern Arizona. This state highway is a vital link in the state's highway system, connecting Kingman to Bullhead City and Laughlin, Nevada. The SR 68 project was the first design-build project to be initiated in rural Arizona. The forty-two million dollar project began in July 2000 and was completed in August of 2002. Traffic levels on SR 68 averaged approximately 12,000 vehicles per day with a substantial amount of truck traffic. SR 68 had few existing street lights along this project segment and this construction project did not include upgrading the roadway lighting.

## **5.1 ACCIDENT REPORTS**

The ADOT Traffic Records Department provided an accident database of the desired roadways during the specific time frames that these highway construction projects occurred:

- I-17: January 1999 to September 2000.
- US 60: 2001 and 2002.
- SR 68: 2000 through 2002.

The database included over 18,000 accidents. Using this database, it was possible to filter the accidents by specific categories to further analyze the data and attempt to draw meaningful conclusions.

The database was filtered down to a workable sample size of accidents with a query that consisted of all accidents that occurred under these specific field conditions: a specific road condition (under construction with traffic allowed, temporary lane closure), object of collision (collision with traffic sign, collision with traffic barricade), and available daylight (daylight or darkness). This query resulted in forty-six accidents resulting from a vehicle hitting a barricade or traffic sign in a construction zone with a temporary lane closure. The accidents that occurred during daylight hours were separated from those that occurred during darkness. The police reports for each of these accidents were obtained and reviewed to determine any trends in accidents that may exist.

### **5.1.1 I-17**

Forty-three of the initially reviewed forty-six accidents occurred on I-17. A review of these forty-three revealed the following observations:

- Twenty-one of the forty-three accidents (49 percent) occurred during daylight hours and the other twenty-two occurred during the darker hours.
- A majority of the twenty-one accidents during daylight hours (eleven) involved vehicles simply hitting barricades, signs, or drums. The remaining accidents were attributed to improper driving, such as bad lane changes (five), losing control of the vehicle (two), and rear-end collisions related to slowing or stopping in the construction zone (three). None of the police accident reports included an indication that the motorist reported a difficulty with the existing traffic control or barricading.
- The nighttime accidents were somewhat different from the daytime accidents. Twenty of these twenty-two accidents were vehicles hitting barricades, signs, barrels, or medians. The other two accidents were multi-car accidents where improper lane changes were the reported cause of the accident. One of these drivers reported seeing the barricades but stated that he didn't know where to go and struck the barricades.

- Many of the drivers that struck barricades or signs stated that the wind blew the object into their travel lane or that the object was already lying in their travel lane when they hit it. No evidence was found in the police reports to validate these claims.

After this initial review of accidents along I-17, it became evident that no clear trends were derived from this initial accident review. Following discussions with the project TAC, it was decided to take a look at sideswipe accidents along this stretch of I-17. It was felt that sideswipe accidents might be a type of accident caused by motorists not understanding the construction traffic control.

A review of the accident database revealed that a total of 224 sideswipe accidents occurred in construction zones with at least one lane closed. Of these accidents, the majority, 138 accidents (62 percent) occurred during daylight hours and 86 (36 percent) during nighttime hours. In comparison, there were 1,524 sideswipe accidents on I-17 during the same time period when no construction activity was present. 1,194 (78 percent) of these accidents were daytime accidents and 330 (22 percent) were nighttime accidents. It is difficult to compare accident rates between construction / non-construction periods or between daylight / nighttime because of the varying traffic volumes and other factors that do not remain consistent. It is, however, interesting to note that a higher percentage of sideswipe accidents occur at night in construction zones than in non-construction zones. The results of this analysis are summarized in Table 8 below.

**Table 8 – I-17 Sideswipe Accident Summary**

<b>Number of Sideswipe Accidents</b>	<b>In Construction Zones</b>	<b>No Construction</b>
During Daylight Hours	138 (62%)	1,194 (78%)
During Nighttime Hours	86 (38%)	330 (22%)
Total	224 (100%)	1,525 (100%)

### 5.1.2 US 60

Three of the initially reviewed forty-six accidents (accidents that occurred in construction zones with the vehicle striking a traffic control device) occurred on US 60. Of these three accidents, one occurred during daylight hours and two during darkness. Two of the three accidents involved eastbound vehicles. A brief summary of these accidents follows:

- February 2, 2001, 9:25 PM: A westbound vehicle’s rear driver’s side wheel came off; the vehicle swerved and hit several cones.
- July 25, 2001, 4:14 PM: An eastbound vehicle reported brake problems, swerved to the right and struck several barricades.

- August 12, 2001, 10:41 PM: An eastbound driver lost control of his vehicle and struck concrete medians on both sides of roadway.

None of these accidents involved drivers that reported any difficulty in seeing traffic barricades or not understanding the construction zone tapers. Similar to the accident review conducted for I-17, this accident review does not reveal any significant trends or results.

The accident review for US 60 was also expanded to include a review of sideswipe accidents. A review of the accident database revealed that a total of thirty-three sideswipe accidents occurred on US 60 in construction zones with at least one lane closed. Of these accidents, the majority, twenty-six accidents (79 percent) occurred during daylight hours and seven (21 percent) occurred during nighttime hours. In comparison, there were 547 sideswipe accidents that occurred on US 60 during the same time period when no construction activity was present. 426 (78 percent) of these accidents were daytime accidents and 121 (22 percent) were nighttime accidents. As with I-17, it is difficult to compare accident rates between construction / non-construction periods or between daylight / nighttime because of the varying traffic volumes and other factors that do not remain consistent. It is, however, interesting to note that for US 60 the percentage of sideswipe accidents that occur at night in construction zones is the same as the percentage of sideswipe accidents that occur in non-construction zones. The results of this review are summarized in Table 9 below.

**Table 9 – US 60 Sideswipe Accident Summary**

<b>Number of Sideswipe Accidents</b>	<b>In Construction Zones</b>	<b>No Construction</b>
During Daylight Hours	26 (79%)	426 (78%)
During Nighttime Hours	7 (21%)	121 (22%)
Total	33 (100%)	547 (100%)

### 5.1.3 SR 68

As mentioned earlier, none of the accidents that were originally evaluated, namely accidents in construction zones where the vehicle struck a traffic control device, occurred on SR 68. During the time period of the design build project on SR 68, forty-four accidents occurred in construction zones on this segment of the route. To better understand these construction related accidents on SR 68, copies of all forty-four accident reports were obtained from ADOT Traffic Records. A review of these accident reports yielded the following observations:

- Thirty-two of the forty-four accidents (73 percent) occurred during daylight hours and the other twelve (27 percent) occurred during the non-daylight hours.

- Of the thirty-two accidents during daylight hours, eleven involved rear-end collisions related to construction slowing or stopping, eight involved vehicles hitting an object such as a sign, barricade, guardrail, rock wall, large bush, airborne rock, or a shifted load, and four involved a sideswipe collision between two vehicles traveling in the same direction. The remaining accidents involved a car fire (two), a vehicle overturning (two), left-turn accident (one), head-on collision (one), sideswipe opposite direction (one), locked brakes (one), or a parked vehicle pulling out into traffic in an unsafe manner (one). None of the accident reports suggested that the motorist had a difficulty with the existing traffic control or barricades.
- Similar to the other two projects' studies, the nighttime accidents were somewhat different from the daytime accidents. Three of the twelve accidents were vehicles hitting the guardrail, ditch, or the temporary concrete barrier. Two accidents resulted in an overturned vehicle. Two accidents were related to parked cars pulling out into traffic in an unsafe manner. The rest of the nighttime accidents involved either a same-direction sideswipe, a rear-end collision related to a construction vehicle stopping, an improper left-turn, or the cause of the accident was unknown.
- None of the accident reports that were reviewed indicated that drivers were confused by the work zone traffic control being used.

#### **5.1.4 Summary**

The standard method of analysis for accident and traffic safety concerns is to develop an accident rate, typically expressed as the number of accidents occurring per million vehicle miles traveled over a stretch of roadway or number of accidents at an intersection per million vehicles entering the intersection. Traffic engineers prefer to analyze accidents over a substantial period of time, often comparing or reviewing three years of accident data. The nature of construction projects makes it difficult to develop accident rates that are meaningful.

Traffic volumes can change significantly when a roadway is under construction and most agencies are hesitant to conduct traffic counts when a roadway is under construction and partially closed. Construction projects often have periods of inactivity, when one segment may have little activity while construction resources are focused on a different segment. Construction activities may be limited to a portion of the day only, such as road closures only implemented at night when traffic levels are typically lower. For these reasons no specific accident rates were developed for the three projects analyzed in this report. Although no accident rates were developed, there were still some observations that may have some significance in a decision to require warning lights on channelizing devices. These observations were:

- A total of the forty-three accidents on I-17 and three on US 60 involved vehicles striking a traffic control device. A review of these accident reports revealed one motorist that stated that he was confused by the traffic control and that this caused the

accident, although he did state that he saw the device before hitting it. There were no reports of motorists not being able to see the traffic channelizing devices.

- Forty-four accident reports were reviewed for the SR 68 design build project, representing all types of accidents reported in a construction zone or noted in the accident report as construction related. None of the accident reports suggested that the driver experienced difficulty with the traffic control or barricade devices or seeing the Ultra Panels. This is especially significant for this project, because unlike the I-17 and US 60 projects that had established ambient lighting, this project was in a rural area with no ambient lighting.

## **5.2 ADOT INCIDENT REPORTS**

ADOT incident reports for the I-17, US 60, and SR 68 projects were reviewed to obtain additional information on traffic accidents occurring in the construction zones identified for study earlier, or if there were additional accidents that occurred in the work zones that were not identified during the accident report review discussed earlier. No new accidents were identified. The incident report logs were also reviewed to determine if there were any complaints or concerns about the visibility of the traffic channelizing devices or issues with the traffic control in general.

### **5.2.1 I-17**

The I-17 design-build project maintained a daily diary of construction activities during the course of this project. This diary included a summary of construction related accidents and the corresponding accident report number. This project has been completed for several years and most of the files have been placed in dead storage and are not readily available. Project staff associated with this project did not recall any specific incidents relative to the use of the Ultra Panels. Although the Ultra Panels without warning lights were approved for use on this project, Type II barricades with warning lights were used throughout much of the construction activities on this project.

### **5.2.2 US 60**

The US 60 design-build project was supported by ADOT staff assigned to the US 60 Field Office. This project staff also maintained an incident log, noting daily if there was an accident or other incident within the construction zone and recording the accident report number. The incident log did not include copies of the accident reports but did include any available pictures of the accident. The incident log did not include any driver comments or summaries.

The incident logs included a record of 363 accidents that occurred within the project limits, although slightly less than half (162 accidents / 45 percent) were construction zone related. Most of the construction zone related accidents (82 percent) occurred during evening hours, which is appropriate considering that most of the work involved evening and nighttime road closures. Eighty percent of the work zone related accidents were rear-

end type accidents, and approximately five percent were sideswipe accidents. There were two fatalities during this time frame within the project limits, although neither was identified as related to the construction zone.

Contractor staff was also instructed to assist stranded motorists when feasible to minimize delay and congestion caused by disabled vehicles. The project did at times increase the speed patrol on newly opened sections of US 60 by using after-hours officers paid directly by the project to help reduce vehicle speeds.

### **5.2.3 SR 68**

This project was managed by the Construction Section of the ADOT Kingman District. An incident log was not maintained during activities within the project limits. Project staff did maintain a folder, in chronological order, of completed police accident reports similar to the accident reports provided by the ADOT Traffic Records Department. Several of these reports contained witness statements that were not included (for confidentiality reasons) in the copies of the reports obtained from the ADOT Traffic Records Department. These reports were reviewed but no new information was obtained. There were no claims of motorists not being able to see the traffic control devices or understand the traffic control. There were noticeably fewer accident reports in this file than occurred during this project; it appears that not all of the accidents were routed from the Department of Public Safety (DPS) officers to ADOT, which is understandable considering that many of the accidents may have happened in the construction zone but were unrelated to the traffic control or construction activities.

This project incorporated a Motorist Assistance Program to assist distressed motorists and minimize the negative impact on traffic flow caused by disabled vehicles. This program maintained a log of motorists assisted, but most of the information contained in these logs was driver and vehicle related. None of the comments included in the log were related to drivers not seeing the vertical panels or understanding the traffic control. The motorists who were assisted were given a survey to comment on the program; all of the comments received were favorable and specifically addressed the Motorist Assistance Program. None of the comment forms that were available for review mentioned problems with the vertical panels or traffic control.

### **5.2.4 Summary**

The incident log maintained for the US 60 project and the accident file maintained on the SR 68 project did not include concerns from motorists or staff regarding the use of the Ultra Panel, complaints that the Ultra Panels were hard to see, or that the traffic control plan was hard to understand. The I-17 incident report log was not available for review.

## **5.3 ADOT TRAFFIC CONTROL LOGS**

Along with the review of the ADOT incident report logs for the I-17, US 60, and SR 68 projects, the traffic control logs for each of these projects were reviewed for any

information regarding the use of the vertical panels without warning lights. The traffic control logs were also reviewed for any complaints or concerns about the visibility of the vertical panels, Ultra Panels, or other traffic channelizing devices used on these projects, or issues with the traffic control in general.

### **5.3.1 I-17**

As mentioned in the previous section regarding the incident logs, the I-17 design build project maintained a daily diary of construction activities during the duration of this project. The design-build contractor kept the traffic control log and associated records, although ADOT staff did maintain a file of approved traffic control plans. This project has been completed for several years and most of the project files and correspondence have been placed in dead storage and are not readily available for review.

ADOT construction staff involved with this project were not aware of any specific concerns regarding the visibility of the traffic control devices used. The traffic control used was a mixture of Type II barricades with warning lights and Ultra Panels without warning lights. Typically, the Type II barricades were used in the taper sections, while the Ultra Panels were used in the tangent sections.

### **5.3.2 US 60**

This project is currently under construction and the project staff maintains a comprehensive traffic control log of traffic control devices in use and lane / road closures implemented on a daily basis. A file folder is maintained for each day and includes a brief description of the work to be conducted that day and the traffic control plan to be implemented. The log also notes the time the traffic control was authorized to be setup and the initial inspection report showing the time the traffic control setup was inspected and any deficiencies or corrections needed. Subsequent inspection reports are also included in the file, noting the status of the traffic control and any required remedial actions. The daily log includes an indication of any traffic accident occurring in the work zone or problems with the traffic control. The file also includes the time the traffic control was removed. By using the information contained in these traffic control logs, ADOT would be able to identify the type of lane closures and traffic control devices that were in use for a specific time, should this need arise. A review of these logs did not indicate any motorist problems or concerns with the traffic control devices in use on this project or with the visibility of the Ultra Panel.

While the Ultra Panel without warning lights was the predominant traffic control device used on this project, devices with lights were used to mark special hazards or on side streets when required by the local jurisdiction. To further complicate matters, while this project was underway, there were five separate interchange rebuild projects on this portion of US 60 that used traffic channelizing devices with warning lights. Road and lane closures for these projects were coordinated with the closures for the US 60 design-build project to minimize impacts and construction zone conflicts.

### **5.3.3 SR 68**

The traffic control logs for this project were kept by the contractor and submitted to ADOT at regular intervals, typically bi-weekly or monthly. The traffic control logs included a brief description of the work to be performed that day and the traffic control plan to be used. Traffic control plans were submitted to ADOT for approval, and when approved, were assigned a traffic control plan number. The traffic control log for each day included the traffic control plan number used and a description of where the plan was implemented. The logs typically included the times the traffic control was placed in the roadway and the time the barricades were removed from the roadway. The traffic control plans identified the channelizing devices needed but did not specifically address the type of device. ADOT construction staff confirmed that the Ultra Panels were the predominant traffic control and channelizing device.

The form also included a space to indicate times of the day when the traffic control was checked and reset, if necessary. Although on most of the days a comment was entered similar to “reset barricades as necessary,” there was no information entered as to how many were reset, how far the barricades were moved from their original locations, or a mention as to why the barricades needed to be reset. There was no mention of problems or concerns with the barricades or traffic control. The notes stated that everything was “okay” and “satisfactory.” The traffic control logs also included a record of when the traffic control devices were cleaned.

Lastly, the form included a space to indicate if a hazard analysis was conducted that day and if a traffic accident occurred. These spaces were filled in on most, but not all of the days. If an accident occurred, there was a space to indicate the accident report number and to verify that a copy of the report was placed in the accident file.

One interesting observation was made while reviewing the traffic control logs for this project. Initially, the project started with a one-page traffic control log but in the middle of the project a change was made and a new daily two-page report was used. This two-page report included more detail on construction activities for the day and also recorded relevant topics such as the weather, temperature, and wind conditions. It appears the change was made, not because of any problems the project was facing, but because a new traffic control manager was hired by the contractor and had used this new form on previous projects.

### **5.3.4 Summary**

The daily construction diaries for the I-17 project have been stored and are not readily accessible for the consultant to review. A review of the traffic control logs for the US 60 and SR 68 projects did not indicate any motorist problems or concerns with the traffic control devices in use on these projects or with the visibility of the Ultra Panel.

## **5.4 INTERVIEWS WITH ADOT CONSTRUCTION STAFF**

Following the reviews of the accident reports, incident logs, and traffic control logs, the consultant also interviewed ADOT construction staff associated with each project. The following sections present the results of these interviews. These interviews were conducted in person, when possible, and over the telephone, when necessary.

### **5.4.1 I-17**

ADOT staff involved in the I-17 project were pleased with the overall performance of the Ultra Panel and would recommend the use of this device on other projects. This recommendation for future use is limited to the use of this device in straight, tangent sections and not for taper sections of roadway or lane closures. The use of the Ultra Panel was introduced to this project after its initiation. Several lessons were learned on this project, which carried over to the US 60 design build project. The lessons learned were:

- A heavier base for the Ultra Panel was needed to increase its stability and to minimize the potential for this device to be knocked over. With a heavier base, the Ultra Panel without sandbags was felt to be more stable than typical vertical panels and almost as stable as Type II barricades.
- ADOT staff was surprised at how fast the Ultra Panels could be set up and picked-up.
- Type III sheeting was needed as a minimum level of retroreflective sheeting to improve the visibility of the Ultra Panel.
- Without the use of the steady-burn warning lights, it was very important to keep the Ultra Panels clean.
- The level of training for the ADOT supervisory staff was increased, with ADOT staff attending ATSSA training classes with the contractor's traffic control staff. This allowed ADOT and contractor to use the same terminology and have a similar understanding of traffic control principles and practices.
- The Ultra Panel is constructed primarily of plastic; it was felt that this material resulted in less damage to a vehicle when hit than a typical vertical panel.

Although there were complaints on this project, ADOT staff did not feel that these complaints were related to the use of the Ultra Panel, but were complaints associated with the general construction activities and closures on a very busy urban highway.

### **5.4.2 US 60**

The US 60 construction staff interviewed were pleased with the performance of the Ultra Panel and would recommend its use on future construction projects. They felt that

the Type III sheeting used on this device was very visible to on-coming traffic and they did not experience or receive any complaints regarding its visibility. They acknowledged and supported the use of warning lights on Ultra Panels that were used to mark hazards or the excavations along the ramp terminals. Both ADOT staff members that were interviewed stated that the Ultra Panel was their preferred traffic control device for channelizing traffic, as long as the device was equipped with Type III or higher reflective sheeting.

There were several reasons expressed as to why these individuals preferred the Ultra Panel. First and foremost, they were impressed with the handle located at the top of the Ultra Panel. They felt that it allowed the traffic control staff to quickly set the traffic control devices, resulting in faster set-ups and break-downs of the construction zone which increased the amount of time available to the contractor and decreased the time that the workers setting up the devices were exposed to traffic.

The staff was not aware of any complaints or concerns from the motoring public driving this route regarding the use of the Ultra Panel or the visibility of this device. They stressed the importance of a consistent maintenance routine to keep the Ultra Panels clean and maximize the retroreflective properties of its sheeting. This regular maintenance cycle is very important to the use of the Ultra Panels without steady-burn warning lights. Similarly, regular maintenance is needed to maintain all barricade lights and batteries. ADOT staff pointed out that not all barricade companies are consistent in providing fully charged batteries and working lights. Diligent efforts are often required by the supervising agency to verify that the lights are working properly. This is especially true on construction projects with a long duration. ADOT staff felt that one of the benefits of not using steady-burn warning lights on the Ultra Panel was the inconsistency typically associated with light and battery maintenance

The ADOT staff were satisfied with the current level of documentation regarding the traffic control logs and documentation of accidents that occurred in the construction zone. They were pleased with the current system developed for the US 60 project and did not recommend any changes. The staff plans to use similar methods and reporting practices on future construction project assignments.

### **5.4.3 SR 68**

ADOT staff involved on this construction project were very pleased with the performance of the Ultra Panels without warning lights. Two individuals were interviewed and neither reported any concerns or issues associated with the Ultra Panels. Both indicated that they would prefer to use the Ultra Panels without warning lights on their next construction project, and would recommended the use of the Ultra Panels on other projects. This project was different from the other two projects because SR 68 is basically a rural route with little ambient lighting except at the west end of the project approaching Bullhead City.

The ADOT staff members felt this device had more reflective sheeting than a standard vertical panel. The sheeting used was Type III (high intensity), which they felt was very effective and easily seen at night. The hollow and stackable features of the Ultra Panel made them easier to work with than standard vertical panels. It was also stated that the Ultra Panel had a larger base and did not seem to fall over as often as previous vertical panels that were used. There were fewer calls from Police and other agencies to have the Ultra Panels reset on this project than on other past projects that used the standard vertical panels. The staff did not recall any specific complaints from the public or other sources regarding concerns about the visibility of the Ultra Panels. They also did not recall any issues or complaints regarding fog, rain, or snow adversely affecting the retroreflectivity of the Ultra Panels and obscuring the ability of motorists to see these devices. The limits of the construction zone and the edges of pavement were well defined with the use of the Ultra Panel.

The staff members interviewed did not support the use of steady-burn warning lights and felt on previous projects that the reflective sheeting tended to outperform the warning lights, especially as the battery life was diminished. Statements also indicated that the lights were hard to maintain, the batteries were continually wearing out, and that the Ultra Panel was just as visible without warning lights.

Both staff employees were also interviewed regarding the current practices of maintaining traffic control logs and documenting accidents in the construction zone. They felt comfortable with the current system and did not recommend any changes. Both individuals planned to use similar methods and reporting practices on future construction projects. It was their opinion that the accident reports prepared by the DPS officers are sufficient and there appears to be little benefit in ADOT maintaining an accident log or database to track accidents in construction zones.

#### **5.4.4 Other ADOT Staff**

The ADOT construction staff that were interviewed were all associated with the three design-build projects discussed above and had experience using the Ultra Panels without warning lights. Representatives from eight different ADOT field construction offices were also interviewed to determine if other ADOT staff had experience using vertical panels and/or the new Ultra Panel or experience using vertical panels and/or Ultra Panels without warning lights. There were some consistencies in the responses. None of these construction offices interviewed had used vertical panels without warning lights, but all stated experience with vertical panels, and about half had experience with the Ultra Panel. Some of the other responses received from the construction offices were:

- The use of vertical panels is preferred over Type II barricades because they are smaller and easier to work with, but have enough reflective area to be seen at night, especially when equipped with a warning light.
- There were concerns with the vertical panels being blown over by wind or gusts generated by high speed trucks. Those that had experience with the Ultra Panel cited

its wider base and greater stability as a benefit. It was also mentioned that it is harder to set up Type II barricades than vertical panels when sandbagging is required.

- Vertical panels tend to be hit by vehicles more than Type II barricades. Several reasons suggested for this were that the vertical panels may not be as imposing as Type II barricades so drivers tend to drive closer to them, and that vertical panels may be used in more restrained areas where drivers have to drive closer to them.
- These individuals stated a strong preference for the use of warning lights on channelizing devices, but especially on vertical panels which have a smaller target area for retroreflective sheeting than Type II barricades. Approximately half of those interviewed felt that steady-burn warning lights are beneficial during daytime and approximately half felt that the lights do not show up during daylight hours.
- None of the individuals that responded indicated weather conditions such as rain, dew, or snow as having caused visibility issues with the vertical panels or other channelizing devices. Most all of the respondents indicated that wind, either natural or truck caused, was an issue, but that proper sandbagging of the vertical panels and other traffic channelization devices tended to successfully address this concern. Keeping the traffic control devices clean and free of mud, dirt, and dust appeared to be a concern and a challenge.
- Generally it was preferred to use vertical panels rather than cones for short term or daylight traffic control.
- It was also mentioned that too much light might be a distraction to drivers, especially if several parallel lines of channelizing devices are used and every channelizing device is equipped with a warning light.

#### **5.4.5 Department of Public Safety**

The Department of Public Safety's (DPS) Metro Highway Patrol has responsibility for the interstates and freeways in the Phoenix metropolitan area, including I-17 and US 60. Informal inquiries within the Metro Highway Patrol concluded that several of the officers felt that the use of the Ultra Panels alone in these construction zones was adequate, and no additional benefit would have been derived from the addition of lights. Again, it is important to note that both the US 60 and I-17 corridors in the Phoenix Metropolitan Area are well lighted with high levels of ambient lighting.

#### **5.4.6 American Traffic Safety Services Association**

The ATSSA is an international association of companies and individuals involved in the roadway work zone traffic control agency. The Arizona Chapter of ATSSA provided a position statement regarding the use of steady-burn warning lights on vertical panels and other channelization devices in roadway work zones. This position statement is presented in its entirety in Appendix C of this report.

The conclusion of the ATSSA Position Statement states:

“The Arizona Chapter of ATSSA wants to be clear in its opposition to the removal of steady-burn lamps from vertical panels used to channel traffic in this State. Although the reasons for this suggested change, to what has historically been exemplar custom and practice in Arizona, have not been stated, Arizona ATSSA offers these thoughts and suggestions in the interest of common sense, reason and most importantly, safety.

“There should be no mistake that all members of Arizona ATSSA, as the very industry most knowledgeable and most impacted by this issue, unanimously disapprove of this proposed change. In support, ATSSA closes with the shared sentiments of its industry partner, 3M Company, in its recent letter to the ADOT State Traffic Engineer, dated March 22, 2002:

‘ . . . we feel that lights add another critical layer of protection and performance to work zone devices. . . . For night performance, the use of high brightness sheeting along with the use of lights creates a commanding work zone, with a clear and unambiguous motorist guidance.

‘We would urge you to continue the use of lights on these devices. . . . our position of support for lights is not a new one, . . .

‘We believe that now is the time to look to enhance safety, not to economize on safety enhancements. We join the Arizona ATSSA chapter and other industry members in our support of lights on work zone devices.’ ”<sup>(42)</sup>

#### **5.4.7 Summary**

The field reviews with ADOT staff yielded useful information. Staff experienced with the use of the Ultra Panel were very pleased with its performance without steady-burn warning lights. ADOT staff liked the Type III sheeting, which is available and frequently used on other traffic channelization devices. Two features that staff liked about the Ultra Panel, that are not available with other types of traffic channelization devices, is its hollow design that makes it stackable and the handle that makes it easy to maneuver.

Staff on three construction projects that used the Ultra Panel without steady-burn warning lights would recommend its use on other future construction projects, although staff on the I-17 project would only recommend its use in tangent sections and not in taper sections. This recommendation for future use without warning lights was limited to Ultra Panels or other devices with the same amount of reflective sheeting (minimum Type III sheeting) as the approved Ultra Panel. Staff associated with these three projects did not recall any specific complaints from the public or other sources regarding the visibility of the Ultra Panel used without steady-burn warning lights.

ADOT construction staff from other construction offices that had not used channelizing devices without the warning lights were less willing to support this concept. They agreed on the necessity to use warning lights to adequately designate the desired

travel path. Half of those interviewed also supported the use of the Type “C” warning lights during daylight lane closures. Staff reported a preference to use vertical panels over Type II barricades or cones, although staff did acknowledge that vertical panels seemed to be knocked over more often.

Informal inquiries within the DPS’s Metro Highway Patrol indicated support for the use of the Ultra Panels in the I-17 and US 60 construction zones without steady-burn warning lights.

The ATSSA has repeatedly stated their position to continue the use of steady-burn warning lights to ADOT on numerous occasions, including various ADOT and ATSSA partnering sessions. ATSSA strongly supports the use of warning lights for the safety of their personnel, for the safety of the workers in the work zones, and for the motoring public.

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## 6.0 RESULTS

The study and analysis portion of this project was divided into several distinct phases and tasks. The work efforts and results of these tasks are summarized in greater detail in the previous sections of this report. Some of the results from these work efforts include the following:

### 6.1 LITERATURE SEARCH

- NCHRP Report 236 recommends the use of steady-burn warning lights on channelization devices used in nighttime construction zones with Type III sheeting.<sup>(5)</sup>
- A report prepared by the Institute of Vehicular Safety addressed the needs of older drivers and the benefit that the warning lights provide these drivers. This report fully supports and stresses the need for the use of steady-burn warning lights on traffic channelizing devices.<sup>(6)</sup>
- A report prepared for ATSSA by KLD Associates concluded that Type “C” steady-burn warning lights should be considered on all channelizing devices used in work zones experiencing high-speed, poor visibility, inclement weather, or locations requiring complex maneuvers.<sup>(7)</sup>
- In 1989, the chairman of the State of Michigan DOT’s Construction Zone Review Team wrote an internal memo stressing the need for the State of Michigan to continue the use of steady-burn warning lights on traffic channelization devices.<sup>(8)</sup>
- The 3M Corporation has written letters to the States of Arizona, Florida, and Michigan encouraging the use of warning lights on traffic control devices. These letters state 3M’s official position supporting the use of steady-burn warning lights on traffic channelizing devices.<sup>(18)</sup>
- TTI Report 01-2293<sup>(9)</sup> and NCHRP 476<sup>(10)</sup> state that brighter sign sheeting increases the recognition and detection of traffic control devices sufficiently so that steady-burn warning lights are not needed on these devices.
- All of the reports suggested that flashing warning lights be used to mark hazards or dangerous locations, and that there may be instances where the use of steady-burn warning lights may be beneficial and their use should be considered.
- NCHRP 476 suggested a minimum sign reflectivity of Type III (also referred to as prismatic) for all traffic control signs. Type IV and Type V sheetings were also

recommended for use, but the higher sign visibility resulting from these sheetings may not be off-set by their considerably higher costs.

- NCHRP 476 also stated that warning lights and batteries used to power the lights may present a risk of broken windshields and potentially lethal flying objects if the light or battery were to become detached from the traffic control device during a collision.<sup>(35)</sup> In contrast to this statement, traffic control devices warning lights in use on roadways today with have passed the crash testing requirements represented in NCHRP 350.
- The new Ultra Panels, a type of vertical panel, have the potential for more area of reflective sheeting than typical vertical panels, although this additional sheeting is typically less than twelve inches above the roadway. These Ultra Panels are hollow, which makes them stackable, lighter, and equipped with a handle that makes them potentially easier to use in construction zones.<sup>(39)</sup>
- Recent developments in vision enhancement systems<sup>(11)</sup> and headlights<sup>(12,40)</sup> may improve driver ability to see traffic control devices, although nothing definitive was found on this subject.

## 6.2 SURVEY OF STATE DOTs

- Of the 34 responses to the survey, 22 agencies (65 percent) use vertical panels to channelize traffic in daytime construction zones and 19 agencies (56 percent) use vertical panels to channelize traffic in nighttime construction zones.
- With the exception of the Alberta DOT, no agency required the use of steady-burn warning lights on traffic control devices to channelize traffic. The Alberta DOT uses Type II barricades and drums with steady-burn warning lights, but not vertical panels or Type I barricades.
- Requirements for the use of steady-burn warning lights or the minimum required retroreflective sheeting do not vary between areas with established ambient lighting and areas without established ambient lighting.
- Type III sheeting was most often cited as the minimum level of retroreflective sheeting on channelization devices required by the state DOTs that responded to the survey.
- Only the Wisconsin Department of Transportation has prepared a final report that documented their study of the relationship between reflective sheeting and the use of warning lights on traffic control devices.

### **6.3 REVIEW OF MUTCD & ADOT TCS**

- ADOT has adopted the 1988 edition of the MUTCD and Revision 3, September 3, 1993, to Part VI,<sup>(1)</sup> which allows but does not require the use of steady-burn warning lights on channelization devices used to channelize traffic in construction zones.
- ADOT has adopted a supplement to the MUTCD which requires the use of steady-burn warning lights on channelization devices used to channelize traffic in construction zones. In June 2002, ADOT adopted a revision to this supplement that dropped the requirement for the use of steady-burn warning lights on channelization devices on roadways that are continuously lighted.
- The FHWA has updated the MUTCD, with the updated version titled the Millennium Edition, which also does not require the use of steady-burn warning lights on channelization devices used to channelize traffic in construction zones. Arizona has not yet adopted the Millennium Edition of the MUTCD.

### **6.4 ACCIDENT REPORTS**

- A total of the forty-three accidents on I-17 and three on US 60 involved vehicles striking a traffic control device. A review of these accident reports revealed only one instance where an individual reported being confused by the construction zone traffic control. The review did not find any instances where motorists stated that they were unable to see the traffic control device.
- Forty-four accident reports were reviewed for the SR 68 design-build project, representing all types of accidents reported in a construction zone or noted in the accident report as construction related. None of the accident reports suggested that the driver experienced difficulty with the traffic control, barricade devices, or an inability to the Ultra Panels use on this project.

### **6.5 INCIDENT REPORTS**

- Typically ADOT Construction Offices do not maintain separate incident logs for their construction projects but rely on the accident reports completed by DPS officers to document accidents within the construction zones.
- A review of the accident file and log maintained by the Motorist Assistance Program for SR 68 did not reveal any information regarding motorists being confused by the traffic control or inability to see the traffic control devices.

## 6.6 TRAFFIC CONTROL LOGS

- i A review of traffic control logs maintained by the US 60 ADOT construction staff did not reveal any information regarding motorists being confused by the traffic control or inability to see the traffic control devices.
- i A review of traffic control logs maintained by the SR 68 contractor did not reveal any information regarding motorists being confused by the traffic control or inability to see the traffic control devices.

## 6.7 CONSTRUCTION STAFF

- i ADOT staff involved with the I-17 construction project were pleased with the performance of the Ultra Panels used without steady-burn warning lights. There were no reported concerns or issues associated with the use of the Ultra Panels. The ADOT staff indicated that they would support the use of Ultra Panels without warning lights only in tangent sections on their future construction projects. They would recommended the use of the Ultra Panels on other construction projects. Several recommendations regarding the use of the Ultra Panel resulted from this project, specifically the use of a heavier base, the use of Type III reflective sheeting, the need to keep the devices clean, and the need for similar training for contractor and ADOT traffic control staff.
- i ADOT staff involved with the US 60 and SR 68 construction projects were very pleased with the performance of the Ultra Panels without steady-burn warning lights used on these projects. The individuals interviewed did not remember any concerns or issues associated with the Ultra Panels. They indicated that they would prefer to use the Ultra Panels without warning lights on their future construction projects, and would recommended the use of the Ultra Panels on other projects. These individuals indicated that adverse weather conditions did not significantly impact the visibility of the vertical panels. Staff from the US 60 project indicated their support for the use of traffic control devices without warning lights was limited to the use of the Ultra Panels or other devices with the same amount and type of reflective sheeting (minimum Type III) as the Ultra Panel.
- i ADOT staff from other ADOT construction offices were interviewed to determine their opinions regarding the use of channelization devices and warning lights. These individuals stated a strong preference for the use of warning lights on channelizing devices, but especially on vertical panels with a smaller target area for retroreflective sheeting than Type II barricades. About half of those interviewed felt that the use of steady-burn warning lights is beneficial during daytime construction and half felt that these lights are not very visible during daylight hours.

## **6.8 DEPARTMENT OF PUBLIC SAFETY OFFICERS**

- i Informal inquiries within the DPS's Metro Highway Patrol, which has responsibility for the interstates and freeways in the Phoenix metropolitan area, indicated support for the use of the Ultra Panels in the I-17 and US 60 construction zones without steady-burn warning lights.

## **6.9 AMERICAN TRAFFIC SAFETY SERVICE ASSOCIATION**

- i The ATSSA, an international trade association representing companies and individuals in the traffic control and roadway safety industry, supports the use of steady-burn warning lights on traffic channelization devices used for nighttime road closures. The Arizona Chapter of ATSSA echoes this position and has expressed their preference for the use of warning lights to ADOT on numerous occasions, including various ADOT and ATSSA partnering sessions. ATSSA strongly supports the use of warning lights for the safety of their personnel, for the safety of the workers in the work zones, and for the motoring public.

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- American Traffic Safety Services Association. *Policy Position Statements*. Fredericksburg, Va.: ATSSA, 2003.

## BIBLIOGRAPHY – WEBSITES

Following is a listing of websites that were reviewed during the course of this study but were not included or mentioned in the study text. They may be of interest to readers of this report.

- <http://www.fhwa.gov> – Website for Federal Highway Administration.
- <http://www.safety.tamu.edu> – Website for Texas A & M University.
- <http://www.tti.tamu.edu> – Website for Texas Transportation Institute, Texas A & M University.
- <http://www.dot.state.la.us> – Website for State of Louisiana DOT.
- <http://www.nmshtd.state.nm.us> – Website for State of New Mexico DOT.
- <http://www.dot.state.ut.us> – Website for State of Utah DOT.
- <http://www11.myflorida.com/trafficoperations/terl/apl/htm> – Website of interest.
- <http://www.dot.state.vt.us> – Website for State of Vermont DOT.
- <http://www.3M.com/tcm> – Website for 3M Corporation.
- <http://www.atssa.com/tcm> – Website for the American Traffic Safety Services Association.
- <http://www.okladot.state.ok.us> – Website for State of Oklahoma DOT.
- <http://www.nevadadot.com> – Website for State of Nevada DOT.
- <http://www.dot.state.ia.us> – Website for State of Iowa DOT.
- <http://www.dot.state.fl.us> – Website for State of Florida DOT.
- <http://safety.fhwa.dot.gov> – Website for FHWA.
- <http://www.ops.fhwa.dot.gov/wz/workzone.htm> – Website for FHWA.

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## **APPENDIXES**

A – List of Survey Respondents

B – List of ADOT Construction Offices Contacted

C – ATSSA Arizona Chapter Position Statement

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## Appendix A – List of Survey Respondents

<b>LIGHT USE STUDY QUESTIONNAIRE RESPONSES</b>		
	<b>STATE / PROVINCE</b>	<b>STATE AGENCY ADDRESS FROM SURVEY RESPONSE</b>
<b>1</b>	Alaska	Alaska Department of Transportation and Public Facilities 3132 Channel Drive Juneau, Alaska 99801
<b>2</b>	Alberta, Canada	Alberta Ministry of Transportation and Utilities 4999-98 Avenue Edmonton, Alberta T8A 5K4
<b>3</b>	Colorado	Colorado Department of Transportation 4201 E. Arkansas E.P. 770 Denver, CO 80222
<b>4</b>	Connecticut	Connecticut Department of Transportation P.O. Box 317546 Newington, CT 06131-7546
<b>5</b>	Idaho	Idaho Transportation Department, Traffic Group P.O. Box 7129, Boise, ID 83707-1129
<b>6</b>	Illinois	Illinois Department of Transportation 2300 S. Dirksen Pkwy. Springfield, Illinois 62764
<b>7</b>	Indiana	Indiana Department of Transportation 100 N. Senate Ave. - IGCN 925 Indianapolis, Indiana 46204
<b>8</b>	Iowa	Iowa Department of Transportation Office of Traffic and Safety 800 Lincoln Way Ames, Iowa 50010
<b>9</b>	Kansas	Kansas Department of Transportation, Traffic 217 SE 4 <sup>th</sup> Topeka, KS 66603
<b>10</b>	Maryland	Maryland Department of Transportation, SHA 7491 Connely Drive Hanover, Maryland 21076-1702
<b>11</b>	Massachusetts	Massachusetts Highway Department State Traffic Engineer's Office 10 Park Plaza Rm 7210, Boston, MA 021116
<b>12</b>	Michigan	Michigan Department of Transportation PO Box 30050 Lansing, Michigan 48909
<b>13</b>	Minnesota	Minnesota Department of Transportation 395 John Ireland Blvd St. Paul, Minnesota 55155
<b>14</b>	Mississippi	Mississippi Department of Transportation P.O. Box 1850, 76-01 Jackson, Mississippi 39215-1850

**LIGHT USE STUDY  
QUESTIONNAIRE RESPONSES – Cont.**

	STATE / PROVINCE	STATE AGENCY ADDRESS FROM SURVEY RESPONSE
15	Missouri	Missouri Department of Transportation P.O. Box 270 Jefferson City, MO 65102
16	Nebraska	Nebraska Department of Roads Traffic Engineering Division
17	Nevada	Nevada Department of Transportation 1263 Stewart Carson City, NV 89712
18	New Hampshire	New Hampshire Department of Transportation P.O. Box 483106 Concord, NH 03302-0483
19	New Mexico	New Mexico State Highway and Transportation Department P.O. Box 1149, Rm 209 Sante Fe, NM 87504
20	New York	New York State Department of Transportation State Campus – Bldg. 5 Albany, NY 12232
21	North Carolina	North Carolina Department of Transportation 1020 Birch Ridge Drive Raleigh, NC 27610
22	North Dakota	North Dakota Department of Transportation Planning Division 608 East Boulevard Avenue Bismarck, North Dakota 58505-0700
23	Oregon	Oregon Department of Transportation 355 Capitol St. N.E. - Room 222 Salem, Oregon 97301-3871
24	Pennsylvania	Pennsylvania Department of Transportation PO Box 2047 Harrisburg, Pennsylvania 17105-2047
25	South Carolina	South Carolina Department of Transportation 955 Park St., P.O. Box 191 Columbia, SC 29202
26	South Dakota	South Dakota Department of Transportation 700 E. Broadway Pierre, SD 57501
27	Tennessee	Tennessee Department of Transportation Thamland Drive, 400 James K. Polk Bldg Nashville, TN 37243-0333
28	Texas	Texas Department of Transportation 125 E. 11 <sup>th</sup> Street Austin, TX 78701
29	Utah	Utah Department of Transportation Address not provided in survey response
30	Virginia	Virginia Department of Transportation 1401 E Broad Street Richmond, VA 23219

**LIGHT USE STUDY  
QUESTIONNAIRE RESPONSES – Cont.**

	STATE / PROVINCE	STATE AGENCY ADDRESS FROM SURVEY RESPONSE
<b>31</b>	Washington	Washington State Department of Transportation PO Box 47344 Olympia, Washington 98504-7344
<b>32</b>	West Virginia	West Virginia Division of Highways Traffic Engineering Division Bldg 5, Room 5, 1900 Kanawha Blvd East Charleston, WV 25305
<b>33</b>	Wisconsin	Wisconsin Department of Transportation Bureau of Highway Operations PO Box 7986 Room 501 Madison, Wisconsin 53707-7986
<b>34</b>	Wyoming	Wyoming Department of Transportation 5300 Bishop Blvd. Cheyenne, WY 82009

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## **Appendix B – List of ADOT Construction Offices Contacted**

- Benson Construction Organization, Safford District
- Casa Grande Construction Organization, Tucson District
- Catalina Construction Organization, Tucson District
- Fourth Street Construction Office, Flagstaff District
- Globe Construction Organization, Globe District
- Kingman Construction Organization, Kingman District
- Rincon Construction Organization, Tucson District
- Santa Rita Construction Organization, Tucson District
- Yuma Construction Organization, Yuma District

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## **Appendix C – ATSSA Arizona Chapter Position Statement**

**AMERICAN TRAFFIC SAFETY SERVICES ASSOCIATION  
(ATSSA) of ARIZONA, Inc.  
2/19/03**

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**ATSSA of Arizona's Position Statement re: ADOT's Commissioned Study  
(a.k.a. Final Report 554) Re: Use of Steady Burn Lights on Vertical Panels**

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**AMERICAN TRAFFIC SAFETY SERVICES ASSOCIATION  
(ATSSA) of ARIZONA, Inc.  
2/19/03**

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**6.4.6 ATSSA of Arizona's Position Statement re: ADOT's Commissioned Study  
(a.k.a. Final Report 554) Re: Use of Steady Burn Lights on Vertical Panels**

**INTRODUCTION**

The American Traffic Safety Services Association ("ATSSA") is a national organization made up of individuals and organizations experienced, and working, in the traffic control industry, whose primary objective is to achieve and maintain the safest conditions possible within the common conditions that are roadway detours and construction zones. ATSSA's commitment to safety not only serves the motoring public, but also the construction industry professionals that work every day (and night) within roadway construction zones to maintain and improve roads all across the country.

As stated in its mantra, "SAFER ROADS SAVE LIVES," ATSSA places safety above all else! It is with this mission in mind that the Arizona Chapter of ATSSA hereby respectfully submits this position statement . . . **in opposition** . . . to any attempts by the Arizona Department of Transportation ("ADOT") to lessen Arizona's historic custom and practice of requiring steady burn lights on all vertical panel traffic control set-ups.

It is currently unclear to ATSSA, why ADOT is pursuing this course. Absent any specifically stated reasons, which have not been offered to ATSSA, the only two motivators that ATSSA has been able to extract from a preliminary review of Report 554 are: (1) cost savings, and (2) convenience resulting from ADOT's acquaintance with a newly designed vertical panel called the "Ultra Panel."

This position statement will attempt to demonstrate that in this context, concerns for public and worker safety should always outweigh concerns regarding minor cost savings and potential personal convenience.

**MUTCD**

The Manual on Uniform Traffic Control Devices ("MUTCD") For Streets and Highways is issued by the U.S. Department of Transportation, Federal Highway Administration ("FHWA"), which codifies the ". . . *uniform standards for traffic control during construction and maintenance operations on streets and highways in the United States.*" It is presumed that ADOT, as well as all others involved in this current issue, is sufficiently familiar with the MUTCD, including its definitions and application of the terms "*shall*" (mandatory), "*should*" (advisory) and "*may*" (permissive). See, MUTCD

1A-5. Therefore, only brief discussion regarding the MUTCD is contained herein, which ATSSA believes is necessary to establishing the fundamental baseline for this opposition.

“Traffic control devices are used to direct and assist vehicle operators in the guidance and navigation tasks required to traverse safely any facility open to the public.” See, MUTCD 1A-1, Purpose of Traffic Control Devices. The MUTCD clearly intends to serve the safety of motorists and workers:

## 6A. INTRODUCTION

. . . Effective temporary traffic control must provide for the safety of workers, road users, and pedestrians. At the same time, it must provide for the efficient completion of whatever activity suspended normal use of the roadway.

See, MUTCD, 6A.

## 6B. FUNDAMENTAL PRINCIPLES

1. Traffic safety in temporary control areas should be an integral and high priority element of every project . . . maintenance and utility work should be planned and conducted with the safety of motorists, pedestrians and workers kept in mind at all times.

See, MUTCD, 6B.1.

The MUTCD also provides that, “*Adequate warning, delineation, and channelization by means of proper pavement marking, signs, or use of other devices that are effective under varying conditions of light and weather **should** be provided where appropriate to assure the driver and pedestrian of positive guidance before approaching and while passing through the work area.*” (Emphasis added.) See, MUTCD, 6.B.3.a.

See also, MUTCD 6D-2, **WORKER SAFETY CONSIDERATIONS**, stating:

Of equal importance to the safety of the public traveling through the temporary traffic control zone is the safety of the worker . . . within the work site. . . these work area conditions almost always present situations that are more confusing for the driver. This creates an even higher degree of vulnerability for the personnel [worker] on or near the roadway.

Following the Fundamental Principles noted above in Section 6B will usually provide the degree of control and traffic operation that will bring about safe conditions for the worker. Of particular importance is maintaining work areas with traffic flow

inhibited as little as possible, providing standard and clear traffic control devices that get the driver's attention and provide positive direction.

(Emphasis added.)

ADOT's current concern is over the use of steady burn lights with vertical panels, as channelizing devices. The MUTCD specifically states that, "*[T]he function of channelizing devices is to warn and alert drivers of conditions created by work activities . . . to protect workers . . . and to guide drivers and pedestrians safely.*" (Emphasis added.) See, MUTCD, 6F-5.a. This section of the MUTCD goes on as follows:

Warning lights on channelizing devices. Consideration should be given to fog, or snow areas, severe roadway curvature, and usually cluttered environments. . . . Warning lights on channelizing devices used in a series **shall be** steady burn.

\* \* \*

Channelizing devices are elements in a *total system* of traffic control devices for use in temporary traffic control zones.

Note: Arizona weather expands the listed conditions above to include dust and dew on reflective surfaces.

Vertical panels are channelizing devices whose **minimum** design specifications are expressly mandated by the MUTCD at Ch. 6F-5.d (1). See also, MUTCD Figure VI-10. As for their intended use, "*Vertical panels may be used to channel traffic, divide opposing lanes of traffic, divide traffic lanes or in place of barricades where space is limited.*" See, MUTCD 6F-5.d (2). Clearly, vertical panels are contemplated as part of an overall temporary traffic control system in areas of high volume work and/or motorist activity, making their importance obvious.

Lighting devices are a necessary added part of the overall traffic control system involved in channelizing traffic. Separate and apart from the vertical panel, the MUTCD recommends that lighting devices, including steady burn lights, be used because, "*[T]emporary traffic control activities often create conditions on or near the traveled way that are particularly unexpected at night, when drivers visibility is sharply reduced. It is often desirable and necessary to supplement retroreflectorized signs, barriers, and channelizing devices with lighting devices.*" (Emphasis added.) See, MUTCD 6F-7.a.

The MUTCD specifically proscribes the benefits and advantages of steady burn lights when channelizing traffic:

As used herein, steady-burning electric lights shall mean a series of low wattage yellow electric lights. . . . if lights are needed to delineate the traveled way through and around obstructions in a

temporary traffic control zone, the delineation **shall** be accomplished by steady burning lights.

Steady burning lights, placed in a line on appropriate channelizing devices, are effective in delineating the proper vehicle path through temporary traffic control zones that require changing patterns or traffic movement. Steady burning lights are also used on detours, on lane closures, when the roadway alignment changes in tapers, and other situations where the head lights do not provide retroreflection to delineate the intended vehicle path.

(Emphasis added.) See, MUTCD 6F-7.d.

If common sense were not enough, the MUTCD makes it clear that, although not an absolute requirement, steady burn lamps are imperative in achieving the highest level of safety when channelizing traffic.

## **VERTICAL PANELS AND LIGHTS AS A SYSTEM**

As noted by the MUTCD sections above, the vertical panels and lighting devices used for channelizing traffic act together as a complete *system* to better guide motorists through temporary traffic control. The steady burn lights are not duplicative or redundant and do not serve the same function as the required reflective sheeting on the face of the vertical panels or channelizing devices.

Reflective sheeting is designed and intended to bounce direct light back at the source, which is what gives it visibility to oncoming drivers; hence the term “retroreflectivity.” The reflective sheeting is dependent on a direct light source for its visibility. A vertical panel in complete darkness, with no light source such as a vehicle head light, is simply not visible.

Steady burn lights, however, provide independent visibility to anyone, even in complete darkness. By design they are visible up to 3000 feet away, which offers oncoming drivers early warning of a work zone. Assuming a light source, reflective sheeting’s visibility from a distance varies. However, even in the best conditions it is never visible from nearly as far away as lights.

Additionally, steady burn lights provide their own obvious benefits when drivers forget to engage their head lights. Typical examples of this common occurrence are when the sun sets while one is driving and when impaired motorists take the road, often forgetting to turn their head lights on. Because the reflective sheeting and the steady burn lights act separately and serve different functions as part of an overall system, the lights ensure visibility when anything compromises the quality or effectiveness of the reflective sheeting such as forgetful or careless drivers, weather, damage and routine wear.

Other benefits/considerations that distinguish the reflective sheeting from the lights include the sight path created by the steady burn lights. Particularly in curving detours, the sight path created by the steady burn lights provides better and earlier guidance for motorists, particularly at night. It goes without saying that these benefits are even greater, and more important, when the driver's vision is impaired by substance or simply compromised by age.

## **ARIZONA'S CUSTOM AND PRACTICE**

For over 40 years, Arizona has admirably held its bar higher than the MUTCD's stated standards in regards to the use of steady burn lights on vertical panels used for channelizing. The MUTCD recommends the use of steady burn lights on all channelizing devices. ADOT has always made steady burn lights a requirement on all channelizing nighttime set-ups.

Consequently, ADOT has always achieved the highest level of motorist/worker safety within these zones and has always given motorists the benefit of every opportunity for proper visibility and comprehension while navigating within these work zones. For ADOT to now lower its level of service and performance and clearly lessen the level of assistance that motorists and workers have come to expect in Arizona, a state where roadway construction both in day and night is prevalent, is simply unthinkable.

## **RESEARCH**

Final Report 554 presumably contains the results of the research performed by DMJM+HARRIS for ADOT on this important issue. As of the submittal of this position statement ATSSA has not reviewed the true final draft of this report. Therefore, comment on the sufficiency of the facts gathered, research performed and analysis offered in Final Report 554 are reserved for appropriate comment at a later time. That notwithstanding, ATSSA urges that before completion and submission, Report 554 explore and consider the following materials that are attached hereto, which constitute some of the materials that ATSSA has been able to compile in the very short time that it was given to provide this submission:

### **A. Michigan DOT Office Memo (10/23/89)**

In this memorandum, MDOT's Construction Staff Engineer addresses the important and continued need for steady burn lights on channelizing devices as part of an overall traffic control *system*, particularly when the device (a barrel in this case) loses its reflective quality (mud splatter in this case).

The point made here is that the overall system provides drivers and workers with every opportunity to be safe, under all reasonably foreseeable circumstances.

## **B. Institute of Vehicular Safety Report (2/4/92)**

In early 1992, the Institute of Vehicular Safety prepared a Report for the Ohio DOT, authored by the Institutes founder, Dr. Bernard S. Abrams, which is attached. In that study, Dr. Abrams stated that, “*The current ruling (by ODOT) of removing steady burn lights violates human factors, visibility, the older driver and nighttime vision to mention a few.*”

Dr. Abrams report speaks, in part, to the invaluable assistance that steady burn lights offer older drivers which is both applicable in Arizona and equally analogous to any driver that has sight limitations either by age, weather or substance impairment. Dr. Abrams reiterates the independent function of steady burn lights and, in addition to the weather concerns noted in the MDOT memo above, he sites the following as reasons in support of steady burn lights: increased vehicular depth perception; early pathway warning and guidance; backup for missing headlights; increased driver perception reaction time; added guidance to older drivers; and visibility from approximately 3000 feet. Dr. Abrams further summarizes:

In summation, use of type “C” warning lights is an excellent, inexpensive system that needs no change in Federal Regulations. In this author’s opinion it has and will continue to contribute to saving lives and injuries.

## **C. KLD Associates, Inc. Study (6/92)**

In yet another 1992 study prepared by KLD Associates for ATSSA’s Fredericksburg, Virginia chapter entitled, “Steady Burn Warning Lights,” the use of steady burn lights is strongly promoted. In that study, KLD Assoc. concluded that steady burn lights: (1) positively influenced driver behavior at distances greater than 1200 feet, producing a higher percentage of correct responses than when no lights were used; (2) the rate of decline in driver responses was far more pronounced at distances over 1000 feet for devices with no lights, than for devices with steady burn lights; (3) older drivers recorded significantly less accurate responses than did younger drivers in all lighting treatments; and (4) the use of steady burn lights resulted in more correct responses by older drivers.

## **D. ATSSA of Florida Letter (12/29/94)**

In 1994 the Florida chapter of the ATSSA addressed this same issue with FDOT reiterating the priority of safety! That letter and its enclosures are also attached. That letter could just as easily apply as written, to Arizona’s chapter of ATSSA, finding itself in the same situation herein. There, Florida ATSSA urged:

The traffic safety industry does not want to see the increase in work zone deaths and injuries which will surely result if proper lighting is not used. Decisions which weaken safety can only

result in litigation, investigations, recriminations, embarrassment and negative media publicity. Such is not the station to which a nationally respected Florida Department of Transportation should descend.

Clearly, Arizona is in large part a retirement and “snowbird” state (much like Florida) where the elderly come to spend winters, if not retire altogether. They alone represent a significant segment of the Arizona driving population that has come to expect and rely on the heightened standards for roadway visibility that Arizona has always practiced. The sentiments of the Florida chapter of ATSSA cited above are strongly shared by its Arizona chapter.

**E. 3M Company Letter (11/2/95)**

On November 2, 1995, 3M Company, through an area sales supervisor, went on record stating the *“position of 3M’s Traffic Control Material Division on the use of steady burn lites as a component of barricades . . .as traffic control devices in construction zones.”* 3M’s remarks included:

*“We have stated and continue to do so that traffic control must be viewed as a system. No one component should have precedence over another.”*

*“. . . steady burn lites are a desired component of barricades . . . , and should be incorporated as a system feature of these devices.”*

*“This combination of reflective sheeting and lighting provides the most effective system approach to these types of traffic control devices.”*

**F. Bob’s Barricades, Inc. Letter (10/25/98) / Broward County Letter (11/16/98)**

On October 25, 1998, Bob’s Barricades owner, Mr. Happy Alter, weighed in on this topic as Florida was again visiting this same issue. The passion and zeal in the industry’s opposition to the removal of steady burn lights from channelizing devices is captured by Mr. Alter, who wrote, *“Removal of steady burn lights is a silent killer on our streets and highways.”* As you can see, Mr. Alter is also aware at that time of 3M’s position stated above.

In response to Mr. Alter’s letter, the Broward County Board of Commissioners wrote back reiterating the concerns for the elderly drivers discussed above, but also confirming a finding that the cost savings, if that is the motivation for removing steady burn lights, is inconsequential: *“As I understand what is being proposed, there is not any consequential cost saving in the elimination of the steady burn lights.”*

## **G. Input From Arizona Municipalities / General Contractors / Experts**

If ADOT decides, at the conclusion of this process, to effectively “lower the bar” on ADOT projects, by not requiring steady burn lights on vertical panels used as channelizing devices, it will create an environment of inconsistency within the state of Arizona. Each municipality within Arizona has its own traffic engineering department which reviews, approves and issues the permits for traffic control within its town or city limits. ATSSA strongly believes, based on informal communications, that many of those towns will still require steady burn lights on vertical panels, notwithstanding the State’s decision to lessen that practice standard.

ATSSA simply suggests that input from each of the Arizona municipalities, with whom the general contractors and traffic control companies have to deal with, be sought and considered in this evaluation process. ATSSA also feels that the input of general contractors, perhaps through the Arizona Chapter of the Association of General Contractors (“AGC”), and of qualified human factors experts should be included in this research, if it has not already been solicited and considered in the study.

### **OTHER REASONS ATSSA OPPOSES REMOVAL OF STEADY BURN LIGHTS**

ATSSA’s commitment is to safety above all other issues. The following is a list of additional reasons (in no particular order of importance) why ATSSA vehemently opposes removing steady burn lights from vertical panels:

#### **Common Sense**

More light means earlier detection! More light means more visibility!  
More light means better guidance! More light means less confusion! More light means fewer accidents! More light means less injured drivers! More light means less injured workers! More light means less damaged work zones! More light is simply safer.

Moreover, ATSSA is unaware of any researched findings that would suggest that having steady burn lights on vertical panels used in channelizing creates confusion or otherwise increases danger to workers or drivers.

#### **Cost**

At least one jurisdiction (Broward County, Fla.) cited above has presumably looked at the issue of cost savings and concluded, not only that this would be an inconsequential amount, but also that the obvious interest in providing the safest roads possible for drivers and construction workers, far outweighs any interest in monetary gain . . . as it rightfully should. In fact, the cost of operating the lights is a fraction of what it used to be before the introduction of the LED technology, which has also enabled the size and weight of the light to be reduced.

ATSSA implores ADOT to resist any temptation to make this decision based on dollars saved, which will certainly prove to be a short sighted approach, given some of the discussion that follows.

### **Liability / Litigation**

If the incidence of accidents rises, as it will surely do with less lights, less guidance through work zones and more confusion (particularly for the substance impaired and elderly) injury or death law suits will increase. Consequently legal defense and indemnification dollars paid by construction defendants, including the State, will increase. Just one serious injury or wrongful death verdict/settlement stemming from an inadequate lighting or confusion theory can immediately cost hundreds of thousands (if not millions) of dollars. That one verdict or settlement alone will likely exceed the amount of any costs saved on the project by not having to pay for steady burn lights on the equipment.

Also, currently, general contractors and sub-contractors are routinely required to defend and indemnify the State in law suits filed against the State that arise out of the operations of the general or sub contractors. If the State, through ADOT, makes the decision to remove steady burn lights from vertical panels, it is foreseeable that many law suits, where an inadequate lighting theory is alleged, will no longer be accepted by the general or sub contractors upon tender by the State, thus forcing the State to incur yet more expense to litigate, not only the underlying injury or death suit, but now potentially an indemnification action. Even if the State prevails in the injury or death law suit, its out of pocket expense may greatly exceed the dollars it saves by this decision.

Before changing the standard practice in Arizona, ATSSA strongly urges ADOT to consult with the Attorney General's office, or other legal counsel to explore these potential ramifications, which if true, will only serve to polarize the State and its construction partners.

### **Driver Expectations**

For years, drivers and workers in Arizona have come to expect and rely on the high quality of guidance and security provided by this State's construction and traffic control industry. To now remove part of what has become a familiar and expected tool in temporary traffic control, which is prevalent in this growing State, will likely result in more hazards, more accidents and more damage by creating a condition that Arizona drivers do not expect.

### **NCHRP Compliance**

The newly designed lighter weight steady burn lamps comply with all of the requirements of the NCHRP 350 test for crash worthiness. Previous concerns that the steady burn lamp fixtures affixed to vertical panels or barricades became deadly or harmful projectiles in accidents are no longer applicable.

## Less Equipment Damage

Because of their less imposing nature, vertical panels are more apt to be struck in a work zone more frequently than the more substantial devices, such as Type II Barricades. The steady burn lamp fixtures make the vertical panels more conspicuous and even provide added reflective quality in day time hours via the reflective ring that is designed around the perimeter of the lens to enhance its visibility.

## CONCLUSION

For all of the reasons stated above, the Arizona chapter of ATSSA wants to be clear in its opposition to the removal of steady burn lamps from vertical panels used to channel traffic in this State. Although the reasons for this suggested change, to what has historically been exemplar custom and practice in Arizona, have not been stated, Arizona ATSSA offers these thoughts and suggestions in the interest of common sense, reason and most importantly, safety.

There should be no mistake that all members of Arizona ATSSA, as the very industry most knowledgeable and most impacted by this issue, unanimously disapprove of this proposed change. In support, ATSSA closes with the shared sentiments of its industry partner, 3M Company, in its recent letter to the Arizona State Traffic Engineer, dated March 22, 2002:

. . . we feel that lights add another critical layer of protection and performance to work zone devices. . . . For night performance, the use of high brightness sheeting along with the use of lights creates a commanding work zone, with clear and unambiguous motorist guidance.

\* \* \*

We would urge you to continue the use of lights on these devices. . . . our position of support for lights is not a new one, . . .

\* \* \*

We believe that now is the time to look to enhance safety, not to economize on safety enhancements. **We join the Arizona ATSSA chapter and other industry members in our support of lights on work zone devices.**

ATSSA, Arizona Chapter  
2/19/03