

| | | | |
|--|--|---|---|
| Report No. ABTR/RD/RR-05/01 | Subject Area Highway and Construction Maintenance Equipment | Project No. 8454-04001 | Report Date October, 2005 |
| Title Snowplow Rear Lighting Research Project | | | Type of Report Public |
| Author(s) D. Paulichuk Alliant Engineering and Consulting Ltd. #200, 18311 - 105 Avenue Edmonton, AB, T5S 2K9 Telephone: (780) 488-8292 | | | No. of Pages Report – 44 Pages Appendices A to F |
| Performing Organization Name and Address Alliant Engineering and Consulting Ltd. #200, 18311 - 105 Avenue Edmonton, AB, T5S 2K9 | | Sponsoring Agency Name and Address Alberta Infrastructure and Transportation Technical Standards Branch 2 nd Floor, 4999 – 98 Avenue Edmonton, AB T6B 2X4 | |
| Supplementary Notes | | | |
| Abstract This study was undertaken to help improve the safety of snowplow vehicles by enhancing the rear lighting visibility to approaching drivers. This research project conducted field trials testing some of the recent developments in lighting technology. New specifications recommended from this study will help both the department and the maintenance contractors in providing improved lighting for visibility of the snowplow vehicles to motorists. | | | |
| Key Words | | Distribution | |
| | | Project Co-ordinator Peter Ing | |

ALBERTA TRANSPORTATION

DISCLAIMER

The opinions, findings and conclusions expressed in this report are those of the author. The contents do not necessarily reflect the official view or policies of the Government of Alberta. This report does not constitute a standard, specification or regulation.

The Government of Alberta does not endorse products or manufacturers. Trade or manufacturer's names appear herein only because they are considered essential to the object of this document.

SNOWPLOW REAR LIGHTING RESEARCH PROJECT



FINAL REPORT

October 2005



SNOWPLOW REAR LIGHTING RESEARCH PROJECT FINAL REPORT



for



October 2005

EXECUTIVE SUMMARY

On behalf of Alberta Infrastructure and Transportation, Alliant Engineering and Consulting Ltd. has completed a detailed review of the Rear Warning Lights used on snowplow trucks in the province of Alberta.

The following report and recommendations made within are based on the information gathered during conversations with suppliers and contractors, a literature review, a highway jurisdictional survey and field trials of various light configurations during actual snowplowing operations.

This project was undertaken to help improve the safety of snowplow vehicles by ensuring that the rear lighting was visible to approaching drivers. This project was also designed to test some of the recent developments in lighting technology.

Since the last review of the snowplow rear warning lights (1980's), major advancements have been made in lighting technologies. These advancements include the continuing emergence of LED lights as an alternative to traditional fluorescent and filament bulbs. The materials from which the lights are constructed have produced much more reliable and brighter warning beacons.

Based on the information gathered during this project, Alliant has made several recommendations regarding the existing warning lighting and the addition of new lighting:

- The existing Stop-Tail-Turn lights, Backup lights and the Rear Identification Lamps will be replaced with LED lighting. This recommendation was made after viewing the existing lights beside the LED lights.
- The existing centre beacon will be upgraded to a Dual Rotating Amber Beacon. It is recommended that both the rear and front beacons be replaced with a dual rotating amber beacon.
- The warning lamps currently in place at the corners of the truck above the box have also been replaced. Amber Red LED Warning Lights will be installed at these locations instead. These new lights were viewed during the field trials and were brighter and more visible than the existing lights, under a variety of weather conditions.
- Additional new elevated Stop-Tail-Turn and Backup lights have also been recommended. These lights are modelled after the current lighting standard used in the province of Saskatchewan. These new lights will be LED lamps, and will be the same size and colour as the existing Stop-Tail-Turn and Backup lights

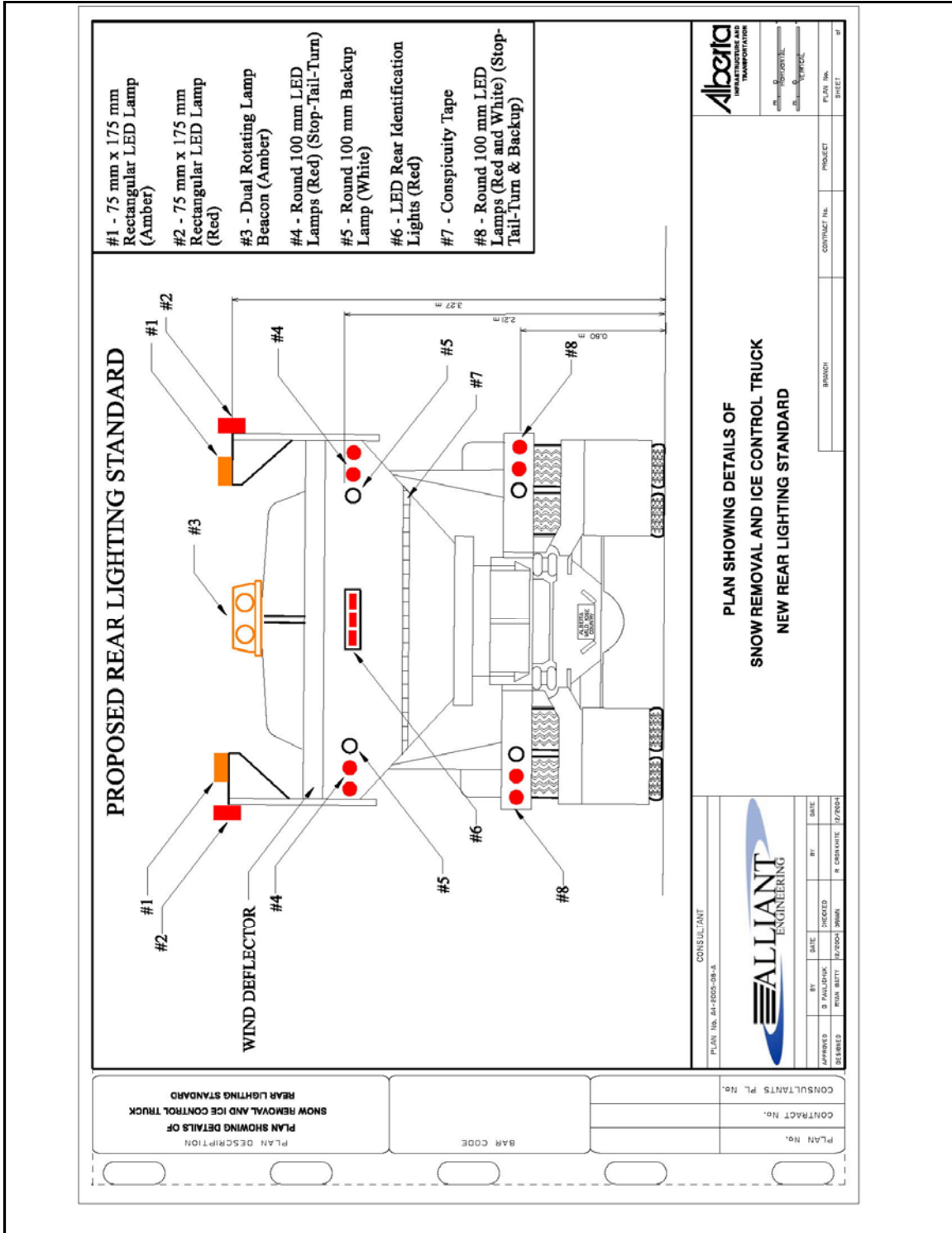
located on the bumper of the snowplow. These lights will help alert drivers following the snowplow of changes in the speed or movement of the snowplow.

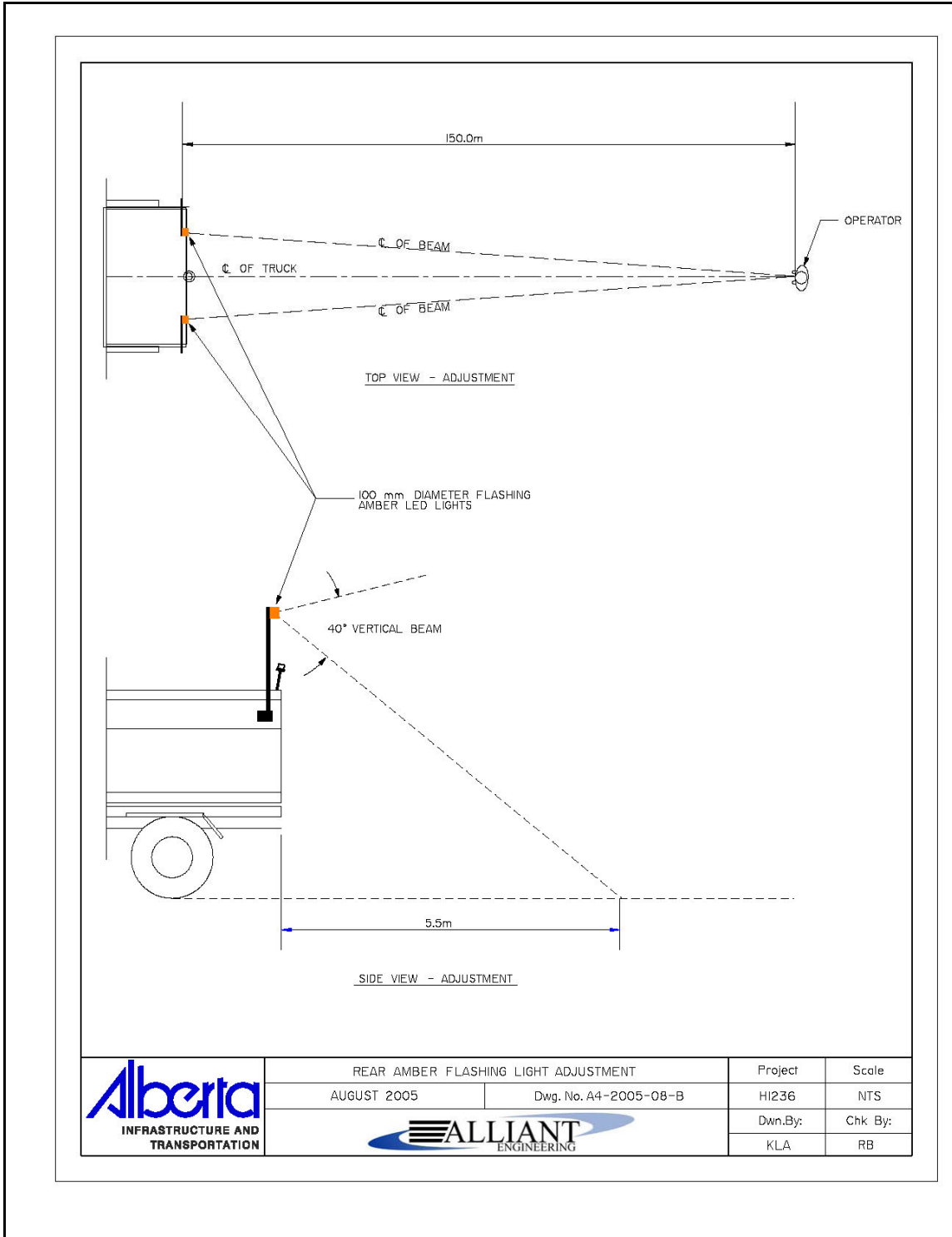
- In addition to the changes to the standard lighting, two strips of reflective tape are recommended to be placed on the back of the snowplow box. This tape will be illuminated by the headlights of approaching vehicles, thus adding another level of warning for drivers.
- A wind deflector has also been recommended for the rear of the snowplow. The wind deflector will be mounted above the box of the snowplow and will help keep the rear warning lights free from snow build-up. This is now especially necessary since the lights on the box are to be LED's.

Drawings summarizing the new lighting standard can be found on Pages iii & iv. Drawings of the old standard are shown on Pages v, vi & vii.

New specifications were developed from these recommendations and should aid both the owner and maintenance contractors in providing improved lighting for being more visible to motorists. These specifications are specific, but general enough to allow several manufacturers and suppliers opportunities to provide lighting. Lighting types and locations will provide a standard across the province that delivers distinction and safety for clearing snow off of highways.

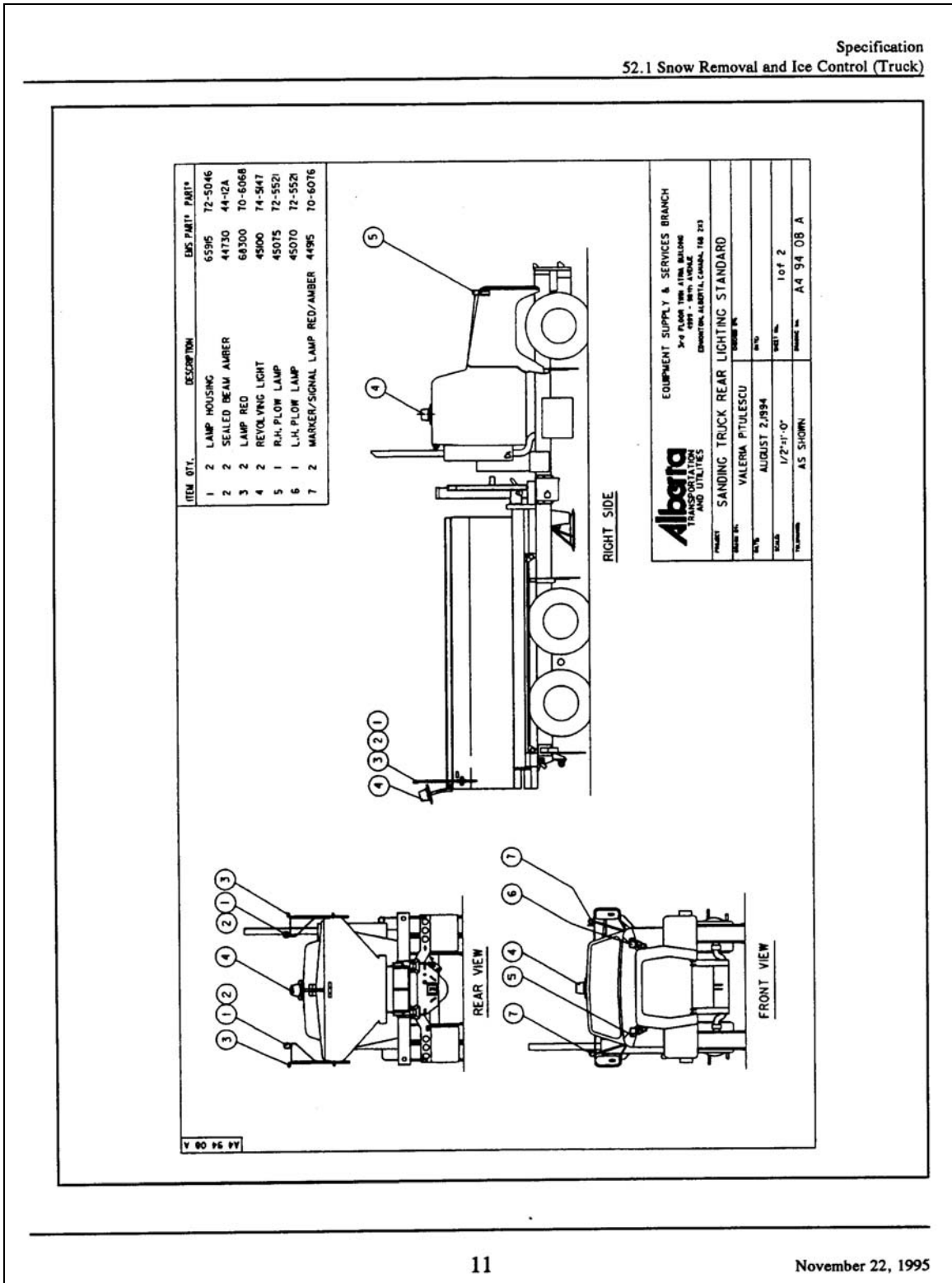
PROPOSED NEW LIGHTING STANDARD





EXISTING LIGHTING STANDARD

Specification
52.1 Snow Removal and Ice Control (Truck)



Specification
52.1 Snow Removal and Ice Control (Truck)

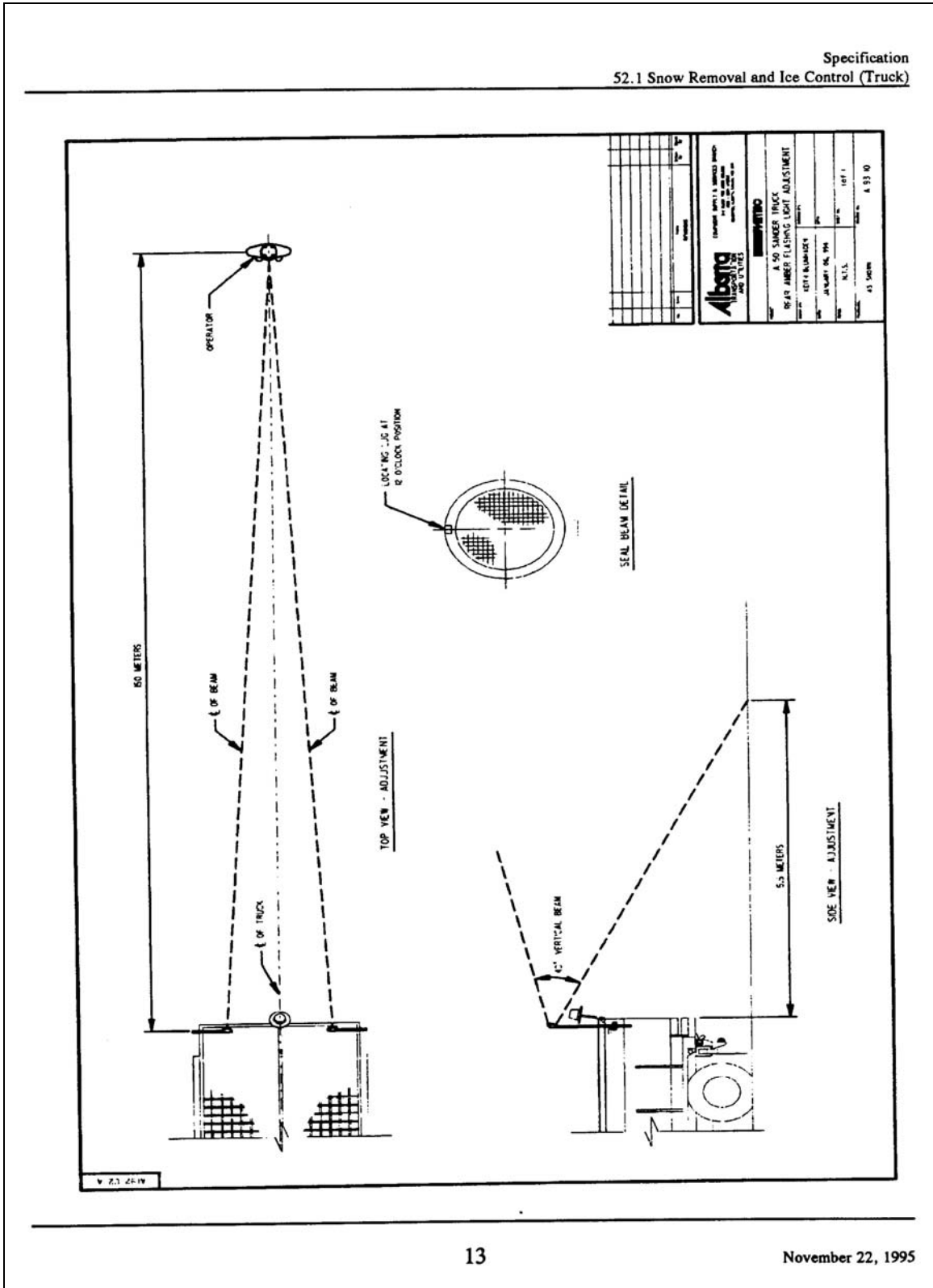


TABLE OF CONTENTS

| | |
|--|------------|
| <i>EXECUTIVE SUMMARY</i> | <i>i</i> |
| <i>PROPOSED NEW LIGHTING STANDARD</i> | <i>iii</i> |
| <i>EXISTING LIGHTING STANDARD</i> | <i>v</i> |
| 1. INTRODUCTION | 1 |
| 2. BACKGROUND | 1 |
| 2.1 Current Specification | 2 |
| 3. SNOWPLOW REAR LIGHTING STANDARDS REVIEW | 2 |
| 3.1 Website Review | 3 |
| 3.2 Literature Review | 3 |
| 3.2.1 Research Paper – “Rear Lighting Configuration for Winter Maintenance Vehicles” | 3 |
| 3.2.2 Research Paper –“Improved Visibility for Snowplow Operations” | 5 |
| 3.3 Highway Jurisdictional Survey | 6 |
| 3.4 New Technologies | 8 |
| 3.4.1 Light Emitting Diodes (LED)..... | 8 |
| 3.5 Lighting Regulations | 11 |
| 3.6 Lighting Manufacturing | 13 |
| 3.6.1 Beacons | 13 |
| 3.6.2 LED Lights..... | 15 |
| 4. EVALUATION STRATEGY & REAR LIGHTING CONSIDERATIONS | 15 |
| 4.1 Evaluation Scope | 19 |
| 4.2 Performance Standards | 19 |
| 4.3 Development of Lighting Trials | 20 |
| 4.4 Lighting Configurations | 21 |
| 4.4.1 Stop, Tail & Turn Lights | 21 |
| 4.4.2 Beacons | 21 |
| 4.4.3 Additional Lights..... | 23 |
| 5. FIELD DEMONSTRATIONS | 26 |
| 5.1 Visit No. 1 - March 20, 2005, Day | 29 |
| 5.2 Visit No. 2 - March 21, 2005, Night | 31 |
| 5.3 Visit No. 3 - March 22, 2005, Night | 32 |
| 5.4 Visit No. 4 - March 22, 2005, Day | 33 |
| 6. RECOMMENDATIONS | 34 |
| 6.1 Recommendations & Discussion | 34 |
| 6.2 Power & Cost Implications | 38 |



| | | |
|----|---|----|
| 7. | <i>NEW STANDARD SPECIFICATION</i> | 40 |
| 8. | <i>CONCLUSION</i> | 43 |
| 9. | <i>CLOSURE</i> | 44 |

| | |
|--------------|--------------------------------------|
| APPENDIX A - | PHOTOS |
| APPENDIX B - | PHASE ONE PRESENTATION |
| APPENDIX C - | RESEARCH PAPERS |
| APPENDIX D - | JURISDICTIONAL SURVEY RESPONSES |
| APPENDIX E - | FIELD TRIAL INFORMATION |
| APPENDIX F - | CURRENT STANDARDS AND SPECIFICATIONS |

1. INTRODUCTION

Alberta Infrastructure and Transportation (AI&T) retained the service of Alliant Engineering & Consulting Ltd. (Alliant) to complete a review of the rear lighting standards for snowplow vehicles within the province of Alberta.

This project is in reaction to two main issues associated with snowplow operations. Firstly, requests from maintenance contractors to use new lighting technologies, which vary from the existing standards. Secondly, ensuring that the warning lights are sufficient to allow drivers to recognize the snowplow and react to it. The findings contained in this report will result in new standards that will be implemented on all snowplow vehicles within the province.

To complete this report Alliant has performed the following tasks:

- literature review
- North American highway jurisdictional survey
- determination of performance standards
- identification of new equipment to be tested
- plan and perform field trials
- presentation to an evaluation panel

All of these tasks will be discussed in more detail later in the report.

The initial phase of this project was from September 2004 to January 2005. This phase included gathering all applicable information, completing the jurisdictional survey and preparing for the field trials. The field trials were completed in March 2005, after which, the final phase of the project began. Evaluating the trials and finalizing the report, were the major aspects of this phase.

2. BACKGROUND

Snowplows are used on the provinces highways for snow removal and ice control. This work is typically completed under adverse weather conditions (i.e. during a snowstorm) and as such, can be quite dangerous. Therefore, the rear warning lighting used on snowplow trucks is very important, for the safety of both the operator and other drivers on the highway.

Prior to the initiation of this review, the last review of the specification for snowplow operations had been completed in November of 1995. The prior review was undertaken

as a result of a large number of rear end collisions involving snowplows. It was at that time that the current standard of red and amber warning lights was instituted, and a large-scale public awareness campaign was initiated. The public awareness campaign was centred on the slogan “Amber and Red Means Snowplow Ahead”.

Since that time no adjustments have been made to the configuration of the rear warning lights on snowplows in Alberta.

2.1 Current Specification

The standard configuration of the rear warning lights used on the province’s snowplows is covered in Section 52.1 of the Alberta Infrastructure and Transportation Highway Maintenance Specifications. A complete copy of the specification can be found in Appendix F.

Drawing A4 94 08 A and Drawing A4 94 08 B, located at the back of the specification, cover the location, type and colour of the rear warning lights. The specification calls for red and amber lights to be mounted above the box on each side of the snowplow. The red lights should be mounted along the outside edges of the vehicle. The amber lights should be installed at the same height as the red lights, towards the centre of the vehicle. A revolving light is also to be included with the rear warning lights specified for snowplows. This light is to be installed above the box of the snowplow in the centre of the vehicle. No measurements are included with the specification regarding the location or height of these lights.

Drawing A1 93 10 indicates the appropriate orientation of the rear warning lights. The amber lights located above the box of the truck should be aligned such that, the centre of the beam from these lights intersect the centreline of the truck at a point 150 m from the lights. These lights should also have a 40° vertical viewing angle, which contacts the roadway surface 5.5 m from the snowplow.

3. SNOWPLOW REAR LIGHTING STANDARDS REVIEW

A review of the standards used for rear lighting on snowplows around North America was completed in the initial stage of this project. This review was used to help determine what types, configurations and colours of lighting to test during the field trials. The review included a review of applicable websites and research papers, a jurisdictional survey and a research into new lighting technologies.

3.1 Website Review

A website review found information regarding snowplow warning lights or other warning devices for twenty one (21) highway jurisdictions within the United States. Although this information was not typically in great detail, it did provide a good background of what other transportation department are using.

All states used warning lights of some type. The number, colours, size location and type varied from state to state. The lighting colours used as warning devices for snowplows were, amber and blue, amber and red, and amber and white. Strobes and rotating beacons were also very popular. Light Emitting Diode (LED) warning devices have been experimented with in several states. However, only Colorado and Iowa currently use them on all vehicles.

Other types of rear warning devices included:

- warning lights on the wing of the snowplow
- snow deflectors to reduce the snow cloud behind the plow, making the lighting more visible
- air blasters to keep snow from building up on the rear lights
- reflective tape placed on the tailgate and bumpers of the plow
- tailgates painted with reflective glass beaded paint
- orange plastic tubes mounted on the edge of the snowplow

3.2 Literature Review

A literature review was conducted to find any literature on recent snowplow lighting experiments and information that could be applicable to our research project. The literature review included, a search for, and review of, research papers and publications from research organizations around North. Two (2) relevant research papers were found during the search. A summary of the research papers will be discussed in the following sections. Complete copies of the research papers can be found in Appendix C.

3.2.1 Research Paper – “Rear Lighting Configuration for Winter Maintenance Vehicles”

This report was prepared by the Lighting Research Center to help reduce the number of rear end collisions with snowplows. The intent is to alert drivers approaching a snowplow from the rear of the snowplows presence, relative speed and distance from the driver, thus reducing the probability of a rear end collision.

Background

Approximately 70% of all accidents involving snowplow trucks are rear end collisions. Although increasing the visibility of the snowplow would be useful in reducing the frequency of these collisions, providing drivers with cues regarding the speed and distance of the snowplow is equally important.

Therefore, lighting should serve two (2) purposes:

- signal other vehicles on the road of the snowplows presence
- provided cues about the snowplows speed and distance

The factors that affect the visibility of the rear snowplow lighting are:

- location of the lights
- background lighting characteristics
- spacing from the lights
- light intensity

Subjective Evaluation

In the winter of 1997 - 1998 field tests of rear lighting configurations were tested. Four (4) lighting configurations were tested:

- conventional flashing amber lighting
- indirect edge delineation, to illuminate the left and right hand edges of the truck only
- alternating high mounted red and amber lights
- horizontal LED light bar in a steady burn configuration

These lighting configurations were tested at night under both clear and heavy snow conditions. Each system was rated on the visibility of the snowplow and the confidence the driver would have in passing the snowplow vehicle.

All of the setups were rated as more visible under clear conditions, as was expected. The LED light bar configuration received the highest ratings for both visibility and confidence to pass, under both clear and heavy snowfall conditions. A modification of this configuration was selected for further testing the following winter.

Closure Detention Test

In the Closure Detention Test, Vertical LED light bars were placed on the left and right edges of the snowplow vehicle and were compared to the conventional flashing amber lighting system. The test involved the snowplow vehicle and observation vehicle travelling at the same speed. The snowplow would then begin to decelerate and the test subject would be asked when the snowplows relative distance began to change. The time between the snowplow beginning to decelerate and the observation by the subject was measured for each setup.

A total of 48 trials were conducted to test the lighting, 24 tests for each configuration. During the tests the deceleration of the snowplow with the vertical light bars was, on average, detected in 9.8 seconds, versus 12.4 seconds for the conventional flashing amber configuration. The 2.6 second reduction in detection time for the vertical light bar configuration translates to a travelling distance of 35 m at 30 mph (48 km/h).

Also found during the trial was a reduction in power requirements for the LED light bars. The LED units required approximately 6 W each, compared to 35 W each for the traditional flashing amber lights.

3.2.2 Research Paper –“Improved Visibility for Snowplow Operations”

Background

The visibility for the snowplow during operation is reduced by a number of factors including, reflected headlight glare, obscured windows and blowing snow. The compromised visibility reduces the operational safety of the snowplow, creating a hazardous situation for both operators and the public. Therefore, there is a need for feature that will improve visibility during snowplow operations.

Field Demonstrations

Laboratory tests and field demonstrations were used to evaluate a variety of wind vanes and other snow deflection devices. Image analysis techniques were used to determine the impacts the different deflection devices would have on drivers following the snowplow.

Conclusions

Side vanes with a 20° angle on the rear of the plow will reduce snow accumulation on the rear lighting on the vehicle by reducing the size of the snow cloud behind the vehicle. Steady burning LED light bars mounted along the rear edges of the snowplow will improve the ability of drivers following the snowplow to detect changes in the speed of the snowplow more easily than traditional lighting configurations.

3.3 Highway Jurisdictional Survey

As part of this project Alliant contacted thirteen (13) North American highway jurisdictions with a questionnaire, regarding the operations of snowplows within their respective highway jurisdictions. Responses were received from five (5) provinces and one (1) state. The responding jurisdictions were:

- British Columbia
- New Brunswick
- Nova Scotia
- Ontario
- Saskatchewan
- Wyoming

The questionnaire contained eleven (11) questions and the responses have been summarized in the following table, however, the complete survey responses can be found in Appendix D.

| | |
|--|--|
| <p>Have rear-end collisions with snowplows been a problem? If yes, what action has been taken to prevent these collisions?</p> | <ul style="list-style-type: none"> • Of the responding jurisdictions, only Saskatchewan reported that this has been a problem. • Saskatchewan reported that problems were more frequent when plowing on the Trans Canada Highway. • To remedy the situation Saskatchewan has implemented the following measures: <ul style="list-style-type: none"> - installation of random flashing “Wig-Wag” lights - application of horizontal strips of reflective tape to the tailgate - installation of additional stop lamps at the midway point of the box |
| <p>What type(s) of snowplow are normally used?</p> | <ul style="list-style-type: none"> • All jurisdictions reported using : <ul style="list-style-type: none"> - spreaders - snowplows - or a combination of the two styles |
| <p>What type(s) of rear lighting do you use?</p> | <ul style="list-style-type: none"> • Strobe lights, beacon lights, flashing amber lights, flashing red lights, tails lights, brake lights and signal lights were reported as being used by the highway jurisdictions. |

| | |
|---|--|
| <p>How many lights are used and how are they arranged?</p> | <ul style="list-style-type: none"> ● The lighting configurations vary, but the typical configuration includes: <ul style="list-style-type: none"> - strobe or beacon lights on the top of the box of the plow - flashing amber and/or red lights above the box - an array of lights on the back of the box |
| <p>Have steady state lights (LED) been used? If yes, what were the results?</p> | <ul style="list-style-type: none"> ● New Brunswick, Nova Scotia, Saskatchewan, and Wyoming have all used LED lights. ● All indicated that the lights provided good visibility, however, there have been problem keeping the lights clear of snow build-up. |
| <p>Have you used reflective tape? If yes, what were the results?</p> | <ul style="list-style-type: none"> ● Nova Scotia uses reflective tape along the edges of the snowplow truck box. The tape has been found to be quite visible. ● Ontario uses reflective tape on the snowplow, and has additional light to help highlight the tape. ● Saskatchewan has placed reflective tape along the top and bottom of the truck box, with very good results. |
| <p>Have you used orange flags? If yes, what were the results?</p> | <ul style="list-style-type: none"> ● New Brunswick, Nova Scotia and Ontario all use orange flags or tubes on the corner of the plow. ● Saskatchewan used flags on the back of the plow in the 1980's but those are no longer in use. ● New Brunswick has indicated that the flags have provided mixed results. ● Ontario has a light directed at he flag to help improve the visibility of the plow tip. |
| <p>Have you used any other rear warning devices? If yes, what kind of device and what were the results?</p> | <ul style="list-style-type: none"> ● Saskatchewan uses a painted black and white checker board pattern on the rear of the plow. This has not been as effective as the reflective tape due to snow build-up. ● New Brunswick has used a diagonal striped pattern but has discontinued it use due to poor results. ● B.C. uses either a diagonal or stripped black and yellow pattern on the rear of its snowplow vehicles. |
| <p>Have you used any devices to eliminate snow</p> | <ul style="list-style-type: none"> ● New Brunswick and Saskatchewan have both used wind deflectors to help minimize the amount of snow |

| | |
|---|--|
| <p>build-up on the rear lighting? If yes, what kind of device and what were the results?</p> | <p>build-up.</p> <ul style="list-style-type: none"> - New Brunswick has had good results with dry, light snow. - Saskatchewan has found that the deflector often becomes plugged with snow. |
| <p>Have you used any devices to minimize the snow cloud behind the snowplow? If yes, what kind of device and what were the results?</p> | <ul style="list-style-type: none"> • Nova Scotia, Saskatchewan and Wyoming all use a device on the plow blade to help prevent snow from coming off the blade and blowing over the snowplow truck. • No information was provided about the effectiveness of this measure. |
| <p>Are any changes to your snowplow rear warning systems planned?</p> | <ul style="list-style-type: none"> • None of the jurisdiction indicated any planned changes. • Ontario has begun to examine the possibility of using LED lighting, but that is in the preliminary phase. |

3.4 New Technologies

Since the last review of snowplow operations and lighting, in November 1995, several advances have been made in lighting technologies. These advances include the materials used to construct the lights and the types of lights themselves.

One of the biggest developments in lighting technologies has been the development of Light Emitting Diodes (LED). These lights are one of the driving forces behind this project, as maintenance contractors have requested permission to use these LED lights on snowplows. The technology behind LED lighting will be discussed in greater depth in the upcoming section.

3.4.1 Light Emitting Diodes (LED)

History

The basis of the Light Emitting Diodes (LED) seen today, dates back to 1907, when Henry Joseph Round observed electroluminescence for the first time. The light however was too dim to be practical, and the materials required were difficult to use, and thus, his research was abandoned.

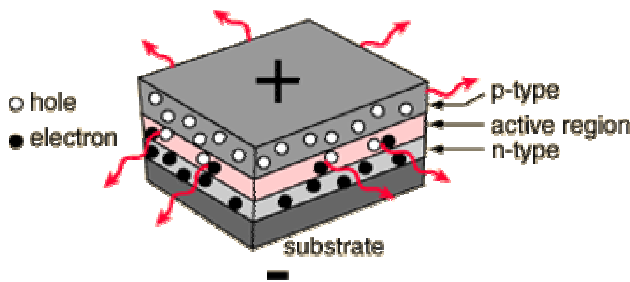
In the 1950's research using Gallium Arsenide helped to create the first modern LED being produced in the 1960's. Because the light created by LEDs is a product of the

materials used, red light was initially the only colour that could be created. By the end of the 1970's additional research had developed yellow and green LEDs in addition to the traditional red.

Further research with different materials has yielded different types of LEDs and more colours. With Gallium Aluminium Arsenide Phosphide came the first super bright LEDs, available in red, yellow and green. Next, with the use of Indium Gallium Aluminium Phosphide, came ultra bright LEDs which could produce new colours, such as, orange-red, orange and blue. New research using fluorescent phosphors have allowed almost any colour to be produced.

Technology

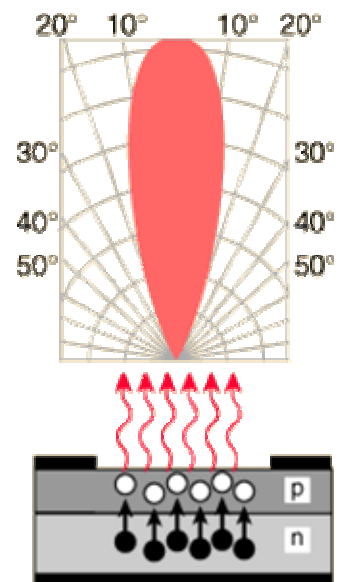
An LED is a special type of diode and is similar to a transistor. Diodes and transistors are solid-state devices that are made from semiconductors such as silicon. The semiconductor is made to contain two types of special impurities. The first type of impurity called N for negative, is a material with an excess of electrons.



The other type of impurity called P for positive has a deficiency of electrons. These two kinds of impurities are dispersed into the semiconductor at different regions, so that a P-N junction, or active region, is created at the border. This is illustrated in the diagram on the left.

Semiconductors do not freely conduct electricity; instead, they can be made to conduct electricity under certain conditions. For diodes, this amounts to connecting electric power across the junction to make the P side more positive and the N side more negative. When this happens, electricity flows freely across the P-N junction and the electrons fill up the holes.

LED's differ from ordinary diodes in that the P and N materials take this energy and convert it to photons, or light. Since the energy involved is a fixed amount, the light that results has only a single wavelength, or colour. Using different materials for the P and N impurities enables the light to be manufactured in different colours.



An LED is a directional light source, with the maximum emitted power in the direction perpendicular to the emitting surface. The typical radiation pattern shows that most of the



energy is emitted within 20° of the direction of maximum light. This is shown in the diagram to the right.

ADVANTAGES

LED light bulbs are miniature bulbs that do not use filaments to produce light. Because their heat generation is low and because they do not rely on a deteriorating material to generate light, LEDs have long operating lifetimes, often tens of thousand of hours. One of the alternatives to LEDs, incandescent bulbs, consume much more power, generate a great deal of heat, and rely on a filament that deteriorates with use.

Light emitting diodes are solid-state devices containing no moving parts and no filaments to break. As such, LEDs handle rough environments including heavy vibration and impact. There is nothing to break, rupture, shatter, leak, or contaminate. The solid-state nature of LEDs makes them extremely rugged and durable—an excellent choice for applications where reliability and dependability are paramount.

Currently available LEDs are more energy efficient than incandescent bulbs, but less than florescent bulbs with the same light output. The power consumption of popular LEDs typically ranges from 30 mW to 200 mW.

The light emitted from an LED is directional. Typical conventional sources such as incandescent, halogen, or fluorescent lights are omni directional, emitting light in all directions. In order to direct the light onto the object to be illuminated, light that is not directed toward the desired location must be redirected using secondary optics or reflectors. Each time a light beam is reflected it loses some of its intensity, resulting in a fixture loss. Typical fixture losses range from 40 to 60%, meaning that in some cases less than half of the light generated by the source is directed in the desired direction. The directed nature of LEDs can result in fixture efficiencies of 80 to 90%, requiring less total lumens to provide the same level of luminance.

DISADVANTAGES

The most significant disadvantage of LEDs is the light output limitation. Currently available LED's emit limited amount of light at a relatively small angle range, while incandescent and florescent light bulbs illuminate in all directions and give out much more brightness of light.

The second significant disadvantage is the high prices of LEDs. The currently available LEDs in the market are 3 to 10 times more expensive than equivalent incandescent light bulbs. However, using LED products in the long run can actually save money, because of the much longer life.

3.5 Lighting Regulations

According to the Federal Motor Vehicle Safety Regulations prepared by Transport Canada, every passenger car, multipurpose passenger vehicle, motorcycle, truck, trailer and bus shall be equipped with the lamps, retro reflective devices and associated equipment required by the Technical Standards Document No. 108, Lamps, Reflective Devices and Associated Equipment. All information regarding the minimum requirements of bulbs and every type of sealed beam lamps used in lighting equipment can be found in this document.

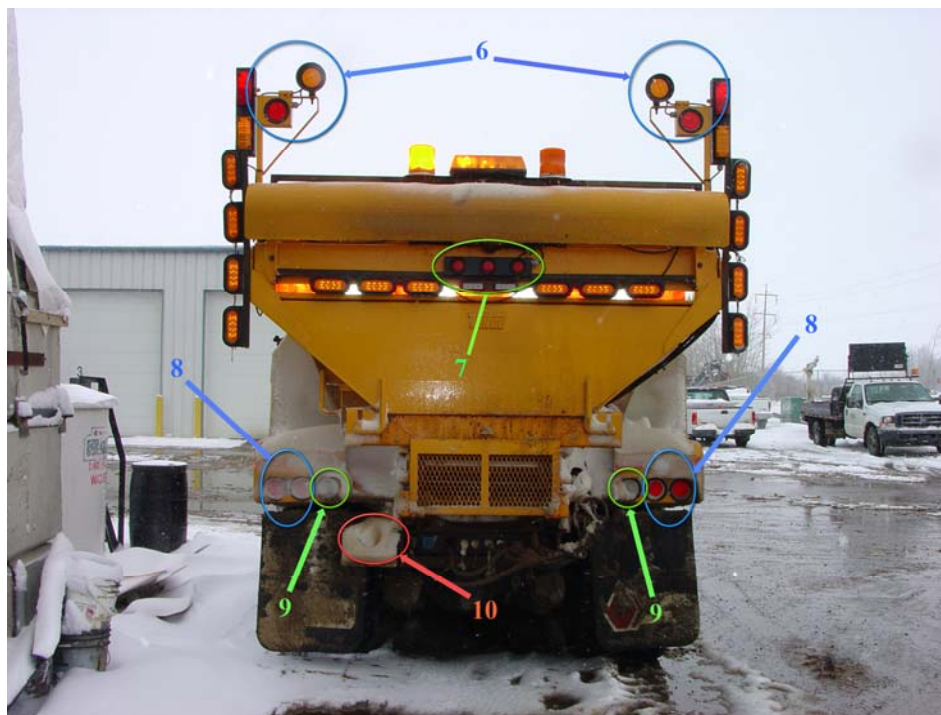
For this report, the minimum rear lighting requirements for snowplows has been discussed. As per the Basic Equipment Required on All Trucks, Buses & MPVs document produced by Transport Canada, the minimum requirement for rear lighting on a Snowplow's is as follows:

| Description | | | | Mandatory Requirements | | | |
|-------------|---|--|---|------------------------|---------------|--|---|
| Area | Equipment | (SAE Lens Coding) | Functional Purpose | Quantity | Colour | Location | Height mm (in.) from the ground |
| 6 | Rear Clearance Lamps Attention: Required for vehicles 2032mm wide or wider, but not required on Truck Tractors | P2, PC* or P3, PC2* *photometrically certified at installation angle. | Show vehicle's width - MAY NOT be combined with tail lamps | Minimum 2 | Red | At widest point - symmetrical - on the rear or near the rear - facing rearward. | As high as practicable - may be lower only if rear ID lamps are at the top. |
| 7 | Rear Identification Lamps (ID) Attention: Required for vehicles 2032mm wide or wider, but not required on Truck Tractors | P2 or P3 | Indicate presence of a wide vehicle. | Exactly 3 | Red | Rear - centre - horizontally spaced 150 mm (6 in.) to 300 mm (12 in.) apart, facing rearward | in Canada: at the top - maybe lower if door header narrower than 25 mm |
| 8 | Tail Lamps | T | Indicate vehicle's presence and width | Minimum 2 | Red | On the rear - symmetrical - as far apart as practicable. | 380-1830 (15-72) |
| | Stop Lamps | S | Indicate braking | Minimum 2 | Red | On the rear - symmetrical - as far apart as practicable. | 380-1830 (15-72) |
| | Rear Turn Signal/Hazard Warning Lamps | I | Indicate direction of turn/ identifies disabled vehicle | Minimum 2 | Red or Yellow | On the rear - symmetrical - as far apart as practicable. | 380-2110 (15-83) |

| | | | | | | | |
|----|---|----|---|-----------|-------|---|------------------|
| | Rear Reflex Reflectors | A | Show vehicles presence and width | Minimum 2 | Red | On the rear - symmetrical - as far apart as practicable - facing rearward | 380-1530 (15-60) |
| 9 | Backup Lamp | R | Illuminate ground behind the vehicle and alert road users | Minimum 1 | White | Rear | No requirement |
| 10 | License Plate Lamp(s) | L | Illuminates license plate | Minimum 1 | White | On the rear - above or at the sides of license plate | No requirement |
| 11 | Centre High Mounted Stop Lamp Attention: Required for vehicles less than 2032mm wide and 4536kg | U3 | Indicates braking | Minimum 1 | Red | On the rear - centreline of the vehicle | 860 (34) minimum |

A full table summarizing the minimum lighting equipment requirements contained in Federal Motor Vehicle Safety Standard 108 can be found in Appendix F.

The following picture displays the current basic lighting equipment being used by Snowplows in the Province of Alberta.



Below is a summary of the lights contained on the snowplow.

- Rear Clearance Lamps (6): One (1) yellow lamp and one (1) red lamp located at each the top-rear-right and top-rear-left of the Snowplow. These are used to indicate the Snowplows width.
- Rear Identification Lamps (ID) (7): Three (3) horizontally spaced red lamps located at the rear of the Snowplow at the centre of the box.
- Tail Lamps (8): One (1) red lamp located at each of the lower left and right corners of the Snowplow.
- Stop Lamps (8): One (1) red lamp located at each of the lower left and right corners of the Snowplow.
- Rear Turn Signal / Hazard Warning Lamps (8): One (1) red lamp and one (1) yellow lamp located at each of the lower left and lower right corners of the Snowplow.
- Rear Reflex Reflectors (8): A red reflector located just above the rear tail lamps and stop lamps on both the left and right sides of the Snowplow.
- Backup Lamp (9): One (1) white lamp located next to each of the Tail Lamps and Stop Lamps at the lower left and lower right corners of the Snowplow.
- License Plate Lamp(s) (10): One (1) white lamp located directly over the license plate on the lower left side of the Snowplow.

3.6 Lighting Manufacturing

A variety of different light types are available from lighting manufacturers. Lighting options can be grouped and detailed as follows:

3.6.1 Beacons

Standard Rotating Beacons (Single)

- Varies in dimensions, height and diameter
- Rotating device is either rotating lamp or rotating mirror
- Multiple lamps used on some (up to 4)
- Between 50 to 200 flashes per minute (dependant on rotator speed)
- Halogen Bulb
- 12 Volts DC (some 24 Volts DC available)
- 40 – 100 Watts, 2 – 8 Amp
- Mostly polycarbonate lenses
- Variety of mounting available

Standard Rotating Beacons (Dual)

- Same as Single Rotating Beacon, except that size is larger and flashes per minute approximately double (300 to 500 flashes per minute)
- Power required is increased (approx. 8 – 16 Amp)

Standard Rotating Beacons (Multiple)

- Same as Single Rotating Beacon, except that flashes per minute and power requirements are increased by the same order of magnitude as the number of increased lights (500 – 2000 flashes per minute)

Standard Strobe Beacons (Single)

- Varies in dimensions, height and diameter
- Strobe tube; double or quad flashing
- Multiple lamps used on some (up to 4)
- Between 50 to 200 flashes per minute (double flash; increases for quad flash)
- Multiple flash patterns available
- 360 degree coverage available in some models
- photocell sensor allows for adjustment of intensity between night & day
- 12 Volts DC (some 24 Volts DC available)
- 2 – 8 Amp (generally less power required than halogen bulb)
- Mostly polycarbonate lenses
- Variety of mounting available

Standard Strobe Beacons (Double)

- Strobe beacons are available in double configurations, however, there is less variety available as compared to double rotating beacons.
- Same details as per single strobe; flashes increase as number of strobes increase

Mini-Bars

- The terminology “Mini-Bar” is loosely utilized in the industry to include multiple lighting arrays from dual rotating beacons to strobes, rotating beacons and LED lights in combination. Because of this variance, the effectiveness and power required is dependant on the combination. Generally, there is direct relation between the number of lights and the power usage.

LED Beacons

- Newer technology has produced LED beacons, with similar attributes to strobe beacons
- Delivers a rotating pattern; more patterns available than strobe beacons

- 360 degree coverage is available
- Intensity is greater than the rotating and strobe beacons
- Low power requirement (< 1 amp at 12 Volts)
- LED beacon life is estimated to be 50 times longer than strobe beacons

3.6.2 LED Lights

LED technology appears to be improving and will likely improve beyond the conclusions of this report. The main area of improvement and difference between manufacturers is the optics utilized with the LED light.

LED diodes themselves appear to be coming from central sources that are used by all manufacturers. Advancement in technology follows the following terminology:

- Generation I - 5mm diode technology
- Generation II - Piranha diode technology
- Generation III - Barracuda diode technology, standard diode and optic package
- Generation 3.5 - Super-LED – a package containing the brightest diode and widest visibility optic technology available.

Generation III appears to be the latest technology available. Besides the optics and various configurations, LED lighting should be fairly consistent in quality amongst manufacturers.

4. EVALUATION STRATEGY & REAR LIGHTING CONSIDERATIONS

Several items were identified during the search and investigation for rear lighting information. They can be grouped in several different categories with many variables as discussed in the following sections.

TYPE OF LIGHT

Incandescent and LED are the identifiable options for light types. Incandescent bulbs have traditionally been used on all snowplow trucks and are presently specified by Alberta Infrastructure & Transportation. LED lights represent newer technology for motor vehicles. The advantages of LED lights are that they provide more intensity, are more durable and require less power.

Since the scope of this study is to improve safety, LED's should be tested as more light intensity will likely translate into more visibility, especially in adverse weather conditions.

- Research Question: Are LED lights more visible as rear lights on snowplow trucks?

INTENSITY

Light intensity is a variable that can be directly related to visibility. Incandescent and LED lights can both vary in intensity. Incandescent bulbs intensity varies by changing the wattage of the bulb. LED lights do not change in intensity generally. An increase in diodes per light cluster will likely increase the intensity. LED intensity can easily be increased by altering the refraction lenses that cover the lights (i.e. PSE Amber "LED X" lights).

The power required by increasing incandescent bulb wattages would be substantially higher than the existing power load for the present lighting standard. Therefore, this option is not being considered.

LED lights require a fraction of the power of incandescent bulbs and therefore increasing the number of diodes in a LED light and using different refraction lenses are considerations. Good optics for LED is essentially for maximum intensity.

- Research Question: How much different / more visible are LED lights when you vary the number of diodes and use improved refraction lenses?

QUANTITY

It is practical to believe that an increased quantity of lights would translate into a more visible snow plow truck. There is obviously a limit to the amount of lights that can physically fit on the rear of the truck, however more may not necessary be better. Atmospheric conditions will present a variable here as well.

- Research Question: How many lights are required to maximize visibility, without blinding motorists?

COLOR

Various lights colors are being used by some agencies. The most dramatic is the combination of white and blue lights. Alberta Infrastructure & Transportation have used amber and red lights for many years. This standard and a campaign of advertisements have created an understanding by motorists that "Amber and Red means Snow Plow Ahead". For this reason alone, color changes will not be investigated in this study. It is

noted that the Department of Highways in Saskatchewan have also recently reviewed their snow plow lighting and plan to utilize amber and red colors as well. Inter-provincial consistency may also be a consideration.

CONFIGURATION

The configuration (location & clustering) of lights is a complicated matter. Light intensity and motorist recognition can both be affected by changes in configuration.

A certain combination of light colors is often used in distinguishing emergency and maintenance vehicles. Light grouping in highly visible locations on the vehicles or in a straight line series are other popular strategies.

Truck type, age and the type of box used will dictate where lights can and need to be placed.

- Research Question: Can changes in lighting configuration improve visibility? What options are the best if so?

FLASHING PATTERNS

Distinctive flash patterns can be used to improve motorist awareness and help identify the vehicle type. For example, a particular flash pattern could signify snowplow trucks. Saskatchewan's Highways and Transportation Department has adopted a particular flashing sequence (PSE Amber 710H flasher) that follows a routine of blinking for the rear elevated amber and red lights ("wig-wag").

- Research Question: Are flashing patterns more effective for visibility? If so, will it give a distinction to motorists? Is the flash pattern reducing the effectiveness of intensity as compared to no flash pattern?

LIGHT POINTING

The existing Alberta Infrastructure & Transportation specification (Drawing A 93 10, "A-50 Sander Truck Rear Amber Flashing Light Adjustment") indicates detailed amber light pointing that focuses on motorists approximately 150 metres behind the truck. This is mainly done to increase the intensity of the warning lights when a vehicle is encroaching up to the rear of the snowplow truck. Awareness should be at a maximum at the 150 metres distance.

Light pointing on any new lighting should be considered as well.

- Research Question: Is lighting pointing still required? Can it be done with new lighting? Is the 150 metres still sufficient, especially when the snowplow brakes rapidly? Which lights should be pointed?

- Research Question: Is there a way to improve the awareness of motorists in adjacent lanes of the snowplow truck (i.e. 4-lane highways)?

FLASHING BEACONS

Flashing warning beacons are used on a variety of motor vehicles for different reasons. Almost every maintenance vehicle utilizes the warning effect of a flashing beacon. A flashing beacon is the minimum standard for all agencies for snowplow awareness lighting.

The color of the flashing beacon varies, but is usually amber. Flashing beacons can vary by the followings aspects:

- rotating beacons
- strobe beacons
- height and width (diameter)
- refraction lenses
- moving versus stationary components
- single, dual or multiple
- LED beacons
- light bars

- Research Question: What improvements can be made to the flashing beacons on the snowplow truck? This includes number, type and placement.

OTHER ITEMS

Along with lighting, other considerations for the snowplow trucks include:

- reflective stripping – for the rear and sides of the snowplow truck
 - distinctive rear-box painted patterns (i.e. checker board)
 - wind deflectors
 - front lighting
 - flashing beacons
 - plow blade lighting – front, back, right, left
 - blade wing lighting & delineating
 - head lights and additional operating lights
- Research Question: What other improvements should be made to increase motorist visibility of the snowplow truck?

4.1 Evaluation Scope

The following list summarizes the Research Questions determined in the previous sections.

1. LED lights
2. Higher Intensity LED Lights
3. Number of Lights needed for sufficient motorist warning
4. Configuration
5. Flashing Patterns
6. Light Pointing
7. Beacon Improvements
8. Other Improvements

The scope of work for this project, as instructed by Alberta Infrastructure & Transportation (AIT), was to examine for improvements to rear lighting on the snowplow trucks. For this reason, other improvements were not thoroughly investigated.

Due to the scale of the project, flashing patterns and light pointing were not reviewed as well. The first step in this process would be to investigate what type of lights and configuration are needed.

4.2 Performance Standards

The present standard for rear snowplow lighting basically involves a drawing, with noted light types and placement, with some angle settings. As part of this project, a new way of specifying lighting requirements was to consider Performance Standards.

Ideally, Performance Standards were to let the maintenance contractor determine the level and effectiveness of lighting required based on reducing accidents and increasing safety. This, however, would not provide consistency throughout the province and may be confusing to motorists.

Another way Performance Standards could be used would be by basing lighting requirements on the following:

- Minimum Visibility Distances
- Light Intensity Measurements
- Distance and Speed Variability Perception
- Minimum Specifications & Performance Benchmarks

The concern of using this strategy is that it would be difficult to measure and check, especially in a variety of atmospheric conditions.

Therefore, in conclusion of this, it was decided that a specific Specification method should be used. The Specification would contain updated lighting requirements, to support today's technology, but have enough flexibility for numerous manufacturers and suppliers. A minimum standard of awareness would have to be maintained through this Specification method.

4.3 Development of Lighting Trials

In order to develop or update the existing rear snowplow lighting specification, it is necessary to evaluate several lighting types and configurations.

The evaluation can be separated into the following categories:

1. Replace all standard lights with LED lights
 - stop, tail and turn lights
 - vehicle identification lights

GOAL: Do LED lights improve visibility?

2. Flashing Beacon – try new technology
 - equivalent single rotating beacon as old standard, except have options
 - improved single rotating beacons
 - strobe beacons
 - revolving beacon with LED directional lights
 - dual rotating beacons
 - light bars

GOAL: Which Flashing Beacons perform the best or a minimum satisfactory level?

3. Elevated Warning Lights
 - increase red warning lights from 2.5" dia. to 4" dia.
 - replace red and amber lights with LED lights (all 4")
 - LED 3"x7" red and amber lights, mounted similar to new Saskatchewan standard

GOAL: What improves the Elevated Warning Lights?

4. Additional or Alternative Warning Lights
 - vertical LED light bars, as per NCHRP Paper #14, August 2001
 - horizontal LED light bar, modification to above
 - optically enhanced LED (LED X) lights

GOAL: Do Additional or Alternate Warning Lights improve visibility?

These categories provide a mixture of items raised from new technology, other agencies review and other research work.

4.4 Lighting Configurations

For the field trials it was decided that 10 new lighting configurations would be tested.

As part of all of the lighting configurations, the lights required by the current standard were all changed to LED lamps. This included the following changes:

4.4.1 Stop, Tail & Turn Lights

- Grote “SuperNova, U.S. 40 Series, 4”, Full Pattern, Stop/Tail/Turn LED Lamp”
 - red: #53312, amber (yellow): #53413
 - all were grommet mounted
 - 6 red lights in total used: 2 – tail, 2- brake, 2 – elevated flashing
 - 2 amber lights in total used: elevated flashing
 - Polycarbonate / Acrylic
 - 12 volt – 0.48 amp each light
 - http://www.grote.com/cgi-bin/product.cgi?product_number=53312



It should be noted that the present AIT specifications calls for a 2.5 inch dia. red elevated light, above the box. For the field trials, a 4 inch dia. red elevated LED light was used as described above.

4.4.2 Beacons

Ten (10) different lighting configurations were used during the field trials. Six (6) different amber warning beacons were evaluated as follows:

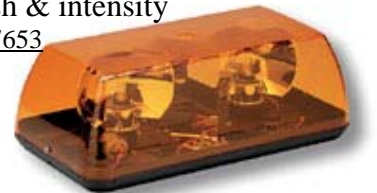
TRIAL #1: Medium Profile, High Intensity Strobe Beacon (Single)

- Grote “Medium Profile, High Intensity Strobe” #77653
 - 7.13” high x 6.5” (base); belt driven
 - Aluminium / Polycarbonate base (alum.) and lens (amber)
 - flash tube, 12 to 24 volts (w/ photocell)
 - 2.3 to 2.9 amp at 12 volts
 - “Smart Strobe” flash – adjusts for day or night work
 - 65 flashes per minute; adjustable double or quad flash & intensity
 - http://www.grote.com/cgi-bin/product.cgi?product_number=77653

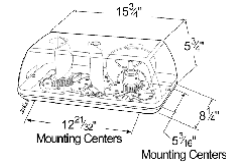


TRIAL #2: High Intensity Beacon (Dual Rotating)

- Grote “15” Hi-Intensity Mini-Bar” #77163
 - dimensions as per drawing



- ABS / Polycarbonate base (black) and lens (amber)
- 50 watt halogen bulbs, 12 volt – 4.1 amp
- 300 flashes per minute
- dual rotating reflectors with fixed mirrors
- http://www.grote.com/cgi-bin/product.cgi?product_number=77163



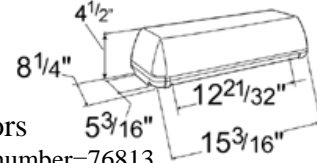
TRIAL #3: 360 Degree LED Beacon (Single)

- PSE Amber “Quantum Flash™”
- 5” high x 6.75” (base)
- 6 - Gen II LED, 12 – 24 volts – 0.5 amp
- amber LEDs with clear lens (w/ special optical enhancement)
- multiple flash patterns, aluminium base
- <http://www.code3pse.com/productdtl.asp?grp=pse&familyid=13&id=231>



TRIAL #4: Low Profile Bar Lamp (Dual Rotating)

- Grote “15” Low Profile Bar Lamp” #76813
- dimensions as per drawing
- Polycarbonate base (black) and lens (amber)
- 55 watt halogen bulbs, 12 volt – 10.5 amp
- 480 flashes per minute, dual belt drive rotators
- http://www.grote.com/cgi-bin/product.cgi?product_number=76813



TRIAL #5: Low Profile Beacon (Single Rotating)

- Grote “Low Profile, Revolving Beacon” #76443
- 7.5” high x 6” (base)
- ABS / Polycarbonate base (black) and lens (amber)
- 55 watt bulb, 12 volt – 5.2 amp
- 160 flashes per minute
- belt drive rotator
- http://www.grote.com/cgi-bin/product.cgi?product_number=76443



TRIAL # 10: LED Low Profile Mini Light Bar

- PSE Amber “LED X™ 2100 Mini Bar”
- 2.1” tall x 22.5” long x 12.25” wide
- 12 volts, 0.5 amps
- amber LEDs with clear lens
- multiple flash patterns
- <http://www.code3pse.com/productdtl.asp?grp=pse&familyid=11&id=204>



All beacons were amber in color and were anticipated to be at least better than or equivalent to the rotating beacon used in the existing AIT standard beacon.

4.4.3 Additional Lights

In addition to testing warning beacons, the field trials also tested a variety of other lighting setups.

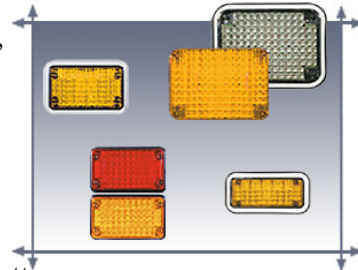
TRIAL #6: High Intensity LED Lights – Multi-Purpose

- PSE Amber “LED X™ Exterior Lights”
- 5” L x 2” H x 1” W
- 12 volts, 0.5 amps
- amber LEDs wide optic
- available in directional, wide & vertical optics
- 7 flash patterns including steady burn
- 2 of the single head models were placed side-by-side for field trial
- <http://www.code3pse.com/productdtl.asp?grp=pse&familyid=12&id=158#lit>



TRIAL #7: Amber & Red “Wig-Wag” Type Lights

- PSE Amber “LED 7” x 3” Perimeter Lights”
- 7” L x 3” W mounted in 2-head black housing
- 12 volts, low amps
- amber and red LEDs
- directional optics
- 20 flash patterns including WIG-WAG pattern
- 2 sets of amber and red units were used and mounted at the elevated locations adjacent to the normal amber and red lights.
- <http://www.code3pse.com/productdtl.asp?grp=pse&familyid=12&id=156>



TRIAL #8: Dual Vertical Amber LED Light Bars – Steady Burn

- Grote “SuperNova, Oval, Stop/Tail/Turn LED Lamp” #53963
- 1 light = 7.5” high x 6” (base)
- 4 lights in total used per light bar, mounted vert.
- used with pigtail #66815 & grommet #92720
- ABS / Acrylic
- amber (yellow) lens
- 12 volt – 0.48 amp each light
- mounted vertically along the edges of the truck
- http://www.grote.com/cgi-bin/product.cgi?product_number=53963



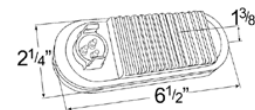
Left Vertical Bar



Right Vertical Bar

TRIAL #9: Horizontal Amber LED Light Bar – Steady Burn

- Grote “SuperNova, Oval, Stop/Tail/Turn LED Lamp” #53963
 - 1 light = 7.5” high x 6” (base)
 - 6 lights in total used, mounted side-by-side
 - used with pigtail #66815 & grommet #92720
 - ABS / Acrylic
 - amber (yellow) lens
 - 12 volt – 0.48 amp each light
 - mounted horizontally along the top of the truck box
 - http://www.grote.com/cgi-bin/product.cgi?product_number=53963



Horizontal Bar



For the field testing, it was necessary to test these additional lights with a consistent beacon. The Low Profile Revolving Beacon (single rotating) was chosen for this.

A drawing detailing each lighting configuration trial is shown in Appendix C. Due to installation logistics, the actual field trial ordering was different than above (different mounting brackets and finding enough space on the rear of the snowplow truck).

All lights were supplied by:

Grote Canada
8 Evergreen Close
St. Albert, AB, T8N 6E2
Mr. Gordon Alloway, Ph: (780) 458-1828



Quest Fabrication
923 – 46 Avenue SE
Calgary, AB, T2G 2A5
Mr. Bruce Buckley, Ph: (403) 287-2845

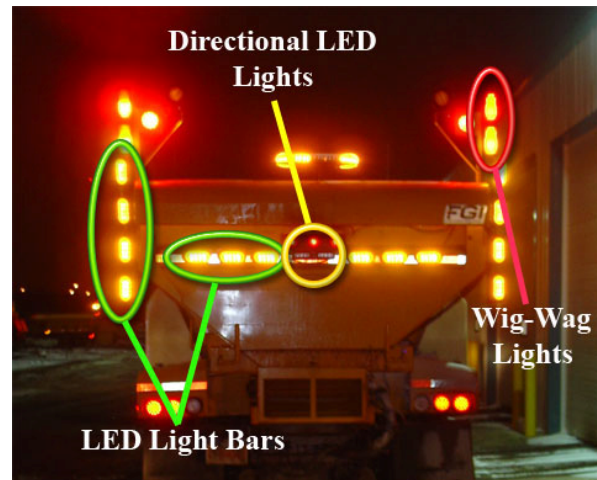
Lighting installation was completed by:

Fort Gary Industries Ltd.
16230 – 118 Avenue
Edmonton, Ph. (800) 663-9366

5. FIELD DEMONSTRATIONS

All of the lights chosen for the field trials were mounted on a single snowplow truck, provided by Alberta Highway Services Ltd – Stony Plain. To facilitate the testing of all of the lights in the same conditions, multiple lights had to be mounted on the snowplow truck at the same time.

The LED Light Bars, Amber-Red Flashing Warning Lights (Wig-Wag) and Directional LED Lights were all mounted to the box of the truck and were present during the entire length of the trials, where they could be turned on and off from inside the cab of the snowplow truck while moving. The picture to the right shows the fixed placement of the LED lights and beacon.



All lights that pertained to the existing standard for snowplow lighting, which are still visible in this picture, were replaced with LED light clusters of equivalent size and shapes for the field trials. This included stop-tail-turn lights and the amber-red warning lights.



The centre beacon on the rear of the truck provided a different challenge for the trials. The changing of the centre beacon for every different trial was not practical, and an alternative method of mounting the lights was required to facilitate the field trials. Six of the seven centre lights were mounted on two removable cross-members, as shown in the picture on the left.

The use of the cross-member allowed for three lights to be controlled from switches wired in the cab of the snowplow. Controlling the lights from inside the truck enabled the test to be completed more rapidly, as the snowplow did not have to stop to change the lights between every trial combination. The remaining single centre light, a low profile LED light bar, was too large horizontally to be mounted with other lights and was mounted separately on a single vertical pole.

Obviously with this set up, some of the beacons were not exactly located at the center of the snowplow truck; however, this was deemed not to be a critical component of the

testing and would not adversely affect testing of the light visibility during the field trials.

Mounting the lights on separate switches, which could be controlled from the cab of the truck, allowed the test group to view several lighting configurations in succession without stopping. Because snowstorms change in intensity over both time and space, being able to switch the lighting configurations while the snowplow truck was in motion allowed different configurations to be viewed under relatively similar conditions. Not requiring frequent stops to change the lighting arrangements also reduced the risk of creating an accident while the test vehicles were parked on the side of the highway.

Prior to the field trials, it was decided that each lighting configuration would be viewed under light and heavy snowfall conditions during the day and at night. This would allow each option to be viewed several times under variable conditions before any recommendations are made. Therefore, four (4) separate field visits were planned as follows:

- Strong snow fall at day; need snow cloud behind snow plow.
- Strong snow fall at night; need snow cloud behind snow plow.
- Light to no snow fall at day; need snow cloud behind snow plow.
- Light to no snow fall at night; need snow cloud behind snow plow.

In order to compare each new lighting package to the existing lighting standard, it was initially planned to have two (2) snowplow trucks proceed along the highway, side by side. The first snowplow truck would be equipped as per the existing Alberta Infrastructure and Transportation snowplow lighting standard. The second would contain the experimental field trial lighting, triggered one at a time. After about 1 minute, each lighting package would be changed. This of course could get complicated since the average running speed of a snowplow truck about 50 - 60 kilometres per hour. On a divided highway, this would cause significant traffic delays, especially with higher volumes area, as is such around Edmonton.

An Operations Plan was developed for the field visits which addressed safety, traffic accommodation and trial procedures. This included three stages: Stage 1 – Stand-By, Stage 2 – Set-Up and Stage 3 – Conduct Field Trial. The Operations Plan is included in Appendix E, “Field Trial Information”. The Operations Plan made provisions for two snowplow trucks running side by side, by providing two pilot vehicles running side by side with flashing arrow boards, one in each lane of the divided highway that would follow the snowplow trucks. Two other vehicles would travel between the snowplow trucks and pilot vehicles: a video truck and evaluation vehicle. The video truck would be responsible for acquiring video tape coverage of the field trials, for others to view in the future. The evaluation vehicle would hold observers that could view the lighting changes and make comparisons first hand. By having the pilot vehicles at the back of the operation, no traffic could get near the snowplow trucks, video truck and evaluation vehicle, thus providing a safe working area for the team. The trade off would be that traffic would be slowed for a 25 – 30 kilometre section, during inclement winter weather.

The location of the field visits was mostly dictated by the location of the shop, where the snowplow trucks worked from. Since the outfitted snowplow truck was required to be in operation during snow storms for regular plowing work, the field visits would have to be done near the shop. Since Alberta Highway Services Ltd. made one of their snowplow trucks available from the Stony Plain shop for this project, the field testing had to occur near Stony Plain. Since two snowplows trucks were to travel side by side and for safety reasons, a divided highway was chosen. In this case, Highway 16 (Yellowhead) was the nearest. For convenience of turning around, the section between the Highway 44 interchange and east of the Highway 43 junction appeared adequate. A north-south highway was considered (Highway 60, north of Devon) however the distance from Stony Plain was impractical due to maintenance scheduling.

A critical component of the field visits was an accumulation of snow before plowing operations began. Without some accumulation of the snow, the snow cloud created during plowing operations would not be very dense and as such, would not give an accurate portrayal of the effectiveness of the lighting trials.

During the demonstrations, a video camera was setup in the lead chase vehicle to capture the footage of the different lighting configurations. The vehicle used was a 1999 Dodge Ram 1500 4x4 pick-up truck, provided by Alliant Engineering. The truck allowed for the video camera to be secured to the centre console of the truck and aimed directly out the front windshield with no obstructions. Ciné Audio Visual of Edmonton provided the video coverage.



All of the trials per field visit were video taped and a DVD, showing each lighting configuration during all of the trials has been provided. Additional photos were taken of the snowplow vehicles before and after the trials were completed and these can be seen in Appendix A.

Two different types of laser range finders were obtained (AI&T's and rented) to determine the distances to the snowplow trucks at the point of visibility from the video truck for each lighting package. These values could essentially provide numeric data relating to the effectiveness of each lighting package (distance and drive perception relationship). During the first field visit on March 20, 2005, afternoon, several attempts to measure these distances were made. Due to blowing snow and both vehicles moving, the range finders proved to be unreliable. Attempts on making any further measurements ceased half ways through this visit. The human judgement of when the lights were visible and the level of visibility also proved to be too great of variable. Therefore, a

purely subjective evaluation would have to be made when comparing each of the lighting packages during the field trials.

The supply of lights and installation was completed by mid February, thus putting the field trials on stand-by, waiting for snowfall.

After some wait for a substantial snowfall event, March 20th, 2005, presented the first opportunity to conduct field trials. A summary of each of the field visits, detailing the conditions and which lighting configurations performed best, is indicated in the following sections.

5.1 Visit No. 1 - March 20, 2005, Day

A snowstorm beginning on the early morning of March 20, 2005, provided the adequate accumulation of snow requiring highway snowplowing. This presented the opportunity to perform the first of the field trials. Field demonstrations commenced at 3:00 pm and concluded at 6:00 pm, on Highway 16 in both the west and east bound lanes.



There was a strong wind blowing out of the west ranging between 25 and 40 kilometres per hour. By the time the trials started, the snow fall had decreased and was very light, but the accumulation of snow on the shoulders of Hwy. 16 was still significant enough to warrant the demonstration.

The initial trials were completed on Hwy. 16 between Hwy. 44 and Rge. Rd. 13. Since two pilot vehicles were not available at the time and safety concerns, the two snowplow trucks travelled in staggered configuration, with the lead truck plowing the travel lane and the other plowing the shoulder. See Photo of video above (WBL's). The initial pass, using two snowplow trucks, started immediately west of Hwy. 779 in the westbound lanes. Due to safety concerns, the two snowplow trucks were to be staggered, placing the snowplow truck with the demonstration lights ahead of the truck with standard lighting.

After approximately three (3) kilometres of attempting to follow the truck with standard lighting, it was decided that the staggering did not provide an effective comparison. Also, the test vehicles had to be very close to the standard lit snowplow truck to see the demonstration lights that were approximately 80 - 100 metres ahead of the standard snowplow truck. At this point, the standard snowplow truck left to complete other

snowplow work and the remaining demonstrations were completed with the single test snowplow truck.

The field trials were continued, travelling in the east and west bound lanes. See Photo from video below.



Quantitative data was recorded using the rented laser range finder for different combinations of lights. The downfall of the data retrieved using the laser range finder was inconsistency.

The distances measured following the sight of the plow depended too greatly on the density of the snow cloud created by the plowing operation. The range finder would not record a distance the same instant as the rear of the truck was sighted. The range finder required the

snow cloud to decrease in density before a measurement could be achieved.

The dissipation of the snow cloud was dependant on the initial density of the cloud, the wind speed and direction of travel (i.e. into or with the wind). There were lights that were clearly not as effective as the comparison lights; however, the data retrieved using the laser range finder showed improved sight distances. After the completion of the first demonstration and an evaluation of the data, the use of the laser range finder was discontinued due to data variability. In summary, the only useful data obtained from this was that complete white-out could still occur at distances of 30 - 50 metres behind the snowplow truck.

After the March 20, 2005, afternoon, demonstration was complete, there were three distinct preferred centre beacons. The two double rotating beacons and the LED 2100 mini bar appeared to stand-out. The LED 2100 mini bar was the most visible of all.

As for the lights mounted directly to the truck, the horizontal and vertical LED lights bars proved to be disappointing and could barely be visible. The directional LED-X lights also offered no significant improvement during the daytime trials. It should be noted that the LED-X lights and LED Quantum Strobe lights were not set properly on this day (afternoon and evening). Both had optional flash patterns which improved visibility. These adjustments were made on March 22, 2005.

The amber-red LED flashing warning lights did make a substantial improvement over the existing red and amber edge lights during the daytime testing. Both old amber-red and new LED amber-red were used during portions of the field trials. The old amber-red lights could barely be seen next to the LED amber-red lights.

Below are photos of the standard lighting (left) and new field trial lighting (right)(with LED 2100 mini light bar). Additional evaluation comments are shown in Appendix E.

EXISTING STANDARD



FIELD TRIAL LIGHTING



5.2 Visit No. 2 - March 21, 2005, Night

The snow continued through the day and therefore allowed for more snowplowing at night, during the early morning hours of March 21, 2005 (12:00 to 1:30 a.m.). Since the Highway 16 location did not contain enough snow on the road surface, Highway 628 (two-lane highway), just south of Stony Plain was chosen for the field demonstrations.

Through most of the trials, little to no snow cloud could be seen behind the test snowplow truck. This visit proved to be more of the “Light to no snow fall at night” variable for testing of the new lights.



All lighting options were tested in relatively the same sequence they were during the afternoon of March 20th. Additionally, several combinations were tried (vertical light bars, horizontal light bar, amber red LED flashing warning lights, LED mini bar, etc.).

The lights that performed well included all except the LED strobe beacon. On a clear night such as this one, almost anything was fairly visible. Of notice was that an excessive amount of glare was experienced from LED-X lights, LED mini bar and several of the combinations. This was especially true when all the test lights were turned on.

The trials proceeded much faster and were over after 1.5 hours.

5.3 Visit No. 3 - March 22, 2005, Night

More snowfall occurred during March 21 & 22, 2005. Field demonstrations continued on Highway 16 during the early morning hours of March 22, 2005 (2:40 to 4:00 a.m.). More snow cloud was encountered than on the previous night, but was limited.

All lighting options were tested in the same sequence they were done in the previous trial visits. Again, several combinations were evaluated including variances with the beacons.



Much of the viewing occurred a fair distance away as compared to the other two visits (150 – 200 metres). This allowed for evaluation from a different perspective. The snow cloud was erratic at best; some white-outs did occur giving indication of which lights are more visible. Over lighting a vehicle was confirmed as per the other night and was validated by the slowing of passing vehicles. This was seen as a reluctance to pass on the divided highway.

The LED strobe and LED-X were much better on this night, as they were properly set with the most visible patterns. The double amber beacons and LED mini bar appeared to be too strong when used with the LED amber red flashing lights (wig-wag). The single rotating amber beacon was the best matched with the LED amber red flashing lights (wig-wag). The vertical and horizontal LED light bars did stand out, but were no match to elevated lights when in decent snow cloud. The LED-X lights could be useful if they were mounted higher. They still seem to piece through the majority of snow clouds.

The LED amber red flashing lights (wig-wag) appeared to mimic an emergency vehicle at night. The flashing sequence was similar to the strobes used on ambulances especially. When combined with a rotating flashing beacon, the “emergency vehicle” effect was lessened. Other LED lights or LED type beacons appeared to “drown-out” the LED amber red flashing lights (wig-wag) and was too bright in clear conditions. Even in the snow cloud, the message to drivers appeared convoluted.

5.4 Visit No. 4 - March 22, 2005, Day

Snowfall continued on March 22, 2005. The last visit for completing field trials conveniently occurred later in the day of March 22, 2005.

Field demonstrations continued on Highway 16 during the afternoon of March 22, 2005 (12:30 to 1:30 p.m.). Wet snow was encountered and site conditions were different from other nights of demonstrations.

All lighting options were tested in the same sequence they were done in the previous trials. Good examples of snow cloud blockages were obtained during this visit.

Several of the lighting package performances were confirmed during this last visit.



The LED light bars (vertical and horizontal) did not perform well again during daylight. They could barely be seen, especially with any snow cloud.

The LED-X flashing lights were better than last daytime visit, however not to the performance level desired. The height of the LED-X played a critical factor in this.

The dual rotating amber beacons and the single rotating amber beacon provided sufficient visibility during the day.

The LED amber red flashing lights (wig-wag) and LED mini bar were the most visible lights. The two in combinations provided the fastest recovery in visibility going through snow clouds.

Combination lighting did not make a noticeable difference, as only the higher mounted lights could be seen during partial white-outs.

6. RECOMMENDATIONS

Based on the information gathered during conversations with suppliers and contractors, the literature review, the highway jurisdictional survey, and the field trials, the following changes to the existing snowplow lighting standards are recommended.

6.1 Recommendations & Discussion

Existing Snowplow Lighting

For the field trials, all of the existing lamps were replaced with LED lamps of equivalent size and colour. Although this variation to the existing standard was only compared briefly during the first field trial, the LED lamps were deemed to be a great deal brighter, and therefore, more visible.

Based on that comparison, Alliant recommends replacing the existing Stop-Tail-Turn and Backup lights with LED lamps. In addition the Rear Identification Marker, which are required by the Transport Canada regulation, should also be changed to LED lights.

The potential draw back of replacing the existing lights with LED lights is problems keeping the lights clean during snowplow operations. LED lights generate far less heat than traditional lights, which may allow snow to accumulate on the lights more rapidly. This situation needs to be avoided, as any snow accumulation will reduce the effectiveness of the lighting. To prevent any snow accumulation, the snowplow truck may need to stop and clean the lights more frequently. Use of wind deflectors in these areas should be encouraged as well.

RECOMMENDATION: It is recommended that all standard vehicle lights be replaced with LED lights. These include the existing Stop-Tail-Turn & Backup lights and the Rear Identification Marker lights.

Elevated Brake and Backup Lights

A critical component to the rear warning lights is the ability of the lighting to warn drivers of changes to the speed and movement of the snowplow truck. This is especially critical when the snowplow truck is slowing down to turn or pulling off the roadway.

The existing Stop-Tail-Turn and Backup lights are located on the bumpers of the snowplow truck. This location is relatively low to the ground and is prone to being obstructed by snow cloud or covered with snow accumulation.

The help ensure that adequate warning is provided to drivers about the movements of the

snowplow truck, it is recommended that additional Stop-Tail-Turn and Backup lights are installed, at a higher location on the truck. This elevation should be the highest possible on the box, without conflicting with the warning lights that confusing drivers. These lights should be separated from all other lights and be distinctive.

These new lights shall be 4” round LED lamps, the same as the lamps on the bumper, and would be located approximately 2.3 m from the roadway surface. Two (2) Stop-Tail-Turn lights will be located vertically along the outside edges of the snowplow.

The Backup light will be located at the same height as the top Stop-Tail-Turn light approximately 0.75 m from the outside edge of the snowplow.



RECOMMENDATION: It is recommended that a second set of LED Stop-Tail-Turn and Backup lights be installed near the top of the snowplow truck box.

Rotating Centre Beacon

During the field trials a total of six (6) warning beacons were tested. This included a strobe light, single and dual rotating beacons, a single LED beacon and a low profile LED light bar. Only two of these are recommended (dual rotating beacons).

The strobe light was visible under all of the test conditions. A photocell, built within the beacon, would alter the intensity to the amount of daylight available. However, due to the short duration of the light burst, distance perception may become difficult. This observation was also made in the research paper titled, “Rear Lighting Configuration for Winter Maintenance Vehicles”, which was discussed in Section 3.2.1. Because of the distance perception problems associated with these lights, Alliant does not recommend using strobe lights on the snowplow vehicles. Generally, the strobe beacon appeared dull and not very bright.

The spatial orientation problems that were found during the testing of the strobe lights were not found during the testing of the other warning beacons. The visibility through the snow cloud of rotating beacons and the light bar was comparable or better than the strobe lights.

Based on the field trials it appeared that both the light bar and the rotating beacons will be effective in alerting drivers to the presence of a snowplow vehicle on the highway in front of them. However, the light bar did appear to be too bright in some cases (clear night) and almost overwhelming to the point of causing a significant amount of glare.

Also, the cost of the light bar does not make it a viable option for installation on the province's snowplow vehicles.

Both the single and dual beam rotating beacons performed well during the field trials. It was noted though, that the dual beam was brighter and easier to spatially judge as a result of the second beam. When considering the entire rear lighting package, a very high intensity or bright beacon may not be necessary. The elevated amber-red LED flashing warning lights should be the most noticeable and the amber beacon shouldn't over-power them. The center flashing beacon will also signify that the snowplow truck is also a maintenance vehicle, unlike an ambulance or fire truck.

The critical factor for the beacon appears to be in the daylight. Most rear-end collisions with snowplow trucks occur during the day. For this reason, the dual rotating amber beacon is recommended for daytime operations. Brighter LED mini bars are also very effective for the day and could be considered (day only). For night work, the dual rotating amber beacon can appear too bright at times. Stronger lights like the LED mini bar can be too bright at night. A single rotating amber beacon is better suited for night, to reduce glare. Since the objective is reduce collisions, the dual rotating amber beacon was chosen to be the best fit for both night and day.

RECOMMENDATION: It is recommended that a dual rotating amber beacon be used on all snowplow vehicles. It should be mounted slightly below the elevated amber-red LED flashing warning lights, at the rear center of the truck box. The rotating beams shall be set so the flashing alternates between beams. Strobes beacons should not be used. LED beacons could be considered if they provide 360 degree coverage, mimic a rotating flashing pattern and can be adjusted to be less intensive at night.

The front flashing beacon, even though outside the scope of this report, should also be changed to the same dual rotating amber beacon as per the rear of the truck. This consistency will also help alert drivers approaching the vehicle in the opposing direction of the snowplow truck.

Amber-Red LED Flashing Warning Lights

In the present rear lighting configuration, a single amber and red lamp is required above the left and right corner of the truck box. During the trials, two (2) options were examined for these lights, replacement with LED lamps of the same size or replacement with LED 75mm x 175mm flashing lights (Wig-Wag).

Both options were an improvement over the existing standard, however the LED 75mm x 175mm flashing lights (Wig-Wag) were easily deemed to be the better of the two. These lights were often the first lights to be seen before, through and after a snow cloud.

The existing bracket used for the elevated warning lights allows for three (3) possible setups of the LED Wig-Wag lights. These options can be seen on *Drawing A4-2005-08-A*. These lights can be installed in the traditional vertical alignment, which was used during the trials, or alternatively the lights could be mounted horizontally on the existing bracket. The lights could also be mounted separately in a similar configuration to the existing standard.

The flashing pattern and timing of these lights is another issue. The rapid flashing and pattern used during the field trials appeared to mimic an emergency vehicle (each light half lit, flashing rapidly, moving up and down). The pattern used by Saskatchewan Highways and Transportation is referred to as a 7-10 pattern (wig-wag pattern). In this pattern, each light flashes individually three (3) times after which all of the lights flash in unison three (3) times to complete the cycle. In order to keep the snowplow vehicles distinguished from emergency vehicles, it is recommended that a similar pattern to existing sequence be used (the red light staying on continuously and the amber flashing). The amber should not flash too rapidly, as this may look like an emergency vehicle. Additional research may be required to properly determine the appropriate configuration and flashing pattern that should be used.

RECOMMENDATION: It is recommended that amber red LED 75mm x 175mm flashing lights be mounted on the elevated brackets on all snowplow vehicles as per *Drawing A4-2005-08-A*. The amber light should be focused as per *Drawing A4-2005-08-B*.

Reflective Tape

As a result of conversations with contractors and the jurisdictional survey, Alliant is recommending that a strip of reflective tape be installed across the width of the truck at the approximate midpoint of the truck box. This location will allow the headlights from approaching vehicles to illuminate the reflective tape, maximizing its effectiveness.

There is a possible problem with this tape becoming obstructed by snow buildup during plowing operation. However if this area is cleared of snow buildup when the lights are checked for snow accumulation, any snow buildup on the reflective tape should be minimized. By motor transportation regulations, two strips of reflective tape are required on the rear of snow plow vehicles. This strip can serve as one of these as well.

RECOMMENDATION: It is recommended that two specialized reflective sheeting strips be used on the rear of all snowplow vehicles.

Rear Wind Deflector

The existing standard for snowplow operations in Alberta does not include a wind deflector to help keep the rear lighting of the snowplow clear. However, wind deflectors are being used by most maintenance contractors in the province as an addition to the rear

lighting requirements.

Saskatchewan and New Brunswick both use a wind deflector on their snowplows. The jurisdictional survey indicated that both jurisdictions have had good results with the wind deflector keeping the rear of the plow clean. However, Saskatchewan has had problems with the wind deflectors becoming clogged with snow, and therefore, reducing the effectiveness of the wind deflector.

Traditional snowplow lights generate a great deal of heat, which helps keep the lights free of snow buildup and visible to following motorists. Because LED light generate much less heat, keeping the lights free from snow accumulation will be more difficult than it had been in the past.

Although this study focused on the rear lighting of the snowplow and a wind deflector was not specifically tested during the field trials, the trial vehicle was equipped with a wind deflector. Throughout the trials this deflector did appear to have an effect on keeping the rear lighting clear of snow buildup, therefore, increasing the visibility of the rear lighting.

RECOMMENDATION: It is recommended that a wind deflector be installed on the rear of all snowplow vehicles above the hopper.

6.2 Power & Cost Implications

It is necessary that when recommendations are made to the rear lighting of the snowplow trucks, it remain practical. Power usage and cost are two measures of being practical. The following table summarizes these items.

| DESCRIPTION | NUMBER OF LIGHTS REQ'D | POWER PER LIGHT (AMPS) | TOTAL POWER REQUIRED (AMPS) | COST PER LIGHT (\$) | TOTAL COST (\$) |
|--------------------------------|------------------------|--|-----------------------------|---------------------|-----------------|
| LED Brake, Tail, Turn & Backup | 6 | 0.5/0.7 | 3.8 | \$ 50.00 | \$ 300.00 |
| LED Back-Up Lamps | 2 | 0.125 | 0.25 | \$ 60.00 | \$ 180.00 |
| LED Rear ID Lamps | 3 | 0.5 | 1.5 | \$ 10.00 | \$ 30.00 |
| LED Elevated Brake, Tail, Turn | 4 | 0.7 | 2.8 | \$ 50.00 | \$ 200.00 |
| Dual Rotating Amber Beacon | 1 | 10.5 (based on 480 fpm; less for slower speeds) | 10.5 | \$ 140.00 | \$ 140.00 |
| LED Red-Amber | | | | | |



| | | | | | |
|--------------------------------------|-----------|------|----------------|-----------|---------------------|
| Warning Lights w/ metal housing | 4 | 0.75 | 3.0 | \$ 170.00 | \$ 680.00 |
| Miscellaneous Wiring & Harnessing | | | | | \$ 500.00 |
| Wind Deflector | | | | | \$ 1 000.00 |
| TOTAL | 20 | | 21.85 * | | \$3 030.00** |

* Note: The total power required for the old rear lighting standard is Brake, Tail & Turn = $6 \times 2.1 = 12.6$, Rear ID Lamps = 1.0, Single Rotating Amber Beacon = 5.5, 2.5" red warning light $2 \times 1.0 = 2$, 4" amber warning light $2 \times 2.0 = 4$. TOTAL = 25.1 amps for 14 lights.

** Note: These costs are estimated based on average unit prices at the time of this report. They do not include additional materials such as grommets, wiring harnesses, etc. No allowance has been made for installation, but could be approximately \$1,500 to \$2,000 per truck. These prices do not take into account for bulk orders or dealer discounts. **Total estimated cost = \$ 5,000 per snowplow truck (rear lighting only).**

7. NEW STANDARD SPECIFICATION

The recommendations made in the previous section represent a recognizable change from the existing Alberta Infrastructure & Transportation lighting standards. The main objective of this project is to revise the existing specification for rear lighting of snowplow trucks, so that it may be applied province wide for all Contract Maintenance Areas. This in turn will provide improved operational safety and consistency amongst maintenance contractors.

Following is a new specification section that can be used to modify or be inserted into the existing specification for snowplow operations (Section 52.1 of the Highway Maintenance Specifications). In addition to the new specification section, two new drawings have also been included on Page iii and iv, which would replace the old lighting diagrams.

“52.1.3.9 Standard Lighting and Additional Warning Devices

Standard lighting for all types of snow removal trucks shall be in accordance with the following sections of this specification. Variances to this specification will only be allowed upon written acceptance by the Department. This applies to new lighting technology, changes in light types, light locations and lighting configurations.

52.1.3.9.1 Rear Lighting

Rear lighting shall be in accordance with Drawing A4-2005-08-A and Drawing A4-2005-08-B and shall comprise of:

- *LED stop, tail and turn lights,*
- *LED rear identification lights,*
- *Raised LED stop, tail, turn and backup lights box mounted,*
- *Dual Rotating Amber Lamp Beacon*
- *LED amber-red flashing warning lights above-box mounted.*

All lighting shall meet or exceed all applicable and current SAE standards.

52.1.3.9.1.1 LED Stop, Tail and Turn Lights

Two (2) red “Stop-Turn-Tail” lights (round) and one (1) clear “Backup” light (round) shall be installed on the bumper of the snowplow truck, on both the left and right sides. These shall be LED lights that are mounted horizontally across the rear bumper of the snowplow truck.

52.1.3.9.1.2 LED Rear Identification Lights

As per motor transportation regulations, rear vehicle lighting shall be centered on the back of the box of the snowplow truck, slightly below the box wind deflector. These shall be red LED lights, sized no larger than the “Stop-Turn-Tail” lights, spaced between 150mm – 300mm apart.

52.1.3.9.1.3 Raised LED Stop, Tail and Turn Lights Box Mounted

Two (2) red LED “Stop-Turn-Tail” lights (round or oval) shall be mounted on both upper corners of the snowplow truck box. These lights shall have a minimum diameter of 100mm and shall be mounted in a vertical configuration, with the “Stop” light mounted above the “Tail/Turn” light. The lights shall be mounted at the highest location possible on the rear of the box, without being obstructed by the wind deflector or other vehicle appurtenances. These red LED lamps will operate as Stop-Turn-Tail lights in conjunction with the Stop-Turn-Tail lights on the bumper on the snowplow vehicle.

A set of clear LED “Backup” lights (2 – round or oval) shall be mounted on the rear of the snowplow truck box, slightly inside (towards the center) of the “Stop-Turn-Tail” lights. These lights shall have a minimum diameter of 100mm and shall be mounted at the highest location possible on the rear of the box, without being obstructed by the wind deflector or other vehicle appurtenances. These clear LED lamps will operate as “Backup” lights in conjunction with the “Back-up” lights on the bumper on the snowplow vehicle.

52.1.3.9.1.4 Dual Rotating Amber Lamp Beacon

A dual rotating amber lamp beacon with minimum dimensions of 115mm (4.5”) H x 380mm (15”) L x 160mm (6.3”) W shall be used, that meets or exceeds SAE J845 Class 1, “360E Warning Devices for Authorized Emergency, Maintenance and Service Vehicles”. The warning beacon shall be mounted in the centre of the vehicle, at the top of the snowplow box, a minimum of 0.75 metres from the top of the box. The beacon shall provide between 250 to 500 flashes per minute, with minimum 50 Watt halogen bulbs. The bulbs shall be setup so that both bulbs do no flash in the same direction at the same time. Strobe beacons shall not be used.

52.1.3.9.1.5 LED Amber-Red Flashing Warning Lights

Two (2) red rectangular LED lights, measuring approximately 75mm wide x 175mm high, shall be mounted vertically on raised extension brackets that are mounted along the outside rear edges of the snowplow box. The lights shall be mounted so that the bottom of the LED lamp is 3.18 metres above the ground.

Two (2) amber rectangular LED lamps, measuring 75mm wide x 175mm high, shall be mounted horizontally, approximately 0.50 metres from the outside edges of the snowplow,

such that the top edge of the light is at the same height as the vertically mounted red LED light.

The amber LED light shall flash on and off at a flash rate of 3 – 5 flashes per second. The red LED light shall remain on at all times in a “steady-burn” mode. The amber lights shall be focused in accordance with Drawing A4-2005-08-B.

52.1.3.9.2 Light Operations – Monitoring and Maintenance

To prevent snow accumulation, all LED lights, except for the LED amber-red flashing warning lights, shall be mounted in locations with wind deflectors above them.

Before plowing operations begin, the rear lighting shall be examined to ensure all lights are operational. If any lights are not operational, they shall be repaired prior to the commencement of any plowing operations. In addition, if any diodes are burnt-out, or have a reduced luminance, they will be replaced prior to any plowing operations

All rear lighting shall be periodically checked to ensure that the lighting is operational and not blocked by snow, mud, etc., in accordance with the Contractor’s safety program.

52.1.3.9.3 Reflective Tape

Two strips of specialized reflective tape shall be located horizontally across the width of the truck, one at the midpoint of the truck, approximately 2 metres from the ground. The second strip can be located as per required by motor transport regulations. The strip of reflective tape shall be reflective (for day and night use), at least 50mm wide and contain alternating blocks of red and white colors.

52.1.3.9.4 Rear Wind Deflector

A rear wind deflector shall be installed above the box of the snowplow in such a manner as to force the flow of air down the rear of the snowplow vehicle. The wind deflector shall extend across the full width of the truck box and be located so that bottom of the wind deflector is located no more than 300 mm from the top of the Raised LED Stop, Tail and Turn Lights.

52.1.3.9.5 Front Lighting

A dual rotating amber lamp beacon, that matches the rear dual rotating amber lamp beacon, shall be mounted on the front of the snowplow truck. The beacon shall be unobstructed and clearly visibly.

8. CONCLUSION

Alberta Infrastructure and Transportation's goal for this project was to complete a review of the rear lighting standards for snowplow vehicles within the province of Alberta. Alliant Engineering commenced this assignment in September 2004 and has now been completed in August 2005. This report provides all the process details of this project along with recommendations.

The project objectives have been completed within the given scope of the work. The recommendations provide a new rear lighting specification that can be utilized immediately for all snowplow vehicles used on Alberta Infrastructure and Transportation highways.

Limitations of this report include:

- side and front lighting review
- patterns for amber-red LED flashing lights
- pointing review for LED flashing lights
- wing and plow blade lighting review
- improved lighting for operators
- reflective tape review
- wind deflector review
- new LED technology after July 2005

Individuals and parties that helped make this project successful include the following:

Gordon Alloway, Grote Canada
Bruce Buckley, Quest Fabrication
Barry Shane, Public Safety Equipment
Fort Gary Industries Ltd., Edmonton
Alberta Highway Services Ltd.
Ciné Audio Visual
Terry Becker, Alberta Infrastructure & Transportation
Neal Reynolds, Alberta Infrastructure & Transportation
Peter Ing, Alberta Infrastructure & Transportation
Steve Otto, Alberta Infrastructure & Transportation
Randy Shaul, Alberta Infrastructure & Transportation
Nick Bucyk, Alberta Infrastructure & Transportation
Ron Stoski, Alberta Infrastructure & Transportation
Paula Campbell, Alberta Infrastructure & Transportation
Alfred Tauscher, Alberta Infrastructure & Transportation

A big thank you to everyone for their contributions.

9. CLOSURE

We trust the information provided meets your present requirements. Should any questions arise, please contact our office at your convenience.

Ryan Batty, E.I.T.
Project Engineer

Warren McKay, E.I.T.
Project Engineer

Darcy Paulichuk, P. Eng.
Senior Project Engineer

Engineering Stamp
Darcy O. Paulichuk, P. Eng.

Permit
Alliant Engineering & Consulting Ltd.

APPENDIX A

PHOTOS



Photo #1 - A view of the existing front and rear standard lighting of typical snowplow trucks. Note that the truck on the right does not comply exactly with the Alberta Infrastructure and Transportation Highway Maintenance Specification, as the top 2.5" red warning light should be mounted sideways on the outer edge.



Photo #2 - Another photo of the rear lighting on a snowplow truck. Again, the red warning lights are mounted on the inside of the mounting bracket inside of on the outside as per specification. The height of the amber and red warning lights also appear to be lower for this truck.

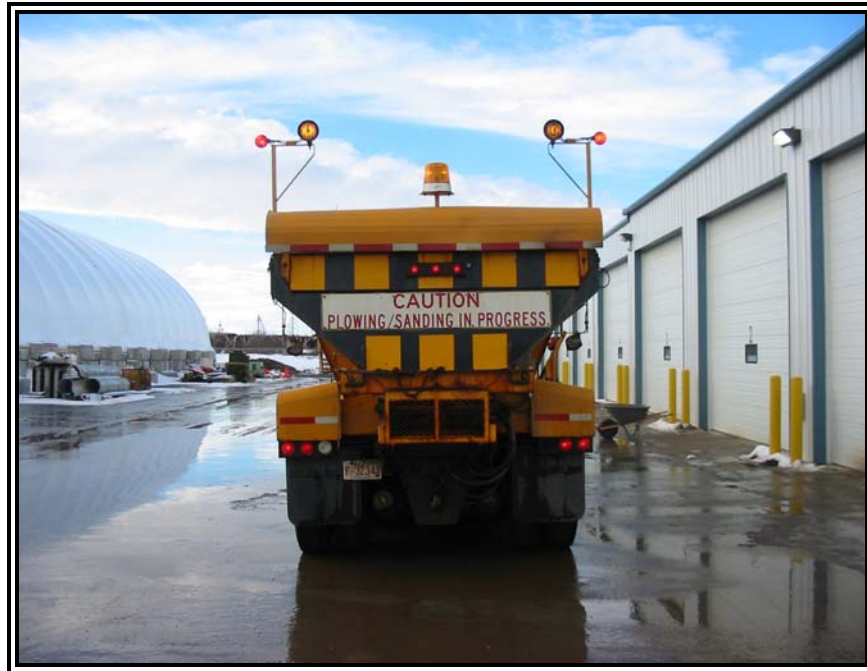


Photo #3 - Viewing another snowplow truck that meets the existing Alberta Infrastructure & Transportation Specification. In this case a checker board pattern, warning sign and reflective tape (wind deflector, above tail lights & upper brackets) have been added.



Photo #4 - Viewing the same snowplow as seen in Photo #3. From this angle the required reflective tape can be seen along the side of the snowplow as well.



Photo #5 - Viewing along the right side of a snowplow truck. Marker lights are used on the side of the truck. An orange warning flag and amber light are used here on the end of the wing.



Photo #6 - A side view of a snowplow. In this photo the wind deflector, used to keep the rear of the truck clear of snow buildup, can be seen. Also, de-icing tanks are being used and are located on the sides of the truck. A front flashing amber beacon and additional headlights are also used.



Photo #7 - Viewing the front of a snowplow. The rotating beacon required on the front of the plow can be seen in this photo. This plow has been outfitted with metal strips with reflective tape for marking the corner of the plow, in lieu of orange flags. Additional elevated headlights are also included to aid the driver.



Photo #8 - This close-up of the rear of the snowplow truck shows the setup of the wind deflectors above the box and over the tail lights. The Rear Identification Lamps can also be seen below the wind deflector.



Photo #9 - Viewing an alternate lighting setup used by Parkland County. In this configuration orange warning flags have been installed to compliment the elevated amber and red warning lights. A dual amber rotating beacon is being used above the box.



Photo #10 - The same snowplow as seen in the above photo, with a front view of the plow. An additional orange warning flags are on the tips of the plow. No major additions to the lighting package is evident.



Photo #11 - A photo of a snowplow truck during plowing operations on January 6, 2005, east of Vegreville on Hwy. 16. In this photo the elevated flashing amber lights are the most visible of the rear warning lights.



Photo #12 - Following the same plow as above, now closer to the snowplow itself. From this distance the tail lights are much more visible than previously. The elevated lights are still visible because they are above the snow cloud.



Photo #13 - Viewing the previous snowplow, slightly closer. Visibility of the lights is sufficient to warn motorists at this distance.



Photo #14 – Rear lighting of a snowplow truck at night. This is a photo of the standard snowplow lighting at a distance. This photo was taken under night conditions.



Photo #15 – Closer view of the snowplow truck seen in photo #14. The individual lights are beginning to become distinguishable.



Photo #16 – Approximately 50 to 75 metres from the rear of the snowplow truck. From this distance each light can be clearly seen. The lighting configuration is slightly different from the specifications where there are two front mounted amber beacons. The elevated amber lights appear to be the brightest.



Photo #17 - This photo is of a new truck box which has been outfitted with snowplow lighting at Fort Garry Industries Ltd.



Photo #18 - This lighting setup has moved the location of the red marker lamp inside the mounting bracket and placed inside a square metal box, as seen previously in Photo #2.



Photo #19 - The warning beacon is a dual amber Whelen beacon. This appears to be a Responder Series, R2HD, with 92,000 beam candle power from 50 Watt bulbs.



Photo #20 - This photo shows the test snowplow truck. This truck has been outfitted to accommodate all of the lighting trials (not all shown). A steel square hollow beam was used to mount a variety of beacons.



Photo #21 - This photo was taken during a break in the field trials. Snow buildup can be seen on the bumpers, partially obstructing the Stop-Tail-Turn and Backup lights.



Photo #22 - This photo has been taken to show the trial snowplow outfitted with the PSE Amber 2100 low profile light bar for use as the centre beacon.



Photo #23 - A side view of the field trial snowplow truck. Snow buildup can be seen on the wind deflector over the Stop-Tail-Turn and backup lights and the side of the truck box. The wind deflectors are not properly working over the tail lights as de-icing tanks are mounted along the box.



Photo #24 - Viewing from the front corner of the trial snowplow. The vertical reflective strips, which have been mounted on each corner of the snowplow blade, can be seen in this photo.



Photo #25 - Another picture from the front of the snowplow. The reflective striping on both corners of the plow can be seen here. A rubber skirt has also been added to the plow blade to help reduce the snow that comes over the truck. A single amber beacon is used on the front of the truck, mounted on the cab.



Photo #26 - This photo show the cross member used to install the warning beacons. Three (3) beacons were mounted to two (2) cross beams to allow different options to be viewed in quick succession in the field.



Photo #27 - During the field trials the above setup was used to record the trials. The video of the trials has been edited and included with this report.



Photo #28 - The video camera was mounted to the centre console of the lead chase vehicle, a 1999 Dodge Ram 4x4. This setup allowed the camera an unobstructed view out the windshield. A second home video camera was set on the dash, as backup video coverage.



Photo #29 - This photo of the trial snowplow truck, outfitted with the low profile light bar as the centre beacon. Snow has built up on the upper wind deflector; however, the wind deflector has kept the back of the plow clear.



Photo #30 - This photo taken at the same stage of the trials as above shows that snow has not only accumulated on the wind deflector but on the vertical LED light bars as well.



Photo #31 - This photo show extensive snow accumulation on the rear of a typical snowplow truck, when no de-icing tank is used.



Photo #32 - This photo of the same snowplow as above, again shows large amounts of snow buildup. On this side of the truck the wind deflector has not been as effective in keeping the lights on the bumper clear.



Photo #33 - This photo shows a direct comparison of the effectiveness of the wind deflectors on each side of the snowplow. In summary, the lower wind deflectors appear to be not working.



Photo #34 - This close-up of the vertical LED light bar shows the snow that accumulated during testing. LED lights generate less heat than traditional lights and are therefore more susceptible to snow buildup.



Photo #35 - The existing tail, brake, rear ID and elevated warning lights were replaced with LED lights for the field trials. These lights can be seen in the above photo.



Photo #36 - This photo shows the entire trial configuration turned on at once. Amber-red LED flashing warning lights, vertical and horizontal lights bars and directional LED were all tested.



Photo #37 - Similarly to the previous photo, this show all of the trial lighting configurations turned on. In addition the PSE Amber 2100 LED low profile light bar is also turned on.



Photo #38 - This photo show the existing front lighting for snowplows turned on. The front lighting was not examined as part of this project.



Photo #39 - The crew used to complete the final round of testing during the afternoon of March 22, 2005.



APPENDIX B

PHASE ONE PRESENTATION

SNOW PLOW REAR LIGHTING

Research Project

by



SNOW PLOW REAR LIGHTING

SCOPE OF PROJECT

- Province Wide Review of Rear Lighting used on AT Highways
- Lighting Standards & HMS
- Equivalent Lighting Equipment
- Safety Improvements for Motorists encroaching from behind Snow Plow
- Compliance with Lighting Regulations

SNOW PLOW REAR LIGHTING



Highway 14, East of Edmonton, 2004

SNOW PLOW REAR LIGHTING

PROJECT TASKS

- North American Highway Jurisdictions Survey
- Literature Review
- Determine Appropriate Performance Standards
- Identification of New Equipment and Types for Trials
- Plan Field Demonstrations
- Organize Evaluation Panel
- Field Demonstrations
- Final Report

North American Highway Jurisdictions Survey

OBJECTIVE:

- To determine what devices and configurations are presently being used
- Likely to be large Diversities between Jurisdictions (i.e. Provinces & Municipalities)
 - Canadian Provinces – Provincial Departments
 - U.S. State Departments of Transportation (DOT's)

Snowplow Rear Lighting Questionnaire

ALLIANT Engineering

Snowplow Rear Lighting Questionnaire

1. How are rear lights with amber lenses configured?

Yes No

If Yes, what are the configurations?

2. What types of amber lens are currently used?

3. What types of rear lighting do you use?

4. How many lights are used and how are the rear lights arranged?

ALLIANT Engineering

5. How are rear lights with red lenses configured?

Yes No

If Yes, what are the configurations?

6. How are rear lights used?

Yes No

If Yes, how many are used?

7. How many lights are used?

Yes No

If Yes, how many are used?

Snowplow Rear Lighting Questionnaire



North American Highway Jurisdictions Survey

Jurisdictions being contacted:

- | | |
|---|------------------------------------|
| <input type="checkbox"/> British Columbia | <input type="checkbox"/> Montana |
| <input type="checkbox"/> Saskatchewan | <input type="checkbox"/> Minnesota |
| <input type="checkbox"/> Ontario | <input type="checkbox"/> Wyoming |
| <input type="checkbox"/> Quebec | <input type="checkbox"/> New York |
| <input type="checkbox"/> Newfoundland | <input type="checkbox"/> Colorado |
| <input type="checkbox"/> New Brunswick | <input type="checkbox"/> Michigan |
| <input type="checkbox"/> Prince Edward Island | |

North American Highway Jurisdictions Survey

Jurisdictions replied:

- | | |
|---|----------------------------------|
| <input type="checkbox"/> British Columbia | <input type="checkbox"/> Wyoming |
| <input type="checkbox"/> Ontario | |
| <input type="checkbox"/> New Brunswick | |
| <input type="checkbox"/> Nova Scotia | |

North American Highway Jurisdictions Survey

Snow Plow Rear Lighting Questionnaire

- Have rear-end collisions with snowplows been a problem?
 - No jurisdiction has a problem.
- What type(s) of snowplows do you normally use?
 - Spreaders, Snowplows, and Combination of snowplows and spreaders

North American Highway Jurisdictions Survey

- What type(s) of rear lighting do you use?
 - Strobe lights, beacon lights, flashing amber lights (on or above), tail lights, brake lights, and signal lights.
- How many lights are used and how are the rear lights arranged?
 - Strobe or beacon lights on top.
 - Lights (Amber and/or Red) above box.
 - Lights on back.

North American Highway Jurisdictions Survey

- Have you used steady state lighting (LED)?
 - New Brunswick, Nova Scotia, and Wyoming have used LED and providing good visibility, but it is tough to keep clean.
- Have you used reflective tape?
 - Nova Scotia ✘ at the outside perimeter of truck with good results.
 - Ontario ✘ additional light to highlight the tape.

North American Highway Jurisdictions Survey

- Have you used orange flags?
 - Nova Scotia, Ontario, and New Brunswick ✧ orange flags or tubes at outside corners of plow.
- Have you used any other rear warning devices?
 - New Brunswick ✧ has used diagonal striped at rear panel but never use anymore due to poor results.
 - BC ✧ diagonal or square pattern.

North American Highway Jurisdictions Survey

- Have you used any devices to eliminate snow build-up on the rear lighting?
 - New Brunswick ✧ wind loovers to deflect wind down the back (Good results w/ dry, light snow).
 - Wyoming ✧ metal spoilers on LED light mounts.
- Have you used any devices to minimize the snow cloud behind the snowplow?
 - Wyoming ✧ metal spoiler on top of spreader.
 - Nova Scotia ✧ rubber skirt on plow to prevent snow from blowing over the truck.

North American Highway Jurisdictions Survey

- Are any changes to your snowplow rear warning systems planned?
 - Ontario ✧ The issue of LED as been raised but no changes are planned.

Web Page Survey ✧ Snow removal device used in US

- Alaska
 - On grader and truck wing tips, install strobe lights.
 - Dump boxes are equipped with strobe lights as well.
- Arizona
 - Snow plows use amber strobe lights on the front.
 - Have strobe lights on all 4 corners placed on the bumper.
 - Have blue and amber strobes on the back.
- Arkansas
 - Use snow plow deflectors.

Web Page Survey ✧ Snow removal device used in US

- California
 - Apply work lights on the wing plow.
 - May apply apply one or more 1-way flashing lights at the corners of the dump box.
- Colorado
 - Use the Whelen snow and fog lights on snow-removal vehicles.
 - Snow-removal vehicles also run a combination of amber and blue lights.
 - Snow plows have strobes on the left- and right-hand side of the cab.

Web Page Survey ✧ Snow removal device used in US

- Colorado (Cont'd)
 - Place strobes on the corner posts of the bed on the rear.
 - Place an LED warning light on the end of the wing plow.
- Connecticut
 - Snow plows are J-style. Some drivers opt to add deflectors.
- Georgia
 - Have lights above the snow plow.

Web Page Survey ☆ Snow removal device used in US

- Idaho
 - Whelen Superstrobe Comet Flash light mounted on the truck cab.
 - A dual rotating halogen light at the top/center rear of the sander.
 - 4 amber halogen lights on the side of the sander, 2 per side. These lights are equipped with a flasher unit to give the appearance of a bouncing ball with lights flashing side-to-side and top-to-bottom.
 - All snow plow trucks have LED taillights.

Web Page Survey ☆ Snow removal device used in US

- Iowa
 - Some snow plows use tail light air blasters.
 - Experimenting with continuity tape placed on orange safety fence on the rear of the vehicle.
 - Snow plow trucks use a dual amber rotating beacon and 2 amber rear-directional alternate-flashing strobes.
- Kentucky
 - Snow plow vehicles have lights on tailgate corners and on the cab.
 - Place lights above the plow.

Web Page Survey ☆ Snow removal device used in US

- Maine
 - Run more lights on snow plows than normal maintenance vehicles.
- Minnesota
 - Snow plows are equipped with 6 amber strobes.
 - 2 white strobes on the rear of the box on all left-hand wing trucks (used during daylight).
 - Double rotating or strobe light; either amber or blue.
 - Trying a few LED Lights.
 - Put reflective tape on wing plows and on the underbody.

Web Page Survey ☆ Snow removal device used in US

- Nebraska
 - White and amber warning lights are mainly used during snow removal.
- New Hampshire
 - Some snow plows have small strobes mounted on the extension arms of the mirrors.
 - Mount some lights on the back side near the tail gate.
- New York
 - Most plows have snow deflectors. Some have deflectors extend out, then down.

Web Page Survey ☆ Snow removal device used in US

- North Carolina
 - Use the standard lighting of 2 high-intensity strobe lights mounted on each side of the cab protector.
 - Also place a yellow strobe mounted on the rear of the in-body material spreaders.
 - Every tailgate on the dump bodies are striped with reflective, glass-beaded paint.
- Ohio
 - Snow plows are ordered in gloss black.
 - Attach 18-inch orange plastic tubes to the outside edge of the moldboard.

Web Page Survey ☆ Snow removal device used in US

- Oklahoma
 - Use snow plow deflectors.
- Pennsylvania
 - Use snow plow deflectors.
- Vermont
 - Use snow plow deflectors.
 - 360-degree light mounted either on a bar on top of the cab or on the upper mirror brackets.
 - Rear-facing lights in the rear body corner posts.
 - 2 large strobes are mounted on swinging plates on the tailgate.

Web Page Survey ☆ Snow removal device used in US

- Vermont (Cont'd)
 - Experimenting with LEDs mounted on the discharge end of the wing plow.
- Virginia
 - An auxiliary snow-removal headlight with park/turn lamps is used.
 - Use clear halogen head lamp and amber park/turn lamps mounted in the grill or fender.
 - Use spreader light mounted under the left rear corner of the dump body, facing down.

Literature Review

- OBJECTIVE:
 - To determine what devices and configurations are available.....Technology has changed!
 - Research Organizations
 - Manufacturers & Suppliers
 - Research Papers & Publications
 - Past Work – AT did a Review in the '80's!

Research Organization



■ Lighting Research Center

Research Papers & Publications

Research Topic

- "Rear Lighting Configuration for Winter Maintenance Vehicles"

Purpose

- To alert drivers of nearby vehicles that the snowplow is on the roadway, and to provide cues to those drivers about the snowplow's relative speed and distance.

Background

- Around 70% of all accidents involving snowplows involve collisions into the rear of snowplow trucks.

Research Papers & Publications

Background (Cont'd)

- Rear lighting on snowplow vehicles should serve 2 distinct purposes:
 - Provide a conspicuous signal to other drivers that the plow is on the road.
 - Provide cues about the plow's operating speed, direction and distance, relative to other vehicles.

Conclusion

- Flashing and strobing lights are less effective than steady-burning lights for estimating relative speed, distance and closure.
- An array of lights will be more effective than a single light source.
- The use of LEDs in the light bars also results in reduced power requirements relative to conventional incandescent sources.

Research Papers & Publications

Conclusion (Cont'd)

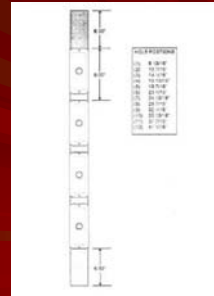
- LEDs are low-power devices, are relatively durable and are becoming more and more cost-effective for signage and signaling applications.
- LEDs appear to be promising technologies for rear lighting and have been demonstrated to provide adequate visibility and closure detection during inclement weather.

Snow Plow Rear Lighting



■ Which snowplow would you rather drive behind?

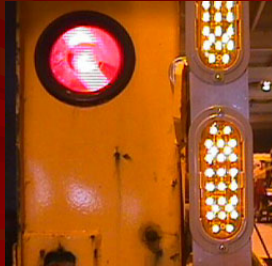
Schematic Diagram of Vertical LED Light Bar Configuration



Rear Lighting and Signaling on Snowplows



Rear Lighting and Signaling on Snowplows (Close Up)



Research Papers & Publications

Research Topic

■ "Improved Visibility for Snowplowing Operations"

Purpose

■ To improve visibility for snowplowing operations.

Background

- Visibility is reduced during snowplowing operations because of reflected headlight glare, obscured windows, and blowing snow.
- Because poor visibility reduces operational safety and contributes substantially to the hazards faced by snowplow operators and motorists, there is a need to identify features that would improve visibility during snowplow operations.

Research Papers & Publications

Conclusion

- Side vanes with a 20-degree angle on the rear of the plow will reduce snow accumulation on the rear lighting of the snowplow vehicle.
- Steady-burning light bars mounted along the rear edges of the snowplow truck will improve drivers' ability to detect changes in the snowplow vehicle's speed and will provide an indication of the vehicle's width.

Manufacturers & Suppliers



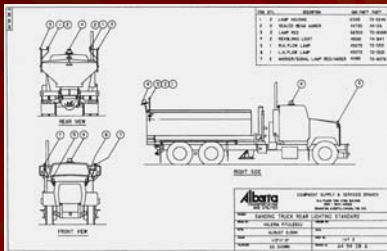
Manufacturers & Suppliers



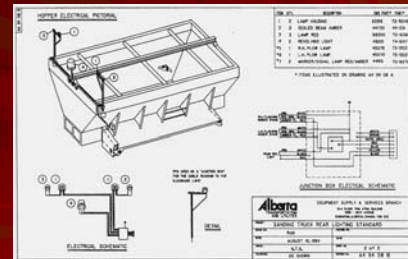
Performance Standards

- Performance Standards vrs. Set Specifications
 - Set Specifications (present AT method since 80's)
 - Specific Light Colors Distinguishing Snow Plow
 - Specific Light Sizes and Placement
 - Specific Light Types - Part Numbers
 - Rear Amber Flashing Light Setting to Spec. Dist.
 - Reflector Tape

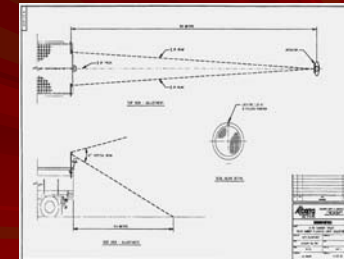
Past Work - Highway Maintenance Specification



Past Work - Highway Maintenance Specification



Past Work - Highway Maintenance Specification



Existing Equipment Standard

- Amber and Red Light on Top
- Tail Lights, Brake Lights
- Beacon Lights at Front and Back
- Reflective Tape at the back and along the side of the snow plow vehicle
- Lights on Wings

Existing Equipment Standard



Existing Equipment Standard



Existing Equipment Standard



Alberta Highway Services – Stony Plain

Existing Equipment Standard



Existing Equipment Standard



Existing Equipment Standard



Existing Equipment Standard



Existing Equipment Standard



Parkland County

Equipment Modifications

- LEDs tail lights on the new model of snow plow vehicle
- Light Placement
- Strobes instead of Rotating Beacons
- Whelen Beacons
- Checker Board Pattern
- Wind Deflectors

Existing Equipment Standard

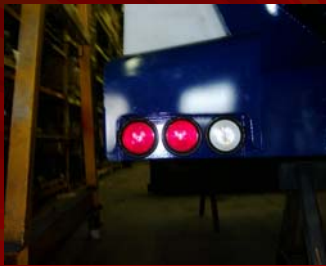


Voker Stevin

Existing Equipment Standard



Existing Equipment Standard



Existing Equipment Standard



Performance Standards

- Performance Standards Better Way?
 - Different Types of Snow Plow Trucks (i.e. age, make, model)
 - Different Types of Boxes
 - Different Configurations of Plows
 - Roadway Differences (Undivided vrs. Divided)
 - Different Regional Weather
 - Several Suppliers

Performance Standards

- How do we determine Performance Standards for this?
 - Based on Visibility Minimum Distance
 - Based on Light Intensity Measurements
 - Based on Distance and Speed Variability Perception
 - Based on Minimum Specifications & Performance Benchmarks

Performance Standards

- CONCERNS
 - Performance Standards hard to check
 - Inconsistency Provincial Lighting Standards
 - Public Understanding & Perception
 - Past AT Education Program
 - AMBER & RED means Snow Plow ahead!
- RECOMMENDATION
 - Stay with Set Specification with defined flexibility
 - Maintain Past AT Technology, just improve!

New Equipment and Types for Trials

- LED's should be used as much as possible (tail lights, brake lights, amber & red lights). Therefore, use on all new Trials with no variance.
- Two Strategies
 - Option A: Use new vertical LED steady state lights on both end of the box, while varying only the beacon.
 - Improved Rotating Beacon
 - Strobe Beacon
 - Whelen Beacon
 - Option B: Vary LED steady state lights between vertical and horizontal on the rear of the box. Vary different types of beacons.
 - Vertical LED Steady State lights with Whelen Beacon
 - Vertical LED Steady State lights with Strobe Beacon
 - Horizontal LED Steady State light with Whelen Beacon

New Equipment and Types for Trials

- All Trials will be have the array of red & amber lights, which maintains our previous standard.
- Existing lighting configuration used as a Benchmark.
- 4 Trial Runs per set.
- Try in different weather, night or day?
- Discussion.....

New Equipment and Types for Trials

- Fort Garry Industries (FGI) has offered to provide materials and install them on our test snow plow (everything will be on switches).
- Alberta Highway Services is willing to help provide a snow plow and operator (cost?)
- Field Demonstrations could be ready to go by mid January.
- Expect period between Jan. 15 to Feb. 15, 2004, for Field Demos.

Field Demonstrations

- An area within Alberta will be chosen for running the Trials.
- Recommendations:
 - Hwy. 14, East of Edm., Divided Section
 - Hwy. 16, East of Adrossan., Divided Section
 - Hwy. 2, North of St. Albert, Divided Section
 - Hwy. 60, North of Devon, Divided Section
- Trials will be conducted when there is a snow storm (min. requirement).
- Photos and Video

Evaluation Panel

- Should Include a Diverse Range of People in the Industry
 - Alberta Transportation
 - Maintenance Contract Inspector (MCI)
 - Operations Manager
 - Operations Engineer(s)
 - Contractors
 - Maintenance Contractor
 - Supervisor
 - Snow Plow Operator

Evaluation Panel (con't)

- Suppliers
 - Lighting Supplier
 - Lighting Installer
- Consultant
 - Project Engineer
 - Project Engineering Assistant
- Total = 10 people
 - Too much? Might be hard to coordinate.
 - More Contractors?
 - Panel should follow some reason criteria.

Evaluation Panel (con't)

- Evaluation Criteria
 - Lighting Intensity
 - Subjective
 - Baseline will be Existing Lighting Configuration
 - Safety Improvements
 - Distance perception to Snow Plow from Motorist
 - Will it allow more passing? Do we want more passing (four-lane highways only).
 - Less Rear-End Accidents
- Evaluation Rating Sheet
 - Rating could be a number system (i.e. 1 to 5)
- Video
 - Don't expect to rely on Video....could be deceiving.

CONCLUSION



Thank you!



APPENDIX C

RESEARCH PAPERS

PAPER #14: REAR LIGHTING CONFIGURATIONS FOR WINTER MAINTENANCE VEHICLES

J. D. Bullough¹, M. S. Rea¹, R. M. Pysar¹, H. K. Nakhla² and D. E. Amsler³

¹Lighting Research Center, Rensselaer Polytechnic Institute, Troy, NY, USA 12180; ²Department of Mechanical Engineering, Aeronautical Engineering and Mechanics, Rensselaer Polytechnic Institute, Troy, NY, USA 12180;

³AFM Engineering Services, Slingerlands, NY, USA 12159

IESNA Annual Conference: Ottawa, ON, Canada; August 5-8, 2001

ABSTRACT

Winter maintenance vehicles for snowplowing often operate when visibility is compromised. Rear lighting on snowplows serves two purposes: to alert drivers of nearby vehicles that the snowplow is on the roadway, and to provide cues to those drivers about the snowplow's relative speed and distance. Flashing and strobing lights have been used on snowplows by many departments of transportation, who consider these lights as having high conspicuity and attention-getting properties. However, most accidents involving snowplows are rear-end collisions by other vehicles, and previous research supports the idea that flashing or strobing configurations are less effective than steady-burning lights at providing cues about relative speed, distance and closure to drivers approaching a snowplow from behind. To test this concept, a prototype steady-burning light bar using light-emitting diodes was developed and tested on a snowplow vehicle, which was also equipped with conventional flashing lights. The ability of subjects following snowplows to detect deceleration of the snowplow was measured with each lighting configuration during nighttime field tests conducted while snow was falling. The mean time to detect closure was significantly shorter with the steady-burning light bar than with flashing lights. Subjective ratings of visibility and confidence for judging speed and distance were also higher with a steady-burning light bar than for the conventional system. The prototype light bar configuration could easily be adapted to existing snowplow vehicles as a retrofit, or it could be incorporated into specifications for new maintenance vehicles.

BACKGROUND

A major problem experienced by snowplow operators is the inability of other vehicle drivers to maneuver safely near the snowplow. Around 70% of all accidents involving snowplows involve collisions into the rear of snowplow trucks.^{1,2} On the surface, the solution to this problem seems to be one of increasing the conspicuity of the snowplowing vehicle. While conspicuity is indeed important, equally important is improving the ability of other drivers to judge the distance, direction and speed of the snowplow relative to their own vehicles, especially in a driving environment where falling snow, oncoming headlights and other flashing signals can contribute to glare and fatigue.³

Rear lighting on snowplow vehicles should serve two distinct purposes:

- Provide a conspicuous signal to other drivers that the plow is on the road
- Provide cues about the plow's operating speed, direction and distance, relative to other vehicles

Lighting systems that are highly conspicuous (e.g., strobe lights) are often poor at providing speed and distance cues, and vice versa. The challenge of rear lighting and signaling for snowplows is finding an effective balance between these purposes.

Review of the relevant literature on rear lighting and signaling shows that several factors affect visibility of a vehicle to other drivers:

- Mounting location⁴
- Temporal light characteristics⁵⁻⁸
- Spatial light characteristics^{9,10}
- Luminous intensity¹¹

Significant cloud accumulation behind the truck can occur while plowing snow. The most effective mounting location for rear lights in this case is as high as possible in order to ensure that the lights will clear the cloud behind the truck. A number of agencies in the U.S. and Canada specify high mounting locations for rear lights, including the Department of Transportation in New York State and the Ontario Ministry of Transport. Such specifications are in general agreement with the recommendations of Marsh.⁴ In addition, a high mounting location permits the maximum lamp intensity to be visible from the furthest distance away from the plow truck. As a following vehicle approaches

the plow truck, the angle between the maximum intensity from the lamp and the driver's view of the source increases, and the intensity toward the following driver decreases, reducing potential for glare.

Flashing lights will be perceived as having higher brightness than steady-burning lights, up to a flash frequency of about 15 flashes per second.⁵ Such brightness enhancement can aid in conspicuity, and several rear lighting systems have been designed to have a flash rate between 5 and 9 flashes per second in order to maximize their perceived brightness.¹² While conspicuity may be greater with such configurations, an observer's ability to make accurate judgments of relative speed or distance may be compromised when flashing or strobing lights are used. Croft⁶ observed that the judgments required in tracking an object were difficult to make under strobing conditions, yet very easy in steady-lighting conditions. Observations made during a study of service vehicle lighting for maintenance operations⁷ similarly pointed out that strobing and flashing systems designed for maximum conspicuity can at the same time reduce one's ability to judge relative speed and distance. Periodic sampling of the field of view in another study resulted in deterioration of one's motion-tracking ability that increased as the distance to the object of interest decreased.⁸

As for spatial characteristics, an investigation of rear lighting packages on vehicles⁹ found that one's ability to accurately estimate relative speed and distance depended also on the spatial extent (size) of the signal system. A single light source provided very poor speed and distance information, while an extended spatial array of sources provided good cues for speed and distance. Changes in apparent size are critical to time-of-arrival judgments,¹⁰ so larger-sized stimuli should be more effective in making such judgments. An approach that involved the use of floodlights to "wash" the rear of a snowplow with light was somewhat effective at night during clear conditions but appeared to be much less effective during inclement weather⁹ because of the much-reduced intensity.

In order to investigate the properties of different rear lighting configurations, several types were mounted on snowplow vehicles and evaluated first in a simple demonstration using subjective ratings, and later in field tests conducted on highways during winter storms at night.

METHOD: SUBJECTIVE EVALUATIONS

Preliminary field demonstrations of several rear lighting configurations were conducted during the winter of 1997/1998. Four configurations were tested on county snowplow trucks in upstate New York:

- Conventional configuration: The typical flashing amber lighting configuration used on snowplow trucks in New York State.
- Indirect edge delineation: An indirect edge delineation system similar in concept to the floodlight approach used by Stout *et al.*¹¹ but designed to illuminate the left- and right-hand edges of the rear of the snowplow truck only.
- Alternating high-mounted: A temporally alternating, high-mounted configuration of two pairs (one amber and one red) of flashing lamps configured so that at all times, either the yellow or the red pair was on. From a distance, this configuration appeared to be two steady-burning points of light that alternated in color between amber and red.
- LED light bar configuration: A horizontal light bar arrangement using light-emitting diodes (LEDs) in a steady-burning configuration. Commercially available LED turn signal units were assembled to form the light bar.

The luminances of the amber lamps in the standard configuration and the alternating high-mounted configuration were measured in the field to be approximately 60,000 to 90,000 cd/m². The red lamps in the alternating high-mounted configuration had a luminance of approximately 13,000 to 15,000 cd/m². Because red lights are higher in perceived brightness than yellow lights of the same luminance,¹³⁻¹⁶ the brightness differences between the yellow and red lamps was smaller than their luminances imply. Luminances of truck surfaces illuminated by the indirect edge delineation configuration ranged from 160 to 290 cd/m². Luminance measurements of the LED light bar were more difficult to measure because the LED units that were used formed arrays of point sources too small to accurately measure with a luminance meter. Spatially-averaged luminances of arrays ranged from about 25,000 to 50,000 cd/m²; the luminance of individual luminous point were significantly higher.

Using a simple questionnaire, county snowplow operators were asked to rate the visibility of each lighting system and to rate the confidence with which they would be willing to pass the snowplow from behind. Each of the ratings were made on a scale of -3 (worst) to +3 (best). Ratings were made at night for both clear weather conditions and heavy snow conditions. Six snowplow operators made subjective judgments of all four lighting configurations. Every operator provided ratings for both weather conditions.

RESULTS: SUBJECTIVE EVALUATIONS

The mean visibility and confidence ratings (and standard deviations) are listed in Table 1. As expected, the ratings were worse for the heavy snow conditions than for the clear conditions. Using within-subjects analyses of

variance (Table 2), the type of lighting configuration had a statistically significant impact on ratings of visibility and confidence ($p < 0.05$), and the ambient weather condition had a significant effect on ratings of visibility and confidence ($p < 0.05$). There was a statistically significant ($p < 0.05$) interaction between lighting configurations and weather conditions for the confidence ratings, but not for the visibility ratings. Because the LED light bar configuration resulted in the highest subjective ratings of visibility and confidence among all of the configurations, a modified version of this configuration was selected for comparison in field tests during the following winter.

METHOD: CLOSURE DETECTION TEST

Based on the preliminary findings from the subjective evaluations, an amber light bar configuration using an array of LED marker lights was developed for field tests in upstate New York during the 1998/1999 winter (see Figures 1 and 2). The LED units used in the light bars were oblong, 7 by 3 in. (18 by 8 cm) devices each with 26 high-output amber LEDs. The devices meet Society for Automotive Engineers (SAE) specifications¹⁷ for amber mid-turn units used on commercial trucks, but were not used for the purpose of turn signaling in this study. Two light bars were developed for use in a vertical orientation on the snowplow trucks; one on each side of the truck, in order to provide information to other drivers about the width of the snowplow truck. In addition, the horizontal orientation studied earlier was found to be impractical for some truck configurations because of protrusions associated with the storage of salt for spreading on roads. The light bars were designed as retrofit units mounted onto the rear of an existing snowplow truck, and were used in conjunction with airfoils designed to help keep the rear of the truck clear of snow buildup.^{18,19}

Because of the previous literature on flashing light configurations and their potential impacts of such configurations on judgments of relative speed and distance,^{6,7} it was hypothesized that the steady-burning light bar configuration would result in improved judgments relative to the flashing light configuration. A field study to investigate this hypothesis was designed with several constraints in mind:

- The study should use equipment and vehicles used during actual snowplowing operations on the road.
- The study should interfere minimally with snowplowing operations.
- Differences in location, weather and ambient light level should be minimized when comparing the alternative lighting configurations.

A single snowplow truck was fitted with both lighting configurations. A closure detection test was developed whereby a subject rode in the passenger seat of a vehicle that was operated at a constant speed (30 mph) and started a fixed distance [100 m; measured using a lidar (*light detection and ranging*) range finder] behind a snowplow truck also moving at the same speed. After a random interval ranging from 20 to 60 sec, an experimenter riding in the snowplow silently signaled to the snowplow operator to decelerate by slowly taking pressure off the accelerator pedal, but without pressing the brake pedal (which would illuminate the truck's brake lights). At the same time the experimenter would start a stopwatch. The subject, who was in cell telephone contact with the experimenter, was instructed to say "Now!" when certain that the following vehicle was beginning to approach the snowplow. The experimenter would stop the stopwatch, record the time, and prepare for the next trial. For each trial, the rear lighting configuration was switched from inside the snowplow cab between the conventional flashing lights and the steady-burning light bars (the first lighting configuration seen in each session also alternated). Twelve trials were conducted during each subject's session, six for each lighting configuration. Large sample sizes were not easily obtainable in the study because actual winter maintenance vehicles were used during plowing operations.

All of the sessions were conducted in one night during the same snowstorm, while the snowplow operator plowed snow and spread abrasive along a several-kilometer circuit on an interstate highway. In this way, the ambient weather and lighting conditions were kept as constant as possible. Three adult subjects with New York State driver's licenses participated in the study; one of these subjects finished two sessions before the study was completed at the end of the night when the snowplow truck returned to its station to refuel. Therefore, a total of 48 trials were conducted; 24 for each lighting configuration.

RESULTS: CLOSURE DETECTION TEST

Figure 3 shows the mean closure detection times for all trials and the mean of the standard deviations for each subject; times for each subject are summarized in Table 3. Using a one-tailed Student's t-test comparing the raw closure detection times for each configuration, the mean closure detection time with the light bar configuration (9.8 sec) was found to be statistically significantly shorter ($p < 0.05$) than with the flashing light configuration (12.4 sec).

DISCUSSION AND CONCLUSIONS

Although flashing and strobing lights have been used by several winter maintenance agencies to provide high conspicuity of the snowplow vehicle, previous research indicates that such sources are less effective than steady-burning lights for estimating relative speed, distance and closure.^{6,7} Furthermore, an array of such lights subtending the width of the snowplow vehicle will be more effective than a single light source.⁹ Based on these previous findings, the results of subjective evaluations of several rear lighting configurations on snowplow vehicles showed that a steady-burning light bar resulted in the highest ratings of visibility and of confidence for passing. When employed in a field study on highways during actual snowplow operations, the light bars resulted in shorter closure detection times than a configuration using flashing lights. The light bar was a retrofit solution that was easily mounted onto the snowplow (Figure 2), and could be incorporated into the truck through future specifications. The results from the investigations presented here, however, are not sufficient to provide estimates of the relative impact of location or flash rate; rather, they are comparisons between two specific configurations as tested in the field.

The 2.6 sec closure detection time improvement found in the present study using the light bar configuration seems small compared to the overall 10-to-12-sec closure detection times that were measured, but even at speeds of 30 mph, 2.6 sec corresponds to a driving distance of 35 m. As pavement conditions are much different during winter storms than under clear weather conditions and likely to have even longer stopping sight distances,²⁰ the shortened response time may give drivers of other vehicles enough driving distance to safely maneuver in the vicinity of the snowplow.

The steady-burning light bar configuration used in the present study could possibly be combined with a dynamic but non-flashing component, located similarly as currently existing flashing lights. Such a component could be linked to the snowplow vehicle's transmission to display or graphically represent the snowplow's speed or direction of travel. Its dynamic nature would increase its conspicuity⁵ but perhaps not impair judgments of relative speed and distance.

The use of LEDs in the light bars also results in reduced power requirements relative to conventional incandescent sources. The amber LED units used in the light bar in Figure 1 are approximately 6 W each; in comparison, incandescent lamps with similar distributions are about 27 W. The amber lamps used in the conventional rear lighting configuration were 35 W each. Because LEDs are low-power devices, are relatively durable and are becoming more and more cost-effective for signage and signaling applications,²¹ they appear to be promising technologies for rear lighting and have been demonstrated to provide adequate visibility and closure detection during inclement weather. They also have less demand on the electrical system of the snowplow truck. No blockage of the light bar by snow or ice was experienced during field demonstrations; the use of airfoils^{18,19} described above will also help to keep rear surfaces clear of snow and ice accumulation.

ACKNOWLEDGMENTS

This work was sponsored by the American Association of State Highway and Transportation Officials, in cooperation with the Federal Highway Administration, and was conducted under the National Cooperative Highway Research Program (NCHRP), which is administered by the Transportation Research Board of the National Research Council. The opinions and conclusions expressed or implied in this paper are those of the research agency. They are not necessarily those of the Transportation Research Board, the National Research Council, the Federal Highway Administration, the American Association of State Highway and Transportation Officials, or the individual states participating in the NCHRP.

Amir Hanna and Lloyd Crowther were the NCHRP program managers. Brian Thompson of Rensselaer Polytechnic Institute is acknowledged for his advice in developing the field tests. Some lighting equipment was supplied by Truck-Lite. Valuable assistance was also provided by individuals from the New York State Department of Transportation: Charles Briggs, John Cook, Joseph Darling, Theodore Day, Joseph DiFabio, Joseph Doherty, Ronald Edwards, Ann Fearnley, Donald Hall, Fredrick Hamson, Michael Jones, Jack Knapp, Jan Mielhede, Martin Natoli, John Phelps, Robert Simpson, Gerald Smith, Ronald Unfus and William Watkins.

REFERENCES

1. Hale, J. (ed.). 1989. *Snowplow Lighting Study: Final Report*, Report No. MN/RD-89/03. St. Paul, MN: Minnesota Department of Transportation.
2. Stutzel, R., S. Burkland, M. Walton, S. Falb, D. Hipnar, J. Houston, D. Kardell, D. Lickteig, V. Martin, R. McCaskey, D. Schumann and D. South. 1995. *Continuous Quality Improvement Snow Plow Accident Study Report*. Ames, IA: Iowa Department of Transportation.
3. Sanders, M. S. and E. J. McCormick. 1993. *Human Factors in Engineering and Design*, 7th ed. New York, NY: McGraw-Hill.
4. Marsh, C. 1957. Highway visibility in fog. *Illum. Eng.* 52:621.

5. Rabelo, C. and O.-J. Grusser. 1961. Die Abhängigkeit der subjektiven Helligkeit intermittierender Lichtreize von der Flimmerfrequenz: Untersuchungen bei verschiedener Leuchtdichte und Feldgrosse. *Psychol. Forsch.* 26: 299 [cited by Graham, C. (ed.). 1965. *Vision and Visual Perception*. New York, NY: Wiley and Sons, Inc.].
6. Croft, T. A. 1971. Failure of visual estimation of motion under strobe. *Nature* 231: 397.
7. Hanscom, F. R. and R. F. Pain. 1990. *Service Vehicle Lighting and Traffic Control Systems for Short-Term and Moving Operations*, NCHRP Report 337. Washington, DC: National Cooperative Highway Research Program.
8. Goodale, M. A., D. Pelisson and C. Prablanc. 1986. Large adjustments in visually guided reaching do not depend on vision of the hand or perception of the target displacement. *Nature* 320: 748.
9. Mortimer, R. G. 1969. Requirements for automobile exterior lighting. In *Visual Factors in Transportation Systems*. Washington, DC: National Research Council.
10. Kruk, R. and D. Regan. 1983. Visual test results compared with flying performance in telemetry-tracked aircraft. *Aviat. Space Environ. Med.* 54: 906.
11. Stout, D., J. Graham, B. Bryant-Fields, J. Migletz, J. Fish and F. Hanscom. 1993. *Maintenance Work Zone Safety Devices Development and Evaluation*, Report No. SHRP-H-371. Washington, DC: Strategic Highway Research Program.
12. McDermott, P. J. and L. M. Ventrella. 1996. Visibility package for snowplow. *4th Intl. Symp. on Snow Removal and Ice Control Technol.*, Washington, DC.
13. Wyszecki, G. and W. S. Stiles. 1982. *Color Science*, 2nd edition. New York, NY: Wiley.
14. Alman, D. H. 1977. Errors of the standard photometric system when measuring the brightness of general illumination light sources. *J. Illum. Eng. Soc.* 7(1): 55.
15. Bullough, J. D., P. R. Boyce, A. Bierman, K. M. Conway, K. Huang, C. P. O'Rourke, C. M. Hunter and A. Nakata. 2000. Response to simulated traffic signals using light-emitting diode and incandescent sources. *Transport. Res. Rec.* (1724): 39.
16. Bullough, J. D., P. R. Boyce, A. Bierman, C. M. Hunter, K. M. Conway, A. Nakata and M. G. Figueiro. 2001. Traffic signal luminance and visual discomfort at night. *80th Ann. Transport. Res. Board Mtg.*, Washington, DC.
17. Society of Automotive Engineers. 2000. *Ground Vehicle Lighting Standards Manual*, HS-34. Warrendale, PA: Society of Automotive Engineers.
18. Bullough, J. D., H. K. Nakhla, B. E. Thompson, M. S. Rea and D. E. Amsler. 1999. *Improved Visibility for Snow Plowing Operations* [final report to National Cooperative Highway Research Program]. Troy, NY: Rensselaer Polytechnic Institute.
19. Rea, M. S. and B. E. Thompson. 2000. Improved visibility for snowplowing operations. *NCHRP Research Results Digest 250*. Washington, DC: National Cooperative Highway Research Program.
20. Olson, P. L., D. E. Cleveland, P. S. Fancher, L. P. Kostyniuk and L. W. Schneider. 1984. *Parameters Affecting Stopping Sight Distance*, NCHRP Report 270. Washington, DC: National Cooperative Highway Research Program.
21. Conway, K. M. and J. D. Bullough. 1999. Will LEDs transform traffic signals as they did exit signs? *Proc. IESNA Ann. Conf.*, New Orleans, LA, p. 1.

Figure 1. Schematic diagram of vertical LED light bar configuration. All dimensions are in inches.

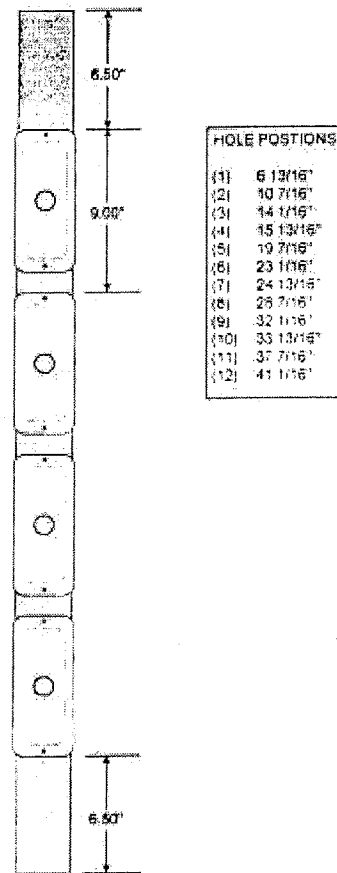


Figure 2. Rear of snowplow truck showing light bars and conventional flashing lights.

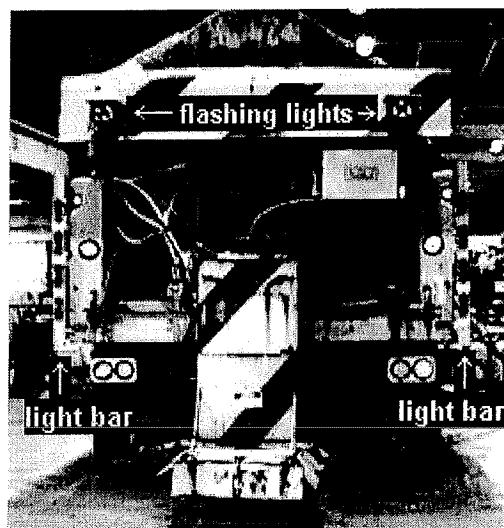


Figure 3. Mean closure detection times and mean standard deviation for each subject, for the conventional and light bar configurations.

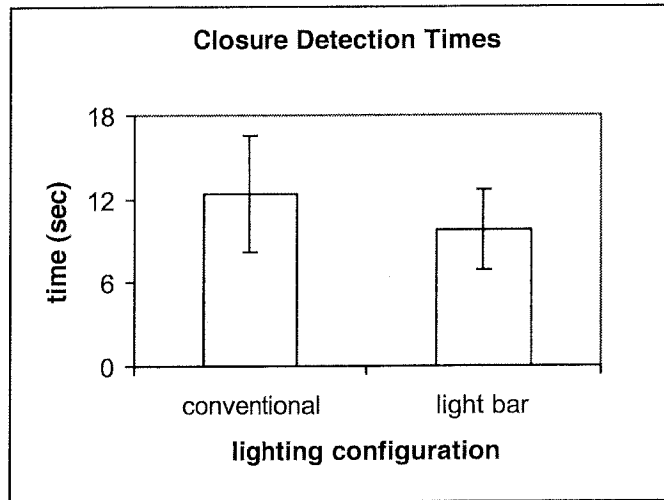


Table 1. Mean ratings of visibility and confidence for rear lighting configurations and standard deviations, for clear and heavy snowing conditions.

| Configuration | Ambient condition | Visibility rating (<i>standard deviation</i>) | Confidence rating (<i>standard deviation</i>) |
|----------------------------|-------------------|--|--|
| conventional configuration | clear | 0.00 (0.89) | +0.50 (1.05) |
| conventional configuration | heavy snow | -0.33 (0.82) | -1.83 (1.17) |
| indirect edge delineation | clear | -0.33 (1.03) | +0.33 (1.21) |
| indirect edge delineation | heavy snow | -0.50 (1.64) | -0.33 (1.03) |
| alternating high-mounted | clear | +2.00 (1.26) | 0.00 (1.26) |
| alternating high-mounted | heavy snow | +1.33 (0.82) | -1.33 (1.21) |
| LED light bar | clear | +3.00 (0.00) | +1.17 (0.75) |
| LED light bar | heavy snow | +2.33 (0.82) | +0.17 (1.17) |

Table 2. Summary tables for within-subjects analyses of variance (ANOVAs) for the (a) visibility and (b) confidence ratings.

a. ANOVA Summary: Visibility Ratings

| Source of variation | SS | df | MS | F |
|-------------------------------|-------|----|------|-------|
| between subjects | 27.7 | 5 | | |
| weather | 2.52 | 1 | 2.52 | 14.8* |
| lighting | 78.9 | 3 | 26.3 | 45.3* |
| weather × lighting | 0.56 | 3 | 0.19 | 0.79 |
| weather × subjects | 0.85 | 5 | 0.17 | |
| lighting × subjects | 8.73 | 15 | 0.58 | |
| weather × lighting × subjects | 3.57 | 15 | 0.24 | |
| total | 122.8 | 47 | | |

*Statistically significant at the $p < 0.05$ level.

b. ANOVA Summary: Confidence Ratings

| Source of variation | SS | df | MS | F |
|-------------------------------|------|----|------|--------|
| between subjects | 39.9 | 5 | | |
| weather | 21.3 | 1 | 21.3 | 118.5* |
| lighting | 14.7 | 3 | 4.89 | 11.9* |
| weather × lighting | 4.67 | 3 | 1.56 | 7.43* |
| weather × subjects | 0.92 | 5 | 0.18 | |
| lighting × subjects | 6.08 | 15 | 0.41 | |
| weather × lighting × subjects | 3.08 | 15 | 0.21 | |
| total | 90.7 | 47 | | |

*Statistically significant at the $p < 0.05$ level.

Table 3. Mean closure detection times and standard deviations, for each subject.

| Subject | Conventional configuration | | Light bar configuration | |
|---------|-----------------------------------|--------------------|-----------------------------------|--------------------|
| | Mean closure detection time (sec) | Standard deviation | Mean closure detection time (sec) | Standard deviation |
| 1 | 9.7 | 3.0 | 6.8 | 1.5 |
| 2 | 11.3 | 4.5 | 8.5 | 2.1 |
| 3 | 14.3 | 5.0 | 12.1 | 5.0 |

National Cooperative Highway Research Program

RESEARCH RESULTS DIGEST

November 2000—Number 250

Subject Areas: IIC Maintenance
IVB Safety and Human Performance

Responsible Senior Program Officer: Amir N. Hanna

Improved Visibility for Snowplowing Operations

An NCHRP digest of the findings from the final report on NCHRP Project 6-12, "Improved Visibility for Snow Plowing Operations," conducted by Rensselaer Polytechnic Institute. Drs. Mark S. Rea and Brian E. Thompson served as Principal Investigators.

INTRODUCTION

This digest describes several means, identified in NCHRP Project 6-12, that could improve visibility for snowplowing operations.

In many parts of the United States, snow and ice control may be the most hazardous duty faced by highway maintenance crews on a regular basis. Visibility is reduced during snowplowing operations because of reflected headlight glare, obscured windows, and blowing snow. In addition, this type of work frequently requires long working hours and is often performed at night during extreme weather conditions. The factors affecting visibility depend on climactic conditions and are often influenced by the features of the plow, the vehicle, and the lighting system. Because poor visibility reduces operational safety and contributes substantially to the hazards faced by snowplow operators and motorists, there is a need to identify features that would improve visibility for both the snowplow operator and the motorists in proximity of the snowplowing vehicle. NCHRP Project 6-12 was initiated to address this need.

The research was conducted under NCHRP Project 6-12, "Improved Visibility for Snow Plowing Operations," by Rensselaer Polytechnic Institute. The research, completed in late 1999, identified several means for improving visibility for snowplowing operations. However, limited tests were conducted in this project to fully evaluate the merits of these means or the practicality of their

unlimited use by highway agencies. This digest provides a summary of the work performed in this research. The material included in this digest is extracted from the final report on NCHRP Project 6-12.

FINDINGS

The project included a review of existing and proposed approaches for improving visibility for snowplowing operations, the identification and development of potential means for improving these operations, and the conduct of limited field tests to evaluate the potential benefits of these means. In performing this work, consideration was given to the visibility of the snowplow operator (forward visibility) and the visibility of the snowplow by the drivers of other vehicles. Forward visibility is affected by the glare caused by back-scattered light reflected from falling snow, rain, and fog. Visibility of the snowplow by other drivers is influenced by the splash of snow and other debris and the snow cloud that occur behind the snowplow truck.

SNOWPLOW TREATMENTS

Several treatments and design alternatives of the front plow for reducing plowover (i.e., the splash on the top of the plow blade that impairs visibility through the windshield) were investigated. Among these alternatives are the use of deflectors or shields to direct splash away from the windshield and mirrors

and the modification of the snowplow geometrical configuration to reduce the amount of snow directed over the top of the plow. Another treatment is the use of a “packing flap” to direct downward the snow particles exiting the front plow discharge and to repack the loose debris at the edge back into the main discharge stream, thus eliminating the potential for creating a snow cloud in windy conditions.

WING PLOW TREATMENTS

When a wing plow is used in snowplowing operations, a snow cloud could form from the snow debris escaping through the gap between the front and wing plows. The use of a “junction flap” to cover the gap between the front plow and the wing plow will help reduce the potential for snow spillage and snow-cloud formation. A junction flap that completely seals the gap between the front and wing plows and smoothly deflects the plow discharge slightly downward would provide the most reduction in snow-cloud formation. However, such a flap will need to be designed in such a manner that it would not restrain the movement of the wing plow or the front plow and impede the plowing operation.

TREATMENTS OF THE REAR OF THE TRUCK

The snow cloud that forms behind the snowplow truck obscures visibility of the truck by other drivers. Several configurations of deflectors and airfoils, which would reduce the size of the snow cloud behind the plow truck and also would prevent buildup of snow and ice on the rear of the snowplow, have been investigated. These configurations included curved vanes and straight-edged deflectors mounted on the rear of the sides of the snowplow truck. The gap between the vane and the truck is usually kept small to avoid interference with the snowplow operator’s view of the side mirrors.

FORWARD LIGHTING

The reflected light from snow, rain, and fog toward the snowplow operator during inclement weather contributes to glare and decreased visibility. The impact on visibility is influenced by the different aspects of the light source (e.g., mounting location, aiming angle, beam spread, and spectral power distribution or color). These factors have been investigated in a number of studies.

REAR LIGHTING AND SIGNALING

Rear lighting of snowplow vehicles provides two distinct functions: a conspicuous signal to other drivers to indicate that the plow is on the road and cues about the plow’s

operating speed and distance relative to other vehicles. Generally, features that enhance one of these functions would often adversely influence the other function. For example, highly conspicuous signals, such as strobe lights, are often poor means for providing speed and distance cues. For this reason, finding a balance between rear lighting and signaling is essential for improving snowplowing operations.

Mounting rear lights as high as possible to clear the cloud behind the truck would permit visibility from the farthest distance. Flashing lights, up to 15 flashes per second, would provide greater brightness than would steady-burning lights. Although conspicuity may be greater when rear lighting systems with a rate of 5 to 9 flashes per second are used, the ability to make accurate judgements of speed and distance is generally impaired when flashing or strobe lights are used. The ability to accurately estimate relative speed and distance depends on the spatial and size characteristics of the light source. For example, a single light source provides poor speed and distance cues while a wide spatial array of sources provides good cues. For this reason, the use of an array of lights with sufficient intensity is more effective than a single light source.

FIELD DEMONSTRATIONS

Extensive laboratory and limited field tests of several snowplow treatments and rear lighting configurations were conducted in this project. Snowplow treatments evaluated and observed in the field included a one-way front plow fabricated of a rolled steel sheet with a 55° cutting angle and a 50° trap angle, a lightweight deflector, packing flaps, and wing plows. Image analysis techniques were used to quantify the improvement in visibility of following drivers. This improvement was estimated to be about 50 percent. Rear lighting configurations included commercial lighting similar to that used by the New York State Department of Transportation, indirect edge delineation using flood lights, two pairs of alternating high-mounted flashing lights (amber and red), and a light bar using light emitting diodes (LEDs) in a steady configuration. An assessment by snowplow operators suggested that the LED light bar configuration provided the highest visibility and confidence in the overtaking of the snowplow by other motorists. Based on this assessment, an amber light configuration that employs an array of LED marker lights was developed and used in further field demonstrations.

CONCLUSIONS

The need to identify features that would provide for safer snowplowing operations through improvements of visibility for the snowplow operators and the other motorists in the proximity of the snowplowing vehicle has been recognized by the state highway agencies and other organizations

involved in snow and ice control. This research identified and evaluated in limited field tests several potential features for improving visibility. The following is a summary of these evaluations:

- Front plows, or front plows used with plow-mounted deflectors, with a trap angle of about 50° will reduce the amount of material blown over the plow and onto the windshield.
- Front plows equipped with packing flaps at the discharge ends of the plow reduce the size of the snow cloud around and behind the snowplow vehicle.
- When wing plows are used, closing the gap between the front plow's discharge end and the intake end of the wing plow will reduce the size of the snow cloud around and behind the snowplow vehicle.
- Side vanes with a 20° angle to the snowplow's body, mounted on the rear of the vehicle, will reduce snow and ice accumulation on surfaces and on the rear lighting of the snowplow vehicle.
- During snowfall, switching off the driver-side headlamp and using an auxiliary passenger-side headlamp will reduce the back-scattered light seen by the operator.
- Shielded headlamps, louvered or cut-off type, that reduce stray light above the horizontal plane will reduce back-scattered light.
- Steady-burning light bars, mounted along the rear edges of the snowplow truck, will improve drivers' ability to detect changes in the snowplow vehicle's speed and will provide an indication of the vehicle's width.

Although the features evaluated in this research yielded some 50-percent improvement in visibility for motorists fol-

lowing the snowplows, it should be recognized that this and other research findings were based on limited field demonstrations. Further field evaluations, and possibly modifications, would be required to make these features practical for the wide range of vehicles used in large-scale snow and ice control operations.

FINAL REPORT

The agency's final report, titled "Improved Visibility for Snow Plowing Operations," gives a detailed account of the project, the findings, and the conclusions. The report, which was distributed to NCHRP sponsors (i.e., the state departments of transportation), is available for loan on request to the National Cooperative Highway Research Program, Transportation Research Board, 2101 Constitution Avenue, N.W., Washington, DC 20418.

ACKNOWLEDGMENTS

The research summarized herein was performed under NCHRP Project 6-12 by Rensselaer Polytechnic Institute of Troy, New York. Drs. Mark S. Rea and Brian E. Thompson served as principal investigators. The research was guided by NCHRP Project Panel F6-12, chaired by Mr. John W. Sheldrake, with members J. Hugh Blaine, Edward J. Fleege, Eldon W. Frechette, Mike Gavin, Earnest N. Herrick, Richard Hunter, L. David Minsk, Salim Nassif, and Andrew L. Sotebeer; liaison members John B. Arens (FHWA), George Schoener (FHWA), and Frank Lisle (TRB); and NCHRP Senior Program Officer Amir N. Hanna.

These **Digests** are issued in order to increase awareness of research results emanating from projects in the CRP. Persons wanting to pursue the project subject matter in greater depth should contact the Cooperative Research Programs Staff, Transportation Research Board, 2101 Constitution Ave., NW, Washington, DC 20418.

TRANSPORTATION RESEARCH BOARD
National Research Council
2101 Constitution Avenue, NW
Washington, DC 20418

NON-PROFIT ORG.
U.S. POSTAGE
PAID
WASHINGTON, DC
PERMIT NO. 8970



AUTOMOTIVE DesignLine

Get the latest news, products, and how-to info for designing automotive electronics. [Sign up](#) for DesignLine newsletter, a weekly e-mail guide of needs of EEs designing automotive systems. [Feedback](#).

[HOME](#)
[HOW-TO](#)
[PRODUCTS](#)
[BLOGS](#)
[NEWS](#)
[FORUMS](#)
[TECH LIBRARY](#)
[ABOUT](#)
[FEEDBACK](#)
[NEWSLETTER](#)
[CONTACT](#)


We think a car can never be
too SAFE, too COMFORTABLE, too EFFICIENT

June 29, 2005

Brighter LEDs drive automotive lighting

By Horst Lengning, Vishay
Intertechnology

LEDs have been manufactured since the early 1970s, but in recent years advances in this technology have accelerated notably. Available brightness for LEDs has increased by several orders of magnitude, starting with less than 0.01 lumen at 20 mA in the late 1970s and reaching more than 1 lumen now. With these improvements, target applications for LEDs have also broadened significantly. At above 0.3 lumens or so, LEDs start to become practical replacements for incandescent lamps. As such they provide a number of advantages, the least of which is their great reliability. In general, today's LEDs will long outlive any of the systems in which they are used.

Nowhere is this characteristic more desirable than in automotive systems, where reliability is a matter both of safety and of avoiding repairs. So it is not surprising that the automotive industry has moved relatively quickly to embrace LED technology wherever possible. In fact, driving further innovation in the LED field because of particular automotive requirements.

Evolution of LED brightness

Between 1970 and 1995, LEDs evolved gradually to offer higher levels of brightness. Since the mid-1990s, however, the pace of evolution has accelerated, with the invention of blue and white LEDs and a doubling of average brightness for the devices.



Improvements in LED brightness are mainly due to advances in substrate material. In the early 1970s, the first gallium arsenide (GaAs) phosphide products, the industry turned to nitride gallium (GaN) and GaP to achieve the first yellow and green LEDs in the late 1970s, and then used double-hetero GaAlAs to achieve luminosities of over 0.1 lm in the early 1990s. Since the mid-1990s, various combinations of indium and gallium have served as the substrates for blue LEDs in colors including blue.

Despite these advances, several problems remained, including the fact that the substrate absorbs much of the light generated by the LED. Several approaches have been taken around this issue. [Lumileds](#), for its part, attacked the problem by using a patented, AlInGaP substrate. Another approach was to add a Bragg reflector grating layer at the substrate. This provides twice the brightness of LEDs with an absorbent substrate, but light emitted at a 90° angle is lost. [Vishay](#) has improved on this solution with an organic adhesion (OMA) technology, in which a mirror surface is grown on a silicon substrate that goes down to the mirror comes out of the front of the device, thus achieving the

same brightness as is achieved with the transparent substrate approach, for approximately a four-fold improvement over standard LEDs.

LED efficiency

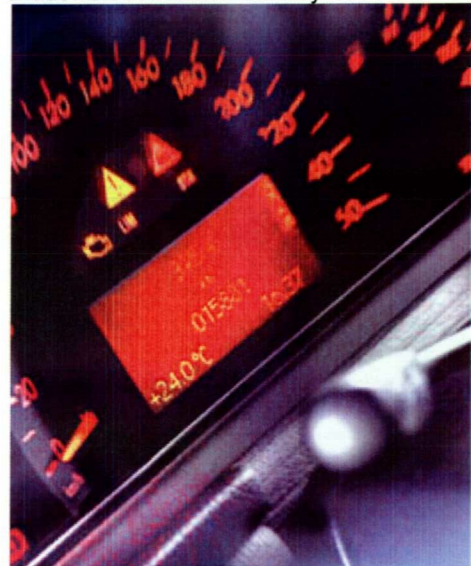
LEDs don't just need to be bright; they also need to work efficiently. This means not only converting electric power into light with high efficiency but also controlling the effect of the heat generated by the current running through the device. A huge challenge of LEDs is that their efficiency drops as temperature, which goes up when more current is applied, has a direct effect on the wavelength of the light they produce. Simply increasing forward current can thus merely change the color of the device without making it any brighter. Thus, die and packaging technologies that allow more brightness with less current.



Vishay has addressed this problem with a series of low-profile PLCC packages that emit light very efficiently and thus reduce the problem of color change brought on by higher current densities.

exclusive PLCC-3, which is pad-compatible with the industry-standard PLCC-4, provides a metallic area through which heat can be dissipated and thus accommodates very bright LEDs powered by forward currents up to 100 mA. Offered in a PLCC-3 package with a low 270 K/W thermal resistance rating, devices in the new TLMx320x series are designed to enable twice the brightness of comparable LEDs in the PLCC-2 package.

LEDs are steadily replacing incandescent lamps in automobiles, both for vehicle interior and exterior lighting. Stringent quality requirements are the rule, not only for device failure rates (where the maximum allowed is typically 0.1 per 10 million pieces) but also for brightness consistency. Consistency in color and brightness is obviously important when LEDs are brought together in an assembly for dashboard illumination, instrument clusters, or entertainment system controls; the brightness of the illuminated areas always needs to be homogeneous; there must be no shadows. But in automotive systems the need for consistency goes beyond purely aesthetic concerns, since nowadays LEDs are used for



of the color scheme of the car interiors and a significant part of how each manufacturer brands their cars. This means that the wavelength of LEDs produced and delivered for a given application is allowed to vary only by an amount that is invisible to the human eye, typically just a few nanometers.

The desire of automotive manufacturers for distinctive LED colors to brand their products has created the need for great expertise in delivering "color on demand," which requires increasingly complex LED products, in which LED dies of different colors are combined in a single package. This creates its own set of design challenges, since the human eye's perception of color depends on its intensity, and colors on the higher end of the spectrum (yellow, for example) overpower colors on the lower end of the spectrum (such as blue) at the same level. To create a true green LED, for example, the luminous intensity of the blue component must be double the intensity of the yellow component.

For exterior lighting, very high levels of brightness are required—since brake lights and mounted stoplights (CHMSLs) must be visible not only after dark but in broad daylight until the advent of OMA technology that Vishay was able to deliver the required level. Mandated requirements now range from 17 cd/m² for taillights to 980 cd/m² for daytime running lights.

In each case, multiple LEDs are used to implement each function; for example, 148 LEDs are needed to implement the taillight assembly for a recent VW model. In the taillight assembly for this car, the same LEDs switch from red to yellow depending on whether they are used as the turn-signal or as part of the brake light. Another popular LED application that has recently been approved for Europe is adaptive lighting, where a smaller or larger portion of the brake light area is lit depending on whether the driver brakes normally or forcefully slams the brakes.

Compared to incandescent lamps, LEDs are extraordinarily low-maintenance devices; with a typical operating lifetime of 50,000 hours, they can outlive any car into which they are installed. For drivers, this means lower maintenance costs, since bulb never have to be replaced, sometimes an annoyance at state inspection time. The use of LED lighting units instead of conventional headlamps further contributes to the overall health of a car by eliminating the need for additional openings into the chassis that can introduce unwanted moisture.

Regionally speaking, Europe is leading the way in the use of LEDs for automotive applications, with more than 80% of new cars featuring LED components. For Japan the comparable figure is 30%, and for North America just 5%. Five years from now, however, it is expected that the U.S. and Japan will see the same level of penetration as in Europe.

Meanwhile, LEDs are continuing to improve. Devices introduced this year are once again doubling the maximum brightness per device, which means that for applications such as automotive exterior lighting, fewer devices will be needed to achieve the same overall level of brightness. Although the brightness of LEDs is increasing rapidly, the price of these devices is relatively stable, so the increased use of LEDs is highly cost-effective.

Horst Lengning is senior manager, product marketing, Visible at Vishay Intertechnology

[HOME](#) | [ABOUT](#) | [FEEDBACK](#) | [CONTACT](#)

[Career Center](#) | [CommsDesign.com](#) | [EEDesign](#) | [EE Times](#) | [Embedded.com](#)
[Planet Analog](#) | [Silicon Strategies](#) | [eeProductCenter](#) | [Electronic Supply & Manufacturing](#) | [NetSeminar Serv](#)



We think a car can never be
too **SAFE**, too **COMFORTABLE**, too **EFFICIENT**

All material on this site Copyright © 2005 [CMP Media LLC](#). All rights reserved
[Privacy Statement](#) | [Your California Privacy Rights](#) | [Terms of Service](#)

APPENDIX D

JURISDICTIONAL SURVEY RESPONSES

BC.

Ryan Batty

From: "Pratt, Mark TRAN:EX" <Mark.Pratt@gems5.gov.bc.ca>
To: <ryan.batty@allianteng.com>
Sent: November 29, 2004 10:41 AM
Attach: SCHEDULE - 12 Equipment Fleet Operations Policy Appendices.pdf

Ryan,
Attached please find a file containing the standard lighting configuration we require of our road & bridge maintenance contractors for snow removal equipment. If you have any other questions I am available at the location/numbers noted below.

Mark C. Pratt

Fleet Services Manager
Ministry of Transportation

PO Box 9850 STN PROV GOVT
4C 940 Blanchard St Victoria
British Columbia
V8W 9T5

Thanks

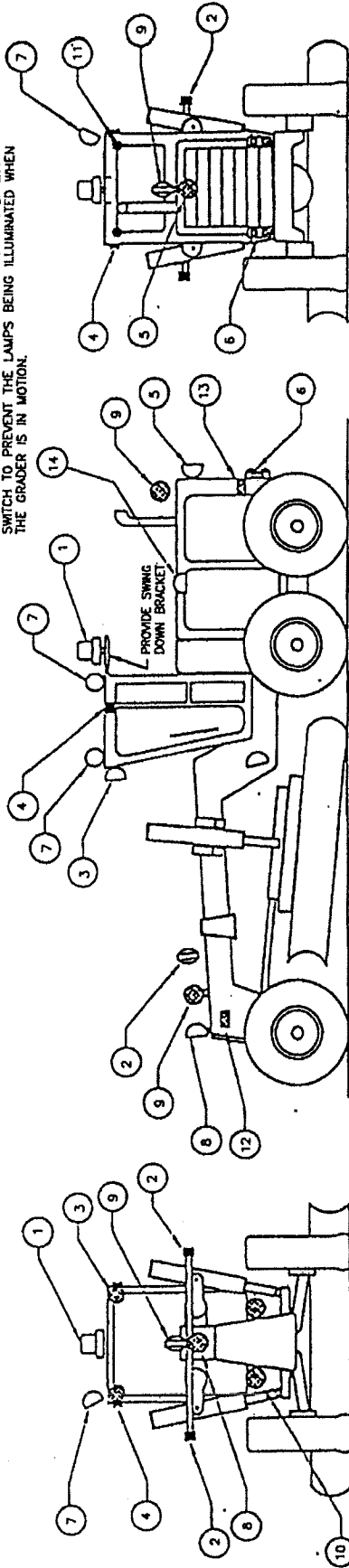
Mp

250 356-6737 Victoria
250 889-8746 Cell
250 356-7276 Fax

mark.pratt@gems5.gov.bc.ca

APPENDIX B

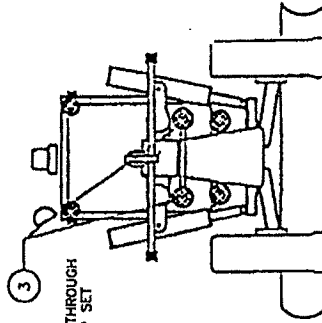
OPTIONAL LIGHTS (ITEM 14) USED TO ILLUMINATE THE REAR TANDEMS SHALL BE WIRED THROUGH A NEUTRAL SAFETY SWITCH TO PREVENT THE LAMPS BEING ILLUMINATED WHEN THE GRADER IS IN MOTION.



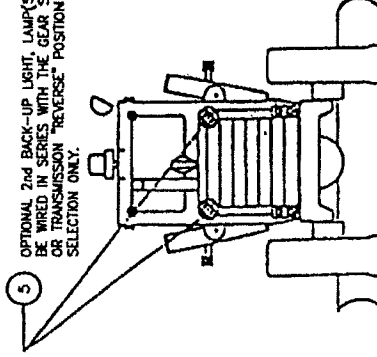
STANDARD LIGHTING CONFIGURATION FOR GRADERS

DRIVE LIGHT (ITEM #9) TO OPERATE WHEN HIGH BEAM IS USED ON HEAD LIGHTS (ITEM #3).
 INTERSECTION LIGHTS (ITEM #9) AND REAR AMBER WARNING (ITEM #11) TO BE CONTROLLED BY SEPARATE SWITCHES.
 TURN SIGNALS TO FUNCTION AS 4-WAY FLASH HAZARD WARNING LIGHTS.

OPTIONAL 2nd BACK-UP LIGHT, LAMP(S) BE WIRED IN SERIES WITH THE GEAR SHIFT OR TRANSMISSION "REVERSE" POSITION SELECTION ONLY.



OPTIONAL 2nd HEADLAMP SET SHALL BE WIRED THROUGH SWITCH TO PREVENT MORE THAN ONE HEADLAMP SET FROM BEING ON AT ONE TIME



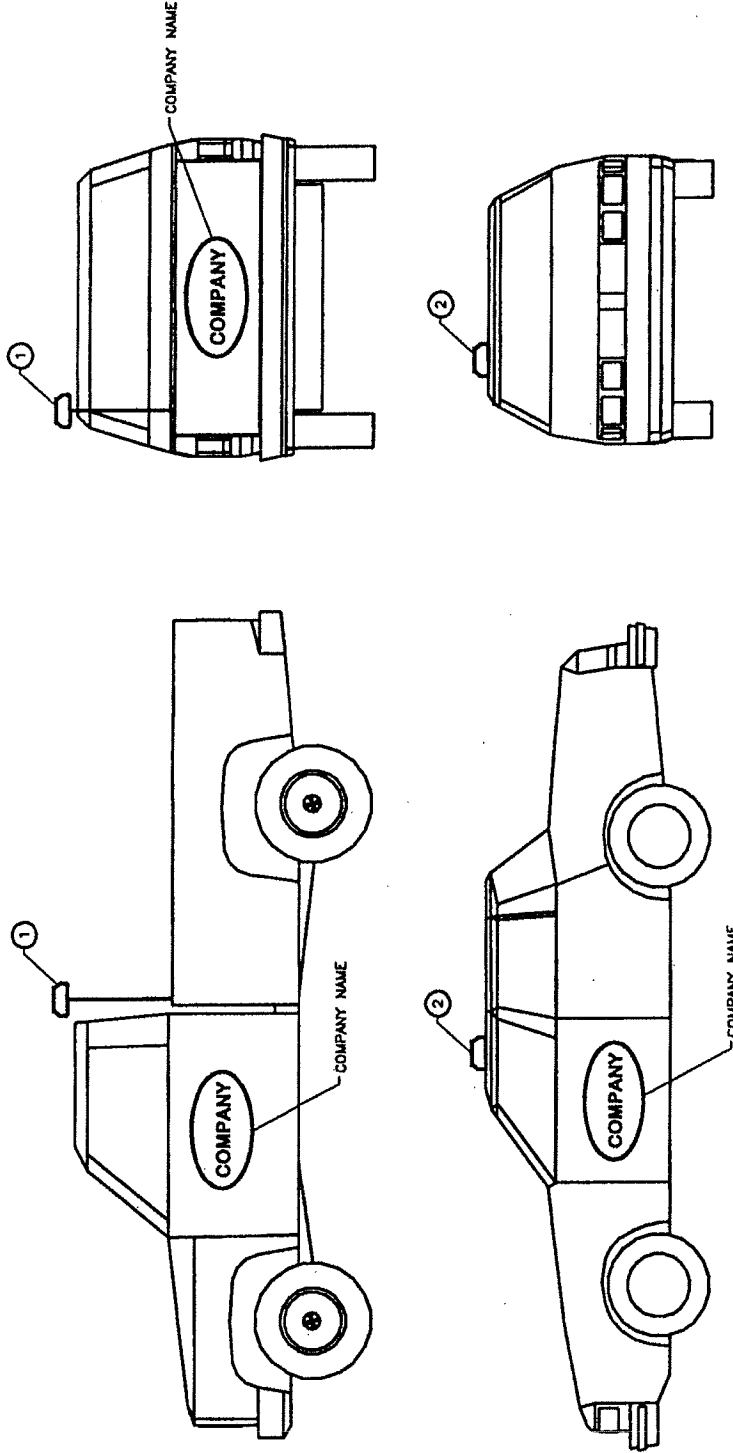
| ITEM | DESCRIPTION | OPTIONAL |
|------|--|----------|
| 1 | WARNING LIGHT, ROTATING, AMBER OR STROBE | |
| 2 | TURNING SIGNAL, SIDE MARKER | |
| 3 | HEAD LIGHTS | |
| 4 | CLEARANCE LIGHTS, SIDE MARKER | |
| 5 | BACK-UP LAMP | |
| 6 | TAIL/STOP/TURN SIDE MARKER | |
| 7 | WING LIGHTS | |
| 8 | DRIVING LIGHTS | |
| 9 | INTERSECTION LIGHTS | |
| 10 | BLADE LIGHTS | |
| 11 | REAR AMBER WARNING | |
| 12 | FRONT REFLECTOR, AMBER | |
| 13 | REAR REFLECTOR, RED | |
| 14 | REAR TANDEN LIGHTS | OPTIONAL |

NOTE: ALL LAMPS TO MEET OR EXCEED MINISTRY OF TRANSPORTATION AND HIGHWAYS SPECIFICATIONS.

OPTIONAL HEADLAMP & BACK-UP LIGHTING

| | | | |
|---|--|---|--|
| | | Province of British Columbia MINISTRY OF TRANSPORTATION AND HIGHWAYS | |
| SCALE NO SCALE DRAWN: _____ DATE: _____ CHECKED: _____ DATE: _____ DESIGNED: _____ DATE: _____ | | SAFETY LIGHTING STANDARD | |
| RECEIVED BY: _____ DATE: _____ | RECOMMENDED: _____ REGION: _____ PROJECT NO.: _____ | ACCEPTED FOR CONSTRUCTION: _____ DATE: _____ | REGIONAL INSPECTOR, LICENSED: _____ DATE: _____ |
| REVIEWED BY: _____ | | | |

APPENDIX C



**STANDARD LIGHTING CONFIGURATION
FOR LIGHT VEHICLES**

| | | | |
|--|-----------------------------------|---|---|
| | | Province of British Columbia MINISTRY OF TRANSPORTATION AND HIGHWAYS | |
| SCALE: NO SCALE | | SAFETY LIGHTING STANDARD | |
| REVISIONS: No. _____ Date _____ Description _____ | RECORDED: No. _____ Date _____ | RECEIVED BY: Name _____ Title _____ | RECEIVED FOR COMPANY: Name _____ Address _____ City _____ Province _____ |

NOTE: ALL LAMPS TO MEET OR EXCEED
MINISTRY OF TRANSPORTATION AND
HIGHWAYS SPECIFICATIONS.

| ITEM | DESCRIPTION | QTY |
|------|---|-----|
| 1 | PERMANENTLY MOUNTED, ROTO OR STROBE LIGHT | 1 |
| 2 | MAGNETIC MOUNT, ROTO OR STROBE LIGHT | 1 |

Snowplow Rear Lighting Questionnaire *NBDOT Response*

1. Have rear-end collisions with snowplows been a problem?

Yes _____ No X

If yes, what action has been taken to prevent these collisions?

2. What type(s) of snowplows do you normally use?

_____ Tandem axle plow trucks with all season combination boxes, equipped with a plow and wing _____

3. What type(s) of rear lighting do you use?

Whalen strobe lights mounted high on the rear box posts in addition to the standard vehicle lighting _____

4. How many lights are used and how are the rear lights arranged?

Two orange/yellow strobes are used, one on each side. They are set to synchronized flash.

5. Have you used steady state lighting (LED)?

Yes x No _____

If yes, what were the results?

We use steady state LED lighting as wing markers on plows used on multi-lane highways. In combination with the use of left hand winds, the LED's have proven effective in minimizing wing run-ins from the rear. _____

6. Have you used reflective tape?

Yes X No _____

If yes, what were the results?

The use of reflective marking tape was included in the fleet lighting policy at the same time as the introduction of the high mount rear strobes. It is therefore difficult to measure the relative impact of the tape. _____

7. Have you used orange flags?

Yes x No _____

If yes, what were the results?

Only for plow markers. They have provided mixed results in the eyes of the operators _____

8. Have you used any other rear warning devices?

Yes X No _____

If yes, what kind of device and what were the results?

1. High intensity rear marker light 2. Diagonal striped panel. The results were poor, and led to the adoption of the engineering grade strobe light policy _____

9. Have you used any devices to eliminate snow build-up on the rear lighting?

Yes x No _____

If yes, what kind of device and what were the results?

We used the a manufactured polyethylene panel with wind louvers set to deflect the air down the back of the truck. They proved successful in some conditions (dry, light snow) but did not function so well in others. The straight strobe light system was deemed to be the most effective _____

10. Have you used any devices to minimize the snow cloud behind the snowplow?

Yes _____ No x

If yes, what kind of device and what were the results?

11. Are any changes to your snowplow rear warning systems planned?

No

Please mail , e-mail or fax your completed questionnaire by December 10, 2004 to:

#200, 18311 – 105 Ave.
Edmonton, AB, T5S 2K9
Phone: (780) 488-8292, Fax: (780) 444-9054
E-mail: ryan.batty@allianteng.com

Personal information that you provide on this form is held strictly confidential. No other use will be made of this information and it will not be released without your written consent.

This survey is being completed by Alliant Engineering on behalf of Terry Becker, P. Eng. and Peter Ing, P. Eng. of Alberta Transportation.

| | |
|---|--|
| Terry Becker, P. Eng. Operations Manager 3rd Fl Administration Building 909 - 3rd Avenue North Lethbridge, AB, T1H 0H5 Phone: (403) 382-4412 e-mail: terry.becker@gov.ab.ca | Peter Ing, P. Eng. Research and Development Engineer 2nd Fl Twin Atria Building 4999 - 98 Avenue Edmonton, AB, T6B 2X3 Phone: (780) 415-1009 e-mail: peter.ing@gov.ab.ca |
|---|--|

NS
←

Ryan Batty

From: "Don Currie" <CURRIEDO@gov.ns.ca>
To: <ryan.batty@allianteng.com>
Cc: "Kevin Mitchell" <MITCHEKE@gov.ns.ca>
Sent: December 2, 2004 1:01 PM
Subject: Snow Plow Lighting Questionare

I have been asked to complete your questionnaire regarding the rear lighting of our snow plows.

1) Have rear-end collisions with snow plows been a problem?

This has not been a problem with our fleet

2) What types of snow plows do we use?

Graders, Loaders, Self propelled snow blowers, Single axle trucks, Tandem trucks, 4 x 4 Trucks, and 6 x 6 Trucks

3) What types of rear lighting do we use?

Trucks - 1 high mount amber strobe light (360 Degree visibility)
 Brake, signal, marker and tail lights, 2 flashing amber lights located at the top outside corners of the dump body.

4) How many lights are used and how are the rear lights arraigned?

Trucks- 1 high mounted amber strobe light mounted behind the cab, on a pedestal which is high enough to be visible 360 degrees. 2 brake / signal combination lights, 2 tail lights, and 2 marker lights mounted 36" off the ground. 2 amber flashing lights located at the top corners of the salt body.

5) Have we used Led lighting

Yes, they give good visibility and lasted longer than conventional lighting.

6) have you used reflective tape?

Yes, all are equipped with red and white reflective tape, it is placed around the outside perimeter if the tailgate.

7) Do we use orange flags.

Not on the rear of the truck; however, we use the orange flexible tubes on the outside corners of our plows and on the outside tip of the wing.

8) Have you used any other rear warning device

Back up alarms, and rear back up lighting.

We have also equipped some of our wing equipped vehicles with an amber flashing led light on the outside tip of the wing , facing rearward.

9) Have you used any devices to eliminate snow buildup on rear lighting

NO

10) Have you used any devices to minimize snow cloud behind the snow plow

We attach a rubber skirt along the top curl on the plow to prevent snow blow over, so that the snow once it is lifted by the plow discharges to the side of the vehicle instead of blowing back over the truck.

11) Are any changes to your snow plow rear warning systems planned?

Not at this time.

For clarification or if you have any further questions I can be reached at 902 - 861 - 1911.

Don Currie
Fleet Training Programs

MINISTRY OF TRANSPORTATION
ONTARIO

Snowplow Rear Lighting Questionnaire

1. Have rear-end collisions with snowplows been a problem?

Yes _____ No

If yes, what action has been taken to prevent these collisions?

Several years ago we re-evaluated our lighting standards to include additional lighting to the rear of the vehicle. Reflective tape was also added to the rear of the wing assemble (Equipment standards attached)

2. What type(s) of snowplows do you normally use?

The ministry has outsourced winter maintenance 100% contracts are divided into two categories. 1. Managed Outsourced areas (MO) 2. Area Managed Contracts (AMC). The contractors are responsible for obtaining their own equipment. The equipment is a mix of Combination snowplow and spreaders, spreaders only and plows only.

3. What type(s) of rear lighting do you use?

MTO Lighting Standard attached.

4. How many lights are used and how are the rear lights arranged?

MTO Lighting Standard attached.

5. Have you used steady state lighting (LED)?

Yes _____ No

If yes, what were the results?

We have tried a few test locations with very little success. The heat required to keep the LED light clear of snow has been an issue in our field trials. We do not accept LED lighting in our current lighting standard.

6. Have you used reflective tape?

Yes No _____

If yes, what were the results?

Reflective tape is used on the wing arms and on the flex stake attached at the end of the wing for visibility. There is also an additional light installed to high light the reflective tape and to identify the wing assembly. (MTO Equipment Standard attached.)

**MINISTRY OF TRANSPORTATION
ONTARIO**

7. Have you used orange flags?

Yes No

If yes, what were the results?

Flags are attached to the front of the plow and to the other tip of the wing assembly. In addition lights are positioned to shine on the plow and flag.

8. Have you used any other rear warning devices?

Yes No

If yes, what kind of device and what were the results?

Several lights have been installed on the rear of the vehicle including high mounted Red Pedestal Lights and high mounted Pedestal Turn Signal Lights. In addition to the blue revolving light we have also included a rear Blue and Amber flashing flood light.

9. Have you used any devices to eliminate snow build-up on the rear lighting?

Yes No

If yes, what kind of device and what were the results?

10. Have you used any devices to minimize the snow cloud behind the snowplow?

Yes No

If yes, what kind of device and what were the results?

11. Are any changes to your snowplow rear warning systems planned?

No, Not at this time although the issue of strobe Vs revolving seal beam continues to be raised including the use of LED lighting. Our current lighting specification dose not allow for either.

**MINISTRY OF TRANSPORTATION
ONTARIO**

Should you require any further information or clarification with regards to the response provided in this survey please call or e-mail me.

**Torben Frederiksen
Fleet Coordinator
Maintenance Office
Ministry of Transportation
2nd Floor South
301 St Paul Street
St Catharines, ON L2R 7R4
Tel. (905) 704-2961
Fax. (905) 704-2848
Torben.Frederiksen@mto.gov.on.ca**

Lamp

ID. No. Description

*Approved Product

- | | | |
|----|--|--|
| 1. | Two (2) shockfree, heavy duty plow Headlights, 7" minimum dia. or rectangular width, complete with halogen sealed beams. | Grote Truck Lite No Replacement 64604 |
| 2. | Two (2) Directional Signal Lights, 4" dia. minimum, double face, double lens (Red to front, Amber to rear), shock-mounted. | Grote Truck Lite 70311 or (OEM) 56020 or (OEM) 70311 or (OEM) |
| 2a | Two (2) Directional Signal Lights, 4" dia. minimum, single face, single lens (Amber) shock-mounted. | Grote Truck Lite 70330Y 56053 w/amber lens 70330Y |
| 3 | Two (2) flange shock-mounted combination Signal, Stop and Tail lights, 4" dia. minimum. | Grote Truck Lite 40202R 450005 w/red lens 40202R |
| 3a | Two (2) Signal, Stop and Tail lights, single face, single lens, shock-mounted. | Grote Truck Lite 70330R 53052 w/red lens 70330R |
| 4 | Five (5) amber Identification lights, single units. | Grote Truck Lite 26765Y or (OEM) 46543 or (OEM) 26765Y or (OEM) |
| 4a | Same as above, with only Three (3) amber Identification lights. | |

* Note: The models listed comply with MTO Standards and SAE Specification. All other products shall conform to these standards.

| | |
|--|-----------------|
| MINISTRY OF TRANSPORTATION - ONTARIO MAINTENANCE OFFICE | |
| LIGHTING IDENTIFICATION | |
| INITIATED: Mar/00 | REVISED: May/00 |
| APPROVED: S.E. Gwartz | |

Lamp

ID. No. Description

*Approved Product

- 5. Five (5) Red Identification and Rear Clearance Lights. I. D. lights may be in a "3-in-a-row" configuration, clearance lights must be single units.
 - Grote 46782 (single unit)
 - Truck Lite 26303R (single unit)
- 5a. As above, but with only Three (3) Red I. D. Lights.
 - Grote 49082 (3-in-a-row)
 - Truck Lite 26303R (single units)
- 6. Four (4) Side Marker Lights, front side - Amber, rear side - Red: Single units, dual bulb, shock-mounted and c/w safeguard. (lights are to be mounted on brackets allowing them to face sideways and be flush mounted).
 - Grote 46782 (red)
 - Truck Lite 26303R
 - Grote 46783 (amber)
 - Truck Lite 26303Y
- 6a. As above, but with Six (6) lamps in total, front and intermediate side - Amber, rear side - Red.
- 7. Two (2) Stop, Tail and Directional Signal lights and Licence light.
 - Grote OEM Std.
 - Truck Lite OEM Std.
- 7a. As above, but with One lamp wired only as a licence light.

8. Available (spare)

9. Back up lights.

- Grote OEM Std.
- Truck Lite OEM Std.

9a. Additional backup light - 5 3/4" minimum.

- Grote 64341 (Beam 4413)
- Truck Lite 80384 (Beam 4412)

10&11. Available (spare)

MINISTRY OF TRANSPORTATION - ONTARIO
MAINTENANCE OFFICE

LIGHTING
IDENTIFICATION

INITIATED: Mar/00 REVISED: May/00

APPROVED: S.E. Gwartz

Lamp ID. No. Description

***Approved Product**

- 12. Spot light, 5 3/4" dia. minimum seal beam, shock mounted on wing post, not more than 12" from the top.
 Grote 64340 (Beam 4435)
 Truck Lite 80384 (w/ Beam 4435)
- 13. Wing Light, 5 3/4" dia. minimum, seal beam with optional Amber lens, shock free mounted.
 Grote 64341 (Beam 4413)
 Truck Lite 80384 (Beam 4412)
- 14. Plow Light, 5 3/4" dia. minimum, sealed beam, shock free mounted. To be mounted on the left side of the "A" frame lifting device with the beam to be directed down to the leading edge of the one way plow.
 Grote 64341 (Beam 4413)
 Truck Lite 80384 (Beam 4412)
- 15. One (1) revolving light, with Blue/Amber lens. Light shall be positioned to be visible from all sides at all times.
 Grote 76225 (Blue)
 76223 (Amber)
 Truck Lite 92600 (Blue)
 92600 (Amber)
 Star 400A

Note: Light must conform with the appropriate SAE spec. using a Amber or Blue lens. J845 light must be Class 1 or 2.

- 15a. As above, but with Two (2) revolving lights mounted on cab roof; One Blue, One Amber.

- 16. Flashing Amber Light, 5 3/4" dia minimum, sealed beam, shock free mounted, as close to the centre as possible, to be focused behind the vehicle, and offset, with the light beam hitting the ground at a point not more than 25' from the rear of the vehicle at the curb-side edge of the pavement.

Grote 64341 Beam 4413 w/amber lens (99893)
 Truck Lite 80384 (lens not available)

MINISTRY OF TRANSPORTATION - ONTARIO
 MAINTENANCE OFFICE

LIGHTING
 IDENTIFICATION

INITIATED: Mar/00 REVISED: May/00

APPROVED: S.E. Gwartz

Lamp

ID. No. Description

*Approved Product

- 17&18. Available (spare)
- 19. One (1) Flashing Blue Light, 5 3/4" dia. minimum, sealed beam, shock-free mounted.
 - Grote 64341 (Beam 4413)
W/blue lens 99895)
 - Truck Lite 80384 (Beam 4412)
Lens not available
- 19a. As above, but with Two (2) Flashing Blue Lights.
- 20. Spinner - Floodlight 4 1/2" dia. minimum, single face, single white lens. (Located to light spinner and surrounding area).
 - Grote 64931 (Beam 4411)
 - Truck Lite 80360 (Beam 4411)
- 21. Available (spare)
- 22. Snow Plow Pedestal Stop & Turn Signal Light 7" dia. minimum, single faced.
 - Grote 78002
 - Truck Lite 90320R (No mounting Bracket)

Note: Separate switches are required for the amber (16) and blue (19) flashing light.

MINISTRY OF TRANSPORTATION - ONTARIO
MAINTENANCE OFFICE

LIGHTING
IDENTIFICATION

INITIATED: Mar/00 REVISED: May/00

APPROVED: S.E. Gwartz

Lamp

ID. No. Description

*Approved Product

23. Red Pedestal Light (non-flashing), 5 3/4" dia. minimum, sealed beam, shock-free mounted and focused straight back to provide the earliest warning.
24. Two (2) Dome - type lights, 32 C. P. Minimum capacity.
- **25. On Rear: One (1) Red Reflector to be mounted within 6" of the left and right sides of vehicle body.
- On Sides: One (1) Red Reflector to be mounted on each side to rear.
- One (1) Amber Reflector to be mounted on each side to front. Only plastic reflex type reflectors can be used.

Grote 64341 beam 4413 w/
red lens 99882
Truck Lite 80384
(lens not available)

Grote 61161
Truck Lite 80354

For vehicles over 30 ft in length: One (1) Amber Intermediate Reflector to be mounted on each side midway between front and rear Reflectors.

**25a. On Rear: One (1) Red Reflector to be mounted on the left and right mud flap in a vertically central position and within 9" of the outside edge of the vehicle.

** The location of the reflectors, measured from the ground is to be not more than 60" and not less than 15".

MINISTRY OF TRANSPORTATION - ONTARIO
MAINTENANCE OFFICE

LIGHTING
IDENTIFICATION

INITIATED: Mar/00 REVISED: May/00

APPROVED: S.E. Gwartz

Lamp

ID. No.

Description

*Approved Product

- | | |
|--|--|
| <p>26. Two (2) flashing Amber lights, 5 3/4" dia. minimum, shock free mounted.</p> | <p>Grote 64341 (Beam 4413) w/ amber lens 99893 Truck Lite 80384 (Beam 4412) lens not available</p> |
| <p>27. One (1) Buggy Clearance light, 4" dia. minimum, double faced, Amber to front, Red to rear, shock mounted.</p> | <p>Grote 56020 (amber & red) Truck Lite 70311</p> |
| <p>28. Wing Light, 5 3/4" dia. minimum, sealed beam, shock free mounted. To be positioned recessed 1 ft. from outside edge of vehicle at the bottom of the tower, NOT attached to dump box, and aimed such that the beam is directed at the rear outside edge of the wing.</p> | <p>Grote 64341 (Beam 4413) Truck Lite 80384 (Beam 4412)</p> |

MINISTRY OF TRANSPORTATION - ONTARIO
MAINTENANCE OFFICE

LIGHTING
IDENTIFICATION

INITIATED: Mar/00 REVISED: May/00

APPROVED: S.E. Gwartz

Snowplow Rear Lighting Questionnaire

1. Have rear-end collisions with snowplows been a problem?

Yes No ESPECIALLY WHEN PLOWING SNOW ON
THE TRANS CANADA HIGHWAY

If yes, what action has been taken to prevent these collisions?

AT PRESENT TIME WE HAVE :

- ① INSTALLED "WIG WAG" RANDOM FLASHING LAMPS ON TOP REAR CORNERS OF BOX
- ② APPLIED TWO HORIZONTAL STRIPS OF RED/WHITE CONSPICUITY TAPE ON ENGAGE
- ③ SECOND SET OF STOP/TAIL LAMPS MOUNTED MIDWAY ON BOX

2. What type(s) of snowplows do you normally use?

- ① Front Mounted Reversible, One Way, and older vintage Rollover
- ② Front Mounted Wing Plow (R.H. only) prior to yr. 2000
- ③ Mid-Rear Mounted Wing Plows (11 ft) after yr. 2000
L.H. & R.H.

3. What type(s) of rear lighting do you use?

Please refer to attached drawings and photos

4. How many lights are used and how are the rear lights arranged?

Please refer to attached drawings and photos

5. Have you used steady state lighting (LED)?

Yes No

If yes, what were the results? Very pleased with ^{LED} wig wag performance
Superior for visibility compared to incandescent type

However, LED Tail lamps are recessed creating snow accumulation
that obscures lamp with snow buildup. — also not as likely to
melt snow accumulations due to low heat output. Recommend
LED manufacturers pursue flush mounting designs to minimize this
problem (at least!)

6. Have you used reflective tape?

Yes No

If yes, what were the results?

Improved visibility due to reflective nature. Very pleased
with performance

7. Have you used orange flags?

Yes No

If yes, what were the results?

At one time prior to mid 1980's orange flags were
mandatory. in conjunction with amber beacon on highway
maintenance vehicles.

Orange flagging is now obsolete for Sask Dept of Highways
(policy)
(We have found better ways to accomplish visibility since)

8. Have you used any other rear warning devices?

Yes No

If yes, what kind of device and what were the results?

White - Black checkerboard with integral air scoop to prevent snow build up.

* Not as effective as reflective material (conspicuity tape)
* Prone to snow accumulation despite air scoop feature and therefore not very effective.

9. Have you used any devices to eliminate snow build-up on the rear lighting?

Yes No

If yes, what kind of device and what were the results?

Rear spoiler type devices - did not work as intended
- plugged with snow.

10. Have you used any devices to minimize the snow cloud behind the snowplow?

Yes No

If yes, what kind of device and what were the results?


Rollover extensions on snowplow blades.

11. Are any changes to your snowplow rear warning systems planned?

Not at the present time.

** The LED wigwag corner lamps have been the most significant and effective device used to date to increase rear visibility to approaching traffic.
* Reflective Tape ranks second.*

Please mail , e-mail or fax your completed questionnaire by December 10, 2004 to:



#200, 18311 - 105 Ave.
Edmonton, AB, T5S 2K9
Phone: (780) 488-8292, Fax: (780) 444-9054
E-mail: ryan.batty@allianteng.com

Personal information that you provide on this form is held strictly confidential. No other use will be made of this information and it will not be released without your written consent.

This survey is being completed by Alliant Engineering on behalf of Terry Becker, P. Eng. and Peter Ing, P. Eng. of Alberta Transportation.

Terry Becker, P. Eng.
Operations Manager
3rd Fl Administration Building
909 - 3rd Avenue North
Lethbridge, AB, T1H 0H5
Phone: (403) 382-4412
e-mail: terry.becker@gov.ab.ca

Peter Ing, P. Eng.
Research and Development Engineer
2nd Fl Twin Atria Building
4999 - 98 Avenue
Edmonton, AB, T6B 2X3
Phone: (780) 415-1009
e-mail: peter.ing@gov.ab.ca

Snowplow Rear Lighting Questionnaire

1. Have rear-end collisions with snowplows been a problem?

Yes No *ESPECIALLY WHEN PLOWING SNOW ON THE TRANS CANADA HIGHWAY*

If yes, what action has been taken to prevent these collisions?

AT PRESENT TIME WE HAVE :

- ① INSTALLED "WIG WAG" RANDOM FLASHING LAMPS ON TOP REAR CORNERS OF BOX*
- ② APPLIED TWO HORIZONTAL STRIPS OF RED/WHITE CONSPICUITY TAPE ON ENGAGE*
- ③ SECOND SET OF STOP/TAIL LAMPS MOUNTED MIDWAY ON BOX*

2. What type(s) of snowplows do you normally use?

- ① Front Mounted Reversible, One Way, and older vintage Rollover*
- ② Front Mounted Wing Plow (R.H. only) prior to yr. 2000*
- ③ Mid-Rear Mounted Wing Plows (11 ft) after yr. 2000*
↳ L.H. & R.H.

3. What type(s) of rear lighting do you use?

Please refer to attached drawings and photos

4. How many lights are used and how are the rear lights arranged?

Please refer to attached drawings and photos

5. Have you used steady state lighting (LED)?

Yes No

If yes, what were the results? Very pleased with ^{LED} wig wag performance
Superior for visibility compared to incandescent type

However, LED Tail lamps are recessed creating snow accumulation
that obscures lamp with snow buildup. — also not as likely to
melt snow accumulations due to low heat output. Recommend
LED manufacturers pursue flush mounting designs to minimize this
problem (at least!)

6. Have you used reflective tape?

Yes No

If yes, what were the results?

Improved visibility due to reflective nature. Very pleased
with performance

7. Have you used orange flags?

Yes No

If yes, what were the results?

At one time prior to mid 1980's orange flags were
mandatory. in conjunction with amber beacon on highway
maintenance vehicles.

Orange flagging is now obsolete for Sask Dept of Highways
(policy)
(We have found better ways to accomplish visibility since)

8. Have you used any other rear warning devices?

Yes No

If yes, what kind of device and what were the results?

White - Black checkerboard with integral air scoop to prevent snow build up.
* Not as effective as reflective material (conspicuity tape)
* Prone to snow accumulation despite air scoop feature and therefore not very effective.

9. Have you used any devices to eliminate snow build-up on the rear lighting?

Yes No

If yes, what kind of device and what were the results?

Rear spoiler type devices - did not work as intended
- plugged with snow.

10. Have you used any devices to minimize the snow cloud behind the snowplow?

Yes No

If yes, what kind of device and what were the results?

Rollover extensions on snowplow blades.

11. Are any changes to your snowplow rear warning systems planned?

Not at the present time.

** The LED wigwag corner lamps have been the most significant and effective device used to date to increase rear visibility to approaching traffic.
* Reflective Tape ranks second.*

Please mail , e-mail or fax your completed questionnaire by December 10, 2004 to:



#200, 18311 - 105 Ave.
Edmonton, AB, T5S 2K9
Phone: (780) 488-8292, Fax: (780) 444-9054
E-mail: ryan.batty@allianteng.com

Personal information that you provide on this form is held strictly confidential. No other use will be made of this information and it will not be released without your written consent.

This survey is being completed by Alliant Engineering on behalf of Terry Becker, P. Eng. and Peter Ing, P. Eng. of Alberta Transportation.

Terry Becker, P. Eng.
Operations Manager
3rd Fl Administration Building
909 - 3rd Avenue North
Lethbridge, AB, T1H 0H5
Phone: (403) 382-4412
e-mail: terry.becker@gov.ab.ca

Peter Ing, P. Eng.
Research and Development Engineer
2nd Fl Twin Atria Building
4999 - 98 Avenue
Edmonton, AB, T6B 2X3
Phone: (780) 415-1009
e-mail: peter.ing@gov.ab.ca

LP MODEL 6106CHS General Specs
 -Dimension 5' H x 16' L x 10.5' W
 -Weight 5 Pounds
 -Polycarbonate Base and Lens
 -Clear Lens
 -Standard HI 55 Watt Rotating Assemblies
 -AAMVA Certified To Meet SAE Requirements

BOSCH PILOT 150
 -Halogen Amber (Jet-co)
 -Driving Lamp
 -Part #26592
 -3303 A SAE Y93

SNOW PLOW LAMPS
 -Grote
 -Part #64261-4 Pair
 -Dimensions 5 1/4" H x 11 3/8" L x 5" W
 -FMVSS SAE Code H18P

CONSPIQUITY TAPE (Grote)
 -Exceeds DOT Requirements
 -Durable, Impact Resistant
 -Solvent Resistant; Easy Installation
 -Reflects Light Even In Daytime
 -Alternating 6" Silver / 6" Red
 -Part #41050 2' x 150' Roll In Window Dispenser

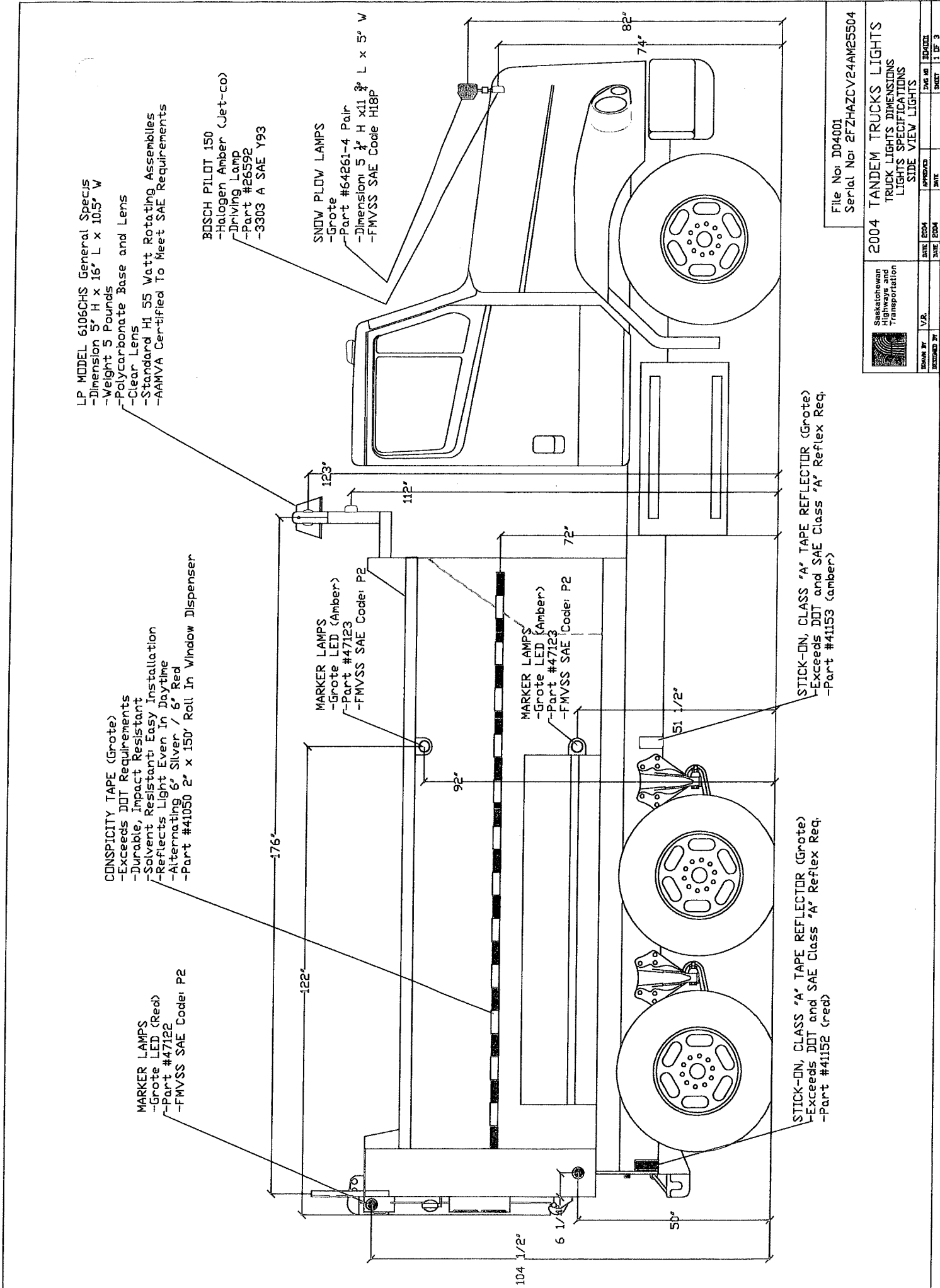
MARKER LAMPS
 -Grote LED (Red)
 -Part #47122
 -FMVSS SAE Code: P2

MARKER LAMPS
 -Grote LED (Amber)
 -Part #47123
 -FMVSS SAE Code: P2

MARKER LAMPS
 -Grote LED (Amber)
 -Part #47123
 -FMVSS SAE Code: P2

STICK-ON, CLASS 'A' TAPE REFLECTOR (Grote)
 -Exceeds DOT and SAE Class 'A' Reflex Req.
 -Part #41152 (red)

STICK-ON, CLASS 'A' TAPE REFLECTOR (Grote)
 -Exceeds DOT and SAE Class 'A' Reflex Req.
 -Part #41153 (amber)



| | | | | | | | | | |
|--|------|------|------|-------------|------|-----|---|----|---|
| DESIGNED BY | V.R. | DATE | ED04 | APPROVED BY | DATE | REV | 1 | OF | 3 |
| Saskatchewan Highways and Transportation | | | | | | | | | |
| 2004 TANDEM TRUCKS LIGHTS TRUCK LIGHTS DIMENSIONS LIGHTS SPECIFICATIONS SIDE VIEW LIGHTS | | | | | | | | | |
| File No: D04001 Serial No: 2FZHACV24M25504 | | | | | | | | | |

LP MODEL 6106CHS General Specs
 -Dimension 5' H x 16' L x 10.5' W
 -Weight 5 Pounds
 -Polycarbonate Base and Lens
 -Clear Lens
 -Standard HI 55 Watt Rotating Assemblies
 -AAMVA Certified To Meet SAE Requirements

REAR WIG-WAG
 -Part #LXEXBIFV-RH
 -Part #LXEXEB-AH
 -Code 3
 -SAE - J1318

MARKER LAMPS
 -Grote LED (Red)
 -Part #47122
 -FMVSS SAE Code: P2

BACK-UP LAMP
 -Grote LED
 -Part #58051 12 Volt
 -Sealed Beam #H76060
 -Dimension: 5 Inch

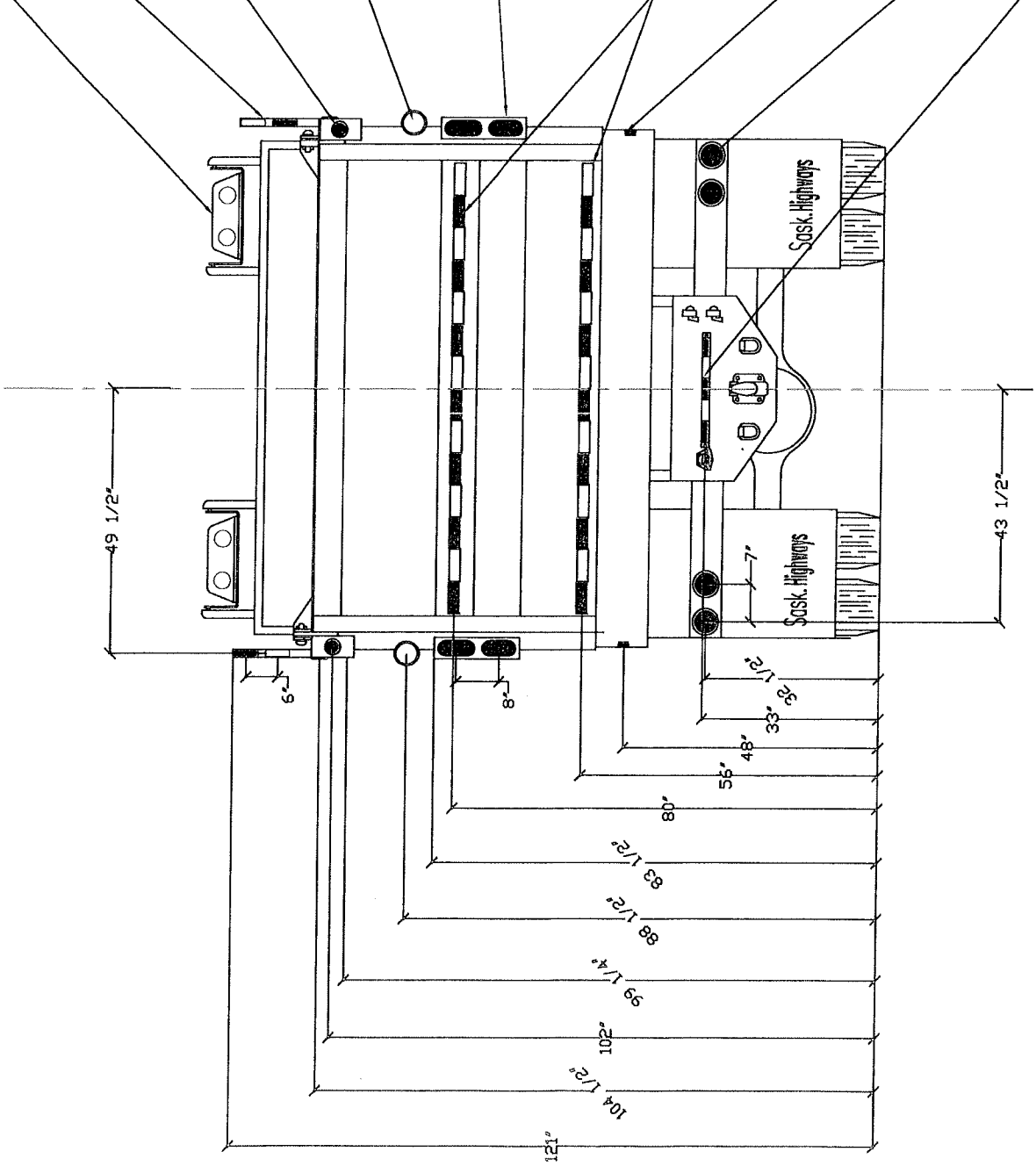
STOP-TAIL-TURN
 -Grote LED (Red)
 -Part #53962
 -FMVSS SAE
 -Code 1, P2, S, T, (Red)
 -Dimension: 2 1/4" W x 6 1/2" H

CONSPICUITY TAPE (Grote)
 -Exceeds DOT Requirements
 -Durable, Impact Resistant
 -Solvent Resistant; Easy Installation
 -Reflects Light Even In Daytime
 -Alternating 6" Silver / 6" Red
 -Part #41050 2' x 150' Roll In Window Dispenser

MARKER LAMPS
 -Grote LED (Red)
 -Part #47122
 -FMVSS SAE Code: P2

STOP-TAIL-TURN
 -Grote LED
 -Part #53252 (Red)
 -FMVSS SAE
 -Code 1, P2, S, T
 -Dimension: 4 1/8" D

IDENTIFICATION BAR LAMP
 -Grote LED (Red)
 -Part #49122
 -FMVSS SAE Code: P2



File No: D04001
 Serial No: 2FZHACV24AM25504

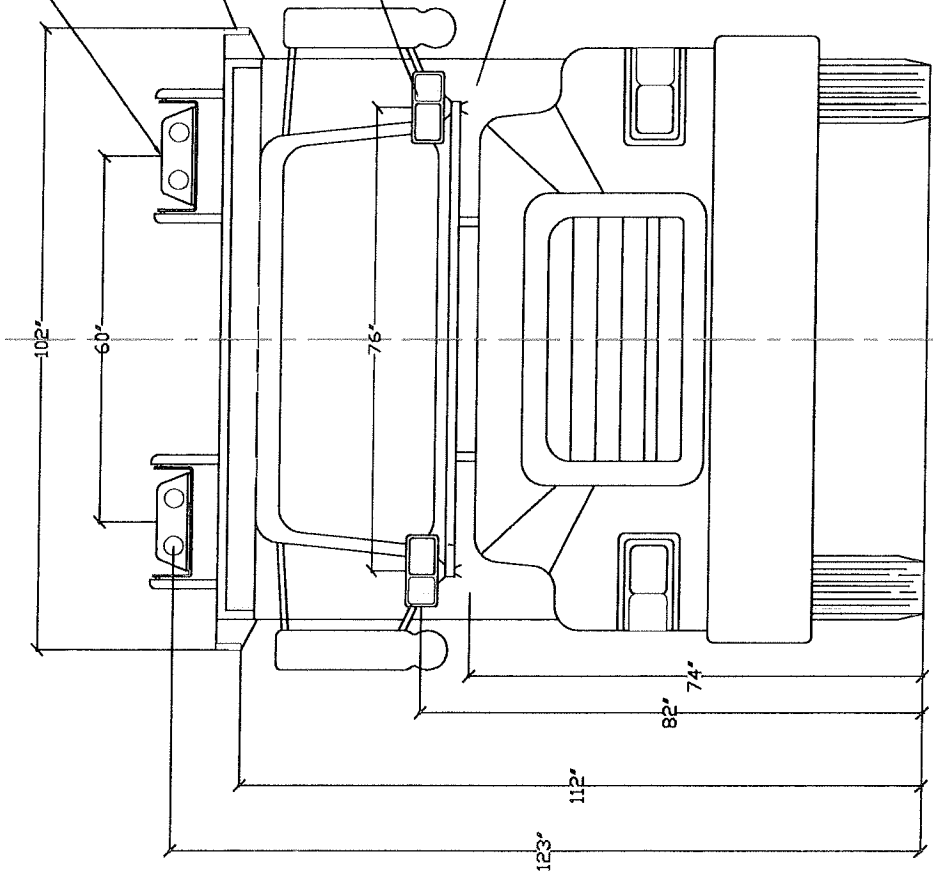
| | | | | | |
|---|------|------------|------------|------------|------------|
| | | DATE E2004 | DATE E2004 | DATE E2004 | DATE E2004 |
| DESIGNED BY | V.R. | APPROVED | DATE | DATE | DATE |
| 2004 TANDEM TRUCKS LIGHTS TRUCK LIGHTS DIMENSIONS LIGHTS SPECIFICATIONS REAR VIEW LIGHTS | | | | | |
| File No: D04001 Serial No: 2FZHACV24AM25504 | | | | | |

LP MODEL 6106CHS General Specs
 -Dimension 5' H x 16' L x 10.5' W
 -Weight 5 Pounds
 -Polycarbonate Base and Lens
 -Clear Lens
 -Standard H1 55 Watt Rotating Assemblies
 -AAMVA Certified To Meet SAE Requirements

THIN-LINE LED LAMPS
 -Grote
 -Part #47243 (Yellow)
 -Dimension: 3"
 -FMVSS SAE Code: P2, P3

SNOW PLOW LAMPS
 -Grote
 -Part #64261-4 Pair
 -Dimension: 5 1/4" H x 11 3/8" L x 5" W
 -FMVSS SAE Code H18P

BOSCH PILOT 150
 -Halogen Amber (Jet-co)
 -Driving Lamp
 -Part #26592
 -3303 A SAE Y93



File No: D04001
 Serial No: 2FZHACV24AM25504



2004 TANDEM TRUCKS LIGHTS
 TRUCK LIGHTS DIMENSIONS
 LIGHTS SPECIFICATIONS
 FRONT VIEW LIGHTS

| | | | |
|--------------|------------|-----------|---------|
| DATE: 2004 | DATE: 2004 | APPROVED: | DWG NO: |
| DESIGNED BY: | DATE: 2004 | DATE: | SHEET |
| VER: | | | 3 OF 3 |

GROTE CONSPICUITY TAPE

- Exceeds DOT Requirements
- Reflects Light Even in Daytime
- ALTERNATING 6" SILVER/6" RED**
- Part # 41050 2" x 150' Roll in Window Dispenser

REAR WIG-WAGS

- Part # LXEXB1FW-RH
- Part # LXEXB1FW-AH
- Code 3
- SAE - J1318

REAR WIG-WAGS

- Part # LXEXB1FW-AH
- Part # LXEXB1FW-RH
- Code 3
- SAE - J1318

MARKER LAMPS

- Grote LED (Red)
- Part #47122
- FMVSS SAE Code: P2

MARKER LAMPS

- Grote LED (Red)
- Part #47122
- FMVSS SAE Code: P2

BACK-UP LAMP

- Grote LED
- Part #58051 12 Volt Sealed Beam #H76060
- Dimension: 5"

BACK-UP LAMP

- Grote
- Part #58051 12 Volt Sealed Beam #H76060
- Dimension: 5"

STOP-TAIL-TURN

- Grote LED
- Part #53962 Red
- FMVSS SAE
- Code I, P2, S, T (Red)
- Dimension: 2 1/4" W x 6 1/2" H

STOP-TAIL-TURN

- Grote LED
- Part #53962 Red
- FMVSS SAE
- Code I, P2, S, T (Red)
- Dimension: 2 1/4" W x 6 1/2" H

STOP-TAIL-TURN

- Grote LED
- Part #53252 Red
- FMVSS SAE
- Code I, P2, S, T
- Dimension: 4 5/16" D

STOP-TAIL-TURN

- Grote LED
- Part #53252 Red
- FMVSS SAE
- Code I, P2, S, T
- Dimension: 4 5/16" D

IDENTIFICATION

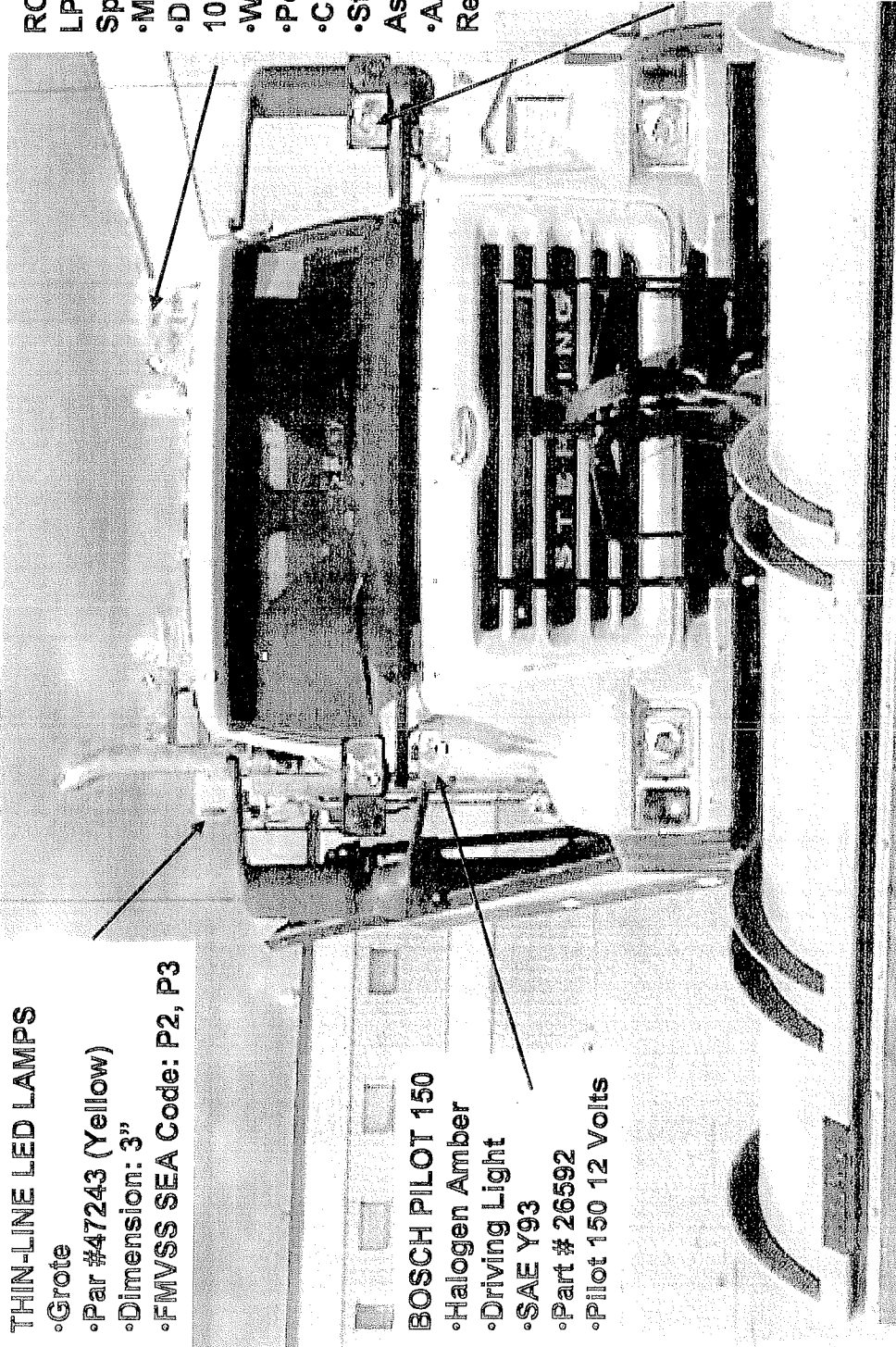
- Grote LED Bar Lamp
- Part #49122 Red
- FMVSS SAE Code: P2
- Dimension 18 11/16" x 1 3/16"

File No: D04001

Serial No: 2FZHAZCV24AM25504

THIN-LINE LED LAMPS

- Grote
- Par #47243 (Yellow)
- Dimension: 3"
- FMVSS SEA Code: P2, P3



BOSCH PILOT 150

- Halogen Amber
- Driving Light
- SAE Y93
- Part # 26592
- Pilot 150 12 Volts

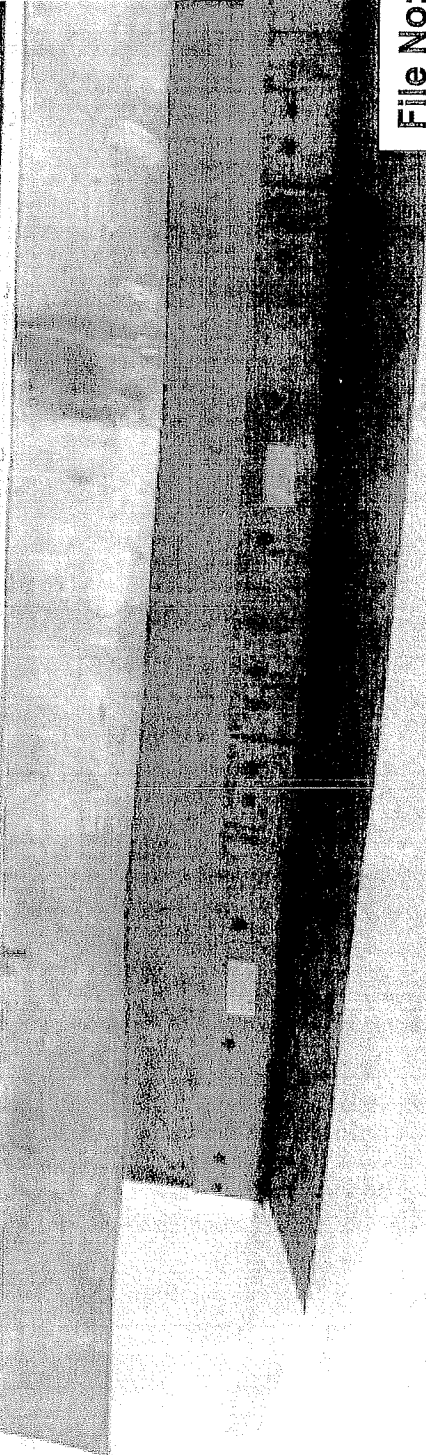
**ROTARY LAMPS
LP MODEL 6106CHS General
Specs**

- Make: PSE AMBER Code 3
- Dimension: 5" H x 16" L x 10.5" W
- Weight 5 Pounds
- Polycarbonate Base and Lens
- Clear Lens
- Standard H1 55 Watt Rotating Assemblies
- AAMVA Certified To Meet SAE Requirements



**PER-LUX, SNOWPLOW
LAMPS**

- Make: Grote
- Part #64261-4 Pair
- Dimensions: 5 1/4 H x 11 3/4" x 5" W
- FMVSS SAE Code H18P
- Bulb: #6545, 40,000 C.P. (HI), 25,000 C.P. (LOW)
- Voltage/Amp. HI 5.0 AMP, HDLT/ - LO - 3.5 AMP
- Bulb #2357, 40/3 C.P. (P,T,18)
- Voltage/Amp: 12.8 V - 2.2 AMP



File No: D04001

Serial No: 2FZHAZCV24AM25504

CONSPICUITY TAPE

- Exceeds DOT Requirements
- Durable, Impact Resistant
- Reflects Light Even In Daytime
- Make: GROTE

ALTERNATING 6" SILVER/6" RED
Part # 41050 2"

THIN-LINE LED LAMPS

- Grote
- Par #47243 (Yellow)
- Dimension: 3"
- FMVSS SEA Code: P2, P3

ROTARY LAMPS

LP MODEL 6106CHS General Specs

- Make: PSE AMBER Code 3
- Dimension: 5" H x 16" L x 10.5" W
- Weight 5 Pounds
- Polycarbonate Base and Lens
- Clear Lens
- Standard H1 55 Watt Rotating Assemblies
- AAMVA Certified To Meet SAE Requirements

PER-LUX, SNOWPLOW LAMPS

- Make: Grote
- Part #64261-4 Pair
- Dimensions: 5 1/4" H x 11 3/4" x 5" W
- FMVSS SAE Code H18P
- Bulb: #6545, 40,000 C.P. (HI), 25,000 C.P. (LOW)
- Voltage/Amp. HI 5.0 AMP, HDLT/ - LO - 3.5 AMP
- Bulb #2357, 40/3 C.P. (P,T,18)
- Voltage/Amp: 12.8 V - 2.2 AMP

MARKER LAMPS

- Grote LED (Red)
- Part #47122
- FMVSS SAE Code: P2,

MARKER LAMPS

- Grote LED (Amber)
- Part #47123
- FMVSS SAE Code: P2,

BOSCH PILOT 150

- Halogen Amber
- Driving Light
- SAE Y93
- Part # 26592
- Pilot 150 12 Volts

File No: D04001

Serial No: 2FZHAZCV24AM25504



Snowplow Rear Lighting Questionnaire

1. Have rear-end collisions with snowplows been a problem?

Yes _____ No X

If yes, what action has been taken to prevent these collisions?

2. What type(s) of snowplows do you normally use?

12' power reverse on the front of 4 and 8
yard dump trucks with 8' wings on the side
of the 8 yds.

3. What type(s) of rear lighting do you use?

Amber rotating lights mounted on the headache rack
of the dump box. Flashing yellow "fog" lights and
red LEDs on spreader

4. How many lights are used and how are the rear lights arranged?

2 yellow "fog" lights that flash mounted 12" above top
of spreader and 20" above 2 red LEDs that
are the truck tail, turn and brake lights



5. Have you used steady state lighting (LED)?

Yes No

If yes, what were the results?

*Good visibility but, they do cover over
with snow*

6. Have you used reflective tape?

Yes No

If yes, what were the results?

7. Have you used orange flags?

Yes No

If yes, what were the results?



8. Have you used any other rear warning devices?

Yes ___ No X

If yes, what kind of device and what were the results?

9. Have you used any devices to eliminate snow build-up on the rear lighting?

Yes X No ___

If yes, what kind of device and what were the results?

Metal spoilers mounted on red LED light mounts. They work well.

10. Have you used any devices to minimize the snow cloud behind the snowplow?

Yes X No ___

If yes, what kind of device and what were the results?

Metal spoiler mounted on rear of spreader above top edge. Works well to keep snow down.



11. Are any changes to your snowplow rear warning systems planned?

Not at this time

Please mail , e-mail or fax your completed questionnaire by December 10, 2004 to:

ALLIANT ENGINEERING
#200, 18311 - 105 Ave.
Edmonton, AB, T5S 2K9
Phone: (780) 488-8292, Fax: (780) 444-9054
E-mail: ryan.batty@allianteng.com

Personal information that you provide on this form is held strictly confidential. No other use will be made of this information and it will not be released without your written consent.

This survey is being completed by Alliant Engineering on behalf of Terry Becker, P. Eng. and Peter Ing, P. Eng. of Alberta Transportation.

Terry Becker, P. Eng.
Operations Manager
3rd Fl Administration Building
909 - 3rd Avenue North
Lethbridge, AB, T1H 0H5
Phone: (403) 382-4412
e-mail: terry.becker@gov.ab.ca

Peter Ing, P. Eng.
Research and Development Engineer
2nd Fl Twin Atria Building
4999 - 98 Avenue
Edmonton, AB, T6B 2X3
Phone: (780) 415-1009
e-mail: peter.ing@gov.ab.ca

APPENDIX E

FIELD TRIAL INFORMATION

Operations Plan for Snow Plow Rear Lighting Field Trials

As part of the Snow Plow Rear Lighting Research Project, field trials will be completed to compare the proposed alternatives to the existing lighting standard. To ensure that all of these trials are completed safely and efficiently the following Field Trial Operations Plan has been completed by Alliant Engineering (Alliant).

Before any field trials begin all parties associated with the trials will meet at Alberta Highway Services' maintenance yard to review the Traffic Accommodation Strategy and Hazard Assessment prepared by Alliant. The lights and lighting controls on the snow plows and the radios that will be used to communicate between vehicles will be checked to ensure they are in proper working order.

STAGE 1 – Stand-By:

Once the snow plow truck is fully equipped with the test lighting, a Stand-By status will be implemented to obtain the following conditions and trials:

- Strong snow fall at day; need snow cloud behind snow plow.
- Strong snow fall at night; need snow cloud behind snow plow.
- Light to no snow fall at day; need snow cloud behind snow plow.
- Light to no snow fall at night; need snow cloud behind snow plow.

The weather will be monitored by Alliant and the Maintenance Contractor (Glen Fassel).

Alliant and the Maintenance Contractor will decide that a weather event is likely going to occur (within 24 hours). This will then set the first level of Stand-By. Within 4 – 6 hours of the potential field trial, this weather event and the availability of the snow plow trucks will be confirmed. The following will then be contacted to be ready for a field trial:

- Video Camera Person
 - Alliant personnel, including manager, snow plow passenger & pick-up truck driver
 - Spectators, AI&T, Others
-

STAGE 2 – Set-Up:

There will be a staging area (approach, road allowance; likely near the Hwy. 60 Interchange) that everyone will meet at, at the designated time. A quick review of the operation and safety procedures will be discussed.

STAGE 3 – Conduct Field Trial:

Once the field trials begin, two snow plows will travel beside each other with two observation vehicles following at a minimum distance of 50 metres. The observation vehicles will be carrying the field evaluation panel and the camera crew. The snow plow in the inside lane will be equipped as per the existing lighting standard while the other snow plow will be outfitted with the alternative lighting options. Both observation vehicles will be outfitted with rotating amber beacons for additional visibility. Communications between all vehicles involved in the trials will be done with 2-way radios.

A set of pilot vehicles will follow the two observation vehicles, side by side. The pilot vehicles will be equipped with flashing diamond warning boards, mounted on the back of the vehicles. They are intended to warn motorists and to not let them pass, until the trial is done.

During the field trial a passenger will be present in both of the snow plows to handle all communication with the observation vehicles so that the driver can remain focused on plowing operations. Changes between the 8 alternative lighting configurations will also be performed by the passenger. Each option will be viewed initially for 30 seconds, after which each option will be viewed for an additional 60 seconds. This will allow the field evaluation panel to view each option prior to evaluation. A copy of the Field Evaluation Form is included with this Operations Plan.

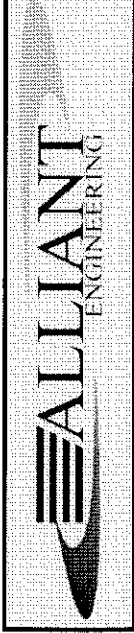
Field trials will be completed during both day and night hours and under clear and reduced visibility conditions. After the field trials are complete, Alliant will review the field evaluations and prepare a summary of the responses and an evaluation form. The responses gathered from the Field and Video Evaluation Forms will be used to make recommendations for changes to the Snow Plow Rear Lighting Standard.

| | | | |
|----------------------------|--------------------------------|-------------------------|--|
| Date: | 25-Jan-05 | Project: | Snow Plow Rear Lighting Research Project |
| Project Number: | H1236 | Project Description: | Field Trials for Snow Plow Rear Lighting Project |
| Project Manager: | Darcy Paulichuk | | |
| Assessment Team & Position | Ryan Batty Project Engineer | # of Employees On-Site: | 2 |

| Hazard Priority Status | 1 - Imminent Danger 2 - Serious | 3 - Minor 4 - O.K. | 5 - Not Applicable |
|------------------------|--|-----------------------|---|
| Item | Hazard | Priority | Hazard Items (Description) |
| 1 | Equipment - maintenance required? | 4 | Pickup trucks need minor maintenance |
| | - proper size/power? | 4 | |
| | - safety devices/guards in place? | 4 | |
| 2 | Vehicles - maintenance required? | 4 | New windshields required |
| 3 | Signals - flagpeople trained? | 5 | N/A |
| | - equipped with paddle, signs, white coveralls, vest, hardhat? | 5 | N/A |
| 4 | Traffic - Everyone equipped with vests? | 4 | Yes |
| | - Will there be signs up? | 4 | No |
| | - Need for arrowboard or pylons? | 4 | No |
| | - Are the signs in good condition? | 4 | N/A |
| | - Divided Hwy(requires signs on both sides)? | 5 | N/A |
| | - Vehicles equipped with flashing beacons? | 4 | Yes |
| | - Roadway shoulders for parking to steep? | 5 | |
| 5 | Illumination | 3 | Trials will be done at night |
| 6 | Housekeeping | 5 | N/A |
| 7 | Material Storage | 5 | N/A |
| 8 | Ventilation - asphalt lab, trenches? | 5 | N/A |
| 9 | Extreme Temperatures (cold/hot) | 5 | N/A |
| 10 | Radiation Exposure - nuclear guage? | 5 | N/A |
| 11 | Flammables | 5 | N/A |
| 12 | Dangerous Pressure - propane | 5 | N/A |
| 13 | Chemicals | 5 | N/A |
| 14 | Hazardous Materials (WHMIS) | 5 | N/A |
| 15 | High Risk Positioning - on roadway | 2 | 2 Observation vehicles will be following snow plows |
| | - raised truck boxes | 5 | |
| | - around equipment | 5 | |
| | - plant site | 5 | |
| 16 | Overhead Hazards | 5 | N/A |
| 17 | Underground Hazards - drilling | 5 | N/A |
| 18 | Confined Space Entry - trenching | 5 | N/A |
| 19 | Excavation - > than 1.5m? vertical slopes? | 5 | N/A |
| 20 | Restricted Access/Egress - lab, roadway | 5 | N/A |
| 21 | Major Lifts (hoisting) | 5 | N/A |
| 22 | Vehicles | 2 | Vehicles approaching from the rear |
| 23 | First Aid Availability/Skills | 4 | 2 First Aiders on-site |

NOTES:

For STEP #2, Complete the "Worksite Hazard Assessment Corrective Actions" form.



**WORK SITE
HAZARD ASSESSMENT
CORRECTIVE ACTIONS**

STEP # 2

Date: 25-Jan-05

Project: Snow Plow Rear Lighting Research Project

Project Number: H1236

Project Description: Field Trials for Snow Plow Rear Lighting Project

Project Manager: Darcy Paulichuk

Assessment Team & Position: Ryan Batty
Project Engineer

of Employees On-Site: 2

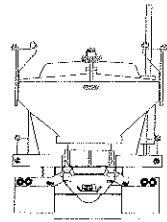
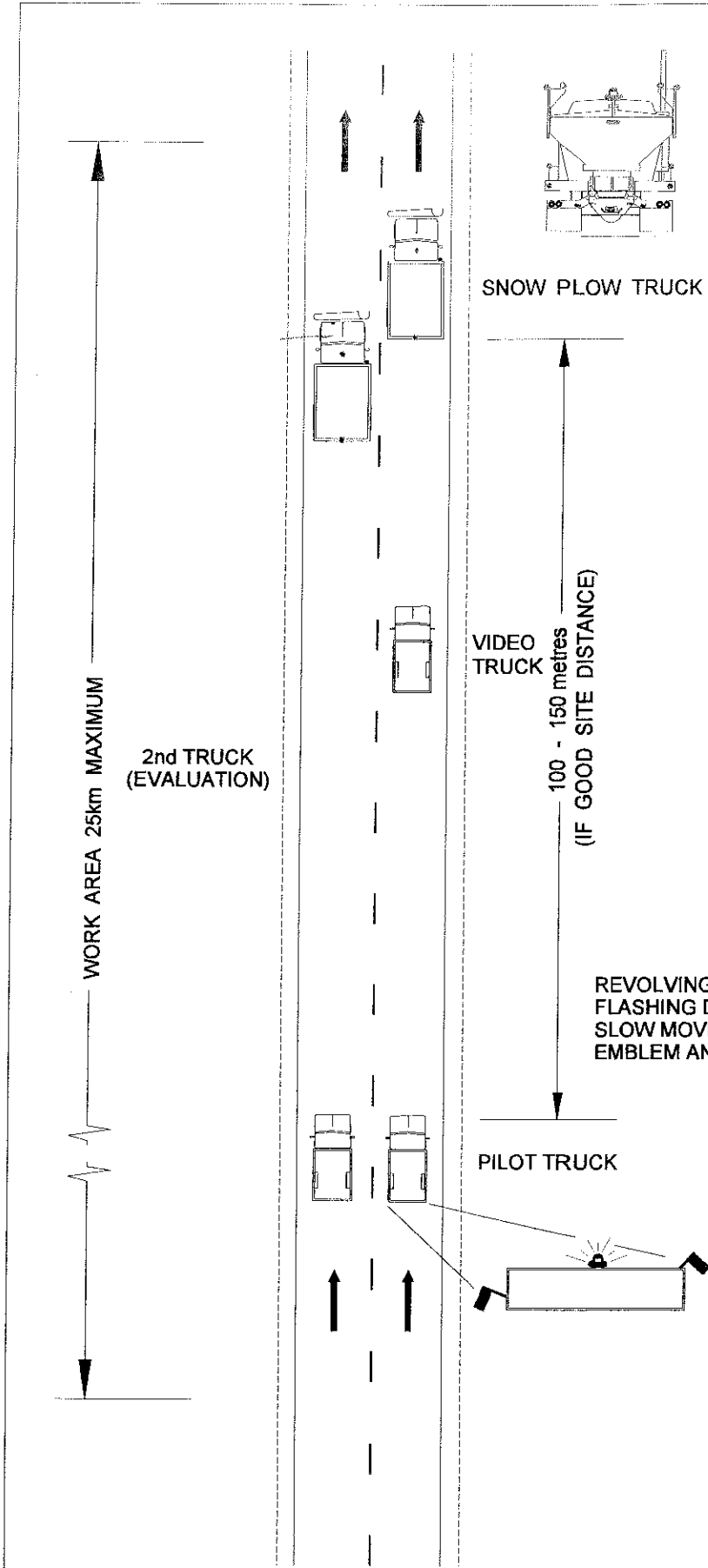
| Hazard Priority Status | | 1 - Imminent Danger | 2 - Serious | 3 - Minor | 4 - O.K. | 5 - Not Applicable | |
|------------------------|----------|---|-------------|-----------|----------|--------------------|--|
| Item | Priority | Recommended Action | | | | Follow-Up | |
| | | Date Action Taken | | | By Whom | | |
| 5 | 3 | If outside the vehicle stay near the shoulder and ensure warning lights are used on all vehicles | | | | | |
| 15 | 2 | Observation vehicles will stay a minimum of 50 m from the snow plows at all times | | | | | |
| 22 | 2 | Pilot vehicles will be used to warn and block traffic approaching from the rear. Will have a designated pull-off area for start-up shut-down for all vehicles | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

Copies To (For Action): Darcy Paulichuk

Copies To (For Information): Alliant's Company Safety Manual

Project Manager's Signature: _____

Date: _____



SNOW PLOW TRUCK

NOTES:

1. Consideration must be given to traffic volume, sight distances, sign spacing, duration of work, night time conditions and other factors to ensure traffic control devices are adequate in each instance.

VIDEO TRUCK
100 - 150 metres
(IF GOOD SITE DISTANCE)



WD-184

REVOLVING LIGHT,
FLASHING DIAMOND BOARD,
SLOW MOVING VEHICLE
EMBLEM AND FLAGS.

PILOT TRUCK

WORK AREA 25km MAXIMUM

2nd TRUCK
(EVALUATION)

| △ | | | |
|-----|-----------|----|------|
| △ | | | |
| No. | REVISIONS | BY | DATE |

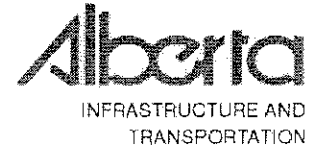
SENIOR PROJECT ENGINEER



Date: JANUARY 2005

TYPICAL SIGNING STRATEGY
SNOWPLOW LIGHTING TRIALS
FOUR LANE DIVIDED HIGHWAY

| | | | |
|---------------------|--------------------|------------------|----------------------|
| Prepared By: RMC | Checked By: DOP | Scale: N.T.S. | Dwg No.: TASP-05-01A |
|---------------------|--------------------|------------------|----------------------|



Field Evaluation Form
for
Snow Plow Rear Lighting Field Trials



Option #1 - High Profile High Intensity Strobe Beacon

1. How did this option compare to the old rear lighting standard?

| | | | | |
|-------|----------------|--------------------|----------------------|---------------------|
| Worse | No Improvement | Slight Improvement | Moderate Improvement | Extreme Improvement |
|-------|----------------|--------------------|----------------------|---------------------|

2. Rate the overall visibility of this configuration.

| | | | | | | | | | |
|------|---|---|---|---|---|---|---|---|-----------|
| Poor | | | | | | | | | Excellent |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

3. Rate the amount of glare with this configuration.

| | | | | | | | | | |
|------|---|---|---|---|---|---|---|---|----------|
| None | | | | | | | | | Blinding |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

4. Rate the ability to judge relative distance with this configuration.

| | | | | | | | | | |
|------|---|---|---|---|---|---|---|---|-----------|
| Easy | | | | | | | | | Difficult |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

5. Rate the density of the snow cloud behind the plow.

| | | | | | | | | | |
|----------|---|---|---|---|---|---|---|---|-----------|
| No Cloud | | | | | | | | | White Out |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

6. Any additional comments about this option.

Option #2 LED Beacon (Grote)

1. How did this option compare to the old rear lighting standard?

| | | | | |
|-------|----------------|--------------------|----------------------|---------------------|
| Worse | No Improvement | Slight Improvement | Moderate Improvement | Extreme Improvement |
|-------|----------------|--------------------|----------------------|---------------------|

2. Rate the overall visibility of this configuration.

| | | | | | | | | | |
|------|---|---|---|---|---|---|---|---|-----------|
| Poor | | | | | | | | | Excellent |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

3. Rate the amount of glare with this configuration.

| | | | | | | | | | |
|------|---|---|---|---|---|---|---|---|----------|
| None | | | | | | | | | Blinding |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

4. Rate the ability to judge relative distance with this configuration.

| | | | | | | | | | |
|------|---|---|---|---|---|---|---|---|-----------|
| Easy | | | | | | | | | Difficult |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

5. Rate the density if the snow cloud behind the plow.

| | | | | | | | | | |
|----------|---|---|---|---|---|---|---|---|-----------|
| No Cloud | | | | | | | | | White Out |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

6. Any additional comments about this option.

Option #3 Quantum Flash Model D3000 Strobe Beacon

1. How did this option compare to the old rear lighting standard?

| | | | | |
|-------|----------------|--------------------|----------------------|---------------------|
| Worse | No Improvement | Slight Improvement | Moderate Improvement | Extreme Improvement |
|-------|----------------|--------------------|----------------------|---------------------|

2. Rate the overall visibility of this configuration.

| | | | | | | | | | |
|------|---|---|---|---|-----------|---|---|---|----|
| Poor | | | | | Excellent | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

3. Rate the amount of glare with this configuration.

| | | | | | | | | | |
|------|---|---|---|---|----------|---|---|---|----|
| None | | | | | Blinding | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

4. Rate the ability to judge relative distance with this configuration.

| | | | | | | | | | |
|------|---|---|---|---|-----------|---|---|---|----|
| Easy | | | | | Difficult | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

5. Rate the density of the snow cloud behind the plow.

| | | | | | | | | | |
|----------|---|---|---|---|-----------|---|---|---|----|
| No Cloud | | | | | White Out | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

6. Any additional comments about this option.

Option #4 Whelen Beacon

1. How did this option compare to the old rear lighting standard?

| | | | | |
|-------|----------------|--------------------|----------------------|---------------------|
| Worse | No Improvement | Slight Improvement | Moderate Improvement | Extreme Improvement |
|-------|----------------|--------------------|----------------------|---------------------|

2. Rate the overall visibility of this configuration.

| | | | | | | | | | |
|------|---|---|---|---|---|---|---|---|-----------|
| Poor | | | | | | | | | Excellent |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

3. Rate the amount of glare with this configuration.

| | | | | | | | | | |
|------|---|---|---|---|---|---|---|---|----------|
| None | | | | | | | | | Blinding |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

4. Rate the ability to judge relative distance with this configuration.

| | | | | | | | | | |
|------|---|---|---|---|---|---|---|---|-----------|
| Easy | | | | | | | | | Difficult |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

5. Rate the density of the snow cloud behind the plow.

| | | | | | | | | | |
|----------|---|---|---|---|---|---|---|---|-----------|
| No Cloud | | | | | | | | | White Out |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

6. Any additional comments about this option.

Option #5 Low Profile Revolving Beacon

1. How did this option compare to the old rear lighting standard?

| | | | | |
|-------|----------------|--------------------|----------------------|---------------------|
| Worse | No Improvement | Slight Improvement | Moderate Improvement | Extreme Improvement |
|-------|----------------|--------------------|----------------------|---------------------|

2. Rate the overall visibility of this configuration.

| | | | | | | | | | |
|------|---|---|---|---|-----------|---|---|---|----|
| Poor | | | | | Excellent | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

3. Rate the amount of glare with this configuration.

| | | | | | | | | | |
|------|---|---|---|---|----------|---|---|---|----|
| None | | | | | Blinding | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

4. Rate the ability to judge relative distance with this configuration.

| | | | | | | | | | |
|------|---|---|---|---|-----------|---|---|---|----|
| Easy | | | | | Difficult | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

5. Rate the density if the snow cloud behind the plow.

| | | | | | | | | | |
|----------|---|---|---|---|-----------|---|---|---|----|
| No Cloud | | | | | White Out | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

6. Any additional comments about this option.

Option #6 Low Profile Revolving Beacon with LED Directional Lights

1. How did this option compare to the old rear lighting standard?

| | | | | |
|-------|----------------|--------------------|----------------------|---------------------|
| Worse | No Improvement | Slight Improvement | Moderate Improvement | Extreme Improvement |
|-------|----------------|--------------------|----------------------|---------------------|

2. Rate the overall visibility of this configuration.

| | | | | | | | | | |
|------|---|---|---|---|---|---|---|---|-----------|
| Poor | | | | | | | | | Excellent |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

3. Rate the amount of glare with this configuration.

| | | | | | | | | | |
|------|---|---|---|---|---|---|---|---|----------|
| None | | | | | | | | | Blinding |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

4. Rate the ability to judge relative distance with this configuration.

| | | | | | | | | | |
|------|---|---|---|---|---|---|---|---|-----------|
| Easy | | | | | | | | | Difficult |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

5. Rate the density if the snow cloud behind the plow.

| | | | | | | | | | |
|----------|---|---|---|---|---|---|---|---|-----------|
| No Cloud | | | | | | | | | White Out |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

6. Any additional comments about this option.

Option #7 - Low Profile Revolving Beacon *w/ Wig Wag Lights*

1. How did this option compare to the old rear lighting standard?

| | | | | |
|-------|----------------|--------------------|----------------------|---------------------|
| Worse | No Improvement | Slight Improvement | Moderate Improvement | Extreme Improvement |
|-------|----------------|--------------------|----------------------|---------------------|

2. Rate the overall visibility of this configuration.

| | | | | | | | | | | |
|------|---|---|---|---|---|---|---|---|-----------|--|
| Poor | | | | | | | | | Excellent | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | |

3. Rate the amount of glare with this configuration.

| | | | | | | | | | | |
|------|---|---|---|---|---|---|---|---|----------|--|
| None | | | | | | | | | Blinding | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | |

4. Rate the ability to judge relative distance with this configuration.

| | | | | | | | | | | |
|------|---|---|---|---|---|---|---|---|-----------|--|
| Easy | | | | | | | | | Difficult | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | |

5. Rate the density if the snow cloud behind the plow.

| | | | | | | | | | | |
|----------|---|---|---|---|---|---|---|---|-----------|--|
| No Cloud | | | | | | | | | White Out | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | |

6. Any additional comments about this option.

Option #8 Low Profile Revolving Beacon with Vertical LED Light Bars

1. How did this option compare to the old rear lighting standard?

| | | | | |
|-------|----------------|--------------------|----------------------|---------------------|
| Worse | No Improvement | Slight Improvement | Moderate Improvement | Extreme Improvement |
|-------|----------------|--------------------|----------------------|---------------------|

2. Rate the overall visibility of this configuration.

| | | | | | | | | | |
|------|---|---|---|---|---|---|---|-----------|----|
| Poor | | | | | | | | Excellent | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

3. Rate the amount of glare with this configuration.

| | | | | | | | | | |
|------|---|---|---|---|---|---|---|----------|----|
| None | | | | | | | | Blinding | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

4. Rate the ability to judge relative distance with this configuration.

| | | | | | | | | | |
|------|---|---|---|---|---|---|---|-----------|----|
| Easy | | | | | | | | Difficult | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

5. Rate the density if the snow cloud behind the plow.

| | | | | | | | | | |
|----------|---|---|---|---|---|---|---|-----------|----|
| No Cloud | | | | | | | | White Out | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

6. Any additional comments about this option.

Option #9 - Low Profile Revolving Beacon with Horizontal LED Light Bar

1. How did this option compare to the old rear lighting standard?

| | | | | |
|-------|----------------|--------------------|----------------------|---------------------|
| Worse | No Improvement | Slight Improvement | Moderate Improvement | Extreme Improvement |
|-------|----------------|--------------------|----------------------|---------------------|

2. Rate the overall visibility of this configuration.

| | | | | | | | | | |
|------|---|---|---|---|-----------|---|---|---|----|
| Poor | | | | | Excellent | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

3. Rate the amount of glare with this configuration.

| | | | | | | | | | |
|------|---|---|---|---|----------|---|---|---|----|
| None | | | | | Blinding | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

4. Rate the ability to judge relative distance with this configuration.

| | | | | | | | | | |
|------|---|---|---|---|-----------|---|---|---|----|
| Easy | | | | | Difficult | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

5. Rate the density if the snow cloud behind the plow.

| | | | | | | | | | |
|----------|---|---|---|---|-----------|---|---|---|----|
| No Cloud | | | | | White Out | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

6. Any additional comments about this option.

Option #10 LED X 2100 Mini Bar Amber Beacon

1. How did this option compare to the old rear lighting standard?

| | | | | |
|-------|----------------|--------------------|----------------------|---------------------|
| Worse | No Improvement | Slight Improvement | Moderate Improvement | Extreme Improvement |
|-------|----------------|--------------------|----------------------|---------------------|

2. Rate the overall visibility of this configuration.

| | | | | | | | | | |
|------|---|---|---|---|---|---|---|---|-----------|
| Poor | | | | | | | | | Excellent |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

3. Rate the amount of glare with this configuration.

| | | | | | | | | | |
|------|---|---|---|---|---|---|---|---|----------|
| None | | | | | | | | | Blinding |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

4. Rate the ability to judge relative distance with this configuration.

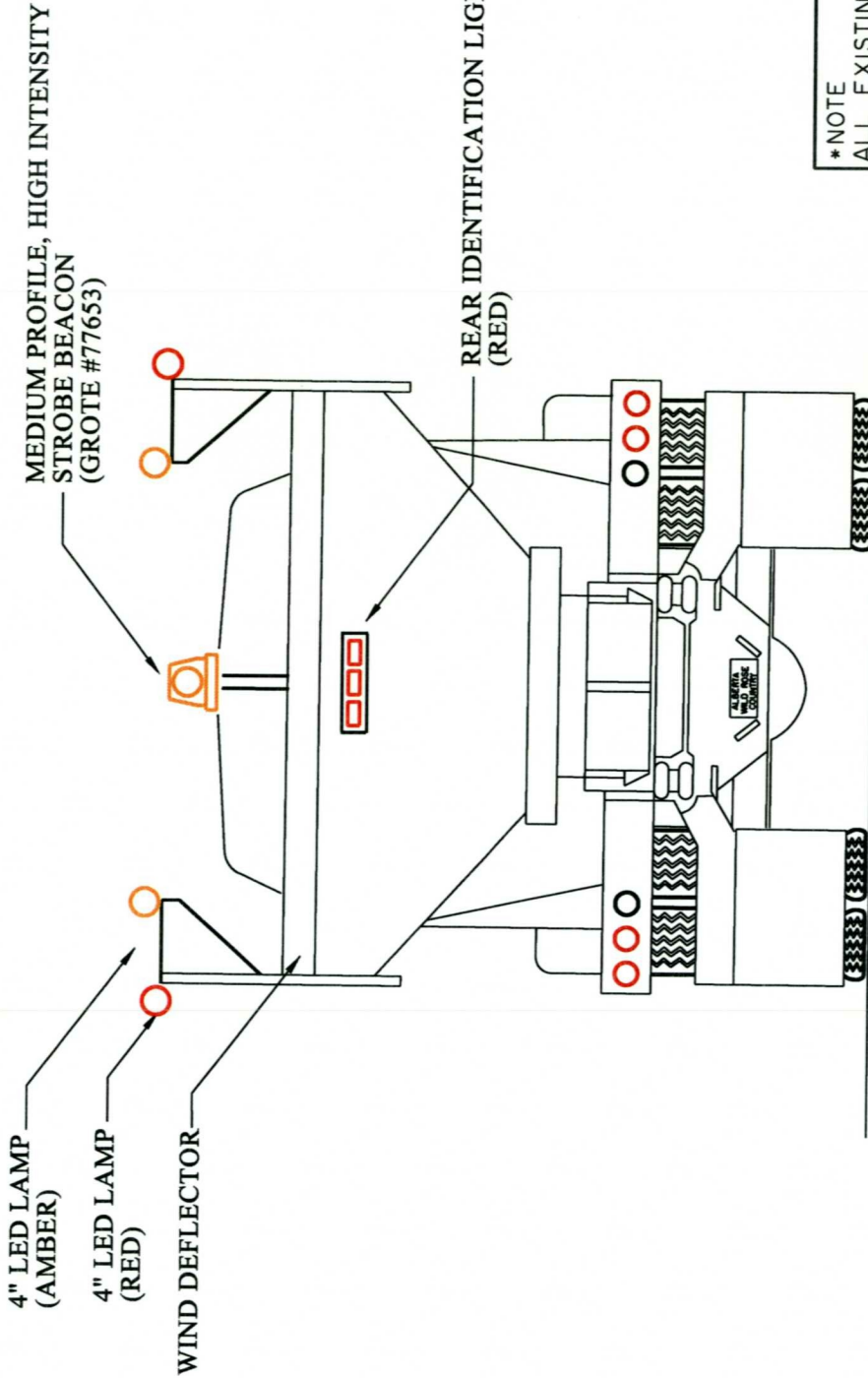
| | | | | | | | | | |
|------|---|---|---|---|---|---|---|---|-----------|
| Easy | | | | | | | | | Difficult |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

5. Rate the density if the snow cloud behind the plow.

| | | | | | | | | | |
|----------|---|---|---|---|---|---|---|---|-----------|
| No Cloud | | | | | | | | | White Out |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

6. Any additional comments about this option.

REAR LIGHTING TRIAL # 1



*NOTE
ALL EXISTING LIGHTS TO BE
REPLACED WITH LED LIGHTS

Alberta
INFRASTRUCTURE AND
TRANSPORTATION

HORIZONTAL
VERTICAL

PLAN No. _____
SHEET _____ of _____

PLAN SHOWING DETAILS OF SNOW REMOVAL AND ICE CONTROL TRUCK REAR LIGHTING STANDARD TRAIL 1

BRANCH H236-2004-SNOWFLOW REAR LIGHTING-01
CONTRACT No. _____ PROJECT _____

PLAN DESCRIPTION
PLAN SHOWING DETAILS OF
SNOW REMOVAL AND ICE CONTROL TRUCK
REAR LIGHTING STANDARD
TRAIL 1

BAR CODE

| | | | |
|--|-------------|---------|--------------|
| CONSULTANT | | | |
| PLAN No. H236-2004-SNOWFLOW REAR LIGHTING-01 | | | |
| APPROVED | BY | DATE | DATE |
| DESIGNED | D PAULICHUK | CHECKED | |
| | R. BATTY | 12/2004 | 12/2004 |
| | | DRAWN | R. CRONKHITE |



PLAN No. _____
CONTRACT No. _____
CONSULTANTS PL No. _____

REAR LIGHTING TRIAL #2

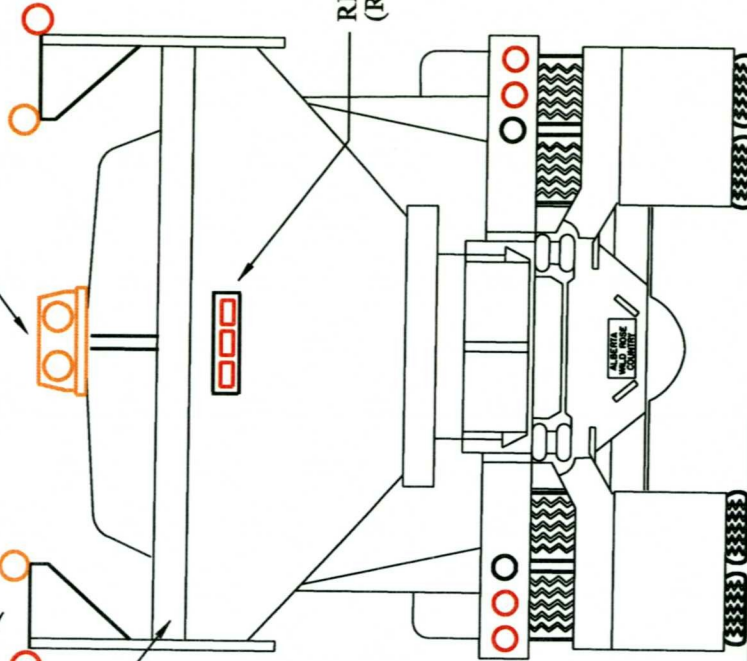
HIGH INTENSITY 15" DUAL ROTATING BEACON (GROTE #777163)

4" LED LAMP (AMBER)

4" LED LAMP (RED)

WIND DEFLECTOR

REAR IDENTIFICATION LIGHTS (RED)



*NOTE
ALL EXISTING LIGHTS TO BE
REPLACED WITH LED LIGHTS

PLAN SHOWING DETAILS OF SNOW REMOVAL AND ICE CONTROL TRUCK REAR LIGHTING STANDARD TRAIL 2

CONSULTANT

PLAN No. HE236-2004-SNOWPLOW REAR LIGHTING-02



| APPROVED | BY | DATE | CHECKED | BY | DATE |
|----------|--------------|---------|---------|--------------|---------|
| DESIGNED | D. PAULICHUK | 12/2004 | DRAWN | R. BATTY | 12/2004 |
| | | | | P. CRONKHITE | 12/2004 |

| | |
|--------------|--------------------|
| PLAN No. | CONSULTANTS PL No. |
| CONTRACT No. | |

| | | |
|--------------------------------------|--------------|---------|
| BRANCH | CONTRACT No. | PROJECT |
| HE236-2004-SNOWPLOW REAR LIGHTING-02 | | |

| | |
|----------|-------|
| PLAN No. | SHEET |
| | of |

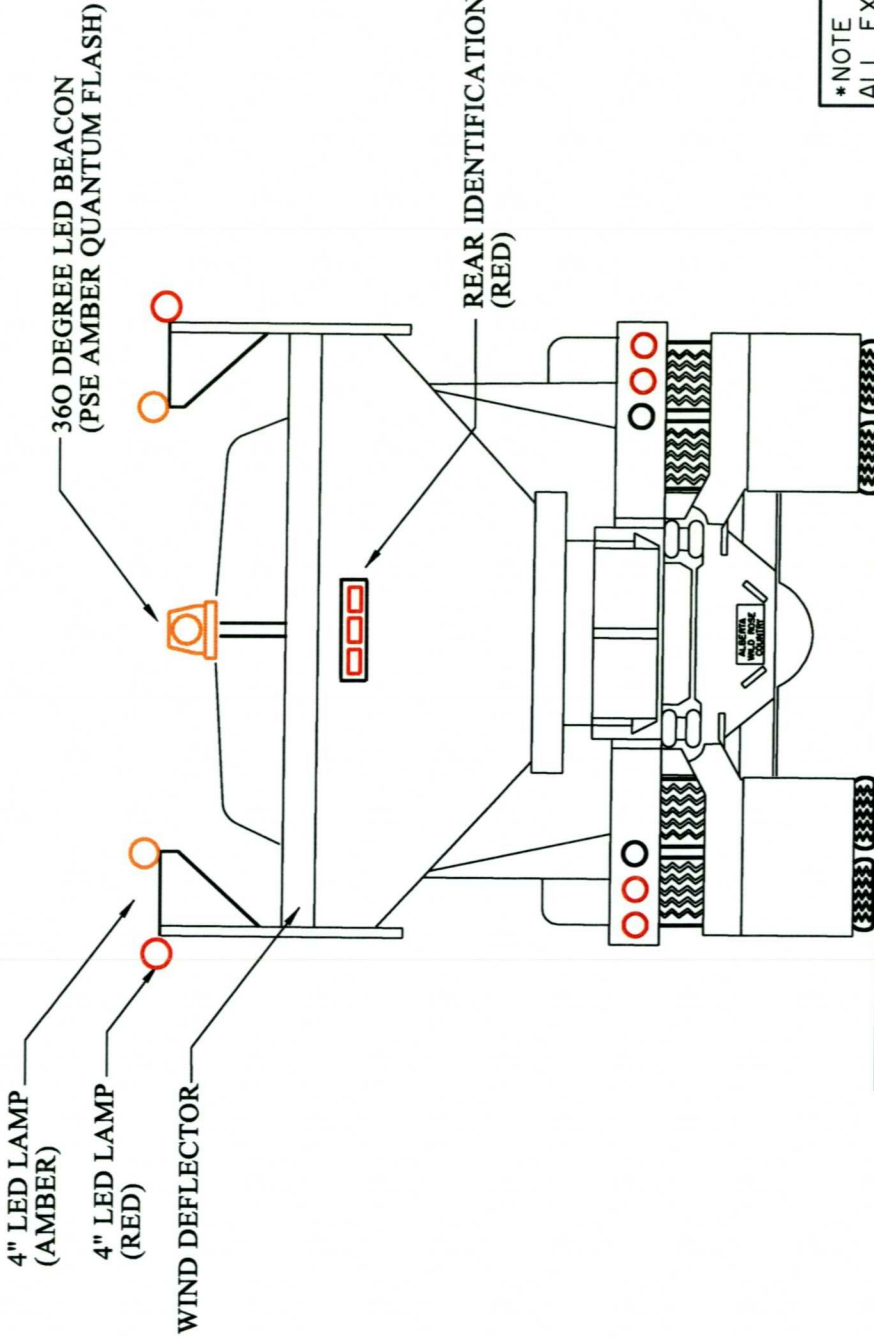
Alberta
INFRASTRUCTURE AND
TRANSPORTATION

0 m
0 m

HORIZONTAL
VERTICAL

| | |
|--|----------|
| PLAN DESCRIPTION | BAR CODE |
| PLAN SHOWING DETAILS OF SNOW REMOVAL AND ICE CONTROL TRUCK REAR LIGHTING STANDARD TRAIL 2 | |

REAR LIGHTING TRIAL # 3



* NOTE
ALL EXISTING LIGHTS TO BE
REPLACED WITH LED LIGHTS

Alberta
INFRASTRUCTURE AND
TRANSPORTATION

0 m HORIZONTAL
0 m VERTICAL

PLAN No. _____
SHEET _____ of _____

PLAN SHOWING DETAILS OF SNOW REMOVAL AND ICE CONTROL TRUCK REAR LIGHTING STANDARD TRAIL 3

| | | |
|-------------------------------------|--------------|---------|
| BRANCH | CONTRACT No. | PROJECT |
| H236-2004-SNOWPLOW REAR LIGHTING-03 | | |

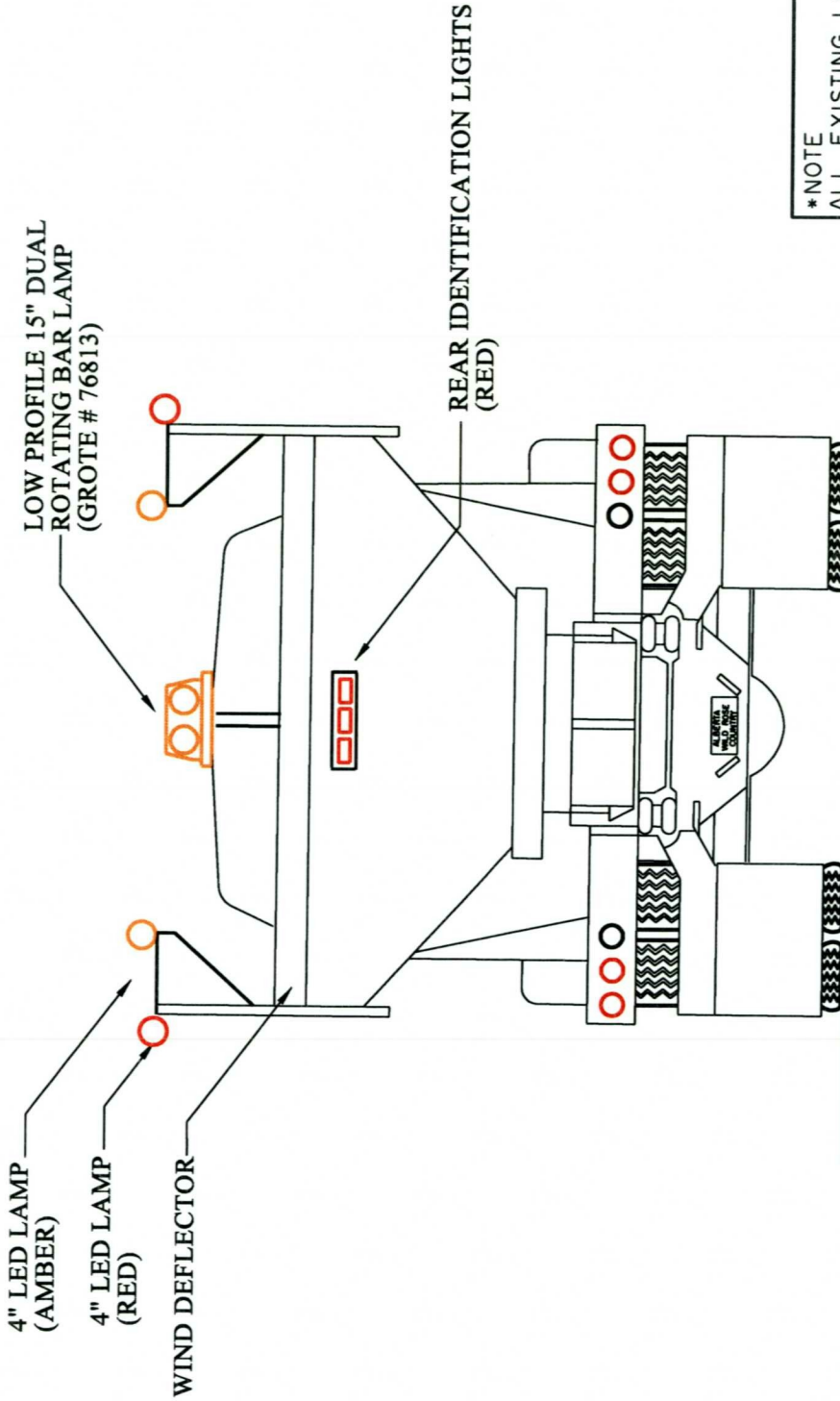
CONSULTANT

PLAN No. H236-2004-SNOWPLOW REAR LIGHTING-03

| | | | | | |
|----------|------------|---------|---------|------------|---------|
| APPROVED | BY | DATE | CHECKED | BY | DATE |
| DESIGNED | D PAULCHUK | 12/2004 | | R CROWHITE | 12/2004 |
| | R BATTY | 12/2004 | DRAWN | | |

| | | |
|--|--------------|--------------------|
| PLAN DESCRIPTION | PLAN No. | CONSULTANTS PL No. |
| PLAN SHOWING DETAILS OF SNOW REMOVAL AND ICE CONTROL TRUCK REAR LIGHTING STANDARD TRAIL 3 | | |
| BAR CODE | CONTRACT No. | |
| | | |

REAR LIGHTING TRIAL # 4



*NOTE
ALL EXISTING LIGHTS TO BE
REPLACED WITH LED LIGHTS

Alberta
INFRASTRUCTURE AND
TRANSPORTATION

0 m HORIZONTAL
0 m VERTICAL

PLAN No. _____
SHEET _____ of _____

PLAN SHOWING DETAILS OF SNOW REMOVAL AND ICE CONTROL TRUCK REAR LIGHTING STANDARD TRAIL 4

BRANCH H236-2004-SNOWFLOW REAR LIGHTING-04
CONTRACT No. _____ PROJECT _____

PLAN DESCRIPTION
PLAN SHOWING DETAILS OF
SNOW REMOVAL AND ICE CONTROL TRUCK
REAR LIGHTING STANDARD
TRAIL 4

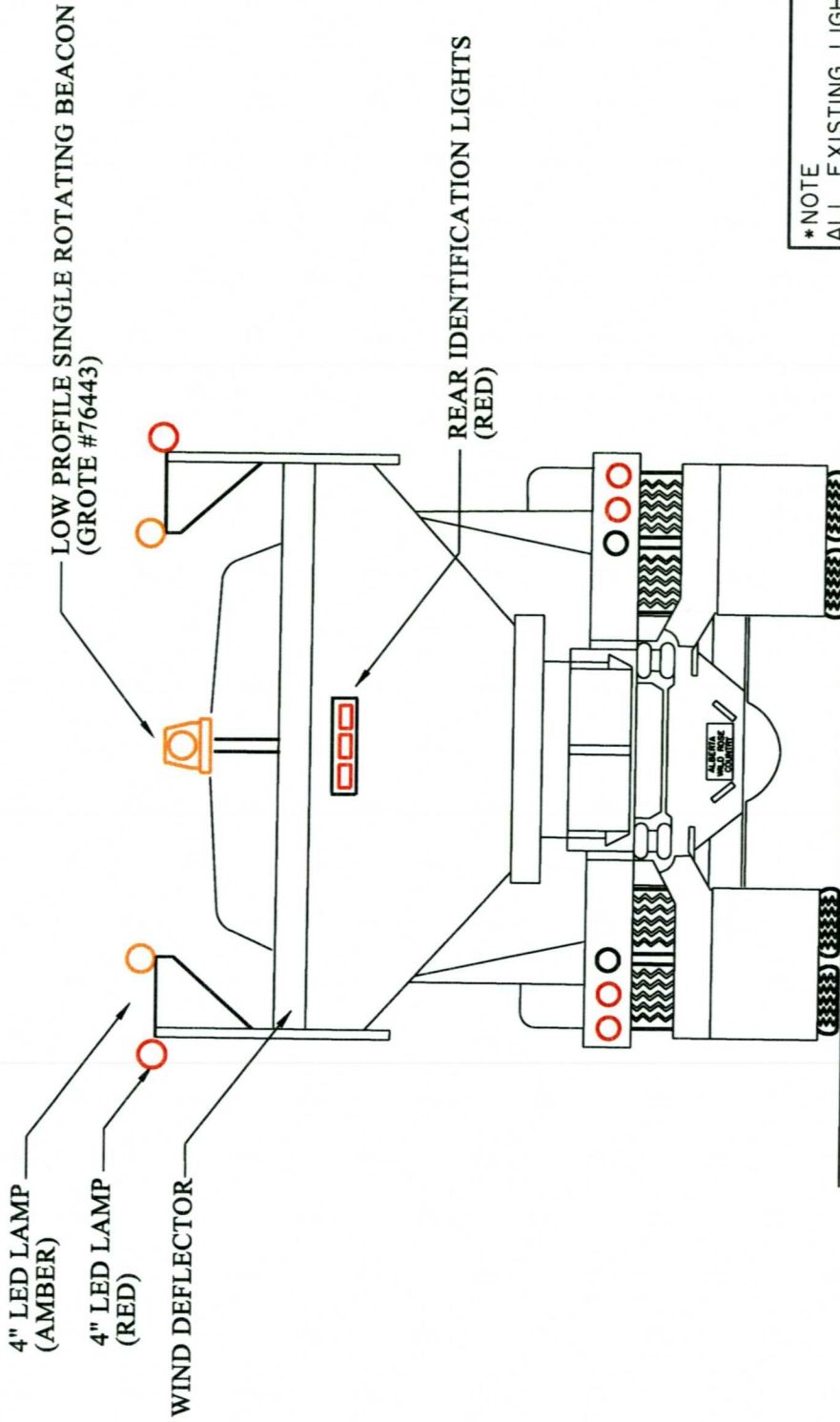
BAR CODE

CONSULTANT
PLAN No. H236-2004-SNOWFLOW REAR LIGHTING-04



| APPROVED | BY | DATE | CHECKED | BY | DATE |
|----------|-------------|---------|---------|--------------|---------|
| DESIGNED | D. PAULCHUK | | | | |
| | R. BATTY | 12/2004 | DRAWN | R. CRONKHITE | 12/2004 |

REAR LIGHTING TRIAL # 5



*NOTE
ALL EXISTING LIGHTS TO BE
REPLACED WITH LED LIGHTS

Alberta
INFRASTRUCTURE AND
TRANSPORTATION

HORIZONTAL
VERTICAL

PLAN No. _____
SHEET _____ of _____

PLAN SHOWING DETAILS OF
SNOW REMOVAL AND ICE CONTROL TRUCK
REAR LIGHTING STANDARD
TRAIL 5

BRANCH: H236-2004-SNOWPLOW REAR LIGHTING-05
CONTRACT No. _____ PROJECT _____

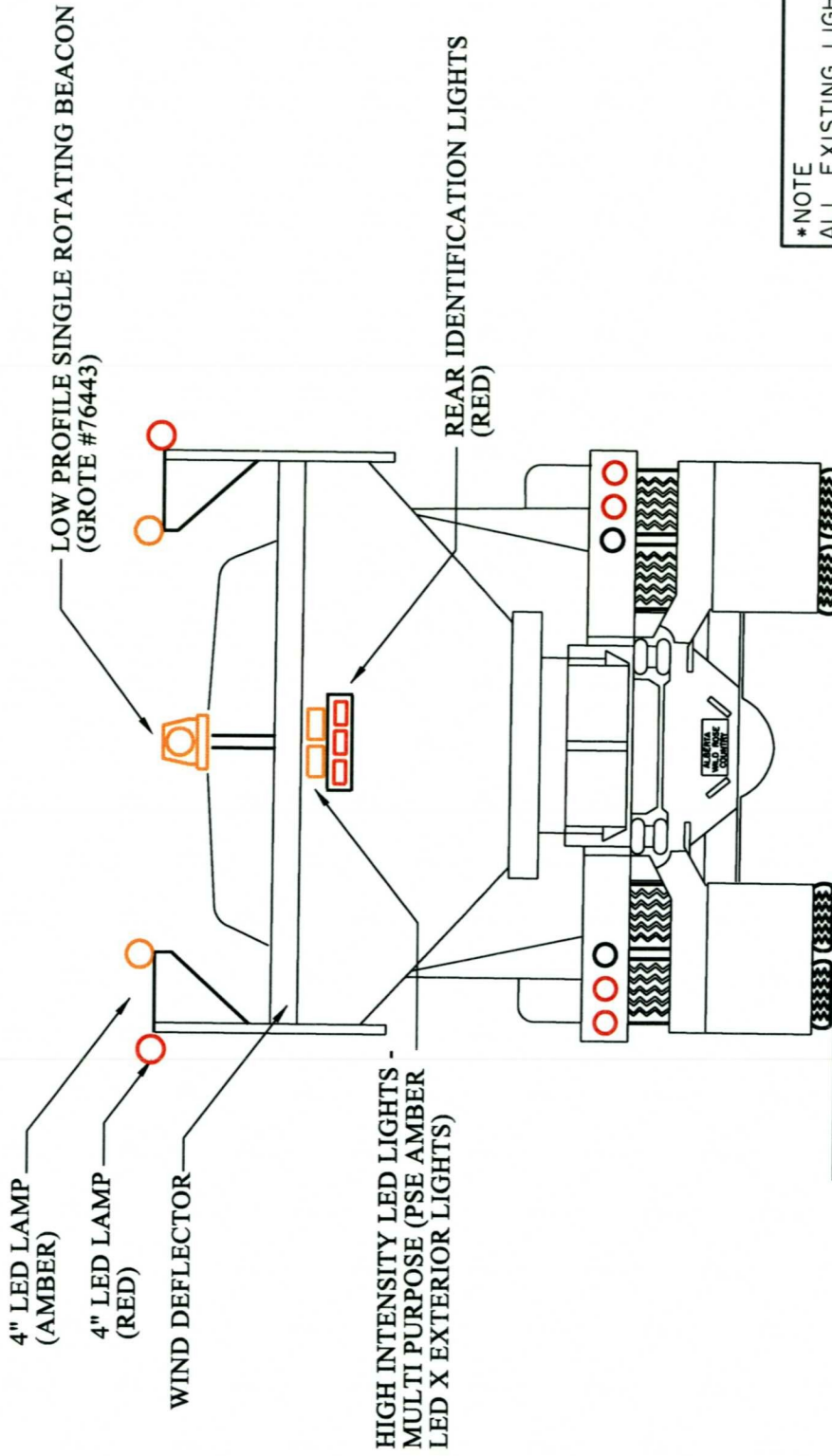
CONSULTANT
PLAN No. H236-2004-SNOWPLOW REAR LIGHTING-05

ALLIANT
ENGINEERING

| APPROVED | BY | DATE | CHECKED | BY | DATE |
|----------|-------------|---------|---------|-------------|---------|
| DESIGNED | D PAULICHUK | 12/2004 | DRAWN | R CRONKHITE | 12/2004 |
| | R BATTY | | | | |

| | | | | |
|--|----------|--------------------|--------------|----------|
| PLAN DESCRIPTION PLAN SHOWING DETAILS OF SNOW REMOVAL AND ICE CONTROL TRUCK REAR LIGHTING STANDARD TRAIL 5 | BAR CODE | CONSULTANTS PL No. | CONTRACT No. | PLAN No. |
|--|----------|--------------------|--------------|----------|

REAR LIGHTING TRIAL # 6



*NOTE
ALL EXISTING LIGHTS TO BE REPLACED WITH LED LIGHTS

Alberta
INFRASTRUCTURE AND TRANSPORTATION

HORIZONTAL

VERTICAL

PLAN No. _____

SHEET _____ of _____

PLAN SHOWING DETAILS OF SNOW REMOVAL AND ICE CONTROL TRUCK REAR LIGHTING STANDARD TRAIL 6

| | |
|--------------|--------------------------------------|
| BRANCH | HE236-2004-SHOWFLOW REAR LIGHTING-06 |
| CONTRACT No. | |
| PROJECT | |

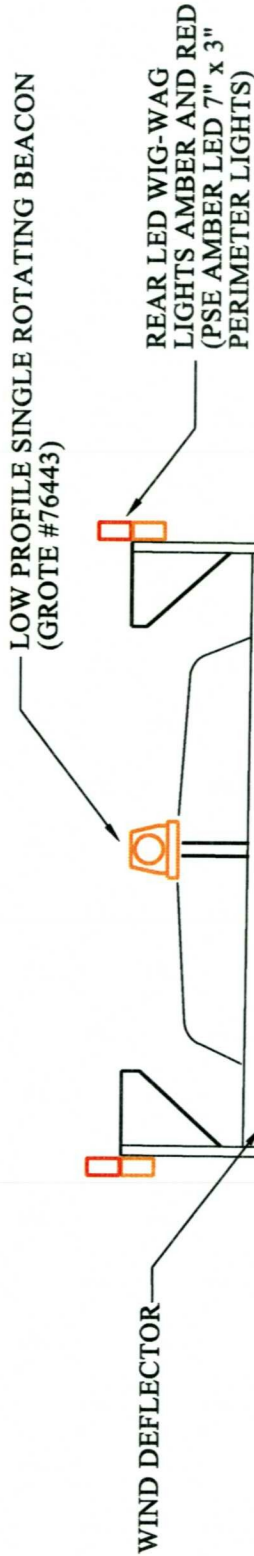
CONSULTANT

PLAN No. HE236-2004-SHOWFLOW REAR LIGHTING-06

| | | | | | |
|----------|--------------|---------|---------|-------------|---------|
| APPROVED | BY | DATE | CHECKED | BY | DATE |
| DESIGNED | D. PAULICHUK | 12/2004 | DRAWN | R. CROWKITE | 12/2004 |

| | | |
|--|--------------|--------------------|
| PLAN DESCRIPTION | PLAN No. | CONSULTANTS PL No. |
| PLAN SHOWING DETAILS OF SNOW REMOVAL AND ICE CONTROL TRUCK REAR LIGHTING STANDARD TRAIL 6 | | |
| BAR CODE | CONTRACT No. | |
| | | |

REAR LIGHTING TRIAL # 7



REAR IDENTIFICATION LIGHTS (RED)

* NOTE
ALL EXISTING LIGHTS TO BE REPLACED WITH LED LIGHTS

PLAN SHOWING DETAILS OF SNOW REMOVAL AND ICE CONTROL TRUCK REAR LIGHTING STANDARD TRAIL 7



PLAN No. _____
SHEET _____ of _____

CONTRACT No. _____ PROJECT _____

BRANCH H236-2004-SNOWPLOW REAR LIGHTING-07

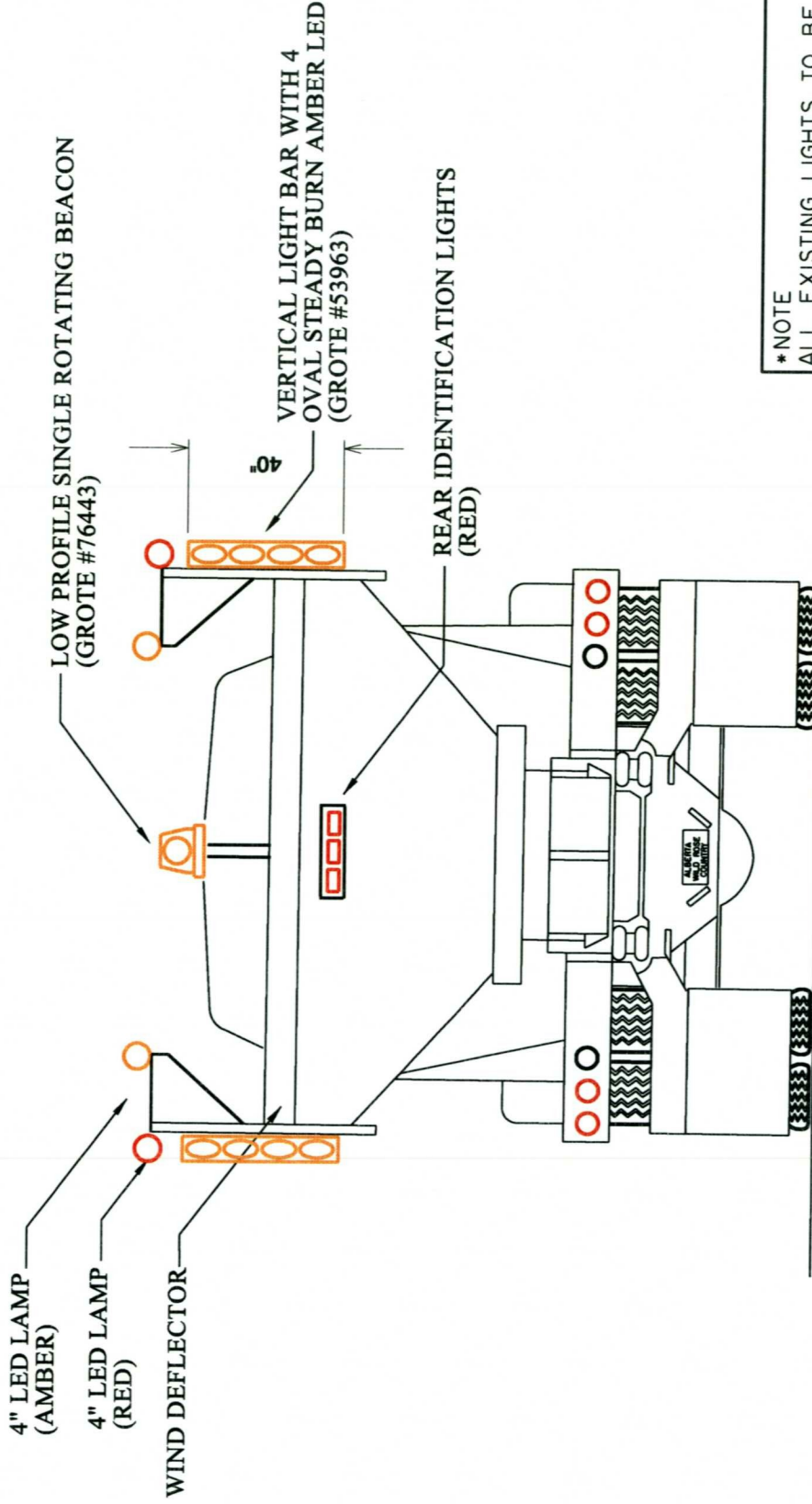
| | | | |
|--|-------------|---------|--------------|
| CONSULTANT | | | |
| PLAN No. H236-2004-SNOWPLOW REAR LIGHTING-07 | | | |
| | | | |
| APPROVED | BY | DATE | DATE |
| DESIGNED | D PAULICHUK | CHECKED | |
| | R. BATTY | 12/2004 | 12/2004 |
| | | DRAWN | R. CRONKHITE |

PLAN DESCRIPTION
PLAN SHOWING DETAILS OF
SNOW REMOVAL AND ICE CONTROL TRUCK
REAR LIGHTING STANDARD
TRAIL 7

BAR CODE

PLAN No. _____
CONTRACT No. _____
CONSULTANTS PL No. _____

REAR LIGHTING TRIAL # 8



*NOTE
ALL EXISTING LIGHTS TO BE
REPLACED WITH LED LIGHTS

Alberta
INFRASTRUCTURE AND
TRANSPORTATION

HORIZONTAL
VERTICAL

PLAN No. _____
SHEET _____ of _____

PLAN SHOWING DETAILS OF
SNOW REMOVAL AND ICE CONTROL TRUCK
REAR LIGHTING STANDARD
TRAIL 8

BRANCH H236-2004-SNOWFLOW REAR LIGHTING-08
CONTRACT No. _____ PROJECT _____

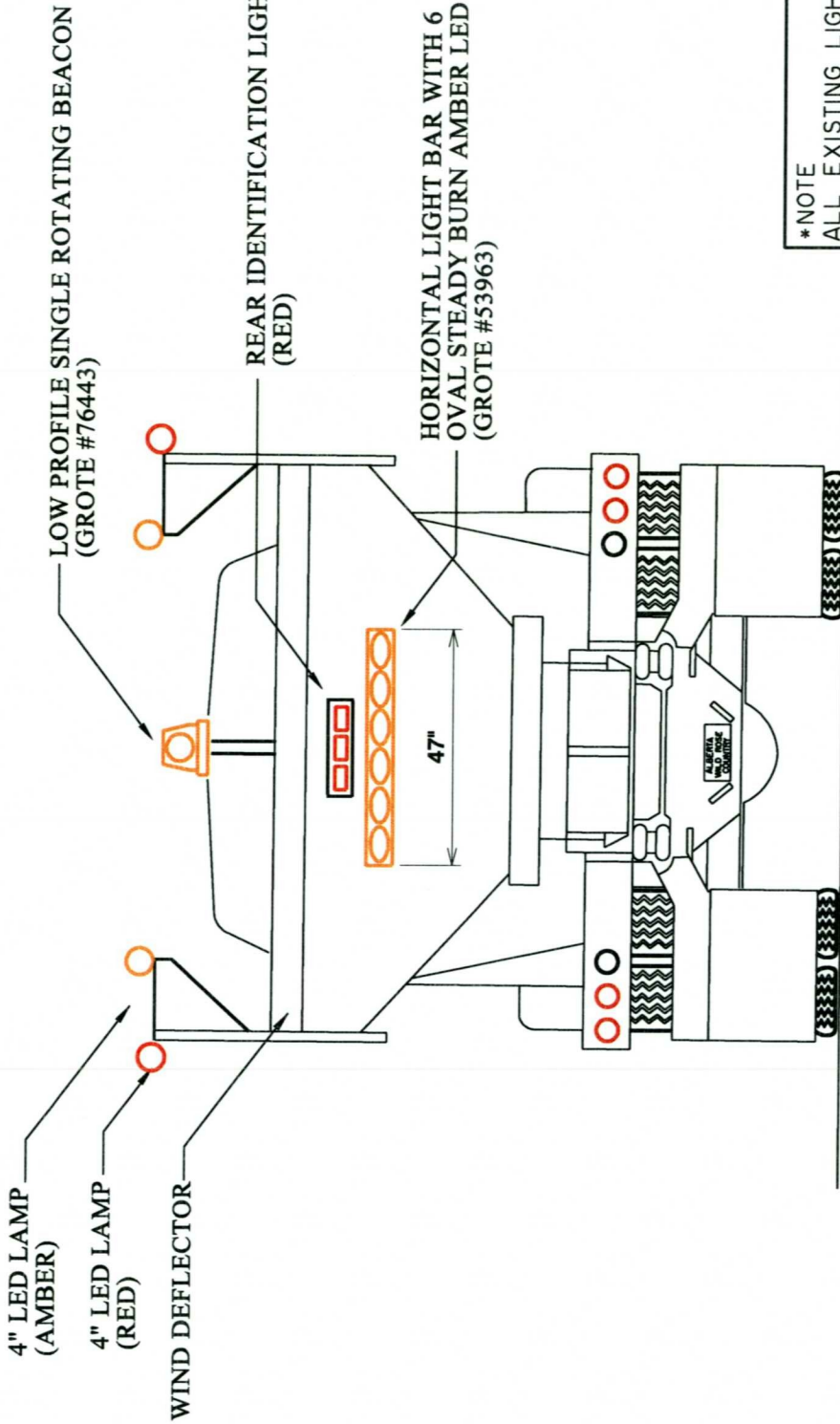
CONSULTANT
PLAN No. H236-2004-SNOWFLOW REAR LIGHTING-08

ALLIANT
ENGINEERING

| APPROVED | BY | DATE | CHECKED | BY | DATE |
|----------|----------|---------|---------|--------------|---------|
| DESIGNED | R. BATTY | 12/2004 | DRAWN | R. CRONKHITE | 12/2004 |

| | | |
|--|--------------------|--------------------------|
| PLAN No. _____ | CONTRACT No. _____ | CONSULTANTS PL No. _____ |
| PLAN DESCRIPTION PLAN SHOWING DETAILS OF SNOW REMOVAL AND ICE CONTROL TRUCK REAR LIGHTING STANDARD TRIAL 8 | BAR CODE | |

REAR LIGHTING TRIAL # 9



PLAN SHOWING DETAILS OF
SNOW REMOVAL AND ICE CONTROL TRUCK
REAR LIGHTING STANDARD
TRAIL 9

Alberta
INFRASTRUCTURE AND TRANSPORTATION

HORIZONTAL

VERTICAL

PLAN No. _____

SHEET _____ of _____

| | | |
|-------------------------------------|--------------|---------|
| BRANCH | CONTRACT No. | PROJECT |
| HE36-2004-SNOWPLOW REAR LIGHTING-09 | | |

| | | | |
|------------|-------------------------------------|---------|-------------|
| CONSULTANT | | | |
| PLAN No. | HE36-2004-SNOWPLOW REAR LIGHTING-09 | | |
| APPROVED | BY | DATE | DATE |
| DESIGNED | D PAULCHUR | CHECKED | |
| | R BATTY | 12/2004 | 12/2004 |
| | | DRAWN | R CRONKHITE |

| | | |
|----------|--------------|--------------------|
| PLAN No. | CONTRACT No. | CONSULTANTS PL No. |
| | | |

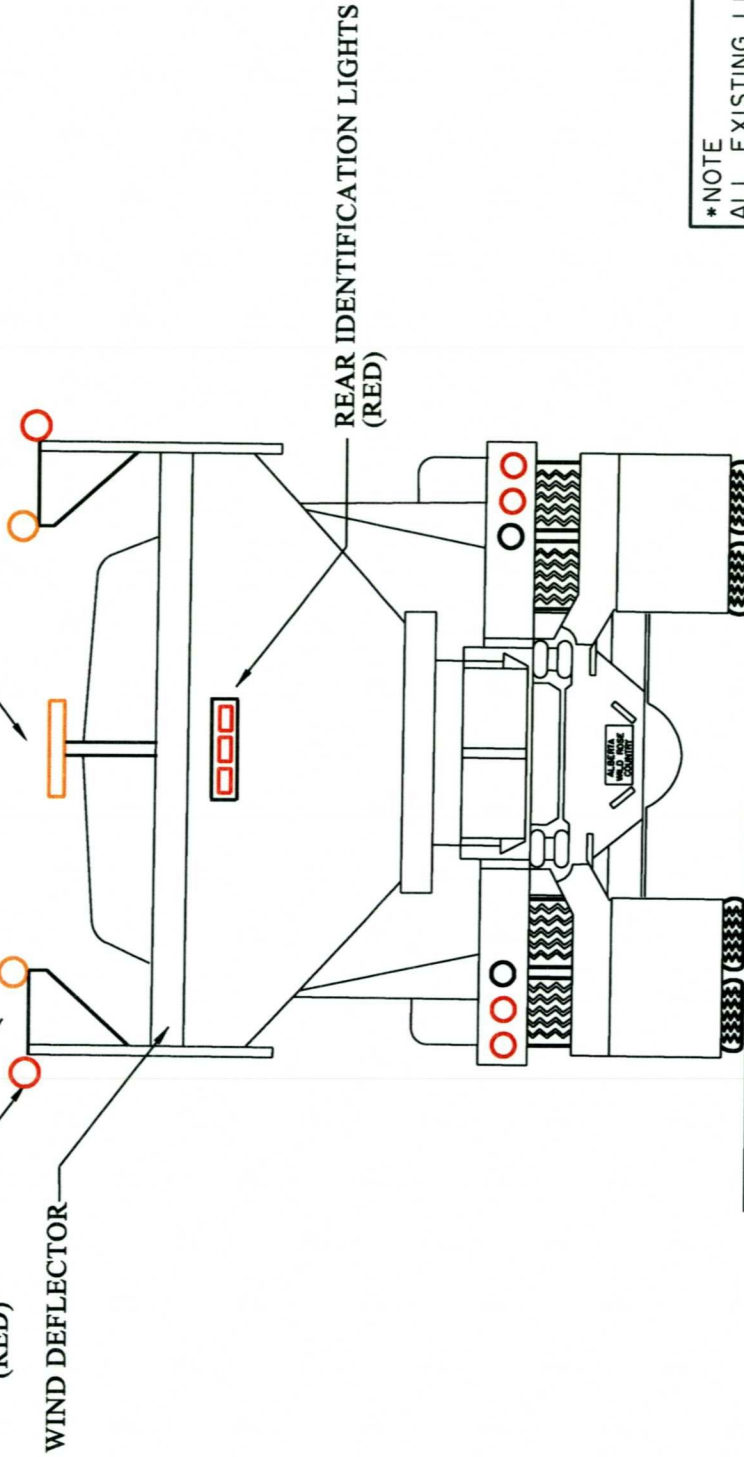
PLAN DESCRIPTION

PLAN SHOWING DETAILS OF
SNOW REMOVAL AND ICE CONTROL TRUCK
REAR LIGHTING STANDARD
TRAIL 9

BAR CODE

REAR LIGHTING TRIAL # 10

4" LED LAMP (AMBER)
 4" LED LAMP (RED)
 WIND DEFLECTOR



* NOTE
 ALL EXISTING LIGHTS TO BE
 REPLACED WITH LED LIGHTS



PLAN No. _____
 SHEET _____ of _____

PLAN SHOWING DETAILS OF SNOW REMOVAL AND ICE CONTROL TRUCK REAR LIGHTING STANDARD TRIAL 10

BRANCH H236-2004-SNOWPLOW REAR LIGHTING-ID
 CONTRACT No. _____ PROJECT _____

| CONSULTANT | | DATE | | BY | | DATE | |
|------------|------------|---------|---------|----|-------------|------|---------|
| APPROVED | D PAULCHUK | CHECKED | | | | | |
| DESIGNED | R BATTY | DRAWN | 12/2004 | | R CRONKHITE | | 12/2004 |



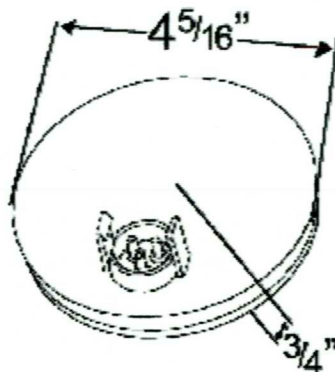
PLAN No. H236-2004-SNOWPLOW REAR LIGHTING-ID

| | | | | |
|---|----------|--------------------|--------------|----------|
| PLAN DESCRIPTION PLAN SHOWING DETAILS OF SNOW REMOVAL AND ICE CONTROL TRUCK REAR LIGHTING STANDARD TRIAL 10 | BAR CODE | CONSULTANTS PL No. | CONTRACT No. | PLAN No. |
|---|----------|--------------------|--------------|----------|



www.grote.com U.S. 800.457.9540 Canada 800.268.5612

SuperNova®, 4", Full Pattern Stop/Tail/Turn LED Lamp



PRODUCT NUMBER

53312 - Red, Grommet Mount

FEATURES & BENEFITS

- Bullet-Proof potted for total circuit board protection
- Hermetic lens-to-housing seal
- Advanced Pin Connection System uses tin-plated, solid brass pin terminations
- Uses same UBS pigtail as Male Pin incandescent

TECHNICAL SPECIFICATIONS

TECHNICAL SPECIFICATIONS

Material: Polycarbonate/Acrylic

FMVSS SAE Code: S/T/T - I, P2, S, T~>Rear Turn - I~>Front P/T - I, P

Finish: Gray

Voltage Amp: Red - 12 V - .48(I,S)/.04(P2,T) AMP

Voltage Amp: Rear Turn - 12 V - .71(I)/.14(P2)

AMP~Front P/T: 12 V - 1.06(I)/.13(P,P2) AMP

Bracket: 93552,

432539251092512925134357243642436554373293190, 93550, 93553, 93683

Grommet: 91740, 91950

Pigtail: 66815,

668416700266842670136681666845670056682366830, 67016, 66846, 66836, 67006

OTHER PRODUCT NUMBERS

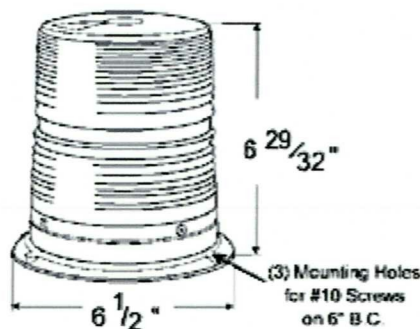
INDUSTRY-WIDE INTERCHANGE

| Company | Finish, Design, Function and Mounting | Function and Mounting |
|------------|---------------------------------------|-----------------------|
| Peterson | -- | 417R |
| Truck-Lite | -- | 44202R |



www.grote.com U.S. 800.457.9540 Canada 800.268.5612

Medium Profile, 360° Strobe Head



PRODUCT NUMBER

77273 - Yellow

FEATURES & BENEFITS

- Three mounting options: integral external, internal and 1" pipe mounting
- Packard connection harness
- Separate power supply required

TECHNICAL SPECIFICATIONS

TECHNICAL SPECIFICATIONS

Material: Aluminum/Polycarbonate

Voltage Amp: 12 to 24 V - 2.6 AMP at 12 V

Accessory: Power Supply: Two Head 99880, >Four Head 99850, Cables: 15' 67070, >35' 67061, Flash Tube: 44601

Lens: Yellow 92633

OTHER PRODUCT NUMBERS

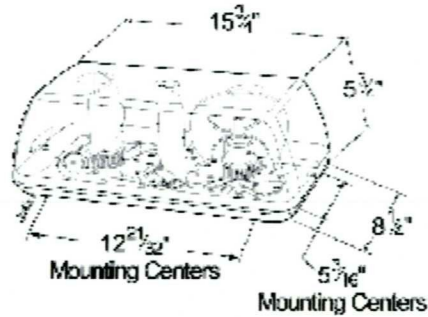
INDUSTRY-WIDE INTERCHANGE

| Company | Finish, Design, Function and Mounting | Function and Mounting |
|-------------|---------------------------------------|-----------------------|
| Signal Stat | -- | 6859A |
| Truck-Lite | -- | 6859A |
| Truck-Lite | -- | 92554Y |



www.grote.com U.S. 800.457.9540 Canada 800.268.5612

Rotating, 15" Hi-Intensity Mini-Bar



PRODUCT NUMBER

77163 - Yellow, Belt Drive

FEATURES & BENEFITS

- Gear driven versions have a self lubricating, heavy duty motor and gear assembly
- Belt driven versions have a silicon belt and stainless steel bearings for long life; belt is resistant to heat and UV light damage
- Halogen bulbs
- 300 flashes per minute
- Separate magnetic mount kit available
- Dual rotating reflectors with fixed mirrors

OTHER PRODUCT NUMBERS

TECHNICAL SPECIFICATIONS

TECHNICAL SPECIFICATIONS

Material: Polycarbonate

Bulb: (2) #795-50 Watt

Voltage Amp: 12 V - 8.8 AMP

Bulb: (2) #90901-50 Watt

Voltage Amp: 24 V - 4.1 AMP

Accessory: Motor: Gear Driven 99260, >Belt Driven 99370, Belt 99250, Bulb: Halogen 90900, >24V 90901

Lens: Red 92882 Yellow 92883 Blue 92885

PSE AMBER™

Code 3 | PSE Amber | International | Sales | Tech Support | About Us | Contact Us

PSE Amber Warning Products

- ▶ New Products
- ▶ Specialty Lighting
- ▶ Lightbars
- ▶ Mini Bars
- ▶ Auxilliary Lighting
- ▶ Beacons
- ▶ D.O.T. Systems
- ▶ ArrowStik®
- ▶ Accessories

PSE Amber Technical Support

Customer Service & Order Support

Request Literature

Install Guides

FAQs

Red/Blue Products

Amber Products

Rep Map

News

Site Map

Home

Distributor/Rep LOGIN

Quantum Flash™

Beacons

THE NEXT GENERATION IN 360 DEGREE WARNING

Easy to install and retrofit on existing vehicles



[Click here](#) for a larger view.

Applications: - Utility, Construction, Security, Snow, Maintenance

VIEW ADDITIONAL PRODUCT INFO



Unique Features

- Permanent or magnetic mount
- 1 inch pipe mount kit available (LLPMK-1H)
- Maintenance-free, never change a bulb again
- Holds up under extreme vibration conditions
- No strobe tubes or lamps to break

Standard Options

- Utilizes 6 of the brightest Gen II LED available in the world
- Amber LEDs with a clear or amber lens with special built-in optics to enhance and focus the LED signal
- Multiple flash patterns: cycle-flash, triple-flash, quad-flash, double-flash fast single, and single-flash
- Can easily replace existing strobe or halogen beacons

General Specifications

- Meets SAE J1318 class II requirements
- 12-24 volt DC
- 0.5 average amp draw
- Dimensions: 6 3/4 inch Deep x 5 inch High
- 5 year warranty
- Waterproof potted circuit board
- Cast aluminum base

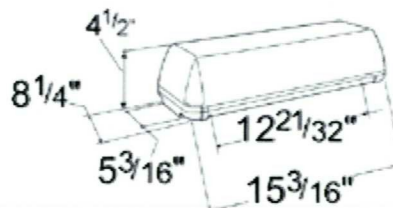
Download Literature

To download the literature listed below, simply "click" [download and view](#). A new window will



www.grote.com U.S. 800.457.9540 Canada 800.268.5612

Rotating, 15", Low Profile, Evolution® Style, Bar Lamp



PRODUCT NUMBER

76813 - Yellow

FEATURES & BENEFITS

- Permanent mount hardware included
- Dual belt drive rotators
- 55 watt, halogen bulbs
- 480 flashes per minute
- Sleek, low-profile lens design
- Silicon belt and stainless steel barrings for long life; belt is resistant to heat and UV light damage

TECHNICAL SPECIFICATIONS

TECHNICAL SPECIFICATIONS

Material: Polycarbonate

Finish: Black

Bulb: #H1, 55 Watt

Voltage Amp: 12 V - 10.5 AMP

Accessory: Motor: Belt Drive 99370, Belt: 99250, Bulb: 90902

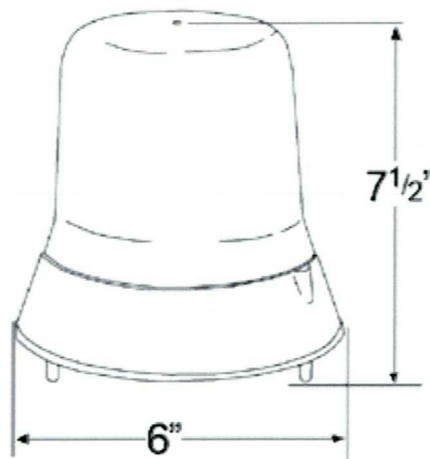
Lens: Yellow 93443

OTHER PRODUCT NUMBERS



www.grote.com U.S. 800.457.9540 Canada 800.268.5612

Low Profile, Revolving Beacon



PRODUCT NUMBER

76443 - Yellow

FEATURES & BENEFITS

- Durable, belt drive rotator
- 160 flashes per minute
- Thread-on lens is quickly secured with a wiggle set screw
- Flush mount

OTHER PRODUCT NUMBERS

TECHNICAL SPECIFICATIONS

TECHNICAL SPECIFICATIONS

Material: ABS/Polycarbonate

Finish: Black

Bulb: #H1, 55 Watt

Voltage Amp: 12 V.- 5.2 AMP

PSE AMBER™

Code 3 | PSE Amber | International | Sales | Tech Support | About Us | Contact Us

PSE Amber Warning Products

- ▶ New Products
- ▶ Specialty Lighting
- ▶ Lightbars
- ▶ Mini Bars
- ▶ Auxiliary Lighting
- ▶ Beacons
- ▶ D.O.T. Systems
- ▶ ArrowStik®
- ▶ Accessories

PSE Amber Technical Support

- Customer Service & Order Support
- Request Literature
- Install Guides
- FAQs

Red/Blue Products

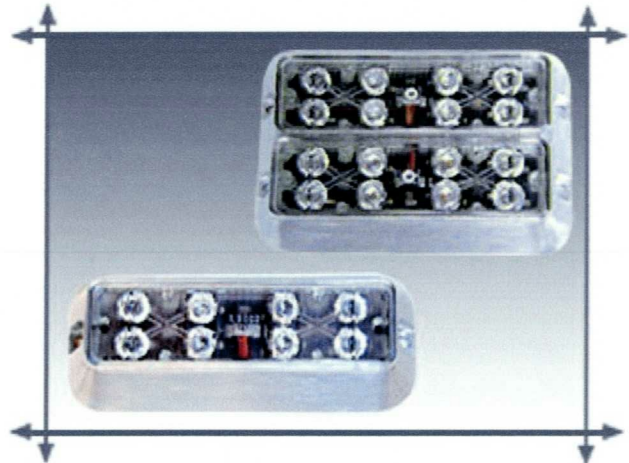
- Amber Products
- Rep Map
- News
- Site Map
- Home

Distributor/Rep LOGIN

PSE AMBER™ LED X™ Exterior Lights

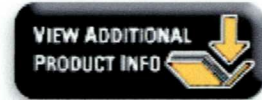
VERSATILE FOR SURFACE MOUNTING

This light has multiple applications



[Click here](#) for a larger view.

Applications: - Utility, Construction, Security, Tow



Unique Features

- Available in single head, stacked dual head, or side-by-side dual head versions
- Available in amber, white, red or combinations
- Available with directional, wide or vertical optics
- Rust-proof aluminum housing

Standard Options

- Available in black or bright aluminum finish
- Flash patterns include: cycle-flash, triple-flash, quad-flash, double-flash, fast single, single-flash and steady burn

General Specifications

- Side-by-side dual head dimensions: 9" x 2" x 1"
- Single head version dimensions 5" x 2" x 1"
- Dual stacked version dimensions 5" x 3.25" x 1"
- Long lasting with a 5 year warranty

Download Literature

To download the literature listed below, simply "click" [download and view](#). A new window will open with the requested literature in PDF format. You may print this file directly and/or save on your system.

[Download and view](#) the LED X Exterior Lights brochure in PDF format.



Code 3 | PSE Amber | International | Sales | Tech Support | About Us | Contact Us

PSE Amber
Warning Products

- ▶ New Products
- ▶ Specialty Lighting
- ▶ Lightbars
- ▶ Mini Bars
- ▶ Auxiliary Lighting
- ▶ Beacons
- ▶ D.O.T. Systems
- ▶ ArrowStik®
- ▶ Accessories

PSE Amber
Technical Support

Customer Service
& Order Support

Request Literature

Install Guides

FAQs

Red/Blue Products

Amber Products

Rep Map

News

Site Map

Home

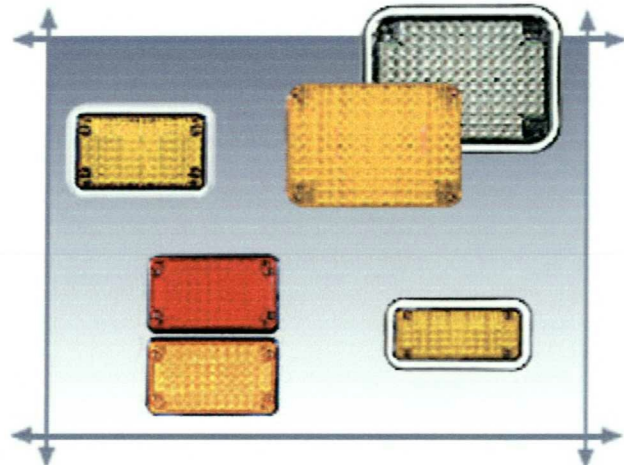
Distributor/Rep
LOGIN

LED Perimeter Lights

Auxiliary Lighting

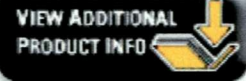
THE BEST ALL-AROUND LED LIGHTS

Directional warning for a wide variety of trucks & other specialty vehicles.



[Click here](#) for a larger view.

Applications: - Utility, Construction, Security, Tow



Unique Features

- 20 flash patterns (returns to preset pattern) including WIG-WAG patterns
- Easy installation (no cut-outs)
- Surface mountable with double-stick tape or screws
- Long life (5 year guarantee)
- Field replaceable outer lens
- Unique triple stack housing available for 4" x 6" lights

Standard Options

- Sealed waterproof power supply

General Specifications

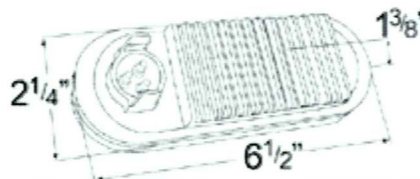
- 12 volt standard (24 volt optional)
- 45 series 3" x 7" (76.2 mm x 177.8 mm)
- 65 series 4" x 6" (101.6 mm x 154.2 mm)
- 85 series 7" x 9" (177.8 mm x 228.6 mm)
- 65ST series 4" x 6"
- Low amp draw
- Impervious to vibration
- Available in red, amber or white
- 3" x 7 or 4" x 6" also available in the following split colors: amber/red or amber/whi
- Available with or without a chrome bezel

Download Literature



www.grote.com U.S. 800.457.9540 Canada 800.268.5612

SuperNova®, Oval, Stop/Tail/Turn LED Lamp



PRODUCT NUMBER

53963 - Yellow, Grommet Mount

FEATURES & BENEFITS

- Advanced Pin Connection System uses tin-plated, solid-brass terminals
- Bullet-Proof potted LED circuit board
- Male pin termination for premium seal ability
- Meets specifications for vertical & horizontal mounting

TECHNICAL SPECIFICATIONS

TECHNICAL SPECIFICATIONS

Material: ABS/Acrylic
FMVSS SAE Code: Red - I, P2, S, T~>Yellow - P2
Finish: White
Voltage Amp: Red - 12 V - .48(I,S)/.06(T) AMP
Voltage Amp: Yellow - 12 V - .48 AMP
Bracket: [43362](#), [43952](#), [43220](#), [43223](#), [43222](#), [43100](#), [43723](#)
Grommet: [92420](#), [92720](#)
Pigtail: [66815](#), [668416700266842670136683066835670066681366814](#), [66823](#), [66816](#), [66845](#), [67005](#)

OTHER PRODUCT NUMBERS

INDUSTRY-WIDE INTERCHANGE

| Company | Finish, Design, Function and Mounting | Function and Mounting |
|------------|---------------------------------------|-----------------------|
| Maxxima | -- | M60100Y |
| Maxxima | -- | M60100Y-01 |
| Peterson | -- | M2875A |
| Peterson | -- | M2875A2 |
| Truck-Lite | -- | 60275Y |
| Truck-Lite | 60891Y | -- |

PSE AMBER™

Code 3 | PSE Amber | International | Sales | Tech Support | About Us | Contact Us

PSE Amber
Warning Products

- ▶ New Products
- ▶ Specialty Lighting
- ▶ Lightbars
- ▶ Mini Bars
- ▶ Auxilliary Lighting
- ▶ Beacons
- ▶ D.O.T. Systems
- ▶ ArrowStik®
- ▶ Accessories

PSE Amber
Technical Support

Customer Service
& Order Support

Request Literature

Install Guides

FAQs

Red/Blue Products

Amber Products

Rep Map

News

Site Map

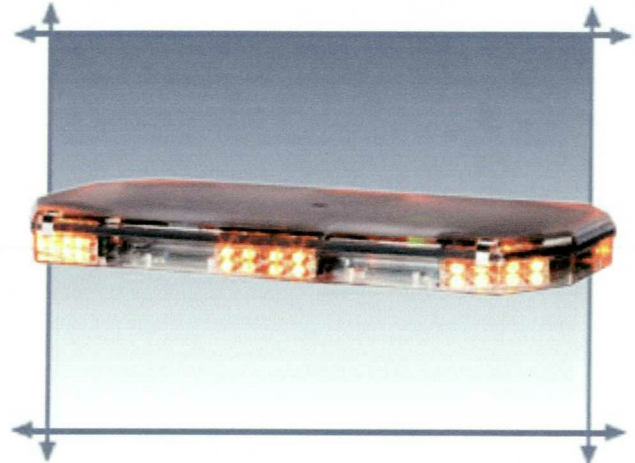
Home

Distributor/Rep
LOGIN

LED X™ 2100 Mini Bar

LOW PROFILE POWER

Powerful LED warning
lighting in a 2.1" low
profile lightbar



[Click here](#) for a larger view.

Applications: - Utility, Construction,
Security, Snow, Maintenance

[VIEW ADDITIONAL
PRODUCT INFO](#)



Unique Features

- Easily customized
- Low maintenance - designed for heavy duty applications.
- Clear lenses and the absence of color in the inlit lightbar gives an inconspicuous appearance for stealth application - until illuminated.
- Build-your-own models available.
- Directional or wide optics available on LED's.

Standard Options

- Magnetic mount available
- Moutning kits sold separately

General Specifications

- Only 2.1" tall
- Low amp draw - only .5 amp per module
- The long-life modules are covered by a 5 year warranty.
- Red, blue, amber or clear lens caps
- When properly configured it complies with SAE and CA Title XIII

Download Literature

To download the literature listed below, simply "click" [download and view](#). A new window will open with the requested literature in PDF format. You may print this file directly and/or save on your system.

Note to File:
Snowplow light pilot project, Field testing, 20 March 2005

I was driving one of the chase cars, so I didn't fill in any of the evaluation forms. My notes from yesterday's tests follow:

Clear loser: The PSE Quantum Flash strobe should not be allowed to replace any light, anywhere on our plow trucks.

Clearance, turn & brake lights:

- LED are acceptable replacements for incandescent bulbs.
- There will probably be an operational issue with cleaning snow off the lower lights on the back; we'll need to change training material to emphasize that the operators need to pull over more often to clean the rear lights

Amber & Red Snowplow lights:

- Steady burn red LED lights worked well both day & night, and are acceptable replacement for incandescent bulb.
- The steady red LED was often seen through the snow cloud at night before any of the rear beacons
- Flashing amber LED worked well at night, less bright during the day when compared to sealed beams. If we change the specs to require more delineation lights on the back of the truck, I can accept replacing the sealed beam amber with a focused LED like we used.

Front rotating beacon: Although we didn't try different lights on the front cab mount, it was clear from following the plow that this beacon is less critical than the rear lights.

- I could accept replacing the front mechanical rotating beacon with any of the following: Grote High Profile High Intensity strobe, Whelen mini-light bar, or Grote Low Profile Revolving beacon

Continuous burn light bars:

- Daytime both the horizontal and vertical light bars (PSE LEDX or LED Perimeter Lights) were barely visible and added no value.
- Nighttime the LED Perimeter lights were a good compromise between brightness and glare; the LEDX made too much glare for clear conditions at night and I don't recommend it.
- The vertical light bar worked well to show the truck's position; it might be an idea to have the top light in red, with 2 or 3 amber lights below.
- The horizontal light bar by itself didn't seem to help much at night; with the vertical it worked well but wasn't really needed – the vertical lights were enough.

Rear rotating beacon:

- The Grote High Profile, High Intensity strobe was just barely as good as the old rotating beacon, and I don't support using it by itself as a replacement.
- The Grote Low Profile Revolving beacon, Whelen mini-light bar, and PSE LEDX2100 (flying saucer) are all acceptable replacement for the rotating beacon without any other change to the lights.

WIG-WAG LCD flashers:

- These worked well by themselves or in combination with a vertical light bar. They were bright enough to show through the snow cloud and the position up with the amber & red lights allowed them to be seen at the thin upper edge of the snow cloud sooner than lights that were lower down.
- Good visibility both day and night.
- Both day and night, when the wig-wag flashers were going the amber and red snowplow lights were inconspicuous. We didn't test it, but I think the wig-wags would overpower turn signals, too. If we allow the wig-wags, I wouldn't recommend having them on all the time. Instead, use them in high risk situations (like clearing approaches, crossing access ramps at interchanges, plowing at speeds less than 30 kph in heavy traffic, etc.)
- Night these had too much glare immediately behind the plow, but OK to the side.

- I do not recommend using the Wig-wag flashers in combination with a bright rear beacon (like the LEDX2100 or Whelen) unless there is also some sort of delineation lighting on the back of the plow – the combination of 3 very bright light clusters is not easily recognizable as a single vehicle

More info needed:

1. Alliant Engineering should put together a chart showing the power requirements for each of the lights tested, so we could compare the power draw on the truck between the existing light system and different combinations of new ones. It won't help if we recommend a new light pattern that ends up using more power than we need now.
2. Obviously, any change to our plow truck specification will have to be written in performance terms, and not use trade names (but we can use trade names as 'acceptable products', we just can't exclude other manufacturer's lights that have the same effect). We need to have a listing of the relevant specs (number of LEDs, voltage, dimensions of light clusters, outer lens type, output intensity, etc.) for any light system we will recommend.
3. Peter Ing needs to start setting up the validation panel workshop; it would be nice to get the video editing done and hold the workshop before the end of this winter.

Steve Otto
21 March 2005



APPENDIX F

CURRENT STANDARDS AND SPECIFICATIONS

52.1 Snow Removal and Ice Control (Truck)

52.1.1 GENERAL

The Work consists of loading trucks, snowplowing and the application of sand, salt or a sand and salt mixture to roadway surfaces.

52.1.2 MATERIALS

The sand and salt mixture shall be obtained from a premixed stockpile, the salt material from a storage shed and the sand from a separate stockpile. The conditions for the supply of these materials is detailed elsewhere in the Contract Specifications or in the Special Provisions.

52.1.3 EQUIPMENT

52.1.3.1 General

The Contractor shall supply all equipment necessary to complete the Work.

52.1.3.2 Loader

The loader shall have a minimum 1.3 cubic metre bucket size.

52.1.3.3 Truck

The number and size of trucks will be specified in the Special Provisions. Tandem axle trucks shall have a minimum 270 horsepower engine or a minimum 325 horsepower engine when equipped with a wing. Single axle trucks shall have a minimum 210 horsepower engine. Gross engine horsepower will be the rating as shown in the manufacturers' specifications. In addition, any trucks which were approved for work with Alberta Transportation and Utilities during the 1994/95 season will also be deemed acceptable.

Each truck shall have a valid Alberta Vehicle registration or equivalent permit and a current Commercial Vehicle Inspection Certificate Decal. The decal shall be displayed on the vehicle at all times. The Contractor shall maintain each truck to the minimum standard established by the commercial vehicle inspection. If, in the opinion of the Engineer, the truck is not in a satisfactory mechanical or safe condition, then it shall be removed from the work site until the necessary repairs have been made.

Each truck engaged in the Work shall be assigned a unique number, that is prominently displayed on the truck, for the duration of the Contract. The doors of each truck shall prominently display the Contractor's company name or logo and phone number.

Standard lighting on the truck shall conform to Drawing A4 94 08 A and Drawing A4 94 08 B and be adjusted in accordance with Drawing A1 93 10.

Trucks shall have a 75 mm wide, orange coloured reflector tape applied near the top and along the full width of the truck hopper at the rear of the vehicle and a similar 75 mm wide tape applied to the full width of the tail plate.

When snowplowing on recently applied sealcoats or asphalt stabilized base course surfaces, as determined by the Engineer, trucks shall be equipped with power floats, castor wheels or rubber blades to reduce damage done to these surfaces. The use of other "protective equipment" will be subject to the approval of the Engineer. Any damage to these surfaces resulting from the snowplowing operation shall be repaired by the Contractor at his expense.

52.1.3.4 Sanding Unit

The sanding unit shall be either a frame mounted or slide-in-box type with a minimum capacity of 6.1 cubic metres or 8.5 cubic metres for tandem axle units and 3.8 cubic metres for single axle units. The sanding unit shall be equipped with height adjustable material deflectors and spinners capable of both clockwise and counter clockwise movements and in-cab controls for regulating the discharge of a sand, salt or a sand and salt mixture, as required by the prevailing road conditions. The Contractor shall ensure the trucks are licensed to carry the minimum capacity.

52.1.3.5 Snowplow

The snowplow blade shall be front mounted one-way for right side plowing only or two-way for both left and right side plowing, as indicated in the Special Provisions. The snowplow shall be equipped with a minimum 3.66 metre wide blade, in-cab controls for lifting and adjusting the plow blade and 330 mm x 410 mm red flags mounted on the top outside edges of the blade.

52.1.3.6 Snowplow Wing

The number of trucks to be equipped with snowplow wings will be specified in the Special Provisions.

The wing attachment shall be mounted to the passenger side of tandem axle trucks.

The snowplow truck shall be equipped with in-cab controls for lifting and adjusting the wing. The wing functions must be quick acting and positively controlled. The wing control system shall have a "panic button" to provide for fast raising of the wing in emergency situations.

The wing adjustment mechanism shall be of a hydraulic telescopic type to allow for variations in the plow width. The minimum length of the wing blade shall be 2.30 metres.

The wing shall have a rear facing clearance light mounted as close to the end of the wing as practical. The light shall be similar in size, shape and capacity as a Dominion Auto Part #706068 Red Clearance Light. The wing shall also be equipped with a 330 mm x 410 mm red flag mounted on its top outside edge.

52.1.3.7 Snowplow Blades

The Contractor shall supply snowplow blades and wing blades.

52.1.3.8 Spread Control Device

All snowplow units, with the exception of the approved units used by Alberta Transportation and Utilities during the 1994/95 season, shall be equipped with a microprocessor based spread control system capable of controlling the application rate of a sand, a sand and salt mixture or salt only. The approved 1994/95 trucks will not be accepted for work if their original spread control devices are removed and not replaced by an equivalent or superior system. Only field proven products in service for at least one year will be considered unless otherwise approved by the Engineer.

The spread control system for new units must be capable of performing the following functions:

52.1.3.8.1 Sand/Salt Application Rate Control

- Controlling an operator determined application rate to an accuracy of $\pm 5\%$ for at least three different materials of varying densities. The system must also allow the operator to chose the type of load (material).
- Each material setting shall have at least ten distinct application rate settings which can be controlled by an operator. The knob or switch used to control the application rate shall provide one increase (or decrease) with one activation of the switch.

| Application Rates (Kilograms per 2-lane kilometre) | | |
|---|--------|---------|
| | Low | High |
| Salt | 50 kg | 400 kg |
| Sand | 370 kg | 1000 kg |

Note: The application rate should be expressed as kilograms per kilometre and should not be affected by spread width.

- Displaying the actual application rate back to the operator when desired.
- A "blast" setting which when activated will provide a maximum application rate.
- A "passing" function which will allow the operator to stop the spinner and the main conveyor for short periods. There can be no delay in continuation of the spreading function after shutting off the passing function.
- An error indicator which will notify the operator when the desired output of the main conveyor is less than expected due to an insufficient flow or high truck speed plus indicate other system related malfunctions.

52.1.3.8.2 Spread Width Control

- The spread width (spinner speed) must be controlled by the operator.
- The spread width control must have a minimum of ten individual settings. The user should be able to specify each setting in the programming mode.
- The spinner rotation direction must be reversible. The spinner must turn at the same speed when switched from one direction to the other while still on the same speed setting.

52.1.3.8.3 Material Calibration

- Material calibration will be required under the following conditions:

- prior to commencement of winter operations, when there is a change of materials or a change in hydraulic components and when requested to do so by the Engineer.
- All calibration calculations and measurements must be performed by the microprocessor. The operators should only be required to input the weight of the unit before and after the calibration.
- The calibration procedure must not require the capture and weighing of any material spread by the sander. Procedures requiring buckets, tarps, boxes or other such devices to catch and weigh materials are unacceptable.
- Calibration procedures must use as large a material sample as possible to ensure adequate precision of the equipment (i.e., 30% of full load).

52.1.3.8.4 Main Control Enclosure

- All circuitry for the Spread Control Device and all necessary controls for their function shall be contained in a "main" control enclosure.

52.1.3.9 **Optional Functions For Spread Control Device**

The Contractor has the option of providing the following enhancements to the Spread Control Device.

52.1.3.9.1 Data Logging

- A control system with the ability to perform data logging. If provided, the data logging should record periodic totals as well as running (yearly) totals of truck kilometres travelled, average truck speed, kilometres sanded by type of material, the amount (weight) of each material used and dating of the information.
- The periodic totals referred to above should be totals for a period determined by the Engineer. The period may vary from a day to a portion of a day to a multiple of a day. The periodic totals should last from one data extraction process to the next.
- Provisions should be made so that yearly totals can be erased in the programming mode only.

- The system should also possess some means of retrieving this data from the controller, either by personal computer or printer link. The Contractor should provide complete details on the method of data retrieval and technical data for the information retrieval devices.

52.1.3.10 Global Positioning System

The Contractor is advised the Engineer proposes to use GPS (Global Positioning System) devices to record location and times of snow removal and ice control Work. The Engineer will provide GPS units at no cost to the Contractor. The Contractor shall cooperate with the Engineer by making the designated snow removal and ice control equipment available, and ensuring data is downloaded and provided to the Engineer at least once per day or as otherwise determined by the Engineer. The Contractor shall take all reasonable precautions to ensure GPS equipment is not damaged and is in working condition. The Engineer plans to begin trial installation during the winter of 1995/96 with full implementation to occur subsequently.

52.1.4 PROCEDURE

52.1.4.1 Snowplowing and Sanding

When trucks are engaged in snow removal activities, the Engineer may require the Contractor to take a time stamped photograph, each hour, through the front windshield of each vehicle. Photographs should be taken as close to the top of the hour as possible. The Contractor shall ensure that the process used to take the photograph does not create a hazard. The undeveloped film shall be provided to the Engineer no later than two business days after the vehicle was engaged in the snow removal and ice control Work. Each roll of undeveloped film shall be properly labelled with the unit number of the vehicle.

The photographs will be used by the Engineer to determine road condition and to determine if snow removal and ice control Work was required.

The cost of taking the time stamped photograph and providing the Engineer with the undeveloped film will be considered incidental to the Work and will not be paid for separately.

In general, truck speeds shall range between 60 and 70 kilometres per hour. Individual truck speed shall be adjusted to meet snow, wind, highway and traffic conditions and the application requirements of the sand, salt or a sand and salt mixture applied.

The angle of the snowplow blade shall be adjusted to remove snow and ice from the roadway in an efficient manner and to the satisfaction of the Engineer.

Plow trucks shall pull over at reasonable intervals to allow traffic to pass. Generally, this interval shall be between 5 and 8 kilometres. However, when traffic is heavy or rear visibility is obscured, this interval shall be shortened.

When plow trucks are operating as multiple unit groupings, they shall be spaced so that traffic can safely pass. Generally the distance between units, on the open highway, shall not be less than 800 metres, but is dependent on snow, weather, and traffic conditions.

When plowing the inside lanes into the median, truck speed shall be adjusted to ensure snow is not deposited on the adjacent roadway.

When approaching railway crossings, plow trucks shall have the plow raised sufficiently to clear the tracks. Snow or ice shall not be deposited on the crossing. Damage to the crossing shall be reported to the local railway authority and to the Engineer immediately. Windrows of snow shall not reduce the lateral sight distance of motorists nor obscure the motorists' vision of railway traffic.

When plowing overpass structures, the operator shall ensure snow is not plowed off the overpass while there are vehicles on the roadway below.

The Contractor shall supply the number of hours and kilometres worked in each "winter segment" per each truck to the Engineer on a daily basis.

The Contractor shall ensure all truck lights are clear of snow, ice and other materials which may reduce the illumination ability of the lights.

52.1.4.2 Application of Sand, Salt or Sand and Salt Materials

Material application rates will be specified by the Engineer.

The Contractor shall maintain a sand/salt usage inventory system, which shall include:

- daily quantities of sand and salt usage from each material stockpile or salt shed for the particular winter segment worked;
- the time and date of loading for each truck unit.

The Contractor shall provide this information to the Engineer on a daily basis. The Engineer will provide a data form for the reporting of this information.

In general, material applications shall be carried out at speeds up to 60 kilometres per hour. However, the individual truck speed shall be adjusted to account for weather, traffic, highway conditions and the type of material being applied.

Unless directed otherwise by the Engineer, the Contractor shall adjust the spinner speed to ensure the spread of ice control materials in the following manner:

- On a Straight-a-Way - The Contractor shall concentrate the placement of ice control materials on the crown area of the road. The crown is designed so that positive surface drainage occurs on both sides of it. If ice control materials are placed on the crown area, then the brine formed by salt and the subsequent melting of snow and ice will drain off the road in two directions.
- On a Curve - The Contractor shall place ice control materials on the high side of the curve so that any melting which may occur will run down the face of the curve and off the roadway surface.
- On Multiple-Lane-Highways - The crown is usually in the middle of the roadway. The Contractor shall place ice control materials on one lane or two lanes at a time but starting with the lane or lanes closest to the roadway crown.

The deflector on the spinner must be regularly checked to ensure proper placement of the material on the roadway. Centre mount spinners shall be equipped with deflectors on both sides.

If an optional spread control device is used, then the Contractor shall download information and provide it to the Engineer on a monthly basis or at any other time requested by the Engineer.

52.1.5 COMMENCEMENT OF WORK

The Contractor shall ensure that equipment and operators are available for work 24 hours a day, 7 days a week and that the loader and a minimum 2/3 of the trucks are ready to commence work within 1 hour of the issuance of the Work Order. The remaining trucks shall be ready to commence work within 2 hours of the issuance of the Work Order. Work will commence at the stockpile site, equipment shop or any other location so designated by the Engineer.

The Contractor shall provide a maximum of three telephone numbers of contact persons authorized to receive a Work Order for snow and ice control work. The Engineer shall be notified at once and in written form, of any changes to these telephone numbers. A fax transmission is considered a written form.

52.1.6 AVAILABILITY RATE

An availability rate is a daily payment made to the Contractor for having snow removal and ice control trucks available to commence work during the date period specified in the Special Provisions. The rate applies individually to trucks and will be paid whether the truck is performing the Work or simply available to perform the Work as described herein.

If the Engineer requests a winter road inspection in accordance with Specification 53.39, Highway Maintenance Work, the Contractor has the option of using regular snow removal equipment operators to perform the inspection. Any such use of equipment operators, will not compromise the Contractor's availability rate and the employee and equipment will be considered to be available to commence work as defined.

In the event of heavy snowstorms or other unseasonable weather which occurs outside of the time period specified for availability, the Contractor shall make sufficient equipment and personnel available at the earliest possible time, regardless of the time period specified for Availability. In these cases, the availability rate will be paid for the additional days worked.

52.1.7 MEASUREMENT AND PAYMENT

52.1.7.1 General

Measurement for snow removal and ice control (by truck) will be in hours for the actual number of hours a snowplow truck is engaged in this activity.

Measurement for the availability rate will be in days for the time both the snowplow truck and loader are available to engage in the Work during the date period specified in the Special Provisions.

Payment for snow removal and ice control will be made at the hourly rate bid per truck for "Snow Removal and Ice Control (Truck)" for the type of truck and auxiliary equipment specified. This payment will be full compensation for supplying the truck and loader (complete with all auxiliary equipment), loading the trucks, snowplowing, hauling materials from the stockpile site to the roadway, applying a sand, salt or a sand and salt mixture as required, and all labour, equipment, tools and incidentals necessary to complete the Work.

The Contractor will not be paid for the time spent travelling from his home base to the designated worksite at the start of the workday nor from the designated site at the end of his work day to his home base. In addition, the Contractor will not be paid for the time spent changing blades, calibrating his equipment, refuelling, repairs or other servicing.

Payment for availability will be made at the daily rate bid per truck for "Snow Removal and Ice Control (Truck) Availability Rate". This payment will be full compensation for ensuring both the snowplow truck and loader are available to commence the Work on any day during the date period specified in the Special Provisions.

Payment for the supply of a spread control device equipped with the "optional functions" will be made at the rate of \$750 per vehicle per year under the bid item "Premiums for Trucks with optional Spread Control Device".

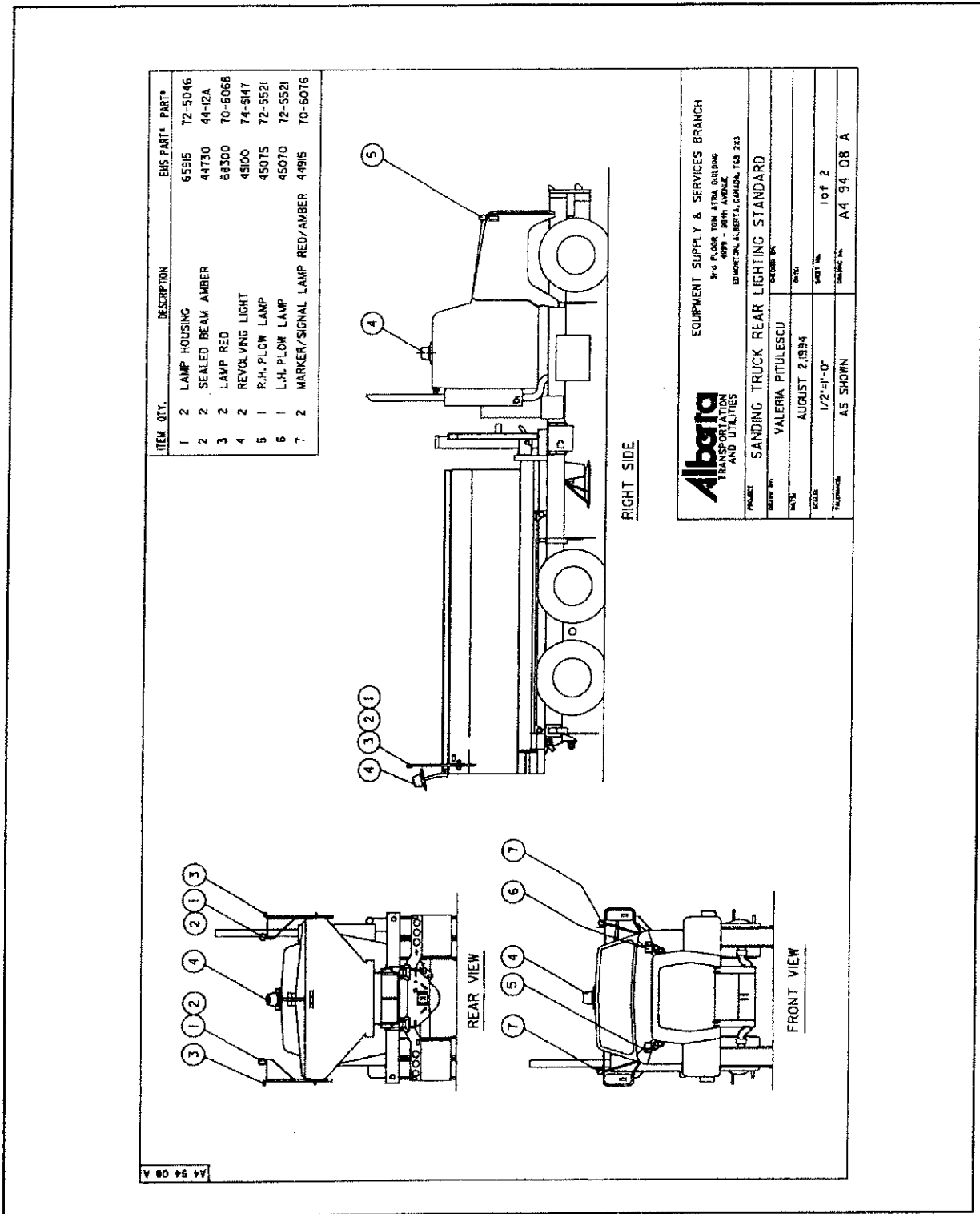
52.1.7.2 Penalties

A penalty of \$100 per hour up to a maximum of \$500 per day will be assessed for each truck unavailable to commence work within the specified time.

A penalty of \$100 per hour up to a maximum of \$500 per day will be assessed for each hour the loader is unavailable to commence work within the one hour response time. In addition, if the Contractor is unable to provide the loader within the specified time on any given day, then the "Availability Rate" will not be paid for any of the trucks at the designated site that day.

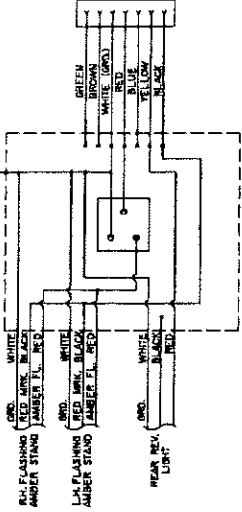
52.1.8 WARRANTY

There is no warranty period for this Work.



| ITEM | QTY. | DESCRIPTION | EQS. PART# | PART# |
|------|------|------------------------------|------------|---------|
| 1 | 2 | LAMP HOUSING | 65915 | 72-5046 |
| 2 | 2 | SEALED BEAM AMBER | 44730 | 44-12A |
| 3 | 2 | LAMP RED | 58300 | 70-6068 |
| 4 | 2 | REVOLVING LIGHT | 45100 | 74-5147 |
| *5 | 1 | R.H. PLOW LAMP | 45075 | 72-5521 |
| *6 | 1 | L.H. PLOW LAMP | 45070 | 72-5521 |
| *7 | 2 | MARKER/SIGNAL LAMP RED/AMBER | 44915 | 70-6076 |

* ITEMS ILLUSTRATED ON DRAWING A4 94 08 A



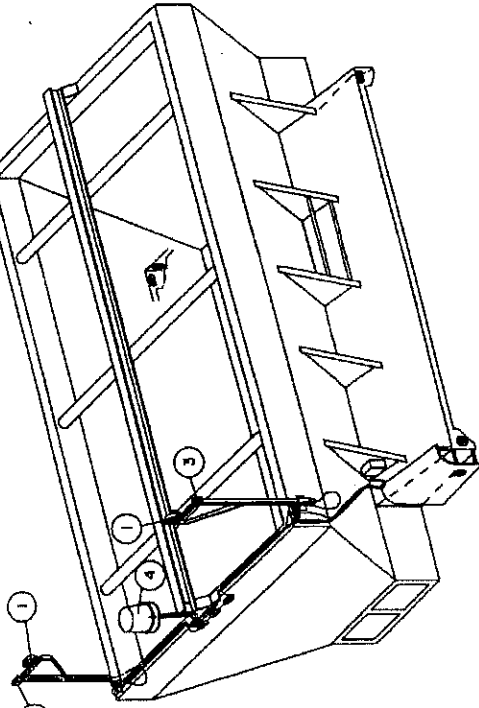
JUNCTION BOX ELECTRICAL SCHEMATIC

Alberta
TRANSPORTATION AND UTILITIES

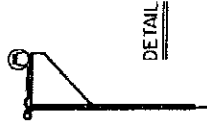
EQUIPMENT SUPPLY & SERVICES BRANCH
3rd FLOOR TOWN ATRIA BUILDING
6809 - 36TH AVENUE
EDMONTON, ALBERTA, CANADA, T6B 2X3

PROJECT: SANDING TRUCK REAR LIGHTING STANDARD
DESIGN BY: [Blank]
DATE: [Blank]
BY: Rob
DATE: AUGUST 10, 1994
SCALE: N.T.S.
SHEET NO: 2 of 2
DRAWING NO: A4 94 08 B

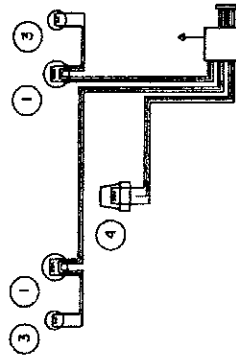
HOPPER ELECTRICAL PICTORIAL



RFL USED AS A "JUNCTION BOX" FOR THE CABLE RUNNING TO THE CLEANWAVE LIGHT

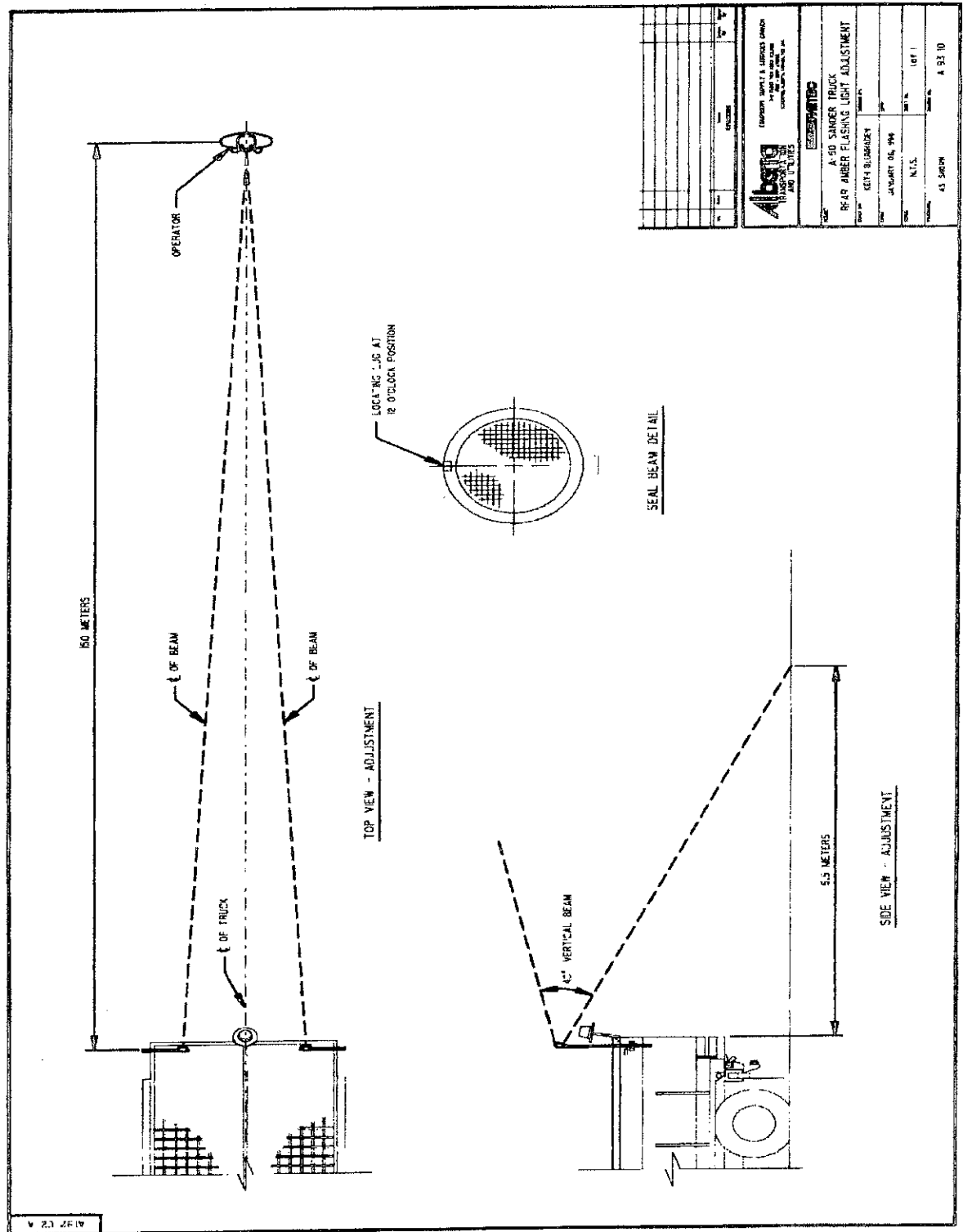


DETAIL



ELECTRICAL SCHEMATIC

A4 94 08 B



Trucks, Buses, MPVs: Federal Lighting Equipment Location Requirements

IMPORTANT NOTE: Every lamp, reflex reflector, and conspicuity treatment (device) must be permanently attached in the location specified below and must comply with all applicable requirements prescribed for it by FMVSS/CMVSS 108. The face of any device on the front/rear and sides should be, respectively perpendicular and parallel to vehicle centerline, unless it is photometrically certified at installation angle. No part of the vehicle shall prevent any device from meeting its prescribed requirements unless an auxiliary device meeting all prescribed requirements is installed.

In Canada: Manufacturers and importers of vehicles must have the proper certification test records demonstrating compliance of lighting components with all prescribed requirements.

This table summarizes lighting equipment requirements contained in Federal Motor Vehicle Safety Standard 108. For complete compliance requirements consult Title 49 - Code of Federal Regulations, Section 571.108. (USA) and Section 108 of the Motor Vehicle Safety Regulations (Canada).

State or Provincial regulations, where they may apply, have not been included.

- Basic Equipment Required on All Trucks, Buses & MPVs
- Additional Equipment for Specific Vehicles:
 - Vehicles 9.1 m (30 ft.) Long or Longer
 - Truck Tractors
- Illustrations of Federal Lightning Equipment Location Requirements
- Contacts

Basic Equipment Required on All Trucks, Buses & MPVs

| Description | | | | Mandatory Requirements | | | |
|-------------|---|---|--|------------------------|-----------------|---|--|
| Area | Equipment | (SAE Lens Coding) | Functional Purpose | Quantity | Color | Location | Height mm (in.) from the ground |
| 1 | Headlamps - Lower Beam | (H, HR) Attention: US: "DOT" lettering required on lens Attention: US & Canada: light source code required on lens | Forward road illumination | Minimum 2 | White | On the front - symmetrical - as far apart as practicable (If 4 lamp system - outboard or above upper beams) | 560-1370 (22-54) |
| | Headlamps - Upper Beam | (H, HR) Attention: US: "DOT" lettering required on lens Attention: US & Canada: light source code required on lens | Forward road illumination | Minimum 2 | White | On the front - symmetrical (If 4 lamp system - inboard or below lower beams) | 560-1370 (22-54) |
| | Parking Lamps- Attention: Required only on vehicles less than 2032mm wide | (P) | Indicate parked vehicle | Minimum 2 | White or Yellow | Front - symmetrical - as far apart as practicable | 380-1530 (15-60) |
| | Daytime Running Lamps | (Y2) Attention: for Canada required, for US optional. Attention: for US, "DRL" lettering required on lens if device is not headlamp | Indicate in-use vehicle | Minimum 2 | White or Yellow | Front - symmetrical - as far apart as practicable | 380 (15) minimum Maximum depends on type of DRL |
| | Front Turn Signal/Hazard Warning Lamps | (I) | Indicate direction of turn / identify disabled vehicle | Minimum 2 | Yellow | Front - symmetrical - as far apart as practicable | 380-2110 (15-83) |

| | | | | | | | |
|----|---|---|--|-----------|---------------|--|--|
| 2 | Front Clearance Lamps- Attention: Required for vehicles 2032mm wide or wider | (P2, PC* or P3*,PC2) *photometrically certified at installation angle | Show vehicle's width | Minimum 2 | Yellow | At widest point - symmetrical - on the front or near the front - facing forward | As high as practicable |
| 3 | Front Identification Lamps (ID) | (P2 or P3) | Indicate presence of a wide vehicle | Exactly 3 | Yellow | on the front - center - horizontally spaced 150 mm (6 in.) to 300 mm (12 in.) apart | As high as practicable or on top of cab |
| 4a | Front Side Marker Lamps | (P2, PC* or P3 ,PC2*) *photometrically certified at installation angle | | Minimum 2 | Yellow | Each side at front - as far forward as practicable | 380 (15) minimum |
| 4b | Front Side Reflex Reflectors | (A) | Front and Rear side marker lamps / side reflex reflector | Minimum 2 | Yellow | At front - symmetrical - as far forward as practicable - facing sideward | 380-1530 (15-60) |
| 5a | Rear Side Marker Lamps ** | (P2, PC* or P3, PC2*) *photometrically certified at installation angle | indicate vehicle's presence and length | Minimum 2 | Red | Each side at rear - as far back as practicable | 380 (15) minimum |
| 5b | Rear Side Reflex Reflectors ** ** not required on Truck Tractors | (A) | | Minimum 2 | Red | Each side at rear - as far back as practicable - facing sideward | 380-1530 (15-60) |
| 6 | Rear Clearance Lamps Attention: Required for vehicles 2032mm wide or wider, but not required on Truck Tractors | (P2, PC* or P3, PC2*) *photometrically certified at installation angle | Show vehicle's width - MAY NOT be combined with tail lamps | Minimum 2 | Red | At widest point - symmetrical - on the rear or near the rear - facing rearward | As high as practicable - may be lower only if rear ID lamps are at the top |
| 7 | Rear Identification Lamps (ID) Attention: Required for vehicles 2032mm wide or wider, but not required on Truck Tractors | (P2 or P3) | Indicate presence of a wide vehicle | Exactly 3 | Red | Rear - center - horizontally spaced 150 mm (6 in.) to 300 mm (12 in.) apart, facing rearward | in Canada : at the top - maybe lower if door header narrower than 25mm in USA: as high as practicable |
| 8 | Tail Lamps | (T) | Indicate vehicle's presence and width | Minimum 2 | Red | On the rear - symmetrical - as far apart as practicable | 380-1830 (15-72) |
| | Stop Lamps | (S) | Indicate braking | Minimum 2 | Red | On the rear - symmetrical - as far apart as practicable | 380-1830 (15-72) |
| | Rear Turn Signal/Hazard Warning Lamps | (I) | Indicate direction of turn/ identifies disabled veh. | Minimum 2 | Red or Yellow | On the rear - symmetrical - as far apart as practicable | 380-2110 (15-83) |
| | Rear Reflex Reflectors | (A) | Show vehicle's presence and width | Minimum 2 | Red | On the rear - symmetrical - as far apart as practicable - facing rearward | 380-1530 (15-60) |
| 9 | Backup Lamp | (R) | Illuminate ground behind the vehicle and alert road users | Minimum 1 | White | Rear | No requirement |
| 10 | License Plate Lamp(s) | (L) | Illuminates license plate | Minimum 1 | White | On the rear - above or at the sides of license plate | No requirement |
| 11 | Center High Mounted Stop Lamp Attention: Required for vehicles less than 2032mm wide and 4536kg | (U3) | Indicates braking | Minimum 1 | Red | On the rear - centerline of the vehicle | 860 (34) minimum |

Additional Equipment for Specific Vehicles:

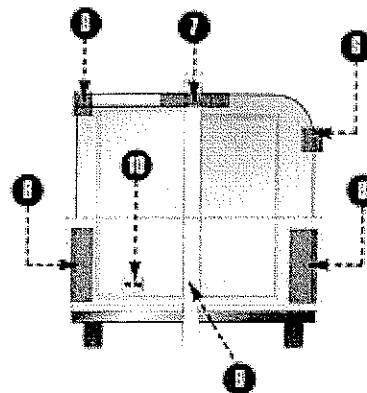
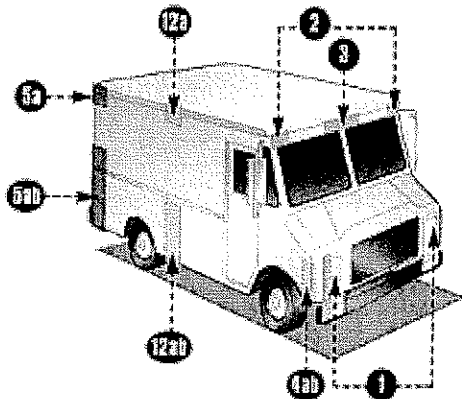
Vehicles 9.1 m (30 ft.) Long or Longer

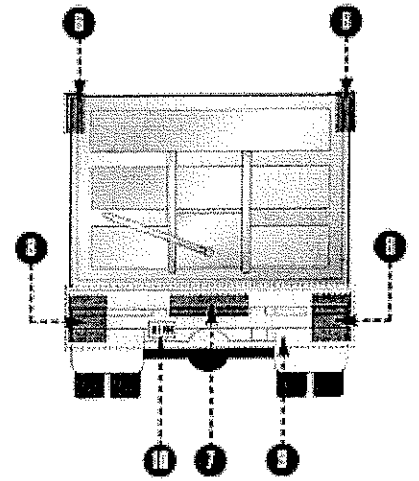
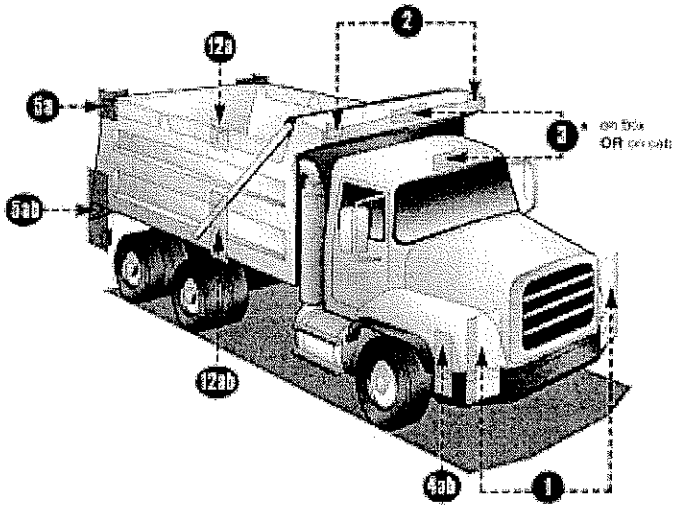
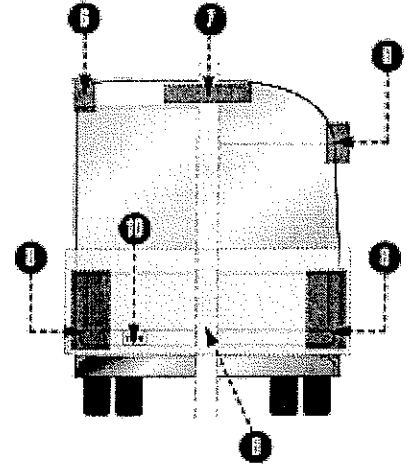
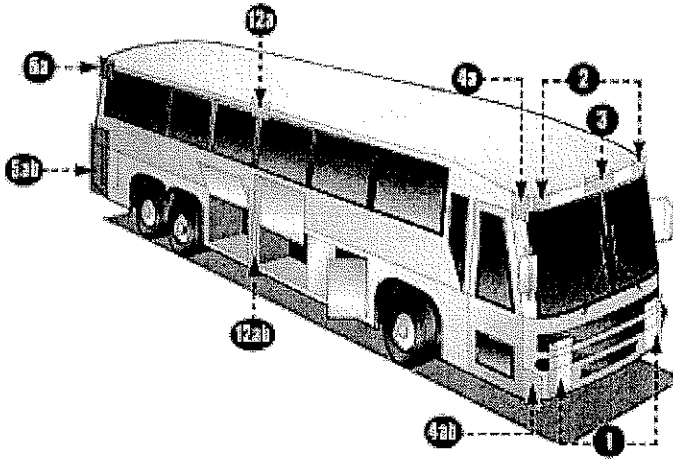
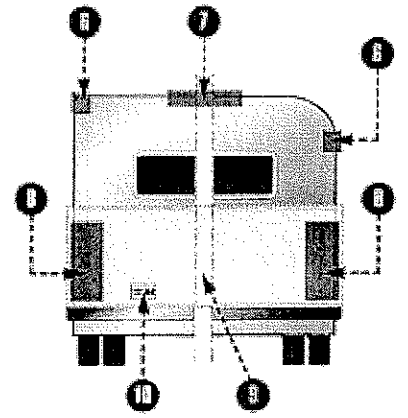
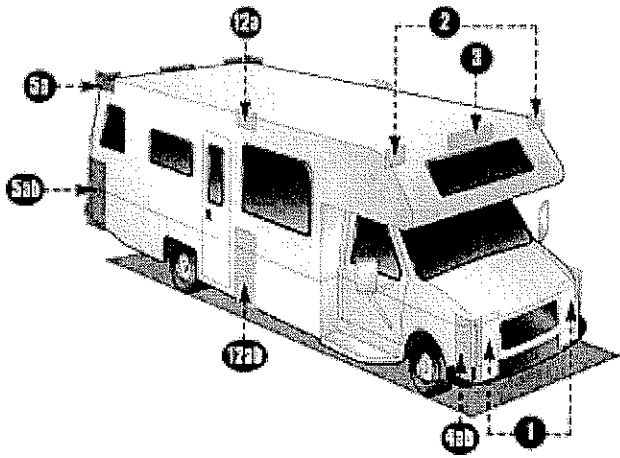
| Description | | | | Mandatory Requirements | | | |
|-------------|-------------------------------------|-------------------|-------------------------------------|------------------------|--------|---|---------------------------------|
| Area | Equipment | (SAE Lens Coding) | Functional Purpose | Quantity | Color | Location | Height mm (in.) from the ground |
| 12a | Intermediate Side Marker Lamps | (P2 or PC) | Indicate presence of a long vehicle | Minimum 2 | Yellow | Each side near center | 380 (15) minimum |
| 12b | Intermediate Side Reflex Reflectors | (A) | Indicate presence of a long vehicle | Minimum 2 | Yellow | Each side near center - facing sideward | 380-1530 (15-60) |

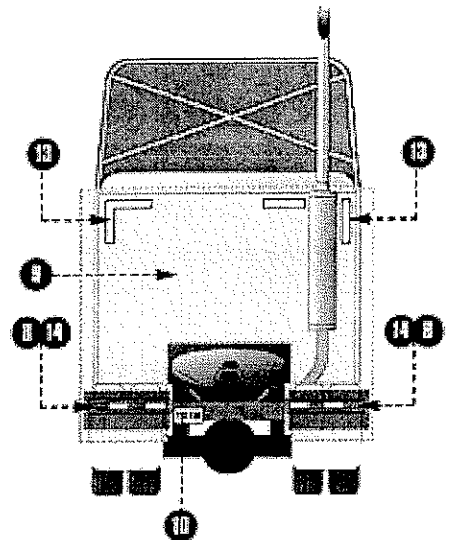
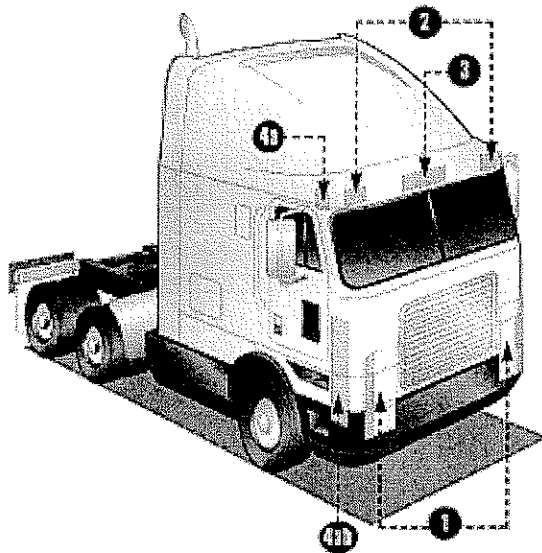
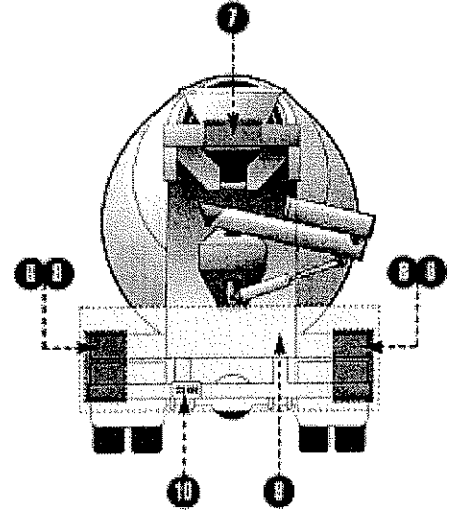
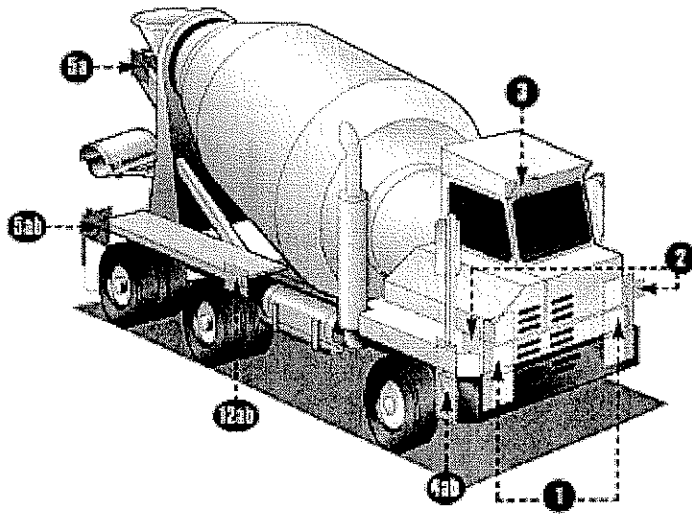
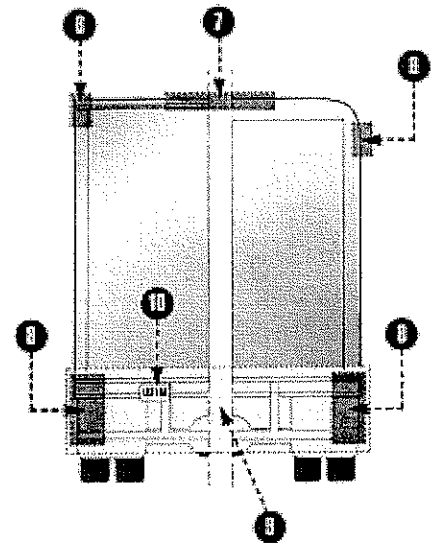
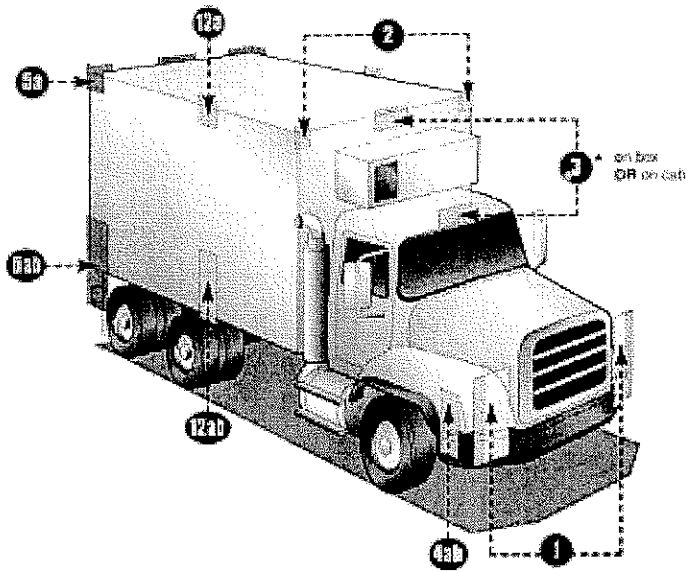
Truck Tractors

| Description | | Mandatory Requirements | | | | | |
|-------------|-------------------------|----------------------------------|---------------------------------------|-----------|---|--|--|
| Area | Conspicuity Treatment | DOT Code | Quantity | Color | Location | Height | Options |
| 13 | Rear Upper Body Marking | DOT-C, DOT-C2, DOT-C3, or DOT-C4 | Exactly 2 pairs of 300mm long strips | White | Rear upper corners of cab - facing rearward | As high as practicable excluding fairings | |
| 14 | Rear Marking | DOT-C, DOT-C2, DOT-C3, or DOT-C4 | Exactly 2 sections of min. 600mm each | Red/White | Rear - facing rearward - on fenders, on mud flaps brackets, or within 300mm below of the top of mud flaps | As horizontal as practicable and not higher than 1525 mm from the ground | If mud flaps not used - on the cab or frame mounted brackets |

Illustrations of Federal Lightning Equipment Location Requirements







[Top](#)

For more information contact:

Marcin Gorzkowski
Transport Canada

Motor Vehicle Safety Enforcement Branch
Fax: (613) 998-4831

Rich Van Iderstine
National Highway Traffic Safety Administration
Office of Safety Performance Standards
Fax: (202) 366-4329

[Return to previous page](#)