

**DEVELOPMENT OF A NIGHTTIME HIGHWAY
WORK SPECIFICATION FOR NOVA SCOTIA**

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ABSTRACT

This paper describes the development and implementation of a specification for nighttime highway construction & maintenance projects in Nova Scotia. The paper will deal with the details of the specification and the lessons learned in the first project in which it was used during the summer of 2002.

Increasing traffic volumes and the demand from the motoring public to minimize delays at work zones throughout North America have led to the scheduling of some highway maintenance and construction activities to nighttime hours.

A major cold planning and re-paving project on one of Nova Scotia's busiest highways during the summer of 2002 had to be carried out during the night to avoid imposing excessive delays on motorists.

A literature search, discussions with most state and provincial agencies, and research data from the Transportation Research Board and other sources were used in the development of the specification. Discussions with other provinces indicate that this may be the first comprehensive nighttime work specification by a Provincial Transportation Agency.

The project was carried out during the summer of 2002 and the specification proved to be achievable and to meet our Department's expectations. Detailed observations made during this initial project will be used to revise the specification for use on some projects in 2003.

1.0 INTRODUCTION

Nova Scotia is finding that higher traffic volumes and demands from motorists to minimize delays are requiring the Department of Transportation & Public Works “the Department” to consider carrying out certain projects at night. Many transportation agencies in North America have also found it necessary to carry out some highway construction and rehabilitation projects at night to avoid imposing excessive delays on highway users.

The decision to work at night is not made lightly. There are certain risks, costs and other challenges associated with night work, which must be weighed against the benefit of reducing delays to highway users. The best way to minimize the safety risks is to clearly identify them and develop strategies to mitigate those risks.

This paper describes the steps taken by the Department to develop a night work specification for use on a highway rehabilitation project in Nova Scotia. The project specification is presented with observations, which were made during the course of the project. Proposed revisions to the original specification are then presented which are based on those observations and information obtained in many of this paper’s references.

2.0 BACKGROUND

The project site is located on Cape Breton Island at the eastern end of the Province of Nova Scotia. The site lies within the Cape Breton Regional Municipality (CBRM). Highway 125 is the main arterial route linking many of the communities in the CBRM and it also serves as the primary artery to connect these communities to the Trans-Canada Highway.

The project site is on Highway 125 outside the city of Sydney, which is commonly known as the Sydney Bypass. The project section is about 9 km in length and is comprised of an arterial standard two-lane, two-way highway with four interchanges. The Cape Breton Regional Hospital is near one of the interchanges, which also makes Highway 125 a main route for the ambulance service.

The annual average daily traffic for this section of highway is approximately 21,000 vehicles per day. During the summer, daily traffic increases to about 25,000 vehicles per day and daytime hourly volumes range between 1000 and 2200 vehicles per hour. During the peak afternoon rush hour, traffic peak flow can exceed 2300 vehicles per hour.

During the winter of 2001/2002 it was decided that this section of highway needed to be rehabilitated. The proposed project included 110,000 square meters of cold planing, 33,000 tonnes of asphalt paving, including polymer modified asphalt in the top lift and about 3.5 kilometers of guardrail installation.

Local Department officials who were familiar with Highway 125 and the traffic volumes immediately recommended that the project be carried out at night. There were alternate routes available but they have limited additional capacity. Work during the day on Highway 125 would result in excessive delay times, which would very quickly become unacceptable to the highway users.

The recommendation was accepted, but since the Department had limited experience with major night work projects it became necessary to develop a set of specifications, which would help mitigate some of

the risks associated with working at night.

3.0 SPECIFICATION

The Department knew that other agencies in North America had found it necessary to do construction work at night, so contact names were obtained through various sources for all the state and provincial agencies in Canada and the United States [Table 1]. Through e-mail and written correspondence, as well as several telephone conversations, the Department was able to gather many existing agency specifications and valuable advice from traffic and construction engineers.

A draft report from the National Cooperative Highway Research Program (NCHRP) Project 17-17, which was developing guidelines for the operation of nighttime traffic control was also obtained. This research, which has now been published in NCHRP Report 476, provided a wealth of guidance for development of the specification.

An Internet search provided further sources of information related to most of the subject areas covered by the night work specification. Use of local colleagues experienced in traffic control design, illumination design and construction helped make the specification practical for conditions in Nova Scotia. Finally, a review of the proposed specification before the project was tendered, was undertaken by the Department.

The project was awarded to Municipal Ready-Mix Ltd. of Sydney, Nova Scotia in early July, 2002. Night work operations started on July 24 and ended on October 5.

The Project Engineer for the project was on-site nightly. Detailed notes related to the night operations and implementation of the specification were kept so that these observations could be used as a basis for revisions to improve the specification.

The following discussion of the specification is separated into the main component areas. The discussion for each component area is broken into a general discussion of the topic, a copy of the specification used on the project, notes on the observations which were made during the project and a proposed specification revision. The revisions are based on work site observations, on guidance provided in the reference materials and advice which was gathered in the course of the original research. The revised specification wording is shown *italics*.

3.1 Hours of Work

Determination of the hours during which lane closures would be permitted was important to the success of the project. There were two goals, which were not necessarily complimentary: determination of the hours during which lane closures would be permitted so that motorist delays would be minimized, and provision of a reasonable “work shift” which would allow for efficient contractor operations.

Traffic volume data was obtained for Highway 125 and the anticipated daily volumes for a typical week during the construction period was plotted [Figure 1]. Practical experience and information from the Department’s traffic division indicated that the capacity for a typical paving work zone with a full lane closure on a two-lane, two-way highway was in the order of 700 to 800 vehicles per hour. However, when this figure was used as the cut-off volume for determining work periods, it would have only

allowed the contractor to work from 9:00 PM to 5:30 AM on weekdays. The resulting work period of only 8.5 hours between work zone set-up to tear-down would have been very inefficient for most paving contractors and would likely have driven the project cost higher.

A reasonable assumption was made that by employing a comprehensive traffic management strategy that 20 to 30 percent of the traffic could be diverted from Highway 125 to alternate routes during the night work hours. Revising the anticipated nighttime traffic volumes resulted in a work period from 7:00 PM to 6:00 AM. This allowed 11 hours of work for the contractor, which was closer to a typical shift.

Hours of work were revised for Saturday and Sunday based on the anticipated traffic distribution for those days. This allowed for longer work periods on the weekend.

Project Specification

The contractor is advised that most work for this contract will be carried out during nighttime hours. For the purposes of this contract “night” is defined as the period beginning at sunset and ending at sunrise as posted by Environment Canada.

Full or partial lane closures (including ramps) will not be permitted during the following hours:

Monday to Friday	6:00 AM to 7:00 PM
Saturday	10:00 AM to 7:00 PM
Sunday	11:00 AM to 7:00 PM

Lane closures not in compliance with these limits will be subject to a lane rental fee of \$750.00 for every 15 minute increment or any part thereof.

Project Experience

The cut-off times chosen proved to be reasonable, based on observations made on the site. Delays early in the evening, when volumes were still fairly high, were often in the 20 minute range. However, after about 9 PM delays consistently fell below 10 minutes.

As a result of comparing Environment Canada posted sunset times with daylight conditions on the site, it was obvious that lighting and nighttime work precautions were needed about half an hour before the posted time.

Proposed Revisions

The contractor is advised that most work for this contract will be carried out during nighttime hours. For the purposes of this contract “night” is defined as the period beginning *one half hour before* sunset and ending *one half hour after* sunrise as posted by Environment Canada.

Full or partial lane closures (including ramps) will not be permitted during the following hours:

Monday to Friday	6:00 AM to 7:00 PM
Saturday	10:00 AM to 7:00 PM
Sunday	11:00 AM to 7:00 PM

Lane closures not in compliance with these limits will be subject to a lane rental fee of \$750.00 for every 15 minute increment or any part thereof.

3.2 Night Work Plan

The night work specification required the contractor to carry out very detailed planning before any work could begin on the project. The idea was to make sure that the contractor had prepared his staff, equipment, and work plans well in advance of the project.

Project Specification

At least 15 days prior to the start of work the contractor must submit 4 bound copies of a detailed “Night-Time Work Plan” for review and approval by the Department. The plan shall become part of the contract and must be updated by the contractor, as operations require.

The plan must include, but may not be limited to:

Traffic Control

- C Detailed written description of all traffic control procedures
- C Detailed drawings of all traffic control procedures & signing including controls for ramp traffic
- C Detailed description of set-up/tear down and lane shift times, sequences & procedures
- C Detailed description of all channelization and guiding devices to be used
- C Detailed plan for handling emergency vehicles passing through the site
- C Frequency and detailed procedure of patrolling the traffic control set-up
- C Detailed procedure for application of temporary traffic markings & erection of shoulder hazard signing
- C Details of personal protective equipment and additional training which will be provided to Traffic Control Persons

Lighting Plan

The lighting plan must be prepared by a person knowledgeable in the science of photometrics and vision.

- C Descriptions and sketches of the layout of light towers including spacing, luminaire height, lateral placement and anticipated illuminance provided.
- C Photometric & physical specifications of all lighting equipment
- C Detailed description of all lighting to be used on construction equipment
- C Methods to be employed to reduce glare
- C Frequency and procedure for checking illumination levels

Special Safety Elements

- C Details of personal protective equipment and additional training which will be provided to workers and equipment operators
- C Details of equipment warning devices which will be employed
- C Detailed Hazard Assessment for night work
- C Emergency response plans

Other Elements:

Noise and vibration abatement methods which may be employed if necessary

Project Experience

Proper planning on a night project is the first important step in mitigating the special hazards of working at night.

The contractor provided a night work plan as required and its preparation ensured that adequate planning had taken place before work had begun. The contractor hired an experienced electrical engineering consultant to design the lighting layout. The consultant proposed lighting configurations, which were intended to meet the illumination specification and minimize glare.

Proposed Revisions

At least *30 days* prior to the start of work the contractor must submit 4 bound copies of a detailed “Night-Time Work Plan” for review and approval by the Department. The plan must be updated by the contractor, as operations require.

The plan must include, but may not be limited to:

Traffic Control

- C Detailed written description of all traffic control procedures (*referenced to drawings*)
- C Detailed drawings of all traffic control procedures & signing including controls for ramp traffic - *all drawings to be on either letter or tabloid size sheets with title blocks*
- C Detailed description of set-up/tear down and lane shift times, sequences & procedures
- C Detailed description of all channelization and guiding devices to be used
- C Detailed plan for handling emergency vehicles passing through the site
- C Frequency of *inspection* and detailed procedure of patrolling the traffic control set-up
- C Details for placing temporary traffic markings & erection of shoulder hazard signing
- C Details of *Traffic Control Person* personal protective equipment
- C *Detailed sketch of proposed temporary sign stand design*

Lighting Plan

The lighting plan must be prepared by a *Professional Engineer* knowledgeable in the science of photometrics and vision.

- C Descriptions and sketches of the layout of light towers including spacing, luminaire height, lateral placement and anticipated illuminance provided
- C Photometric & physical specifications of all lighting equipment
- C Detailed description of all lighting to be used on construction equipment
- C Methods to be employed to reduce glare
- C *Contractor's* frequency and procedure for checking illumination levels

Special Safety Elements

- C Details of personal protective equipment *which will be required for workers*
- C *Detailed lesson plans for training which will be given to workers*

- C Details of equipment warning devices which will be employed
- C Detailed Hazard Assessment for night work
- C Emergency response plans

Other Elements

- C Noise and vibration abatement methods which *will* be employed *where* necessary

3.3 Signing

Signing is especially important at night because of the lack of visual cues in comparison to daylight conditions. It is important that motorists take notice of the work zone approach signs because night work is relatively unexpected in comparison with daytime activities.

All signing on the project had to be made with American Society for Testing and Materials (ASTM) Type III sheeting to ensure high retroreflectivity. All signs had to be mounted so that the bottom of the sign was at least 1.5 meters above the shoulder elevation. Raising the sign helped to avoid a common situation where shoulder height signs are blocked by vehicles ahead of a motorist in the traffic stream. By raising the sign, the observation angle is minimized so that more light is reflected back to the observer, thus making the sign appear brighter. Also, by mounting the sign essentially perpendicular to the roadway and vertical, the entrance angle is minimized. This allows the retroreflective material to perform well so that more light is reflected back to the observer making the sign appear brighter.

Project Specification

Signing:

Materials: All signs shall have retroreflective sheeting, which meets the requirements of ASTM Type III sheeting.

Placement: Signs shall be erected at a minimum height of 1.5 m. They must be essentially perpendicular to the direction of traffic and vertical. The sign shall be adequately supported to ensure minimal movement from this position.

Flashing Light Units: Units shall have dimmable lights which prevent glare. Non-functioning lamps and bulbs shall be replaced immediately.

The minimum sight distance to the flashing light unit shall be 460 meters. The unit shall be aimed so that it is clearly visible from this distance to the traffic control person station.

Project Experience

Pilot vehicles were used for all lane closure operations on the project and proved to be very useful at guiding traffic through the work zone and to some extent controlling speed. Early in the project it became evident that flashing light units were almost invisible to work vehicle drivers in the lane closure, when they approached the units from behind. Reflective tape was used to outline the units.

The temporary sign stands fabricated by the contractor worked well in most circumstances, but many of the base connections cracked during a night of high winds. Sign stand design should be addressed in the

planning stage of the project.

Road geometry and traffic control conditions may not allow the flashing light unit to be visible at the specified distance in all cases. However, attempts should be made to maximize this distance for each set-up.

Proposed Revisions

The provisions of the Nova Scotia Temporary Traffic Control Manual apply to this project. *A pilot vehicle shall be used to guide traffic during all lane closures on this project.*

Additional minimum requirements for work at night on this project are as follows.

Signing:

Materials: All signs shall have retroreflective sheeting which meets the requirements of ASTM Type III sheeting.

Placement: Signs shall be erected at a minimum height of 1.5 m *to the bottom of the sign*. They must be essentially perpendicular to the direction of traffic and vertical. The sign shall be adequately supported to ensure minimal movement from this position.

Flashing Light Units: Units shall have dimmable lights which prevent glare. Non-functioning lamps and bulbs shall be replaced immediately. *Red and white reflective tape shall be applied to all sides of the unit such that it defines the outline of the unit.*

The unit shall be *erected and aimed* so that it is clearly visible from the *greatest distance practical* to the *approaching traffic*.

3.4 Channelization Devices

One of the most important methods of mitigating some of the nighttime risks was to try to prevent any penetration of the closed lane by an errant motorist. Channelization devices are critical to achieve this objective.

The cones required under Nova Scotia's current traffic control manual are only 450mm high with one band of reflective material. The cones specified for night work operations on this project were higher and had two bands of reflective material. The larger cone with more reflective material was preferable since they would create more of a "wall" effect with the channelization devices. Standard traffic barrels were used as required in Nova Scotia's Traffic Control Manual for taper areas.

The maximum spacing for channelization devices permitted on this project was 12 meters. This is less than the spacing which would have been allowed on this class of highway during the day. This aided in the creation of a "wall" effect to try to prevent penetration of the work zone by motorists.

There was also a requirement that two barrels be placed transversely across a closed lane at 250-meter intervals. The idea was to alert an errant driver that they were in the wrong lane.

Project Specification

Materials: Retroreflective sheeting for all channelization devices (cones and barrels) shall meet the requirements of ASTM Type I sheeting.

All cones shall be a minimum of 700mm in height with two reflective bands as described in figure A-1 of this specification. Barrels may be used in place of cones.

Ballast for all channelization devices shall be placed at ground level.

Placement: The maximum distance permitted between channelization devices for areas where the speed limit is 80kmh to 100kmh shall be 12 meters.

Two drums shall be placed transversely across the closed lane at a spacing of 250 meters to alert errant drivers

Project Experience

The twelve meter spacing did not seem small enough when traffic speeds in the work zone were very low. It became apparent that spacing should be based on actual speeds in the work zone, which is often controlled by the pilot vehicle rather than by posted speed limits.

There were several motorist penetrations of the lane closure observed. All of them were at ramp or gore areas when speeds were relatively low. These areas require closer spacing than long tangent areas where speeds tend to be higher and driver demand is lower.

Proposed Revisions

Materials: Retroreflective sheeting for all channelization devices (cones and barrels) shall meet the requirements of ASTM Type I sheeting.

All cones shall be a minimum of 914mm in height with two reflective bands as described in figure A-1 of this specification. Barrels may be used in place of cones.

Ballast for all channelization devices shall be placed at ground level.

Placement: The maximum distance permitted between channelization devices shall be based on work zone operating speeds (not posted speed limits) as follows:

<u>Estimated Operating Speed (km/h)</u>	<u>Maximum Spacing (m)</u>
30 -49	6
50 - 69	9
70 and greater	12

Devices used at gores and intersections shall be spaced at intervals equal to one-half of the values shown the above table.

Two drums shall be placed transversely across the closed lane at a spacing of 250 meters to alert errant drivers.

3.5 Traffic Control Persons

Night requirements for traffic control persons are set out in the Nova Scotia Temporary Traffic Control Manual. The requirements outlined in the specification were meant to supplement these traffic control procedures.

Project Specifications

Training: All traffic control persons shall receive specific training on night work operations.

Illumination: The traffic control person shall be illuminated from above at minimum of Level I illuminance as defined in section 3.6 of this specification.

Visibility: In addition to their standard protective equipment, Traffic Control Persons shall wear white coveralls and have reflective material added to their hard hats which is visible from all sides. Additional reflective materials must be worn such that they are visible under the entire range of body motions. They must also be equipped with a flashlight complete with semi-transparent red cone.

Project Experience

Traffic control persons attended the general worker training sessions but did not receive additional formal training on night traffic control procedures. They did, however, receive specific instruction on the site.

The contractor fabricated telescopic light towers for erection at the traffic control stations. Two 1000-watt halogen lamps were used, which were powered by a portable generator. The contractor was able to attain Level 3 lighting at these stations, which allowed the traffic control person to “stand out” from the site lighting in the background.

Early in the project it was noticed that if the traffic control person stood directly beneath the light, they would often stand in their own shadow which tended to “dull” their bright clothing. It was found that placing the traffic control person about 5 meters from the light tower with the light cast on them allowed their bright clothing to stand out. The lights were positioned on the shoulder and aimed so that they were not blinding to the traffic control person.

Radio communication with the other traffic control persons and the pilot vehicle operator were essential for providing priority passage of emergency vehicles through the site.

Proposed Revisions

Training: All traffic control persons shall receive *training in addition to the general worker training which deals specifically with nighttime traffic control procedures.*

Illumination: The traffic control person shall be illuminated from above at minimum of Level 3 illuminance as defined in section 3.6 of this specification.

In the event of failure of any portion of the lighting system at a traffic control person station, all operations must be discontinued until the required illumination is restored.

Visibility: In addition to their standard protective equipment, Traffic Control Persons shall wear a high-visibility coverall which meets the requirements for CSA Z96-02 Class 3 apparel. They shall also have a minimum of 80 cm² of reflective material added to their hard hats which is visible from all sides. They must also be equipped with a flashlight complete with semi-transparent red cone.

Communications: All traffic control persons shall be equipped with radios so that they have communications with each other and the pilot vehicle operator.

3.6 Workers

Workers were required to receive training related specifically to safe work practices at night. Wearing reflective materials provides visibility for workers when they were in unlighted areas. The specification required all workers to wear reflective safety vests, to add reflective materials to their hard hats and to add other reflective materials so that they were visible under the full range of body motions.

Project Specification

Training: All workers shall receive specific training on night work operations.

Visibility: In addition to their standard protective equipment, all workers shall wear light colored clothing and have reflective material added to their hard hats. Additional reflective materials must be worn such that the workers are visible under the entire range of body motions.

Project Experience

The contractor's safety consultant developed a training program for the workers, which was to be attended before work began. The training program included such topics as night work hazards, vision and visibility concepts, the importance of reflective materials and the Personal Protective Equipment requirements for the site. Once an employee had completed the training he was issued a card certificate.

Occasionally there were workers and Department staff who occasionally arrived on site that had not been able to take the formal training. These people were trained on the site before they were allowed to start working. The training was in the form of a "toolbox" talk in which the main areas of the formal training were covered. They were also issued additional reflective materials and personal protective equipment in order to meet site requirements.

The contractor's workers wore a common type of safety vest made from a mesh fabric with a yellow plastic reflective material on the front and back. The contractor met the requirement of providing additional reflective material so that workers were visible under the full range of body motions by issuing all their employees with reflective armbands.

After the contract had been awarded the Department became aware of a new Canadian Standards Association (CSA) standard that was under development for high visibility garments. The Department was able to get a draft copy of the final standard and had vests for Departmental staff fabricated to those standards. This enabled Department staff to meet the requirement for additional reflective materials. These vests provided superior visibility in comparison to the standard Nova Scotia vests during low-light and night conditions.

Proposed Revisions

Training: All workers shall receive specific training on night work operations.

Visibility: In addition to their standard protective equipment, all workers shall wear a *high-visibility vest or jacket which meets the requirements for CSA Z96-02 Class 2 apparel*. They shall also have a *minimum of 80 cm² of reflective material added to their hard hats which is visible from all sides*.

3.7 Work Vehicles

All haul trucks had to post a sign on the tailgate indicating “Work Vehicle Do Not Follow”. The idea was to prevent what can be a very common occurrence even during day operations. Often the traffic stream behind a haul truck will follow the truck when it pulls into the closed lane. The Department wanted to try to prevent this type of lane closure penetration by motorists because of the added hazards of working at night.

The Department also required that all vehicles be outfitted with a rotating incandescent light. Strobe lights were not permitted. This was based on a suggestion from NCHRP Report 476, which noted that strobe lights do not give good rate of closure information to approaching motorists.

Project Specification

Training: All vehicle operators shall receive specific training on night work operations.

Visibility: In addition to their standard protective equipment, all equipment operators who leave their vehicles shall wear light colored clothing and have reflective material added to their hard hats. Additional reflective materials must be worn such that the workers are visible under the entire range of body motions.

Flashing Lights: All vehicles in the work area must operate rotating or flashing incandescent amber lights visible in 360 degrees around the vehicle. Strobe lights are not permitted.

Reflectorized Markings: All work vehicles including trucks must have red and white reflective tape applied to all sides such that it defines the outline of the vehicle.

Truck Message Signs: All trucks, which are required to enter and exit the lane closure will display a sign on their rear which reads “WORK VEHICLE - DO NOT FOLLOW”. The sign shall be reflectorized and at least 0.6m X 1.2 M with black letters on an orange background.

Truck Turning: To avoid confusing motorists and to improve site safety, trucks will not be permitted to turn around on the site. After delivery of their load all trucks must proceed to the next interchange to turn.

Project Experience

The truck signs proved to be very effective at preventing the stream of traffic from following the trucks into the lane closure.

Departmental staff compared the performance of strobes and incandescent lights on the site . There

seemed to be some “residual” light remaining even when the reflector on the incandescent light was facing away from the observer so they have a “constant target” as they are approaching the work vehicle. The strobe, however, did not provide a “constant target”

Proposed Revisions

Training: All vehicle operators shall receive specific training on night work operations.

Visibility: In addition to their standard protective equipment, all equipment operators who leave their vehicles shall wear *a high-visibility vest or jacket which meets the requirements for CSA Z96-02 Class 2 apparel*. They shall also have *a minimum of 80 cm² of reflective material added to their hard hats which is visible from all sides*.

Flashing Lights: All vehicles in the work area must operate rotating or flashing incandescent amber lights visible in 360 degrees around the vehicle. Strobe lights are not permitted.

Reflectorized Markings: All work vehicles including trucks must have red and white reflective tape applied to all sides such that it defines the outline of the vehicle.

Truck Message Signs: All trucks, which are required to enter and exit the lane closure will display a sign on their rear which reads “WORK VEHICLE - DO NOT FOLLOW”. The sign shall be reflectorized and at least 0.6m X 1.2 M with black letters on an orange background.

Truck Turning: To avoid confusing motorists and to improve site safety, trucks will not be permitted to turn around on the site. After delivery of their load all trucks must proceed to the next interchange to turn.

3.8 Lighting

The specification identified three levels of lighting, which would be required in certain circumstances.

Level 1 illumination was basic site lighting for safety, which was required where workers on foot would normally be carrying out their duties. The secondary benefit is that this level of light is also sufficient to carry out most highway construction activities.

Level 2 illumination was used for workmanship and inspection. Level 2 lighting had to be provided for 30 meters behind the paver so that mat defects could be identified and corrected immediately.

Level 3 illumination was intended for cases where very high visibility was required.

Project Specification

Illuminance: The level of illuminance required for various tasks will be defined in three “levels”.

Luminaires must be of sufficient wattage and/or quantity to provide a minimum average maintained horizontal illuminance as follows.

Level I:	59 Lux
Level II:	108 Lux

Level III: 215 Lux

Work Area: The following illuminance levels shall be provided:

For paving and planing operations

Level II - 15m ahead to 30 m behind the paving or milling machine

Level I - 120m ahead to 250 m behind the paving or milling machine and in all other areas regularly occupied by workers and inspection staff.

For shouldering operations

Level II - 15m ahead to 30 m behind the shouldering machine

Level I - 75m ahead to 75 m behind the shouldering machine and in all other areas regularly occupied by workers inspection staff.

Glare: All luminaires shall be located and directed in such a way to minimize glare to both motorists and work vehicles.

Measurement of Illuminance: The contractor shall provide, for use by the Engineer, a photometer capable of measuring the level of illuminance.

Project Experience

Illumination values attained were generally lower than those predicted in the design, but were still acceptable. Glare problems were minimal and usually due to improperly aimed lamps or by an unfortunate combination of tower placement and road geometry.

The light units were moved regularly to keep up with operations. Through the course of the project it frequently became necessary to have the lamps re-aimed to comply with the design geometry and illumination requirements.

During the initial measurements of the site illumination it was found that if the photometer operator or somebody close was wearing reflective materials, photometer measurements could rise to as much as double the actual illumination value.

The light towers which the contractor chose to use on this project had four-1,000 watt metal halide lamps on a 9 meter extendable mast. For most of the project the contractor had 16 towers set at 50 meter spacing which meant they could light 800 meters of roadway at any time. The towers were "leap-frogged" ahead with the moving operations.

The light levels specified were adequate for the purposes intended with the exception that Level 3 was used at the traffic control person stations as discussed earlier in this paper.

The contractor also added lighting to supplement the specification requirements. Lights were added to improve visibility in the hopper, on the operator deck and in the auger chamber of the paver. Lights were also added in similar areas on the material transfer vehicle.

Proposed Revisions

Illuminance: The level of illuminance required for various tasks will be defined in three “levels”. Luminaires must be of sufficient wattage and quantity to provide a minimum average maintained horizontal illuminance as follows.

Level 1:	60 Lux
Level 2:	110 Lux
Level 3:	220 Lux

Work Area: *Level 1 illumination shall be provided in all areas which workers and inspection staff regularly carry out their duties. In addition to this basic requirement the following illuminance levels shall be provided :*

For paving operations :

Level 2 - a minimum of 15 m ahead of the paver or material transfer vehicle to 30 m behind the paver.

Level 1 - a minimum of 120m ahead to 250 m behind the paver.

For cold planing and shouldering operations :

Level 1 - a minimum of 120m ahead to 250 m behind the planer or shouldering machine

For guardrail operations :

Level 1 - a minimum of 100 m ahead to 100 m behind the section under construction.

Glare: All luminaires shall be located and directed in such a way to minimize glare to both motorists and work vehicles. *If severe glare is noted from any travel path, the contractor must adjust the lighting to reduce the glare to an acceptable level.*

Measurement of Illuminance: *Measurements shall be taken at a height of 500 millimeters above the roadway, in a uniform pattern spaced at 3 meters throughout a representative test area.*

Illumination measurements are to be made by a person familiar with using a photometer and the operator shall not wear reflective materials while taking the measurements.

The contractor shall check the illumination levels on the site each time a change in lighting configuration is made and/or at least once every 5 working days. A copy of the measurements shall be given to the Engineer within 24 hours.

The contractor shall also provide on-site, for use by the Engineer, a photometer capable of measuring the level of illuminance.

Lighting Maintenance: The contractor shall replace non-functioning lamps immediately. The luminaire aiming shall be checked daily. The luminaires shall be cleaned regularly.

Lighting units must be completely removed from the roadway and shoulders when not being used.

3.9 Accommodation of Traffic

The specified maximum allowable delays for the project were based on a standard special provision included in most of the Department's roadway projects.

Project Specification

Delays: On this Contract the Work Zone, consisting of the Work Area and Buffer Area, shall not exceed 1.5 km in length, unless authorized by the Engineer.

The Contractor shall carry out their work activities in such a manner to minimize traffic delays. The following maximum time delays to traffic shall be adhered to:

- a) an accumulative 20 minutes through the Contract limits, and
- b) 10 minutes through any one Work Zone.

The Contractor will be required to adjust work activities, minimize the length and/or number of Work Zone(s), to adhere to these limits.

During times of high traffic volumes, should the limits not be met, the Contractor may be required to stop work activities and pull off the road until volumes permit restarting.

Project Experience

There were only a few delays over 20 minutes, which occurred early in the evening at times of highest traffic flow.

Proposed Revisions

No changes proposed

3.10 Traffic Control Maintenance

Once inspectors are satisfied that all the specification requirements have been met, it becomes important to ensure the Contractor complies with them for the duration of the project.

One of the requirements was that traffic control devices had to meet condition guidelines as laid out in "Quality Guidelines for Work Zone Traffic Control Devices" by the American Traffic Safety Services Association. The guideline gives both a written description and visual example as to what is acceptable and unacceptable.

Project Specification

Traffic control maintenance: The contractor must employ a full time traffic control supervisor with enough staff to ensure adequate patrol and maintenance of all traffic control devices.

All signs, channelization devices and other traffic control devices shall be kept clean and in good condition. The minimum standard for acceptability shall be the latest edition of "Quality Standards for

Work Zone Traffic Control Devices” by the American Traffic Safety Services Association.

All traffic control devices must be completely removed from the roadway and shoulders when not being used.

Lane Openings: Prior to opening any lane to traffic all the temporary pavement markings, hazard markers and low/high shoulder signs must be in place.

Project Experience

The Department developed a night work site inspection checklist, which covered all the areas of the specification to aid in recording compliance from the contractor. Any deficiencies would be noted, discussed with the contractor, a copy of the inspection form would be given to the contractor, and then a follow up inspection on subsequent nights would be undertaken.

It was observed that temporary markings are an important traffic control device and must be visible at night to be effective for this type of operation.

Proposed Revisions

The contractor must employ a full time traffic control supervisor with enough staff to ensure constant patrol and maintenance of all traffic control devices.

Traffic Control Devices: All signs, channelization devices and other traffic control devices shall be kept clean and in *acceptable* condition. The minimum standard for acceptability shall be the latest edition of “Quality Standards for Work Zone Traffic Control Devices” by the American Traffic Safety Services Association.

All traffic control devices must be completely removed from the roadway and shoulders when not being used.

Lane Openings: Prior to opening any lane to traffic all the temporary pavement markings, hazard markers and low/high shoulder signs must be in place.

Temporary markings must be spaced at a maximum of 10 meters. Markings may be made with an approved temporary marking tape or with a combination of painted marks and temporary overlay markers. Where painted marks are used they must be coated with glass beads and temporary overlay markers (TOM’s) must be placed at a maximum spacing of 20 meters over the painted marks.

3.11 Traffic Control Trial

A trial set-up of all lighting and traffic control systems was undertaken before work is allowed to start to ensure that the night work specification would be met.

Project Specification

Prior to the start of work, a traffic control trial shall be carried out for inspection by the Contractor and a Department representative. The trial shall involve setup and operation of the full traffic control system and work area lighting system. No work shall commence until approval is given by the Department to proceed

The specification required that the contractor set up his full traffic control and lighting system for inspection by the Department prior to any work starting.

Project Experience

The traffic control trial is absolutely necessary to make sure everything is working according to plan before construction actually begins. During the initial trial on this project the Department identified non-compliance for site illumination. The contractor discovered the template, which had been used for aiming the lamps, was fabricated incorrectly. All the lamps had to be re-aimed with a template based on the correct design geometry.

Proposed Revisions

No revision proposed

4.0 CONCLUSION

The specification was achievable and the project was completed safely and successfully. The quality of the work was very good and traffic delays were minimized. It is estimated that during the entire 10 week construction period that this section of Highway 125 carried in excess of 1.5 million vehicle trips and there were no work zone or delay related complaints

The project also provided an opportunity to make observations, which will be used to improve future specification revisions.

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TABLES

STATE OR PROVINCE DOT	Replied with No Comments	Replied with Comments	Replied with Specifications
Alabama	X		
Alaska		X	
Alberta		X	
Arizona		X	X
Arkansas		X	
British Columbia		X	
California		X	X
Colorado		X	
Connecticut	X		
Delaware		X	
Florida		X	X
Georgia	X		
Hawaii		X	
Idaho		X	X
Illinois		X	
Indiana	X		
Iowa		X	
Kansas		X	
Kentucky		X	
Louisiana		X	
Maine	X		
Maryland		X	X
Manitoba		X	
Massachusetts		X	X
Michigan		X	X
Minnesota		X	X
Mississippi		X	
Missouri		X	X
Montana		X	
Nebraska		X	X
Nevada		X	
New Brunswick	X		

STATE OR PROVINCE DOT	Replied with No Comments	Replied with Comments	Replied with Specifications
Newfoundland		X	
New Hampshire		X	
New Jersey		X	X
New Mexico		X	
New York		X	X
North Carolina		X	X
North Dakota			
Ohio		X	
Oklahoma	X		
Ontario		X	
Oregon		X	X
Pennsylvania			
Prince Edward Isl.		X	
Quebec		X	
Rhode Island	X		
Saskatchewan		X	
South Carolina		X	X
South Dakota		X	
Tennessee		X	
Texas	X		
Utah		X	
Vermont	X		
Virginia	X		
Washington		X	X
West Virginia		X	X
Wisconsin		X	
Wyoming	X		
OTHER SOURCES			
City of Edmonton		X	X
U.S. FHWA		X	
Penn. Turnpike		X	X

Table 1 - Results of E-Mail Request for Night Work Information

FIGURES

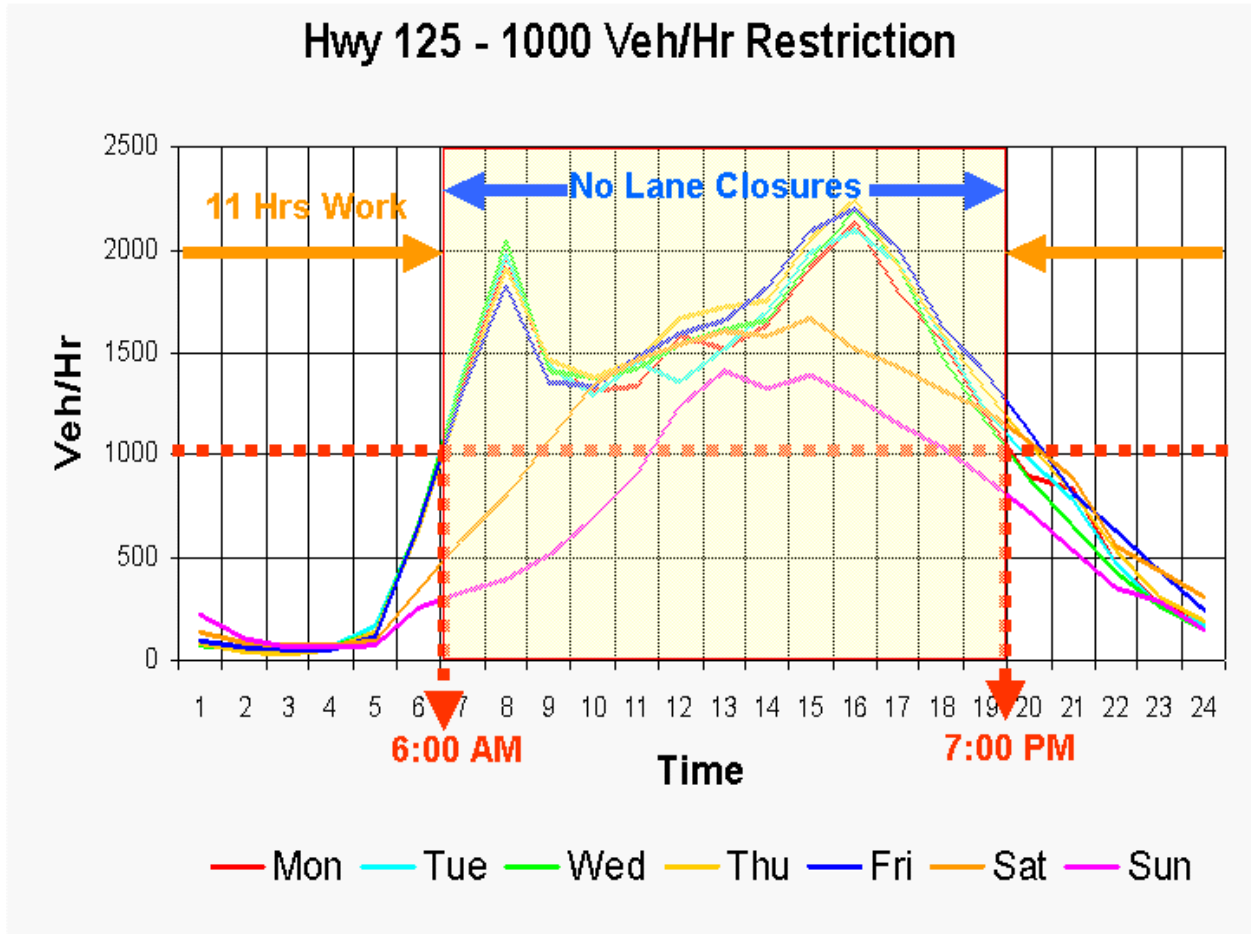


Figure 1 – Example of Hourly Traffic Volume Plot