ROAD SAFETY AND VEHICLE MAINTENANCE

STUDY ON WORN-OUT VEHICLE HEADLIGHT LENSES

By

CAA-Quebec

Quebec City, Fall 2010
Spotlight on safety

Promoting road safety and enabling members to make the best possible choices regarding vehicles as consumer goods is a constant concern for CAA-Quebec. With this in mind, we conducted the study you are about to read.

The idea was simple. CAA-Quebec technical services experts have observed for some time that, unlike the glass headlights installed on the majority of vehicles not so long ago, the plastic lenses made of polycarbonate that cover the headlights of most late-model cars do not age nearly as well... especially in terms of weathering the effects of abrasives, sunlight, etc.

Recognizing the importance for motorists of being able to rely on optimal illumination for better road safety, CAA-Quebec wanted to assess the difference in the lighting provided by cars with worn-out headlight lenses and those whose headlight lenses were later refurbished through polishing. The results were striking.

CAA-Quebec is therefore pleased to “shed light” on a situation that should concern not only drivers but also vehicle manufacturers and all stakeholders who make road safety a priority. And as you will see, this situation can be remedied by a simple and inexpensive maintenance procedure.

Paul A. Pelletier
President and Chief Executive Officer
CAA-Quebec wishes to thank...

- The Centre de formation en transport de Charlesbourg: for making its facilities available to conduct certain tests.

- Solotech, a Quebec City firm specializing in lighting and illumination tests, as well as 3M Canada: for professional services procured and the numerous refurbishments of headlight lenses done during the tests.

- Everyone at CAA-Quebec who contributed to this study and its public release.
Summary

To measure the extent of the incidence of worn-out headlight lenses, CAA-Quebec first sent its experts in October 2010 to various public parking lots in Quebec City to examine a sample of vehicles. This exercise revealed that 30% of the vehicles checked had headlights that showed obvious problems of opacity, and the problems were very serious in nearly 15% of cases.

Wanting to evaluate the loss of illumination associated with this phenomenon, CAA-Quebec, using a luxmeter, measured illumination, i.e. the amount of light received (measured in lux) by the object being illuminated before and after refurbishment of the headlight lenses. The results of these tests, conducted in a room with no light source, showed a difference in illumination of up to 525% lux or 6 times more.

Other tests conducted on a closed track also identified the impact of headlight lens opacity on visibility. Twelve different-sized matte black panels were placed at various distances. The results show that the driver of the vehicle with headlights in good condition could see the panels about 60 metres sooner than someone driving the vehicle with worn-out lenses. In summary, the improvement in visibility ranged from 92% to 1,200%.

In view of these findings, CAA-Quebec recommends that motorists check the condition of their headlights when they notice a certain degree of deterioration, rarely before the car is at least three years old. It suggests the necessary corrective measures then be made to maintain the best possible visibility. Moreover, it believes that vehicle manufacturers should address the importance of keeping headlights in good condition in the various maintenance manuals they produce for their customers. This would raise consumer awareness about this issue.

An example of illumination measurement

At a distance of 8 metres*, CAA-Quebec was able to measure the following results of the pre-test on a Hyundai Accent 2000:

<table>
<thead>
<tr>
<th>Headlight Condition</th>
<th>Low beam:</th>
<th>High beam:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Worn-out headlights</td>
<td>less than 50 lux</td>
<td>less than 80 lux</td>
</tr>
<tr>
<td>Refurbished headlights</td>
<td>nearly 225 lux</td>
<td>nearly 500 lux</td>
</tr>
</tbody>
</table>

*Distance used during safety inspections by the Société de l’assurance automobile du Québec
# Table of contents

1.0 Introduction .............................................................................................................. 5
2.0 Background .................................................................................................................... 5
3.0 Methodology and general issue ........................................................................................ 6
4.0 The various tests ........................................................................................................... 8
  4.1 The pre-test .................................................................................................................. 9
  4.2 Test conducted at the Centre de formation en transport de Charlesbourg .................... 10
  4.3 First test on a closed track: visibility on several objects ................................................. 11
  4.4 Second test conducted on a closed track: visibility in a more realistic environment ...... 12
5.0 Conclusion and recommendations .................................................................................. 13

APPENDICES ..................................................................................................................... 14

Appendice 1 – Press release ................................................................................................. 15

Appendice 2 – Headlight photos, before and after refurbishment ........................................ 17

INDEX ............................................................................................................................................. 18
List of charts and diagrams

Figure 1 - Number of vehicles affected by headlight lens opacity out of a sample of 500 vehicles........................................................................................................................................7

Figure 2 - Vehicules in the sample that require headlight refurbishment according to their age (medium to severe opacity)..................................................................................................7

Figure 3 - SAAQ’s Mechanical Inspection Guide .................................................................................................................................8

Figure 4 - Verification of headlight illumination with a Honda Civic 1998 using a luxmeter, before and after refurbishment of an opaque lens..............................................................................9

Figure 5 - Verification of headlight illumination with a Ford Taurus 2002 using a luxmeter, before and after refurbishment of an opaque lens................................................................................10

Figure 6 - Verification of headlight illumination with a Chrysler PT Cruiser 2001 using a luxmeter, before and after refurbishment of an opaque lens........................................................................11

Figure 7 – Results of the test conducted on a closed track with a vehicle.................................................................................................12
1.0 Introduction

Experts are aware of the phenomenon of worn-out headlight lenses in late-model cars but it is poorly documented. For several years, for example, experts with CAA-Quebec’s Automotive Advisory Services have been raising awareness about this subject among members. But until now the agency had no “measured” data in this regard to support its recommendations. Hence the present study, whose main objective is to demonstrate the impact of headlight lens opacity and wear on driving.

The first part of the study provides an overview of the situation (background). It then reviews the methodology used and the general issue. It later describes the various tests that were conducted and the results obtained. In conclusion, two recommendations are made.

2.0 Background

It is common to note that the headlights of older vehicles are more opaque than those of newer vehicles. However, a very old car (more than 15 years) may have headlights in good or excellent condition if they are made of glass. Glass headlights are more resistant to debris and weather conditions than those made of polycarbonate (plastic). Also, generally speaking, headlight lenses from one manufacturer cannot be said to be more resistant than another because the materials used (glass or polycarbonate) vary from one model to another, even among the same manufacturer. Finally, headlight opacity may begin to occur in the early years of a vehicle’s use, or 3 to 4 years.

Driving conditions, weather conditions, mileage and the motoring environment will also impact the condition of the headlights.
• **Causes of headlight opacity**: Sunlight, various projectiles (sand, gravel), calcium and salt.

• **Vehicle age in Quebec**: In 2009, the average age of the Quebec automobile fleet was 7 years. In 1993, the number of light passenger vehicles (cars and trucks) over 10 years old on our roads was 425,000. In 2009, it was more than 1 million. (Source: Société de l’assurance automobile du Québec)

• **Headlight illumination and the Highway Safety Code**: Section 238 of the Highway Safety Code states that a law enforcement officer may require the driver of a road vehicle to clean the headlights, lights and reflectors of the vehicle when the level of dirt or an obstructing material reduces their effectiveness. The offending motorist faces a fine ranging from $60 to $100.

3.0 **Methodology and general issue**

CAA-Quebec wanted to compare the illumination provided car headlight lenses in good condition with others worn out by weather, various abrasives and debris found on roads (sun, salt, calcium, grit and more). To do so, it used a high-precision instrument, a luxmeter, to measure the illumination, or more precisely the amount of light reflected off a surface when it’s illuminated by headlights. A series of indoor tests as well as others on a closed track were performed to show, in real conditions, the loss of illumination caused by the opacity of headlights. During these tests, various objects, such as matte black panels of different sizes, were placed along the roadside to measure, with the luxmeter, light projected by the headlights on these objects.

A total sample of 500 vehicles was analyzed by CAA-Quebec's Automotive Advisory Services in September and October 2010. The 500 vehicles were observed in public parking lots. Of these 500 vehicles, 15.5% had headlight lenses with medium opacity and 14.4% were in very poor condition. This initial analysis showed that nearly 30% of the vehicles observed had headlight lenses that were moderately to very severely worn out.

The following two tables show the number of observed vehicles affected by headlight opacity compared with the entire sample and according to their age.
Figure 1 - Number of vehicles affected by headlight lens opacity out of a sample of 500 vehicles

![Bar chart showing the number of vehicles affected by light, medium, and severe opacity.](image)

Figure 2 - Vehicles in the sample that require headlight refurbishment according to their age (medium to severe opacity)

![Bar chart showing the percentage of vehicles requiring refurbishment.](image)

With such a large number of vehicles observed (500) and considering the inspection methodology, it is reasonable to assume that these proportions apply to vehicles in the Quebec automobile fleet which have the same characteristics (age, model).
4.0 The various tests

Four different tests were conducted, each designed to check a different aspect.

Regarding indoor tests, the method and illumination measurements were based on the Société de l’assurance automobile du Québec (SAAQ) *Mechanical Inspection Guide*.

**Figure 3 - SAAQ’s Mechanical Inspection Guide**

Source: Société de l’assurance automobile du Québec.
4.1 The first test

The test: Verification of headlight illumination, in lux, on a white screen, before and after refurbishment of an opaque lens

The vehicle: Honda Civic 1998

Figure 4 - Verification of headlight illumination with a Honda Civic 1998 using a luxmeter, before and after refurbishment of an opaque lens

The results: In the low-beam tests, the vehicle with worn-out headlight lenses obtained a reading of 50 lux, compared with 160 once the headlight lenses were refurbished, for a 220% improvement in illumination. The high-beam tests showed that worn-out headlight lenses generated 145 lux, compared with 380 for refurbished ones, improving illumination by 162%.
4.2 **Test conducted at the Centre de formation en transport de Charlesbourg**

**The test:** Verification of headlight illumination, in lux, on a white screen

**The vehicle:** Ford Taurus 2002

Figure 5 - Verification of headlight illumination with a Ford Taurus 2002 using a luxmeter, before and after refurbishment of an opaque lens

![Bar chart showing headlight illumination before and after refurbishment.](chart.png)

**The results:** In the low-beam tests, the vehicle with worn-out headlight lenses obtained a reading of 105 lux, compared with 310 once its headlight lenses were refurbished, for a 195% improvement in illumination. The high-beam tests showed the worn-out headlight lenses generated 125 lux, compared with 380 for the same headlights with refurbished lenses, improving illumination by 204%.
4.3 First test on a closed track: visibility on several objects

The test: Verification of headlight illumination, in lux, on several objects
The vehicle: Chrysler PT Cruiser 2001

Figure 6 - Verification of headlight illumination with a Chrysler PT Cruiser 2001 using a luxmeter, before and after refurbishment of an opaque lens

The results: CAA-Quebec measured the actual illumination in lux of worn-out and then refurbished headlights on certain objects, such as a bicycle, a stroller and a motorcycle (see Legend of objects used below). Lighting improvements of up to 400% were observed.

Legend of objects used
Object type, distance of measurement, location, headlights in low- or high-beam mode.

<table>
<thead>
<tr>
<th>Code</th>
<th>Object</th>
<th>Distance from the vehicle</th>
<th>Headlight type</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Bicycle</td>
<td>at 10 m on the right</td>
<td>low beam</td>
</tr>
<tr>
<td>B</td>
<td>Bicycle</td>
<td>at 10 m on the right</td>
<td>high beam</td>
</tr>
<tr>
<td>C</td>
<td>Stroller</td>
<td>at 15 m on the left</td>
<td>low beam</td>
</tr>
<tr>
<td>D</td>
<td>Stroller</td>
<td>at 15 m on the left</td>
<td>high beam</td>
</tr>
<tr>
<td>E</td>
<td>Motorcycle</td>
<td>at 20 m far right</td>
<td>low beam</td>
</tr>
<tr>
<td>F</td>
<td>Motorcycle</td>
<td>at 20 m far right</td>
<td>high beam</td>
</tr>
<tr>
<td>G</td>
<td>Moped</td>
<td>at 25 m to the right</td>
<td>low beam</td>
</tr>
<tr>
<td>H</td>
<td>Moped</td>
<td>at 25 m to the right</td>
<td>high beam</td>
</tr>
<tr>
<td>I</td>
<td>Door</td>
<td>at 30 m in front</td>
<td>low beam</td>
</tr>
<tr>
<td>J</td>
<td>Door</td>
<td>at 30 m in front</td>
<td>high beam</td>
</tr>
</tbody>
</table>
4.4 Second test conducted on a closed track: visibility in a more realistic environment

The test: Verification of headlight illumination on panels strategically located on the road

The vehicle: Hyundai Accent 2000

Figure 7 – Results of the test conducted on a closed track with a vehicle

<table>
<thead>
<tr>
<th>Condition and type of headlight</th>
<th>First panel visible at a distance of…</th>
<th>Half the panels visible at a distance of…</th>
<th>All panels visible at a distance of…</th>
</tr>
</thead>
<tbody>
<tr>
<td>Worn out – Low beam</td>
<td>50 metres</td>
<td>35 metres</td>
<td>5 metres</td>
</tr>
<tr>
<td>Refurbished – Low beam</td>
<td>115 metres</td>
<td>95 metres</td>
<td>65 metres</td>
</tr>
<tr>
<td>Improvement in %</td>
<td>130%</td>
<td>171%</td>
<td>1,200%</td>
</tr>
<tr>
<td>Worn out – High beam</td>
<td>65 metres</td>
<td>55 metres</td>
<td>25 metres</td>
</tr>
<tr>
<td>Refurbished – High beam</td>
<td>125 metres</td>
<td>110 metres</td>
<td>95 metres</td>
</tr>
<tr>
<td>Improvement in %</td>
<td>92%</td>
<td>100%</td>
<td>280%</td>
</tr>
</tbody>
</table>

The methodology: The objective of the demonstration on a closed track was to show the difference in visibility between headlight lenses in good condition and worn out headlight lenses, in an environment that’s as realistic as possible. To do this, a dozen black matte panels of different sizes were placed on the road, the first at a distance of 140 metres and the last at 190 metres. Three measurements were made in metres: when the driver was able to see the panel, when he was able to see half of the panels, and when he was finally able to see them all.

The tests demonstrate beyond a doubt the effectiveness of refurbished headlight lenses compared with damaged ones. During testing with high-beam lights, the driver of the vehicle with refurbished lenses was able to see the first panels 60 metres earlier than when driving the vehicle with worn-out lenses. Considering that a car travels 14 metres per second at a speed of 50 km/h, the driver of the vehicle with refurbished headlights had 4 more seconds to make a decision and respond.

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1 In addition to the vehicle driver, three other expert witnesses participated in the tests to evaluate and determine the differences in illumination.
accordingly to the approach of the panels. The chart in section 4.4 shows the measured results schematically.

Note: The method used by CAA-Quebec during testing on a closed track is based on that of certain independent entities, including the Consumer Reports organization.

5.0 Conclusion and recommendations

This CAA-Quebec study clearly demonstrated the loss of luminosity caused by the opacity of headlight lenses damaged by weather, various abrasives and debris. When driving at night, lack of light may reduce the reaction time of a motorist who has to make a decision regarding the presence of an obstacle on the road. Although drivers can play an important role by being more aware of this phenomenon, all vehicle manufacturers should include, in the maintenance manuals they provide to consumers, recommended maintenance guidelines for headlight lenses.

CAA-Quebec therefore recommends:

- That drivers check the condition of their headlight lenses every three years and, if necessary, have them polished in order to gain the best possible visibility;

- That manufacturers include guidelines on maintenance of headlight lenses in maintenance manuals delivered on purchase of all the cars they build.

➢ Click here to view CAA-Quebec's demonstration video or go to http://www.caaquebec.com/video/video-used_headlightV2.html.
CAA-Quebec study: worn-out headlights threaten safety

Quebec, October 28, 2010 – A new CAA-Quebec study shows that automobile headlight lenses damaged by harsh weather, abrasives and debris become so opaque that they can reduce lighting effectiveness to half that of headlights in good condition. Tests conducted on a closed track confirm this: a motorist travelling 50 km/h at night will have four more seconds to react to an emergency if the headlights are in good condition and undamaged.

A widespread problem
To study the damaged-headlight phenomenon, CAA-Quebec first sent its experts to various public parking lots to look at a representative sample of Quebec’s vehicles. This exercise concluded that 30% of vehicles checked showed obvious signs of headlight opacity, and the problems were very serious in nearly 15% of cases.

Results in a controlled environment …
Using a luxmeter, CAA-Quebec measured illumination (in other words, the quantity of light received by the object being illuminated) before and after the refurbishment of headlight lenses. The results of these tests, conducted in a closed room with no light source, are surprising. They show a difference in illumination of up to 525% lux or 6 times more.

… and on a closed track
Other tests, conducted on a road circuit, also enabled the measurement of the impact of headlight lens opacity on visibility. Black panels of various dimensions were placed at different distances. The results show that the driver of a vehicle with headlights in good condition could see the panels 60 metres sooner than someone driving a vehicle with damaged lenses. The improvement in visibility varied from 92% to 1,200%. For full results of this study, view our video.

“When you are driving at night – especially at this time of year with darkness coming earlier – it is essential to see as far ahead as possible in order to be prepared for any eventuality,” says Sophie Gagnon, CAA-Quebec’s Senior Director, Public and Government Relations. “Considering that more than 90% of the information needed when driving a car comes from visual searching, it is fundamental to have optimal vision, especially at the time of year when many children will be walking on our streets for Halloween.”

The CAA-Quebec tests were conducted when weather conditions were favourable to driver visibility. It could be even more difficult, for example, to notice a pedestrian who is farther away and at the side of the road when it is snowing or raining heavily.

Causes of headlight deterioration
Although headlight opacity is more widespread among vehicles that are more than five years old, CAA-Quebec has observed that it can occur in the earlier years of a vehicle’s life. More than age, the material used to make lenses is at issue. Thus, glass headlights on a vehicle that is more than 10 years old may be found to be in excellent shape, whereas headlights made of polycarbonate are more easily damaged by abrasives and debris such as sand, calcium or salt, as well as by sunlight and rain.
Low-cost corrective measures
To restore headlights to like-new condition, CAA-Quebec recommends dealing with a specialized company that renews lenses completely and sustainably, using a polishing technique. A number of products are sold, but their results are not always long-lasting. “Treatments are available to remedy headlight opacity, and they are not expensive,” Ms. Gagnon says. “There is therefore no excuse for tolerating headlights that fail to illuminate the road sufficiently. With the increasing number of trips taking place in the dark over the coming weeks, all drivers win by having better visibility.”

About CAA-Quebec
CAA-Quebec, a not-for-profit organization founded in 1904, provides automotive, travel, residential and financial services and privileges to its one million members.

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Appendice 2 – Headlight photos, before and after refurbishment

**The vehicle**: Volkswagen Golf TDI 2001
Luxmeter, lux and lumens: Did you know...

**Luxmeter (photometer):** A luxmeter is a device that measures the amount of light received by an object or reflected on a lighted surface.

**Lux:** Is the illumination of a surface that receives, in a uniform manner, a luminous flux of one lumen per square metre.

**Lumen:** Unit used to measure luminous flux or luminous power.

**Examples of illumination measured in lux**

- Full moon: 0.5 lux
- Well-lit street at night: 20 to 70 lux
- Sunny day: about 50,000 lux