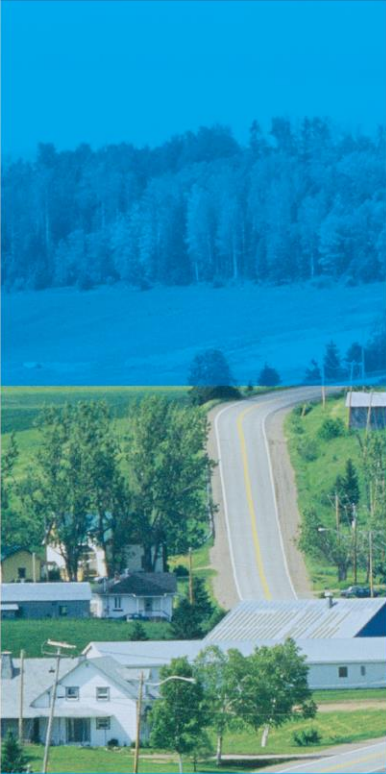


MINISTÈRE DES TRANSPORTS


Pavement markings at the Ministère des Transports du Québec

Innovative Measures to Improve Environmental Performance



2015





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INTRODUCTION

The Ministère des Transports du Québec (Quebec Department of Transport – MTQ) is very conscious of the importance of reducing the environmental impacts of its activities, and has made sustainability a core component of its Mission. In that regard, road-marking is one of the areas of expertise where the MTQ has shown a high degree of cutting-edge leadership and proactivity in recent years.

The road network under the jurisdiction of the MTQ includes over 90,000 km of road markings, which are essential to the safety of all road users. To ensure the continued visibility of road markings, the MTQ conducts an extensive annual repainting program, which calls for vast quantities of materials, including 3.8 million litres of paint and 2.8 million kg of glass microbeads, which are added to the paint during application in order to enhance the night-time visibility of the road markings.

Considering the quantities of materials used, it was essential to implement specific measures to reduce their environmental impact. Innovative and cutting-edge measures have been put forward to reduce the release of harmful products without diminishing the quality of the road markings.





GENERAL INFORMATION ON PAINT MANUFACTURE

The manufacture of road marking paint is a highly complex process. Each of the many types of paints used in road markings requires very specific quantities of numerous ingredients. Modifying one or the other of these ingredients can considerably impact the physicochemical properties and performance of a paint product.

The main components of road marking paint include the following:

- A bonding agent that adds to the resistance and durability of the paint application;
- A solvent that facilitates the amalgamation of all products during the manufacturing process, and evaporates at the time of application;
- Pigments that provide colour and opacity to the paint. Pigments are made of very fine mineral or organic powders;
- Fillers, including powders adding certain specific properties, such as increased durability of road markings, in addition to reducing manufacture costs;
- Additives that assist in maintaining and balancing paint product properties, including coalescing agents, anti-skinning agents and fungicides.

In addition to these base components, the MTQ requires that road marking paints feature the following properties:

- A shortened drying time for ease of application, especially on high-volume roads;
- A high degree of opacity to allow full and complete coverage of black pavement materials with a single coat of paint;
- A sufficient degree of viscosity to allow application by a road marking truck at a rate of 20 km/h. For alkyd and water-based paints, a road marking truck can apply 2,000 litres of paint per hour;
- Paint applicability under varying climate conditions, including cold temperatures and high humidity conditions;
- Enhanced wear-resistance to protect from traffic and winter road-maintenance activities;
- Enhanced retro-reflectivity for improved night-time visibility of road markings through the addition of glass microbeads;
- Enhanced colourfastness and resistance to ultraviolet rays and traffic.

In order to fulfill all of these requirements, paint manufacturers initially opted for the development of alkyd paints, which the MTQ used predominantly in the past. Although less durable, this type of product can be applied under winter conditions, which is a major advantage in Quebec.

In recent years, other road marking products have become available, including enhanced alkyd paints, water-based paints, epoxy resins, methyl methacrylates (MMA) and polymer strips. Each of these products comes with its own set of advantages and drawbacks.



OBJECTIVES, CONDITIONS OF IMPLEMENTATION AND ENVIRONMENTAL REPERCUSSIONS

Considering that each year, half of the road marking products used in Quebec are applied on roads under MTQ jurisdiction, the Department has deployed considerable efforts and shown strong leadership in significantly improving the environmental record of its' road marking activities. In addition to enhanced road safety, actions implemented have significantly contributed to reducing the environmental impacts of road marking activities. Specifically, five key environmental practices have been implemented in recent years. They include:

- The use of recyclable containers;
- The elimination of products containing lead chromate;
- A significant reduction in the quantity of volatile organic compound emissions;
- The use of recycled glass and restrictions concerning heavy-metal content in the manufacture of glass microbeads;
- The optimization of the quantity of paint applied to the road markings.

To achieve these objectives, the MTQ established specific criteria for all road marking products. Each product to be used on the MTQ road network is subjected to a certification process, which includes an analysis of product components as well as a performance assessment, including specific tests to measure product durability and retro-reflectivity (for enhanced night-time visibility of road markings).


Objective 1: Use recyclable containers to allow the elimination of 15,000 metal drums and 140,000 microbead storage bags annually

In 1993, the MTQ took the first major steps in its' commitment to enhanced environmental responsibility by making the use of recyclable paint containers compulsory. These recyclable 1,100 litre containers replaced the 15,000 metal drums of paint used annually, each of them containing only 200 litres of paint. The same approach was used in making compulsory the replacement of the 20 kg bags of microbeads with recyclable plastic drums with a 330 kg capacity. The life expectancy of these new paint and glass microbead storage drums is approximately 10 years.

The use of recyclable containers has also helped optimize the efficiency and cost-effectiveness of road marking operations by facilitating the adoption of a just-in-time approach to these operations. In addition to its' environmental benefits, this approach has led to reduced down times and simplified truck re-filling operations requiring less manpower. According to MTQ estimates, the switch to recyclable containers has resulted in costs savings in the order of one million dollars annually.

Objective 2: Prevent the release of 235 000 kg of lead chromates annually

During the manufacture process, pigments are added to the paint composition to achieve the requisite standard white and yellow road marking colours. There are two main types of pigments:

- 
- Mineral-based pigments, including titanium dioxide, lead chromate and iron oxide; and
 - Organic-based pigments, which include carbon-based organic chemistry by-products.

In the past, all yellow paints used by the MTQ included mineral-based pigments. Therefore, as 1.5 million litres of yellow paint are used annually, 235,000 kg of lead chromate were released into the environment each year.

In 1998, the MTQ began looking for alternatives in an effort to limit the use of lead chromates in road marking products. As part of this process, tests were conducted with paints containing organic-based pigments. Preliminary results proved unsatisfactory, as the paint did not conserve its colour over the long-term.

In 2003, the problem of rapid colour degradation in paints containing organic pigments was resolved for the majority of road marking products available on the market. However, another problem was identified: certain organic pigments generated very low retro-reflectivity. This resulted in lower night-time visibility of road markings, which could directly impact road safety. One year later, manufacturers had removed from their products all organic pigments affecting retro-reflectivity.

The MTQ subsequently modified its' requirements in order to discontinue the use of products containing lead chromates. The replacement of these products was implemented gradually over three years, from 2005 to 2007. Since then, the MTQ no longer uses any such products, therefore preventing the release of 235 000 kg of lead chromates into the environment annually.

The MTQ was the first government agency in Canada to eliminate the use of products containing lead chromates. Health Canada followed suit three years later, banning the use of these products in 2010.


Objective 3: Reduce the use of volatile organic compounds by 1,5 million kg

Each year, pavement-marking activities on the MTQ road system require close to 3.8 million litres of paint. In the past, the use of such quantities of alkyd paints resulted in the dispersal of 1.5 million kilograms of volatile organic compound (VOC) emissions into the environment. When paint is applied, VOC emissions occur when the high concentrations of solvents in the road marking paints are released into the atmosphere.

VOCs have a considerable impact on the environment. They contribute to the formation of ground-level ozone, which is one of the main components of smog. It should be noted that smog is an important problem that affects the health of Canadians, contributing to thousands of premature deaths, hospitalizations and emergency-room admissions yearly¹.

In 1998, in response to its concerns regarding the environmental impacts of VOCs, the MTQ started testing various products to replace alkyd-based paints. To that end, it established benchmark sites at various highway locations to test and compare the durability of various replacement products.

¹ ENVIRONMENT CANADA, *Strategic Plan for Implementing the use of Low VOC Traffic Marking Coatings*, 2007



Certain products, such as epoxy resins, showed promising results that seemed to pave the way for the complete elimination of VOC content. However, these products were more expensive and required complex and specific application conditions with which it would be difficult to comply. As a result, it was becoming difficult to foresee replacing alkyd-based paints with epoxy resins across the entire MTQ road network.

In the early 2000s, the MTQ established a certification process for water-based products. These products immediately offered better results than alkyd-based paints, in addition to greatly reducing the quantity of VOC emissions into the atmosphere. The MTQ subsequently tested these materials on over 10,000 km of roadways to assess their performance.

In December 2005, although there were no environmental standards regulating VOCs in Quebec or in Canada, MTQ authorities decided to replace the use of alkyd-based products with water-based products. This decision was made first and foremost to reduce environmental impacts, as water-based products were more costly. In addition, the seven MTQ-owned road-marking trucks were replaced with machinery purpose-designed for the application of water-based products.

Considering that the alkyd-based paints in use at the time emitted approximately 400 grams of VOC per litre, and given that water-based paints and epoxy resins emit approximately 100 g/L and 5 g/L respectively, eliminating the use of alkyd-based paints has resulted in approximately 1.1 million less kilograms released into the atmosphere annually. This is a clear and significant benefit from both an environmental and a public health standpoint.

Environment Canada has since drawn up legislation limiting the use of VOC emitting products in road marking paints. Specifically, as of September 10, 2012, the use of road paints containing over 150 g/L VOC content is prohibited between May 1st and October 15th. The MTQ played an active role in the preparatory work prior to the drafting and dissemination of this legislation.


The MTQ fulfilled this requirement long before the implementation of these regulations.

Objective 4: Limit organic solvent emissions by restricting the use of alkyd-based paints with low VOC content

Following the implementation of the legislative changes, paint manufacturers developed alkyd-based paints with VOC content below 150 g/L. To achieve this level, organic solvents (most often acetone-based) are used. This type of paint is more and more widespread, considering its' ease of application under cold or damp conditions.

In the fall of 2013, the MTQ conducted an analysis of these new products, focusing on key characteristics such as durability, environmental impacts and worker safety.

Considering the amount of paint products used by the MTQ, the use of low-VOC, alkyd-based products would result in the dispersal of over 1.4 million Kg of organic solvents into the atmosphere annually. These emissions are considerably more than those from water-based paints, which in comparison would generate only 380 000 kg of solvents annually.



In comparing costs, low-VOC, alkyd-based paints are slightly less durable than water-based paints. However, as they contain acetone-based solvents, they come with a greater risk of explosion, which can compromise the safety of workers and road users during road marking operations.

And so, as part of its commitment to sustainability, the MTQ has decided to limit the application of these products during the winter months, as no other product can be applied at that time.

Objective 5: Improve the sustainability record by using 2.8 million recycled glass microbeads annually and by limiting the microbeads' heavy metal content

Since the mid-1940s, the MTQ has required the addition of glass microbeads during the road marking application process. Through an optical phenomenon called retro-reflectivity, these microbeads act as a mirror, reflecting the light of the headlights back to the driver's vision. Thus, road markings become more visible, especially at night, which increases road safety.

In 2007, the MTQ analysed glass microbeads from different companies and originating in different countries. Results showed that the heavy metal content of the microbeads can be very high, depending on the country of origin. In addition, standard practices at the time did not encourage the use of recycled materials.


The MTQ proceeded to introduce a new clause to its purchasing contract requiring that the glass residues used in the manufacture of microbeads must contain at least 90% recycled glass. Also, in 2013, the MTQ modified its' contract specifications restricting the heavy metal content of glass microbeads to only a few parts per million (PPM), specifically 75 mg/kg for Antimony (Sb), 50 mg/kg for Arsenic (As), 20 mg/kg for Cadmium (Cd), 20 mg/kg for Mercury (Hg) and 50 mg/kg for Lead (Pb).

There are two main motives for these actions. The first is to avoid importing heavy metals that can contaminate the environment, as road marking by-products tend to migrate to the road shoulders, potentially contaminating the adjacent ecosystems. The second is to encourage recycling, to reduce the quantity of waste and to divert waste away from landfill sites.

This new direction has led to the recycling of close to 2.8 million kilograms of glass annually, in Quebec only. The MTQ has taken a major step toward sustainability, and these leading-edge measures have since been adopted by the majority of transport administrations across North-America.

Objective 6: Optimize the use of materials while maintaining road marking visibility

Considering the vast expanse of the road network under MTQ jurisdiction, it is essential to continually monitor the state of road markings, as to the presence of line markings (durability) and night-time visibility (retro-reflectivity). It was of key importance for the MTQ to design a monitoring system and an exhaustive inspection program to assess these characteristics.



In terms of road marking durability, the entire 90,000 km MTQ road network is inspected annually, in the spring. This inspection is conducted using the classification system outlined in Appendix B. The inspection is conducted in April, as this is the most crucial time of year in regard to the need for road markings. The collection of detailed data on the state of road marking has led to considerable procedural improvements that have made the network safer for all road users. These improvements have been very beneficial. The presence of visible road markings has grown from 73 % to 93 % between 2008 and 2013.

From a Canadian perspective, the MTQ remains today the only jurisdiction to conduct this type of detailed analysis on an annual basis. This detailed monitoring enables the MTQ to determine road markings application rates based on the presence and state of remaining markings. With the implementation of this new approach in 2013, the MTQ has saved 150,000 litres of paint annually, which represents an annual cost savings of \$450,000. In addition, this approach improves the MTQ's environmental record by again reducing the quantity of harmful products released into the environment.

In the same vein, a functional classification of retro-reflectivity has been developed, as outlined in Appendix C. To measure and validate the retro-reflectivity of road markings, the MTQ has acquired a purpose-designed vehicle, the first of its kind in Canada, equipped with a high-performance measuring apparatus to assess road marking retro-reflectivity at speeds up to 100 km/h. Over 20,000 km of road markings are measured annually. The MTQ also owns 14 additional portable retro-reflectivity measuring devices.


The MTQ continues to analyse various products and application methods, and based on the retro-reflectivity data collected, it will be possible to identify innovative approaches to continually optimize the quantities of paint and glass microbeads used annually.

CONCLUSION

In the field of horizontal signage, the MTQ has shown a strong sense of leadership by implementing several concrete measures to improve its' environmental record. Specifically, road marking operations have been optimized and new practices have been adopted, particularly in regard to the replacement of metal drums with recyclable containers, the elimination of lead chromates and the considerable reduction of the VOC contents in road marking paint products.

In addition, by encouraging the use of recycled glass, the MTQ has significantly improved its sustainability record. The MTQ was actually the first North-American transport administration to adopt and implement this practice. Also, by establishing a method to conduct detailed and precise measurements of road marking conditions, the MTQ has been able to significantly reduce its paint consumption, with the added benefit of substantial cost savings.

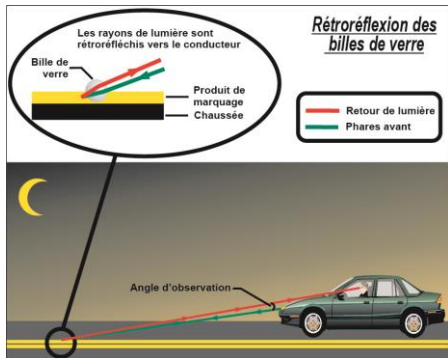
Implementing these leading-edge initiatives has had undeniable positive environmental repercussions. The MTQ contributes to the population's well-being by using more environmentally responsible products. Indeed, across the entire road network, products providing higher environmental performance are replacing products having been recently deemed more damaging to the environment. Also, robust new measures have been implemented to encourage the use of recycled materials. Together, these actions contribute to a more rational and



sustainable use of resources. The MTQ is also implementing practices to improve the durability of road markings, which will result in a safer road network for all users.





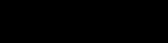
This entire initiative has one more substantial and important role. The MTQ is serving as a model for the rest of Canada. Several provinces and municipalities are already following suit and are going green by using road marking products that are more respectful of the environment.

ANNEXE A



ANNEXE B – LA CLASSIFICATION POUR LA DURABILITÉ DU MARQUAGE

Classification fonctionnelle de la durabilité

CLASSE	INTERVALLE (%)	COULEUR	
1	96 à 100	VERT	
2	75 à 95	JAUNE	
3	50 à 75	ORANGE	
4	15 à 50	ROUGE	
5	0 à 15	NOIR	



Exemple de carte de durabilité



ANNEXE C – LA CLASSIFICATION POUR LA RÉTRORÉFLEXION DU MARQUAGE

Classification fonctionnelle de la rétroréflexion (mcd/lux/m²)

A	250 et plus	BLEU	
B	175 à 249	VERT	
C	100 à 174	JAUNE	
D	50 à 99	ORANGE	
E	Moins de 50	ROUGE	

- **Les valeurs de rétroréflexion sont en mcd/lux/m².**
 - A. Rétroréflexion minimale du marquage de couleur blanche que tous les types de produits doivent obtenir lors de l'application initiale.
 - B. Rétroréflexion minimale du marquage de couleur jaune que tous les types de produits doivent obtenir lors de l'application initiale.
 - C. Minimum de rétention de la rétroréflexion que le marquage doit obtenir selon les données probantes des chercheurs pour maintenir un niveau de visibilité minimale.
 - D. Rétroréflexion en dessous du seuil minimal et, normalement, lorsque le marquage atteint ce seuil, il devrait être refait.
 - E. Rétroréflexion en dessous du seuil de visibilité de nuit du marquage.



