The traffic paint material used for the majority of Alberta’s pavement markings is alkyd paint. This type of paint contains approximately 50% solvent by volume. Environmental regulations in the near future may mandate the elimination or drastic reduction of solvents in all paints.

Traffic paints based on acrylic emulsion resins in which the vehicle is water instead of solvents are readily available in the market place.

Rohm and Haas Company and IBIS Products Limited jointly applied waterborne stripes of several products to Alberta Transportation test track (Highway 16 East, near Highway 21 Overpass) on June 2, 2000.

The lines were evaluated for general appearance and luminous directional reflectance (glass bead loss) at 28 days, 151 days and 365 days. Retro-reflectivity readings were also undertaken on each test stripe using the Mirolux 30 Field Retro-reflectometer.

Supplementary field trials have also been conducted and reported.

The study of waterborne painted roadway lines was undertaken to quantify the effect various paint types, glass bead types and wet film thickness rates have on retro-reflectivity and durability.
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ALBERTA TRANSPORTATION
TECHNICAL STANDARDS BRANCH
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STUDY OF WATERBORNE HIGHWAY TRAFFIC PAINT

1.0 INTRODUCTION

All paints contain pigments, volatile vehicles (solvent or water – a thinning agent) and non-volatile vehicles (resins - drying oils that cure by oxidation after evaporation of the solvent). There are two common paint products available in the market today – alkyd paints that use a solvent and waterborne paints that use water as the carrier. Currently alkyd traffic paint material is used for the majority of Alberta’s pavement markings.

CANTOX ENVIORNMENTAL INC conducted a study for Environment Canada in 2000 to review the potential for reduction of VOC (volatile organic compounds) in the Industrial Maintenance Coating (IMC) sector. VOCs contribute to greenhouse gasses and as such are a target for reduction. The report determined that … “The most significant opportunity for VOC reduction for the IMC sector was found to lie in the Traffic Markings sub-sector, largely due to the potential for switching from solvent-borne to water-borne applications. VOC reduction opportunities for the non-traffic Industrial Maintenance Coatings sector were smaller, but significant nonetheless. Assuming the recommendations presented in this report were implemented across Canada, there is an opportunity to reduce VOC emissions for the overall IMC sector by about 27%, well above the 20% objective established under the national management plan.”

Alberta Transportation is interested in the potential for the use of waterborne paints in lieu of alkyd paints for traffic markings. Aside from the reduction of VOCs by the use of waterborne paints it has been suggested that they would provide a more durable lane delineator line.

Rohm and Haas Company and Ibis Products Limited jointly applied waterborne test stripes of several products on June 2, 2000, to an asphalt concrete
pavement surface of the Alberta Transportation line paint Test Section (Highway 16 East, near Highway 21 Overpass) Appendix A. Five different bead types, two wet film thickness (15-mil and 30-mil) and 2 different resins were applied on the test track in order to determine the most effective combinations and application rates. The 15 mil wet film thickness is equivalent to the department’s standard 38 litres per line kilometre application rate.

The test lines were evaluated at 28 days, 151 days and 365 days for general appearance and luminous directional reflectance (glass bead loss). Retro reflectivity readings were taken on each test stripe using the Mirolux 30 Field Retro-reflectometer.

2.0 OBJECTIVES

The objectives of the study are to:

• determine the effect application rate has on retro-reflectivity and durability.
• determine the effect various types of beads have on retro-reflectivity and durability of the waterborne paints.
• determine the combination of paint thickness and bead type that provides the best value results.

3.0 BACKGROUND

Alkyd traffic paint is used in Alberta for the vast majority of pavement markings. This type of paint contains approximately 50% solvent by volume. Environmental regulations in the near future may mandate the elimination or drastic reduction of solvents in all paints.

Pavement markings require periodic remarking due to the deterioration of the lines caused by traffic, snow removal activities and environmental forces. Alkyd solvent-based paints are inexpensive to buy and apply but typically last less than a year. Failure modes for the pavement marking include poor adhesion, chipping abrasion, poor bead retention and discoloration. Factors that effect the performance include paint formulation, surface preparation, weather conditions, traffic volume and type of surface (seal coated or plain ACP). Although roadway lane lines are typically painted only once per year in Alberta there is a need to paint up to 3 applications per year on some roadway segments.

Saskatchewan and Manitoba experimented with waterborne traffic paints in the 90’s using various film thicknesses and bead types. The focus of their investigation was the application characteristics and techniques required as well as the long-term effects of the material on the equipment.
4.0 ROAD PERFORMANCE EVALUATION

The present method of selecting traffic paint is based on the Road Service Test (Paint Stripe Evaluation – ASTM D713) (Appendix B) performed on asphalt concrete pavement. General appearance and bead loss are the primary factors in the rating system. The Road Service Test is regarded as the most thorough method of assessing paint stripe durability. There is no documented study that shows any significant correlation between laboratory-measured properties and field performance.

A total of 58 waterborne stripes (100 mm wide) were applied to a bituminous surface on the department’s highway 16 test track by Rohm and Haas. Rohm and Haas provided the paint application equipment for the various paint and glass bead applications (Appendix C – Equipment).

The stripes were evaluated by a four-member panel, to determine the general appearance and luminous directional reflectance (bead loss) of each test stripe. The road stripes were evaluated as per the Road Service Test (ASTM D713) for Evaluation of Pavement Marking Materials (Appendix B).

Retro-reflectance readings were also taken along each line (4 readings per line including one in wheel path) using the Mirolux 30 Field Retro-reflectometer.

The Road Service Test evaluations and Retro-reflective readings were undertaken on June 29, 2000, November 1, 2000 and June 2, 2001.

5.0 EQUIPMENT DESCRIPTION

The Mirolux 30 Field Retro-reflectometer is a precision instrument designed to measure retro-reflective materials in field applications. This instrument provides accurate retro-reflectivity measurements over the range from 20 to 1200 mcd/Lux/m². Canasphere Industries Ltd., Calgary, provided the instrument to Alberta Transportation for our use.

Retro-reflectivity is dependent on several factors:

- the number of glass beads
- depth of embedment (60% embedment of glass bead in paint is optimum)
- quality of the glass bead
- type of pigment in the paint
- ability of paint to hold the bead
- wearing properties of the paint
6.0 TYPE OF PAINT AND BEAD USED

<table>
<thead>
<tr>
<th>LINE NO.</th>
<th>PAINT ID</th>
<th>RESIN SYSTEM</th>
<th>GLASS BEAD</th>
<th>WET FILM THICKNESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>IBIS Regular</td>
<td>Fastrack 2706</td>
<td>AC-110</td>
<td>15 mil</td>
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<tr>
<td>4</td>
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<td>Fastrack 2706</td>
<td>Flex-o-Lite</td>
<td>15 mil</td>
</tr>
<tr>
<td>10</td>
<td>IBIS Regular</td>
<td>Fastrack 2706</td>
<td>Alberta Local</td>
<td>15 mil</td>
</tr>
<tr>
<td>17</td>
<td>Rohm &amp; Hass</td>
<td>Control Regular</td>
<td>AC-110</td>
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<td>Control Regular</td>
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<tr>
<td>27</td>
<td>Rohm &amp; Hass</td>
<td>Control Regular</td>
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<td>15 mil</td>
</tr>
<tr>
<td>34</td>
<td>IBIS Premium</td>
<td>Fastrack HD-21</td>
<td>P35</td>
<td>15 mil</td>
</tr>
<tr>
<td>36</td>
<td>IBIS Premium</td>
<td>Fastrack HD-21</td>
<td>Flex-o-Lite</td>
<td>15 mil</td>
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<tr>
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<td>Fastrack HD-21</td>
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</tr>
<tr>
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<tr>
<td>57</td>
<td>Rohm &amp; Hass</td>
<td>Control Premium</td>
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<table>
<thead>
<tr>
<th>LINE NO.</th>
<th>PAINT ID</th>
<th>RESIN SYSTEM</th>
<th>GLASS BEAD</th>
<th>WET FILM THICKNESS</th>
</tr>
</thead>
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<td>5</td>
<td>IBIS Regular</td>
<td>Fastrack 2706</td>
<td>AC-110</td>
<td>15 mil</td>
</tr>
<tr>
<td>7</td>
<td>IBIS Regular</td>
<td>Fastrack 2706</td>
<td>Flex-o-Lite</td>
<td>15 mil</td>
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<tr>
<td>14</td>
<td>IBIS Regular</td>
<td>Fastrack 2706</td>
<td>Alberta Local</td>
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</tr>
<tr>
<td>24</td>
<td>IBIS Premium</td>
<td>Fastrack HD-21</td>
<td>AC-110</td>
<td>15 mil</td>
</tr>
<tr>
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<td>IBIS Premium</td>
<td>Fastrack HD-21</td>
<td>P-35</td>
<td>15 mil</td>
</tr>
<tr>
<td>31</td>
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<tr>
<td>41</td>
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<td>Fastrack HD-21</td>
<td>P-35</td>
<td>30 mil</td>
</tr>
<tr>
<td>46</td>
<td>IBIS Premium</td>
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<td>Visi-L-511</td>
<td>30 mil</td>
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<tr>
<td>47</td>
<td>IBIS Premium</td>
<td>Fastrack HD-21</td>
<td>Flex-o-Lite</td>
<td>30 mil</td>
</tr>
</tbody>
</table>

7.0 GLASS BEADS

The sole function of glass spheres (beads) in highway marking is to maximize the reflectivity of the markings, thus improving the driving environment and increasing highway safety. The beads actually cause the light beam to be focused and then returned to the driver’s eyes by a process known as retro-reflection.
8.0 PAINT AND BEAD DESCRIPTIONS

<table>
<thead>
<tr>
<th>Resin</th>
<th>Description</th>
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<tbody>
<tr>
<td>Fastrack 2706</td>
<td>1st Generation, Fast Dry, 100% all Acrylic Waterbased Polymer</td>
</tr>
<tr>
<td>Fastrack HD-21</td>
<td>100% all Acrylic “Durable” Waterbased Polymer</td>
</tr>
<tr>
<td>Control Regular</td>
<td>Rohm &amp; Hass control sample – no data supplied</td>
</tr>
<tr>
<td>Control Premium</td>
<td>Rohm &amp; Hass control sample – no data supplied</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Beads</th>
<th>Description</th>
<th>Manufacturer</th>
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</thead>
<tbody>
<tr>
<td>AC-110</td>
<td>Standard AASHTO M-247 Bead</td>
<td>Potters</td>
</tr>
<tr>
<td>Flex-o-Lite</td>
<td>Standard AASHTO M-247 Bead</td>
<td>Flex-o-Lite</td>
</tr>
<tr>
<td>P-35</td>
<td>0.4 mm Glass Bead</td>
<td>Potters</td>
</tr>
<tr>
<td>Visi-L-511 Bead</td>
<td>≈ 1.0 mm Glass Bead (L-511)</td>
<td>Potters</td>
</tr>
<tr>
<td>Alberta Local</td>
<td>Moisture resistant, Specification CB-00</td>
<td>Potters</td>
</tr>
</tbody>
</table>

Note: The Standard AASHTO M-247 Bead is a Dual Silane Coated Bead

9.0 FIELD MEASUREMENTS

Retro-reflective readings outside of wheel path were taken on each waterborne paint stripe (Table 1 and 2). Readings were taken near the shoulder, center of lane and centerline of each stripe. Two readings were taken at each location and the average for each line was plotted (Charts 1, 2, 5 and 6). Readings were also taken on the wheel path for each stripe and plotted (Charts 3, 4, 7 and 8).

Based on the results of the road evaluation, a service factor “R” for both general appearance and luminous reflectance was determined as per the following:

$$ R = \frac{r_1t_1 + r_2t_2 + r_3t_3 + \ldots + r_nt_n}{t_1 + t_2 + t_3 + \ldots + t_n} $$

Where;

- $R$ = Service Factor or R Value
- $r_n$ = Average rating for the panel of 4 on a particular date
- $t_n$ = Time lapse between successive ratings

A weighted service factor was calculated using a 50% weighting for general appearance and a 50% weighting for luminous directional reflectance. The weighted service factor for both white and yellow paint stripes are shown in Charts 11 and 14. The “R” values for general appearance and bead loss are shown in Charts 9 and 10 and Charts 12 and 13.

Note the electronic (Mirolux 30) readings are only a measure of the quantity of light reflected using a specific instrument. The bead loss ratings are subjective ratings between 1-10, evaluating quantity of beads retained after specific intervals of wear.
10.0 DISCUSSION OF RESULTS

Field Results

The following process was used to review and generate the attached charts and graphs.

1. Retro-reflective readings were taken on each line using the Mirolux 30 instrument. Three readings were taken along each line and averaged. A reading was also taken on the wheel path for comparison purposes.

   Retro-reflective readings were conducted at 28 days, 151 days and 365 days.

2. Road performance evaluation consisted of a panel of 4 people (Don Stefanyk (AMEC), Jim Skwarrok (AMEC), Ron Stoski and Joe Filice (Alberta Transportation) who visited the site on June 29, 2000, November 1, 2000 and June 2, 2001 to evaluate each line performance.

   The evaluation was conducted for General Appearance and for Bead Loss of each line based on the ASTM D713 Road Service Test (Appendix B).

   When evaluating the paint lines, the wheel path section of the lines was observed and rated. The evaluation was conducted on days that were clear and sunny.

3. The results were all documented and plotted for white and yellow paint lines respectively. The following charts were generated as a result of the field study:

   Traffic Paint Retro-reflection

   A. Charts 1 and 2, White Traffic Paint, 15-mil to 30-mil wet film thickness (outside Wheel Path).
   B. Charts 3 and 4, White Traffic Paint, wheel path readings (WP), 15-mil to 30-mil wet film thickness.
   C. Charts 5 and 6, Yellow Traffic Paint, 15-mil to 30-mil wet film thickness (outside Wheel Path).
   D. Charts 7 and 8, Yellow Traffic Paint, wheel path readings (WP), 15-mil to 30-mil wet film thickness.

   Traffic Paint Road Performance

D. Chart 12, Yellow Traffic Paint, Appearance only “R” Values, 15-mil to 30-mil wet film thickness.
E. Chart 13, Yellow Traffic Paint, Bead Loss Only “R” Values, 15-mil to 30-mil wet film thickness.
F. Chart 14, Yellow Traffic Paint, Weighted “R” Values, 15-mil to 30-mil wet film thickness.

11.0 OBSERVATIONS

Retro-reflectivity Outside of Wheel Path

White Lines

Retro-reflectivity of the painted white lines remained high outside the wheel path (Charts 1 and 2). The retro-reflectivity for all the white lines at 28 days were over 200 mcd/m²/lux with a high of 379 mcd/m²/lux. At 151 days, the lowest reading was 140 mcd/m²/lux while the highest reading was 268 mcd/m²/lux. At 365 days, the lowest reading was 96 mcd/m²/lux while the highest reading was 196 mcd/m²/lux. Of the top four retro-reflective readings, three are paint lines with 30-mil wet film thickness and one is a paint line with 15-mil wet film thickness.

Yellow Lines

For the yellow painted lines outside the wheel path (Charts 5 and 6) the retro-reflectivity at 28 days ranged from a low of 136 mcd/m²/lux to a high of 346 mcd/m²/lux. At 151 days the lowest reading was 88 mcd/m²/lux and the highest reading was 228 mcd/m²/lux. At 365 days the lowest reading was 54 mcd/m²/lux and the highest was 152 mcd/m²/lux. The 30-mil wet film thickness paint lines also faired well, as there are three 30-mil lines in the top four.

Retro-reflectivity in Wheel Path

White Line

Retro-reflectivity in the wheel path at 28 days ranged from 134 to 249 mcd/m²/lux but drastically reduced at 365 days from 29 to 51 mcd/m²/lux (Charts 3 and 4). The 30-mil wet film thickness paint lines did not fair any better than the 15-mil wet film thickness paint lines. The increase of the paint application rate did not have a significant influence on the retro-reflectance after a winter cycle.

Yellow Line

Retro-reflectivity in the wheel path for the yellow lines performed very similarly to the retro-reflectivity in the wheel path for the white lines (Charts 7 and 8). The increase of the paint application rate (30-mil) did not have a significant influence on the retro-reflectance after a winter cycle.
Road Performance Evaluation

The paint lines were evaluated at 28 days, 151 days and 365 days for general appearance and luminous directional reflectance (glass bead loss). The wheel path of each line is evaluated for general appearance and bead loss. Scoring is based on a scale from 0-10 for general appearance and bead loss. Based on the results of the road evaluation, a service factor “R” for both general appearance and luminous directional reflectance was determined and plotted for both the white and yellow lines. A weighted service factor was also calculated using a 50% weighting for general appearance and a 50% weighting for luminous directional reflectance (bead loss).

Appearance Only “R” Values

White Lines

The general appearance rating varied from a low of 3.6 to a high of over 7 at 365 days (Chart 9). The IBIS Regular paint with the various beads performed poorly (Lines 1, 4 and 10), while the Rohm & Hass and IBIS Premium paints were rated very well for general appearance (Chart 9). The 30-mil wet film thickness lines out performed the 15-mil wet thickness lines for general appearance. It appears that the increase in application rate does improve the durability and general appearance of the line (chart 9, lines 49,51,55 and 57).

Yellow Line

The general appearance rating varied from a low of 5.0 to a high of over 7 at 365 days (Chart 12). The performance of the IBIS Regular paint (lines 5, 7 and 14) was poor (similar to the performance for the white paint lines), IBIS Premium paints were rated very well for general appearance. The increase in application rate to 30-mil wet film thickness appears to improve durability (Chart 12, lines 41, 46 and 47).

Bead Loss Only “R” Values

White Lines

The bead loss exhibited rapid deterioration over the 365 days of service (Chart 10). The lines with the increased application rate (30-mil wet film thickness) did not fair any better than the 15-mil lines. Line Number 39 (IBIS Premium, Fastrack HD-21) with AC-110 glass bead performed the best.

Yellow Line

The bead loss was as rapid for the yellow lines as for the white lines (Chart 13). Similar to the white lines, the increased application rate (30-mil) did not show any significant improvements in the paint holding the beads. Line Number 24 (IBIS Premium, Fastrack HD-21) with AC-110 glass beads performed the best.
Weighted "R" Values

White Lines

Based on the weighted "R" values (general appearance and bead loss) the IBIS Regular, Fastrack 2706 paint system (Lines 1, 4 and 10) performed poorly with the highest rating of 2.5 at 365 days (Chart 11). The IBIS Premium, Fastrack HD-21 and Rohm & Hass paint systems performed much better based on the weighted “R” values. Of the four 30-mil wet film thickness lines, three were rated the highest of all lines evaluated. The increase in the application rate to 30-mil does improve the durability and general appearance of the paint.

Yellow Lines

The weighted “R” values for the yellow lines are similar to the values for the white lines with the IBIS Regular, Fastrack 2706 paint systems (Lines 5, 7 and 14) being rated the lowest (Chart 14). The IBIS Premium, Fastrack HD-21 performed better. However the 30-mil wet film thickness lines did not perform much better than the 15-mil wet film thickness of the same paint systems (Chart 14).

Bead Performance

Comparisons of bead loss (Charts 10 and 13) by bead type, resin type and line thickness indicates that the AC110 bead provided the best performance followed by the Flex-o-Lite bead. This observation is based upon comparisons of line groupings 1, 4, 10; 17, 19, 27; 34, 36, 39; 49, 51, 55; 5, 7, 14; 24, 30, 31; and 41, 46, 47.

The Visi-L-511 bead (lines 46 and 49) did not perform well and is not recommended for use at this time.

Resin Performance

Comparison of the appearance of the various lines by bead type and thickness (lines 1, 17& 39; 4, 27 & 36 on Chart 9 and lines 5 & 24 and 7 & 31 on Chart 11), indicates that the HD21 resin provides the best performance while Fastrack 2706 resin performed the poorest.

Wet Film Thickness

Based upon a comparison of 30 mil and 15 mil thick lines with consistent bead types (lines 51 & 36 and 47 & 31 with Flex-o-Lite beads and 55 & 34 and 41 & 30 with P35 beads), the 30 mil wet film thickness provides better long term durability and bead retention.
12.0 SUMMARY OF OBSERVATIONS

In studying the comparative graphs of the bead loss vs. retro-reflection in wheelpath, some similarities exist (Charts 4 and 10, 8 and 13). On the white and yellow paint results, the samples with the highest retro-reflectance compared closely to the bead loss rating for the same samples (comparing retro-reflectance to bead loss rating in the wheelpath).

The results of this study indicate that an increase in application rate does not have a significant influence on the retro-reflectance after a winter cycle but does improve the durability and general appearance of the paint line. Paint line durability and rate of deterioration are functions of the time the paint is exposed to weather, oxidization, snowplow and vehicle damage.

In the retro-reflection study, readings were taken in the wheel path and outside the wheel path. The retro-reflection readings inside the wheel path were drastically reduced after the initial reading at 28 days. At 151 days, only one line was above the 100 mcd/m²/lux for the white paint (Chart 4, Line 39) and all lines in yellow paint were below the 100 mcd/m²/lux (Chart 8). At 365 days all lines, with the exception of line number 39 (white), were well below 50 mcd/m²/lux.

Readings taken outside the wheel path faired much better. The retro-reflectivity readings did not drastically reduce after the initial readings at 28 days (Chart 2). At 151 days all white lines were well over 100 mcd/m²/lux with many of the lines above 200 mcd/m²/lux (Chart 2). For the yellow lines, all readings at 151 days were well above the 100 mcd/m²/lux except for line No. 7 which was below, and only one line (No. 46) was above 200 mcd/m²/lux (Chart 6). At 365 days all lines (white and yellow) were above 100 mcd/m²/lux (Charts 2 and 6) with the exception of 3 lines (No. 4 white and No. 7 and 14 yellow).

**Road Test**

The road service test is conducted under actual road conditions using transverse test lines. This practice covers the determination of the relative service life of traffic marking materials. This practice is an accelerated evaluation of wear characteristics and bead retention of fluid traffic markings.

There is a significant difference in retro-reflection values taken on the wheel path vs. outside the wheel path. In the wheel path the retro-reflection values drop off dramatically over time; outside the wheel path they drop off gradually over time.

In reality, traffic lines are predominately placed longitudinal to the roadway, therefore not subjected to the same vigorous wear of the transverse lines. If this reasoning is acceptable, then the waterborne traffic paint lines have performed very well after 1 year (365 days) of service.
13.0 COMPARISON WITH ANNUAL TEST TRACK RESULTS

Direct comparisons between the waterborne test track and the annual traffic line test track are not possible due to differences in equipment and evaluation benchmarks. However, the 2000 annual test track included waterborne paint lines such that a relative comparison with alkyd paints can be demonstrated.

Based on the results observed over 175 days the waterborne paints were rated higher than the alkyd paints with the exception of one waterborne line that used non-standard glass beads.

Details of the 2000 annual test track are included in appendix ‘D’.

14.0 2001 and 2002 WATERBORNE FIELD TRIALS

2001 Waterborne Trials

The 2001 waterborne paint line trials applied in the Red Deer region (CMA 17) by Lafrentz Road Services Ltd. are reported to have worked out well. Lafrentz monitored the retro-reflectance (using a Mirolux 30 field retro-reflectometer) of the waterborne paint lines over a two-month period. The initial readings taken were all well over 200 mc/m²/Lux, which is equivalent to typical alkyd paint line initial readings. However, after approximately 3 months of wear the retro-reflection had only decreased marginally with retro-reflection readings in the 200-mc/m²/Lux range.

Lafrentz has also pointed out that the waterborne paint lines were applied without heating, resulting in faster drying, which reduced vehicle tracking of paint lines.

2002 Durable Waterborne Trial (Deerfoot Trail)

In 2002, Ibis Products Ltd. and Rohm and Haas proposed to trial a new durable waterborne marking (trade name DuraQuick system) in Alberta. The DuraQuick system is a specially formulated thick film waterborne traffic paint that has been designed to match the performance of quality durable materials (thermoplastics).

Rohm and Haas claim that the durability of their patented DuraQuick systems crosslinking gives the binder tenacious adhesion to glass beads. The HD-21A waterborne paint is applied at 25 mils wet, which requires additional time to dry to prevent vehicle-tracking problems. To reduce the time to dry, Rohm and Haas has introduced a new product called AquaSet QS-1 drying additive. The DuraQuick system combines the two following products:

- Fastrack HD-21A – 100% acrylic crosslinking durable resin designed for thick film paints.
- AquaSet QS-1 – Additive that promotes drying in thick film paints.
The DuraQuick marking system was placed on the Deerfoot Trail (Calgary) for evaluation purposes on August 14, 2002 (S. bound 17 ave interchange). DuraQuick marking system was placed at 25 mils wet film (wft) thickness using the sandwich method of application. This method called for the following:

1. First paint gun to put down approximately 10 mils wft of Fastrack HD-21A paint.
2. Followed by the application of AquaSet QS-1 (bell type dispenser).
3. The second paint gun putting down 15 mils wft of Fastrack HD-21A paint.
4. And finally the application of glass beads.

The DuraQuick system was placed on the right shoulder and left skip line. The right skip line was placed without the QS-1 additive for comparison purposes. Fastrack 3427 yellow paint was applied to the left shoulder (Fastrack 3427 is a second generation Fastrack product). (see appendix ‘E’ for photographs of the sandwich method of application)

Retro-reflective readings were taken using the Mirolux 30 field retro-reflectometer on August 28, 2002 and November 14, 2002. The initial set of retro-reflective readings exhibited readings in the 200 mcd/m²/lux range (chart 19, Appendix E). The second set of retro-reflective readings dropped off significantly to the 80 to 120 mcd/m²/lux range. The QS-1 additive does not appear to impact the performance of the HD-21A paint products.

A final evaluation was planned in the spring of 2003. However at the time the final assessment was conducted field observations revealed that the HD-21A waterborne paint had been applied over existing durable markings (thermoplastic). The manufacturers recommended application for the HD-21A durable waterborne paint is for pavements less than 5 years old and with no accumulation of paint layers. Therefore the rapid deterioration in retroreflectivity observed in the fall of 2002 may have been due to poor adhesion of the HD-21A to the existing durable markings.

The Fastrack 3427 yellow paint line exhibited similar results, however the retro-reflective readings did not drop off to the extent that the HD-21A systems. This may be due to the snowplows not being in direct contact with the paint line, which is adjacent to the concrete barrier.

2002 Durable Waterborne Trial (Highway 623)

Lafrentz Road Services Ltd. of Edmonton applied HD-21A waterborne paint lines (white & yellow) on a new pavement at highway 623 (E. of hwy. 814) in September 2002 (the QS-1 drying additive was not used on this trial). The application consisted of two thin layers of paint applied two weeks apart.
White Line

Initial – 7.2-mil (184µm) layer of HD-21A waterborne paint with a glass bead application rate of 700 grams per liter.

Second Layer – 9.2-mil (233µm) of HD-21A waterborne paint with a glass bead application rate of 690 grams per liter.

Yellow Line

Initial – 7.95-mil (202µm) layer of HD-21A waterborne paint with a glass bead application rate of 700 grams per liter.

Second Layer – 8.4-mil (213µm) of HD-21A waterborne paint with a glass bead application rate of 690 grams per liter.

Field observations of April 17, 2003, show that the HD-21A waterborne paint system is performing very well after a winter cycle (see appendix ‘F’ for photographs). The yellow centerline is in very good shape and would be rated a 7 for appearance and bead retention. The white edge lines are also performing very well and would be rated a 6 for appearance and bead retention.

For comparison purposes retroreflective readings (using the Mirolux 30 meter geometry instrument) were taken on June 16, 2003 at various locations on highway 623 of the HD-21A waterborne paint lines and alkyd paint lines. The HD-21A waterborne paint lines exhibited higher retroreflective values than the alkyd paint lines taken in the same general area as shown in appendix ‘F’ chart 20.

The HD-21A waterborne paint lines are providing very good delineation after one winter cycle. Based on the very good performance of this process on highway 623, it is likely that this marking could provide 2 years of service. Roadway centerlines are painted yearly with the edge lines done in alternating years.

15.0 CONCLUSIONS

1. Initial retro-reflectivity is higher when an application rate of 15 mil is used.

   Although increased application rates will generally provide improved durability there is no long-term improvement in retro-reflectivity. Therefore, the cost increase in the higher application rate may not justify its use.

2. The larger (VISI-L-511) glass beads used with the waterborne lines (Line No. 49 and 46) provided higher initial retro-reflection but exhibited rapid deterioration after 365 days of service (Charts 2, 4, 6 and 8).

3. The HD-21 resin system paints outperformed the other products as summarized in the following tables.
### White

<table>
<thead>
<tr>
<th>Line No.</th>
<th>Paint ID</th>
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<th>Wet Film Thickness</th>
<th>Glass Bead</th>
<th>Weighted ‘R’</th>
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</tr>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>365 Days</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>151 days</td>
<td>365 Days</td>
</tr>
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<td>Rohm&amp;Haas</td>
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<td>P-35</td>
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<td>AC-110</td>
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<td>3.90</td>
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</table>

The weighted ‘R’ value for white line No. 39 (15mil) is virtually the same as 30mil lines 51, 55 and 57. Based on the individual appearance and bead loss components of the weighted score, line No. 39 provides better night time performance and lines 51, 55 and 57 provide better daytime performance.

Similarly the weighted ‘R’ value for yellow lines No. 24 (15mil) and No. 47 (30mil) are virtually the same. However, the individual components are also virtually identical. Given the similarities in performance of these lines it is unlikely that the 30mil application would be cost effective.

4. Based upon the 2000 Traffic Paint test deck results, waterborne paints exhibited higher weighted ‘R’ values and higher long-term retro-reflectivity as compared with traditional alkyd paints. (Appendix D)

5. Field trials suggest that the HD-21A resin paint products could provide extended serviceability as compared to alkyd paint products.

6. Paint applications on new ACP benefit from the application of two thin coats rather than one full application.
16.0 RECOMMENDATIONS

1. A wet film thickness of 15 mils (38 l/lane-km) is recommended at this time due to the minimal gain in weighted R values as a result of increased film thickness.

2. Dual coated beads (AC-110 or Flex-o-Lite) are to be used with the waterborne paints. The current standard Alberta local bead is not to be used for this application.

3. The department should consider moving towards the use of waterborne traffic paints as a result of the improved weighted R values associated with the product. In order to allow the industry time to adjust to this practice a phased implementation is suggested:
   - 25 -30% use in 2004
   - 50 – 75% use in 2005
   - Full implementation by 2006

17.0 IMPLICATIONS OF RECOMMENDATIONS

- Currently waterborne paints are more expensive than alkyds (although Saskatchewan apparently purchases them at a competitive price).

- Waterborne paints require specialized (stainless steel or plastic) equipment. Paint applicators require time to adjust their operations to deliver waterborne paints.

- Reductions of VOC’s will be realized with the use of waterborne paints.

- Potential higher public acceptance of paint line quality.

- Alkyd paints may still be required during early spring and late fall due to temperature limitations of waterborne paints.

- Potential for less tracking with waterborne paint based on field and applicators observations.

- Potentials for longer serviceability particularly for lower volume roads.
<table>
<thead>
<tr>
<th>Line ID</th>
<th>Paint ID</th>
<th>Resin System</th>
<th>Wet Film</th>
<th>Glass Bead</th>
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<th>01-Nov-00 M-30</th>
<th>2-Jun-01 M-30</th>
<th>29-Jun-00 M-30</th>
<th>01-Nov-00 M-30</th>
<th>2-Jun-01 M-30</th>
<th>General App</th>
<th>Bead Loss</th>
<th>General App</th>
<th>Bead Loss</th>
<th>General App</th>
<th>Bead Loss</th>
<th>General App</th>
<th>Bead Loss</th>
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</table>
Chart 1

White Traffic Paint Retro-reflection Outside Wheel Path
(15mil & 30mil)

Note: Line 49, 51, 55 & 57 30 mil

Chart 2

White Traffic Paint Retro-reflection Outside Wheel Path
(15 & 30mil)

(28 days) (151 days) (365 days)

Line No.

(28 days) (151 days) (365 days)

Retro-reflection
Chart 3

White Traffic Paint Retro-reflection Inside wheel Path
(15mil & 30mil)

Note: Line 49,51,55&57 30mil

Chart 4

White Traffic Paint Retro-reflection Inside Wheel Path
(15mil & 30mil)

Note: Line 49,51,55&57 30mil
Chart 5

Yellow Traffic Paint Retro-reflection Outside Wheel Path
(15mil & 30mil)

Retro-reflection

(28 days) (151 days) (365 days)

Note: Line 41, 46 & 47 30mil

Chart 6

Yellow Traffic Paint Retro-reflection Outside Wheel Path
(15mil & 30mil)

Retro-reflection

(28 days) (151 days) (365 days)
Chart 7

Yellow Traffic Paint Retro-reflection Inside Wheel Path
(15mil & 30mil)

- 5
- 7
- 14
- 24
- 30
- 31
- 41
- 46
- 47

Note: Line 41, 46 & 47 30mil

Chart 8

Yellow Traffic Paint Retro-reflection Inside Wheel Path
(15mil & 30mil)

- 28 days
- 151 days
- 365 days

- 5 7 14 24 30 31 41 46 47
- 30mil
Chart 9

White - Appearance Only 'R' Values 28 Days, 151 Days & 365 Days (15mil & 30mil)

Chart 10

White - Bead Loss Only 'R' Values 28 Days, 151 Days & 365 Days (15mil & 30mil)
Chart 11

White - Weighted 'R' Values (15mil & 30mil)  
28 Days, 151 Days & 365 Days

Chart 12

Yellow - Appearance Only 'R' Values 28 Days, 151 Days & 365 Days (15mil & 30mil)
Chart 13

Yellow - Bead Loss Only 'R' Values 28 Days, 151Days & 365 Days (15mil & 30mil)

Chart 14

Yellow - Weighted 'R' Value 28 Days, 151 Days & 365 Days (15mil & 30mil)
Appendix ‘A’

Highway 16 Test track, 2000 Waterborne Traffic Paints
Appendix ‘B’

Road Service Test (Paint Stripe Evaluation – ASTM D713)
### STUDY OF WATERBORNE HIGHWAY TRAFFIC PAINT
#### ROAD SERVICE TESTS
##### ASTM D713

<table>
<thead>
<tr>
<th>FACTOR RATED</th>
<th>DESCRIPTION</th>
</tr>
</thead>
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| a) General Appearance – 50% | Includes: - Abrasion  
- Bleeding  
- Chipping  
- Colour  
- Cracking  
- Dirt Retention  
- Hiding Power  
- Wrinkling  
- Other Failure Types  
As viewed from 2 – 4m, comparing worn and unworn areas, as well as comparing the stripe to panel at the same time, with the same paint thickness and subsequently stored in a cool, dry location. |
| Rated out of 10. | |
| b) Luminous Directional Reflectance | Includes: - Bead Loss  
- Paint Reflectance  
As measured either visually, in sunlight or in an artificial light beam at night, or by a directional reflectance meter. |
| -50% | |
| Rated out of 10. | |

**Total = 100%**

### RATING OF SUBJECTIVE TESTS

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<th>% Lost</th>
<th>Desirable Feat.</th>
<th>% Retained</th>
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<td>100</td>
<td>10</td>
</tr>
<tr>
<td>Slight Trace</td>
<td>1</td>
<td>Excellent</td>
<td>99</td>
<td>9</td>
</tr>
<tr>
<td>Trace</td>
<td>2 – 4</td>
<td>Very Good</td>
<td>96 – 98</td>
<td>8</td>
</tr>
<tr>
<td>Slight</td>
<td>5 – 7</td>
<td>Good</td>
<td>93 – 95</td>
<td>7</td>
</tr>
<tr>
<td>Slight to Moderate</td>
<td>8 – 12</td>
<td>Fairly Good</td>
<td>88 – 92</td>
<td>6</td>
</tr>
<tr>
<td>Moderate</td>
<td>13 – 18</td>
<td>Fair</td>
<td>82 – 87</td>
<td>5</td>
</tr>
<tr>
<td>Moderate to Marked</td>
<td>19 – 25</td>
<td>Fairly Poor</td>
<td>75 – 81</td>
<td>4</td>
</tr>
<tr>
<td>Marked</td>
<td>26 – 34</td>
<td>Poor</td>
<td>66 – 74</td>
<td>3</td>
</tr>
<tr>
<td>Very Marked</td>
<td>35 – 47</td>
<td>Bad</td>
<td>53 – 65</td>
<td>2</td>
</tr>
<tr>
<td>Severe</td>
<td>48 – 68</td>
<td>Very Bad</td>
<td>32 – 52</td>
<td>1</td>
</tr>
<tr>
<td>Complete Failure</td>
<td>68 – 100</td>
<td>None</td>
<td>0 - 31</td>
<td>0</td>
</tr>
</tbody>
</table>

* AS ESTIMATED BY RATING PANEL
Appendix ‘C’

Highway 16 Test track, Equipment
Equipment
Appendix ‘D’

2000 Annual Test Track Results
Alberta Transportation conducts a Road Service Test (6 months) on paint test stripes for a number of paint formulations annually. Evaluations are conducted monthly for a total of 6 months. The best performing paint lines are then selected for the following years road paint application.

The 2000 (annual) traffic line paint test track was applied by AMEC Engineering, which included 12 alkyd and 5 waterborne traffic line paints. These paint lines were applied on the same day that Rohn and Haas applied the waterborne paint lines.

The best performing Alkyd and Waterborne paint lines on the 2000 annual test track (based on Weighted ‘R’ Values) are listed in the following table for comparison purposes:

### White

**Annual Test Track (Alkyd)**

<table>
<thead>
<tr>
<th>Line No.</th>
<th>Wet Film Thickness</th>
<th>Weighted ‘R’ (175 Days)</th>
<th>Mirolux 12 Retro-reflectivity (175 Days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>15 mil</td>
<td>6.88</td>
<td>119</td>
</tr>
<tr>
<td>5</td>
<td>15 mil</td>
<td>6.68</td>
<td>113</td>
</tr>
<tr>
<td>6</td>
<td>15 mil</td>
<td>6.18</td>
<td>120</td>
</tr>
<tr>
<td>1</td>
<td>15 mil</td>
<td>5.59</td>
<td>97</td>
</tr>
<tr>
<td>4</td>
<td>15 mil</td>
<td>5.07</td>
<td>105</td>
</tr>
<tr>
<td>3</td>
<td>15 mil</td>
<td>4.83</td>
<td>104</td>
</tr>
</tbody>
</table>

Waterborne applied to Annual test track

<table>
<thead>
<tr>
<th>Line No.</th>
<th>Wet Film Thickness</th>
<th>Weighted ‘R’ (175 Days)</th>
<th>Mirolux 12 Retro-reflectivity (175 Days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>15 mil</td>
<td>7.23</td>
<td>123</td>
</tr>
<tr>
<td>8</td>
<td>15 mil</td>
<td>7.09</td>
<td>128</td>
</tr>
<tr>
<td>7</td>
<td>15 mil</td>
<td>3.90</td>
<td>81</td>
</tr>
</tbody>
</table>

Note: Line number 7 of the waterborne paint line used a large bead, which did not perform very well.

### Yellow

**Annual Test Track (Alkyd)**

<table>
<thead>
<tr>
<th>Line No.</th>
<th>Wet Film Thickness</th>
<th>Weighted ‘R’ (175 Days)</th>
<th>Mirolux 12 Retro-reflectivity (175 Days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>15 mil</td>
<td>6.84</td>
<td>94</td>
</tr>
<tr>
<td>7</td>
<td>15 mil</td>
<td>6.53</td>
<td>88</td>
</tr>
<tr>
<td>3</td>
<td>15 mil</td>
<td>6.09</td>
<td>100</td>
</tr>
<tr>
<td>8</td>
<td>15 mil</td>
<td>5.85</td>
<td>78</td>
</tr>
<tr>
<td>6</td>
<td>15 mil</td>
<td>5.37</td>
<td>80</td>
</tr>
<tr>
<td>5</td>
<td>15 mil</td>
<td>4.51</td>
<td>86</td>
</tr>
</tbody>
</table>

Waterborne applied to Annual test track

<table>
<thead>
<tr>
<th>Line No.</th>
<th>Wet Film Thickness</th>
<th>Weighted ‘R’ (175 Days)</th>
<th>Mirolux 12 Retro-reflectivity (175 Days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>15 mil</td>
<td>7.84</td>
<td>131</td>
</tr>
<tr>
<td>1</td>
<td>15 mil</td>
<td>6.75</td>
<td>109</td>
</tr>
</tbody>
</table>
When comparing the Weighted ‘R’ results for the best performing Alkyd paint lines Versus the Waterborne paint lines at 175 Days; the results are favorable for the waterborne paints. As shown on the above comparison tables for white and yellow lines, the waterborne lines placed on our annual test track have outperformed the Alkyd paint lines.
Appendix ‘E’

2002 Durable Waterborne Trial (Deerfoot Trail)
HD-21A Waterborne paint trial (Deerfoot Trail, Aug. 14, 2002, between 17\textsuperscript{th} Avenue and Glenmore trail)

Chart 19

Deerfoot Trail retro readings HD-21A (Aug. & Nov. 2002 readings)
Appendix ‘F’

2002 Durable Waterborne Trial (Hwy. 623)
Hwy. 623, Alkyd paint looking east.

HD-21A waterborne paint, white edge line.
HD-21A WB paint lines looking west.

HD-21A paint lines. Paint lines look excellent after winter cycle.
HD-21A WB white edge line, good bead retention and very good appearance.

HD-21A WB paint lines providing very good delineation after one winter cycle.
HD-21A WB yellow centerline

Chart 20

HD-21A, SH623, E. of SH814

<table>
<thead>
<tr>
<th>Location</th>
<th>S. edge line (W)</th>
<th>Centerline (Y)</th>
<th>N. edge line (W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>W. side of Bridge</td>
<td>100</td>
<td>50</td>
<td>20</td>
</tr>
<tr>
<td>E. side of Bridge</td>
<td>150</td>
<td>100</td>
<td>50</td>
</tr>
<tr>
<td>Range rd 233</td>
<td>HD-21A</td>
<td>HD-21A</td>
<td>HD-21A</td>
</tr>
<tr>
<td>Range rd 241</td>
<td>HD-21A</td>
<td>HD-21A</td>
<td>HD-21A</td>
</tr>
</tbody>
</table>

Note: 2 year old alkyd paint on N. edge line