The Joys of Watching Paint Dry (or the Brisbane City Council Pavement Marking Materials Trial)

Dallas Lee
Brisbane City Council

KEYWORDS: Line Marking, Linemarking, Pavement Marking, Road Marking, Waterborne Paint, Thermoplastic.

ABSTRACT

The variety of pavement marking materials and products available to the traffic engineer today is vast and continues to grow! With a wide range of properties, and additives such as glass beads, anti-skid materials and curing agents, the choice is becoming more of a dilemma than ever.

This is the challenge facing Brisbane City Council (BCC) today. With over 5,400 kilometres of sealed road, ranging from residential cul-de-sacs to major arterials, the choice of pavement marking material is critical to ensure longevity of the product and value for money for Council whilst maintaining safe and clear guidance to the road user.

BCC has established two pavement marking test decks containing in excess of twenty-two different products or materials. The decks contain samples of the four major types of pavement marking materials – cold-applied plastics, waterborne paint, thermoplastics and linemarking tapes. The materials are used in combination with glass beads and anti-skid material. The trial also includes examples of raised retro-reflective pavement markers and adhesives.

Since being established in August 2005, the decks have been tested on a regular three monthly basis for visual signs of wear, retro-reflectivity and skid resistance. We wish to share these results and revised processes as examples of an applied engineering technique addressing practical implementation issues.

1 INTRODUCTION

The Brisbane City Council (BCC) is the largest Local Government organisation in Australia and controls over 5,500km of sealed road. This road network is continually growing with the construction of new roads by Council and private developers.

With an aging population and greater vehicle kilometres being travelled each year, the responsibility on road authorities (both local and state) to provide a safe and efficient road network is growing. An integral part of providing this safe road network is the provision of clear delineation and guidance for all road users. For this reason the choice of the correct pavement marking material or system is critical.

Council abandoned the use of solvent-borne roadmarking paints in the 1990's and now uses waterborne paint and hot applied thermoplastic with large drop-on beads for all it's pavement marking requirements. The hot applied thermoplastic material also contains intermix glass beads for long term retro-reflective performance. It is now recognised that this approach may not be delivering best outcomes for road users and Council due to inappropriate material selection for the site leading to accelerated wear. Tighter controls and restrictions on maintenance and capital budgets demand longer life expectations from pavement markings – often well above their intended lifespan. This again has a detrimental the provision of regulation and safe guidance of traffic.

As there has been no field trials of pavement marking materials since the mid 1980's, it was decided to conduct a new trial to test current materials and systems under local conditions.

2 BACKGROUND

2.1 Brisbane City Council Pavement Marking Specification

BCC currently employs a "Method-based" specification system. This is due to the restraints on resources and the delivery/installation processes that requires the use of an internal supplier. The Reference Specification for Civil Engineering Works 2001, S150-Roadworks was recently revised and published in April 2006.

2.2 Changes to BCC Method of Installation

In addition to the above changes to the Specification and Standards, Council has been investigating a number of alternatives to its current work methods. The trial was also seen as a opportunity to evaluate some of these changes.

2.2.1 Equipment

The most notable of the equipment changes was the purchase of a new machine for the application of WB paint for longitudinal lines. This machine has the capability to accurately apply WB paint to thicknesses of up to 600 µm WFT, along with the immediate application of beads and anti-skid material. It is hoped that the testing will prove that lines installed using this machine will provide acceptable performance for use in residential streets and as edge-lines on higher trafficked streets.

Figure 1: New BCC WB Paint Machine for longitudinal lines

Pending the successful evaluation of the WB paint machine, a new machine using the same the platform will be considered for the application of hot applied thermoplastic.

2.2.2 Materials

Council is keen to explore the use of alternative road marking materials. The use of preformed thermoplastic material for many transverse and small longitudinal line sections has proved very successful over the past few years due to the user friendly application method, quicker installation times and consistent material thickness.

The use of temporary tape application is also being actively investigated to improve the safety of temporary worksites and special events.

Previous trials of primers for thermoplastic materials met with mixed results. For this trial, test stripes with and without primer were installed in an effort to determine the ability of the material to bond to the road surface and avoid delamination.

3 TRIAL INFORMATION

3.1 Trial Locations

Two trial sites were sought for the proposed test decks. The sites had to provide a suitable level of traffic wear over a short timeframe (accelerated testing) but provide the ability to access the site with minimal interruption to traffic as well as providing a safe work zone.

3.1.1 Trial Site 1 – Kingsford Smith Drive

Kingsford Smith Drive at Eagle Farm in Brisbane's inner north-west was chosen as the primary and largest test site. The site is on a heavy vehicle route providing access to the Gateway Motorway from a large industrial area.

Traffic counts indicate that approximately 12,500 vehicles/day/lane travel over the test deck, with a heavy vehicle composition of 12.5%. It is recognised that this site is a "worst case" high impact location for pavement marking materials.

3.1.2 Trial Site 2 – Gregory Terrace

Gregory Terrace is in the northern inner-city suburb of Bowen Hills. It is on a suburban route and is more typical of a "busy" Brisbane road – with approximately 7,500 vehicles/day/lane and a commercial vehicle composition of 4.5%.

Figure 2: Kingsford Smith Drive Trial Site

Figure 3: Gregory Terrace Trial Site

3.1.3 Trial Materials – Description

A total of twenty-six different products and product combinations were installed. These included:

- Two-part cold applied plastic (Poly Methyl Methacrylate or PMMA);
- Seven brands of waterborne (WB) paint;
- Two brands of hot applied thermoplastic, (screed and extrusion) and two brands of pre-formed thermoplastic;
- Temporary and permanent Linemarking tapes;
- Raised Reflective Pavement Markers (RRPM), a total of five manufacturers with two adhesives, hot-melt pad and 2-pack epoxy (Kingsford Smith Drive site only);

A full description of the materials applied and their systems (beads, anti-skid materials) are described in the following two sections.

3.1.4 Trial RRPM Materials – As Applied

RRPM Number	Manufacturer Number	Method of Fixation	Install Date
1	1	Flexible 2-pack epoxy	21/08/05
2	2	Flexible 2-pack epoxy	21/08/05
3	1	Hot-melt bitumen pad	21/08/05
4	2	Hot-melt bitumen pad	21/08/05
5	3	Hot-melt bitumen pad	21/08/05
6	4	Flexible 2-pack epoxy	17/12/05
7	5	Flexible 2-pack epoxy	17/12/05

3.1.5 Trial Pavement Marking Materials – As Applied

Product Number	Material Type	Material Thickness				Surface Beads[#]		Anti-Skid Material[§]		Primer		Date Installed	Comments
		Target WFT	Target DFT	Achieved WFT	Achieved DFT	Applied	Target Rate	Applied	Target Rate	Thermo	Tape		
1[A]	PMMA	2.5mm	N/A	NT	NT	Y	450g/m^2*	Y	250g/m^2*	N/A	N/A	21/08/05	Contractor installed
2	WB Paint	300µm	N/A	250µm	230µm	Y	300g/m^2*	N	N/A	N/A	N/A	21/08/05	Hand spryaer/cart
3	WB Paint	300µm	N/A	220µm	175µm	Y	300g/m^2*	N	N/A	N/A	N/A	21/08/05	Hand spryaer/cart
4	WB Paint	300µm	N/A	200µm	190µm	Y	300g/m^2*	N	N/A	N/A	N/A	21/08/05	Hand spryaer/cart
5	WB Paint	300µm	N/A	250µm	220µm	Y	300g/m^2*	N	N/A	N/A	N/A	21/08/05	Hand spryaer/cart
6	WB Paint	300µm	N/A	220µm	200µm	Y	300g/m^2*	N	N/A	N/A	N/A	21/08/05	Hand spryaer/cart
7	WB Paint	300µm	N/A	220µm	200µm	Y	300g/m^2*	N	N/A	N/A	N/A	21/08/05	Hand spryaer/cart
8a	Thermoplastic 1 (Screed)	N/A	2.5mm	N/A	1.5mm	Y	450g/m^2*	Y	250g/m^2*	N	N/A	21/08/05	
8b[A]	Thermoplastic 1 (Screed – Primed)	N/A	2.5mm	N/A	1.5mm	Y	450g/m^2*	Y	250g/m^2*	Y	N/A	21/08/05	
9a	Thermoplastic 1 (Extrude)	N/A	2.5mm	N/A	1.8mm	Y	450g/m^2*	Y	250g/m^2*	N	N/A	21/08/05	
9b[A]	Thermoplastic 1 (Extrude – Primed)	N/A	2.5mm	N/A	1.8mm	Y	450g/m^2*	Y	250g/m^2*	Y	N/A	21/08/05	

10a	Thermoplastic 2 (Screed)	N/A	2.5mm	N/A	1.8mm	Y	450g/m^2 *	Y	250g/m^2 *	N	N/A	21/08/05	
10b[A]	Thermoplastic 2 (Extrude – Primed)	N/A	2.5mm	N/A	1.8mm	Y	450g/m^2 *	Y	250g/m^2 *	Y	N/A	21/08/05	
11a	Thermoplastic 2 (Extrude)	N/A	2.5mm	N/A	1.7mm	Y	450g/m^2 *	Y	250g/m^2 *	N	N/A	21/08/05	
11b[A]	Thermoplastic 2 (Extrude – Primed)	N/A	2.5mm	N/A	1.7mm	Y	450g/m^2 *	Y	250g/m^2 *	Y	N/A	21/08/05	
12	Preformed Thermoplastic 1	N/A	2.5mm	N/A	1.9mm	Y	450g/m^2 *	Y	250g/m^2 *	Y	N/A	21/08/05	
13	Preformed Thermoplastic 2	N/A	2.5mm	N/A	2.6mm	Y	450g/m^2 *	Y	250g/m^2 *	Y	N/A	21/08/05	
14	Permanent Linemarking Tape	N/A	N/A	N/A	1.7mm	N/A	N/A	N/A	N/A	N/A	Y	21/08/05	Product withdrawn from market by manufacturer, material 17 is replacement material from supplier

15	Temporary Linemarking Tape	N/A	N/A	N/A	800µm	N/A	N/A	N/A	N/A	N/A	Y	21/08/05	Premature failure – discontinued in test
16	WB Paint	500µm	N/A	550µm	350µm	Y	450g/m^2 Ω	Y	250g/m^2 Ω	N/A	N/A	21/08/05	Applied with new BCC WB Paint Longitudinal Linemarking marchine
17	Permanent Linemarking Tape	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Y	01/10/05	Replacement material for Material 14.
18[A]	Temporary Linemarking Tape (Yellow)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Y	06/12/05	Replacement for Material 15.
19[A]	WB Paint	500µm	NT	NT	NT	Y	450g/m^2 Ω	Y	250g/m^2 Ω	N/A	N/A	01/06	Applied using BCC WB Paint Longitudinal Linemarking marchine, curing accelerant
20[A]	WB Paint	500µm	NT	NT	NT	Y	450g/m^2 Ω	Y	250g/m^2 Ω	N/A	N/A	01/06	Applied using BCC WB Paint Longitudinal Linemarking marchine, curing accelerant
21b[A] & 21e[A]	WB Paint	500µm	NT	NT	NT	Y	450g/m^2 Ω	N	N/A	N/A	N/A	03/06	Applied using BCC WB Paint Longitudinal Linemarking marchine, Sample

													(b) is Yellow, sample (e) is White.
21c[A] & 21f[A]	WB Paint	500µm	NT	NT	NT	Y	450g/m^2 $_{\Omega}$	Y	250g/m^2 $_{\Omega}$	N/A	N/A	03/06	Applied using BCC WB Paint Longitudinal Linemarking marchine, Sample (b) is Yellow, sample (e) is White.

Legend

NT	Not Tested	#	Class 'D' Large Beads	§	Crushed Quartz material	[A]	Applied at Kingsford Smith Drive site only
N/A	Not Applicable	*	Hand applied (shaker cans)	Ω	Machine Applied		

4 TRIAL OUTCOMES

Skid resistance and retro-reflectivity testing was conducted on both sites in August/September and December 2005 and skid resistance and retro-reflectivity testing on the Kingsford Smith Drive site in March 2006.Further testing is proposed at both sites in June and September 2006. The results are shown in Sections 4.1 and 4.2.

4.1 Skid Resistance Testing Results

Table 4-1 is a summary of the results obtained for the skid-resistance testing at both test sites. Testing was conducted with a British Pendulum testing machine and results are reported as a BPN number. Is should be noted that BCC has adopted a desirable target skid-resistance value of 55 BPN.

Table 4-1 –Skid Resistance Test Results

		Kingsford Smith Drive												Gregory Terrace								
Product Number	Material Type	Overall Average				Wheelpath Average				Between Wheelpath Average				Overall Average			Wheelpath Average			Between Wheelpath Average		
		Aug '05	Dec '05	Mar '06	Jun ‘06	Aug '05	Dec '05	Mar '06	Jun ‘06	Aug '05	Dec '05	Mar '06	Jun ‘06	Aug '05	Dec '05	Jun ‘06	Aug '05	Dec '05	Jun ‘06	Aug '05	Dec '05	Jun ‘06
1	PMMA	51.5	55	58.5	56.5	47	52	59	53	56	58	58	58	Not Installed at This Site								
2	WBP(H)	60.5	54.5	57.5	49.5	74	48	56	45	47	61	59	59	60	49.5	49	59	51	56	61	48	42
3	WBP(H)	63	57.5	54.5	56	71	52	50	53	55	63	59	59	58	47	57	63	52	63	53	42	51
4	WBP(H)	55	66	55.5	54	47	54	55	51	63	78	56	56	61.5	47.5	54	66	44	57	57	51	51
5	WBP(H)	54	65.5	49	50	57	64	45	50	51	67	53	53	62	45.5	50	71	45	50	53	46	50
6	WBP(H)	60.5	70	62	54.5	54	66	55	50	67	74	69	69	62.5	52.5	55.5	65	49	55	60	56	56

7	WBP(H)	70.5	66.5	62	NT	67	66	62	NT	74	67	62	NT	59	48.5	56.5	57	45	59	61	52	54
8	HA TP	80.8	58.5	71.3	62	76.5	55.5	67.0	64	85.0	61.5	75.5	60	37	56.5	72	35	61	75	39	52	69
9	HA TP	83.3	107	68	NT	78	132	64.5	NT	88.5	82.5	71.5	NT	42	53.5	65.5	44	55	71	40	52	60
10	HA TP	90	62.8	61	NT	86	59	57	NT	94	66.5	65	NT	58.5	55.5	63.5	51	55	66	66	56	61
11	HA TP	83.8	62	62.5	59.5	76.5	59.5	62	58	91	64.5	63	61	52	56	63	48	57	65	56	55	61
12	PF TP	93	60.5	60	59.5	93	59	57	56	93	62	63	63	86.5	54.5	65.5	91	59	70	82	50	61
13	PF TP	95.5	59	55.5	NT	95	58	58	NT	96	60	53	NT	91.5	64.5	65	93	62	71	90	67	59
14	LT	92	56.5	60	54.5	92	53.5	54	45	92	59.5	66	64	73.5	51	60	73	47	65	74	55	55
15	LT	NT				NT				NT				66.5	56	NT	67	56	NT	66	56	NT
16	WBP(M)	62.8	53	59.5	56.5	57.3	49	57	54	68.3	57	62	59	NT	57.5	NT	NT	59	NT	NT	56	NT
17	LT	NM	64.5	61.5	56.5	NM	68	57	48	NM	61	66	65	NM	52.5	NT	NM	50	NT	NM	55	NT

4.2 Retro-reflectivity Testing Results

Table 4-2 is a summary of the results obtained for the retro-reflectivity testing. Results are reported in mcd/lux/m^2. Is should be noted that a target installation level is 250 mcd/lux/m^2 and the accepted intervention is 100 mcd/lux/m^2.

Table 4-2 –Retro-reflectivity Results

Product Number	Material Type	Kingsford Smith Drive								Gregory Terrace Retro					
		Overall Average				Wheelpath Average				Overall Average			Wheelpath Average		
		Sept '05	Dec '05	Mar '06	Jun '06	Sept '05	Dec '05	Mar '06	Jun '06	Sept '05	Dec '05	Jun '06	Sept '05	Dec '05	Jun '06
1	PMMA	170	165	156	158	183	160	148	135	Not Installed at This Site					
2	WBP(H)	322	243	187	144	314	191	126	91	220	198	182	204	183	175
3	WBP(H)	178	114	96	71	168	96	71	43	60	42	36	48	33	31
4	WBP(H)	218	99	75	51	222	61	26	18	220	171	142	208	143	115
5	WBP(H)	393	310	254	201	429	321	250	193	190	131	117	166	119	83
6	WBP(H)	287	178	133	88	316	118	78	31	106	73	67	92	60	55
7	WBP(H)	152	89	85	63	138	63	51	40	302	271	252	315	266	247
8	HA TP	66	45	67	56	53	41	77	66	32	16	39	32	16	45
9	HA TP	55	60	87	75	41	57	91	66	11	23	68	12	26	75
10	HA TP	148	125	119	79	151	110	96	68	45	83	140	44	81	136
11	HA TP	110	105	109	91	46	53	86	72	3	78	130	4	77	125
12	PF TP	132	102	84	71	143	71	50	45	158	201	131	164	190	113
13	PF TP	159	144	158	123	155	121	134	95	203	233	181	181	193	166
14	LT	785	548	333	221	768	408	149	62	663	737	523	722	763	380
15	LT	779	MPF			738	MPF			861	707	491	889	643	388

16	WBP(M)	614	382	265	226	605	265	150	118	582	535	475	615	546	476
17	LT	NM	550	209	205	NM	398	209	89	NM	346	76	NM	284	62
18	LT	NM	243	183	165	NM	249	183	125	Not Installed at This Site					
21b	WBP(M)	NM	NM	85[]	230	NM	NM	85[]	226	Not Installed at This Site					
21c	WBP(M)	NM	NM	53[]	171	NM	NM	50[]	153	Not Installed at This Site					
21d	WBP(M)	NM	NM	81[]	338	NM	NM	62[]	345	Not Installed at This Site					
21f	WBP(M)	NM	NM	58[]	281	NM	NM	50[]	289	Not Installed at This Site					

Result Tables Legend

PMMA	Poly Methyl Methacrylate	PF TP	Pre-formed Thermoplastic	NT	Not Tested	MPF	Material Prematurely Failed
HA TP	Hot Applied Thermoplastic	LT	Linemarking Tape	NM	New Material	Bold	Best performing materials (Retro-reflectivity)
WBP(H)	Waterborne Paint, Handcart Applied	WBP(M)	Waterborne Paint, Machine Applied	XX[]	Installation result, not considered valid		

4.3 RRPM Sample Results

Of the original RRPM's installed, all those installed using the 2-pack epoxy had delaminated from the road pavement by December 2005, only three months after installation. The samples installed using the hot melt bitumen pads are still in place, though both have been moved or shoved from their original position. There has been no failure of any of the RRPM's themselves.

4.4 Results – Graphed Examples from Kingsford Smith Drive

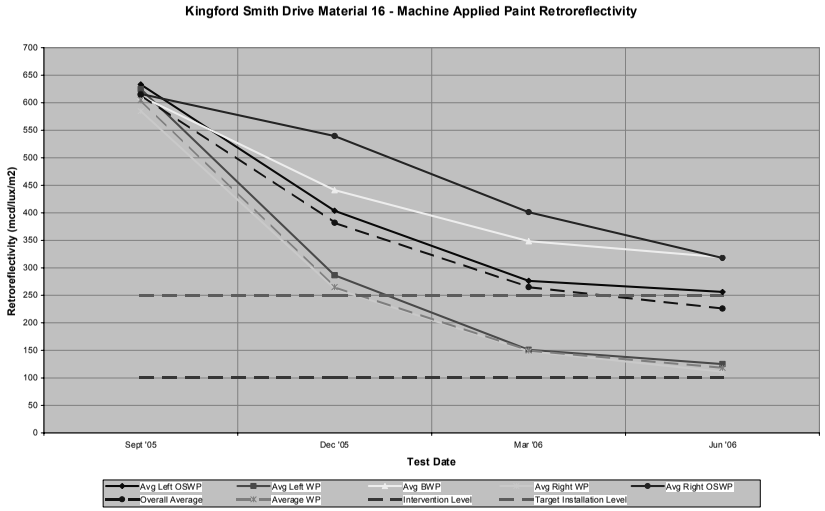

Figure 5: High Performing Retro-reflective Material – Material 16 (Machine Applied WB Paint)

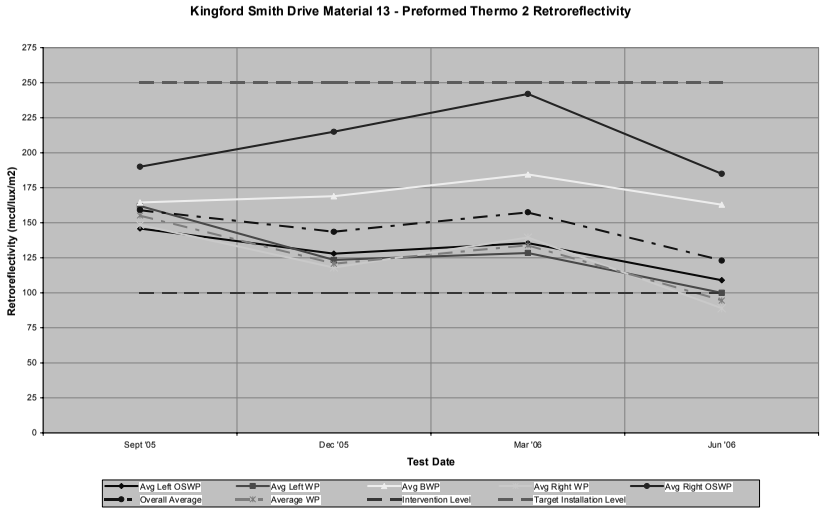

Figure 6: High Performing Retro-reflective Material – Material 13 (Pre-formed Thermoplastic)

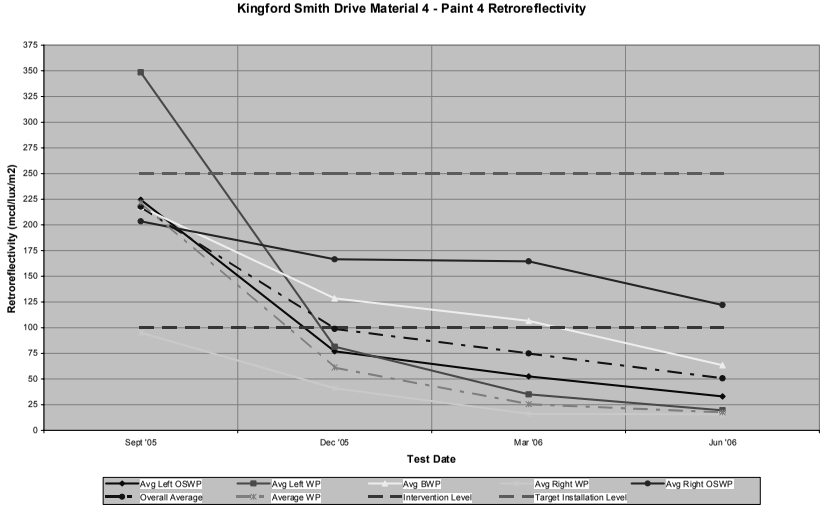

Figure 7: Poor Performing Retro-reflective Material – Material 4 (WB Paint – Handcart)

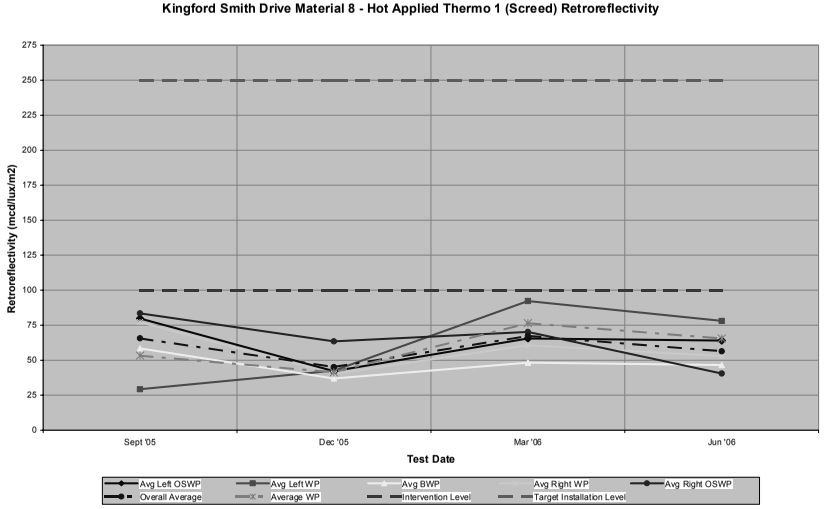

Figure 8: Poor Performing Retro-reflective Material – Material 8 (Hot-applied Thermoplastic)

5 DISCUSSION OF RESULTS AND CONCLUSIONS

There have been large difference in the retro-reflective performance between the two sites – the impact of traffic on Kingsford Smith Drive having a far greater effect than on the materials at Gregory Terrace.

Best performers on Kingsford Smith Drive and Gregory Terrace were Material 1 (PMMA, not installed at GT), Material 4 (WB Paint, Gregory Terrace), Material 5 (WB Paint, Kingsford Smith Drive), Material 13 (Preformed Thermoplastic), Material 14 (Permanent Tape) and Material 16 (Machine Applied WB Paint).

Results from the testing show that material thickness is critical for bead retention and therefore overall line performance. Those lines installed with low wet film thickness (WFT) WB paint (products 2 to 7) have all had significant reduction in brightness due to low bead retention. By comparison, product 16 (machine applied WB paint) with a high WFT has performed exceptionally well, with results equalling or bettering some of the other products, including the thermoplastic and PMMA materials. This has shown that this system may be suitable for use in residential streets and some longitudinal lines on busier roads (eg. edge lines, island outlines, painted tails and chevrons) which do not suffer the impact of normal traffic.

The permanent linemarking tape has produced the best early retro-reflectivity results, with values of 785 mcd/lux/m^2 overall average and 768 mcd/lux/m^2 average for the wheelpaths. However the tapes have had deteriorated quickly to have readings of 221 mcd/lux/m^2 and 62 mcd/lux/m^2 respectively and have experienced problems with delamination, especially when exposed to shear forces or turning traffic.

Initial retro-reflectivity results for the hot-applied thermoplastic materials were low, but they improved over time as traffic wear exposed more of the mixed-in beads.

The lowest performing individual materials for retro-reflectivity are a WB paint (product 4) with values of 75 mcd/lux/m^2 overall average and 26 mcd/lux/m^2 for wheelpaths and a thermoplastic (product 8a) with values of 70 mcd/lux/m^2 overall average and 73 mcd/lux/m^2 for wheelpaths.

The most consistent performing material was Material 1 – PMMA, which while achieving a retro-reflectivity less than target installation values (170 mcd/lux/m average and 183 mcd/lux/m wheelpath), has varied little over the duration of the trial. The material still comfortably exceeds the adopted intervention standard (183 mcd/lux/m average and 135 mcd/lux/m wheelpath).

All materials produced initial skid resistance values above the desirable level and have subsequently maintained this level to date.

The testing has shown that controls over installation are critical and failure to achieve the manufacturers specified material application requirements has a definite effect on long term performance.

6 ACKNOWLEDGMENTS

We wish to acknowledge the efforts and cooperation of the following:

- staff and field crew of Signs and Lines Operations of Brisbane City Works for their efforts in installing the trial sites, especially Luke Riley and Colin Shulz;
- Bob Carnaby of Potters Industries for the retro-reflectivity testing undertaken during the course of the trial'