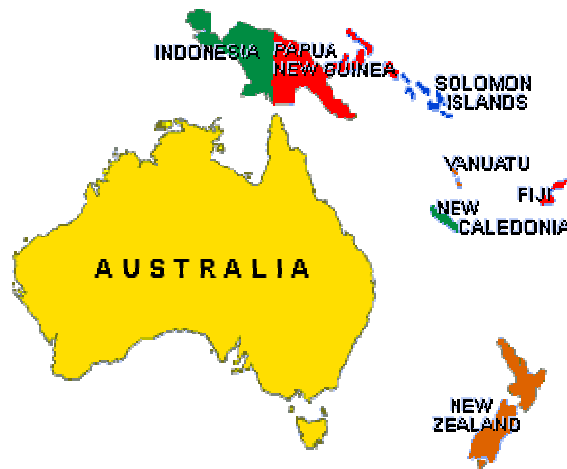


State of the Nation

Pavement Marking Specifications and Performance in Australia

Bob Carnaby
Potters Asia Pacific
bcarnaby@potters.net.au

NZRF Conference
Bay of Islands, NZ
22nd – 24th August 2007



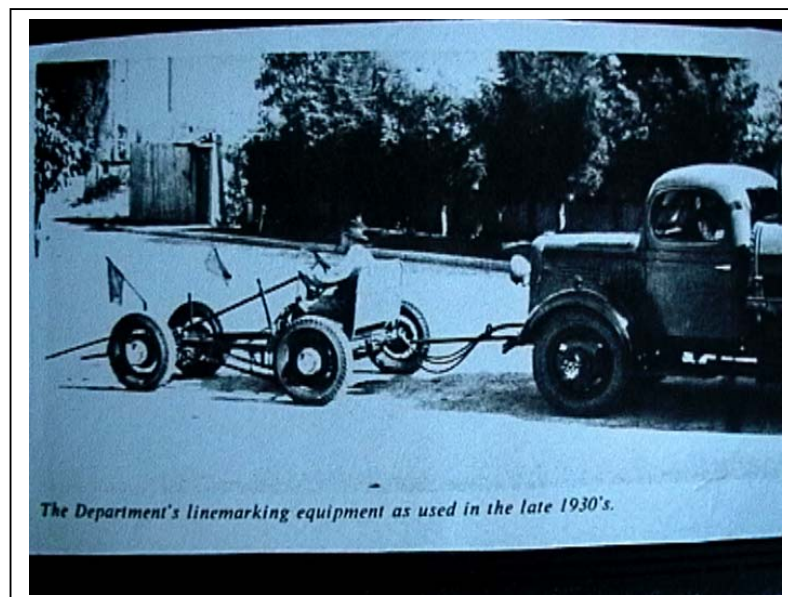
Introduction

This paper sets out to present an overview of the main pavement marking systems and performance requirements as specified by each State and Territory Road Authority in Australia. Also included is information on 'intervention levels' and some variations to what may be considered the 'norm'. Raised pavement markers are not addressed and audible tactile markings are only covered in part.

As it was in the beginning

In Australia the first spray painting of centre lines on the State Highway system commenced in New South Wales in 1938.

N.S.W.'s first linemarking machine consisted of a specially designed chassis on pneumatic tyres, pushed forward by a lorry. Three air operated spray guns were mounted on a chassis. A blower was added to clear dust from the road surface prior to painting. Yellow paint was chosen initially as tests and observations in both Australia and America then indicated that this colour was the most readily visible under the widest range of atmospheric and pavement conditions. Traffic needed to be kept off the line for about 20 minutes after being sprayed to avoid line damage. The rate of application was varied by up to 33% according to the texture of the pavement. The variation of application was achieved by regulating the speed of the vehicle. The best days output up to 1939 was 42.6 line kms. The daily average output exceeded 16 line kms. The two-vehicle crew consisted of a lorry driver, a machine operator, and an attendant who operated the compressor and placed small double-sided wet-paint signs on the roadway as the machine moved ahead. A light truck followed, picking up the wet paint signs and keeping up the supply of paint. The cost of linemarking averaged less than \$AU9/km (broken centre line).



Above: NSW DMR (RTA) linemarking equipment, late 1930's.

The use of painted lines certainly improved the day time delineation and helped to channel the traffic, but at night the lines were hard to see, and they were found to wear rapidly

In the early 1940's in some overseas country during World War II, glass-beaded lines were used on highways to expedite the movement of traffic during 'blackouts'.

Reflectorisation of lines in Australia by using drop-on glass beads for improved night time visibility did not commence until the mid to late 1950's.

Linemarked roads are a part of everyday driving today, and it is difficult to imagine what it would be like to drive without them.

Road Marking Products

These days there are five products that are mainly used for roadmarking in Australia.

These are:

1. Waterborne Paint
2. Solvent Based Paint
3. Thermoplastic
4. Cold Applied, two component, Plastic
5. Glass Beads

Each of these products are available in a variety of grades / qualities:

1. Waterborne Paint
 - Conforming to AS/NZS 4049 Part 3
 - Conforming to APAS GPC-P-41/5
 - Conforming with nothing
2. Solvent Based Paint
 - Conforming to AS/NZS 4049 Part 1.
 - Conforming with APAS GPC-??
 - Chlorinated rubber formulation
 - Alkyd formulation
 - Conforming with nothing
3. Thermoplastic
 - Hydrocarbon formulated
 - Alkyd formulated
 - Conforming with AS/NZS 4009 Part 2
 - Conforming with nothing
 - Suitable for:
 - Extrusion
 - Spray
 - Screed
 - Profiled
 - Preformed
4. Cold Applied, two component, Plastic
 - Suitable for
 - Spray, two component
 - Spray, single component, with activated glass beads
 - Roll on
 - Trowel
 - Brush or squeegee
5. Glass Beads
 - Conforming with AS/NZS 2009-2006
 - Conforming with nothing

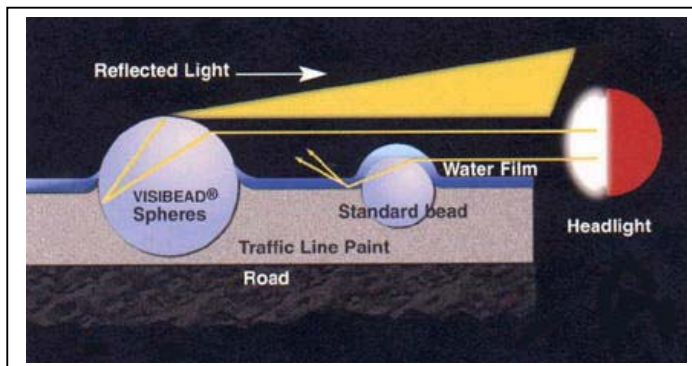
- There are five types identified in the standard. These are:
 - *Type A beads (premix beads)*
These are usually incorporated into low durable paints.
 - *Type B beads (drop-on beads)*
For surface application onto wet painted markings.
 - *Type C beads (intermix beads)*
For incorporation into the material (usually thermoplastic, at a minimum rate of 20% by mass).
 - *Type D beads (large wet-weather beads)*
For surface application to wet painted markings, or incorporated into the marking.
 - *Type D-HR beads (large wet-weather beads with improved retroreflectivity. 'Entry Level' is set at 600mcd/lux/m²)*
For surface application to wet painted markings, or incorporated into the marking.



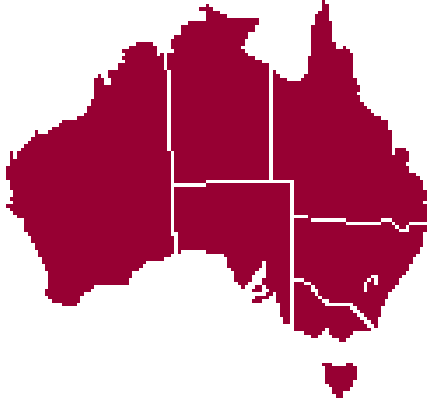
Today's Australian Scene

Although there are Australian Standards that cover roadmarking, each Australian State and Territory has its own version. This can vary from variations in paint type approval systems, to material application rates and even line pattern dimensions. As an example, Victoria specifies their double barrier lines as two lines of 100mm wide each, while in Queensland the same line pattern is of two 80mm wide lines. New South Wales specifies a dry paint film thickness of 0.3mm, while Queensland specifies a lower film thickness of around 0.2mm. South Australia will not allow straddling of the centreline while marking, while most other states do allow it. And so it goes.

One big change in the past decade has been the shift from solvent-based paints to waterborne paint. All State Road Authorities now use / specify waterborne paint almost exclusively. Only a few local governments can be found to still be using solvent based paints. The environment and Occupational health were two good reasons to change. But the thing that really drove the change was the performance in durability, and the improved capability in the retention of glass beads, particularly large beads to AS2009-2002 Class D 'wet-night-visible glass beads'.



Left: Demonstrating how the size of glass beads influences the visibility of painted pavement markings during wet night driving conditions.



Australia

The one thing that is consistent, within the most progressive States of Australia at least, is the realisation of the worth of well maintained pavement markings.

In the past couple of years there has been considerable interest in the performance of painted pavement markings. Decision Makers now want lines to measurably perform in a variety of conditions and in various ways. They no longer want the lines to be just white and straight. They want lines that will last in measurable performance and lines that can safely perform by being very visible at day, at night, and during rainfall. It appears that roadmarkings may no longer be considered *just* another road maintenance activity. Roadmarking is now in the Road Safety arena. And it's about time.



Tasmania

Tasmania has a full road maintenance performance contract in the south of the State that takes in responsibility for pavement markings, while the remainder of the State is covered by Road Marking Spec R64. The pavement markings of choice are thermoplastic and waterborne paint systems.

Tasmania's current Specification R64, produced in February 2005, sets out the following Spec:

Painted Markings

Type	Minimum dry film thickness	Glass bead Type	Minimum glass bead rate
Temporary markings	200 micron dft	Type B	300g/m ²
Standard Markings	300 micron dft	Type D	400g/m ²
*Durable Markings	300 micron dft	Type D	400g/m ²

*NOTE: Durable markings are based on waterborne paint HD21A polymer

Thermoplastic Markings

Type	Thickness	Tolerance	Bead Type	Bead Rate
Extrude	2.5mm	Within 0.5mm	Aggregate / beads 50/50	500g/m ²
Spray	1.0mm	Within 0.5mm	Type D	300g/m ²

Cold Plastic

Two component cold applied plastic may be used as a replacement for other materials listed above. Cold plastic should be applied in accordance with manufacturers instructions. Surface applied particles are to be the same as specified for other products above.

Evidence of Compliance

Retroreflectivity (30m geometry) initial measures required within 2 weeks of marking:

Type	Minimum mcd/lux/m ²	Remark if less
Temporary	150	120
Standard	200	150
Durable	250	200
Thermoplastic	150	120

NOTE:

1. Markings below the minimum and above the re-mark levels will be subject to 10% reduction in the scheduled rates.
2. Markings with initial retroreflectivity that are more than 100mc/lux/m² above the minimum will be subject to a 10% increase on the scheduled rates.



Victoria

Vicroads has all their roads maintained by roadmarking contractors. In country areas the long lines are mostly of waterborne paint and they specify a glass bead that is a little smaller than the Type D bead. The bead is identified as an E20. All lines within town limits are of Thermoplastic, with some Cold Plastic. Most markings are maintained on a set time cycle. Greater Melbourne is mostly Thermoplastic, with some Cold Plastic. The contracts to date have been Schedule of Rates, but trial Performance Contracts, currently being run, may change that. The Draft performance requirements have minimum dry retroreflectivity set at 90mcd/lux/m², and a minimum wet-retroreflectivity of 60mcd/lux/m².

Vicroads have two method based pavement markings specifications. One for new works (Part 772 Pavement Marking - New Surfaces, April 2007) and one for remarkings (Part 721 Pavement Marking - General, April 2007). Vicroads Chapter 15 Pavement Markings Edition 3 Revision 1, April 2006, sets out marking dimensions and other details. Vicroads use a glass bead size that is outside the particle size distribution of the Standard, AS/NZS 2009 : 2006. The glass bead is identified as E20. The particle size distribution is shown below and can be compared with other standards glass bead sizes.

Table 1. Particle Size Distribution of Glass Beads

Sieve size µm	% Passing			% Retained
	Type B Drop-On Glass Beads	E20 Glass Beads (Vicroads Spec)	Type D Wet-night Glass Beads	Type C Intermix Glass Beads
2.36				
2.0				
1.7			100	
1.4		100	95 - 100	
1.18		95 - 100	80 - 95	0 – 3
1.0		80 - 95	10 - 40	
0.85	100	10 - 40	0 - 5	5 – 20
0.71		0 - 5	0 - 2	
0.60	90 - 100	0 - 2		
0.42	35 - 75			65 – 95
0.30	15 - 45			
0.15	0 - 5			
0.075	0 - 1			
Pan				0 – 10

NOTE: The glass beads must comply with the requirements specified in AS/NZS 2009 and Australian Paint Approval Scheme (APAS) Specification 0042. The amount of heavy metals in the beads shall not be greater than that specified in APAS Specification 0042 (refer to Section 3, Table 1, and Appendix A), a copy of which can be found at the following website:
<http://www.apas.gov.au/pdfs/0042.pdf>

New Markings and Re-Marks

New markings are usually applied under lump sum contracts. For painted markings there is a requirement for an initial coat to be applied and left for a period before applying a second coat. Waterborne paint must be used, but the Principal may allow the use of solvent based paint where weather conditions dictate.

The second coat of painted markings is to be applied within 4 to 8 weeks after the initial marking is applied. The table 2 below sets out the specified types and quantities:

Table 2. Minimum Requirements – Paint and Glass Beads

	Paint Water-borne, or Solvent-borne (where permitted)	Glass Beads
Linemarking (longitudinal)		
New Markings (initial application only)	0.3 mm minimum dry film thickness	Type B Drop-on at 250g/m ²
Remarking (including second application on new markings)		
M, A and B category Roads	0.3 mm minimum dry film thickness	E20 at 250g/m ²
C category Roads	0.2 mm minimum dry film thickness	Type B Drop-on at 250g/m ²
Roads without M,A,B,C classification		
Roadmarking (all other markings)		
All Marking	0.3 mm minimum dry film thickness	Type B Drop-on at 250g/m ²

It is a requirement that the Contractor measures the retroreflectivity (30m geometry instrument) between 25 and 25 days after the application of the second coat of pavement marking. The minimum required retroreflectivity, when measured in accordance with the Spec, is 200mcd/lux/m².

For application of thermoplastic as new work the following materials and application rates are required. (The Contractor shall allow for any extra material required when placing on coarse chip seals):

Table 3. Minimum Requirements – Thermoplastic, Cold Plastic, Tapes and Glass Beads

Material	Applied Minimum Thickness, Glass Bead and Other Requirements
Thermoplastic	
sprayed markings	2.0 mm minimum thickness with a minimum of 250 g/m ² of Type B drop-on glass beads retained on the marking surface
extruded line markings	2.0 mm minimum thickness on longitudinal lines with intermix beads intermixed and a minimum of 250 g/m ² of Type B drop-on glass beads retained on the marking surface
extruded road markings ⁽¹⁾	3.0 mm minimum thickness on intersections with intermix beads intermixed and a minimum of 250 g/m ² of Type B drop-on glass beads retained on the marking surface

Material	Applied Minimum Thickness, Glass Bead and Other Requirements
preformed markings	2.3 mm with a minimum skidding resistance value of 45 BPN (British Pendulum Number)
profiled edge lining ⁽¹⁾	8.0 mm minimum thickness with a minimum of 250 g/m ² of Type B drop-on glass beads retained on the marking surface

Table 3 (continued)

Material	Applied Minimum Thickness, Glass Bead and Other Requirements
Cold-applied Plastic	
sprayed line markings ⁽²⁾	1.0 mm minimum thickness for longitudinal line markings only with a minimum of 250 g/m ² of E20 glass beads retained in and on the marking surface
sprayed road markings ⁽²⁾	2.0 mm minimum thickness for all roadmarkings with intermix beads intermixed and a minimum of 250 g/m ² of Type B drop-on glass beads retained on the marking surface
trowelled, screeded, or extruded markings ⁽¹⁾	2.0 mm minimum thickness with Type C intermix beads intermixed and a minimum of 250 g/m ² drop-on Type B glass beads retained on the marking surface
Pliant Polymer Tape	as supplied
<p>⁽¹⁾ The minimum thickness specified shall be the height above the upper road surface level including glass beads.</p> <p>⁽²⁾ The minimum thickness specified shall be the height of the cold-applied plastic material between the glass beads on a metal test plate.</p> <p>⁽³⁾ All other thicknesses shall be as measured on a metal test plate including glass beads.</p>	

Table 3 (continued)

Material	Applied Minimum Thickness, Glass Bead and Other Requirements
Cold-applied Plastic	
sprayed line markings ⁽²⁾	1.0 mm minimum thickness for longitudinal line markings only with a minimum of 250 g/m ² of E20 glass beads retained in and on the marking surface
sprayed road markings ⁽²⁾	2.0 mm minimum thickness for all roadmarkings with intermix beads intermixed and a minimum of 250 g/m ² of drop-on glass beads retained on the marking surface
trowelled, screeded, or extruded markings ⁽¹⁾	2.0 mm minimum thickness with intermix beads intermixed and a minimum of 250 g/m ² drop-on glass beads retained on the marking surface
Pliant Polymer Tape	as supplied
<p>⁽¹⁾ The minimum thickness specified shall be the height above the upper road surface level including glass beads.</p> <p>⁽²⁾ The minimum thickness specified shall be the height of the cold-applied plastic material between the glass beads on a metal test plate.</p> <p>⁽³⁾ All other thicknesses shall be as measured on a metal test plate including glass beads.</p>	

It is a requirement that *all* markings measure an initial 200mcd/lux/m², in accordance with the Specification (30m geometry retroreflectometer), when measure 25 to 35 days after application..

But how well is the Pavement Marking Asset Being Managed?

During late February 2007 a random survey was conducted of some of the Vicroads road asset, with the object to identify pavement marking condition, using portable retroreflectometer measurement equipment. The survey took in many state highways and included rural and urban situations, covering in excess of 2,500 road kilometres, involving more than 7,000kms of linemarking.

The pavement marking condition (results from this survey) was generally found to be consistently poor. This may be due to a combination of things, such as poor quality systems, poor maintenance programming and poor surveillance. One would expect, after thousands of kilometres of linemarking survey, to find more than the odd measure near to the median of performance.

The survey was conducted between 24th February and 2nd March 2007.

NOTES:

1. The survey was conducted with the intention of complete random selection. A frequency of approx 15 to 20km intervals was selected in most cases and located at readily identifiable landmarks (To permit follow up re-checks of recorded data).
2. Only the lower travel-direction centreline mean was recorded. (As is the practise of other State Road Authorities).

Publishing the measured results in this paper has been avoided..

*[“The higher the initial CIL/m² (retroreflectivity), the longer the life of the line” -
Dr JE Kemp, RTA Report No 1841.2, 1998]*



Western Australia

Term Maintenance Contractors (full road maintenance contracts awarded for 10 year terms to the likes of Boral, CSR Emoleum etc), of which there are eight, service this State's requirements. Most pavement making is sub-contracted out to roadmarking contractors. Intervention levels have been set as a minimum performance requirement. Most of the State's markings are of waterborne paint and drop-on glass beads. There is limited use of Thermoplastics and Cold Plastics. Wet-night-visible glass bead treatment have been used in some blackspot areas, as have audible tactile markings. The Pavement Marking Spec for WA is identified as MRWA Spec 604 - January 2007.

Generally waterborne paints are used for all longitudinal pavement markings. Where thermoplastic is used, the specification for dimensions and thickness can be found in Drawing No 9931 0199. Longitudinal thermoplastic is used for audible tactile markings as selected locations. The specified paint system application rates are given below in Table 1. Application rates selected from the table below are at the discretion of the Principal.

TABLE 1. ROAD MARKING PAINT AND GLASS BEAD APPLICATION RATES

PAINT TYPE	COMMENTS	DRY FILM THICKNESS (Minimum)	GLASS BEAD TYPE	GLASS BEAD APPLICATION RATE
SOLVENT (Prior Approval Required)	Maintain existing marking	200µm	AS/NZS 2009 Type B	300g/m ² +/- 50g/m ²
	Install new marking	300µm	AS/NZS 2009 Type B	300g/m ² +/- 50g/m ²

WATER BORNE	Maintain existing marking	200µm	AS/NZS 2009 Type B	300g/m ² +/- 50g/m ²
	Install new marking	300µm	AS/NZS 2009 Type B	300g/m ² +/- 50g/m ²
	Maintain existing marking	320µm	AS/NZS 2009 Type D	500g/m ² +/- 50g/m ²
	Install new marking (Asphalt)	320µm	AS/NZS 2009 Type D	500g/m ² +/- 50g/m ²
	Install new marking (Aggregate)	400µm	AS/NZS 2009 Type D	500g/m ² +/- 50g/m ²

NOTES 1. Prior approval is required for the use of solvent based paints.

2. There are heavy metal limitations set for glass beads in Main Road Standard 71-06-1398.

For transverse and other marking applications, two component cold applied plastic or thermoplastic is used. The application rate is specified as 2.5mm ±0.5mm for either pavement marking material.

Intervention levels for *all* markings is set at:

- Retroreflectivity for white markings >100mcd/lux/m²
- Retroreflectivity for yellow markings >70mcd/lux/m²
- Skid resistance .45 BPN.

But how well is the Pavement Marking Asset Being Managed?

During early January 2007 a random survey was conducted of some of the MRWA road asset, with the object to identify pavement marking condition, using portable retroreflectometer measurement equipment. The survey took in many state highways and included rural and urban situations, covering in excess of 3,000 road kilometres, involving more than 7,000kms of linemarking.

The pavement marking condition (results from this survey) was generally found to be consistently poor. This may be due to a combination of things, such as poor quality systems, poor maintenance programming and poor surveillance. One would expect, after thousands of kilometres of linemarking survey, to find more than the odd measure near to 350mcd/lux/m² or above. Even a few more 200 measures might have been encouraging. This was rarely the case.

The survey was conducted between 2nd January and 7th January 2007.

NOTES:

1. The survey was conducted with the intention of complete random selection. A frequency of approx 20 to 25km intervals was selected in most cases and located at readily identifiable landmarks (To permit follow up re-checks of recorded data).
2. Only the lower travel-direction centreline mean was recorded. (As is the practice of other State Road Authorities).

Publishing the measured results in this paper has been avoided..

[“The higher the initial CIL/m² (retroreflectivity), the longer the life of the line” - Dr JE Kemp, RTA Report No 1841.2, 1998]



Northern Territory

The Northern Territory Pavement Marking Spec is listed under NT Spec 14 Road Furniture. Most pavement markings in the Territory are of waterborne paint. The waterborne paint quality requirement is the same as required in other States and includes APAS 0041/05 and AS4049 Part 3. Thermoplastic and cold-plastic are to be supplied as recommended by the manufacturer and conforming with AS4049 Part 2 and APAS Spec 0041/4. All glass beads are to conform to AS/NZS 2009 : 2006 Type C Intermix glass beads.

Table 1. Application Rates

Material	Longitudinal Markings	Transverse and Other Markings
Water borne Paint dry film thickness (excluding surface applied beads)	> 0.250 mm	> 0.250 mm
Water borne Paint wet film thickness (excluding surface applied beads)	> 0.400 mm	> 0.400 mm
Surface applied glass beads (rate retained in the paint surface)	Type C Intermix glass beads > 300g/m ²	Type C Intermix glass beads > 300g/m ²
Thermoplastic cold film thickness	> 1.5 mm	3.0 mm + 1.0 mm
Surface applied glass beads (rate retained in the painted surface)	Type C Intermix glass beads > 300g/m ²	Type C Intermix glass beads > 300g/m ²

Tolerances for paint applications are set at +0.05mm. Loss of glass beads after 3 weeks shall not exceed 10% of total applied.

The Territory is serviced by Contractors. No retroreflectivity measure requirements are mentioned in the specification. There are no intervention levels mentioned.

The Specification is due for review soon.



South Australia

South Australian pavement marking is covered by SA Spec 246 Application of Pavement Markings, February 2006. Contractors service this State's requirements. Waterborne paint and drop-on sized glass beads are almost exclusively used for all longitudinal markings. Angular quartz and waterborne paint is specified for all transverse markings. Some preformed thermoplastic and Type D-HR glass bead markings and some Cold-plastic and Type D-HR glass bead markings have been used as a spec upgrade in greater Adelaide.

The State is divided into four separate contracts. Surveillance by Transport SA is serviced by Materials Technology Section of the Department. Retroreflectometers are used to measure the performance as an investigation tool, and to justify remark scheduling. Reflectometers are of 30m geometry and calibrated to international CIE Standards.

For new work, two coats of paint shall be applied. Each coat shall be applied together with a concurrent application of glass beads. The first coat shall be fully cured prior to the application of the second coat.

Table 1. PAINT APPLICATION

ITEM TO BE TREATED	PAINT			ADDITIVE	
	TYPE	COLOUR	FILM THICKNESS	TYPE	RATE
Longitudinal Lines	Waterborne pavement marking	White	Wet 300 – 375 μm . *	Type B Drop-on Glass Beads	Min. Retained 275 g/m ²
Pavement messages, symbols, chevrons, diagonals & transverse lines	Waterborne pavement marking	White	Dry 250 – 350 μm .	Premixed with Crushed Quartz	Min. 0.50 kg/L
Traffic island and	Latex exterior	White	New: dry 60 – 90 μm .	Type B	Min. Retained

ITEM TO BE TREATED	PAINT			ADDITIVE	
	TYPE	COLOUR	FILM THICKNESS	TYPE	RATE
median kerbing	flat or low gloss		Maintenance: dry 40 – 60 µm.	Drop-on Glass beads	275 g/m ²
Pavement bars	Latex exterior flat or low gloss	Yellow	New: dry 60 – 90 µm. Maintenance: dry 40 – 60 µm.	Type B Drop-on Glass Beads	Min. Retained 275 g/m ²
Clearway markings	Waterborne pavement marking	Yellow	Wet 300 – 375 µm. *	Type B Drop-on Glass Beads	Min. Retained 275 g/m ²
No standing zones	Waterborne pavement marking	Yellow	Wet 300 – 375 µm. *	Type B Drop-on Glass Beads	Min. Retained 275 g/m ²
Blacking-out	Waterborne pavement marking	Black	Dry 250 – 350 µm.	Premixed with Crushed Quartz	Min. 0.50 kg/L
Rail crossing box hatchings	Waterborne pavement marking	Yellow	Dry 250 – 350 µm.	Premixed with Crushed Quartz	Min. 0.50 kg/L

Retroreflectivity

The measurement of retroreflectivity, as referenced in procedure TP 950, shall be carried out using an MX 30 reflectometer calibrated to a nationally recognised reference standard. If the retroreflectivity at any test location should fall below the value shown in Table 2 below, the affected area, as defined in TP 950, shall have the pavement marking re-applied.

TABLE 2 RETROREFLECTIVITY

AADTE* >10 000 vehicles per day			
Days of Wear	10 to 20	160 to 180	360 to 380
Retroreflectivity, mcd/m ² /lx	240	165	No requirement specified
AADTE 4 000 to 10 000 vehicles per day			
Days of Wear	10 to 20	160 to 180	360 to 380
Retroreflectivity, mcd/m ² /lx	240	175	No requirement specified
AADTE 1 000 to 4 000 vehicles per day			
Days of Wear	10 to 20	160 to 180	360 to 380
Retroreflectivity, mcd/m ² /lx	240	220	No requirement specified
AADTE<1 000 vehicles per day			
Days of Wear	10 to 20	160 to 180	360 to 380
Retroreflectivity, mcd/m ² /lx	265	235	225

* Annual Average Daily Traffic Estimates.

Skid Resistance

Skid resistance shall be greater than 45 BPN, until at least the issue of the Final Certificate, when measured in accordance with TP344 or TP345. If the skid resistance is below 45 BPN the Contractor shall re-apply pavement marking to the affected area.

Test Procedures

The following test procedures shall be used to verify conformance with the Specification:

TEST	TEST PROCEDURE
Determination of Skid Resistance with the GripTester	TP344
Operation of a British Pendulum Portable Skid Tester	TP345
Determination of Retroreflectivity of Pavement Markings	TP907



Queensland

The Queensland Department of Main Roads sets out the requirements for Pavement Marking in their Specification MRS11.45, December 2006. Most of the work in Queensland is carried out in house by government employees. Contractors pick up some shire work, and small quantities of Main Roads work is awarded to them. Most Main Roads work is Schedule of Rates. There is quite a bit of audible tactile edge-lining in some eastern regions and at Blackspot locations across the State. The southern half of the State operates under Spec MRS 11.45. The marking system that is used for the maintenance of longitudinal markings is waterborne paint with Type B glass beads. One southern border region (Warwick) has for some years specified Type D wet-night-visible sized glass beads and waterborne paint for all longitudinal lines on Federal Highways.

The retroreflectivity of pavement markings, both new and repainted, shall be measured between 10 and 20 days after the commencement of normal wear, at a frequency set out in Annexure MRS11.45.1. Glass bead types used may be either Type B or Type D. The retroreflectivity minimum, measured between 10 and 20 days after application, shall be 350mcd/lux/m²; and retroreflectivity minimum before repainting shall be 150mcd/lux/m².

Transverse markings shall contain crushed quartz. New markings shall include 2 coats of the specified application of both paint and glass beads.

Table 1 Application Rates for Paint and Glass Beads

Work Type	Glass bead coverage (minimum per coat)	Wet paint application rate.
Longitudinal markings First coat Type B glass beads	>300g/m ²	0.375 litres/m ² ±25
Longitudinal markings Second coat Type B glass beads	>300g/m ²	0.375 litres/m ² ±25
Longitudinal markings Repaint Type B glass beads	>200g/m ²	0.300 litres/m ² ±25
Longitudinal marking Optional for second coat or repaint Type D wet-night-visible glass beads	>400g/m ²	0.500 litres/m ² ±25
Transverse markings Type B glass beads	>300g/m ²	0.350 litres/m ² ±25

Crushed quartz is to be applied to all transverse markings as per Table 2.

Table 2 Application rates for Crushed Quartz

Material 0.4 to 0.7mm white crushed quartz	Transverse lines
* If stirred into paint prior to application	>500g/litre
* If surface applied	>200g/litre

Thermoplastic (conforming to AS4049 Part 2), where specified, shall be applied at the following rates in Table 3:

Table 3 Thermoplastic application rates

Location	Minimum thickness (mm)
Longitudinal	2
Transverse	2

NOTE: The surface applied glass bead rate for thermoplastic shall not be less than 0.18kg/m²

Audio Tactile Visibility Improvement

Type D-HR wet-night-visible glass beads shall be mixed into the thermoplastic, intended for use as audible tactile markings, at a rate of not less than 20% by mass. In addition, Type D-HR wet-night-visible glass beads, with a proprietary adhesion coating, shall be surface applied to audio tactile markings at a retained rate of 500g/m²

Delineation Safety Upgrade

There has been a new delineation strategy introduced for Northern and Central Queensland that will convert the Spec, during 2007 to 2012, to durable wet-night-

visible markings to upgrade the entire Northern and Central Regions. The strategy is based on past years of field trials that have proven the system to be more durable and more visible for all driving conditions. The system comprises thick film waterborne paint (min 300 micron dft) and Type D-HR glass beads applied at 500 to 560g/m². Once implemented, this will see the northern half of Queensland, covering seven Districts, marked with the new improved system.

The marking frequency shall primarily be determined by reflectometer readings using a purpose built machine having 30 m geometry.

Performance standards for linemarking are as follows:

- Average readings over a road section shall not be below 150mcd/lux/m² in rural areas.
- 10%ile low results shall not be below 150mcd/lux/m².

The delineation upgrade will see edge-line widths increased to 150mm on National Highways and State Strategic Roads by June 2010. All other roads will have their edge-line upgrade applied by June 2012.

Brisbane City Council

Brisbane is the Capital of Queensland. Brisbane City Council uses a mix of Thermoplastic, Cold-Applied Plastic and Waterborne paint as their marking systems. Adhesion coated Type D-HR wet-night-visible sized glass beads are specified for all applications. Brisbane Council intends to introduce performance requirements. Currently they have introduced an extended warranty period of twelve months, and have introduced minimum initial standards to be maintained for the first year at above standards of 250mcd/lux/m² for dry retroreflectivity, 180mcd/lux/m² for wet retroreflectivity, and 45BPN for skid resistance. Significant additional funding has been injected into the roadmarking budget to lift the safety standard of both longitudinal and transverse markings.



New South Wales

The Road Authority has its own crews that service most of the State's requirement for longitudinal lines in country areas. Most of these lines are maintained with waterborne paint and Type D wet-night-visible sized glass beads on roads under State control. Transverse and other markings in rural areas are serviced by contractors using a mix of waterborne paint, thermo and pmma. Local government roads are serviced by a mix of government crews and contractors. Greater Sydney is mostly thermoplastic, with some Cold Plastic, and mostly serviced by contractors. The work serviced by Road Authority crews has performance requirements built into the spec (RTA Spec R146). Remarks are not programmed until they near the set 'wet' and 'dry' retroreflectivity intervention levels. These levels vary depending on the road heirachy and the retroreflectivity levels set for it in the Spec. Most other contracts, carried out by Contractors, are Schedule of Rates (to RTA Spec R141,). But this is expected to change to Performance Contracting within the next six months, where the two existing Spec are to be merged to one and renamed R141W. Spec R141W will contain information in relation to intervention, intervention levels and management of intervention lag time.

The RTA has their own in-house specifications for cold plastic, thermo, waterborne paint and glass bead, which compliment the Australian Standards. CSIRO APAS Spec 0042 is called up for heavy metal limitations in glass beads.

Spec R141

The following table sets out the Spec for waterborne paint, under Spec RTA R141, July 2005:

Table 1 RTA Spec R141 for Waterborne Paint and Glass Beads

Material	Longitudinal lines	Transverse and other lines
Dry paint (excluding beads)	≥0.300mm	≥0.200mm
Surface applied glass beads		
Type (AS2009)	Type D	Type B
Retained Rate	≥400g/m ²	≥300g/m ²
0.4 to 0.7 white crushed quartz		
If stirred into paint prior to application		≥500g/litre
If surface applied		≥200g/m ²

Table 2 below sets out the requirements for non-profiled thermoplastic per R141:

Table 2 Non Profiled Thermoplastic and Glass Beads

Material	Longitudinal lines Spray or extrude	Transverse and other markings Screed	Transverse and other markings Preformed
Thermoplastic cold film thickness	≥1.8mm	3.0mm ±1.0mm	
Surface applied glass beads			
Type (AS2009)	Type D-HR adhesion coated	Type B	Type B
Retained rate (surface)	≥400g/m ²	≥300g/m ²	≥300g/m ²
1.0 to 2.0mm white crushed quartz	≥200g/m ²		
0.4 to 0.7mm white crushed quartz		≥200g/m ²	≥200g/m ²

Table 3 below sets out the requirements for two-part Cold Applied Plastic, per R141:

Table 3 Two Part Cold Applied Plastic and Glass Beads

Material	Longitudinal lines	Transverse and other markings Trowelled, screeded or extruded	Transverse and other markings Sprayed
Cold-applied material thickness (excluding surface beads)	0.50mm ±0.05mm (wet)	2.0mm ±0.2mm (dry)	1.0mm ±0.1mm (wet)
Complete marking thickness			2.0mm ±0.2mm (dry)
Surface applied glass beads			
Type (AS2009)	Type D-HR adhesion coated	Type B	Type B
Retained rate in painted surface	≥400g/m ²	≥300g/m ²	≥300g/m ²
1.0 to 2.0mm white crushed quartz	≥200g/m ²		
0.4 to 0.7mm white crushed quartz		≥200g/m ²	≥200g/m ²

Spec R146

The RTA's in-house performance Spec is identified as R146 (July 2001). Because it is a performance Spec, the roads are divided into segment lengths, for the purpose of measurement of performance. The following table sets out the road hierarchy and section lengths:

Table 1. Road Section Lengths

Existing road hierarchy	Proposed road hierarchy	Intended condition description	Section length	
			Urban	Rural
6,5	M	Provision of a superior standard of pavement markings	600 m	3 km
5	A	Provision of a consistent high standard of pavement markings	600 m	3 km
4,3	B	Provision of a consistent medium standard of pavement markings	600 m	12 km
2,1	C	Provision of a basic safe and trafficable standard of pavement markings	600 m	30 km

Performance Criteria

Retroreflectivity

Some extracts follows, “The acceptance for reflectivity of any pavement marking will be based on a statistical analysis of the marking as determined in Annexure R146/3. The dry Lower Retroreflectivity Value (LRV) to be used in the statistical analysis is listed in **Error! Reference source not found.**” (Table 2).

“For longitudinal linemarking, the analysis will be based on the particular road’s section length. The section lengths for urban and rural zones are listed in Table R146.1 (Table 1) of this Specification.”

“Any pavement marking that fails to meet the statistical acceptance requirements specified in Annexure R146/3 shall be remarked.”

“The dry Lower Retroreflectivity Value (LRV) for any longitudinal linemarking is:”

Table 2 Retroreflectivity Requirements

Existing road hierarchy	Urban		Rural	
	LRV	Period	LRV	Period
6	160	12 months	140	12 months
5	160	12 months	140	12 months
4	160	12 months	160	12 months
3	180	12 months	160	12 months
2	180	12 months	200	12 months
1	180	12 months	200	12 months

“The wet Lower Retroreflectivity Value (LRV) for any longitudinal linemarking shall be 70% that of the dry LRV and shall be measured in accordance with Annexure R146/4.” (not included in this paper)



Australian Capital Territory

The ACT road network is serviced by both government crews and contractors. Waterborne paint and high performance wet-night-visible sized glass beads (Type D-HR) are mainly used for all long lines. Transverse and other markings are a mix of Thermoplastic and Cold Plastic. In past years contracts have been either Schedule of Rates, or Performance. The Performance requirements have included dry retroreflectivity, wet retroreflectivity, and skid resistance. Although the Standards were set high, markings appear to have been maintained only as funds were available. So there is a mix of very safe markings and markings that obviously require some attention.

More recently the performance spec has been merged with the method-based spec to some degree, to produce one pavement marking Specification. This Spec was produced in November 2006 as a working draft, intended to service the Territory and Municipal Services (TAMS) ACT Roads Division as their Pavement Marking Spec (ID Number not known?) over the following 12 months. The performance requirements have been re-drafted to be included in this method based Spec. The Spec will once again be the subject of industry consultation and review after this 12 month period.

The spec requires that glass beads shall be applied uniformly to all markings and shall be applied over the whole surface of the marking in such a manner as to produce a uniform, properly bonded coverage.

Glass beads for surface applications to waterborne pavement marking materials for longitudinal lines shall comply with AS2009 Class "D" beads. In addition, the refractivity index shall be either greater than 1.55 or virgin glass (Type D-HR) with a refractivity index greater than 1.50.

Glass beads for surface applications to all Long Life Material (LLM) pavement marking materials shall be adhesive coated.

The requirement for waterborne paint systems is now specified as follows:

Table 1 Application Rates – Waterborne Paint and Glass Beads

Material	Water Borne Paint		Solvent Based Paint	
	Longitudinal Line marking	Transverse Lines and Other Markings	Longitudinal Line marking	Transverse Lines and Other Markings
Dry paint thickness (excluding surface applied Drop On beads)	$\geq 0.300\text{mm}$	$\geq 0.200\text{mm}$	$\geq 0.175\text{mm}$	$\geq 0.175\text{mm}$
Surface applied Drop On beads/quartz:-	$\geq 500\text{g/m}^2$	$\geq 400\text{g/m}^2$	$\geq 400\text{g/m}^2$	$\geq 400\text{g/m}^2$
Alternative Surface applied large glass beads	$\geq 500\text{g/m}^2$	-	-	-

The application rates for thermoplastic systems follows:

Table 2 - Application Rate - Non Profile Thermoplastic Material and Glass Beads

Material	Longitudinal Line marking	Transverse Lines and Other Markings	
		Screeded, Sprayed or Extruded Thermoplastic	Preformed Thermoplastic
Thermoplastic cold film thickness (excluding surface applied glass beads)	$\geq 1.5\text{mm}$	$3.0\text{mm} \pm 0.5\text{mm}$	-
Thermoplastic application thickness	-	-	$2.5\text{m} \pm 0.5\text{mm}$
Surface applied Drop On beads / quartz	$\geq 500\text{ g/m}^2$	$\geq 400\text{ g/m}^2$	$\geq 400\text{ g/m}^2$
Alternative Surface applied large glass beads	$\geq 500\text{ g/m}^2$	-	-

The application rate for PMMA follows:

Table 3 - Application Rates - Two Part Cold Applied Pavement Marking Material and Glass Beads

Material	Longitudinal Line marking	Transverse Lines and Other Markings	
		Trowelled, Screeded or Extruded	Sprayed or Rolled
Dry Cold Applied Plastic thickness (excluding surface applied Drop on beads)	0.55mm ± 0.05mm	2.0mm ± 0.20mm	1.0mm ± 0.1mm
Surface applied Drop On beads:-	≥750 g/m ²	≥750 g/m ²	≥1200 g/m ²
Alternative surface applied large glass beads	≥750 g/m ²	-	-

There are many references to NSW RTA Specifications throughout the document, including the spec for all materials, including limitation for heavy metals in glass beads as shown in Table 4:

Table 4 – Heavy metal content for Glass Beads

Heavy Metal	Requirement
Arsenic (As) Antimony (Sb) Lead (Pb)	Not greater than 50ppm each element
Mercury (Hg) Cadmium (as the oxide) (Cdo) Chromium (tri-valent) (Cr ₂ O ₃)	Not greater than 10ppm each element

Reflectivity Testing

The Spec requires that the pavement marking reflectivity is to be provided by application of solid glass beads to the pavement markings, expressed in millicandelas per lux per square metre (mcd/lux/m²) as measured by an MX30 retroreflectometer or approved equivalent.

Testing is to be performed within six weeks of the pavement markings application, but no sooner than three weeks and shall be tested at the frequency specified in Table 6 (below). The contractor shall provide a report to the superintendent that includes a clear description of the locations of all representative test sites and shall include all reflectivity readings and reflectivity values associated with the test sites. The

locations of all representative test sites and reading locations are to be easily identifiable on site using a method that is approved by the superintendent. The Superintendent shall witness and confirm the reflectivity test results on the site. Each representative test site shall include five readings taken within close proximity of each other (ie approx 1m apart). The average of these five readings will represent the reflectivity value for that representative test site.

All pavement markings shall be applied in such a manner that 80% of representative test sites do not have less than the specified reflectivity values shown in Table 5. Any markings where the reflectivity value is between 80% and 100% of the specified value will be subject to additional reflectivity testing at additional points as specified and witnessed by the Superintendent, at the contractor's expense. These sections will be required to be remarked, unless 80% of the reflectivity values, from this further testing as specified and witnessed by the Superintendent, equals or exceeds the specified reflectivity values.

All sections where representative test sites are less than 80% of the specified reflectivity values shown in Table 5 will be required to be remarked , until 80% of the reflectivity values, from further testing as specified by the Superintendent, equals or exceeds the specified reflectivity value, at the contractor's expense.

Friction Testing

The skid resistance of pavement markings shall be as specified in Table 5. The skid resistance (in BPN) shall be measured by a laboratory, which is registered for skid resistance testing with the National Association of Testing Authorities.

Skid resistance testing shall be arranged by the Contractor, and carried out on markings within the critical paths of the pavement at locations identified by the Superintendent. These will generally include markings within intersections involving hold and stop lines, arrows, pavement messages, and other markings identified in Table 5. Testing is to be performed within six weeks of the pavement markings application, but no sooner than three weeks and shall be tested at the frequency specified by the Superintendent.

The contractor shall provide a report to the Superintendent that includes a clear description of the locations of all test sites identified by the Superintendent, and shall include all applicable friction test results and, the original copies of the National Association of Testing Authorities laboratories test certificates.

Table 5 Line marking Reflectivity and Friction Testing Requirements
(White markings unless otherwise stated)

Line Type	Code	Description	Reflectivity (mcd/lux/ m ²)	Friction (bpn)
SEPARATION LINES	S1	ALL ROADS (EXC RURAL)	250	
	S1	RURAL ROADS	250	
	S2	MULTILANE CARRIAGE WAY IN URBAN AREAS	250	
BARRIER LINES	S3	CYCLE OR FOOTPATH	NR	
	B1	TRAFFIC LANES	250	
	B2	PARKING BAY	NR	
	B3	RESERVE PARKING, KEEP CLEAR IN CAR PARKS (YELLOW LINES)	NR	
		KEEP CLEAR IN TRAFFIC LANES (YELLOW LINES)	50	45
	B4	NO CROSSING IN ONE DIRECTION	250	
LANE LINES	B5	NO CROSSING EITHER DIRECTION	250	
	B6	CYCLE OR FOOTPATH	NR	
	L1	RURAL ROADS & SUB-ARTERIALS	250	
	L2	ARTERIALS	N/A	
	L3	ARTERIALS SPECIAL CONDITIONS	N/A	
CONTINUITY LINES	L4	EXIT LANE ON ROUNDABOUT	100	45
	L5	TRANSIT LANE	250	
	C1	CONTROLLED INTERSECTIONS, SHORT TAPERS, TURNING LINES	100	45
		LONGITUDINAL C1's AT CENTRE AND SIDE OF ROADS	250	
	C2	BUS BAYS, DISABLED PARK'G, LOADING ZONES, TAXI RANKS (YELLOW LINES)	50	45
MERGE LINES	C3	PARKING BAYS	NR	
	M1/ M2	MERGE, DIVERGE, LONG TAPERS, ACCELERATION & DECELERATION	100	45
EDGE LINES	E1	EDGE LINE LEFT HAND SIDE	250	
	E3	DIVIDED ROAD RIGHT HAND SIDE	250	

Line Type	Code	Description	Reflectivity (mcd/lux/ m ²)	Friction (bpn)
CROSS WALK LINES	XW L	TRAFFIC SIGNALS, CONTROL INTERSECTIONS	100	45
	SCS	CROSSING MARKS AT SCHOOL CROSSINGS	100	45
STOP LINES	ZC	ZEBRA CROSSING STRIPES	100	45
	SL1	AT TRAFFIC SIGNALS & SCHOOL CROSSINGS	100	45
	SL2	AT PRIORITY INTERSECTIONS	100	45
HOLD LINES	HL1	GIVE WAY AT CONTROLLED INTERSECTIONS	100	45
TRANSVERS E	TB	TRANSVERSE BAR SPEED REDUCTION	100	45
OTHER MARKINGS		CHEVRON MARKINGS IN TRAFFIC LANES	100	45
		OTHER MARKINGS AND MESSAGES IN TRAFFIC LANES	100	45
		MARKINGS AND MESSAGES IN PARKING AREAS	NR	
COLOURED SURFACE COATING	WG	WHITE GORE	100	45*
	CSC	COLOURED SURFACE COATING	NR	55

Notes to Table 5:

1. Unless otherwise stated, reflectivity values for yellow markings are to be 50% of the values specified for white markings.
2. NR: No requirement for reflectivity
3. * Friction test requirement applies to gores on concrete paving only (ie not kerb faces).

TABLE 6 Minimum Frequency of Testing of Pavement Markings

Characteristic Analysed	Test Method	Minimum frequency of testing
Waterborne Paint		
Wet/Dry Film Thickness	RTA T841	Two per day per line type AND after pressure, speed settings are changed.
Surface Friction	RTA T231	Frequency of testing will be based on the tendered Pay Item for the relevant contract. Testing shall be carried out on markings identified in Table 11.9 as specified by the superintendent.
Thermoplastic Pavement Marking Material		
Wet/Dry Film Thickness	See Clause 11.11.2 (ii) and 11.11.2 (iii)	Two per day per line type AND after pressure, speed settings are changed.
Surface Friction	RTA T231	Frequency of testing will be based on the tendered Pay Item for the relevant contract. Testing shall be carried out on markings identified in Table 11.9 as specified by the superintendent.
Cold Applied Pavement Marking Material		
Wet/Dry Film Thickness	RTA T841	Two per day per line type AND after pressure, speed settings are changed.
Surface Friction	RTA T231	Frequency of testing will be based on the tendered Pay Item for the relevant contract. Testing shall be carried out on markings identified in Table 11.9 as specified by the superintendent.
Glass Beads		
Application rate of glass beads	RTA T1208	Two per day or 1 per site visit of linemarker, whichever is the greater AND after pressure, speed settings are changed.

Characteristic Analysed	Test Method	Minimum frequency of testing
Reflectivity Reflectivity values	The Roads ACT retroreflectometer (MX 30) will be the reference unit and a reproducibility factor of 10% will be accepted for other MX 30 units. See Clause 11.06.2	One representative test site is required for each line type within every 200 lineal metres of road pavement on the subject road (Regardless of the extent of pavement markings within that length of road pavement.) Each representative test site shall include five readings taken within close proximity of each other (ie approx 1m apart). The average of these five readings will represent the reflectivity value for that representative test site. The subject road is to include any side road (if specified in the contract) on which the markings do not extend further than 70m from the transverse markings on the subject road. Reflectivity test readings for repeat testing, will be based on an average of five readings in the vicinity of the initial readings, i.e. within 20 metres Reflectivity values for white and yellow markings are specified in Table 11.9.
Coloured surface coatings		
Binder Thickness		In accordance with the Contractor's written procedure
Surface Texture	RTA T240 RTA T192	One per lot
Surface Friction	RTA T231	Frequency of testing will be based on the tendered Pay Item for the relevant contract. Testing shall be carried out on markings identified in Table 11.9 as specified by the superintendent.
Delamination and Ravelling		In accordance with the Contractor's written procedure
Colour	AS 1580.601.1	One per lot.

Let There be Light

What the world's experts say about the importance of pavement markings:

- *"Unfortunately, [the] potential benefit - and well proven effectiveness - of road markings is not sufficiently exploited by the relevant decision makers [to improve road safety]." (Introduction, COST 331).*
- "Large glass beads are used to add wet weather retroreflectivity to conventional markings. The beads need to be at least 1mm in size" CIE International Commission on Illumination, 1999 .
- *"The majority of traffic fatalities occur at night" Boyce 1981.*
- *"Traffic fatalities are 3 to 4 time higher at night, than day" Boyce 1981.*
- *"Improved night-time visibility for drivers can be a major factor in reducing accidents" Boyce 1981.*
- *"The higher the initial CIL/m² (retroreflectivity), the longer the life of the line" - Dr JE Kemp, RTA Report No 1841.2, 1998*
- *"For highway speeds above 80 km/hr, a minimum RL value of 150mcd/lux/m² was recommended". Transport Research RECORD 1657, Migletz, Graham, Bauer and Harwood.*
- *For roads with an AADT of 5,000, the minimum retroreflectivity required is 150mcd/lux/m² (30m geometry) (Dravitzski, Laing & Potter, Opus Labs NZ. 2004).*
- *The Australian Institute of Traffic Planning and Management (AITPM) says that line marking, which is described as "an essential element of a modern road system", is the most cost effective road safety measure. Line marking can reduce car accidents by as much as 60%, the report says, and with correct levels of contrast and brightness the reflective lines can prevent crashes on bends, at night on rural roads. ('Linemarking Standards - Searching for best Practice' – May 2004. See www.aitpm.com)*
- Retroreflectivity has more influence over end of line detection distances than head lamp illumination, (Zwahlen & Schnell, Uni of Ohio USA 1998).
- *"Faded edgelines are worse than no edgelines at all. This complicates a drivers ability to maintain visual stability. Optic flow in driving, using edgeline motion is effective visual cue for control of heading and lateral control". Molino KA 82nd TRB 2003.*
- *"Retroreflectivity threshold value should be in the range 140-156mcd/lux/m², based upon maintaining a crash rate below the overall average" Abboud and Bowman 81st TRB 2002.*
- Peter Moses, MRWA, paper entitled 'Edge Lines and Single Vehicle Accidents', 1986, Peter found that by using wider edge-lines (150mm) the visual perception of edge-lines by those effected by alcohol and drowsiness resulted in better vehicular trajectories. In this study, analysing only the single vehicle run-off-the-road type accident, not involving alcohol or mechanical failure, the number reduced from 83 to 55. A reduction of 34%. This may appear to be 'old news' and not relevant to today's times. However, nearly twenty years later, in the same State, another member of MRWA, Mr B Kidd, presented a paper at the Austroads 2001 Road Safety Conference, entitled

'Crash Patterns in Western Australia', statistics are presented that argue the benefits of improved night time delineation. Some extract follow: "In taking traffic into account it is shown that both the risk and the severity of crashes is higher at night time than daytime particularly in the open road environment". "The results should not only be useful to road safety agencies in WA but also to agencies elsewhere in Australia". "A total of 38,100 crashes were reported in 2000". "The risk analysis based on amount of travel found that the night-time crash risk on the open road is about 3 times greater than that of day light hours". "The severity of crashes at night is higher than that during the day both in the urban and open road environment". "In the open road environment the annual cost of night time crashes was estimated to be \$108M being 46% of total open road crash costs. This suggests that half of open road safety resources should be directed at night time treatments. In urban areas the annual cost of night time crashes was estimated to be \$291M being 35% of total urban crash costs. In this case the results suggest that a third of urban road safety resources should be directed at night time treatments".

For the Information of the Uninitiated



The two lines pictured on the left side image are both very visible when viewed on a dry night. But when the road is wet, as shown on the image on the right, the picture tells a different story.

The only difference is the size of the glass beads used. Large glass beads conforming to AS/NZS 2009-2002 Type 'D' or 'D-HR' wet-night visible glass beads can provide this level of delineation during wet night conditions.



Final Comment

If Type B beads and waterborne paint systems are your interest, or new durable wet night systems are your interest, then you couldn't go past the South Australian model. If Type D AND Type D-HR beads and waterborne paint are your interest, then look at NSW Spec R146, or the ACT Spec. But keep an eye on Queensland. With the Main Roads Department's Northern and Central pavement marking policy and Spec, and the Brisbane City Council Spec, we are seeing higher performance marking systems with durable track records (both using Type D-HR glass beads), being produced

The Last Word

For near fifty years the roadmarking industry has been in stagnation. Things are dramatically changing now though, and quickly.

Roadmarking is out of the road maintenance arena and into the road safety arena. Decision makers want more than thick white lines. The move across Australia, and indeed across the world, is to safer and more durable markings. Not more durable in the sense that they are just thick, but more in the measurable performance areas that deliver continuous service to the travelling public by providing lines that can guide in almost all driving conditions, day and night, wet and dry.

Appendix 1

Glass Bead Particle Size Distribution to AS/NZS2009:2006.

Sieve size, μm	Glass bead type			
	A	B	C	D
	Percent RETAINED by mass	Percent PASSING by mass	Percent RETAINED by mass	Percent PASSING by mass
1700				100
1400				95-100
1300			Trace	
1180			0-3	80-95
1000				10-40
850		100	5-20	0-5
710				0-2
600	0	90-100		
425	10-30	35-75	65-95	
300	40-60	15-45		
212	20-40			
150		0-5		
108				
75		0-1		
Pan	0-10		0-10	

Biography - Bob Carnaby

Bob Carnaby has been involved in the road-marking industry for the past thirty-nine years. He has worked in both the public and private sector, always directly involved with road-marking application activities. Over this period Bob has managed road-marking operations, consulted to ARRB Transport Research, sat on Standards committees, and chaired sub committees in the areas of safety and development of training with the Australian Road Marking Industry Association. He has initiated and been involved with large scale road-marking field trials in various parts of the Asia Pacific Region, Europe and the United States.

Bob has presented papers at domestic and international conferences such as, ARRB, Austroads Road Safety, AITPM, Roadmarking Industry associations of Australia and New Zealand, and the Indian Road Congress.

Bob is employed by Potters Asia Pacific as Product Manager, for road safety products.

