WAKA KOTAHI
NZ TRANSPORT AGENCY

NZTA M07 NOTES: 2022

NOTES FOR THE SPECIFICATION FOR ROAD MARKING MATERIALS

New Zealand Government

1 INTRODUCTION

NZTA M07 specification sets out the minimum requirements for materials used for road marking. It describes the process used for the assessment and approval of marking materials and the management of the List of Approved Products.

The 2022 update to M07 revises the approval process and provides clarification on the way in which approvals are renewed for materials on the List of Approved Products. The update also widens the means by which performance of candidate materials are demonstrated by allowing Australian Paint Approval scheme (APAS) certification to be presented as evidence of performance.

The List of M07 Approved Products can be used to assist product selection. Products on the list have demonstrated successful application and properties through field trials to the level indicated.

It is important that appropriate product selection and application are used to obtain the required road marking performance. Specifiers and applicators are encouraged to understand products in direct consultation with manufacturers/suppliers including application rates and application conditions with respect to the specific site and performance expected.

These notes are prepared to assist understanding of properties and introduce concepts for management of road markings. The notes are not intended to cause change in accepted policies and practices for the selection and use of delineation materials but are provided for information and explanation only.

2 PROPERTIES

2.1 General

The 2022 version of NZTA M07 references the AS 4049 series of standards for Paints and Related Materials – Pavement Marking Materials. Either a field trial in New Zealand or APAS certifying compliance with the relevant part of AS 4049 may be used to demonstrate field performance.

2.2 Definitions

In the context of this 2022 version of M07 specification, and these Notes terminology is defined as follows:

(a) Colour: Uniformity in colour is necessary to provide a consistent experience to road users, essentially the white needs to be readily recognisable to road users as white and the yellow as yellow, and there needs to be an unequivocal distinction between the two colours because of their different roles. In the past some high build materials have appeared satisfactory in the day but have appeared pale yellow at night under headlights, and this was because they were, in effect, under-pigmented. Colour may be determined precisely by spectrophotometer in the laboratory but in the field a comparison with colour swatches that are standard colours from AS 2700 is sufficient. Colour is also recorded in the on-road performance trial but that allows for a level of colour loss or discoloration which is controlled by limits set according to the discolouration or grey scale.

(b) Condition in the container: At delivery, the material “in the container” should be in good condition and consistent (e.g. free of lumps or skinning) for use as intended. “Condition in the container” typically applies to liquid materials and the test is framed accordingly but the concept is equally important for solid materials. That is if a material is expected to be a free-flowing powder it should not contain hard clumps, but no tests for solid materials are currently specified.

(c) Consistency: Consistency describes the overall flow properties of a material. This is important in achieving an even application and consistency of performance

(d) Density: Quality check used as an indicator that the product contains its main ingredients in the expected proportions but is not sensitive to those ingredients used only in very small quantities.

(e) Early washout resistance: Applies only to waterborne paints, as waterborne materials are based on emulsions. Even when touch-dry they can be re-emulsified when wetted. While solvent based materials may be damaged by early rain, they are not emulsions and so do not re-emulsify. The test is an indication that the paint will have a reduced risk of washing off the road in the event of rain soon after application

(f) Fineness of grind: Sufficient grind (particle size) minimises pigment settling and assists dispersion of particles. Achieving a certain particle size of the pigment is critical for good hiding power.

(g) Fineness of paint: A property to avoid clogging of application equipment

(h) Flow resistance: Indicative of the distortion of marking lines under traffic in hot conditions and important for clarity of the road marking when initially applied.

(i) Heat stability: Heat stability is relevant to thermoplastics. Some materials can discolour if overheated or heated multiple times. "Heat stability" checks the luminance (colour) is satisfactory after extended heating.

(j) Non-volatile content: Refers to the solids (binder and pigment) after the solvent or water is gone. Volume of solids is a direct indication of the amount of wet material to apply to achieve a desired dry film thickness and is used by contractors in setting the flow rates through the guns. Solvent borne materials have typical volume solids contents of 50-55%, waterborne materials about 65%, "cold" plastic nearly 100% and thermoplastic 100%

(k) No pick-up time: Aimed at avoiding materials that will take excessive amount of time to set up. This has practical and traffic control implications. This is a laboratory result with relevance to on-road application, but the no pick-up time laboratory result is not "advice" or a guarantee of on-road performance as the time will be influenced by the actual conditions at time of application

(l) ONF: "One Network Framework". The One Network Framework is the Waka Kotahi new national classification system. It is used to determine the function of our roads and streets, and inform decision making.

(m) Resistance to bleeding: This applies to solvent paints which have been known to interact with bitumen and cause a brown staining which continues to come through successive coats.

(n) Skid Resistance: High build materials have been claimed in the past to be implicated in cycles "tramlining" on the edge of the marking and the skid resistance of markings greater than 0.9mm thick has been set at 55BPN or greater, whereas other markings which are thinner need be only 45BPN or greater.

(o) Softening point: The point as which material reaches a certain stiffness in a standardised test. It is important as the material should not be too stiff in cold conditions as it can be prone to cracking or too soft in warm conditions as the material may flow. Thermoplastic (and Cold Plastic) high build materials need to be textured to provide wet night visibility, and this texture would flatten under trafficking if the softening point was too low.

(p) Specular gloss: Specular gloss is the perception by an observer of the mirror-like appearance of a surface. The aim is to limit specular gloss to assist visibility. The desire is to have what is known as an eggshell type finish; light should hit it and scatter so exhibiting no reflective sheen.

(q) Tramlining: A term used with high build markings when a bicycle is crossing a marking at a narrow angle and the wheel drags along-side the marking rather than riding up and over the edge. This reportedly can happen when the marking has a low level of friction and is like the effect of steel rails, such as tram tracks.

2.3 Road Marking Approval Processes

At present, prior to a marking being approved for widespread use, on-road trials are used to assess the performance of road markings. While data gathered from normal use in other forms of contract can be useful it usually does not provide the full range of the progression of the product from application, through mid-service life to near end of life. Product guarantees that are not supported by objective performance data are not a recommended form of product selection.

The M07 specification permits both transverse and longitudinal trials. Transverse trials provide accelerated testing of marking performance under trafficking, but there are some components of environmental degradation especially when testing products which have extended, long life or ultra-long-life performance. M07 allows that additional sample areas may also be tested and reported. For transverse lines, readings in between the wheel paths are also suggested as this provides data on the performance in a less severely trafficked environment more akin to the longitudinal trial. This "between wheel path" area also has a longer period for the product to set up before it is heavily impacted by trafficking.

The longitudinal trial is a time-based trial without the same accelerated wear component as the transverse trial. Longitudinal trials may extend from 1 to 5 or more years in duration and with these time periods the environmental degradation of the marking will occur. Often this will be hardening over the hotter summer period so that markings lose adhesion to the road or to the retained beads.

Lines on straights and internal curves are often crossed by vehicles. Lines on the outside of corners are seldom crossed.

The M07 specification has limited trials to reasonably high traffic situations so as to ensure wear is a combination of trafficking and environmental degradation.

Trials are undertaken in what are usually favourable application conditions and represent performance in the particular location under the specific conditions of that trial

Many location and application condition variables will influence performance, so that actual performance within a contract may be better or worse than has been indicated by the on-road trail but the trial will provide a reasonable ranking of products. Later in the notes a process of monitoring and managing the road marking performance in specific contract area is recommended

2.4 Approved Products List

The approved products list is based on the results from on-road performance trials where the product will have been applied in certain conditions, at a certain thickness and with particular beads. The parameters which the certification is based, and the quality assurance testing regime should be sought from the manufacturer/supplier when considering a product.

3 SERVICE-LIFE EXPECTATIONS

3.1 Basic material characteristics

Generic Information about materials used in road marking can be found in the NZRF Road Marking Materials Guide. Notes for the NZTA Specification for Pavement Marking (P12) also provide guidance on materials and managing their performance. The following definitions provide a brief description of the materials covered by M07:

(a) Solvent borne materials: Historically paint type road markings have been denoted as water borne or solvent borne but it should be noted that neither the solvent nor the water remains in the paint and thereafter plays no part in the long-term performance. Solvent borne paints of the alkyd resin type are typically less expensive pavement marking materials and typically have short service lives. As a relatively low-cost and short-life option, some agencies choose to re-mark solvent borne road markings on a fixed schedule, instead of re-marking based on objective measurements or monitoring. Solvent borne paints referred to as chlorinated rubber type are a more durable marking often with extended lives, with the application advantages of the solvent borne materials, such as in general being able to be applied in cooler weather and higher humidity in comparison to waterborne materials.

(b) Water borne materials: Water borne materials are typically acrylic emulsion type materials with a high non-volatile content, typically 65%. Despite the name they contain a significant component of solvents that mix with water such as alcohols to assist the drying. They are regarded as the more durable of the paint type markings but there can be a wide range of performance within the generic type. The base polymer is more resistant to aging which contributes to service life often of two years and sometimes more. Extended drying times in high humidity such as during night-time application and early washout risk are issues with these marking types. However, the high non-volatile content does make them very suitable for applications where large diameter (Type D) glass beads are needed.

(c) Thermoplastic materials: Thermoplastic materials are a 100% solid material which soften and melt to a fluid at temperatures between 150 – 180°C. They are composed of binders which are typically simple hydrocarbon resins but sometimes with an addition of thermoplastic rubber block copolymer, 20 - 30% glass beads intermixed in the formula, aggregate for skid resistance, pigment and filler. They are applied in high builds usually 2 - 3mm thick and wear by abrasion to expose fresh material

so that they provide a long-lived consistent performance. When laid both skid resistance and reflectivity can be less than required so a surface layer of drop on glass beads and aggregate is needed for the interim period until wear through to the underlying material occurs. In most cases a textured surface or raised marking profile (e.g. structured, dots) is needed to provide wet night visibility. The high skid resistance can cause tyre blackening which reduces daytime visibility. Thermoplastic materials are long life materials where progressive wear exposes more fresh material.

(d) Tapes: Pre-formed tapes are manufactured to a range of performance levels from medium to very high visibility and include products which retain their visibility in all conditions even falling rain. The materials have a high initial cost but can be laid by very simple equipment. As a manufactured product, if it is adhered properly, the performance is certain. Materials can last up to 10 years especially on asphaltic surfaces. Equipment capable of laying normal contract area lengths is not commonly available in New Zealand as demand is currently low.

(e) Catalysed Systems: Multi-component materials, sometimes known as “cold applied plastic”, are produced on site through the reaction of two or more separate chemical reactants. Most commonly these are methyl methacrylate polymers which are reacted through a mixing gun to form a solid long-life marking. The material also contains intermixed beads similarly to thermoplastics, but they are reputed to be hard products which wear only slowly. There is a small amount of evidence of reflectivity drop off as the surface glass beads are worn down but are not refreshed by the exposed internal beads. However, the material can be easily refreshed with a thin overlay coat of new material. As with all long-life markings, tyre blackening and dirt pick up can reduce daytime visibility, but night-time visibility is not affected by this.

(f) Glass Beads: Retroreflectivity is provided by glass beads that are dropped onto the paint whilst still wet or pre-mixed into thermoplastic or catalysed systems. There are different beads available depending on the surface the marking is being applied to and the desired level of performance. The paint thickness must be tailored for the size of beads to ensure that enough beads are retained. A compatible combination is important, and the manufacturer/supplier should be able to give advice. In the past it has been often claimed that glass beads improve skid resistance, but this is only true in part. Glass beads improve the skid resistance of materials when on a flat surface to between 30 BPN and 40 BPN, with the large diameter beads giving the lower skid resistance. Therefore, often a clear angular material also needs to be dropped on to give the desired skid resistance. Glass beads may also require an adhesion coating, as in AS/NZS 2009 clause 5.9 to prevent premature bead loss.

3.2 Life Cycle Considerations

There are numerous studies comparing the environmental and human health impacts of solvent, waterborne and long-life road markings (thermoplastic and cold applied plastic). Based on the information available at the time, Waka Kotahi has come to the conclusion that water based paints and cold applied plastics present the lowest environmental and safety impacts due in part to the low emission of volatile organic compounds for water based systems and lower energy consumption and longevity of cold plastics.

3.3 Other factors

Besides properties of the product and its application, other factors affect performance of road markings and should be considered in selection of an appropriate product, and are described as follows:

(a) Traffic volumes and composition: Performance of road markings degrades sooner with higher traffic volumes and a higher proportion of heavy vehicles within the traffic composition. In these situations, the use of long-life products may be more cost effective especially if the markings are currently being replaced more than once per year.

(b) Weather during application: Many products especially water borne paints may perform better if initial application of the road marking is performed during summer with warm dry weather, especially when nights are warm. This allows for the material to set up more quickly and will resist the effects of trafficking more quickly. Chlorinated rubber materials may also be improved by warmer conditions immediately post application. Remarking schedules generally aim to avoid winter remarking, except where specialised materials may be being used.

(c) Road surface type and condition: M07 provides for separate approvals on a chip seal surface and on an asphaltic surface which includes the typical surfaces of dense asphalt, open-graded porous asphalt, and SMA. There are several reasons, which include:

(i) Wear on chip seal surfaces: Wear on chip seal surfaces is usually much more rapid than on asphalt surfaces. The difference in service life may be a factor of 2 or more. The wear mechanism on chip seal also differs from that of asphalt. On chip seal it is often by the paint getting plucked from the tops of the chips, whereas on asphalt it is primarily abrasion through the paint and loss of beads out of the well adhered paint film. It should also be noted that paint type markings are effectively being spread over a 30% greater area because of the texture of chip seal compared to asphalt.

(ii) Visibility in the wet: On chip seal the sloping chip faces, and overall texture ensure a reasonable visibility in the wet even when standard beads are used. However, on asphalt either the marking must be textured, or large diameter beads need to be included and sometimes both are used. Markings with a structured pattern or an audio-tactile profile (ATP) should be considered for asphalt surfacings.

(iii) Remaining service life: The remaining service life of the road surface should be factored into the selection of the marking especially when longer life markings are being considered. Remaining surface life should at least be equal to the break-even point in choosing the longer life marking instead of the standard marking.

(iv) Surface profile and porosity: The road surface profile and porosity can also influence how much material is needed, especially when high build markings are used.

(d) Abnormal and localised high wear areas or prone to unpredictable events: High stress areas such as intersection, approaches to round-abouts or roads subject to gritting and, snow ploughing can have short delineation lives. In these cases, long life material should be considered. Such markings will minimise disruption to road users arising from frequent remaking, and also reduce the exposure to hazards for road marking operators.

(e) Quality Control in application: Performance of products will depend on the quality of application. Advice should be sought from the supplier as to the appropriate materials handling practices and application methods.

(f) Film thickness: Dry film thickness can have an impact on the durability of a product, however applying more film thickness may not align with the proposed re-marking schedule or contract format and film thickness needs to be compatible with the bead size and application. Thick films of paint can also take longer to dry and set up than a thinner paint film, so much so that better performance does not result. Bead embedment is complex and is more than a simple film thickness bead diameter calculation. The rheology of the paint is critical, and it needs to wet the bead and effectively move up onto and grab the bead and lock it in. It is recommended to take plates as part of an audit process to verify that the film thickness recommended by the manufacturer is being applied. Clause 9 of M07 which outlines the field trial provides a suitable process.

(g) Skid Resistance: In the past it has been often claimed that glass beads improve skid resistance, but this is only true in part. Glass beads improve the skid resistance of materials when on a flat surface to between 30 BPN and 40 BPN, with the large diameter beads giving the lower skid resistance. Therefore, often a clear angular material, or grit, also needs to be dropped on to give the desired skid resistance. The effect of this grit and the beads is to reduce the reflectivity from what it would have been if only beads had been used. For paint type markings the underlying surface often contributes to skid resistance so over chip seals, adequate skid resistance may be achieved with the marking with standard beads only. However, on asphalt surfaces with large diameter beads, additional grit is usually needed. For high build markings, the marking properties dominate the skid resistance and whether grit is needed depends on the product. However usually some initial drop on grit with drop on beads is required.

4 SELECTION AND MANAGEMENT OF ROAD MARKINGS

4.1 General

Pavement markings are often considered to be a minor maintenance treatment and as a result are not regarded as an integral part of many pavement management systems. However, the importance of road marking to safety and driver satisfaction cannot be overestimated. As such, like any other asset it is recommended that the condition and performance of road markings be tracked through comprehensive periodic inspections to monitor the suitability of products being used and identify "optimal" investment strategies.

The following discussion is aimed at providing clients and contractors with an understanding of the theoretical basis of how line markings are perceived and how they can be managed.

4.2 Road Markings Role and Required Outcomes

New Zealand has a mixed delineation system of edge marker posts, reflective raised pavement markers and road markings. Edge marker posts show the general route ahead for typically 200 to 500 metres, often further. Reflective Raised Pavement Markers (RRPMs) provide a more definite view of the pavement in the middle distance of 80 to 200 metres and road markings provide the near field view which is particularly important for correct placement of the car in the lane and road. Road markings therefore are a key part of a system which enhances driver safety, contributes to road user satisfaction and assists traffic flow.

Therefore, outcomes for delineation are:

(a) There is a high degree of driver satisfaction and improved safety because the delineation is satisfying driver demand

(b) For the road owner, there is an effective use of materials across the wide range of wear intensities on the network to meet this driver demand

(c) For the contractor, the processes needed to ensure driver demand is met, are simple to understand and provide.

4.3 Selecting a Road Marking Material

Products listed in M07 are classified in Table 1 according to the following three parameters,

(a) The type of surface the marking is being applied to (asphalt or chip seal)

(b) The level of visibility required

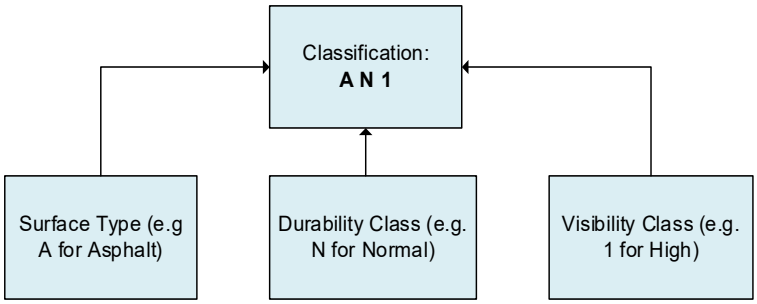
(c) The level of traffic wear resistance desired, referred to as durability.

Each class of material is designated with a three-digit code

Table 1: Approval Classifications

Product Visibility	Surface Type Product Durability					
	Asphalt			Chip Seal		
	Normal	Extended	Long	Normal	Extended	Long
High	AN1	AE1	AL1	CN1	CE1	CL1
Standard	AN0	AE0	AL0	CN0	CE0	CL0

Figure 1: Example Road Marking Paint Classification



Guidance on selecting a visibility class and product durability class is provided in clauses 4.4 and 4.5 respectively.

4.4 Assessing the Visibility Class Needed

The visibility of a marking depends on its size and reflective properties, which are in turn influenced by the lighting situation, other traffic and the driver's visual ability. All these factors can be brought together within visibility modelling to establish the reflectivity requirements of various road types so as to meet the needs of drivers for markings which afford safe and comfortable driving. This approach is described in more detail in clause 6 of this document.

Table 2 has been developed using the visibility model, known as VISIBILITIE and input parameters relevant to New Zealand roads. The purpose of the table and the supporting notes is to allow Specifiers to link the M07 Visibility Classifications to a road type and suggested level of reflectivity at the end of the products life. Work is currently being undertaken on developing policies on where high visibility markings should be applied on the network and as such the recommendations in Table 2 are subject to change.

Table 2: Suggested M07 visibility class for white materials and minimum end-of-life reflectivity levels for various road types

M7 Visibility Class	Road type	Minimum end-of-life reflectivity levels for road type		
		R_L in dry	R_L in wet	Daytime Q_d
High	High volume open roads (>5000 AADT on an undivided carriageway), Motorways Urban areas with visual distractions such as lighting and pedestrians in commercial and shopping areas Where a traffic safety strategy has identified the need for improved delineation	150	50	80
Standard	Medium volume rural roads (1000-5000 AADT)	100	35	80
Standard	Low volume rural road (200 to 1000 AADT)	100	35	80
Standard	Urban road (suburban)	70	25	80

(a) High Volume Open Road: The "high volume open road" equates to high visual demand and this is where drivers are likely to be on dipped beam but with quite heavy oncoming and/or following traffic. There will be roads with approximately 5,000 vehicles per day and usually two-lane unseparated carriageway. A lit motorway generally does not represent a high visual demand but due to the very high volume of traffic and frequent lane changing then the same road marking performance could be advised. In the One Network Framework (ONF) these would be, National, and Regional roads.

(b) Medium Volume Rural Road: A "medium volume rural road" equates to "normal" visual demand. These are roads which the driving is mainly on dipped beam but both oncoming traffic and any following traffic is light, just one or two vehicles at a time. Roads of this type would include the lower volume State Highways and the higher volume local authority rural roads. In the ONF these would be Arterials and Primary Collector roads.

(c) Low Volume Rural Road: The “low volume rural road” equates to a situation of low visual demand, traffic volumes are low (200 to 1,000 vehicles per day) and driving is mainly on full beam with approaching traffic thinly spread. The road types encompassed would be the very low volume State Highways and the majority of local authority rural roads. In the ONF these would be Secondary Collector and Access roads. While visual demand requires only a retroreflectivity of 70mcd/lx/m^2 M7 products are required to have 100mcd/lx/m^2 to be approved for use. What this means is that the road markings may have an extended life on these low volume roads.

(d) Urban areas: For urban roads the speed is mainly 50 km/h but can be 70 km/h on major arterials. The effect of this low speed when using the VISIBILITIE model is that road markings do not need to be very bright to give 1.8 seconds preview time and hence the 70 mcd/lx/m^2 as in the table. Therefore, many urban streets, especially all roads secondary collector and less in the hierarchy can be classed as low visual demand. However, VISIBILITIE does not take into account the complexity of the background. Commercial areas have many other lights providing distractions and on-road wet reflections at night. Pedestrians are also present. Urban arterials and primary collectors are often multi-lane and heavily trafficked and pedestrians are also present. In sign visibility models such as “Sign Life”, signs need to be brighter in commercial areas to be conspicuous (able to stand out from the surrounds). Therefore, using this same concept central business districts and large suburban shopping areas, can be classed as “high visual demand” while arterials, primary collectors and small suburban commercial areas as “normal visual demand”. Another consideration is that urban areas commonly have smooth textured surfaces which can result in poor road marking visibility in the wet; as such a high standard of wet retroreflectivity may be desired.

4.5 Assessing the Durability Class Needed

4.5.1 General

Guidance on where each M07 product durability class should be considered is provided below. These recommendations are based around achieving the lives indicated through the on-road performance trial and should be applied to the network in the larger scale, e.g.10 - 30 km length of road, not just on the micro scale such as at intersections, tight curves or entrances.

4.5.2 Long life:

Rural high wear areas where traffic volumes, especially very heavy vehicle volumes, are high or where the road alignment encourages crossing of the road markings. Therefore, high wear intensity roads would be:

(a) Roads with tight radius bends such as those over hills/mountains or through gorges

(b) Roads with an AADT greater than 5000 or high number of heavy vehicles, e.g. 500+ heavy commercial vehicles per day (HCV II).

Urban high wear areas such as the central business district and other major commercial areas and industrial areas. National and regional links, especially multi-lane roads and most heavy vehicle bypasses, may also be high wear.

For these areas a “long life classification” marking should be considered but if remaining pavement or surfacing life is short then an extended life marking would be an alternative.

4.5.3 Extended Life:

(a) Rural medium wear areas, mainly roads which are straight or have moderate curve radius (250 to 400 m) with AADT between 3,000 to 5,000 or 100 to 500 heavy commercial vehicles per day (HCV II). This would therefore include most of the regional and primary collector roads and the busiest local authority rural roads

(b) Urban medium wear area will be arterials and primary collectors, secondary collector with predominantly car traffic

For these areas an “extended life classification” marking is recommended however “long life classification” may be suitable depending on the past performance of marking on the particular road being considered.

4.5.4 Normal life:

(a) Rural low wear-areas are roads with low to moderate traffic volumes, e.g. up to 3,000 AADT and low volumes of heavy commercial vehicles (< 100) and roads with straight to moderate curvature. This includes therefore, nearly all local authority rural roads and lower volume State Highways

(b) Urban low wear areas include secondary collector and access roads. Traffic on these streets will be almost solely cars with infrequent heavy traffic.

For these areas a “normal life classification” is suitable

4.6 Typical Material Selection Under ONF

With the information above it will be possible to select a material from the approved product list based on the marking durability (for each of the two main surface types) and retroreflectivity level required.

A basic summary of material classifications that could typically be used under the ONF is provided below.

(a) National and Regional: CL1, AL1, CE1 AE1

(b) Arterial and Primary collector: CL0, CE0

(c) Secondary collector, Access, and Local: CN0, AN0

These recommendations are a guide and the choice of material does depend on the particular network. It is recommended that the performance of materials is monitored to ascertain lives achieved locally and that an evaluation of the costs and benefits is undertaken to determine whether the expense of a higher cost marking material can be recovered by the overall benefits of less frequent marking.

5 MANAGING THE PERFORMANCE OF ROAD MARKINGS

5.1 General

The following sets out a method of managing the performance of the road marking. The two key elements are standard asset management practice:

(a) Knowing the expected performance of the marking. This information can be obtained from the supplier and also by experience with that marking or a very similar product in a similar use situation.

(b) Testing the performance in a systematic manner to verify that the expected performance is being delivered. Testing is undertaken at a few points along the performance-deterioration curve to confirm that the performance-deterioration profile is as expected.

5.2 Testing programme

The points below suggest when testing should be carried out to manage the performance of road markings:

(a) At the time of re-marking testing should then be done to ensure that the initial performance levels expected for the material are being achieved. The performance levels expected at this point are the initial values for the material, not the minimum values for the Contract.

(b) Measurement of the condition at about 50% of the expected life of the road marking confirms that the rate of deterioration of the material is as expected. If it differs, a re-forecast of the end-of-life should be made. Before the bulk of the road marking needs replacement, road markings in high-wear areas may need replacement.

(c) When the road markings have been in place for about 80% of the expected life the engineer could request the contractor to either:

(i) measure the condition of road markings to better identify the actual end-of-life, so as to both extract this remaining life and to properly schedule re-marking so that it occurs comfortably before any road marking falls below the required performance criteria; or

(ii) not measure the condition of road markings but re-mark the contract area when the material deterioration curve and testing indicate there is about 10% of the life remaining (and the cycle is then re-entered at step 5.2 (b) above).

5.3 Testing

5.3.1 Monitoring Sites

Most of the test equipment is handheld and so only a small sample of the markings can be practically tested. The location of monitoring sites where testing is to be carried out needs to be established. The monitoring sites selected should be representative of the high-wear areas, medium- (normal-) and low-wear areas of the contract area; and of the road marking systems used throughout the contract area. As a rough guide the number of sites should be the carriageway length in kilometres divided by 20. Within each Monitoring Site, five testing sections are to be identified. Each of these testing sections is approximately 5m long. Testing is to be conducted within these testing section lengths.

5.3.2 Properties to be tested

There are five main properties for assessment: retroreflectivity in the dry condition, retroreflectivity in the wet condition, skid resistance, colour, and daytime visibility:

(a) Retroreflectivity should be measured at every Monitoring Site.

(b) Colour and daytime visibility: An initial appraisal of colour and of daytime visibility should be done at each Monitoring Site. A full assessment and recording of colour should be carried out only where the initial appraisal gives doubt as to whether it conforms.

(c) Daytime visibility is assessed as Qd and is recorded automatically by reflectometers when measuring retro reflectivity.

(d) Skid-resistance: Skid-resistance is generally an inherent property of the material, and should need to be measured at only a few of the monitoring sites for each type of marking material to establish that the system is skid resistant:

(i) Standard paint-type road markings over chip seal generally comply in part because of the road texture

(ii) Standard paint-type road markings applied over asphalt usually need a grit additive to ensure sufficient skid resistance.

High-build and long-life road markings (such as thermoplastic, two-part systems) usually require a mixture of drop on beads and angular material to give initial skid resistance. The marking will then wear through to the underlying material and continue to maintain skid resistance, but this should be checked to ensure that an intermediate period of low skid resistance has not occurred, where the angular material has worn off but wear through has not occurred.

6 DRIVER VISIBILITY DEMAND

Having regard to driver demand is essential as it provides a strong link to a good theoretical base of the role of road markings in the driving task and the performance required. This theoretical base is the European COST 331 programme of the late 1990s as well as similar work at the same time in the USA (Zwahlen, Schnell etc.).

Primarily road markings are used for placement of the vehicle and the research found that a forward view of 1.8 seconds ahead was desirable.

Two key properties of the marking affect visibility.

(a) Retro-reflectivity which is the ability of the marking to reflect the car lights back to the driver. Embedded glass beads provide this property but textured surfaces, such as chip seal, or textured markings assist

(b) Reflectivity from diffuse lighting which is lighting from the surrounds such as street lighting, and the weak daylight of early dawn or twilight.

The visibility of road markings depends mainly on the size of the marking (width, which determines area per unit length) and its reflective properties (whether retro-reflectivity or diffuse reflectivity) which therefore are affected by the many sources of lighting such as light source (car lights on high beam or dipped beam and level of street lighting) degree of daylight, the height and placement of the lighting (e.g. car or truck; and the effective position of the drivers eyes above the road surface) and presence of oncoming or following traffic.

The driver's visual abilities are also important, and these decrease with age. Vehicle speed is the key factor in converting forward view in metres into driving time ahead in seconds, such that brighter markings are needed where the speed is 100km/hr than when driving is in urban areas where speed is 50km/h. All of these factors can be brought together to calculate forward view using a visibility model developed with the European COST 331 programme called VISIBILITIE.

The advice of these notes is based on design criteria in research papers (Dravitzki et al ARRB 2002 and NZRF 2003), and is that delineation should provide 1.8 seconds of forward view for a 70-year old driver driving in the traffic conditions of the first hour of winter darkness.

This design criterion provides equal levels of visibility by changing the retroreflectivity. To explain this criterion briefly:

(a) Driver visual abilities are good and fairly even across the 20 to 50-year age band. There is a modest drop at age 60, a very significant drop at age 70 and average visual ability by age 80 is only about half that of younger drivers. The 70 years old (age band 65 to 75) are therefore as a group, still often in the workforce or travelling in winter evenings. However, at 80 years old (age band 75 to 85) there is a high degree of self-regulation to avoid rural driving at night.

(b) The 1.8 seconds equates to about 50 metres ahead at 100 km/h. However, given their better eyesight, most drivers will have closer to 2.5 to 3 seconds which is about 70 to 84 metres of forward view.

(c) Higher levels of service in the future could be based on providing longer preview times or alternatively providing the 1.8 seconds for the very old (80-year age group) drivers.

To identify appropriate reflectivity levels, the criterion is then applied to straight road sections noting route alignment can also limit forward view, and in some cases, such as concave vertical curvature, increase it.