

NOTES FOR THE SPECIFICATION FOR PAVEMENT MARKING

These notes are for guidance and are not to be included in the contract documents.

Where numbers have been assigned to paragraphs these relate to the corresponding numbered clauses of the specification.

1. SCOPE

The specification covers all pavement marking, including the initial marking and overmarking of both non-reflectorised and reflectorised markings, on sealed or paved road surfaces.

2. QUALITY ASSURANCE REQUIREMENTS

Evidence of an approved quality assurance system as defined under Clause 3 is required. This system has various mandatory technical requirements suitable for audit, provides proof of work undertaken and should be utilised by the Engineer.

Engineers are encouraged to become conversant with the Contractors quality system and to utilise the quality records for determining daily procedures and work practices. At the start of the contract the requirements of the quality plan should include the finer points associated with the day to day organisation of the marking operation and any particular requirements requested by the Engineer.

3. DEFINITIONS AND ABBREVIATIONS

An additional explanation has been included where references to thermoplastic materials also applies to other long life markings such as Profiled Markings (audible tactile markings), two-part polyesters, water shedding lines, providing they are approved for use by Transit New Zealand (Transit).

The Transit QG Notes provide useful guidelines on the role of each party involved in the Quality Assurance (QA) process.

4. MARKING DETAILS

The specification is intended to be used for the painting of those pavement markings approved by Transit.

Markings approved by the Transit Authority are:

- (i) Regulatory markings as required by the Traffic Regulations 1976.
- (ii) Markings in accordance with Transit/Land Transport Safety Authority's *Manual of Traffic Signs and Markings Part II: Markings*.

4.1 General

Transit's *State Highway Maintenance Standards* sets standards to ensure that roadmarkings maintain a minimum level of effectiveness throughout the year. Concentrating the remarking to short periods such as prior to holiday periods, places excessive demands on both contractors and paint suppliers, that are both difficult and costly to satisfy.

Work should instead be programmed to be spread throughout as much of the year as is practicable and contract periods should be coordinated on a district or regional basis to obtain the most economic use of the industry's resources.

Build up of paint layers should be avoided because it produces very poor skidding resistance. Build up is more likely to occur outside normal wheel paths. Therefore, at the planning stage check the need for the remarking of shoulder stripes, painted islands and similar areas so that remarking can be specifically excluded where warranted.

The specific schedules for each contract should be as defined in the standard contract documents (SOMAC).

All included items must comply with Transit standards.

5. MATERIALS

5.3 Thermoplastic Materials

Monitoring has shown that good long term markings can be achieved with thermoplastic and other long life materials, and that a life exceeding 4-6 remarks with conventional paints is achievable. Failures, where they have occurred, have often occurred early after application.

The following items provide guidance for the use and application of thermoplastic and other long life roadmarking materials.

(i) Application

Failures tend to be application related, although untidy application but correctly done can still give good performance. It appears that these

materials, compared to paint, are considerably more technically demanding of the applicator, and in general the standard of workmanship requires monitoring until the Contractor has acquired the necessary skills. Therefore, consideration must be given to matters such as the experience of the contractor to apply these markings so that the expected performance is achieved.

(ii) Road Surface

There is a trend for markings to be more durable on asphaltic concrete than on chipseal surfacings. On chipseal there is often wear by chipping off the tops of the stones, which can happen early in the life of the marking. On both dense grade and open grade porous asphalts, wear is by abrasion of the marking which takes much longer than chipping or flaking. Failures on the smoother surfaces, where they occur, appear to be application related.

Care is required when applying these materials to open grade porous asphalt surfaces to ensure no water is trapped within the surface pores. For example, even though the road surface appears dry, delamination can occur if water is trapped beneath the porous surface. When the hot material is applied it causes the water to come to the surface as steam and sometimes perforates the thermoplastic marking thereby reducing adhesion.

It is also important that the Engineer is aware of the following factors and that the Contractor has addressed these issues prior to application:

- ensure the road surface is clean from film or dirt;
- where applied over existing markings, ensure compatibility with the existing markings and that they are either worn or abraded. A tack coat may be beneficial; and
- marginal conditions including damp, cold or windy weather. Adjustment of the application criteria must suit the climatic conditions.

(iii) Daytime Appearance

Many of the long life markings show considerable discolouration from tyre blackening which gives a dirty daytime appearance, although nighttime visibility is still often very good. This is a noticeable change on existing paints which tend to keep quite clean.

Having quantifiable standards for daytime visibility will be increasingly necessary. At present, there appears to be some situations of inadequate performance. Quantified methods of assessing daytime visibility still require further investigation.

(iv) Nighttime Appearance

The nighttime appearance (reflectivity) of the markings is generally acceptable, though often not exceptional. This arises from products being

developed to pass the specified values of M/20 which, for reflectivity, is not high. However, higher values could be easily achieved and pilot trials have shown that it is likely they would be readily retained long term. Trials have shown the need for markings to have an additional coating of glass beads to provide reflectivity until the glass beads embedded in the material are exposed.

(v) Planning

There is an increased need for planning when long life markings are to be used. The contract sites, when selected, should remain in place for several years.

Experience has shown that the dull daytime appearance of thermoplastic markings does not indicate that the life of the marking, namely nighttime retroreflectivity, has expired. Where thermoplastic materials have been repainted with traditional roadmarking paints the paint has shown to have poorer reflectivity and skid resistance than the thermoplastic.

(vi) Service Life

Thermoplastic markings may be used on chipseal and asphalt road surfaces where it is economically justified. It appears that thermoplastic markings can give at least two and possibly up to three years or more service on a chipseal surface even on high volume roads (15,000-20,000 AADT). Service life over a dense grade or open grade porous asphaltic concrete surface will probably be significantly longer than for chipseal.

When using thermoplastics, future maintenance plans should be checked to ensure that roadworks and the like will not prematurely end the marking life.

5.3.1 Pre-Formed Thermoplastic Material

As with thermoplastic material, pre-formed material, although applied in a different manner, must comply with the M/20 specification and have similar characteristics as defined in Clause 5.3 above.

5.4 Other Long Life Roadmarking Materials

Several other types of long life materials and products are available for use and may be considered where appropriate. Where these materials don't suit the criteria defined in M/20 evidence must be provided supporting their suitability. Generally this will include overseas test results and the Engineer must be satisfied that they have been trialed on pavements similar to New Zealand surfacings, especially chipseal surfaces, for a similar period of time/trafficking to the M/20 requirement (minimum 3 million vehicle passes). The accompanying laboratory test results detailing the material properties and composition must provide sufficient technical information for the Engineer to confirm their characteristics with these results to be from a recognised source. The Engineer may also decide to request a warranty to cover possible defects within the first 1 to 2 years.

Examples of these materials include:

- Two-part Polyester or Polyurethane (e.g. Degadur*) - a two part polyester spray or cold applied polyurethane, similar in finished appearance to thermoplastic. These markings show similar if not more daytime discolouration than thermoplastic but adequate nighttime retroreflectivity.
- Profiled Thermoplastic Markings (e.g. Vibraline*) - these markings have a dual purpose by providing long life and have a raised profile at regularly spaced intervals to create an audible warning to motorists that travel across these profiled lines. It is important to remember when recommending these products that a “slump resistant” material is specified. The inclusion of fibres or thixotropic additives is required to provide stability for the raised ribs.

An Opus Central Laboratory Report *Review of the Best Practice for the Use of Rumble Strips in New Zealand* produced in 1997, gives detailed descriptions on the various types of raised or profiled markings available for use in New Zealand. This report also includes broad specifications on the dimensions of the profiles. Until more detailed information becomes available this report may be used as a guide to the use of profiled markings.

- Water Shedding Markings (e.g. Rainline, Hydrolite*) - these are thermoplastic low-profile markings with grooves or channels marked into the hot material as it is applied to increase the speed at which the rainwater runs off the line. This increases the nighttime retroreflectivity during wet road conditions. Care must be taken to ensure that the grooves are aligned at the correct angle (angular or perpendicular to the longitudinal line) to maximise visibility and expedite watershed. As with thermoplastic an application of glass beads is necessary at the time of application to provide acceptable levels of retroreflectivity before traffic wear exposes the imbedded glass beads.

* Note: These are only some examples of products available and these proprietary brand names should not be included in the contract documents.

The British Standard BS 3262:1989 specifies the requirements for some of these alternative long life materials and may be used as a basis for specifying these products in conjunction with New Zealand field trials, especially where these products are to be applied to chipseal surfaces.

Application Techniques

Extra care must be taken when applying these long life materials. Experience to date has highlighted adhesion problems which can greatly reduce the life of these markings. Items to consider during application include:

- application temperature of the material (critical for profiled markings);
- road temperature;
- road surface condition e.g. wet/dry/possible water in the porous asphalt voids;

- road surface type e.g chipseal, asphalt (open /dense), concrete, etc; and
- compatibility with existing markings, e.g. possible road film build on painted markings may cause adhesion problems.

5.7 Paint Thinners

Where any materials apart from thinners are to be supplied by the Contractor then this must be stated in the Contractors' quality plan. The thinners must suit the paint to be used and recommendations for its use must be nominated by the paint manufacturer.

Paint in accordance with M/7 should not require any thinners unless it is being applied at a paint temperature around or below 10°C. As the use of excess thinners may have an adverse effect on the service life of markings and cause other problems thinners should be limited to 5% by volume. When thinners are used the wet film thickness must be increased to compensate for the higher volatile content of the paint.

5.8 Testing Costs

Testing of Suspect Paint

When it is suspected that a batch of paint does not conform to specification the following process should be initiated.

- Check;
 - that the applicator has a current certificate of compliance and is operating correctly;
 - that road condition(s) and traffic control are suitable;
 - that the thinners used (if any) are appropriate;
 - that the dry film thickness obtained with the paint complies with the TNZ P/12 specification; and
 - that the paint has been adequately mixed before adding to the applicator container and that the continuous agitation (where applicable) has been employed.
- If the above checks do not reveal the cause of the problem then despatch a one litre sample of the paint to an approved laboratory capable of determining components of the paint using infrared spectra analysis "fingerprinting".

6. PLANT AND EQUIPMENT

The Contractor is to provide all plant and equipment.

Plant is required to hold a current Certificate of Compliance issued in accordance with either TNZ T/8 Specification for Roadmarking Paint Applicator Testing or TNZ E/4 Specification for Certification of Thermoplastic Roadmarking Applicators and Pre-

Heating Tanks. Handspray equipment or hand propelled applicators cannot be certified in terms of TNZ T/8 or E/4.

Equipment Types

Type A applicators are vehicle mounted applicators used for the bulk of roadmarking, particularly state highways.

Type B applicators are pedestrian-controlled applicators, but there are no limitations on their layout. The operator may walk with or sit on the applicator. There is a limitation on the length of Type B applicators to ensure they can work within small areas of lane closure.

Type B applicators are required to clean and apply paint to the same standards as Type A. The only specific limitation on work that may be completed with a Type B applicator relates to automatic segment control.

Clause 7.2 gives the Engineer power to direct applicator types in specific circumstances. Where it can be predicted that a Type B applicator must be used for certain markings, these should be detailed in the job specification.

It is essential to check that the certificate is current and applies to the unit to be used in the contractual works. Any modifications or physical changes in the unit during the works which may affect the compliance must be checked and when necessary the work must be stopped until the unit is reinspected for compliance.

6.2 Certification at Time of Tender

Certification

The Engineer should check to ensure that the Quality Assurance Programme (QAP) certification is current and that the expiry date is identified at the start of a contract. Another check should be made on the anniversary date to ensure that the certificate has been reissued.

This check on certification also applies to equipment certification under T/8 and E/4.

7. TRAFFIC AND PUBLIC SAFETY

Some safety provisions on the applicator are included in the Certificate of Compliance but it is essential to ensure that these are operational and that all the requirements of this clause are satisfied.

On some heavily trafficked motorway sections, it may be necessary to include specific requirements within the contract documents under Operational Requirements; this may include the provision for the marking to be carried out at night. When this is required it must be clearly stated in the approved Quality Plan.

7.1 Traffic Control

The extent of traffic control is governed by the drying rate of the paint. It is therefore the responsibility of the Contractor to avoid, by the use of cones or flags, or to remove, any unwanted paint marks caused by tyre transfer of wet paint. (Refer also to Clause 8)

Closure of lanes must be satisfactorily supervised, more particularly on motorways. The Transit G/1 Specification for Temporary Traffic Control, Schedule 1 allows for specific requirements pertaining to traffic control in specialised areas or circumstances to be incorporated within the contract requirements.

8. PROTECTION OF PAVEMENT MARKINGS

It is the Contractors responsibility to fully protect the markings while they are drying and the risk associated with vehicles traversing the wet paint. The removal of resulting tracking of paint is the Contractors full responsibility and is to be included as part of the Contractors' risk when pricing the contract.

It is important that all evidence of tracked paint is removed to avoid possible driver confusion especially in wet conditions and at night.

Refer to Clause 14.2.1 relating to paint removal.

9. SETTING OUT NEW MARKINGS

The normal responsibility of the Contractor is to set out all new marking from pilot marks and the ends of the continuous sections of *no-overtaking* and *no stopping* lines. These would typically be provided by way of *set-out* plans or reference pegs/markers placed by the resurfacing contractor.

When a different method of setting out is to be adopted, this must be stated in the job specification and full details of layout provided.

In the setting out of edge lines in horizontal curve sections the edge lines should be marked as defined in Chapter 3 (Table 3.5) Austroads *Rural Road Design Guide*, which relates to the extra widening of the surfacing.

Intersection markings for right-turn bays, paint islands etc, should be provided in plan form to the Contractor. Additionally, key points must be defined on the pavement surface to ensure the required markings are in the correct position.

9.3 New Thermoplastic Markings

It is common practice on newly resurfaced roads to mark the new lines with paint and to leave the surface to settle for a few months prior to applying the thermoplastic markings. The Contractor is to ensure that the thermoplastic material is compatible with the paint.

10. DIMENSIONAL TOLERANCES

Width of lines and paint film thickness can vary rapidly with changes in paint viscosity caused by temperature changes or addition of thinners. Consequently, these parameters should be checked regularly in the initial stages of a contract. As remedial action (removal of paint, respraying etc) is expensive, once satisfaction is obtained, spot checks should be sufficient.

It is important that, for lengths of effectively single lane pavement, including single lane bridges, the centre line and other markings which are not required, or require special positioning, are clearly defined.

Urgent work is not to be confused with the remarking of isolated worn heavily trafficked sections, but primarily relates to the initial marking of pavement following the application of a seal or paving coat. The Transit requirements are set out in the Transit publication *State Highway Maintenance Standards*.

It is essential that sufficient communication is maintained with the Contractor and, if the initial advice is sufficiently early, it is recognised that contractors can often programme their work to be in the vicinity of the new surfacing.

11. PREPARATION OF SURFACE

If the surface to be painted has the remains of a recent shoulder grading exercise or for any other reason there is coarse material (other than the normal fine dust), then the surface must be thoroughly cleaned (broomed) by the Maintenance Contractor (as specified by the road controlling authority) before the Contractor commences marking.

The Contractor is responsible for the removal of the inherent dust and detritus before the paint is applied. The applicator Certificate of Compliance provides assurance that a suitable cleaning system is included on the applicator. Contract supervisors should check that the cleaning system is operated during all marking operations.

It is essential that the pavement surface is dry before paint is applied.

Where a newly sealed road has paint applied, especially before the surplus chip is removed, it is important that the markings are remarked before these new markings start to show signs of extensive wear.

12. APPLICATION OF MATERIALS

12.1 Paint

The TNZ M/7 specification determines the required type of paint suitable for application based on a new paint classification system. For example, paints are classified in two groups according to final dry film thickness, either 180 or 220 microns. They are then grouped according to their ability to withstand trafficking as outlined below:

Paint Classification	Minimum Vehicle Passes (M/7 field test)
Class A	1,000,000
Class B	1,500,000
Class C	2,000,000

Paints are also classified as either rapid drying (no-pickup time < 7 minutes) or slow drying (no-pickup time > 7 minutes) as defined in M/7.

For acrylic (waterborne) paints consideration must be given to the *dry through* time especially where the paint is applied in marginal climatic conditions such as, at night or in colder or humid weather.

Mixing of Paint

Section 12.1 requires continuous agitation of the paint, except where manufacturers can provide evidence of no settlement. However, prolonged agitation at the specified level may cause entrainment of air. It is permissible for the frequency of agitation, or the energy input to be reduced once the paint is adequately mixed provided this does not cause problems due to separation of the components of the paint.

Some materials may not require agitation but before accepting this the paint manufacturer is required to demonstrate that the paint can be stored for three months without evidence of any settlement. The Engineer should be satisfied that the method of agitation prior to and during application is adequate for the task and is in line with the manufacturers recommendations. For example, a new technique currently being trialed is to supply paint in polyurethane bladder bags which are contained within a collapsible steel framework.

12.1 Paint (e)

Where an applicator is to mark double yellow no overtaking lines using a dual spray system, the operator must demonstrate that the reflective properties of the outside line (for opposing traffic) are fully realised; i.e. traffic travelling in the opposite direction to the direction of application must gain the full reflective benefits of the line comparable to the line marked for vehicles travelling in the same direction as the applicator. The applicator must provide evidence that the bead application meets these reflective requirements.

12.2 Thermoplastic Material

With new materials and increased technology becoming available consideration should be given to requiring the manufacturers instructions regarding the preparation and application of new materials to be included in the Quality Plan.

Evidence must be produced to state that these alternative techniques will not affect the performance or durability of the markings.

12.4 Reflectorised Lines

It is essential that the specification be followed for the initial marking of reflectorised lines otherwise lack of reflectorisation and premature loss can occur. For the application of beads, pressure dispensing is essential and the certificated applicator provides this. When checking the application of beads it should be noted that some beads should sink below the paint surface and some will have only a very small proportion of their volume protruding. This is a desirable condition and ensures that the line retains its reflective properties as wear occurs.

12.4.1 Paint

Coverage of beads on the total painted area requires the Engineer to check that the beads applied during application of the paint cover the full width of lines marked. For example, wind may cause the beads to deviate from alignment during application with the result that only a portion of the line has the required reflectivity.

T/8 and P/12 require that the beads sink to the base of the paint layer and adhere satisfactorily to the paint. Should this requirement not be met the layout and operation of the bead dispenser should be checked.

On a rough textured surface such as chipseal, beads tend to be concentrated on the faces pointing against the direction of traffic travel. Hence the requirements for reflectorised markings to be applied in the normal vehicular direction of travel. (Refer to Clause 12.1 (e) above for double yellow no overtaking lines)

Hand spraying and bead spreading by hand is not permitted.

The maintenance period for determining acceptable retroreflectivity of reflectorised markings would normally be three months as defined in NZS 3910 *Conditions of Contract for Building and Civil Engineering Construction* but this may be less for high wear areas and is at the discretion of the Engineer. This should be noted in the Quality Plan prior to commencing the contract.

12.4.2 Thermoplastic Material

When measuring the reflectivity of profiled markings it is important to measure between the raised ribs when using a hand held instrument such as a MiroLux, because the geometry of the ribs offer an artificially high reading.

13. APPLICATION RATES

The minimum application rate has been more precisely defined in the specification. The basic method for determining dry film thickness of painted road markings is on zinc coated plates. The method of measurement is more clearly defined in Appendix A.

An alternative method has been developed for determining the actual in situ application rates and may be used as a surveillance tool by the Engineer. Washers are placed in groups along the line to be remarked and collected after the roadmarking applicator has painted the line. These discrete washers are barely visible and provide a tool for verifying the Contractors records. The method for determining dry film thicknesses is more clearly defined in Appendix 1 of these Notes.

A third method is to determine paint usage using the contractors quality records including daily materials records and details on paint consumption with calculations for determining dry film thicknesses throughout the day, for varying paint batches and during the contract. The Contractor should demonstrate the method for controlling application rates, actual dry film thicknesses and regular plate film testing. Records of paint usage (litreage) should be available for inspection at all times with certificates for each batch of paint giving the percentage volume solids necessary to calculate dry film thicknesses. This method is particularly important for reflectorised markings where the beads make it difficult to assess insitu dry film thicknesses.

The certified applicator has the facility to apply paint at the specified dry film application rates within the tolerances. However, the actual dry film application rate must be checked. One direct and accurate method currently available is to place zinc coated steel plates on the line to be marked and to measure the film thickness with a magnetic thickness gauge (e.g. elcometer) once the paint is dry. Some of the plates used must be wider than the finished line to enable checking that a uniform covering of paint has been applied to the line (suggest 150 mm square plates for 75 or 100 mm lines). It is important to ensure that the instrument used to measure the paint film thickness is calibrated using calibrated thickness gauge shims.

Approximations to the dry film thickness can be obtained by measuring applicator travel speed, wet film thickness, paint consumption etc. These methods should only be used to enforce contractual conditions where they clearly indicate non-compliance. Clause 13.1 below identifies an alternative surveillance technique for monitoring in situ paint film thicknesses.

These wet film thicknesses and application rates are only approximations as the non-volatile content of the paint can vary between batches, brands and formulations, variations in temperature, therefore are a guide only and should not be defined in the job or contract specification. When thinners are used, the wet film thickness and application rate must be increased.

13.1 Paint

Previous specifications have required minimum paint film thickness of 150 microns. It was expected that the mean value of readings taken on a plate would be 180 microns but in practice 150 microns was treated as the acceptable mean paint film thickness. The new criteria specified in Equation 1 Appendix A of the

specification appears less stringent than was previously practised but in actual fact requires a greater film thickness to be applied to remain above the required minimum thickness.

The contractor should be aware of his control on application rates and variance in paint distribution along and across the plate. Appendix 1 provides more background information on determining dry paint film thickness.

13.2 Thermoplastic Material

In most cases difficulty is experienced when trying to measure a large number of film thicknesses on a plate with the micrometer which is a common instrument used to measure markings greater than 2.0 mm in thickness. In these instances the number of readings on a plate will need to be modified to suit these limitations. Note that the latest elcometers are capable of measuring the depth of material up to approximately 13 mm.

14. NON-CONFORMING MARKINGS

14.1 General

Proper removal and remarking of substandard marking at the Contractor's expense must be obtained when warranted.

14.2.1 Paint Removal

Paint or bitumen obliteration of paint markings has an adverse effect on skid resistance and in some light conditions the lines are clearly visible and could be misleading. Where markings are removed, especially those that have been in place for a lengthy period of time, all evidence of the markings are to be removed. This applies particularly to *wording* or *arrows* which require a wider area to be cleaned so that all evidence of the image is removed to eliminate any confusion for the motorist where the shadowed outline may remain.

Therefore removal is by one of the recognised methods, such as:

- (i) Immediately water blasting off the erroneous markings, although care must be taken to ensure that water does not penetrate the bituminous layer and ingress the road base.
- (ii) Sandblasting.
- (iii) Burning, although extreme care must be taken to protect the bituminous surface and all necessary consents must be obtained from road controlling and local/regional authorities.

14.2.3 Thermoplastic Removal

Options for removal of thermoplastic and other long life markings include:

- (i) High pressure wet slurry blasting with the detailed method approved by the Engineer, followed by the removal of sand detritus from the pavement surface.
- (ii) Excess oxygen type burner, approved by the Engineer, complying with all Resource Management Regulations, Occupational Safety and Health requirements and used in accordance with manufacturers instructions, followed by brooming as necessary to remove remaining thermoplastic.
- (iii) *Grinding off* the material.
- (iv) Shot blasting.

It is important to ensure that a detailed method of removal and disposal of the removed material (removed markings, sand, shot) is outlined in the quality plan.

Removal of old markings is particularly important in the case of profiled markings where excessive build up of the material is to be avoided. When resurfacing consideration must be given to removing the markings prior to applying the new surface to avoid possible delamination problems and a build-up or unevenness in the new surface.

15. MATERIALS RECORD

This diary should express completed work in terms of route position and should be used in checking payment although it is essential that the total lengths of the various markings are known in advance so that there is not dependence on the diary for payments.

Details of the minimum requirements to be included in the materials record should be clearly outlined in the Contractor's Quality Plan. The materials record should be available for inspection and show detailed daily work practices and material applied.

The Engineer is encouraged to work with the Contractor to understand work practices and to conduct site visits to view the roadmarking operation.

16. PROGRAMMES OF WORK

Details regarding the programme of work and URGENT WORK, are specified in the standard contract documents (SOMAC) and should also be contained in the Contractor's Quality Plan.

17. MAINTENANCE OF THERMOPLASTIC MATERIAL

17.1 Maintenance Period

Due to the relatively high cost and expected long life of this material it is important that a maintenance period be enforced to ensure adequate adhesion and acceptable retroreflectivity of the markings.

18. BASIS OF PAYMENT

The schedule of quantities should be compiled to group items as far as is practicable. The units of measurement are outlined in the standardised contract documents (SOMAC).

Markings on highways of different character (eg, rural, urban and motorway) should be separately scheduled to ensure that tenderers have the opportunity of tendering fair rates for the different effort required on each type of highway.

APPENDIX 1

1. PAINT FILM THICKNESS MEASUREMENTS

1.1 Paint Film Thickness

The film thickness of the paint is required to be measured by the Contractor on an ongoing basis as part of their QAP and records of the film thicknesses be made available to the Engineer as required. The tests are carried out by spraying paint onto zinc coated steel plates allowing the paint to dry and using an Eddy current non destructive device such as an Elcometer to measure the dry film thickness.

If any test site is found to have a paint application of less than the lower specified limit (150 microns), the Contractor is responsible for developing and performing a suitable remedy after it has been agreed by the Engineer to the contract.

In addition to the Contractor testing the film thickness, surveillance performed by the Engineer should include occasional film thickness testing. However, this test has not been found useful for surveillance due to the ease of its manipulation.

For example, if the Engineer travels to where the Contractor is working and requests that the Contractor spray over a test plate the Contractor can ensure that a sufficient quantity of paint is deposited on the plate. Consequently the Engineer is generally more covert and places the test plate in the expected path of the Contractor and collects the plates after the Contractor has been past.

This seems like a good idea but the test plates used are required to be typically 150 mm by 150 mm, consequently they are easily spotted by the Contractor and if required extra paint can be sprayed as the applicator passes over the plate. If the Contractor is guilty of under spraying and the plate is not seen until it is passed the Contractor can still recover by backing up over the plate to bend it. Once it is bent, it is an invalid test medium. Even if the Contractor misses it completely and the plate has the evidence that the Contractor is under spraying any vehicle that runs over the plate will again make it invalid.

This is still the currently used method for determining dry film thickness, but other methods are now available to determine actual in situ paint thicknesses.

1.2 New Test for Verifying Paint Film Thickness

1.2.1 Modified Plate System

It was found that the current system of measuring paint thickness on plates was inadequate so before a new procedure could be developed the current procedure needed to be improved. A modified system was developed and this system is outlined in Appendix A of the specification. The modified system would provide the basis for a comparison with any new method.

1.2.2 New Procedure for Measuring Paint Film Thickness

A number of alternative techniques were trialed, the most successful of these comprised using zinc plated washers. The diameters of these washers were made as large as possible to limit side effects but they needed to be unobtrusive so would not attract special attention from the roadmarker. It was found that an optimum diameter for the washers was 35 mm.

After a number of trial formats it was found that a minimum of three washers was enough to give the same level of confidence as the modified steel plate procedure.

One washer was placed in the centre of the line to be painted and one to the left and the other to the right of centre. Although only three washers were required to yield suitable data, it was considered prudent to add two additional washers, one to the left and the other to the right of the centre of the marking, to improve the chances of three complete hits in case of line wander. These washers did not need to be clustered, they could be spread along the line within a 100 m length.

In trials undertaken the washers were fixed to the road surface using 'Blu.Tack'. This procedure produced a 95% retention rate after six weeks although it is sensible to retrieve the washers well before this time to avoid any traffic wear.

1.2.3 Measurement Procedure

The measurement procedure consists of taking ten readings around each washer. The readings from all the washers are used (30 readings) to obtain an average.

The standard deviation of the paint film thicknesses from the washers are comparable to that measured on the plates. Both the standard deviations are about 40. This indicates that the variability of the thickness measurements is similar whether they are measured on plates or washers. Consequently, the procedure using the washers could replace the plates with no reduction in accuracy of the measurements.

The equations and method for measurements on a plate are given in Appendix A of the specification. The following method is used to determine dry film thickness of paint on washers:

2. METHOD FOR MEASURING PAINT FILM THICKNESS ON WASHERS*

2.1 Measurements

Measurements shall be taken on three washers with readings taken from ten locations on each washer.

The minimum film thickness when measured by washers is given by:

$$\text{MWT} = \text{Wav} + 22 - (0.45 \times \text{Wsd}) \quad (\text{Equation 2})$$

Where:

MWT = Minimum Paint Film Thickness (on washers)
Wav = Average of 30 readings on 3 washers
Wsd = Standard Deviation of 30 washer readings.
22 = Statistically determined factor

* A magnetic film thickness gauge such as an Elcometer 256F is a suitable instrument.

3. RECOMMENDED USE OF THE TEST RESULTS

When surveillance is being carried out by the Engineer to verify the thickness of paint films using either the plates or washers the following is recommended:

1. If the mean film thickness of the paint marking is greater or equal to 170 microns (or $\text{MWT} \geq 150$ microns) no action is necessary.
2. If the markings have fallen below the mean of 170 microns the Contractor should be notified and initiate corrective action to ensure that the average is above the required minimum. The Engineer may decide to inspect the quality records and ask the Contractor to provide evidence that the correct volume of paint has been applied.
3. If the markings are found to be below the minimum as defined in either Equation 1 (specification) or Equation 2 above, a non-conformance notice should be issued with a request that corrective action be taken to:
 - improve the procedures to ensure that the non-conformance does not happen in the future; and
 - remedy the markings that are below the minimum.