NOTES TO THE PERFORMANCE BASED SPECIFICATION FOR ROADMARKING

1. OVERVIEW AND INTENT OF PERFORMANCE BASED SPECIFICATION

Road owners provide roadmarkings as a means of improving the safety of the road user and providing for the more orderly flow of traffic. A performance based specification environment allows for a Contractor to provide this service to the road user on behalf of the road owner. The role of the roadmarking contractor is therefore significantly different from that at present.

Rather than the old role of providing a product when required, the Contractor's new role is to monitor the performance of roadmarkings in the contract area and undertake remedial action (remarking) when the marking performance is insufficient. It is conceivable that either no or minimal remarking occurs in a contract period, and the Contractor's fee is for monitoring only. This new arrangement can only flourish when both road owner and Contractor are focused on the needs of the road user. The Contractor must have a commitment to the owner's objectives of providing quality and service to the road user, while the road owner must trust the Contractor to share the responsibility, but this trust must be supported by a level of prudent surveillance.

The performance contract has the following essential elements:

- Minimum performance criteria for the roadmarking.
- A minimum durability (or longevity) for which the marking must attain these minimum performance criteria.
- A system of monitoring performance of the marking by the Contractor and of audit surveillance by the owner centred around the expected life of the marking.
- A system of staged payments through the contract.
- A database to record the details of the contract area, the materials used, and the monitoring results.

- A quality system from the Contractor.
- The ability to allow for road maintenance within the period.
- Penalties for under-performance.

The need for these elements are:

- The minimum performance criteria sets minimum levels for each specified parameter to ensure the markings are clearly visible to the driver.
- A minimum durability is required to minimise the disruption to the road user, and to allow practical time cycles of monitoring and remarking by the Contractor and surveillance by the roading authority.
- An expected durability needs to be included so that the higher cost of longer life materials can be offset by the benefits of reduced monitoring and surveillance.
- Stage payments reflect the new role of the Contractor in carrying out an ongoing service of monitoring and remarking.
- The database protects the road authority by providing a means of information by which they can monitor the value of the asset. It protects new contractors in reducing uncertainty and the existing contractor from being under-priced by the under-informed.
- A quality system by the Contractor firstly demonstrates their commitment to service, and secondly reduces the need for audit surveillance. The Contractor will be expected to be competent in material selection, performance monitoring and material application.
- Road maintenance will occur in the contract period, and the reinstatement of the markings needs to be recognised within the contract.

In this performance based specification some indicative pass criteria, test methods and monitoring methods have been proposed for piloting. These will need to be confirmed or modified in response to these pilots and by further research.

2. PERFORMANCE CRITERIA

2.1 Colour and Colour Change

Colour and colour change can be measured by instruments, but these are primarily laboratory based instruments for measuring on flat substrates. Measurements on a chipseal will be uncertain.

Colour needs to be measured only approximately and is therefore measured sufficiently by reference to a colour card. A standard set of discolouration scales are used to measure the difference in colour from that of the colour card.

A requirement for colour to be met at nighttime has been introduced as it has been noted some materials, eg thermoplastic appeared almost white at nighttime. This however is not an inherent problem of those materials as it is known thermoplastic which is a true yellow have been used in the United Kingdom for many years.

This type of performance is not acceptable as yellow markings are used to indicate no passing lines, an important safety feature.

2.2 Daytime Visibility

It is intended to replace this test with an objective test once further research into diffuse reflectometers is complete. The CIE publication recommends a viewing distance of 20-30 m on straight sections and 150 m on curves, as necessary for safe night-time driving. In daytime there is assistance provided by the informal delineation. However, 150 m viewing distance should be easily achieved in daytime, and this value has been adopted as it should provide effective delineation should the informal delineation be deceptive. There will be some situations where this value might not be achieved in wet daytime conditions, especially on asphaltic concrete, and with the sun directly ahead at low angles. Some latitude should be given for this requirement in these situations. Daytime visibility and colour can become an issue with long life markings, which have a much longer time to accumulate dirt and tyre blackening and may appear quite grey.

2.3 Night-time Visibility

Appendix 3 provides the explanation as to why a common base for reflectivity must be used. Opus Central Laboratories at present hold both the reference plates and Transit Mirolux 12 retroreflectometer and are able to advise on calibration and adjustment to the common base.

2.4 Wet Visibility

The time when markings are most needed is in wet night-time conditions. At this stage a suitable test for wet conditions *is available but requirements* have yet to be developed. Some reduction in retroreflective properties is acceptable as the wet road is darker than the dry, and reflective contrast is more easily attained with the wet road. The wet test is similar to the dry test with the retroreflectometer. The marking is wetted with water from a bucket, and after 1 minute's draining, the retroreflection is measured. 50-70 $mcd^{-2}.lux^{-1}$ is probably reasonable when wet. 100 $mcd^{-2}.lux^{-1}$ would be very good and equal to the best of overseas materials.

There will be implications in this requirement. Markings on chipseal can maintain quite a good visibility in the wet because of the irregular surface and good drainage. However, most current markings over asphalt will "disappear" in the wet. It has been noticed that standard thermoplastic markings can be badly affected in the wet. There are technologies such as profiled lines or large diameter beads which will give improved performance.

2.5 Skid Resistance

Where skid resistance is specified for markings 45 BPN is a reasonable figure for paint and 50 BPN has been included for longer life products such as thermoplastic materials. Values higher than 55-60 BPN often result in the marking becoming quite discoloured from tyre blackening.

The 30 BPN chosen as the default minimum in previous versions of this specification has now been increased to a minimum of 45 BPN for paint products.

Some indicative values taken during the M/7 paint trials are as follows:

skid resistance of unmarked road chipseal	60-70 BPN
skid resistance of unbeaded lines	38-55 BPN
skid resistance of beaded lines	54-66 BPN

For painted markings the addition of beads on the chipseal appears to significantly improve the skid resistance, and this improvement is maintained, even with bead loss, as the resultant craters provide a microtexture. As markings wear by paint loss, the skid resistance obviously starts to approach that of the unmarked road.

Where the marking is applied over lower texture such as small chipseals, surfaces in a semi-flushed state, or over successive builds of paint, the skid resistance will be less certain and should be subject to more frequent assessment.

Skid resistance on thermoplastics needs to be closely monitored initially as some processes can result in a line only 30 BPN or less. The addition of glass beads does not necessarily increase skid resistance in all cases and in some instances an initial sprinkling of grit or quartz may be required.

Readings on the road surface will be variable. Transfund Report No. 73 describes techniques for assessing the road surface friction with the British Pendulum Tester (BPT). On large chipseals a standard deviation of 4 and ranges of 10-12 can occur. This variability can reduce to 6-7 BPN and a standard deviation of 3 on smoother surfaces.

To allow for this variability, 4 out of 5 tests are expected to be 4.5 BPN (or 50 BPN) or greater**. No further allowance for variability is then made.**

It is thought that skid resistance could also be measured by mobile instruments such as the GripTester, a small towable trailer type instrument about the size of a wheelbarrow. Conversions from GripTester readings to equivalent BPN values are available. However there may be practical difficulties of ensuring that the Grip Tester stays on the line under test. It can however be used in a hand push mode which could be useful on difficult traffic control sites.

2.6 Wear/Paint Loss

The degree of wear by paint loss is not specified as a direct requirement. Loss of paint will show first as a decline in retroreflectivity, and when more significant as a decline in daytime visibility.

2.7 Minimum Durability

Specifying a minimum durability is a key element of the performance based specification. It is a de facto or more site specific way of ensuring that markings of reasonable quality are used, especially with the removal of the current type approval (M/7) system for products. With short-life markings there is:

- little certainty that there are sufficient road markings for the road user;
- high surveillance costs imposed on the road authority/consultant; and
- excessive disruption with frequent remarking.

Three months is seen as the lowest acceptable minimum durability, but a minimum level can be specified in the contract. For example, for a busy road a 12 month minimum durability could be required.
In practice it is expected that the high cost of monitoring associated with short-life materials will encourage the use of much more longer life materials.

3. EXPECTED LIFE

Expected life is another means of ensuring that materials used are adequate without recourse to a type approval list. The expected life estimation must be much more soundly based than a hopeful guess. **Consultants should expect contractors to present relevant test data to support their estimation of expected life.** It is expected that Contractors will up-skill in understanding how the available materials perform in different environments, and will avail themselves of proper test information (especially from their suppliers).

The expected life must be identified so that realistic monitoring/audit and payment programmes can be set and assessment of residual life can be made.

To ensure that Clause 3 "Minimum Durability" is achieved, it is suggested that expected life should exceed the minimum durability required by a factor of at least 1.2 times.

4. MONITORING

Monitoring of performance is the key feature of the specification and the Contractor's main role is to provide assurance to the Engineer that the required performance is being delivered.

Provision has been made for monitoring to be undertaken shortly after the Contractor takes over the contract area or alternatively soon after the network has been remarked to bring it up to the P/20 standard. This is part of the process of getting the Contractor to take ownership of the condition of the asset as it allows the Contractor to confirm the information provided in the database. This point is where concerns/discrepancies in the database should be raised.

Consideration needs to be given to the extent of monitoring required. For a marking in a high wear area with a short life, the marking will be frequently replaced. Monitoring costs would, under this schedule, probably be more than the marking cost. This would tend to drive the selection of markings strongly in the direction of selecting long life markings. It would be possible to reduce the monitoring frequency by allowing for the values after remarking to be assumed from the quality control plan. Further reductions could be achieved by allowing reduced monitoring on markings with a well established service history, so that all monitoring is focused at the end of life. This, however, will tend to favour contractors using established materials, and disadvantage those seeking to be innovative. In addition, with a long life marking there will be possibly several years of service where no formal monitoring occurs. The road owner would probably desire quantitative information be provided on an annual basis. However, requiring

proportionally more monitoring on long life materials than on short life materials may be desirable. Allowance has also been made for a lower level of measurement where the Contractor clearly exceeds the minimum values and it is readily apparent the performance is being delivered. The specification therefore allows for two types of flexibility. Firstly, the trade-off in monitoring frequency between long-life and short-life materials; the second is the trade-off in monitoring intensity between marginal performance and high performance materials. Allowance should be made that a scheduled monitoring could be replaced directly with a remark.

Clause 6.5 has been introduced together with Appendix 5 to give guidance on developing an appropriate level of testing to provide assurance of conformance.

Informal monitoring, which shall be "drive-over" visual assessments of the markings, can be undertaken by the Contractor at any time so long as there is no disruption to traffic flows. The Contractor will need to develop skills to be able to subjectively assess that the marking readily exceeds minimum required values. Where there is any doubt, measurement should be undertaken.

Obviously it would be desirable to have mobile instruments to measure the whole area. This is done in some countries. However, up until now they are expensive ($200,000-$300,000) and the current relatively short life of paint markings means that an annual or bi-annual survey is not a useful measure of current performance. However, several lower cost alternatives are being developed locally. These will help make monitoring less expensive as less traffic control will be required.

When mobile instruments are being proposed for the monitoring, data showing the correlations to the hand held units should be provided. Mobile instruments should be demonstrated as being reliable on: several road surface types; on bends and straights, on the flat, uphill and downhill; and over several degrees of road roughness. Contractors should describe how the instruments average data in a way that ensures its integrity such as being able to identify and exclude spurious readings..

5. MEASURING REFLECTIVITY

Retroreflectivity is likely to be the key property which defines performance. It is essential that the contractor becomes fully informed on retroreflectivity measurements, and undertakes the necessary procedures to ensure reliable measurements.

Reflectivity is the likely main determinant of contract compliance and variability of equipment a likely cause of friction. It is recommended that contractors and consultants discuss and agree on the methods of measurement early in the contract. Some on site measurements and comparison with visual performance is suggested.

When measuring on a road surface, measurements can be highly variable between repeat readings at approximately the same location. The extent of variability appears related to both the marking type and the road surface. For example, thermoplastic markings on asphalt concrete provide fairly consistent repeat readings. Paint on chipseal can be highly variable at approximately the same location, as well as varying considerably along the road. Where measurements are highly variable, additional measurements should be made so that a stable average is obtained.

The method in this specification refers measurements back to a common base of values obtained for reference plates measured by standard optometry.

A T-series specification is in development and will when published supersede Appendix 3 of this Specification.

6. MARKING RESEALS

While it would be preferable for the Contractor to remark the new laid seal, it appears this is not the normal practice. However, the weighting should be for the reseal contractor to use only materials compatible with those intended to be used by the Marking Contractor rather than vice versa.

Allowance for reseals should also include remedial maintenance carried out under P/17 conditions which might either destroy or significantly degrade the marking.

7. INFORMATION AVAILABLE TO TENDERS

There is likely to be significantly different information available where the contract is from a method based to a performance based contract compared to a contract following a performance based contract. For the former, information is likely to be sparse, and may be limited to listing the markings and time of last remarking. It would be normal in transition situations to allow for total area-wide remarking to bring the contract area up to standard. Thereafter, lines should be maintained above the minimum levels.

8. ABNORMAL AREAS

Abnormal areas would include areas where high wear may occur but its occurrence is quite unpredictable, eg flooding, slips, gritting, etc. It would not normally include areas where high wear may occur but it is easily predictable, for example a heavy vehicle entry point such as a quarry. There may be also areas where, for example, a shoulder is narrow and gravel is tracked over the marking causing higher wear. This also is not abnormal as it is predictable. There has been considerable discussion about including gritting as an abnormal event and it depends on the circumstances. Gritting

can greatly reduce the life of some markings but has little effect on high durability markings such as thermoplastic. Ideally a highly gritted area would have a marking such as thermoplastic applied so as to ensure the availability of markings to road users. Therefore gritting is an abnormal event unless the engineer provides an estimate of the frequency of gritting so that the contractor can price accordingly. Significant, eg 20%, departures from this estimate are, however, abnormal events. Contractors are expected to be knowledgeable about areas for which they are tendering.

Where abnormal areas occur it is important that the road markings are still managed. Markings in abnormal areas should not be abandoned. The Engineer should be mindful of the high standard imposed on the contractor and of the risks to drivers if marking expected to be in place are severely degraded. Damaged markings should be reinstated as soon as practical, or if ongoing problems such as bleeding are occurring other systems such as raised pavement markers and/or signs and even surface treatment should be considered as appropriate to the risk that is present.

9. DATABASE

The database is seen as a key feature which will operate to protect the subsequent Contractor from inheriting a "lemon", the existing Contractor from being undercut by the uninformed, and the roading authority from claims that the asset was not in the condition portrayed. It is envisaged that while subsequent Contractors will inherit an existing database, for new contracts the Engineer will prepare the initial database prior to seeking tenders.

10. CRITERIA FOR ACCEPTANCE

The acceptance criteria are based on the understanding of how markings are used by road users.

Appendix 1 to the notes is taken from draft Transit New Zealand's Report PR3-0123 Roading Signage and Delineation and discusses a driving model and its implications from delineation.

Fig.1 illustrates how the level of safety is related to the level of delineation.

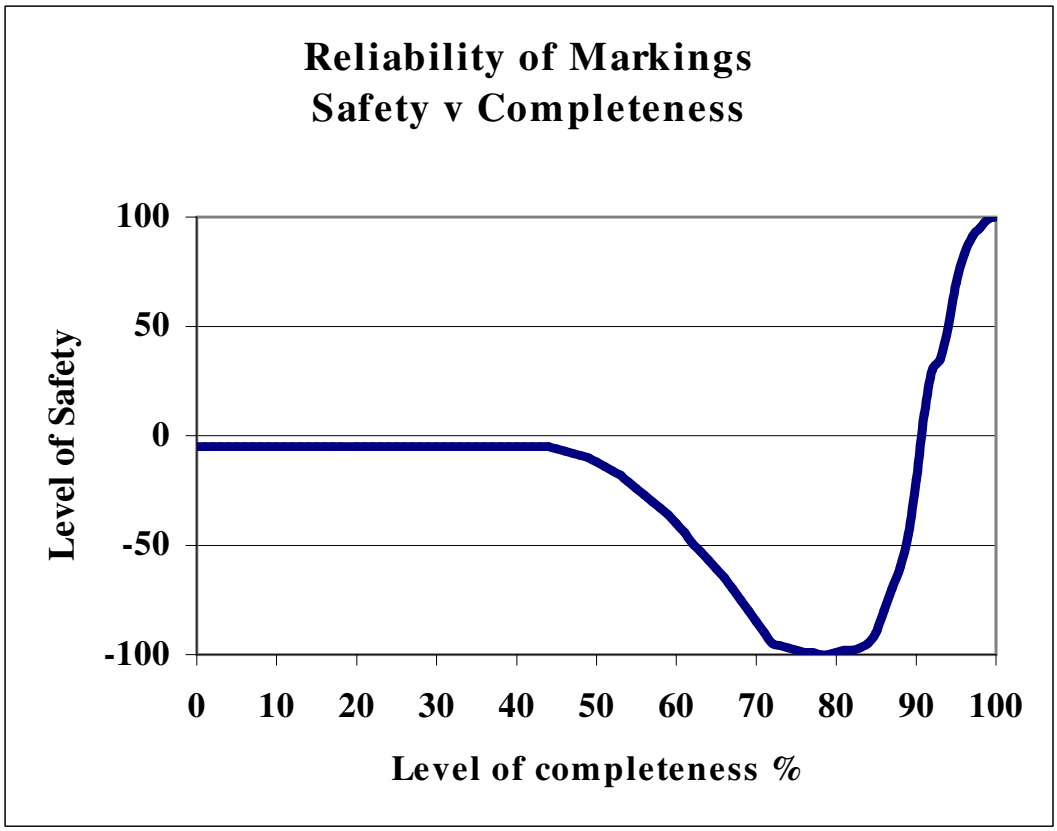

Fig 1 : Model of Level of Safety versus Level of Delineation

Drivers can safely drive without any delineation, by adjusting demand eg low speeds. As delineation is progressively added, it will be little used by drivers as there can be little reliance placed on delineation being present. However, when delineation is complete, the driver will use the delineation as it can be relied on, and adjust their driving load accordingly, ie speed up, reduce concentration.

Because the driver is now relying on the delineation, small areas below required performance levels can create a significant hazard as drivers must rapidly adjust to the increased driving load caused by the poor delineation. The safety system can therefore rapidly become a danger system because its inadequacies are not apparent. As performance further decreases then its inadequacies become more obvious to the driver who therefore places less reliance on the delineation and the level of safety rises.

In a methods based specification the Engineer is taking responsibility for the safety system. The Marking Contractor is only providing markings as directed and historically payment is related more linearly to delivery of markings. However in a performance based system much of the responsibility for the safety system is transferred to the Contractor and because of this, payment schedules are related to provision of a safety system rather than the provision of markings.

11. TRANSITION FROM P/12 TO P/20 CONTRACTS FOR REGIONS

The Engineer need to be mindful that many of the superior markings now available need to be applied in the more favourable conditions of late spring to early autumn. Even conventional markings cannot be usually applied in winter. Contracts starting 1 July will therefore cause the contractor difficulty unless some transition arrangement is made, for example a P/12 remark in autumn so as to carry the regions remarking over until late spring. It is poor practice to just leave the markings in a degraded state until the new contractor can remark them.

12. TRIALLING OF TNZ P/20 (PILOT) PERFORMANCE BASED ROADMARKING SPECIFICATION

These notes were originally included to provide guidance to regions trialling the P/20 (Pilot). It is left in these notes to be used if the Engineer considers likely tenderers will need time to develop their skill with a P/20 contract.

1. Recommended Schedule of Testing and Frequency

Refer to Table 1. This is based upon a Formal Monitoring programme as specified in P/20 and should be clearly explained in the Contractor's Quality Plan.

The Contractor could be asked to indicate the cost to complete **one** complete monitoring circuit, to allow modification of the programme given the uncertainty of the life of the product to be applied. This will allow the frequency of monitoring to be adjusted.

2. Roadmarking Materials

All material applied must comply with the relevant Transit NZ specifications (M/7 & M/20) with the exception that materials currently being trialed under the TNZ M/7 specification will be accepted provided they comply with all of the specified performance criteria. (That is, they may not yet be formally approved by Transit NZ but evidence is to be submitted showing full compliance).

3. Quality Requirements

All equipment used to undertake application should be TNZ T/8 certified unless specific approval is given by the Engineer to use an alternative system. All testing/monitoring equipment must have evidence of current calibration and documented techniques for verification.

The Contractor shall have a Transit NZ approved Quality Assurance system as specified in TNZ P/12.

4. Payment

Some form of lump-sum or accelerated payment may be reasonable to enable the road contractor to bring a contract area up to standard with high quality materials. If early payment is made, it is important that there is still sufficient incentive for the contractor to keep the markings up to standard for the remainder of the contract.

It is suggested that a early payments should only be a proportion of the total, and that it be made only after the initial performance has been measured. Only about 30% of the payments should be in an accelerated form.

Performance Criteria	Requirement	Location	Number of Tests	Frequency
Colour	As specified, using a colour scale. (obtainable from NZ Standards)	At the same locations as retroreflectivity test areas.	1 test per 50 metres, equalling 5 per 200 metre lot.	Monitoring to be undertaken as specified or alternatively, bi-monthly. **(As per P/20 or as nominated by the Engineer and is dependant upon the length of contract and the life of nominated materials. Suggestion, that for a pilot bi-monthly trial be adopted for the first 6 months until the life expectancy of the product is confirmed and then move to the specified monitoring frequency)**
Daytime Visibility	As specified	Whole contract area	Drive-over of the complete contract area during daylight.	
Night-time Visibility	Retroreflectivity - (day-time) as specified	A sample site = 200 metres in length. 5 sub-sites to be located at 50 metre spacings within this site. (Eg. 5 sub-sites located at - 0m, 50m, 100m, 150m & 200m)	Up to15 readings within a 5 metre length to obtain a stable average. These 5 metre sub-sites to be recorded every 50 metres over a 200 metre length.	
	Visibility (night-time)	Use areas compliant for retroreflectivity (to be clearly marked on the road) for a reference when comparing the balance of the contract area	Drive-over of the complete contract area at night.	
Skid Resistance	As specified, or for M/7 & M/20 approved products reduced testing as nominated in this schedule. **(Unbeaded markings require full testing as specified. Thermoplastic markings in particular should be closely monitored when first laid).**	At the same locations as retroreflectivity test areas.	5 measurements at 10 metre spacings on a minimum of 10 sites. (at least 1 site on asphalt where applicable)	Tests required within 1 week of each application of a particular product and at least once per year. When using an approved product, sufficient tests to verify adequate skid resistance.

Formal Monitoring - As Specified in P/20 and is based on **5%** of the Contract Area plus any Non-complying areas.