SPRAYED TREATMENTS

INTRODUCTION

These notes are based substantially on the Austroads Sprayed Sealing Guide, published in 2004. For more detailed information, refer to this guide and other referenced publications, AAPA’s specialised training courses on Selection and Design of Treatments, and Field Procedures, and the Austroads/AAPA Pavement Work Tips series.

THE NATURE OF SPRAYED SEALS

In its most basic form, a sprayed seal consists of a single layer of bitumen sprayed as a hot liquid, followed immediately by a single layer of crushed aggregate. Sprayed seals are held in place by a combination of adhesion between binder and aggregate, mechanical interlock between adjoining aggregate particles and the cohesive binder filling void space between aggregates.

Sprayed seals are an important component in the road system in Australia and New Zealand. Much of Australia is sparsely populated with large distances between centres of population. Providing a network of sealed roads has necessitated the development of outstanding skills in low-cost road construction and maintenance techniques, particularly the use of thin sprayed bituminous treatments on pavements constructed from locally available materials (often of marginal quality) or fine crushed rock.

Sprayed seals are an economical surfacing and the techniques developed in Australia and New Zealand allow them to be used effectively as initial treatments on roads carrying up to several thousand vehicles per day. They can also be used, with some limitations, as retreatments on bound pavements (such as asphalt or concrete) on all but the most heavily trafficked roads to provide improved texture, or to waterproof and protect the pavement due to cracking, permeability, or ravelling of the surface.

The Australian (and New Zealand) road system comprises some 900,000 km of roads of which 350,000 km are surfaced with sprayed seals, asphalt or concrete. In rural areas sprayed seals are the predominant type of surfacing and account for around 70% of the total length of all surfaced roads. In urban areas, asphalt and concrete surfaces predominate due to added structural strength, durability, improved resistance to surface stresses and lower maintenance.

Traffic has a major effect on performance of sprayed seals.

Priming and primersealing involve the use of lower viscosity cutback bitumen to obtain the necessary penetration and/or adhesion to the underlying pavement.

The performance of sprayed seals deteriorates through gradual hardening of binder. Eventually, the seal will require maintenance intervention because of loss of aggregate or minor cracking to avoid weakening of the underlying pavement, leading to a need for increased surface repair. A system of planned periodic maintenance, to resurface sprayed seals before they reach a critical level of deterioration that leads to loss of pavement performance, is most important in the management of roads surfaced with sprayed seals.

Sprayed seal performance can also deteriorate because of aggregate wear and polishing, or aggregate embedment, leading to loss of surface texture and reduced skid resistance, particularly in wet weather conditions. Intervention and treatment may therefore be required earlier than otherwise required due to long term hardening alone. Premature deterioration may also occur due to loss of aggregate or through flushing of binder as a result of incorrect design of application rates or poor work practices.
SELECTION OF TREATMENTS

1. INTRODUCTION

This section provides guidance for the selection of sprayed bituminous surfacing treatments to meet the environmental, serviceability, structural and economic requirements for new work and rehabilitation work.

Sprayed seals used as initial treatments on unbound granular, concrete or timber surfaces, generally require the use of either a prime or primerseal.

Other types of sprayed bituminous surfacing include surface enrichment and dust laying. These are generally applied without any cover aggregate.

2. PRIME

A prime is an application of a primer to a prepared granular base. It usually consists of a bitumen and cutter oil or specially formulated bitumen emulsion primer and is placed without a cover aggregate. Penetration of the prime into the base varies, but for granular base materials it is typically 5–10 mm.

As it has no aggregate, it should not be trafficked and a more substantial surfacing treatment should be scheduled after the prime has dried. Drying can take up to 48 hours depending on the climate and the nature of the base.

A prime is used to:

- bind and penetrate the surface of an unbound granular layer
- provide a bond onto which a subsequent bituminous surfacing can adhere
- provide a surface which retards the absorption of the bitumen, from a subsequent bituminous surfacing, into the pavement
- assist in waterproofing and protecting the pavement
- assist with the curing of stabilised pavements
- provide a temporary surface for traffic (though it should be noted that the life of the primed surface exposed to traffic is brief).

A prime is always recommended over granular pavements that are to be surfaced with a sprayed seal, or to be surfaced with asphalt where the depth of surfacing is less than 50 mm. A prime is also recommended for bonding of sprayed seals or asphalt to timber or concrete surfaces.

3. PRIMERSEAL

A primerseal is an application of primerbinder sprayed onto a prepared pavement surface and covered with a layer of aggregate. It allows both immediate trafficking and permits a delay in placing of the final surfacing. It is used as an initial treatment to a more permanent bituminous surfacing. It is intended to carry traffic for a longer period than a prime (typically about 1–2 years), before the application of a permanent bituminous surfacing.
A cutback primerbinder is manufactured with between 10% and 20% cutter oil (and adhesion agents) to assist the primerbinder to ‘wet’ and penetrate the surface of the pavement (preferably to 2−5 mm). If the bitumen in the primerbinder is not cut back sufficiently, it could ‘ball’ (i.e. it may not be uniformly spread across the pavement) and/or it may not bond to the underlying surface.

A bitumen emulsion primerbinder may also be used. The emulsion primerbinder must uniformly ‘wet’ the surface of the pavement if it is to bond to the underlying pavement. Emulsion used as primerbinder can be either standard emulsion or specially formulated for this purpose, and must perform the same function as cutback bitumen.

For both cutback and emulsion types of primerbinder, the pavement surface should normally be dampened (not wet) immediately prior to application of the primerbinder to assist in the ‘wetting’ process.

For sealing work on new pavements, the initial treatment usually results in a choice between applying a prime followed by a seal, or applying a primerseal followed by a seal within one to two years. The following table provides a summary of the advantages and disadvantages of both alternatives.

<table>
<thead>
<tr>
<th>Initial Treatment Type</th>
<th>Advantages</th>
<th>Disadvantages</th>
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| Prime and seal         | 1. Generally more economic in overall cost  
2. Reduces the absorption of seal coat binder into the pavement  
3. Thicker waterproof layer  
4. Strong bond to the pavement  
5. May be used to protect pavement prior to sealing  
6. Easier to cope with non-uniform pavement condition and texture | 1. The pavement surface must be dry  
2. Best results are obtained in dry/warm conditions  
3. Two-stage process  
4. The primer must be dry and set up before sealing  
5. Use of pavement by traffic is restricted  
6. Rain may cause uncured primer to be washed off the pavement with loss of primer and risk of environmental damage |
| Primerseal             | Can be placed on a damp pavement (dried back to about 60-70% of optimum)  
One step process that can be opened to controlled traffic immediately it is completed  
Allows repair of pavement deficiencies prior to final seal. | Relatively short term treatment and must be followed by a final seal to complete the treatment within 1 to 3 years  
Cutback bitumen primerseals require 3 to 12 months curing  
Rain soon after pavement construction can lead to problems such as aggregate embedment, binder emulsification, stripping of aggregates and pick-up on vehicles |

Table 1: Advantages and disadvantages of primerseals and prime and seals (from Austroads 2003)
Sprayed Treatments

4. SPRAYED SEALS

General

The general term used in Australia for an application of bituminous binder and aggregate is ‘sprayed seal’, commonly shortened to ‘seal’. When placed as a retreatment of an existing bituminous surfaced pavement, it is referred to as a ‘reseal’. In New Zealand, the terms ‘bituminous seal’ and ‘chipseal’ are also used. The term ‘chip’ is a reference to the description of aggregate particles used in sealing work.

The basic form of sprayed seal is a single application of binder followed by a single application of aggregate, also called a ‘single/single seal’. It is generally assumed that a seal is single/single unless specifically stated.

Multiple application seals are generally described in the sequence of application of binder and aggregate, for example:

- Double/Double = two applications of binder and two applications of aggregate.
- Single/Double = a single application of binder and a double application of aggregate.

Specialised seals and reseals are also used to meet specific circumstances, and include single/single seal with scatter coat, strain alleviating membrane, strain alleviating membrane interlayer, geotextile reinforced seal, fibre reinforced seal, dry matting, cape seal, high stress seal, and inverted seal. Enrichment and rejuvenation are not seals in the true sense but use much of the same equipment and procedures. Types of sprayed seals commonly used in Australia and overseas are described below.

Purpose of Sprayed Seals

The purpose of a sprayed seal is to:

- Provide a durable, safe and dust-free surface.
- Minimise the rate of pavement wear and whole-of-life maintenance costs.
- Protect the base from the effects of traffic and the environment by preventing moisture ingress into the pavement structure.
- Provide adequate skid resistance and noise reduction characteristics over the life of the surfacing.

Distress Modes

Sprayed seals are subject to a number of distress modes, which may operate independently or interact. The primary mechanisms are illustrated below. The potential distress modes must be addressed when looking at the selection, design and whole-of-life cost analyses of surfacing treatments.

A further distress mode is that of shearing, i.e. the disruption of the binder/aggregate bond. In extreme cases, sections of the seal may be peeled off. High shearing forces typically occur where there are significant volumes of turning vehicles, such as at roundabouts or turning lanes and intersections. Sprayed seals do not have a high resistance to shearing forces and alternative surfacing types (such as asphalt) may need to be considered in these circumstances.
Sprayed Treatments

신형 모드

Oxidation of binder
Stripping
Polishing of aggregate
Bleeding or flushing
Cracking
Aggregate loss
Loss of skid resistance

Potholes

Figure 3: Distress modes for sprayed seals

Single/Single Seal
In its most common form, a sprayed seal involves the spraying of a single layer of binder and incorporating a single layer of aggregate.

Figure 4: Single/single Seal (Single application of binder & single application of aggregate)

Multiple Application Seals
Multiple application seals, comprising more than one application of binder and/or aggregate, may be used for specific applications.

Double/double seals are used when:
- additional waterproofing must be ensured
- the traffic noise from a single/single application is unacceptable
- where a more robust seal is required, e.g. heavily traffic roads such as haul roads, roads subject to snow clearing operations, inundation and other such applications.

Figure 5: Double/double Seal (two applications of binder and two applications of aggregate)
Sprayed Treatments

Special Purpose Seals

**Single/single seal with scatter coat**
A single/single seal with a scatter coat is a seal in which a smaller aggregate is used to provide temporary mechanical interlock between the larger particles during the construction compaction, initial trafficking and curing. It is not intended that the second aggregate be permanently lodged in the seal, and most will be lost during the early service life of the seal.

![Figure 6: Single/single Seal with a scatter coat](image)

**Strain alleviating membrane (SAM)**
A Strain Alleviating Membrane (SAM) is a sprayed seal with a polymer modified binder (PMB). It is used to alleviate strains that occur in the pavement in order to delay the onset of reflection cracking and reduce its extent and severity. SAM sprayed seals are generally not effective unless used with aggregate sizes of 10 mm or larger. The use of smaller aggregates is not recommended.

![Figure 7: Strain Alleviating Membrane (SAM)](image)

**Strain alleviating membrane interlayer (SAMI)**
A Strain Alleviating Membrane Interlayer (SAMI) is similar to a SAM but placed as an interlayer to asphalt surfacing. SAMIs should preferably use size 10 mm aggregate and be covered with asphalt within two days. The use of larger aggregate is not recommended. The binder in a SAMI is usually more heavily modified than that used in a SAM.

A strain alleviating membrane or interlayer may also be constructed as a geotextile reinforced seal

![Figure 8: Strain Alleviating Membrane Interlayer (SAMI)](image)

**Geotextile reinforced seal (GRS)**
Geotextile reinforced seals (GRS) represent an effective sprayed sealing technique for treating badly cracked and distressed pavements (bound and unbound), particularly where the crack movements are slow and relatively large.

![Figure 9: A Single/single Geotextile Reinforced Seal](image)

Geotextile reinforced seals may be single/single or double/double seals.

Geotextile reinforced seals can also be used as an alternative interlayer membrane (SAMI) under asphalt overlays. In heavy duty situations (≥ 750 heavy vehicles per lane per day), a friction key (7 mm aggregate seal) under a GRS may be required on smooth surfaces to ensure reliable performance of the surfacing. In very high shear areas such as intersection, braking and turning areas, GRS SAMI treatments are not recommended.

A further application for geotextile reinforced seals is as a surfacing treatment on pavements constructed with poor quality pavement materials (e.g. clay). This treatment has been successfully used in remote areas on lightly trafficked roads where reasonable quality granular pavement materials are unavailable and pavements must be constructed using local clay soils (RTA 1993).

![Figure 10: Application of Geotextile Reinforced Seal to pavements](image)
**Sprayed Treatments**

**Fibre reinforced seal (FRS)**
Fibre reinforced seal (FRS) is a proprietary process which is used to minimise reflection cracking and provide a strong, waterproof seal. FRS generally uses a polymer modified emulsion and glass fibre reinforcing. A purpose-built sprayer is used which, on a single pass:

- sprays a thin application of binder onto the pavement
- cuts the required amount of fibre glass to length, generally in the range of 60–90 mm, and blows this onto the binder
- sprays a second application of binder over the cut fibre (see Figure 11).

FRS may be used for surfacing cracked pavements or as a SAMI between asphalt layers. FRS has some construction advantages, such as:

- curved alignments are easily accommodated
- construction is faster than GRS, being a single pass operation
- typically requires less binder than GRS.

![Figure 11: Fibre Reinforced Seal showing - showing binder and fibres](image)

**Dry matting**
Dry matting is a technique using two applications of aggregate sandwiched around a solitary application of bitumen emulsion binder. It is a corrective treatment used to restore surface texture of partly stripped surfaces.

![Figure 12: Dry matting technique](image)
Cape Seal was developed and first used in Cape Province, South Africa. It is constructed by applying a single/single seal to the pavement (usually using a size 20 mm aggregate) followed by a slurry surfacing.

This type of treatment provides a very robust surfacing and the surface characteristics are substantially those of slurry. It has been used in rural areas to provide a surfacing with high shear resistance, comparable to that of asphalt, but in areas where asphalt is not economically available.

**High stress seals (HSS)**

A High Stress Seal (HSS) is a bituminous seal or reseal treatment used for pavements subjected to heavier than normal traffic loading due to braking, accelerating or turning vehicles.

The binder in a HSS normally contains multigrade bitumen or polymer modifiers, which improve aggregate retention after adhesion is established. A HSS may be applied as a single/single, single/double or a double/double application.

**Inverted seal**

An inverted seal is a double/double seal that is ‘inverted’ from the normal double/double seal, such that the smallest size aggregate is on the bottom coat, and the largest size aggregate is on the top coat. For example, it is a 7/14 rather than a 14/7 seal. Both applications are laid on the same day.

This type of seal is useful in restoring uniformity to a surface that has a variation in transverse surface texture. It is also suitable in treating bleeding seals where a possible increase in tyre noise is not a problem.

**Special Binder and Aggregate Systems**

A range of special binder and aggregate systems are used for specific applications such as high skid resistance and additional surface protection. Generally they involve the use of some form of resin, polyurethane or acrylic binder to give the extra levels of performance required, as well as the use of special aggregate materials such as calcined bauxite.

In most cases these treatments are supplied as proprietary systems and must be applied by specialised contractors with the appropriate equipment and expertise to undertake the work.
Sprayed Treatments

Surface Enrichment and Rejuvenation

An enrichment treatment is used to extend the life of an existing sprayed seal surface by providing additional fresh binder to prevent aggregate loss. It consists of spraying a light application of a light grade of bituminous material (cutback or emulsion) or foamed bitumen onto the surface so that it can run into the voids in the existing aggregate. While the treatment is not a sprayed seal as such, it is applied using the same equipment.

As this treatment increases the amount of binder in the layer, care must be taken to ensure that adequate surface texture remains. This treatment extends the life of the surfacing by ensuring the retention of the existing cover aggregate, and can waterproof the surface.

Surface rejuvenation is a similar process to an enrichment treatment where a proprietary rejuvenating agent is sprayed onto the existing surface and replaces the lost oils and resins in oxidised bitumen. Rejuvenation can extend the life of an existing seal by reducing the effects of binder oxidation.

Enrichment and rejuvenation treatments are normally only used where traffic can be diverted onto another lane or road and traffic volumes are low.

Dust Laying

Dust is a nuisance and can cause safety problems due to restricted vision and settling on road signs. The choice of treatment will depend upon the magnitude of the problem but common treatments include:

- frequent application of water
- treating the surface with diluted bitumen emulsion
- spraying proprietary dust palliatives.

Manufacturers’ instructions should be followed for proprietary products.

![Figure 15: Dampening down dusty surface](image1)

![Figure 16: Dust laying techniques can be applied to other engineering works as well as road pavements](image2)

Geotextile Seals

To perform its required function, the geotextile reinforced seal (GRS) requires a significantly higher total binder content than a conventional bitumen seal.

Additional binder is required to:

- saturate the geotextile
- tack/bond it to the surface
- retain the aggregate under severe climatic conditions.
Sprayed Treatments

This may be achieved by either using a heavier application of conventional bitumen or using a PMB in the seal coat. The advantages of using the modified binders are that they are less likely to soften during hot weather and bleed or lose aggregate.

Surface Enrichment

The choice of materials depends on the availability, type of plant and cost of material. The two materials commonly used are cutback bitumen and bitumen emulsion.

There is no formal design procedure and the rates are based on field experience and expected performance. Generally the binder rate of application is between 0.5 and 0.8 L/m² depending on existing texture, traffic and life expectancy of the treatment.

Figure 16: Hungry coarse seal coat before (left) and after applying a surface enrichment of 0.7 L/m² of cutback bitumen (100-0-20)

Fibre Reinforced Seals

This is a proprietary process, and the Contractor generally designs the binder application rates and aggregate spread rates. The design is based on standard procedures modified to take into account factors and allowances developed for this process. The rates used are generally heavier than for a normal seal, along similar lines to a PMB seal design.

REFERENCES

AP-G76/04 : Sprayed Sealing Guide