DELIVERING FOR QUEENSLAND

Technical Note 175

Selection and Design of Sprayed Bituminous Treatments

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Queensland Government

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1 Introduction

Sprayed bituminous treatments (hereafter called sprayed seals) are the most common type of road surfacing on the road network administered by the Department of Transport and Main Roads.

The department has adopted (with amendments) the seal design method outlined in the Austroads *Guide to Pavement Technology – Part 4K: Selection and Design of Sprayed Seals* (AGPT04K), hereafter referred to as "Part 4K" except as amended by this technical note.

This technical note outlines amendments to Part 4K that apply to departmental projects.

For ease of reference, section numbers in this technical note align with the applicable section numbers in Part 4K. References to section numbers, tables, figures, equations, and appendices are to be read as references to both this technical note and Part 4K. Where additional sections, tables, figures, equations, and appendices are included in this technical note, these are numbered with a prefix of Q.

This technical note is intended to be a guide for professional, trained, experienced, and knowledgeable sprayed seal designers who:

- work within the confines of government policies, guidelines, and road network requirements
- are aware of, assess, and apply risk management and budgetary constraints to the road system as a whole and its various components
- optimise initial designs and in-service treatments to suit budget and whole-of-life cost issues
- apply sound principles and data to a design, construction, or production activities; and
- consider local area or project-specific issues, including when the typical assumptions and standards in this technical note are being considered.

As this technical note is a guideline, reference to it in contract documents will typically require project-specific requirements appropriate for the contract to be included in a project design brief.

Alternatives and exceptions to Part 4K and this technical note’s typical design assumptions and standards may be necessary for the designer’s project-specific design. In making these decisions, designers are implicitly evaluating the risks and benefits to the project based on application of the relevant practice and technology. Seal designers will recognise that there may be compounding and interconnected risks and/or opportunities when multiple changes to typical values are applied in determining a sprayed seal treatment solution.

3 Types of sprayed seal treatments

3.4 Other treatments

3.4.1 Variable rate spraying

Sealing with a variable rate spray bar is the process of spraying different binder application rates across the width of a spray run in a single pass.

This process facilitates the optimisation of the seal design to address the most common types of defects in sprayed seal surfacings, which are:

- flushing / bleeding in the wheel paths, and/or
- stripping in non-wheel path areas (i.e., around the centreline, between wheel paths, and on shoulders).

Sealing with a variable rate spray bar could be considered in the following situations:

- as a remedial treatment for existing seal defects (e.g., flushed / bleeding wheel paths)
- where there is significantly different surface texture across the lane (e.g., where the difference in texture allowance is ≥ 0.3 L/m² between the wheel path and non-wheel path areas), and/or
- where there is a high percentage of equivalent heavy vehicles (EHVs) and/or a high AADT:
  - this combination can sometimes result in a uniform spray rate across the road which is too low to avert stripping in untrafficked areas (i.e., around the centreline, between wheel paths, and on shoulders) and too high to avert flushing in the wheel paths.

The underlying principle of variable rate seal design is to:

- design for the wheel paths, and
- increase the spray rate for the non-wheel path areas to account for the higher risk of stripping in these areas.

A special note on variable rate seals and seasonal considerations:

Due to the reduced binder application rate in low-spray areas, sufficient time under traffic at higher temperatures is required to ensure adhesion of the aggregate before the onset of cold weather. Therefore, it is highly desirable for any variable rate seal to be subjected to at least one month of hot / warm weather under traffic before the onset of cold weather. Variable rate seals are not typically used when the expected daily minimum air temperatures are < 10°C within one month after completion of the works.

4 Selection of treatments

4.5 Selection of aggregate

4.5.2 Aggregate size

Part 4K recognises nominal aggregate sizes ranging from sand up to 20 mm are used in sprayed seals and states the primary use of 16 mm and 20 mm aggregates is in combination with a smaller sized aggregate in double / double or single / single seals with scatter coats.

It is desirable for aggregate in the second application to be approximately half the average least dimension (ALD) of the aggregate in the first application. Common combinations of aggregate in double / double and single / single seals with scatter coats are:

- 10 mm with a 5 or 7 mm aggregate
- 14 mm with a 5 or 7 mm aggregate
- 16 mm with a 7 mm aggregate, and
- 20 mm with a 10 mm aggregate.

In addition to the above information from Part 4K, the department does allow for the combination of robust 16/10 mm seals and 14/10 mm seals where the additional measures for each condition have been considered.

Table Q4.3.2 – Average least dimension considerations for sprayed seal treatments

Condition	Additional measures
Where the aggregate in the second application of aggregate is approximately half the ALD of the aggregate in the first application.	This aggregate is acceptable for use. Refer to any further contract-specific requirements.
Where the aggregate in the second application is greater than half the ALD of the aggregate in the first application.	Flakiness Index (FI) for the second layer of aggregate should be in the angular range of 16-25% to ensure adequate interlock of the second application of aggregate with the first application of aggregate. Supplementary requirements may need to be applied to Annexure MRTS22.1 *Supply of Cover Aggregate* to achieve this objective.
	Spread rate on first application of aggregate to have adequate voids to allow interlock of second application of aggregate. This can be achieved by using a more open or lighter spread rate on the first application of aggregate, approximately 10-20% lighter than typical rates.
	Total binder application rate reduction of up to 0.2 L/m² could be considered for these seals to account for the lower aggregate spread rates on the first coat

4.8 Selecting an initial seal

Section 4.8 of Part 4K provides general guidelines for selection of initial seals based on traffic and climatic conditions. The following additional guidance should be considered by designers:

- Although the use of initial seals with polymer modified binders (in either hot binder or emulsion form) has been trialled by a number of jurisdictions in Australia, the department has limited experience with the use of these binders in initial seal applications.
- Austroads report AP-T276-14 provides further information about the design and performance of initial seals where crumb rubber modified binders have been used, and
- AAPA Advisory Note 20 provides further guidance on the requirements for PMB emulsions as these binders are not covered by the department's bituminous emulsion Specification.

Risk management principles should be applied when selecting, designing, and constructing initial seal treatments with polymer modified binders (in either hot or emulsion form) or crumb rubber binders on departmental projects, particularly at high-risk sites, until more experience has been gained with their use.

Whilst there are potential performance benefits from the use of polymer modified binders for initial seals, they may not be suitable for initials seals as they may be more susceptible to failures (e.g., stripping, poor adhesion to the underlying pavement), and should be used with care and local experience by exception only.

Poor pavement surface preparation (i.e., provision of a dry and/or dusty surface that has not been adequately broomed) can lead to the initial seal not adhering adequately to the underlying pavement. This is particularly the case for:

- cementitiously stabilised / modified pavements
- cutback bitumen where the percentage of cutter oil used is relatively low (e.g., AMC7), and
- bituminous emulsions.

4.8.1 Binder type

Departmental projects have typically utilised a more limited range of binders for initial seals than that outlined in Table 4.6 of Part 4K. The primary factors influencing the selection of binder for initial seals on departmental projects are the prevailing weather conditions, pavement type and condition, timing of secondary seal, and traffic loadings. Spraying initial seals with the appropriate temperature (to obtain appropriate viscosity) and spray nozzles will result in a uniform spray rate and ensure adequate contact / adhesion with the aggregate.

A guide to the selection of common types and grades of cutback bitumen used for initial seals on departmental projects (excluding foamed bitumen stabilised pavements) is as follows:

- typical winter grade, cool to cold prevailing weather conditions – AMC6:
  - binder grade is sometimes changed to AMC5 if cold, wet weather is anticipated on the days following application of seal, and
  - binder grade is sometimes changed to AMC7 if hot weather is anticipated during construction and/or on the days following construction.
- typical summer grade, warm to hot prevailing weather conditions – AMC7.

Adjustment to the cutback bitumen grade or cutter oil content may be required due to the following factors:

- porosity of the pavement surface (e.g., stabilisation), and/or
- site-specific conditions (such as short-term changes to traffic conditions and environmental factors).

For some highly absorptive pavement materials, the use of C170, C320 or multigrade bitumen may also be appropriate binders in high temperature conditions on low traffic roads.

Note that it is typical in some Transport and Main Roads districts to reduce the initial seal curing time to 2 weeks prior to application of final surfacing by utilising AMC7 or high binder content CRS bituminous emulsions (HBCE). Flushing and/or bleeding risks must also be considered, assessed, and any necessary risk mitigation measures put in place prior to secondary seal works being undertaken. It is typically recommended to allow 6 months curing for cutback initial seals and 3 months for high binder content emulsion initials seals. Appropriate curing times between initial and secondary seal applications should be specified in contract documents.

HBCEs (>67% binder) are more suited to cooler and/or damp conditions, however, it is important that the compatibility of the bituminous emulsion with the pavement material and cover aggregate is verified prior to use. Either verification with the binder manufacturer or site trial can be used to determine compatibility of the emulsion (i.e., cationic or anionic). Local experience with the use of these binders on similar works and material type (including geology) can also be used to assess suitability of emulsion for initial seal binders.

Emulsion seals are not recommended when pavement surface temperatures at the time of construction (including the breaking and curing periods) are outside the range of 10-50°C. Emulsion seals may also experience early seal life damage until the binder has sufficiently cured. This needs to be considered during sealing operations, back-brooming, and up to 48 hours after completion of sealing, and adequate traffic management should be implemented to minimise risks.

Double / double initial seals are more suited to higher traffic and/or higher stress applications, such as sharp corners, intersections, and turning areas.

Single / double initial seals (i.e., scatter coats of smaller aggregate as a secondary layer) are acceptable on low traffic and low-risk sites to improve robustness of surfacing. In these situations, loose aggregate can be a hazard and poses a higher risk of traffic accidents or stone chips for public vehicles and these risks need to be assessed and managed appropriately.

HBCE and cutback binders are both suitable for double / double and single / double initial seals, however, when cutback double / double seals are the selected treatment type, it is recommended to use AMC7 binder to minimise the risk of flushing.

Q4.8.1.1 Initial seals on foamed bitumen stabilised pavements

The feature of foamed bitumen stabilised pavements influencing the design of bituminous surface treatments is the presence of bitumen in the stabilised basecourse.

The preferred sealing treatment for foamed bitumen stabilised pavements is an initial seal.

It is generally desirable to reduce the cutter oil content for initial seals on foamed bitumen stabilised basecourses due to the potential for such cutbacks to soften the bitumen in the surface of the basecourse. This can lead to excessive aggregate embedment and/or flushing in the subsequent sprayed seal application.

Binder types typically used for initial sealing of foamed bitumen stabilised pavements are summarised in Table Q4.8.1.1.

Table Q4.8.1.1 – Binder grades typically used for initial sealing of foamed bitumen stabilised pavements

Ambient temperature	Binder type
Cold	High Binder Content Emulsion (HBCE)[1]
Warm	High Binder Content Emulsion (HBCE)[1], or C170 or AMC7[2]
Hot	C170, C320 or M500 bitumen

Notes:

1. Consideration may be given to the use of polymer modified emulsion products. Refer AAPA Advisory Note 20 for the requirements that need to be included in Clause 1 of Annexure MRTS12.1 *Sprayed Bituminous Emulsion Surfacing*, and
2. Where cooler temperatures may be experienced, consideration may be given to the use of AMC7.

A 10 mm aggregate is typically used for initial sealing of foamed bitumen stabilised pavements. 7 mm aggregate can be considered for initial sealing that will be covered by a subsequent layer with minimal trafficking.

Bitumen already in the base may permit a reduction in application rates as outlined in Section 6.2.4 of Part 4K, provided that there is sufficient binder to maintain the integrity of the initial seal.

4.8.2 Aggregate size

In addition to the guidance provided in Section 4.8.2 of Part 4K, selection of aggregate size for initial seals requires consideration of several factors, including the traffic loading, time period between initial seal and the secondary surfacing treatment, as well as the aggregate size to be used for the secondary surfacing treatment. Table 6.3 of Part 4K can be used as a guide to assess the compatibility of aggregate used in the initial seal and the subsequent seal treatment.

4.9.2 Geotextiles

In addition to the guidance provided in Section 4.9.2 of Part 4K, C170 bitumen is typically used as the binder in geotextile reinforced seals (GRS) on departmental projects. M500 multigrade bitumen has also been trialled as the binder on departmental projects and is an acceptable binder to use in GRS applications.

The use of S9R, S9RF, S15R or S15RF binder for GRS reseal applications is acceptable where approved by the Administrator.

4.10 Selecting a sprayed seal

For sealing works constructed during ideal weather conditions (dry and warm / hot conditions), Table 4.7 of Part 4K should be used as a preliminary guide to the selection of sprayed seal treatments, noting that this table is only a guide, and variations based on local experience may be considered.

For sealing works constructed during less-than-ideal or unfavourable weather conditions (wet and/or damp conditions), consider using bituminous emulsion binders and/or double / double treatments to reduce the risk of early life stripping during these conditions. Further guidance can be found in Technical Note 186 *Sealing in Cold Weather Conditions*.

5 Design method

5.3 Aggregate size and shape

5.3.1 Average Least Dimension (ALD)

Currently, the department uses AS 1141.20.3 *Methods for sampling and testing aggregates, Method 20.3: Average least dimension – Calculation (nomograph)* method for ALD inputs in seal design. This method involves the calculation (or use of a nomograph) of ALD from the grading, median size, and flakiness index.

5.4 Surface texture

An allowance (Section 6.2.2 of Part 4K) is added or subtracted to the binder application rate based on the measurement of the surface texture by the sand patch method, using Austroads (2008) AG:PT/T250-08 *Modified Surface Texture Depth (Pestle Method)*.

Use of a laser texture meter is also acceptable for measurement of surface texture as per Q715 test procedure. Note that the texture adjustment equations must be applied for sprayed seal surfaces as per Q715.

Network survey texture measurements shall not be used for seal design inputs.

5.5 Design process

5.5.3 Initial treatments – primes

It is recommended that cutback primes are not used on foamed bitumen stabilised bases.

Table 5.4 of Part 4K provides some guidance on the typical rate of application of primer. However, the application rate may need refinement when using new material sources and to account for the porosity of the final prepared pavement surface. This issue can be addressed by undertaking a priming trial.

Figure Q5.5.3 – Small scale priming trial

The priming trial usually involves the application of different grades and/or application rates by hand to small areas of prepared pavement. The appearance of the resulting primed surfaces is then compared and used to determine the most appropriate grade and rate of application.

5.5.4 Other seals

Strain alleviating membrane interlayer (SAMI)

Transport and Main Roads typically uses a 14 mm (instead of a 10 mm) nominal size aggregate[1] for SAMI seals, which enables the use of higher binder application rates (typically around 2.0-2.5 L/m²) for enhanced resistance to reflective cracking. However, this may be reduced to around 1.5-1.8 L/m² in high shear areas, such as at the approach to signalised intersections or where the risk of flushing, bleeding and/or binder pick-up is a risk. Note that in high shear areas, milling prior to placement of a SAMI can offer enhanced mechanical interlock between the bituminous layers and could be considered in lieu of a reduction in binder application.

Waterproofing seals under asphalt (WP-A)

The WP-A treatment type with a PMB is designed the same as a SAMI seal, except that a 10 mm nominal size aggregate is typically used to achieve a lower binder application rate (typically around 1.5-1.6 L/m²). Binder selection for these seals as approved by the Administrator.

It is recommended that PMBs be used in WP-A seals, however, a C170 binder can be used (where approved by the Administrator) in the following circumstances:

- where the total area to be sealed is minimal, requiring a small quantity of binder and it is deemed impractical to batch a PMB in this situation, and
- where small, isolated sections of granular pavement are exposed during profiling / milling, and it is not practical to complete a prime and single / single seal during the operations.

If possible, it is also good practice to tack the exposed granular surface prior to applying the C170 WP-A seal to ensure adequate adhesion to the base.

Single / single seals for waterproofing granular layers (S/S)

Where granular pavement is exposed during the milling or construction process, the department typically requires the use of a prime followed by a single / single seal or initial seal to waterproof the pavement. Cutback or emulsion prime can be used to provide adhesion of the granular pavement to the single / single seal and adequate curing times for the prime must be adhered to. Where trafficking of the surface is required immediately, initial seals can be placed in lieu of prime and seal.

[1] 16 mm nominal size aggregate is sometimes used where 14 mm aggregate is not locally available. Binder application rates should be increased as appropriate where 16 mm is used for SAMI sealing.

Note that there may be reduced adhesion between a primed granular pavement and polymer modified binder in comparison to a primed granular pavement and unmodified (C170) binder.

Table Q5.5.4 provides further guidance on the typical aggregate sizes, binder rates, and applications of SAMI, WP-A and single / single seals for use under asphalt layers.

Binder additives

No cutter should be used in SAMI or WP-A seals. Consideration can also be given to remove adhesion agent in (sealing) binders in hot and dry conditions subject to approval of the Administrator.

Table Q5.5.4 – Guidance on surfacing under asphalt layers

	S/S	WP-A	SAMI
Purpose	Waterproof the underlying pavement.	Waterproof the underlying pavement.	For use on cracked pavements to reduce the risk of cracking reflecting through to the pavement surface.
Placement	Between the asphalt surfacing and a primed unbound, lightly bound or heavily bound pavement.	Between the asphalt surfacing and other asphalt pavement layers, or between an initial seal or an asphalt surfacing.	Over a cracked pavement that has an existing bituminous treatment (either seal or asphalt).
Aggregate size (mm)	14, 10 or 7 mm	14 or 10 mm 14 mm must be used under SMA14	14 or 16 mm
Typical spread rate (m^2/m^3)	For 14 mm and 10 mm, 1000-1100 / ALD. For 7 mm, 220 m^2/m^3	1000-1100 / ALD	1000-1100 / ALD
Typical spray rate (L/m^2)	≥ 1.0 L/m^2 for 7 mm seals ≥ 1.2 L/m^2 for 10 mm seals ≥ 1.5 L/m^2 for 14 mm seals	≥ 1.5 L/m^2 for 10 mm ≥ 1.8 L/m^2 for 14 mm	≥ 1.8 L/m^2 (typically, 2.0-2.5 L/m^2) Reduce to 1.5-1.8 L/m^2 in high shear locations such as the approach to signalised intersections and roundabouts where the risk of deformation and shoving of the asphalt surfacing is a risk[3].

	S/S	WP-A	SAMI
Binder classes allowed in MRTS11	C170, C240, C320 M500, or C170 with 5 parts crumb rubber	S20E or S25E, S15R, S15RF and S18RF[1] C170[2] subject to approval by Administrator	S25E or S18RF
Binder class typically used	C170	S20E or S25E	S25E

Notes:

1. Transport and Main Roads has limited experience with the use of S15R, S15RF and S15RF binder grades for WP-A treatments and the risk associated with the seal binder bleeding through the asphalt in hot weather (due to its lower softening point compared to S20E and S25E) is yet to be determined. Usage of these binder grades should be limited to small scale trials until more experience is gained with their use in this application.
2. Consider reducing binder application rate for WP-A seals where C170 has been approved by Administrator to minimise risk of bleeding through asphalt surfacing, and
3. SAMI can be removed at high shear locations where risk of movement of the seal and subsequent shoving of asphalt is deemed too high, such as highly trafficked intersections. In these situations, the use of milling prior to tack should be considered to improve mechanical interlock of the bituminous layers.

SAMI and WP-A binder calculations

In accordance with Part 4K Equation 4, the binder application rates for SAMI and WP-A seals shall be calculated as:

Design binder application rate = (0.17 × ALD × BF) + allowances (rounded to nearest 0.1 L/m²)

Interlayer seals – aggregate spread rates for SAMIs and WP-As

SAMI and WP-A interlayer treatments are single / single seals, however, aggregate spread rates are typically 20% lighter than standard single / single seal spread rates to ensure adequate adhesion of asphalt layers to binder. Overspreading of aggregate can cause debonding and/or shoving failures on the final asphalt surfacing. Aggregate should also be clean, dry, and free of dust, with a light application of precoat.

An example of the visual appearance of a 10 mm aggregate for a WP-A interlayer seal is shown in Figures Q5.5.4.1 and Q5.5.4.2 below.

Figure Q5.5.4.1 – 10 mm WP-A aggregate at 170 m²/m³

Figure Q5.5.4.2 – 10 mm WP-A aggregate at 170 m²/m³

6 Seal design input parameters

6.1.2 Adjustments to the basic voids factors

Adjustment for traffic effects (Vt)

As per Table 6.2 in Part 4K, low or non-trafficked areas, such as shoulders, medians, and parking areas, have a standard adjustment the basic voids factor (Vt) of +0.02. The department notes, that in some situations, the inclusion of this factor for non-trafficked areas (particularly for double / double seal applications), the final design binder rate can be excessive. In determining if this value is appropriate when completing a double / double seal design, the following assessment should be made:

- where traffic is < 100 v/l/d (such as wide shoulders), a Vt factor of 0.00 can be used, or
- where the through lane traffic counts are used to determine the seal design for narrow shoulders, medians, rest areas, and centrelines, a Vt factor of +0.02 can be used.

The department recommends reviewing final design binder rates for single / single seals where traffic is < 100 v/l/d and consider the use of a Vt factor of 0.00 on areas such as heavy vehicle rest areas with very high heavy vehicle percentages, high stress areas (that may experience vehicle “wander”), and hot climates.

6.2 Binder application rate

6.2.2 Allowances applied to the basic binder application rate

Surface texture allowance (As)

Note 3 to Table 6.3 in Part 4K refers to sprayed seal surfacing applied to existing surfaces and states:

This treatment might not be advisable depending on the shape and interlock of aggregates so alternative treatments (surface enrichment, small size seal or others) should be considered.

It is common for 10 mm initial seals to be the selected treatment type, which can provide high texture results when designing secondary or subsequent seals. To reduce the texture of the initial seal, consideration can be given to:

- use of 7 mm initial seals for low volume traffic
- use of 10 / 7 mm or 14 / 7 mm double / double initial seals for higher traffic volumes or high stress locations, and
- use of 14 mm or 10 mm single / single seals with a rack-in or scatter coat of 7 mm aggregate.

Existing 10 mm and 14 mm seals that have surface textures in the wheel paths between 1.7 mm and 2.2 mm can be considered suitable for reseal without further treatment in low traffic and low stress situations.

Table Q6.3 of this technical note replaces Table 6.3 of Part 4K.

Table Q6.3 – Surface texture allowance for existing surfacing, As (L/m²)

Existing surface	Aggregate size of proposed seal	Measured texture depth (mm)	Surface texture allowance (L/m²)
14, 16 or 20 mm seal	5 or 7 mm	0–0.3	Note 1
		0.4–0.6	Note 2
		0.7–0.9	+0.1
		1.0–1.3	+0.2
		1.4–1.9	+0.3
		2.0–2.9	+0.4
		> 2.9	+0.5
	10 mm	0–0.3	-0.1
		0.4–0.5	0
		0.6–0.7	+0.1
		0.8–0.9	+0.2
		1.0–1.3	+0.3
		1.4–1.8	+0.4
		1.8–2.2	+0.5
		> 2.2	Note 3
	14 mm or larger	0–0.3	-0.1
		0.4–0.5	0
		0.5–0.6	+0.1
		0.6–0.7	+0.2
		0.8–0.9	+0.3
		1.0–1.3	+0.4
		1.4–2.2	+0.5
		> 2.2	Note 3

Existing surface	Aggregate size of proposed seal	Measured texture depth (mm)	Surface texture allowance (L/m²)
10 mm seal	5 or 7 mm	0–0.3	Note 1
		0.4–0.9	+0.1
		1.0–1.4	+0.2
		1.5–2.0	+0.3
		2.1–2.7	+0.4
		> 2.7	+0.5
	10 mm	0–0.3	Note 1
		0.4–0.7	+0.1
		0.8–1.1	+0.2
		1.2–1.7	+0.3
		1.7–2.2	+0.4
		> 2.2	Note 3
	14 mm or larger	0–0.2	Note 1
		0.3–0.6	+0.1
		0.7–0.9	+0.2
		1.0–1.2	+0.3
		1.3–1.7	+0.4
		1.7–2.2	+0.5
		> 2.2	Note 3

Existing surface	Aggregate size of proposed seal	Measured texture depth (mm)	Surface texture allowance (L/m²)
5 or 7 mm seal	5 or 7 mm	0–0.3	Note 1
		0.4–0.9	+0.1
		1.0–1.5	+0.2
		1.6–2.2	+0.3
		2.3–3.2	+0.4
		> 3.2	+0.5
	10 mm	0–0.3	Note 1
		0.4–0.7	+0.1
		0.7–1.1	+0.2
		1.2–1.8	+0.3
		1.8–2.2	+0.4
		> 2.2	Note 3
	14 mm or larger	0–0.2	Note 1
		0.3–0.6	+0.1
		0.7–0.9	+0.2
		1.0–1.4	+0.3
		1.5–2.0	+0.4
		> 2.0	+0.5
Asphalt / Microsurfacing	All	0–0.1	0
		0.2–0.4	+0.1
		0.5–0.8	+0.2
		0.9–1.4	+0.3
		> 1.4	+0.4

Notes:

1. Embedment considerations are dominant.
2. Specialised treatments are necessary.
3. This treatment might not be advisable depending on the shape and interlock of aggregates so alternative treatments (e.g., surface enrichment, small size seal or others) should be considered, and
4. For application of aggregate sizes greater than 14 mm, adopt the allowance applicable to 14 mm aggregate.

6.2.3 Embedment allowance (Ae)

Notwithstanding the requirements of Part 4K, feedback from practitioners in Queensland has indicated that excessive embedment of seals and initial seals into underlying pavements is typically avoided when the prepared surface is sufficiently “hard” to produce ball penetration test results not more than the following limits at the time of sealing:

a) 3.0 mm on high traffic roads (> 2000 v/l/d), and

b) 4.0 mm on low traffic roads (≤ 2000 v/l/d).

In situations where the above ball penetration criteria is not met, one or more of the following treatments may be required to reduce the ball penetration of the prepared pavement surface to acceptable levels immediately prior to sealing:

a) If due to moisture, defer sealing to allow the surface to harden as it dries back. The surface should be retested once it has dried sufficiently.

b) Re-prepare the pavement for any of the following issues:

   i. insufficient density has been achieved in the base course

   ii. laminations with the base course

   iii. loose or bony surface preparation, and/or

   iv. excessive slurrying of the base course.

c) Strengthen the base course if a relatively low-quality base course material has been used. This may include:

   i. improving the quality of the base course material, and/or

   ii. stabilising the base course material.

d) Apply a small aggregate (≤ 7 mm) seal as the first seal to act as an ‘armour-coat’ to minimise the amount of embedment of the larger aggregate applied at a later date.

It is important to review all construction data (including, but not limited to, compaction, dry back, and proof-rolling) to ensure conformity to specifications in conjunction with site ball penetration (embedment) results. Ball penetration is an indicator of moisture in the top 10 mm of the pavement surface layer only and results can be highly variable with continued back-watering of pavements. Ball penetration tests should only be conducted on dry pavement to provide an accurate indication of the likely embedment of the surfacing layer.

Note that re-working pavement layers (e.g., tyning and recompacting) to rectify high embedment results can degrade the pavement and lead to premature failures.

6.3 Binder factor

6.3.1 Single / single seals

Table Q6.4 of this technical note replaces Table 6.4 of Part 4K.

Table Q6.4 – Binder factors for single / single seals

Treatment type	Binder	Binder factor
Conventional seal (S/S)	C170, C240, C320, or a blend of C170 and 5 parts crumb rubber	1.0
	M500	1.1
Unmodified emulsion seal	Conventional emulsion (60%)	1.0
	High bitumen content emulsion (≥ 67%)	1.1
Modified emulsion seal	Use binder factors below for the PMB that has been emulsified	
High stress seal (HSS1)	S10E, S35E, S9R, S9RF	1.0
	S15E, S15R, S15RF, S20E	1.1[1]
Strain alleviating membrane (SAM)	S10E, S35E, S9R, S9RF	1.2
	S15E, S15R, S15RF, S20E	1.3[1]
Strain alleviating membrane interlayer (SAMI)	S25E, S18RF	1.3-1.5[2]
Waterproofing seal under asphalt (WP-A)	S20E, S25E, S15R[3], S15RF[3], S18RF C170 as approved by Administrator	1.3

Notes:

1. Typical binder factor may be reduced by 0.1 in high stress environments, lower modified binders, high traffic volume applications, and/or high temperature locations to minimise flushing or binder pick-up.
2. Transport and Main Roads has limited experience with the use of S18RF binder grades for SAMI treatments. Usage of these binder grades should be limited to small scale trials until more experience is gained with their use in this application, and
3. Transport and Main Roads has limited experience with the use of S15R, S15RF and S18RF binder grades for WP-A treatments and the risk associated with the seal binder bleeding through the asphalt in hot weather (due to its lower softening point, compared to S20E and S25E) is yet to be determined. Usage of these binder grades should be limited to small scale trials until more experience is gained with their use in this application.

6.3.2 Double / double seals

Table Q6.5 of this technical note replaces Table 6.5 of Part 4K.

Table Q6.5 – Binder factors for double / double seals

Treatment type	Binder	Binder factor[1]
Conventional seal (S/S)	C170, C240, C320, or a blend of C170 and 5 parts crumb rubber	1.0
	M500	1.1
Unmodified emulsion seal	Conventional emulsion (60%)	1.0
	High bitumen content emulsion (≥ 67%)	1.1
Modified emulsion seal	Use binder factors below for the PMB that has been emulsified	
High stress seal (HSS2)	S10E, S35E, S9R, S9RF	1.0
	S15E, S15R, S15RF, S20E	1.1[1]
Extreme stress seal (XSS)	S15E, S15R, S15RF, S20E	1.1
Strain alleviating membrane (SAM)	S10E, S35E, S9R, S9RF, S15E, S15R, S15RF, S20E	1.1

Notes:

1. Under very heavy traffic conditions with high percentages of heavy vehicles, these factors may be reduced by 0.1 but should not reduce the binder factor to less than 1.0.

6.7 Aggregate spread rate

The department has reviewed the spread rates provided in Section 6.7 of Part 4K for design of sprayed seals and has provided an updated calculation based on current site operations and known spread rates used in practice for single / single seals and the second application of a double / double seal with little or no trafficking between applications.

Rates provided are guidance only and can vary based on flakiness index, existing surface conditions, and previous experience with similar works and/or aggregates.

For single / single seals, the typical aggregate spread rates shown in Tables Q6.8, Q6.9, and Q6.10 replace Tables 6.8, 6.9, and 6.10 in Part 4K.

Table Q6.8 – Aggregate spread rates for single / single seals

Binder	Aggregate size (mm)	Aggregate spread rate (m²/m³)
All binder types	14, 16 and 20 mm	900 / ALD – 950 / ALD
	10 mm	800 / ALD – 850 / ALD
	7, 5 mm	750 / ALD – 800 / ALD
	7, 5 mm (no ALD)	180–230

Table Q6.9 – Aggregate spread rates for scatter coats

Binder	Aggregate size (mm)	Aggregate spread rate (m²/m³)
All binder types	Scatter coat (generally 7 or 5 mm aggregate)	250–350

Table Q6.10 – Aggregate spread rates for SAMI and WP-A seals

Binder	Aggregate size (mm)	Aggregate spread rate (m²/m³)
All binder types	SAMI, WP-A, 10 or 14 mm aggregate	1000 / ALD – 1100 / ALD

Typically, emulsion seals and PMB seals can have a heavier spread rate due to increased binder application rate.

It is noted that aggregate should have gaps or "windows" between particles after spreading and prior to rolling to ensure adequate space for aggregate to orient onto its ALD after rolling.

An example of the visual appearance of 14 mm aggregate before rolling and after rolling is shown in Figures Q6.8.1, Q6.8.2, and Q6.8.3 below.

Figure Q6.8.1 – 14 mm aggregate typical appearance prior to multi-tyred rolling

Figures Q6.8.2 and 6.8.3 – 14 mm aggregate typical after multi-tyred rolling

6.7.4 Double / double seals

For the first application of aggregate on a double / double seal, Table Q6.11 of this technical note replaces Table 6.11 of Part 4K.

Table Q6.11 – Double / double seal design aggregate spread rates for the first application seal, with little or no trafficking between applications

Binder	Aggregate spread rate (m² / m³)
C170, C240, C320, multigrade bitumen, PMB	950 / ALD
Emulsion and cutback binders	850 / ALD

It is strongly recommended both applications of aggregate for double / double seals (i.e., the entire double / double seal) be completed on the same day to:

- minimise the risk of stripping of the first layer of aggregate as the binder application rate is generally lower than a single / single seal, and
- ensure adhesion between binder and aggregate layers by limiting the potential for dust, debris, and dirt to be tracked onto the surface prior to application of the second layers.

For the second application of aggregate on a double / double seal, the spread rates shown in Table Q6.12 of this technical note replaces Table 6.12 of Part 4K.

Table Q6.12 – Double / double seal design aggregate spread rates for second application, little or no trafficking between applications

Binder	Aggregate size (mm)	Aggregate spread rate (m²/m³)
All binder types	10	850 / ALD – 900 / ALD
	7	800 / ALD – 850 / ALD
	7, 5 (no ALD)	180–250

References

1. AAPA 2015, *Emulsion Primes, Rubber Latex Modified and PMB Emulsion Specifications*, Advisory Note 20
2. Austroads 2008, *Modified Surface Texture Depth (Pestle Method)*, AP-PT/T250
3. Austroads 2014, *Double/Double Primerseal Inspections*, AP-T276-14
4. Austroads 2018, Austroads *Guide to Pavement Technology – Part 4K: Selection and Design of Sprayed Seals*, AGPT04K
5. Department of Transport and Main Roads 2019, Technical Note 186 *Sealing in Cold Weather Conditions*