Government of Western Australia

# Engineering Road Note No. 7

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MAIN ROADS Western Australia

## BITUMEN SCRAP RUBBER SEALS

### 1. INTRODUCTION

This Engineering Road Note is intended to provide guidance on the use of rubberised bitumen in the application of sprayed treatments. The guide only deals with the use of granulated scrap rubber and not with polymer modified binders.

The note describes the circumstances in which the use of rubberised binders should be considered, and gives details of material requirements, binder composition and application rates, equipment and field procedures.

### 2. USES

Granulated scrap rubber is added to bitumen to provide an elastic binder whose properties can be an advantage in a number of circumstances, i.e.:

#### 2.1 Prevention of Reflection Cracking

Cracks in a pavement will normally reflect through any thin bituminous surfacing unless it is specifically designed to prevent this occurrence. The use of rubberised binders provides one means of preventing or minimising reflection cracking. When used as a surface treatment the application of a rubberised seal is termed a strain alleviating membrane (SAM). When used as a layer prior to the application of an asphalt overlay the system is known as a strain alleviating membrane interlayer (SAMI).

A complete understanding of the applicability of rubberised bitumen as a SAM or SAMI is not presently available, however, the treatments are considered most effective when the existing pavement or surface cracks have relatively stable fatigue cracks. The treatment of shrinkage cracks which open and close markedly with changing environment is not as effective, although some reduction in the extent and width of reflection cracking can be expected.

SAMs or SAMIs are only intended for application to pavements, which are basically sound structurally, apart from the occurrence of cracks. The treatments should be carried out before the pavement has been weakened by the ingress of water through the cracks.

#### 2.2 Waterproof Bridge Deck Membrane

Experience has shown that rubberised bitumen can provide an effective waterproof membrane for bridge decks because of its ability to be applied at high application rates and to resist the reflection of cracks in the deck.

### 3. MATERIALS

#### 3.1 Bitumen

Class 170 bitumen conforming to the requirements of, AS 2008 "Residual Bitumen for Pavements" should be used unless otherwise directed.

### 3.2 Rubber Granules

The rubber granules should be natural or synthetic rubber, which may be processed from scrap tyres or other, approved rubber products. The granules should not contain more than 0.1 percent (by mass) of foreign material such as iron, steel or sand. The quantity of ferrous material can be determined in accordance with MRWA Test Method WA 237.1.

The particle size distribution of the rubber granules should conform to the following requirements when tested in accordance with MRWA Test Method WA 236.1.

| Sieve Size | Percent Passing (by mass) |
|---|---|
| 2.36 | 100 |
| 1.18 | 95 – 100 |
| 0.15 | 10 maximum |
| 0.075 | 2 maximum |

The rubber granules should not contain more than 20 percent of flakey or elongated particles. The bulk density of the rubber granules should be not more than 350 kg/$m^3$ when tested in accordance with MRWA Test Method WA 235.1.

### 3.3 Slow Curing Cutting Oil (Distillate)

Slow curing cutting oil should conform to the following requirements:

| PROPERTY | REQUIREMENT |
|---|---|
| DISTILLATION | |
| Initial Boiling Point | 170 - 195°C |
| Final Boiling Point | 360 - 400°C |
| Temperature @ 50% recovery | 250 - 290°C |
| FLASH POINT | 65°C min |
| VISCOSITY AT 40°C | 2.0 - 4.0 $mm^2/s$ |
| MISCIBILITY WITH EQUAL PARTS OF CLASS 170 BITUMEN | Complete no precipitation |
| WATER CONTENT | 0.05% max |

TABLE 1: SLOW CURING CUTTING OIL PROPERTIES

### 3.4 Medium Curing Cutting Oil

The medium curing cutting oil should conform to the following requirements:

| PROPERTY | REQUIREMENT |
|---|---|
| DISTILLATION | |
| Initial Boiling Point | 132 - 160°C |
| Final Boiling Point | 265°C max |
| Temperature at 50% Recovery | 220°C max |
| FLASH POINT | 35°C min |
| RELATIVE DENSITY AT 25°C kg/L | 0.78 - 0.82 |
| MISCIBILITY WITH EQUAL PARTS OF CLASS 170 BITUMEN | Complete no precipitation |
| % AROMATICS (% Vol) | 15 min |
| WATER CONTENT | 0.05% max |
| VISCOSITY AT 40°C | 1.0 - 1.4 $mm^3/s$ |

TABLE 2: MEDIUM CURING CUTTING OIL PROPERTIES

### 3.5 Adhesion Agent

One of the following approved concentrated adhesion agents should be incorporated in the binder:

Bitumite Concentrate

Radiamine 6681

Redicote N422

### 3.6 Aggregate

Standard 10 mm, 14 mm or 16 mm aggregate conforming to Main Roads' specifications should be used for SAMs or SAMIs. The aggregate should be precoated with distillate, or if preheated aggregate is used, with bitumen.

Standard 5 mm aggregate should be used on waterproof bridge deck membranes. Precoating is not required.

### 3.7 Bitumen Emulsion

CRS/50 and ARS/50 grades of bitumen emulsion for priming and crack patching respectively should conform to the requirements of AS 1160.

### 3.8 Rubber Latex Emulsion

Natural rubber latex emulsion containing 60% rubber (high ammonia grade) should be used when possible for blending with bitumen emulsion to provide a crack patching fluid. (Available ex Rubber Latex (Australia) Melbourne.)

### 3.9 Anti-Foaming Agent

Dow Corning Fluid DC-200/12500 CS should be used as an anti-foaming agent. This can be handled more conveniently by making up a 1% solution in distillate and adding this solution to the bitumen at a rate of 150 mls per 1000 litres of bitumen.

## 4. BINDER COMPOSITION

### 4.1 Rubber Content

Recommended proportions of rubber for the various uses described are as follows:

| Use | % Rubber Content (% by mass of residual binder excluding MC Cutter) |
|---|---|
| SAM | 18 |
| SAMI | Minimum 18 |
| Waterproof Bridge Deck Membrane | 20 |

TABLE 3

Note: Rubber should be considered part of the residual binder. See paragraph 9 for example of calculations of volumes and masses.

### 4.2 MC Cutting Oil

Recommended proportions of MC Cutting Oil for varying road temperatures are as follows:

| | % MC CUTTING OIL (% By volume of total binder at 15°C) | | | |
|---|---|---|---|---|
| **Pavement Temp °C** | **45+** | **38 - 45** | **32 - 38** | **25 – 32** |
| **Rubber Content** | | | | |
| 15 - 17 | 5 | 6 | 7 | 8 |
| 17 - 18 | 6 | 7 | 8 | 9 |
| 18 - 20 | 7 | 8 | 9 | 10 |

TABLE 4

### 4.3 Adhesion Agent

A minimum of 1.0% (by mass of residual binder) of an approved concentrated adhesion agent should be included in the binder.

## 5. BINDER APPLICATION RATE DESIGN

The design of binder application rates is not critical with rubberised binder because of its reduced temperature susceptibility, however to maximise the effectiveness of a SAM or SAMI the rate should be higher than normal seal or reseal design rates. The following rates are recommended as a guide, however rates should be varied as required to suit circumstances.

| Treatment | Aggregate Size (mm) | Total Binder Application Rate L/m$^2$ (15°C) |
|---|---|---|
| SAM or SAMI on old seal (coarse text.) | 10 | 2 |
| | 14 | 2.5 |
| | 16 | 3 |
| SAM or SAMI on old asphalt | 10 | 1.5 |
| | 14 | 2 |
| | 16 | 2.5 |
| Waterproof Membrane Bridge Deck | 5 | 1.5-1.8 |

TABLE 5

## 6. EQUIPMENT

In general the equipment used for rubberised bitumen work is the same as for conventional sealing works except that a modified sprayer is required.

The sprayer should comply with the relevant sections of “Specifications for Mechanical Sprayers of Bituminous Material” issued by Austroads. In addition the sprayer should be fitted with a circulating system which should include a return pipe along the full length of the bottom of the tank fitted with upward directed jets every 50 mm and downward directed jets in the vicinity of the internal suction pipe such that the contents of the tank can be circulated through this bottom pipe at a rate of approximately 800 L/min so that the rubber can be kept homogeneously dispersed in the bitumen at all times. The sprayer tank should be fitted with a valve controlled bottom outlet to facilitate external circulation if the need arises. The heating capacity of the sprayer should be such as to ensure reheating of the blended product at a rate of approximately 30°C per hour.

In addition the sprayer should be fitted with B6 nozzles and include the appropriate calibration certificate for this nozzle size which is only to be used for spraying rubberised binder.

## 7. FIELD PROCEDURES

Apart from some exceptions explained in this note, field procedures are similar to those used in conventional hot sprayed sealing works. The exceptions are important and unless rubberised bitumen works are properly planned and executed considerable difficulties can be expected both in the blending and spraying and in achieving adequate adhesion.

### 7.1 Storage of Rubber

The rubber granules should be supplied in hessian bags, which must be stored under cover and protected against moisture ingress.

### 7.2 Loading and Blending

The following procedure describes blending of the bitumen and rubber in the field.

The rubber blending machine should be connected to the storage tanker outlet and the sprayer inlet by bitumen hoses, which should be as short as practical to minimise heat loss. Bitumen should be allowed to flow under gravity from the storage tanker to the blending machine then after mixing with the rubber the blend should be sucked into the sprayer via the normal sprayer inlet port and bitumen pump. The flow of bitumen and rubber should be co-ordinated to provide a steady throughput and thorough mixing of both materials by regulating the feed control setting and bitumen flow rate. Rubber loading may be simplified by placing the required predetermined mass of rubber on a vehicle tray of the appropriate height and location so as to minimise lifting and delays in transfer. Care should be taken to avoid blocking the blending device and bitumen hoses with excess rubber.

*Safety precautions should be observed and additional care should be taken because of the higher than normal temperatures involved. The addition of rubber to bitumen usually results in considerable swelling of the binder due to foaming and maximum quantities loaded into the sprayer should be limited to provide for this, otherwise overflow will occur*.

The recommended sequence for loading and blending is as follows:

(a) Preheat the bitumen in storage to 205°C

(b) Add anti-foam solution to the sprayer
(Dow Corning Fluid DC-200/12500CS 1-2 parts/million)

(c) Commence transfer of a small amount of hot bitumen from storage to sprayer via the rubber blending machine to warm the bitumen hoses and the blender

(d) Continue transfer of the bitumen and add the rubber to the bitumen during the transfer using the blending machine set for maximum throughput without clogging

(e) If all the rubber has not been loaded by the time the bitumen transfer has been completed then the blender inlet should be connected to the bottom dump outlet of the sprayer and the remaining rubber added while circulating the contents of the sprayer

(f) On completion of loading the rubber, circulate the contents of the loaded sprayer using the bottom return pipe for a minimum period of one hour to allow sufficient reaction time

(g) Reheat while circulating (as in (g)) to 190 to 200°C. Ensure the sprayer is filled to a safe volume for heating.

(h) Add MC Cutter and circulate for a minimum period of 15 minutes to ensure a uniform and homogenous mixture.

(i) Add adhesion agent shortly before spraying and circulate the contents of the tank for a minimum period of 15 minutes. This operation may be done when the MC Cutter is added, however the period between adding the adhesion agent and spraying all of the binder should not exceed 8 hours.

It is recommended that a check be kept on bitumen quantities by dipping the bitumen storage vessel during and after transfer because foaming makes the reading of volumes in the sprayer difficult.

### 7.3 Surface Preparation

The pavement should be repaired and crack patched well before sealing works are undertaken. Any repairs of crack patches must be stable before sealing and should not contain volatile materials likely to soften the seal binder. The most appropriate patching fluid is an 80/20 blend of ARS/50 bitumen emulsion and latex rubber emulsion.

### 7.4 Spraying

7.4.1 Minimum Pavement Temperature

The minimum pavement temperature for spraying of rubberised binder should be 25°C unless hot (150°C min) bitumen precoated aggregate is used. When practical pavement temperatures below 30°C should be avoided.

7.4.2 Spraying Temperature

The spraying temperature should be between 190 and 200°C.

7.4.3 Spraying Width

To ensure a uniform distribution with the viscous rubberised binder the spray bar width should not exceed 4.0 m.

7.4.4 Application

Apart from the exceptions just described, normal operating procedure should be followed when spraying the binder. Dipping of the sprayer to determine volumes and rates may be difficult due to foaming, however, where possible dipstick readings should be taken before and after each spray run. Where sprayer dippings are considered inaccurate, spray rate calculations should be based on the volume of binder transferred from the storage tanker (see 7.2). Note that B6 nozzles should be fitted and an appropriate calibration certificate should be used to ensure correct application rates are achieved using these nozzles.

### 7.5 Spreading and Rolling Aggregate

Cover aggregate (precoated) should be spread and rolled as soon as possible after spraying to ensure the aggregate is pushed into the binder before the latter cools and becomes too viscous. Embedment and adhesion of the aggregate is more difficult to achieve than with conventional hot sprayed bitumen work and time is more critical.

## 8. RECORDS

Normal sealing records should be kept, modified as required to incorporate details of the proportion of rubber used.

## 9. CALCULATIONS

The use of rubber and solid adhesion agents introduces the need to include proportioning by mass. The necessary calculations are best illustrated by example, e.g.:

Require 4 000 litres of total binder at 190°C with the following components:

(a) 20% Rubber as a % by mass of the residual binder (excluding MC cutter)

(b) 5% of MC Cutter as % by volume of total binder

(c) 1% of Adhesion Agent as % by mass of residual binder

### 9.1 Volume of MC Cutter Required

(a) Reduce the total volume of binder at 190°C to a volume at 15°C assuming the rubber has a similar coefficient of expansion to the bitumen and that standard volume con- version tables apply, i.e.:

$$4000 \text{ x } 0.8944 = 3578\text{L at } 15^{\circ}\text{C}$$

(b) Calculate volume of MC Cutter at 15°C

$$\frac{5}{100} \text{x} 3578 = 179\text{L at } 15^{\circ}\text{C}$$

### 9.2 Mass of Residual Binder (Bitumen/Rubber/Adhesion Agent)

(a) Volume of residual binder at 15°C

$$3578 - 179 = 3399\text{L}$$

(b) Convert to mass using density of blend 1.04 kg/litre as the most suitable approximation for all blends likely to be used, i.e.: 3 399 x 1.04 = 3 535 kg.

### 9.3 Composition of Residual Binder by Mass

79% Bitumen, 20% Rubber, 1% Adhesion Agent

### 9.4 Volume of Bitumen Required

(a) Mass of bitumen at 15°C

$$\frac{79}{100} x 3535 = 2793 \text{ kg}$$

(b) Volume of bitumen at 15°C

Volume = Mass/Density where density = 1.02

$$\frac{2793}{1.02} = 2738\text{L at } 15^{\circ}\text{C}$$

(c) Convert Volume at 15°C to Volume at 200°C say using standard volume conversion tables:

2 738 ÷ 0.8886 = 3 081 L at 200°C

### 9.5 Mass of Rubber Required

$$\frac{20}{100} x\, 3535 \quad = \; 707$$

### 9.6 Mass of Adhesion Agent Required

$$\frac{1.0}{100} x\, 3535 \quad = \; 35$$

### 9.7 Final Proportions

| | |
|---|---|
| Bitumen: | 3 081 L at 200°C |
| Rubber: | 707 kg |
| Adhesion Agent: | 35 kg |
| MC Cutter: | 179 L at 15°C |

### 9.8 Worksheet

A worksheet for determining the proportions of bitumen, rubber, adhesion agent and cutter is shown on the following page.