STABILITY AND FLOW OF ASPHALT: MARSHALL METHOD

1 SCOPE

This method describes the procedure for the determination of the Stability and Flow values of asphalt produced either in the laboratory or at a mixing plant and compacted using Marshall Apparatus. This method is only suitable for asphalts with a nominal maximum particle size up to and including 20mm.

2 SAFETY

This method does not attempt to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of the method to establish appropriate occupational health and safety practices that meet statutory regulations.

3 REFERENCED METHODS

Australian Standards

AS/NZS 2891.2.1 Sample Preparation- Mixing, quartering and conditioning of asphalt in the laboratory

AS/NZS 2891.5 Determination of stability and flow – Marshall Procedure

Main Roads Western Australia

WA 701.1 Sampling procedures for asphalt

WA 705.1 Preparation of Asphalt for Testing

WA 733.1 Bulk Density and Void Content of Asphalt

WA 733.2 Bulk Density and Void Content of Asphalt – Vacuum Sealing Method

4 DEFINITIONS

(a) **Reheating** – where a sample of asphalt has cooled sufficiently to require heating to facilitate sample division.

5 APPARATUS

(a) **Marshall compaction mould** assembly, having essential dimensions complying with AS/NZS 2891.5 and Table 1 for working tolerances.

TABLE 1

APPARATUS	VALUE	WORKING TOLERANCE
Average internal diameter, mm	101.6	±/- 0.5

(b) **Automated Marshall compaction hammer** essential dimensions complying with AS/NZS 2891.5 and Table 2 for working tolerances. The automated Marshall compaction hammer shall be mounted on a solid base such as a concrete block of mass at least 50 kg.

TABLE 2

APPARATUS	VALUE	WORKING TOLERANCE
Mass, kg	4.535	±/- 0.02
Drop Height, mm	457	±/- 1.0
Foot diameter, mm	98.5	+/- 0.5

(c) **Testing head** having essential dimensions complying with AS/NZS 2891.5.

(d) **Flow meter** such as dial gauge, calibrated revolution counter or displacement transducer with recorder capable of measuring the vertical deformation of the test specimen to the nearest 0.1 mm.

NOTE: A revolution counter may be calibrated to measure flow by recording the number of revolutions required to displace the load platen on the testing machine a distance of 1mm.

(e) **Testing machine** capable of applying forces up to 22kN, equipped with a movable head or base that travels at a rate of 48 to 54 mm/minute when the force is being applied. The testing machine should be equipped with a load indicating device (such as a proving ring or load cell) readable to at least 30 N. The load indicating device does not necessarily have to indicate the load in Newtons.

NOTE: Alternatively a suitable form of force recorder of at least equal sensitivity may be used.

(f) **Water bath**, at least 150 mm deep with a perforated shelf about 50 mm from the bottom, with a mechanical agitator and thermostatically controlled to maintain a temperature of 60°C ± 1°C.

(g) Thermostatically controlled **heating oven** with mechanically forced air circulation capable of maintaining temperature within the range of 100°C to 200°C.

(h) **Balance** of at least 2 kg capacity readable and accurate to at least 0.1g with a Limit of Performance (F) of not more than 0.5 g.

(i) **Thermometer** for the water bath readable to or with scale divisions of 0.5°C or less.

(j) Digital PT100 **Thermometer** probes readable to 0.1°C and capable of handling temperatures up to 200°C without damage to the lead or probe.

(k) **Mixing apparatus**, trays, tongs, insulated mittens, spatulas, timer, marking crayons, etc.

(l) **Paper discs** approximately 100 mm diameter.

(m) External **vernier callipers** readable to at least 0.5 mm.

6 PROCEDURE

6.1 SAMPLE PREPARATION

6.1.1 Laboratory Mix

(a) Obtain a test sample of asphalt that has been prepared and conditioned in accordance with AS/NZS 2891.2.1.

(b) Bring the test sample to the required temperature in Table 3 as detailed in Procedure 6.2. If an alternative workability additive is used other than Sasobit, or Sasobit is used at a different dose rate the temperatures in Table 3 are not applicable. Testing shall be done in accordance with AS/NZS 2891.5, Appendix B to determine the temperature at which an equivalent air void content will be achieved in comparison to use of the PMB or bitumen without an additive. The testing shall use at least 4 Marshall specimens at each temperature in the determination.

TABLE 3

Binder Type	Dense Graded Asphalt	Open Graded Asphalt	Stone Mastic Asphalt
All PMB and bitumen classes	Temperatures as required in AS/NZS 2891.5		
Class 170 Bitumen with 1.5% Sasobit	125 ± 3		
Class 320 Bitumen with 1.5% Sasobit	135 ± 3		
Class 600 Bitumen with 1.5% Sasobit	140 ± 3		
A20E with 1.5% Sasobit		120 ± 3	150 ± 3
A15E with 1.5% Sasobit	150 ± 3		

6.1.2 Plant Mix

(a) Obtain a test sample taken in accordance with WA 701.1.

(b) Bring the test sample to the required temperature in Table 3 as detailed in Procedure 6.2. Prepare reheated test samples in accordance with WA 705.1.

6.2 PREPARATION OF TEST SPECIMENS

(a) Place a clean assembled mould, base and extension collar in an oven for at least one hour. The temperature of the oven is dependent upon mix type and binder class and shall be in accordance with Table 3.

(b) Using sample division, obtain a test portion from the test sample. The mass of the test portion should be such that when compacted, a specimen of 63.5 ± 6.5mm height is produced.

NOTE: The mass necessary to give the desired specimen height of 63.5mm may be calculated using the expected bulk density of the compacted material. Usually a mass between 1 200 g to 1 250 g is required.

(c) Remove the assembled mould from the oven and place a paper disc in the mould.

(d) Place the test portion as a single lot into the mould.

NOTE: It is permissible to prepare more than one mould before commencing compaction provided the specimens are maintained at the correct temperature.

(e) Determine the temperature of the test portion. If the temperature is more than 3°C lower than the compaction temperature in Table 3 place the mould into the heating oven and measure the temperature of the test portion with the thermometer placed in the centre of the mould.

(f) If the temperature is more than 3°C higher than the compaction temperature in Table 3 place the mould into the heating oven and measure the temperature of the test portion with the thermometer placed close to the outer edge of the mould.

(g) Condition the specimen in the heating oven set to the temperatures of Table 3 until compaction temperature is achieved. Record the temperature of the test portion to the nearest 0.1°C when the thermometer reading is stable.

(h) Remove the thermometer from the mould, place a paper disc on the surface of the asphalt and place the mould assembly plus test portion in position in the compaction pedestal then compact the test portion to the specified number of blows of the steel rammer falling freely from a height of 457 mm. Invert the mould and apply the same number of blows to the other end of the test portion. Where more than one test portion is compacted at the same time, invert and swap the moulds.

NOTE: It is permissible to compact more than one test portion at a time provided the correct number of blows is applied to the test potion and each portion is maintained at the correct temperature.

(i) Remove the mould plus test specimen from the compaction pedestal and mark the test specimen with an identification number.

(j) Allow the mould plus test specimen to cool in air until no deformation will result when removing the test specimen from the mould.

(k) Repeat Procedure 6.2(a) to 6.2(k) to produce at least two test specimens.

6.3 DETERMINING STABILITY AND FLOW

(a) Measure the height of each test specimen to the nearest 1 mm. The height shall be measured four times at approximately equally spaced distances around each specimen. Calculate the average specimen height to the nearest 1mm and discard any specimen having an average height outside the range of 57 to 70 mm. Specimens discarded shall be replaced by a test portion obtained from the same test sample and compacted in accordance with Procedure 6.2(a) to 6.2(k).

(b) Determine the Marshall density if required in accordance with WA 733.1 or WA 733.2.

(c) Maintain the testing head at a temperature between 20°C and 40°C.

(d) Place the test specimens in a water bath at a temperature of 60°C ± 1°C for 30 to 40 minutes.

(e) Remove a test specimen from the water bath and place it centrally, and on its side, in the lower segment of the testing head. Place the upper segment of the testing head on the test specimen then place the complete assembly in position in the testing machine.

NOTE: The testing head should be clean and if necessary, the guide rods lubricated so that the upper segment will slide freely.

(f) Apply the force to the test specimen so that the rate of deformation is 51 ± 3 mm/min ensuring the flow (vertical deformation) meter begins to register as the load is applied. Record the maximum force and the flow meter reading (Note: corresponding to the maximum force). Complete Procedure 6.3 (e) and 6.3 (f) within 30 seconds of removal of the test specimen from the water bath.

NOTES:

(i) If using a proving ring as a force measuring device correct the flow for movement in the proving ring.

(ii) If it becomes apparent that the test cannot be completed within 30 seconds and no load has been applied to the test specimen, return the specimen to the water bath and continue from Procedure 6.3(d).

(g) Remove the testing head plus test specimen from the testing machine then remove the specimen from the testing head.

(h) Repeat Procedure 6.3(e) to 6.3(g) for the remaining test specimens.

7 CALCULATONS

(a) Calculate the stability for each test specimen using the formula:

$$Stability = Max.Load \times Height\ Correction\ Factor$$

Where:

Maximum Load = maximum force applied in kN. When using a proving ring the maximum force is calculated by multiplying the proving ring dial gauge reading by the proving ring factor.

Height Correction Factor = factor for correcting the stability for specimen height in accordance with Table 4.

TABLE 4
Height Correction Factor

Height of Specimen (mm)	Height of Correction Factor
57	1.19
58	1.16
59	1.13
60	1.10
61	1.07
62	1.04
63	1.01
64	0.99
65	0.96
66	0.94
67	0.92
68	0.90
69	0.88
70	0.86

(b) Calculate the average stability of all specimens tested.

(c) Calculate the flow as the vertical deformation of the test specimen between the initial application of the force and the maximum force. When using a revolution counter calculate the flow using the formula:

$$Flow = (Final\ Rev.Count - Initial\ Rev.Count) \times Rev\ Factor$$

Where:

Flow = vertical deformation of the test specimen in mm

Rev. Factor = revolution factor in mm/Rev.

NOTE: When using a revolution counter as the flow measuring device and proving ring as the force measuring device, subtract the proving ring deformation from the measured flow to obtain the actual flow of the test specimen.

(d) Calculate the average flow of all specimens tested.

8 REPORTING

(a) Report the average stability to the nearest 0.1 kN and the average flow to the nearest 0.1 mm.

(b) Report the number of blows to the Marshall test specimen.

(c) Report the average compaction temperature of the test portions to the nearest 0.1°C.

9 ISSUING AUTHORITY

Document Owner	Delegated Custodian
Manager Materials Engineering	Pavements Manager

10 REVISION STATUS RECORD

Date	Section	Revision Description / Reference
06-11--2018	6.2(g)	New conditioning in a set oven requirement
06-11-2018	6.1.1(b)	Requirements for workability additives
13-01-2017	6.11(b) 6.1.2(b)	Now refers to Procedure 6.2 for heating or cooling of Marshall specimens
13-01-2017	6.2(a)	Bitumen changed to binder
13-01-2017	6.2(d) 6.2(h)	Removed paper and thermometer going into mould from 6.2(d) and placed into 6.2(h)
13-01-2017	6.2(e) 6.2(f)	New clauses on cooling and heating of Marshall specimens
13-01-2017	6.3(a)	Corrected Procedure numbering
13-01-2017	6.3(f)	Corrected Procedure numbering