BITUMEN DURABILITY
DYNAMIC SHEAR RHEOMETER METHOD

1 SCOPE

This method describes the procedure for determining the durability of bitumen based on the accelerated ageing of bitumen to determine the time required for bitumen to reach a specified viscosity level using a Dynamic Shear Rheometer (DSR).

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 this method to establish appropriate occupational health and safety practices that meet statutory regulations.

3 REFERENCED METHODS

The following documents are referenced in this test method:

International Standard

ASTM D 7175 Determining the Rheological Properties of Asphalt Binder Using a Dynamic Shear Rheometer

Australian Standard

AS/NZS 2341.13 Long Term Exposure to Heat and Air

Austroads Test Method

AGPT/T194 Long Term Ageing Resistance of Bitumen using the Pressure Ageing Vessel (PAV) and the Dynamic Shear Rheometer (DSR)

4 APPARATUS

The following equipment as specified in ASTM D7175.

- Dynamic Shear Rheometer
- DSR test plates 25mm diameter
- Environmental chamber
- Temperature controller
- Internal DSR temperature measurement device
- Loading device
- Data acquisition device
- Trimming tool
- Portable temperature measurement device

Additional equipment:

- Metal or glass container to heat bitumen
- Metal spatula for working bitumen in a container
- Infrared heating lamp

5 VERIFICATION

(a) Determine the temperature offset of the internal DSR temperature measurement device using the portable temperature measurement device at the test temperature of 45°C. Verify the temperature offset every three months.

(b) Verify the accuracy of the torque transducer in accordance with ASTM D7175.

6 PREPARATION OF APPARATUS

Prepare the apparatus for testing in accordance with ASTM D7175.

7 SAMPLE PREPARATION

7.1 EXPOSURE OF THE BITUMEN FILM

Deposit a film of bitumen on the walls of sample bottles, expose the bitumen film and recover and mix the exposed bitumen in accordance with AS/NZS 2341.13.

7.2 PREPARING BITUMEN FOR DSR TESTING

(a) Place the treated bitumen under a heating lamp in a metal or glass container along with the lower test plate of the DSR. Heat the bitumen until it is warm enough to be malleable (of a consistency that it can be transferred to the DSR test plate as a softened material).

Note: Have the heating lamp about 200mm above the container to minimise exposure of the bitumen to excessive heat.

(b) Transfer using a spatula a portion of bitumen on to the lower DSR test plate and mount the test plate on the DSR.

Note: Approximately 0.7g – 0.9g of bitumen should be sufficient.

(c) Increase the temperature of the top and bottom test plates of the DSR to a temperature where the bitumen will begin to flow. Leave the DSR at this temperature for about 3 minutes.

Note: For Class 170 that has been ageing treated, this pre-heating temperature may be between 80 – 100°C depending on the length of exposure to heat and air.

(d) Decrease the gap between the test plates to 1.1mm so that the top test plate is in contact with the bitumen.

(e) Set the temperature of the upper and lower test plates to the test temperature of 45°C ± 0.1°C then decrease the gap between the test plates to 1.05mm.

(f) Trim the excess bitumen using a trimming tool from around the perimeter of the gap between the two test plates. The trimmed surface should be flush with the perimeter of the test plates (refer to images in AGPT/T194).

Note: Brief heating of the trimming tool with a butane torch has been found to be effective for achieving a neat finish.

(g) Decrease the gap to 1mm and a slight bulge in the bitumen between the test plates should be noticeable (refer to images in AGPT/T194).

(h) Condition the bitumen at this gap setting and temperature for 5 minutes and commence the measurement of viscosity without delay.

8 MEASUREMENT OF VISCOSITY

(a) Set the DSR to stress controlled creep mode.

(b) Prior to the creep test do a brief manual flow test for about 10 to 20 seconds with a target shear rate of 0.005s^{-1} to determine an approximate target stress level for the next step.

Note: If the target shear rate is not achieved during the flow test increase the time of the flow test.

(c) Condition the bitumen without load for 5 minutes.

(d) Using at least four stress settings that span the target shear rate of 0.005s^{-1} (relevant to the expected target stress level identified during the manual flow test at Procedure 8b) perform the creep test starting at the lowest stress step towards the highest stress step (one stress step to be followed immediately by the next stress step with no rest period between each step). Allow 3 minutes creep loading period for each stress step. Recommended stress values are shown in Table 1. There must be at least two steps on each side of the target shear rate.

TABLE 1

Creep Step	Stress Pa)
1	130
2	210
3	330
4	520
5	820
6	1300
7	2060
8	3300
9	5180
10	8200
11	13000
12	20600
143	32700

(e) Data collected by the DSR during each stress setting shall be time, compliance and strain for the last 60 seconds for each stress setting.

(f) All testing shall be completed within 2 hours of placing the bitumen on the test plate. If not the test is invalid and the bitumen should be removed and the test plates cleaned. Repeat the test from Procedure 7.2.

9 CALCULATONS

(a) Calculate Creep Compliance(*j*):

$$j = \frac{\varepsilon}{\sigma}$$

Where: ε = strain
σ = stress

(b) Calculate the viscosity:

$$\eta = log\frac{\Delta T}{\Delta j}$$

Where: η = viscosity in log Pa.s
ΔT = difference in time in seconds
Δj = difference in compliance

Note: Viscosity needs to be calculated using all data points obtained during the last 60 seconds of each stress setting. For this, a linear fitting to time (in y-axis) and j (in x-axis) data is required for the results obtained during the last 60 seconds. The slope of the linear fitting is the viscosity calculated as above.

(c) Calculate shear rate γ:

$$\dot{\Upsilon} = \frac{\Delta\varepsilon}{\Delta T}$$

Where: $\dot{\Upsilon}$ = shear rate in s^{-1}
ΔT = difference in time
$\Delta\varepsilon$ = difference in strain

Note: Shear rate needs to be calculated using all data points obtained during the last 60 seconds of each stress setting. For this, a linear fitting to strain (in y-axis) and time (in x-axis) data is required for the results obtained during the last 60 seconds. The slope of the linear fitting is the shear rate calculated as above.

(d) Plot viscosity results (logPa.s) against shear rate (s^{-1}) in a linear scale graph.

(e) Determine by linear interpolation and not extrapolation the viscosity (logPa.s) at a shear rate of $0.005s^{-1}$.

10 DETERMINATION OF DURABILITY

Determine the durability of bitumen in accordance with AS/NZS 2341.13 using a Specified Apparent Viscosity Level (SAVL) of 5.67 log Pa.s at 45°C at a shear rate of $0.005s^{-1}$.

11 REPORTING

The following information shall be reported:

(a) For each period of treatment the viscosity result to the nearest 0.01 log Pa.s and exposure time to the nearest day.

(b) Time to reach the Specified Apparent Viscosity Level (SAVL) to the nearest 0.1 day.

12 ISSUING AUTHORITY

Document Owner:	**Delegated Custodian**:
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13 REVISION STATUS RECORD

Page No.	Section	Revision Description / Reference
1	3	AS/NZS 2341.5 & 2341.10 deleted and Austroads T194 added
1	4	New equipment added
1-2	7.2	Clauses (a) to (d) and (f) to (h) reworded
2	8	Clauses (b), (c) and (d) reworded and Table 1 added
3	9	Notes added to (b) and (c) and Clauses (c) and (d) reworded
3	10	SAVL amended to 5.67 logPa.s
3	11a	Amended wording
All	All	New method