Standard Practice for
Multiple Stress Creep Recovery Test of Asphalt Binder Using a Dynamic Shear Rheometer (MSCR)

1. Scope

1.1 This practice covers the identification of elastomeric response of modified asphalt binders by means of percent recovery obtained in the Multiple Stress Creep Recovery test (MSCR). The MSCR test is conducted using the Dynamic Shear Rheometer (DSR) at the high performance grade (PG Grade) temperature of the asphalt binder. It is intended for use with residue from Test Method AASHTO T240 (ASTM D 2872) (RTFOT) which is designed to simulate plant aging.

NOTE 1—Modified asphalt binders may phase separate or form skins during oven conditioning in Test Method T240 (ASTM D 2872) (RTFOT); the results from subsequent testing of this residue may not be representative of modified asphalts short-term aged under field conditions.

1.2 The percent recovery in the MSCR test of asphalt binders is affected by the type and amount of polymer used in the polymer modified asphalt binder. The percent recovery value is intended to provide a means for determining if the polymer used in modification will provide an elastomeric response, but cannot account for the type of elastomer used.

1.3 The values stated in SI units are to be regarded as the standard.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:

D 8 Terminology Relating to Materials for Roads and Pavements

D 2872 Test Method for Effect of Heat and Air on Rolling Film of Asphalt (Rolling Thin-Film Oven Test)

2.2 *AASHTO Standards:*

AASHTO M320 Standard Specification for Performance Graded Asphalt Binder

AASHTO T240 Effect of Heat and Air on Rolling Film of Asphalt (Rolling Thin-Film Oven Test)

AASHTO T315 Determining the Rheological Properties of Asphalt Binder Using a Dynamic Shear Rheometer (DSR)

3. Terminology

3.1 Definitions:

3.1.1 Definitions of terms used in this practice may be found in Terminology D 8 determined from common English usage, or combinations of both.

4. Summary of Practice

4.1 Asphalt binder is first aged using Test Method AASHTO T315 (ASTM D 2872) (RTFOT). A sample of the RTFO aged asphalt is tested using Test Method AASHTO T315 (ASTM D 7175-05) (DSR). The 25 mm parallel plate geometry is used with 1 mm gap setting. The sample is tested in creep at two stress levels followed by recovery at each stress level. The creep portion of the test lasts for 1s which is followed by a 9s recovery. Ten creep and recovery cycles are tested at each stress level.

5. Significance and Use

5.1 This method is designed to evaluate the ability of a modified binder to maintain elastic response at two different stress levels while being subjected to ten cycles of stress and recovery. Percent recovery obtained at the higher stress level used in this test can be used to detect the presence of an asphalt modifier that results in an asphalt binder with elastic properties.

6. Procedure

6.1 Condition the asphalt binder in accordance with Test Method AASHTO T315 (ASTMD 2872) (RTFOT).

6.2 *Sample preparation:* The sample for the multi-step creep and recovery test is prepared the same as for AASHTO T315 (ASTM D 7175-05) using 25 mm plates. The temperature control will also follow the AASHTO T315 (ASTM D 7175-05) requirements.

6.3 *Test protocol:* The test is run at the selected temperature using a constant stress creep of 1.0 second duration followed by a zero stress recovery of 9.0 second duration. The test is run at two stress levels 100 Pa and 3200 Pa. Ten cycles are run at each of the two stress levels for a total of 20 cycles. The commanded full stress for each creep cycle shall be achieved within 0.05 seconds from the start of the creep cycle. The stress and strain shall be recorded every 0.1 seconds for the total length of the test on a running time such that in addition to other data points the data points at 1s and 10s are explicitly recorded. There are no rest periods between creep and recovery cycles or changes in stress level. The total time required to run the two-step creep and recovery is 200 seconds.

6.4 Analyze and record the creep and recovered strain for the 100 Pa and 3200 Pa creep stress levels as follows:

6.4.1 For each of the ten cycles record the following:

6.4.1.1 Initial strain value at the beginning creep portion of each cycle. This strain shall be denoted as ε_0.

6.4.1.2 The strain value at the end of the creep portion (i.e after 1 s) of each cycle. This strain shall be denoted as ε_c.

6.4.1.3 The adjusted strain value at the end of creep portion (i.e. after 1 s) of each cycle

$$\varepsilon_1 = \varepsilon_c - \varepsilon_0$$

6.4.1.4 The strain value at the end of the recovery portion (i.e after 10 s) of each cycle. This strain shall be denoted as ε_r .

6.4.1.5 The adjusted strain value at the end of recovery portion (i.e. after 10 s) of each cycle

$$\varepsilon_{10} = \varepsilon_r - \varepsilon_0$$

6.4.2 For each of the ten cycles calculate the following at creep stress level of 100 Pa:

6.4.2.1 % recovery $\varepsilon_r(100, N)$ for N = 1 to 10

$$\varepsilon_r(100, N) = \frac{(\varepsilon_{10} - \varepsilon_1)*100}{\varepsilon_1}$$

6.4.3 For each of the ten cycles calculate the following at creep stress level of 3200 Pa:

6.4.3.1 % recovery $\varepsilon_r(3200, N)$ for N = 1 to 10

$$\varepsilon_r(3200, N) = \frac{(\varepsilon_{10} - \varepsilon_1)*100}{\varepsilon_1}$$

7. Hazards

7.1 Use standard laboratory safety procedures in handling the hot asphalt binder when preparing aging specimens and removing the residue from the pressure vessel. Use special precaution when lifting the pressure vessel.

8. Calculation

8.1 Using the results obtained in Sections 6.4.2.1 and 6.4.3.1 determine the average percent recovery for the asphalt binder at creep stress level of 100 Pa and 3200 Pa as shown in the following equations:

8.1.1 Calculate average % recovery at 100 Pa:

$$\%\varepsilon_r(100, Avg.) = SUM(\varepsilon_r(100,N))/10 \quad \text{for } N = 1 \text{ to } 10$$

8.1.2 Calculate average % recovery at 3200 Pa:

$$\%er(3200, Avg.) = SUM(er(3200,N))/10 \quad \text{for } N = 1 \text{ to } 10$$

Note: A value of 15% recovered strain at 3200 Pa ($\%\varepsilon_r(3200, Avg.) \exists 15$) at the binder grade temperature is a preliminary value under consideration for determining if the binder has suitable elastomeric properties.

9. Report

9.1 Report the following information:
9.1.1 Sample identification,
9.1.2 PG Grade and Test Temperature, nearest 0.1°C,
9.1.3 percent recovery at 100 Pa, $\%Rec_{25}$
9.1.4 percent recovery at 3200 Pa, $\%Rec_{3200}$

10. Precision and Bias

10.1 Since this is a practice, precision and bias statement are not needed.

12. Keywords

12.1 Elastic Recovery, DSR, Creep and Recovery, %Rec, percent recovery, polymer modification, elastomer identification, modified asphalt binders, RTFOT, Multiple Stress Creep and Recovery Test, MSCR.

APPENDIX
(Non Mandatory Information)

X1. SAMPLE CALCULATIONS

A typical test data plot consisting of ten cycles of creep and recovery at 100 Pa creep stress is shown in Figure 1. The plot for 3200 Pa creep stress is similar to Figure 1 and will not be shown here. Test data from cycle number 1 is plotted in Figure 2 for further clarification.

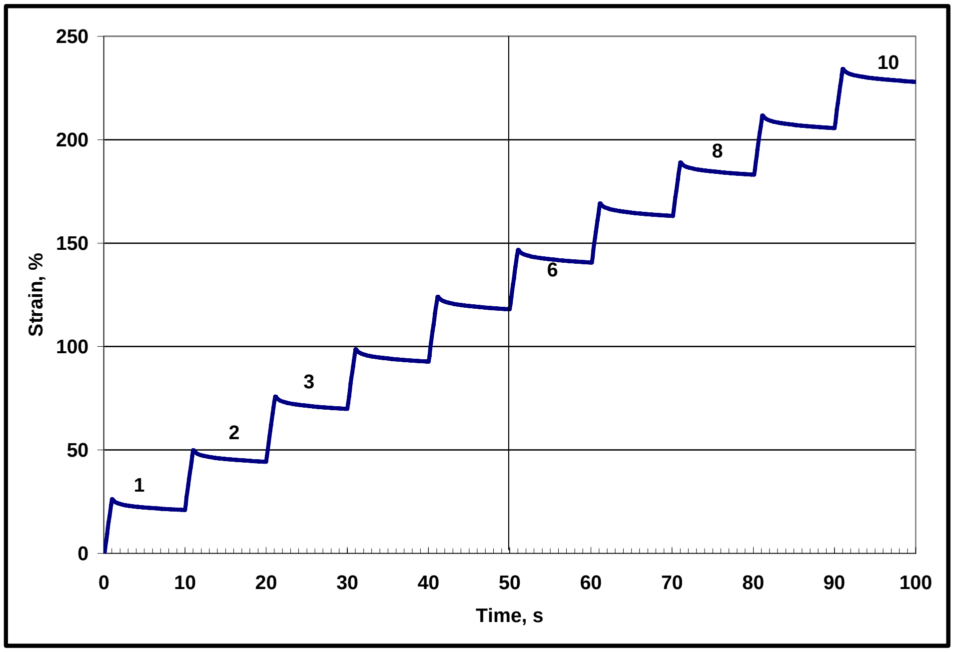

Figure 1. Test Data Plot Showing Typical Ten Cycles Creep and Recovery with Creep Stress of 100 Pa.

Sample Calculations:

Calculation of %Recovery for cycle number 9 (see Figure 2):

1. Determine strain at the start (Initial strain): ε_0 = 183 %
2. Determine strain at 1 s creep end time point: ε_c = 212 %
3. Determine adjusted creep end strain at 1s point: $\varepsilon_1 = (\varepsilon_c - \varepsilon_0)$ = (212 – 183) % = 29%
4. Determine strain at 10 s recovery end time point: ε_r = 206.0 %
5. Determine adjusted recovery end strain at 10 s time point: $\varepsilon_{10} = (\varepsilon_r - \varepsilon_0)$ = (206 – 183) % = 23%
6. Determine % Recovery for cycle number 9 with 100 Pa creep stress: $\varepsilon_r(100, 9)$:

$$\varepsilon_r(100,9) = \frac{(\varepsilon_{10} - \varepsilon_1)*100}{\varepsilon_1}$$

For creep stress level of 100 Pa and cycle number 9 the %recovery will be: (29-23)*100/29.0) = 21%

Follow the above example to calculate % recoveries for all ten cycles for both creep stress levels of 100 Pa and 3200 Pa.

Average % recovery for 100 Pa: %ε_r(100, Avg.) = Average(ε_r(100,1) to ε_r(100, 10)

Average % recovery for 3200 Pa: %ε_r(3200, Avg.) = Average(ε_r(3200,1) to ε_r(3200, 10)

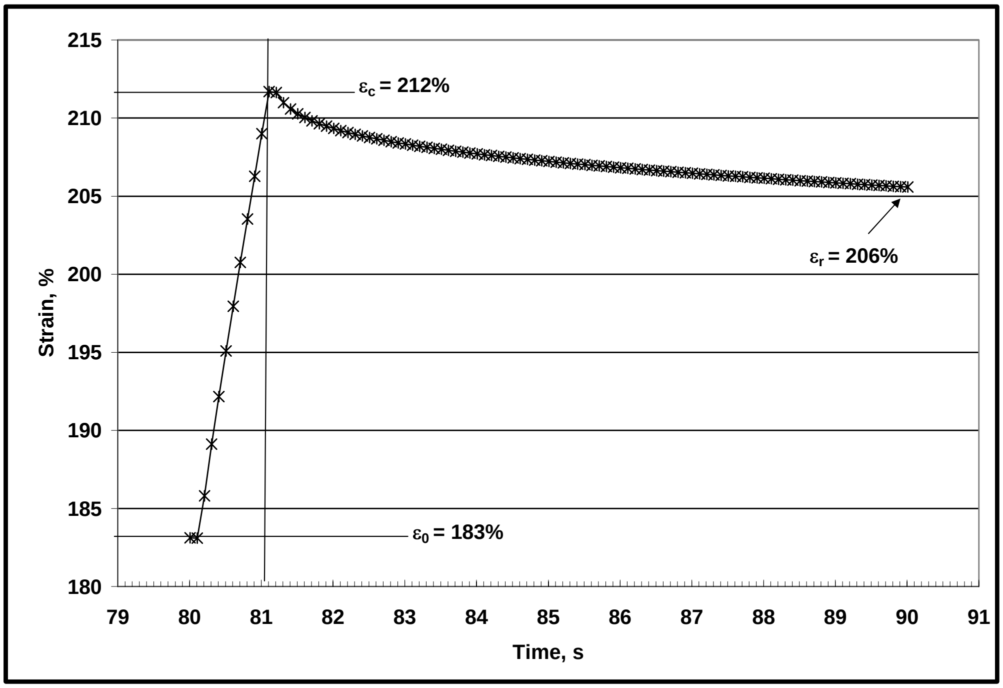

Figure 2. Test Cycle No. 9 Data Plot Showing Creep and Recovery with Creep Stress of 100 Pa.