Test Procedure for

CALCULATING VISCOSITY FROM PENETRATION

TxDOT Designation: Tex-535-C

Effective Date: August 1999

1. SCOPE

1.1 This procedure describes the calculation of viscosity from penetration test results. The penetration of the asphalt is determined in accordance with Tex-502-C, which conforms to ASTM D 5.

1.2 The calculation procedure presented is derived from a paper presented by R.L. Davis at the 1981 meeting of the Association of Asphalt Paving Technologists, entitled *The ASTM Penetration Method Measures Viscosity*.

1.3 Perform the penetration test at any temperature; the calculated viscosity is the viscosity of the sample at that temperature.

1.4 The values given in parentheses (if provided) are not standard and may not be exact mathematical conversions. Use each system of units separately. Combining values from the two systems may result in nonconformance with the standard.

2. APPARATUS

2.1 *Penetrometer*, equipped for a 100 g needle weight and 5-sec. penetration time, as specified by ASTM D 5.

2.2 *Apparatus*, as specified by ASTM D 5.

3. PROCEDURE

3.1 Determine the penetration of the asphalt in accordance with Tex-502-C.

3.2 Calculate the viscosity of the material in accordance with Sections 4.1 and 4.2.

3.3 Alternative method: calculate viscosity using Section 5, Table 1.

4. CALCULATIONS

4.1 The calculation of the viscosity depends upon the radius of the needle as it penetrates the asphalt. If the needle has the approximate shape of a truncated cone at the end of a

cylinder, the effective radius is a function of the depth of penetration. Consequently, use either of two equations to calculate viscosity.

4.1.1 Use this equation for penetrations less than or equal to 54:

$$\mu = \frac{1.559719 \times 10^{9} \bullet \ln\left(\frac{0.0275}{3.94 \times 10^{-6} \bullet P + 0.000075}\right)}{P^{2}}$$

Where:

μ = viscosity in poise

P = penetration in penetration units.

4.1.2 Use this equation for penetrations greater than 54:

$$\mu = \frac{1.559719 \times 10^{9} \bullet \ln\left(\frac{0.0275}{0.0005 - \frac{0.0114488}{P}}\right)}{P^{2}}$$

Where:

μ = viscosity in poise

P = penetration in penetration units.

5. TABULATED VALUES

5.1 The data in Table 1 is based on the equations in Section 4. Use this as an alternative to hand calculations.

Table 1—Viscosity from Penetration

Penetration	Viscosity (Poise)	Penetration	Viscosity (Poise)
20	2.02×10^{7}	48	3.15×10^{6}
21	1.83×10^{7}	49	3.01×10^{6}
22	1.66×10^{7}	50	2.88×10^{6}
23	1.51×10^{7}	51	2.76×10^{6}
24	1.38×10^{7}	52	2.65×10^{6}
25	1.26×10^{7}	53	2.54×10^{6}
26	1.16×10^{7}	54	2.44×10^{6}
27	1.07×10^{7}	55	2.35×10^{6}
28	9.95×10^{6}	56	2.26×10^{6}
29	9.24×10^{6}	57	2.17×10^{6}
30	8.59×10^{6}	58	2.09×10^{6}
31	8.02×10^{6}	59	2.02×10^{6}

Penetration	Viscosity (Poise)	Penetration	Viscosity (Poise)
32	7.49×10^6	60	1.95×10^6
33	7.02×10^6	61	1.88×10^6
34	6.59×10^6	62	1.81×10^6
35	6.19×10^6	63	1.75×10^6
36	5.83×10^6	64	1.70×10^6
37	5.50×10^6	65	1.64×10^6
38	5.19×10^6	66	1.59×10^6
39	4.91×10^6	67	1.54×10^6
40	4.65×10^6	68	1.49×10^6
41	4.41×10^6	69	1.45×10^6
42	4.19×10^6	70	1.40×10^6
43	3.98×10^6	71	1.36×10^6
44	3.79×10^6	72	1.32×10^6
45	3.61×10^6	73	1.28×10^6
46	3.45×10^6	74	1.25×10^6
47	3.29×10^6	75	1.21×10^6