VISCOSITY DATA FOR ASPHALTS USED BY THE TEXAS HIGHWAY DEPARTMENT

by

R. N. Traxler
Research Engineer
Texas Transportation Institute

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TEXAS TRANSPORTATION INSTITUTE
Texas A. & M. College
College Station, Texas

ABSTRACT

REPORT: Progress Report No. 6 Research Project No. 15 (2-8-59-9)

TITLE: Viscosity Data for Asphalts Used by The Texas Highway Department

PERIOD: June 1, 1962 to June 1, 1963

OBJECTIVE: To establish specifications to assure use of superior asphalts by the Texas Highway Department.

EXPERIMENTAL: Viscosities were determined for (a) 9 asphalts (150-200 penetration) obtained in 1959, (b) 24 asphalts (85-100 penetration) obtained in 1962, (c) 18 asphalts (120-150 penetration) obtained in 1962, and (d) 9 asphalts (150-200 penetration) obtained in 1962. Viscosities at 77°F were measured in the thin film (Hallikainen) viscometer, and those at 140° and 275°F were measured in the Cannon-Manning vacuum type capillary tube viscometer.

CONCLUSIONS:

1. Many of the asphalts supplied to the Texas Highway Department pass the minimum viscosity requirements proposed at 275°F.

2. Less than 40 percent of the same asphalts pass the proposed minimum viscosity requirements at 140°F.

3. It will be necessary to eliminate the current minimum penetration requirements to permit all of the producers to meet the proposed minimum viscosity limits at both 140° and 275°F.

RECOMMENDATIONS:

It is recommended that:

1. The following viscosity limits be established as tentative specifications for purchase of asphalt paving cements:

Grade	Viscosity - Stokes at 140°F.	275°F.
AC-20	2000-3000	3.0+
AC-10	1000-1500	2.0+
AC-5	500-750	1.5+

2. If an asphalt meets the minimum viscosity requirement at 275°F but fails at 140°F, the asphalt shall be acceptable if the value at 140°F is not more than 10 percent below the requirements given above.

3. The current minimum penetration specifications be dropped in order to make the above viscosity specifications of practical value.

FUTURE WORK:

1. The Highway Department Laboratories will test numerous samples received during the 1963 and subsequent seasons for viscosities at 77°, 140°, and 275°F. Thus, no more work on this subject will be done under Research Project No. 15, Some special situations may require attention.

2. An extensive program is underway to determine the rate of hardening of asphalt cements during preparation and handling of the hot mixture, laying on the road and during a year of pavement service. The data obtained will also be correlated with numerous laboratory tests.

3. A program is underway on the use of chemical additives to improve the properties of asphalt, especially resistance to hardening by oxidation.

4. Progress Report No. 7 concerning the susceptibility of asphalts to hardening by oxidation will be released soon.

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TABLES

VISCOSITY DATA FOR ASPHALTS USED BY THE TEXAS HIGHWAY DEPARTMENT

I. OBJECTIVES FOR RP-15

The objectives of the project are:

(1) Investigate the paving asphalts used by the Texas Highway Department,

(2) Establish specifications to assure use of superior asphalts by the Department, and

(3) Determine how the durability of paving asphalts can be improved.

II. HISTORY

Research Project 15 "Modifications of Properties of Asphalt" (now identified as 2-8-59-9) was started February 1, 1959. This report is concerned with objectives (1) and (2) listed on the previous page.

During the paving season of 1959 twenty-five drum samples of paving asphalt were obtained from the field by Texas Highway personnel and shipped to the Texas Transportation Institute at College Station. Eleven of the samples were 85-100 penetration grade, five were 120-150 penetration grade, and nine were 150-200 penetration grade materials. The 25 samples represented asphalts from 12 different producers. Progress Reports 1 through 5 of Research Project No. 15 give extensive data obtained on these asphalts. Report No. 2 "Temperature - Viscosity Data on Asphalt Cements" presented viscosity data on the 85-100 and 120-150 penetration asphalts and limited data on the softer 150-200 penetration material.

In 1962 Texas Highway Department personnel collected small samples from 51 paving projects and shipped them to College Station. This report gives viscosity data at 77°, 140°, and 275°F on these 51 asphalts and on the nine 150-200 penetration grade materials collected in 1959.

III. CONCLUSIONS

The following conclusions are drawn from the data presented in this report.

1. Many of the asphalts supplied to the Texas Highway Department pass the minimum viscosity requirements proposed at 275°F.
2. Less than 40 percent of the same asphalts pass the proposed minimum viscosity requirements at 140°F.
3. It will be necessary to eliminate the current minimum penetration requirements to permit all of the producers to meet the proposed minimum viscosity limits at both 140° and 275°F.

IV. RECOMMENDATIONS

It is recommended that:

1. The following viscosity limits be established as tentative specifications for purchase of asphalt paving cements:

Grade	Viscosity - Stokes at 140°F.	275°F.
AC-20	2000-3000	3.0+
AC-10	1000-1500	2.0+
AC-5	500-750	1.5+

2. If an asphalt meets the minimum viscosity requirement at 275°F but fails at 140°F, the asphalt shall be acceptable if the value at 140°F is not more than 10 percent below the requirements given above.

3. The current minimum penetration specifications be dropped in order to make the above viscosity specifications of practical value.

V. FUTURE WORK

1. The Highway Department Laboratories will test numerous samples received during the 1963 and subsequent seasons for viscosities at 77°, 140°, and 275° F. Thus, no more work on this subject will be done under Research Project No. 15. Some special situations may require attention.
2. An extensive program is underway to determine the rate of hardening of asphalt cements during preparation and handling of the hot mixture, laying on the road and during a year of pavement service. The data obtained will also be correlated with numerous laboratory tests.
3. A program is underway on the use of chemical additives to improve the properties of asphalt, especially resistance to hardening by oxidation.
4. Progress Report No. 7 concerning the susceptibility of asphalts to hardening by oxidation will be released soon.

VI. EXPERIMENTAL

1. Materials Investigated

(a) Nine 150-200 penetration grade asphalts obtained during the 1959 season (see Progress Report No. 1, dated February, 1961).

(b) Fifty-one asphalts from as many projects collected during the 1962 season. Twenty-four were 85-100 penetration; 18 were 120-150 penetration, and 9 were 150-200 penetration grade asphalts.

2. Methods Used for Measuring Viscosity

The Hallikainen thin film (sliding plate) viscometer was used to obtain viscosities at 77°F.

The Cannon-Manning vacuum type capillary tube viscometer was used to obtain viscosities at 140° and 275°F.

Both types of viscometers are illustrated and their operation described in Progress Report No. 2 of this project.

TABLE 1

Viscosities of 150-200 Penetration Asphalts
Obtained by the Texas Highway Department During 1959

Asphalt	Pen. at 77° F.	Stokes at 77° F. (1)	Stokes at 140° F. (2)	Stokes at 275° F. (2)
10 - B	160	0.29×10^6	890	2.9
11 - B	177	0.26×10^6	695	2.4
8 - B	188	0.22×10^6	670	4.0
6 - B	170	0.24×10^6	635	2.9
12 - B	168	0.24×10^6	545	1.9
1 - B	163	0.32×10^6	525	1.8
2 - B	185	0.24×10^6	470	1.5
5 - B	150	0.32×10^6	435	1.9
7 - B	172	0.32×10^6	400	1.6
Proposed Limits for AC-5			500 - 750	1.5+

(1) Using sliding plate viscometer. Viscosity calculated at 5×10^{-2} sec^{-1} rate of shear.

(2) Using Cannon-Manning vacuum type capillary tube viscometer.

3. Viscosities at 77°, 140° and 275°F.

(a) 150-200 penetration asphalts (1959)

Table 1, facing, shows the viscosities in stokes obtained for the 175 penetration grade asphalts obtained from the field by Texas Highway Department personnel during 1959. All nine are essentially Newtonian materials. The proposed viscosity limits shown in Table 1 are those proposed by the Asphalt Institute and the Ad Hoc Committee on Asphalt of the Highway Research Board for AC-5 grade. All nine of the asphalts pass the minimum of 1.5 stokes at 275°F. Three of them failed to meet the minimum requirement of 500 stokes at 140°F.

For sake of uniformity stokes are shown at 77°F instead of poises. This practice continues throughout the report.

TABLE 2

Average Viscosities of 85-100 Penetration Grade Asphalts Used by the Texas Highway Department During 1962

Asphalt	No. of Samples	Pen. at 77°F.	Stokes at 77° F.(1)	Stokes at 140°F.(2)	Stokes at 275°F.(2)
13	1	86	1.2×10^6	3010	5.6
14	1	98	0.85×10^6	1990	3.8
3	5	89	1.1×10^6	1830	4.0
11	3	88	1.2×10^6	1620	3.1
6	3	85	0.82×10^6	1430	3.3
2	1	99	0.65×10^6	1260	2.2
1	3	88	1.35×10^6	1210	2.6
5	1	87	0.8×10^6	1060	2.6
7	4	87	0.9×10^6	1025	2.3
9	1	85	1.0×10^6	900	2.3
9	1	90	1.0×10^6	1710	4.1
Proposed Limits for AC-20				2000-3000	3.0+

(1) Using sliding plate viscometer. Viscosity calculated at 5×10^{-2} sec^{-1} rate of shear.

(2) Using Cannon-Manning vacuum type capillary tube viscometer.

(b) 85-100 Penetration asphalts (1962)

The viscosity values for the 90 penetration grade asphalts used by the Texas Highway Department during 1962 are shown in Table A-1 of the Appendix.

Average values for the materials supplied by each of the 10 producers are given in Table 2, facing. (Only one sample was obtained from producers 2, 5, 13, and 14). Asphalt 13 is the only one that shows appreciable non-Newtonian flow at 77°F. Two samples of Asphalt 9 were obtained. Data on both are given in Table 2 because the asphalts are distinctly different and probably were prepared from different crude sources. It would not be sensible to average the viscosity values of these two samples at 140° and 275°F.

The proposed viscosity limits at 140° and 275°F are those advocated by the Asphalt Institute, the Ad Hoc Committee on Asphalt of the Highway Research Board, and others for AC-20 grade. Five of the asphalts met the requirement of 3.0+ stokes at 275°F. Only two (asphalts 13 and 14) met or approached the minimum of 2000 stokes proposed at 140°F.

The data shown in Table 2 confirm the contention that satisfactory viscosity values cannot be attained by some producers if they also have to meet the minimum 85 penetration currently specified. Penetration values as low as 70 to 75 would be required for certain producers to meet the minimum requirements of 2000 stokes at 140°F and 3.0+ stokes at 275°F.

TABLE 3

Average Viscosities of 120-150 Penetration Grade Asphalt Used by the Texas Highway Department During 1962

Asphalt	No. of Samples	Pen. at 77° F.	Stokes at 77°F. (1)	Stokes at 140°F. (2)	Stokes at 275°(2)
13A	1	118	0.72×10^6	2510	4.8
11A	3	139	0.41×10^6	1007	2.7
3A	4	139	0.43×10^6	965	2.8
2A	1	123	0.46×10^6	930	2.1
6A	5	138	0.39×10^6	873	2.7
1A	2	130	0.64×10^6	740	2.15
7A	2	125	0.50×10^6	660	1.85
Proposed Limits for AC-10				1000-1500	2.0+

(1) Using sliding plate viscometer. Viscosity calculated at 5×10^{-2} sec^{-1} rate of shear.

(2) Using Cannon-Manning vacuum type capillary tube viscometer.

(c) 120-150 penetration asphalts (1962)

Viscosity data on the 135 penetration grade asphalts used by the Texas Highway Department during 1962 are detailed in Table A-2 of the Appendix.

Average values for the materials obtained from each of the seven producers are shown in Table 3, facing. Only one sample each of Asphalts 2A and 13A was obtained. Data for viscosities at 77°F indicate that none of the asphalts show any appreciable tendency toward non-Newtonian characteristics.

The proposed limits at 140° and 275°F are those currently advocated by the Asphalt Institute, the Ad Hoc Committee on Asphalts of the Highway Research Board and others for AC-10 grade. Three of the asphalts met or approached the limits proposed at 140°F. One asphalt failed the minimum of 2.0 stokes at 275°F. In order to meet the viscosity requirement four sources would have to be processed to penetrations below the 120 minimum now specified.

TABLE 4

Average Viscosities of 150-200 Penetration Grade Asphalts Used by the Texas Highway Department During 1962

Asphalt	No. of Samples	Pen. at 77°F.	Stokes at 77°F.(1)	Stokes at 140°F.(2)	Stokes at 275°F.(2)
6B	3	164	0.24×10^6	633	2.3
11B	1	185	0.26×10^6	595	2.2
1B	1	172	0.48×10^6	550	1.8
7B	4	175	0.26×10^6	354	1.45
Proposed Limits for AC-5				500-750	1.5+

(1) Using sliding plate viscometer. Viscosity calculated at 5×10^{-2} sec^{-1} rate of shear.

(2) Using Cannon-Manning vacuum type capillary viscometer.

(d) 150-200 penetration asphalts (1962)

Detailed viscosity data on nine samples of 175 penetration grade asphalts from 4 producers are shown in Table A-3 of the Appendix. These asphalts were used by the Texas Highway Department during the 1962 season. Only one sample each was obtained from producers of Asphalts 1-B and 11-B. None of the materials possessed significant non-Newtonian properties.

Table 4, facing, gives average values for the samples from each producer. It is interesting to compare these data with those in Table 1 for AC-5 used 3 years previously from the same refiner.

Each producer involved supplied a slightly less viscous asphalt in 1962 as compared with their 1959 material. The exception was Asphalt 1B which was essentially the same for both periods. The limits shown at 140° and 275°F are the same as given in Table 1 (1959 asphalts).

TABLE 5

Average Viscosities of Asphalts Received by Texas Highway Department From Four Major Producers During 1962

85-100 Penetration Grade Asphalts

Asphalt	Stokes at 77°F.(1)	Stokes at 140°F.	Stokes at 275° F.
3	1.1×10^6	1830	4.0
11	1.2×10^6	1620	3.1
6	0.82×10^6	1430	3.3
1	1.35×10^6	1210	2.6
Proposed Limits for AC-20		2000-3000	3.0+

120-150 Penetration Grade Asphalts

Asphalt	Stokes at 77°F.	Stokes at 140°F.	Stokes at 275°F.
11A	0.41×10^6	1007	2.7
3A	0.43×10^6	965	2.8
6A	0.39×10^6	873	2.7
1A	0.64×10^6	740	2.15
Proposed Limits for AC-10		1000-1500	2.0+

150-200 Penetration Grade Asphalts

Asphalt	Stokes at 77°F.	Stokes at 140°F.	Stokes at 275°F.
3B	-------	-----	---
6B	0.24×10^6	633	2.3
11B	0.26×10^6	595	2.2
1B	0.48×10^6	550	1.8
Proposed Limits for AC-5		500-750	1.5+

(1) Viscosity calculated at rate of shear of 5×10^{-2} sec^{-1}.

4. Average Viscosities of Asphalts Received From Four Major Producers During 1962

Table 5, facing, is a compilation of the average viscosities for samples of the three penetration grades of asphalt produced by four major sources and collected during 1962.

Considering the 85-100 penetration (AC-20) grade materials: three of the producers met the minimum viscosity requirement of 3.0 stokes at 275° F but none met the minimum of 2000 stokes at 140°F. Asphalt 3, however, approached this value. Again, it should be pointed out that eliminating the 85 penetration minimum requirement would permit these refiners to meet the proposed viscosity limits.

Referring to the 120-150 penetration (AC-10) grade asphalts: All four of the producers met the minimum viscosity requirement of 2.0 stokes at 275°F but only one attained the minimum requirement of 1000 stokes at 140° F and that was by a small margin. The elimination of the penetration requirement is again necessary if all producers are to meet the proposed viscosity minimums.

Samples of 175 penetration grade asphalt were obtained from only three of the major producers during 1962. These met the proposed viscosity limits.

VII. APPENDIX

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TABLE A-1

Viscosities of 1962 Samples of 85-100 Penetration Grade Asphalt from the Texas Highway Department

Asphalt	TTI No.	Pen. at 77°F	Stokes at 77°F[1]	Stokes at 140°F[2]	Stokes at 275°F[2]
13	54	86	1.2×10^6 (1.5×10^6)	3010	5.6
14	138	98	0.85×10^6 (0.85×10^6)	1990	3.8
3	108	82	1.4×10^6 (1.4×10^6)	1990	4.1
	3	83	1.1×10^6 (1.1×10^6)	1930	4.1
	93	88	1.0×10^6 (1.0×10^6)	1830	4.0
	57	94	1.1×10^6 (1.1×10^6)	1760	4.0
	87	98	0.9×10^6 (0.9×10^6)	1640	3.7
Average		89	1.1×10^6 (1.1×10^6)	1830	4.0
11	96	88	1.1×10^6 (1.1×10^6)	1720	3.2
	27	81	1.5×10^6 (1.5×10^6)	1590	3.1
	32	96	1.0×10^6 (1.1×10^6)	1550	3.1
Average		88	1.2×10^6 (1.2×10^6)	1620	3.1

TABLE A-1 (Cont.)

Asphalt	TTI No.	Pen. at 77°F.	Stokes at 77°F.(1)	Stokes at 140°F.(2)	Stokes at 275°F.(2)
6	12	79	0.80×10^6 (0.85×10^6)	1560	3.3
	9	86	0.85×10^6 (0.85×10^6)	1540	3.4
	150	89	0.80×10^6 (0.80×10^6)	1210	3.2
		—		—	—
Average		85	0.82×10^6 (0.82×10^6)	1430	3.3
2	39	99	0.65×10^6 (0.70×10^6)	1260	2.2
1	69	78	1.75×10^6 (1.70×10^6)	1290	2.7
	113	88	1.3×10^6 (1.3×10^6)	1210	2.6
	6	99	1.0×10^6 (1.1×10^6)	1130	2.4
		—		—	—
Average		88	1.35×10^6 (1.3×10^6)	1210	2.6
7	72	85	1.0×10^6 (0.95×10^6)	1050	2.3
	101	86	0.9×10^6 (0.85×10^6)	1030	2.3
	124	87	0.85×10^6 (0.90×10^6)	1030	2.3
	112	92	0.85×10^6 (0.8×10^6)	1000	2.2
		—		—	—
		87	0.9×10^6 (0.85×10^6)	1025	2.3

TABLE A-1 (Cont)

Asphalt	TTI No.	Pen. at 77° F.	Stokes at 77° F. (1)	Stokes at 140°F.(2)	Stokes at 275°F.(2)
5	129	87	0.8×10^6 (0.8×10^6)	1060	2.6
9	75	85	1.0×10^6 (1.1×10^6)	900	2.3
	144	90	1.0×10^6 (1.0×10^6)	1710	4.1
Proposed Limits				2000-3000	3.0+

(1) Using sliding plate viscometer. First value calculated at 5×10^{-2} sec^{-1} rate of shear. Second value (in parentheses) calculated at power input of 1000 ergs/cm/sec.

(2) Using Cannon-Manning vacuum type capillary tube viscometer.

TABLE A-2

Viscosities of 1962 Samples of 120-150 Penetration Asphalt From the Texas Highway Department

Asphalt	TTI No.	Pen. at 77°F.	Stokes at 77°F.[1]	Stokes at 140°F.[2]	Stokes at 275°F.[2]
13-A	145	118	0.72×10^6 (0.76×10^6)	2510	4.8
11-A	34	124	0.54×10^6 (0.54×10^6)	1110	2.7
	82	151	0.32×10^6 (0.32×10^6)	965	2.8
	130	141	0.36×10^6 (0.36×10^6)	945	2.6
		139	0.41×10^6 (0.41×10^6)	1007	2.7
3-A	22	119	0.54×10^6 (0.54×10^6)	1135	3.0
	16	148	0.38×10^6 (0.38×10^6)	930	2.7
	115	134	0.46×10^6 (0.50×10^6)	920	3.0
	79	155	0.34×10^6 (0.35×10^6)	875	2.6
Average		139	0.43×10^6 (0.44×10^6)	965	2.8
2-A	146	123	0.46×10^6 (0.46×10^6)	930	2.1
6-A	58	134	0.41×10^6 (0.41×10^6)	925	2.8

TABLE A-2 (Cont.)

Asphalt	TTI No.	Pen. at 77°F.	Stokes at 77°F.[1]	Stokes at 140°F.[2]	Stokes at 275°F.[2]
	40	134	0.375×10^6 (0.375×10^6)	925	2.8
	61	123	0.44×10^6 (0.435×10^6)	920	2.9
	103	139	0.36×10^6 (0.36×10^6)	910	2.4
	46	145	0.37×10^6 (0.37×10^6)	685	2.7
		___	___	___	___
Average		138	0.39×10^6 (0.39×10^6)	873	2.7
1-A	121	133	0.66×10^6 (0.64×10^6)	750	2.2
	64	128	0.62×10^6 (0.59×10^6)	730	2.1
		___	___	___	___
		130	0.64×10^6 (0.62×10^6)	740	2.15
7-A	13	118	0.50×10^6 (0.50×10^6)	670	1.9
	118	132	0.50×10^6 (0.49×10^6)	650	1.8
		___	___	___	___
		125	0.50×10^6 (0.495×10^6)	660	1.85
Proposed Limits				1000-1500	2.0+

(1) Using sliding plate viscometer. First value calculated at 5×10^{-2} sec^{-1} rate of shear. Second value (shown in parentheses) calculated at power input of 1000 ergs/cm/sec.

(2) Using Cannon-Manning vacuum type capillary tube viscometer.

TABLE A-3

Viscosities of 1962 Samples of 150-200 Penetration Asphalt from the Texas Highway Department

Asphalt	TTI No.	Pen. at 77°F.	Stokes at 77°F.[1]	Stokes at 140°F.[2]	Stokes at 275°F.[2]
6-B	28	157	0.26×10^6 (0.25×10^6)	700	2.4
	19	165	0.23×10^6 (0.23×10^6)	605	2.3
	49	169	0.23×10^6 (0.22×10^6)	595	2.3
Average		164	0.24×10^6 (0.23×10^6)	633	2.3
11-B	43	185	0.26×10^6 (0.24×10^6)	595	2.2
1-B	76	172	0.48×10^6 (0.47×10^6)	550	1.8
7-B	151	161	0.28×10^6 (0.27×10^6)	420	1.5
	133	163	0.30×10^6 (0.295×10^6)	415	1.5
	88	186	0.25×10^6 (0.24×10^6)	355	1.4
	109	191	0.22×10^6 (0.20×10^6)	325	1.4
Average		175	0.26×10^6 (0.25×10^6)	354	1.45
Proposed Limits				500-750	1.5+

(1) Using sliding plate viscometer. First value calculated at 5×10^{-2} sec^{-1} rate of shear. Second value (in parentheses) calculated at power input of 1000 ergs/cm/sec.

(2) Using Cannon-Manning vacuum type capillary tube viscometer.