TEMPERATURE-VISCOSITY DATA ON ASPHALT CEMENTS

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ABSTRACT

Report: Progress Report No. 2 — Research Project No. 15

Title: Temperature — Viscosity Data on Asphalt Cements

Period: February 1, 1959 to September 1, 1962

Objective: Establish specifications to assure use of superior asphalts by the Texas Highway Department.

Experimental: Viscosities of 25 asphalts of 85-100 and 120-150 penetration used by the Texas Highway Department were determined at temperatures from 51 to 325°F. Measurements were made by the microfilm (sliding plate), Saybolt-Furol (efflux), Brookfield (rotating spindle), and capillary tube (Cannon-Manning vacuum-type) viscometers.

Conclusions: Kinematic viscosity limits at 275° F should be higher than those prescribed by the Asphalt Institute. A range of kinematic viscosity at 140°F should be made a specification test for quality paving cements. A range of absolute viscosity at 95°F should be given careful consideration.

Recommendations: (1) The Highway Laboratories should be equipped with the capillary tube type of viscometer so they may be able to evaluate the viscosity of asphalts at 140° and 275°F.

(2) The viscosity requirements at 275°F for asphalt cements should be increased 50 to 60 percent over those now stipulated by the Asphalt Institute. The present and proposed limits are as follows:

Penetration Grade

	60-70		85-100		120-150		200-300	
	Stokes	SSF	Stokes	SSF	Stokes	SSF	Stokes	SSF
Asphalt Institute	2.4+	120+	1.7+	85+	1.4+	70+	1.0+	50+
Proposed by TTI	3.5+	160+	3.0+	135+	2.4+	110+	1.7+	80+

(3) Kinematic viscosities at 140°F should be included in purchase specifications. The suggested range of viscosity at 140°F is:

85-100 pen. grade	1400 to 3000 stokes
120-150 pen. grade	1000 to 1400 stokes

(4) Consideration should be given to the establishment of an absolute viscosity range at 95° F as a complement to and possible eventual replacement of the ASTM penetration test at 77° F. The State Highway Laboratories should be equipped with a microfilm viscometer in order to accumulate viscosity data at 95° F.

Future Work: Additional temperature-viscosity data will be accumulated on asphalts used in the construction of pavements under conditions where observations can be made on ease of construction and service life. A pressing need is the development of correlations between laboratory tests such as are discussed in this report and durability in the field. Thus, the Texas Highway Department is collecting samples of asphalt from various producers used at particular hot-mix installations throughout the State of Texas during the summer of 1962.

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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" was started on February 1, 1959. The studies described and discussed in this report are concerned with objectives (1) and (2) listed above.

Much time and effort have been expended during the past 30 years in developing methods and techniques for measuring the absolute viscosity (poises) and kinematic viscosity (stokes) of all kinds and consistencies of asphalts. In spite of the progress that has been made the standard (but empirical) tests such as ASTM penetration at 77° F/ 100 gms/5 secs., R & B° F softening point, and ductility at 77° F, cms, are still the basis for purchase specifications. There is an urgent need for substitution of accurate viscosity data in place of these empirical tests in specifications for quality asphalts. Most of the asphalts used in the RP-15 studies have been evaluated for viscosity over a wide range of temperature. The data obtained are given in this report.

III. CONCLUSIONS

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

1. The Saybolt-Furol and Brookfield viscometers give data which check quite well with those obtained by the Cannon-Manning vacuum-type capillary viscometer.
2. Kinematic viscosity limits 50 to 60 percent higher at 275°F than those prescribed by the Asphalt Institute were developed from measurements made in the capillary viscometer.
3. Either a lower limit or a range of kinematic viscosity at 140°F should be made a specification test for quality asphaltic paving cements.
4. A lower limit or a range of absolute viscosity at 95° F appears to be a specification test worth careful consideration.

IV. RECOMMENDATIONS

It is recommended that:

1. The Highway Laboratories at Austin be equipped with and personnel trained to operate the capillary tube type of viscometer in order that they may be in a position to evaluate asphalt cements at 140°F and 275° F in terms of kinematic viscosities.

2. The viscosity requirement at 275° F for asphalt paving cements should be increased 50 to 60 percent over those now stipulated by the Asphalt Institute. The present and proposed limits are as follows:

Penetration Grade

	60-70		85-100		120-150		200-300	
	Stokes	SSF	Stokes	SSF	Stokes	SSF	Stokes	SSF
Asphalt Institute	2.4+	120+	1.7+	85+	1.4+	70+	1.0+	50+
Proposed by TTI	3.5+	160+	3.0+	135+	2.4+	110+	1.7+	80+

3. Kinematic viscosities at 140° F should be included in purchase specifications. The suggested range of viscosity at 140° F is:

85-100 pen grade	1400 to 3000 stokes
120-150 pen grade	1000 to 1400 stokes

4. Consideration should be given to the establishment of an absolute viscosity range at 95° F as a complement to and possible eventual replacement of the ASTM penetration test at 77°F. The State Highway Laboratories should be equipped and personnel trained to operate the microfilm viscometer in order to accumulate viscosity data at this temperature.

V. FUTURE WORK

Temperature-viscosity data will continue to be accumulated on asphalts used in the construction of pavements under conditions where observations can be obtained on ease of construction and service life.

A most pressing need is the development of correlations between laboratory tests such as are discussed in this report and durability in the field. The Texas Highway Department is collecting samples of asphalt cements from various producers used at particular hot-mix installations throughout the State of Texas during the summer of 1962.

TABLE 1

Paving Asphalts Studied

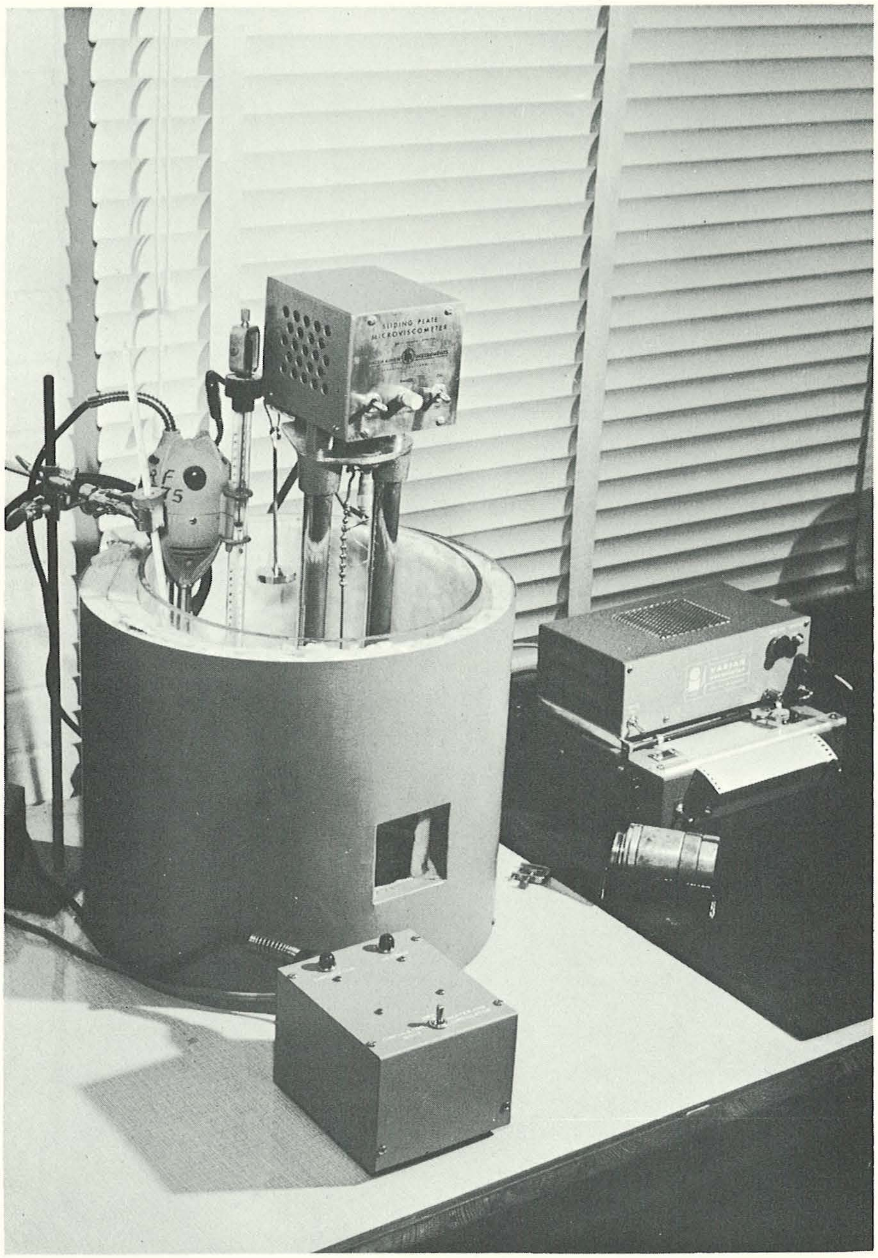
Asphalt No.	Viscosity, Megapoises* @77°F	Penetration 77 F/100 gms/ 5 sec.	Softening Point, R & B° F
	OA-90 Asphalts		
6	0.70	89	118
4	0.80	93	115
7	0.80	94	117
5	0.85	90	115
8	0.90	98	116
9	0.90	90	117
2	0.90	92	111
10	1.00	92	119
1	1.10	92	117
3	1.20	90	117
11	1.30	93	117
	OA-135 Asphalts		
6A	0.36	133	111
7A	0.40	144	111
11A	0.49	133	111
3A	0.54	142	111
1A	0.59	132	111
	OA-175 Asphalts		
6B	0.21	170	104
8B	0.21	188	106
2B	0.22	185	103
11B	0.23	177	107
12B	0.24	168	104
10B	0.27	160	109
5B	0.29	150	109
7B	0.30	172	108
1B	0.30	163	108

*One megapoise is one million poises. One megapoise is about 100 million times the viscosity of water.

VI. EXPERIMENTAL

1-Materials Investigated

Twenty-five different asphalts manufactured by 12 producers were obtained from the field by Texas Highway Department personnel during the spring and summer of 1959. Table 1, facing, lists the asphalts by grade and a number which designates the producer. Viscosity in poises at 77° F, ASTM penetration at 77° F/100 gms/5 sec. and softening point, R & B°F are shown. Within each grade the asphalts are listed in increasing order of absolute viscosity at 77° F. Complete standard tests on the 25 asphalts were obtained by the Texas Highway Laboratory and are given in Table A-1 of Progress Report No. 1 of RP-15, dated February 1, 1961.



MICROFILM VISCOMETER

FIGURE I

2-Methods Used for Measuring Viscosities

Four different apparatus and techniques were used to measure the viscosities of the various asphalt paving cements over the range 50 to 300°F. Each are described briefly.

(a) Sliding plate (microfilm) viscometer. This apparatus, which is illustrated in Figure I, facing, was used to measure viscosities over the temperature range from 10 to 55°C (50 to 131°F). In the operation of this viscometer a film of asphalt from 25 to 50 microns thick is placed between 2 by 3 cm glass plates. Exact thickness of the asphalt film is determined by weighing the assembly. After the plates and samples have been brought to the test temperature measurements are made at four different shearing stresses (applied loads) which result in four different rates of shear. These rates are recorded automatically, A rheology diagram is constructed by plotting rate of shear vs shearing stress and the best straight line is drawn through the points. Viscosities are calculated at a shearing stress of 5×10^{-2} $sec.^{-1}$ or a power input of 1000 ergs/sec./cm.[3] All of the viscosities can thus be compared at a common rate of shear which is necessary when evaluating non-Newtonian asphalts.

(b) Saybolt-Furol Viscometer

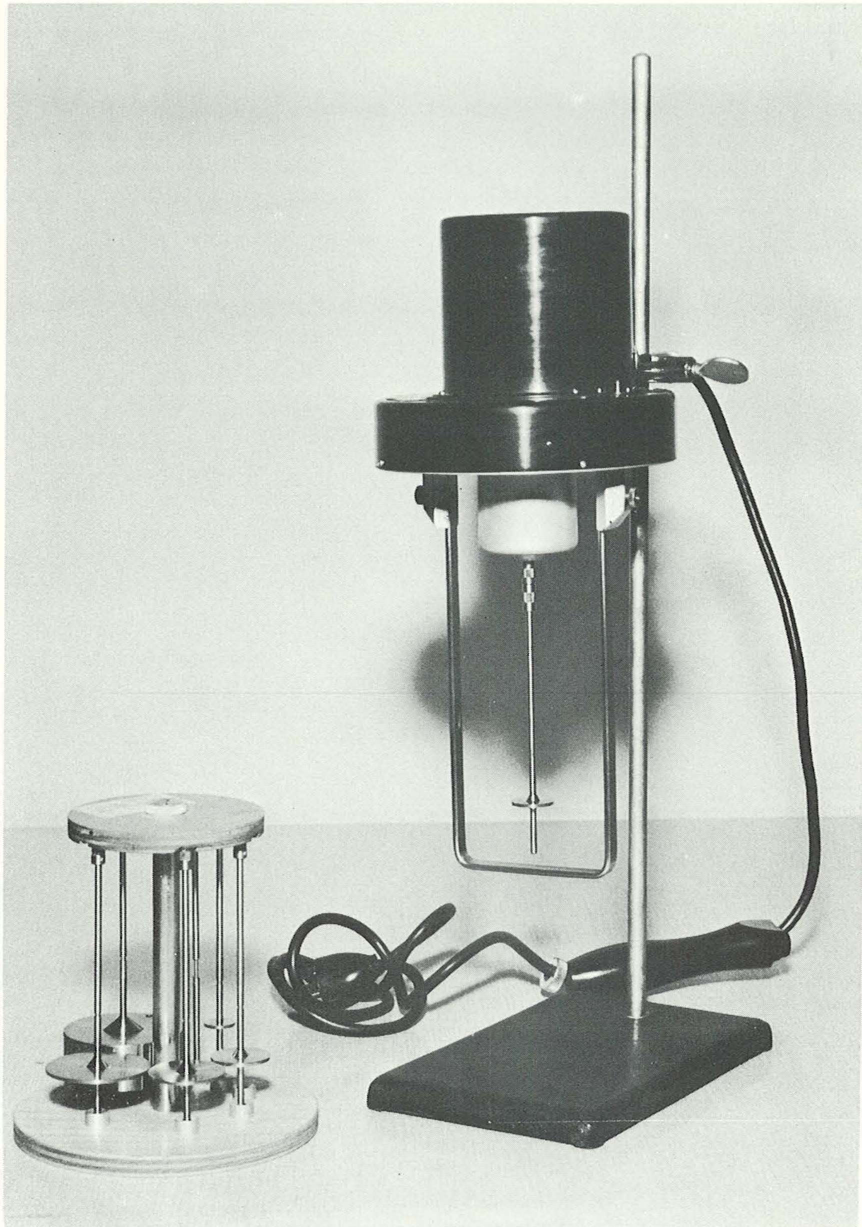
This apparatus comprises a temperature controlled oil bath in which is fixed a tube-like cup with an outlet aperature of exact dimensions. The asphalt is placed in the receptacle and brought to the desired temperature. A glass receiver which is marked to show a 60 ml content is placed under the outlet of the receptacle. The stopper which closes the outlet of the tube is withdrawn and the number of seconds required for the flow of 60 ml is recorded as the Saybolt-Furol viscosity. The procedure is described in ASTM E102-57. The values in SSF may be converted to poises by the following formula if the time of efflux is more than 80 seconds.

$$\frac{\eta}{d} = 0.0216\ F$$

where η = viscosity in poises

d = density gm/cm^3

F = Saybolt-Furol seconds



BROOKFIELD VISCOMETER

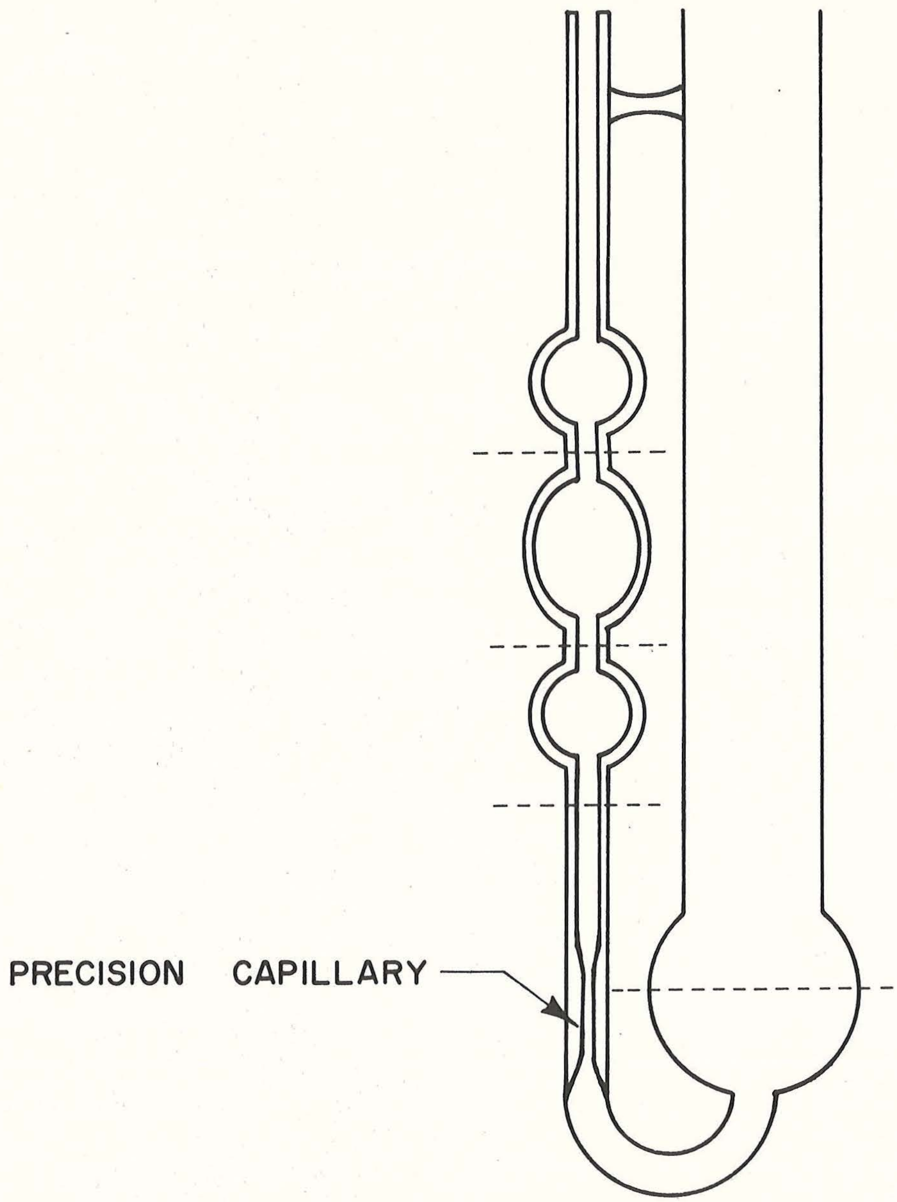
FIGURE II

(c) Brookfield Viscometer

This instrument which is illustrated in Figure II, facing, is composed of a spindle rotating at a constant speed while immersed in the asphalt at known temperature. Measurement of the drag on the spindle is indicated on a dial by a pointer attached to the spindle shaft. Spindles are supplied which cover a wide range of viscosity and since four different rates of shear can be obtained with each spindle non-Newtonian flow characteristics can be evaluated. It is possible with the Brookfield to measure viscosities up to about 10,000 poises.

FIGURE III

CANNON-MANNING VACUUM TYPE VISCOMETER



(d) Vacuum-type Capillary Tube Viscometer

This kind of apparatus can be used to measure viscosities in the range of 0.1 to 50,000 poises (or stokes) by employing different size tubes. The temperature of the bath surrounding the asphalt sample and the measuring tube is accurately controlled. When temperature equilibrium has been established the asphalt is drawn through the capillary by application of a constant vacuum. The velocity at which the asphalt moves through the tube is measured by a stop watch. Viscosity is a function of the velocity of flow, the magnitude of the vacuum and the dimensions of the capillary. The kind of tube used for the measurements given in the following pages is illustrated in Figure III, facing. This is known as the Cannon-Manning vacuum type viscometer.

TABLE 2

Absolute Viscosities of 85-100 Pen. Grade Asphalt Paving Cements

Calculated at 1000 ergs/sec/cm^3

Asphalt No.	Pen. @ 77°F 100 gms/5 secs.	Poises at				
		51°F (10.6° C)	77°F (25° C)	95°F (35° C)	104°F (40° C)	131°F (55° C)
6	89	4.4×10^7	6.8×10^5	7.1×10^4	3.5×10^4	2.2×10^3
7	94	5.1×10^7	8.7×10^5	7.1×10^4	2.7×10^4	2.0×10^3
4	93	7.4×10^7	8.0×10^5	8.2×10^4	4.6×10^4	2.3×10^3
8	98	11.2×10^7	9.6×10^5	8.2×10^4	3.9×10^4	2.2×10^3
5	90	8.1×10^7	8.7×10^5	8.9×10^4	3.2×10^4	2.0×10^3
2	92	8.5×10^7	10.0×10^5	11.3×10^4	2.9×10^4	2.3×10^3
10	92	7.4×10^7	10.0×10^5	11.3×10^4	3.3×10^4	2.6×10^3
1	92	7.2×10^7	11.3×10^5	11.5×10^4	3.8×10^4	2.2×10^3
9	90	9.2×10^7	11.6×10^5	13.0×10^4	4.8×10^4	2.1×10^3
11	93	13.3×10^7	11.8×10^5	12.2×10^4	6.0×10^4	3.3×10^3
3	90	16.0×10^7	14.4×10^5	17.0×10^4	6.4×10^4	4.3×10^3

3. Viscosities at 51 to 131°F

The eleven 85-100 penetration grade asphalts listed in Table 1 were tested in the microfilm viscometer at 51, 77, 95, 104 and 131°F. Viscosities were calculated at a rate of shear of 5×10^{-2} reciprocal seconds and also for a power input of 1000 ergs/sec/cm^3. The data obtained at the five temperatures and calculated by either method gave straight lines when log temperature was plotted versus log viscosity. However, when viscosities on the asphalts were also obtained at temperatures from 140 to 300°F the low temperature values calculated at 5×10^{-2} sec^{-1} did not attach themselves to the high temperature viscosity curves. But, by using the power input method for calculating the viscosities at 51 to 131°F good adjustment was made with the high temperature-viscosity curves.

Table 2, facing, gives the values for the eleven asphalts at 51 to 131°F calculated by the power input method. It will be noted that Asphalt No. 3 with a penetration at 77°F of 90 has a viscosity at 95°F of 170,000 poises whereas Asphalt No. 6, giving a penetration at 77° of 89, has a viscosity at 95°F of only 71,000 poises. Although these materials have the same penetration No. 3 is 2.4 times more viscous at 95°F than No. 6.

Extensive data in the microfilm viscometer were not obtained on the five 120-150 penetration grade asphalts. Measurements were made only at 77° and 95°F. The viscosities obtained are shown in Table 3. Here the values are listed in order of ascending viscosity at 95°F.

TABLE 3

Absolute Viscosities of 120-150 pen. Grade Asphalt Paving Cements
Calculated at 1000 ergs/sec/cm^3

Asphalt No.	Penetration @ 77° F 100 gms/5 secs	Poises at 77°F (25° C)	Poises at 95°F (35°C)
7	144	4.0×10^5	3.9×10^4
6	133	3.6×10^5	4.5×10^4
1	132	5.9×10^5	5.0×10^4
11	133	4.9×10^5	7.9×10^4
3	142	5.4×10^5	8.1×10^4

4. <u>Viscosities at 160° -325° F determined by Saybolt-Furol and Brookfield Viscometers</u>

The 85-100 penetration grade asphalts evaluated in the microfilm viscometer were tested over the approximate range 160-325° F in the Saybolt-Furol and/or Brookfield viscometers. The values are given in Tables A-1 and A-2 of the Appendix.

Fairly good straight lines were obtained by plotting (log temperature versus log viscosity) data obtained by the microfilm, Saybolt-Furol and Brookfield viscometers. The eleven 85-100 penetration asphalts gave curves which showed an inflection point about 20° F above the softening point of the asphalt. This is characteristic of all slightly non-Newtonian asphalts (such as these paving cements). At temperatures below their softening points they are non-Newtonian and a few degrees above the softening point they become essentially Newtonian.

TABLE 4

Kinematic Viscosities of Asphalt Paving Cements at 140 to 275° C

Sample	Stokes 140° F	Approx. SSF 140° F.	Stokes 175° F.	Approx. SSF, 175° F.	Stokes, 275° F.	Approx. SSF, 275° F.
			OA-90 Asphalts			
10	2630	119,000	205	9,400	4.8	220
3	2600	119,000	250	11,400	5.4	245
8	2580	118,000	260	11,900	7.0	320
4	1810	83,000	195	8,700	4.3	195
11	1630	75,000	160	7,300	3.4	155
9	1450	66,000	150	6,800	3.1	140
2	1420	65,000	145	6,600	3.1	140
6	1380	63,000	155	7,100	3.5	160
1	1250	57,000	125	5,700	3.0	135
5	1030	47,000	110	5,000	3.3	150
7	1010	46,000	105	4,800	2.6	120
Asphalt Inst. Spec.					1.7+	85+
TTI Proposed Spec.					3.0+	135+
			OA-135 Asphalts			
3A	1150	52,000	150	6,800	3.8	175
6A	1040	50,000	135	6,200	4.2	190
11A	1120	51,000	120	5,500	3.1	140
1A	650	30,000	75	3,400	2.3	105
7A	560	25,000	65	3,000	1.9	85
Asphalt Inst. Spec.					1.4+	70+
TTI Proposed Spec.					2.4+	110+

5. <u>Kinematic Viscosities Determined at 140°, 175° and 275° by the Vacuum Capillary Tube Viscometer</u>

The eleven 85-100 and five 120-150 penetration asphalts were tested by the vacuum capillary tube method at 140, 175 and 275°F. Data are shown in Table 4, facing. The values at 140°F are shown to the nearest 10 stokes, those at 175°F to the nearest 5 stokes and those at 275°F to the nearest 0.1 stoke. For the convenience of those familiar with Saybolt-Furol viscosities but not with the stokes units of kinematic viscosity, the approximate SSF value corresponding to the viscosity in stokes are given.

6. Suggested Viscosity Limits at 275°F

Asphalt technologists, especially those free from the current economic pressures resulting from the large demand and restricted supply of high grade asphaltic crude oil, agree upon the need for specifications which will more fully protect the interest of the consumer. Current specifications utilizing ASTM penetration, ductility and R & B softening point often do not eliminate asphalts that may have inadequate flow and durability properties. In view of this weakness of the empirical tests currently used in specifications for asphalt paving cements, the inclusion of absolute or kinematic viscosities appears to offer the best means of establishing specficiations which will better protect the consumer's interest.

On Table 4 the current Asphalt Institute Specifications for viscosities at 275° F are shown in stokes and Saybolt-Furol seconds. The higher-values proposed by the Texas Transportation Institute are given adjacent to the AI specifications. Limits for 85-100 penetration asphalts are raised from 1.7+ stokes and 85+ SSF to 3.0+ stokes and 135+ SSF. Those for 120-150 penetration asphalts are raised from 1.4+ stokes and 70+ SSF to 2.4+ stokes and 110+ SSF. The higher limits proposed should assure the use of asphalts which will handle better during construction of a pavement. These proposed limits are 50 to 60 percent higher than those advocated by the Asphalt Institute (See page 54 of The Asphalt Handbook, Manual Series, No. 4, March 1960).

All of the asphalts shown in Table 4 pass AI requirements but the quality of paving asphalts can be improved by increasing the required minimum viscosity at 275°F for each paving grade. The proposed minimum viscosities compare well with those now specified by the Louisiana Highway Department.

At this time data are not available on 60-70 and 200-300 penetration asphalts but we believe the viscosity specification at 275°F of these harder and softer asphalts should be revised upward.

TABLE 5

Data Obtained for N.B.C.A.

Absolute and Kinematic Viscosities of 85-100 Pen. Asphalts

			Absolute Viscosities Poises (1)				Kinematic Viscosities Stokes (2)			Approx SF Sec. (3)			
Sample	Pen. @ 77°F	R & B °F	77°F	95°F	104°F	131°F	140°F	175°F	275°F	140°F	175°F	275°F	Field[4] Exp.
IA	87	108	1.4×10^6	2.1×10^5	6.4×10^4	4.0×10^3	3010	285	5.5	138,000	13,000	250	Satis.
IB	77	121	1.8×10^6	2.2×10^5	9.9×10^4	2.5×10^3	2770	280	4.9	127,000	12,000	225	Satis.
IC	90	116	1.5×10^6	2.0×10^5	7.3×10^4	2.8×10^3	2580	295	5.6	118,000	13,500	255	Satis.
ID	87	105	1.3×10^6	1.8×10^5	6.0×10^4	5.0×10^3	2520	235	4.8	115,000	10,700	220	Satis.
IE	93	111	1.3×10^6	1.6×10^5	5.8×10^4	2.5×10^3	2100	195	3.0	96,000	8,900	135	Tender
IF	82	118	0.9×10^6	1.2×10^5	3.2×10^4	2.3×10^3	1320	155	2.8	60,000	7,100	130	Tender
IG	95	113	0.9×10^6	1.0×10^5	3.2×10^4	1.9×10^3	1220	120	2.1	55,000	5,500	95	Tender
IIA	86			1.3×10^5			1790	165	3.2	82,000	7,500	145	Satis.
IIB	86			1.0×10^5			1090	105	1.9	50,000	4,800	85	Tender
Asphalt Inst. Current Specification									1.7+			85+	
Proposed Limits: Satisfactory									3.5+			160+	
Questionable									3.1-3.4			136-159	
Unsatisfactory									3.0-			135-	

(1). Determined in the Hallikainen micro-film viscometer. Values calculated by power input method.
(2). Determined by the vacuum type capillary tube viscometer.
(3). Calculated from the preceding values in Stokes.
(4). Samples marked satisfactory caused no difficulty during rolling and compaction.

7. Suggested Absolute Viscosity at 140°F

Various agencies in the U. S. concerned with bituminous technology are currently investigating the establishment of viscosity specifications at 140°F. From the data shown in Table 4 and the values given in Table 5, which were obtained in connection with TTI studies for the National Bituminous Concrete Association, it is concluded that specifying the following viscosities at 140°F would assure use of superior asphalts.

Penetration Grade	Range of Viscosity (Stokes) @140°F
85 - 100	1400 to 3000
120 - 150	1000 to 1400

The lower limits of 1400 stokes for 85 - 100 grade and 1000 stokes for 120-150 grade asphalts are the important values in these proposed specifications.

8. Consideration of Absolute Viscosity at 95° F

While reviewing the development of specifications which would assure purchase of an entirely satisfactory asphalt, a viscosity value at atmospheric temperatures should be considered. Thought was first given to viscosities determined in the microfilm viscometer at 77°F. However, for some of the harder asphalts rheological complications, due to non-Newtonian flow, develop at this temperature. Consequently viscosities at 95°F appear to be more promising because of the greater accuracy of the measurements.

The viscosities at atmosphere temperature (e.g. 95°F) should first be considered as complementary to the ASTM penetration test at 77°F and later the penetration test could be dropped from the purchase specification. The penetration test measures to some degree the adhesiveness of the asphalt and consequently there is some valid argument for its retention in a specification.

VII. APPENDIX

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TABLE A-1

High Temperature

Viscosities of OA-90 Asphalts

Determined in Saybolt-Furol Viscometer

Asphalt No. 1

Temp. °F	Poises	Saybolt-Furol Secs.
346.9	0.66	33.5
346.9	0.65	32.8
293.0	1.67	83.5
294.8	1.70	84.8
277.5	3.73	185.4
278.6	3.79	188.4

Asphalt No. 2

Temp. °F	Poises	Saybolt-Furol Secs.
325.4	0.96	45.8
324.9	0.96	47.4
295.6	1.57	77.0
294.9	1.59	77.8
271.4	3.33	161.4
271.4	3.28	159.3

Asphalt No. 3

Temp. °F	Poises	Saybolt-Furol Secs.
323.6	1.48	73.0
322.7	1.52	75.0
299.4	2.46	122.6
299.3	2.50	123.8
275.2	4.89	237.6
273.9	4.92	239.0

Asphalt No. 4

Temp. °F	Poises	Saybolt-Furol Secs.
324.5	1.40	70.5
323.6	1.41	71.0
294.3	2.59	129.4
293.2	2.62	131.0
275	4.28	212.3
274.5	4.43	220.0

TABLE A-1 cont.

Asphalt No. 5

Temp. °F	Poises	Saybolt-Furol Secs.
323.6	0.94	46.8
321.8	0.90	45.0
298.4	1.45	71.8
298.4	1.44	71.0
271.7	2.97	145.3
271.0	2.86	140.0

Asphalt No. 6

Temp. °F	Poises	Saybolt-Furol Secs.
323.1	1.13	58.2
322.7	1.09	56.4
289.4	1.85	94.6
288.5	1.87	95.6
263.8	3.54	179.0
263.1	3.59	181.5

Asphalt No. 7

Temp. °F	Poises	Saybolt-Furol Secs.
324.5	0.84	41.5
322.7	0.82	40.1
297.8	1.28	62.4
296.9	1.27	62.0
272.3	2.51	121.0
271.7	2.56	123.3

Asphalt No. 8

Temp. °F	Poises	Saybolt-Furol Secs.
348.4	1.54	79
300.2	4.53	230.2
297.2	4.05	208.4
271.4	8.76	445.2
271.4	7.93	403.0
242.2	19.10	949.6

TABLE A-1 cont.

Asphalt No. 9

Temp. °F	Poises	Saybolt-Furol Secs.
322.1	1.03	52.4
321.8	1.06	53.7
295.7	1.81	91.2
293.9	1.77	89.2
271.4	3.23	161.5
271.7	3.18	159.0

Asphalt No. 10

Temp. °F	Poises	Saybolt-Furol Secs.
325.9	1.41	71.5
325.4	1.38	70.1
295.2	2.36	118.5
294.8	2.39	119.8
273.8	4.75	236.8
272.9	4.82	240.2

Asphalt No. 11

Temp. °F	Poises	Saybolt-Furol Secs.
324.5	1.19	59.4
323.1	1.25	62.5
295.2	2.30	113.4
294.8	2.25	110.8
275.0	3.88	189.4
274.5	3.92	191.4

TABLE A-2

High Temperature

Viscosities of OA-90 Asphalts

Determined in Brookfield Viscometer

Asphalt No. 1

Spindles #1, 2, 3, 5 — Speed - 10 RPM

1st Run Temp. °F	1st Run Poises	2nd Run Temp. °F	2nd Run Poises
307	1.06	300	1.26
275	2.10	287	1.75
250	3.92	263	3.01
236	10.40	253	4.45
213	24.68	234	12.16
193	66.00	212	22.80
175	148.00	192	62.00
162	235.00	167	215.20

Asphalt No. 2

Spindles 1, 3, 6 — Speed - 10 RPM

302	1.38	304	1.19
272	3.52	298	1.45
240	6.60	276	2.33
230	7.55	262	3.40
220	23.30	250	5.27
180	137.00	239	8.75
165	348.00	214	28.80
		196	73.50
		172	141.00
		160	298.00

Asphalt No. 3

Spindles #1, 2, 4, 6 — Speed - 10 RPM

303	2.02	302	2.30
264	5.14	292	3.47
252	7.00	270	4.51
215	18.80	264	5.16
195	57.30	216	54.00
179	278.00	192	121.00
164	566.00	176	323.00
		150	673.00

TABLE A-2 cont.

Asphalt No. 4

Spindles #1, 3, 6		Speed - 10 RPM	
1st Run		2nd Run	
Temp. ° F	Poises	Temp. ° F	Poises
316	1.54	317	1.34
299	2.02	302	2.05
262	5.84	278	2.97
236	12.80	265	4.03
210	31.25	250	11.50
194	82.40	230	18.70
170	261.00	207	35.00
		182	100.00
		159	338.00

Asphalt No. 5

Spindles 1, 3, 6		Speed - 10 RPM	
300	1.25	312	1.23
209	4.41	275	2.60
247	8.00	254	5.65
206	24.70	204	30.30
174	121.00	182	113.00
161	252.50	157	298.00

Asphalt No. 6

Spindles 1, 3, 4, 6		Speed - 10 RPM	
321	1.17	305	1.44
275	2.80	296	1.75
256	4.74	268	3.07
215	18.90	258	5.14
182	74.50	202	24.00
162	373.00	183	102.40
		153	655.00

Asphalt No. 7

Spindles 1, 3, 6		Speed - 10 RPM	
304	1.05	293	1.52
263	3.48	230	6.60
246	5.95	228	7.34
215	14.50	192	50.00
186	48.10	156	201.00
162	255.00		

TABLE A-2 cont.

Asphalt No. 8

Spindles 1, 4, 6, 3		Speed - 10 RPM	
1st Run		2nd Run	
Temp. ° F	Poises	Temp. ° F	Poises
294	4.15	302	3.25
241	14.00	275	6.40
194	88.00	246	17.50
183	201.00	216	43.60
162	466.00	170	326.00
		160	705.00

Asphalt No. 9

Spindles 1, 2, 3, 6		Speed - 10 RPM	
313	1.17	309	1.32
240	13.40	279	2.65
211	31.50	258	4.00
193	98.00	228	19.50
170	257.00	196	50.90
		177	159.00
		156	483.00

Asphalt No. 10

Spindles 1, 3, 6, 7		Speed - 10 RPM	
319	1.76	292	2.46
278	5.01	261	7.25
236	14.90	234	14.50
201	72.70	205	66.60
176	326.00	180	225.00
156	723.00	150	945.00

Asphalt No. 11

Spindles 1, 3, 6		Speed - 10 RPM	
323	1.19	318	1.67
285	3.55	279	4.06
242	9.50	230	13.80
201	47.10	197	43.90
182	148.00	177	223.00
168	336.00	164	487.00