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PROPERTIES OF ASPHALT CEMENTS USED IN VIRGINIA AND THEIR EFFECTS ON PAVEMENT PERFORMANCE

Interim Report

Task 1. -- Evaluation of Asphalt Characteristics

by

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Research Consultant

(The opinions, findings, and conclusions expressed in this report are those of the author and not necessarily those of the sponsoring agencies.)

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SUMMARY

Results of usual tests for specification compliance and special tests to show viscosity-temperature susceptibility and ductility-penetration relationships for asphalts supplied for use by the Virginia Department of Highways and Transportation in 1983 are reported.

The results to date have not revealed any asphalts with unusual properties. Differences in viscosity-temperature susceptibilities of products from different suppliers were relatively small. The results also indicate that satisfactory performance of properly designed and placed mixtures would be expected with all of these products, but a firm conclusion to this affect cannot be drawn until the ability of the asphalts to adhere to aggregates is determined. Such tests are planned.

The addition of a requirement to asphalt cement specifications that the ash not exceed 0.40 percent is recommended. Such a requirement would provide protection against products from unusual refining processes that contain appreciable amounts of organic sodium salts.

Conversion to SI Units

$t_{°F.} = 1.8\ t_{°C.} + 32$

Centimeter*	=	0.1 metre
Poise*	=	$1.000\ 000 \times 10^{-1}$ Pa.s.
Centistoke*	=	$1.000\ 000 \times 10^{-6}\ m^2/s$

*Unit customarily used in asphalt testing. Although not a standard SI unit it is based on the metric system.

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INTRODUCTION

The poor performance of some asphalt pavements over the last few years has raised questions concerning the quality of the design and construction of such pavements. Because of the disruptive influence of the 1973 embargo on oil imports and the increased emphasis on maximizing energy production since that time, the possibility that the characteristics of asphalt cements may have changed has been suggested. It has further been implied that if changes have occurred, present specifications for asphalt cements may be inadequate. In view of these concerns, there is interest at the national level for a major research effort on the properties of asphalt cements.

The possibility that materials being supplied to asphalt contractors in Virginia may have changed significantly prompted a survey of major suppliers to the state in 1983 and the collection of samples from various construction projects. The physical characteristics of these materials have been determined and special studies have been conducted to ascertain if, on the basis of present knowledge, significant changes in their performance characteristics would be expected. Consideration has also been given to the possibility that asphalt cement specifications need to be revised to (1) assure that unsatisfactory products are not supplied, and (2) that significant differences in materials being supplied by the same contractor on the same job do not occur without adequate notice to the state and contractor. This report is a preliminary summary of the tests made and the findings to date relating to the physical characteristics of the asphalt cements.

QUESTIONNAIRE ON SOURCE

A questionnaire, included as Appendix A of this report, was directed to all asphalt suppliers likely to supply asphalts for construction projects in Virginia in 1983. As indicated, the primary purpose was to ascertain from the suppliers what information they had concerning the petroleum source or sources from which their asphalts were obtained and the viscosity characteristics of the materials. Replies were received from four refineries. One of these indicated that the source of crude was proprietary information. The other three reported their asphalts to be blends of crudes from different sources and that the percentage of each crude might vary over a wide range depending on availability at any given time. In view of this general situation, no further consideration was given to the sources of the crudes from which the asphalts supplied to the Virginia Department of Highways and Transportation were obtained.

SAMPLES COLLECTED AND TEST RESULTS

At the time acceptance samples for asphalts being supplied to the state were taken, an additional two gallons were provided the Research Council for special tests. A total of 32 samples from 11 distribution locations representing seven refineries were collected. In addition to the usual acceptance tests, special tests as shown in Table 1 were conducted. In addition to the results given in Table 1, ductilities at five centimeters per minute were determined at 77°F. and 60°F. All these values were greater than 150 cm., the maximum length of the ductilometer, except the value for sample number 100, which was 140 cm. at 60°F.

Table 1

Table 1
Characteristics of Asphalts Used by Virginia Department of Highways and Transportation in 1983

Producer Code	Sample No.	Viscosity at: 140°F., V_o, poises	Viscosity at: 275°F. centistokes	Thin-film Oven Test: Viscosity Residue at 140°F., V_{tf}, poises	Thin-film Oven Test: Ratio V_{tf}/V_o	Softening Point °F.	Specific Gravity at 77°F.	Penetration at: 77°F.	Penetration at: 60°F.	Penetration at: 50°F.	Penetration at: 45°F.	Penetration at: 39.2°F.	Ductility 5 cm./min. at: 50°F., cm.	Ductility 5 cm./min. at: 45°F., cm.	Ductility 5 cm./min. at: 39.2°F., cm.	Ash %
A	100	1959	409	8788	4.5	123.7	1.029	70	25	14	12	9	9.7	6.2	B[a]	0.03
	110	1904	392	5257	2.8	124.5	1.030	66	26	14	11	8	9.2	6.2	B[a]	0.09
	123	-	-	-		124.7	1.027	64	25	14	11	8	9.5	6.2	B[a]	0.10
B	101	2258	514	3580	1.6	121.2	1.035	91	36	19	14	11	142	9.7	8.0	0.03
	105	2316	513	6479	2.8	120.2	1.033	93	35	19	15	12	135	9.7	6.7	0.08
	109	1942	379	3908	2.0	123.2	1.028	80	31	18	12	9	117	7.0	B[a,b]	0.09
	120	-	-	-	-	119.7	1.032	97	37	20	16	11	131	14.7	7.5	
C	102	1911	409	4726	2.5	122.2	1.026	78	30	17	13	9	13.7	7.2	B[a]	0.03
	103	1886	406	4380	2.3	121.2	1.027	75	29	16	12	9	22.2	6.5	B[a]	0.00
D	104	1937	397	-	-	122.2	1.028	77	29	15	14	9	18.2	7.0	5.0	0.01
	111	1775	300	3732	2.1	121.7	1.027	75	28	15	12	9	43	7.2[c1]	B[a]	0.09
	121	-	-	-		118.2	1.023	84	29	17	12	9	136	36.5	7.2	0.10
E1	107	2004	419	-	-	122.2	1.029	73	27	14	12	8	45	7.2	B[a,d]	0.02
	108	2050	468	-	-	120.2	1.033	100	38	22	16	11	26	10.5	6.7	0.34
	113	2254	377	5326	2.4	121.2	1.033	96	37	20	16	11	148	10.5	7.5	0.28
	119	1874	414	6588	3.5	121.7	1.028	78	29	17	13	9	58	9.0	B[a,e]	0.12

Table 1 (continued)

Producer Code	Sample No.	Viscosity at: 140°F., V_o, poises	Viscosity at: 275°F. centistokes	Thin-film Oven Test: Viscosity Residue at 140°F., V_{tf}, poises	Thin-film Oven Test: Ratio V_{tf}/V_o	Softening Point °F.	Specific Gravity at 77°F.	Penetration at: 77°F.	Penetration at: 60°F.	Penetration at: 50°F.	Penetration at: 45°F.	Penetration at: 39.2°F.	Ductility 5 cm./min. at: 50°F., cm.	Ductility 5 cm./min. at: 45°F., cm.	Ductility 5 cm./min. at: 39.2°F., cm.	Ash %
E2	115	1687	397	5148	3.1	119.7	1.031	92	36	21	18	12	44	9.2	6.7	0.01
	118	1805	402	5383	3.0	122.2	1.032	91	35	21	16	12	67	9.5	6.5	0.02
	125	1805	402	5383	3.0	121.7	1.032	88	36	20	16	12	36	9.7	6.0	0.19
F1	116	1895	393	5796	3.1	122.0	1.026	69	24	14	11	8	36	8.2	B[a]	0.04
	126	2238	471	5137	2.3	122.2	1.033	88	34	18	14	9	146	13.0	7.0	0.04
2	128	1742	372	3739	2.1	122.2	1.025	71	24	13	10	6	26	7.0	B[a]	0.09
	130	1957	399	4007	2.0	123.7	1.028	63	21	12	7	7	12.5	8.0	6.2	0.04
G1	106	1760	407	4570	2.6	119.2	1.030	88	35	19	15	11	45	8.2	5.7	0.23
	112	1741	312	4826	2.8	120.2	1.033	95	38	21	16	13	77	10.5	7.5	0.16
	114	2069	450	5506	2.7	120.2	1.029	88	33	19	16	11	56	9.0	6.2	0.24
	122	-	-	-	-	120.7	1.030	91	37	21	16	12	62	9.5	5.7	0.16
2	117	2130	448	5998	2.8	122.0	1.034	86	33	20	15	11	88	7.2	6.0	0.05
	124	1928	427	5211	2.7	123.0	1.032	86	35	20	16	12	53	7.7	5.5	0.21
3	127	1736	413	-	-	120.5	1.032	97	37	22	17	11	48	13.0	7.0	0.10
	129	1656	400	5749	3.5	121.0	1.031	96	37	21	16	10	40	10.5	6.7	0.22
	131	1796	422	4913	2.7	121.7	1.034	94	35	21	16	10	46	8.0	6.2	0.19
	Max.	2258	514	8788	4.5	124.7	1.035	100	38	22	18	13	148	36.5	8.0	0.34
	Min.	1656	300	3580	1.6	118.2	1.023	64	21	12	7	6	12.5	7.0	B[a]	0.00

a1 - Specimens broke at approximately 0.25 cm.
b1 - Ductility at 41°F. = 4.2 cm.
c1 - Average of 4 tests
d1 - Ductility at 41°F. = 40 cm.
e1 - Ductility at 41°F. = 6.7 cm.

DISCUSSION OF TEST RESULTS

Viscosity at 140°F. and 275°F.

All the materials tested were AC-20 grade, and the results reported in Table 1 show good quality control by all suppliers in meeting the viscosity requirements.

The maximum viscosity at 140°F. was 2,258 poises and the minimum was 1,656. The specification requirement is 2,000 ± 400. The average for all samples was 1,929 poises, with a standard deviation of 178. The requirement for viscosity at 275°F. is a minimum of 300 cs. The minimum test result obtained was 300 cs. and the maximum was 514 cs.

Thin-film Oven Test

All samples met the state's requirement for the viscosity of the residue after the thin-film oven test. The highest result was 8,788 poises. It should be noted that results for other asphalts from the same supplier having similar properties in all other respects had significantly lower viscosities of the residue, which indicated that this result may be attributable to testing error. The ratio of the viscosities of the thin-film residues to the original viscosities of the asphalts ranged from 1.6 to 4.5. However, if the high result is disregarded, the upper value of the ratio is 3.5. This is a normally expected range, and no unusual hardening of any of these asphalts should occur during properly controlled pugmill mixing.

VISCOSITY-TEMPERATURE SUSCEPTIBILITY

Since all the asphalts had viscosities at 140°F. meeting the AC-20 specification, the penetration at 77°F. provides a general measure of differences in the viscosity-temperature susceptibility of the asphalts. Table 1 shows that the minimum penetration at 77°F. was 64 and the maximum was 100. Eighteen of the asphalts would be graded as 85-100 under the penetration system and 5 would be 60-70. Nine asphalts had penetration values between these two grades.

Penetration-temperature relationships are demonstrated in Figure 1. The results for sample 108, which had the highest penetration at 77°F., and those for sample 130, which had the lowest, are plotted. All other samples lie between these two extremes with only small differences in the slopes of the penetration-temperature line.

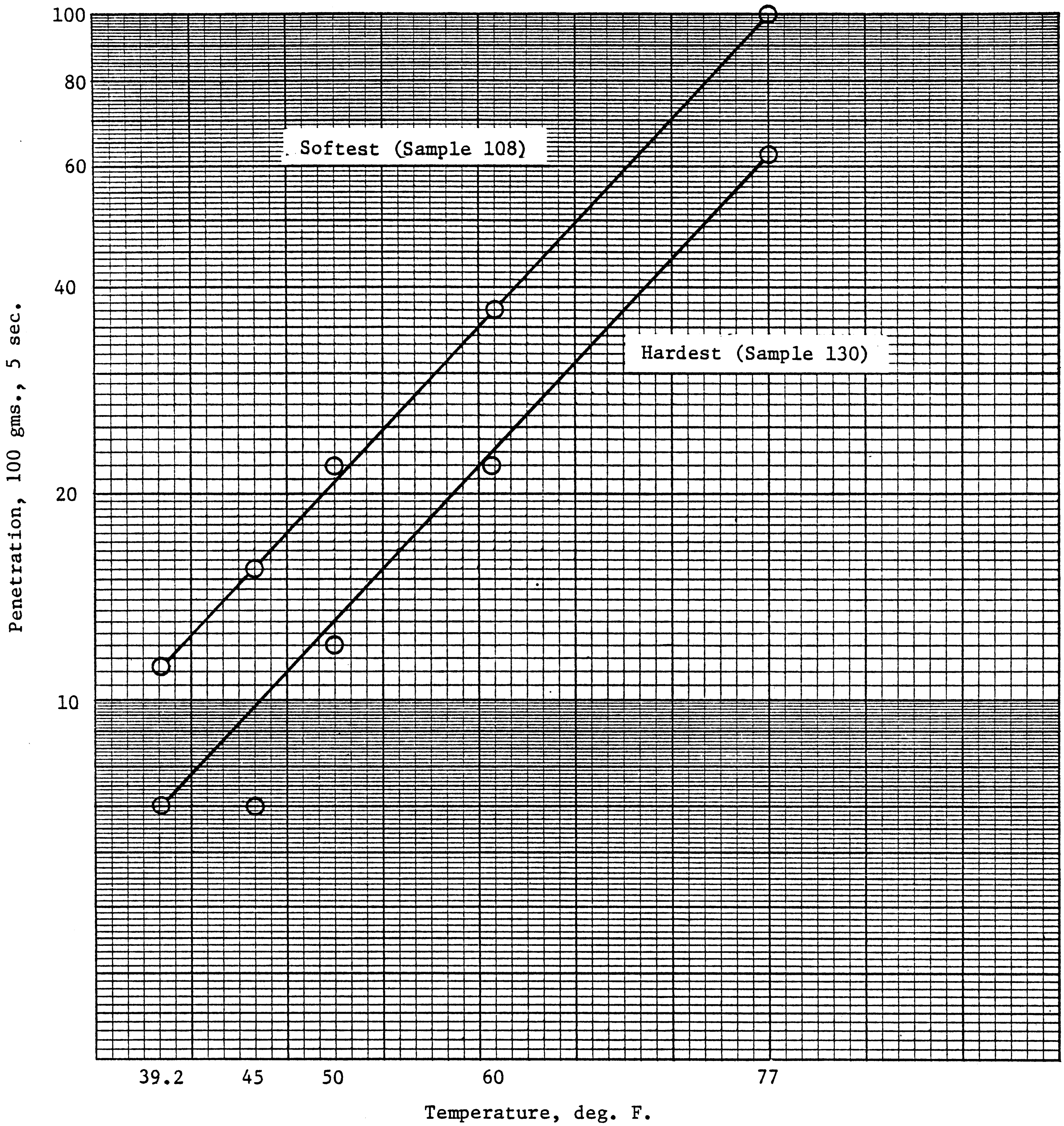

Figure 1. Penetration-temperature relationship.

Softening Point and Specific Gravity

The softening point and specific gravity of each asphalt were determined primarily as a means of detecting any unusual materials or wide differences in materials from the same supplier. As given in Table 1, there were relatively small differences in these characteristics for all the asphalts tested. Softening points ranged from a 118.2°F. minimum to a 124.7°F. maximum. Specific gravities were also relatively uniform -- ranging from 1.023 to 1.035.

Penetration-Ductility Relationships

Penetrations and ductilities were determined at five temperatures between 39.2°F. and 77°F. These results provided a comparison of penetration-ductility relationships. A review of field performance and laboratory data for penetration and ductility by Halstead in 1963 showed that although many asphalts had very short (or zero) ductilities when measured at low temperatures, the important criterion was the ductility for a given penetration. The asphalts that had short ductilities at relatively high penetration were most likely to perform poorly under field conditions. It was suggested that the critical values were identified by a curve approximately defined by ductility values of 100 cm. at 50 penetration, ductility values of 20 cm. at 30 penetration, and ductility values of 10 at 25 penetration. All pavements made with asphalts having ductility-penetration lines below (or to the right of) this critical curve gave poor service, even though there was no evidence of severe hardening. While it was also shown that excessive hardening resulting in very low (or zero) ductilities could result in poor service, the primary cause in this case was the hardening itself and not low ductility.

Figure 2 shows the ductility-penetration relationship for the four asphalts supplied by producer B, the plotted data being obtained from tests at 39.2°F., 45°F., and 50°F. All ductility values at 60°F. and 77°F. were greater than 150 cm. This curve is typical of those obtained where asphalts of different consistencies are derived from crudes from the same source or a blend of crudes from different sources by steam or vacuum distillation. All points fall close to the same straight line, even though observations at the same temperature might indicate significant differences in ductility values.

A greater spread of results is indicated by Figure 3, which depicts the relationships for four asphalts from producer F. These values are indicative of more variation in the source of the crudes or in the percentages of different crudes in the blends of feed stock from which the asphalts are obtained than those shown for the asphalts supplied by producer B. However, the significant indications from both Figures 2 and 3 are that the ductility-penetration relationships for all these asphalts are well within the satisfactory zone as defined by the work of Halstead previously discussed. All asphalts tested showed satisfactory ductility-penetration relationships.

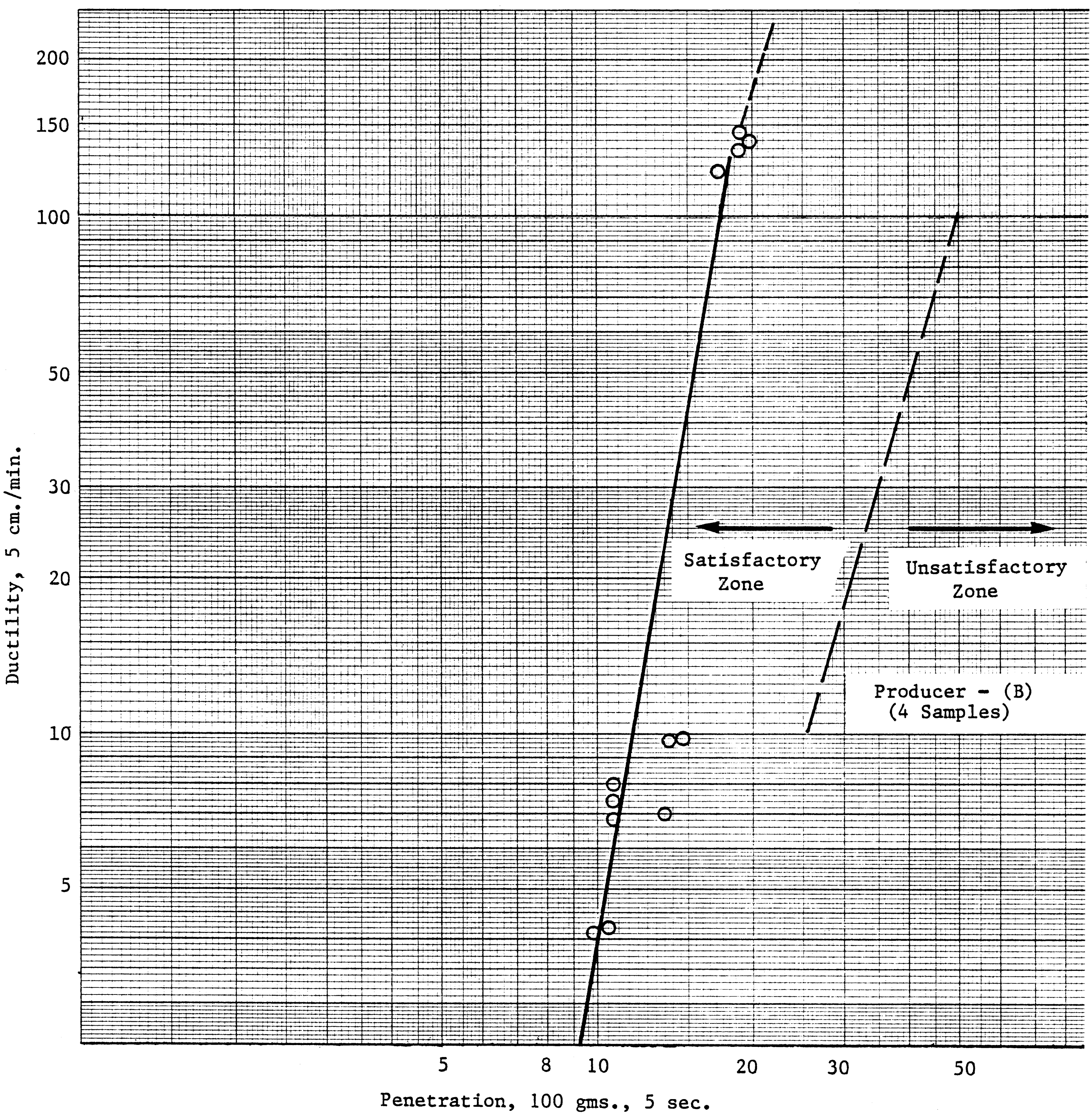

Figure 2. Ductility-penetration relationship of asphalts from producer B.

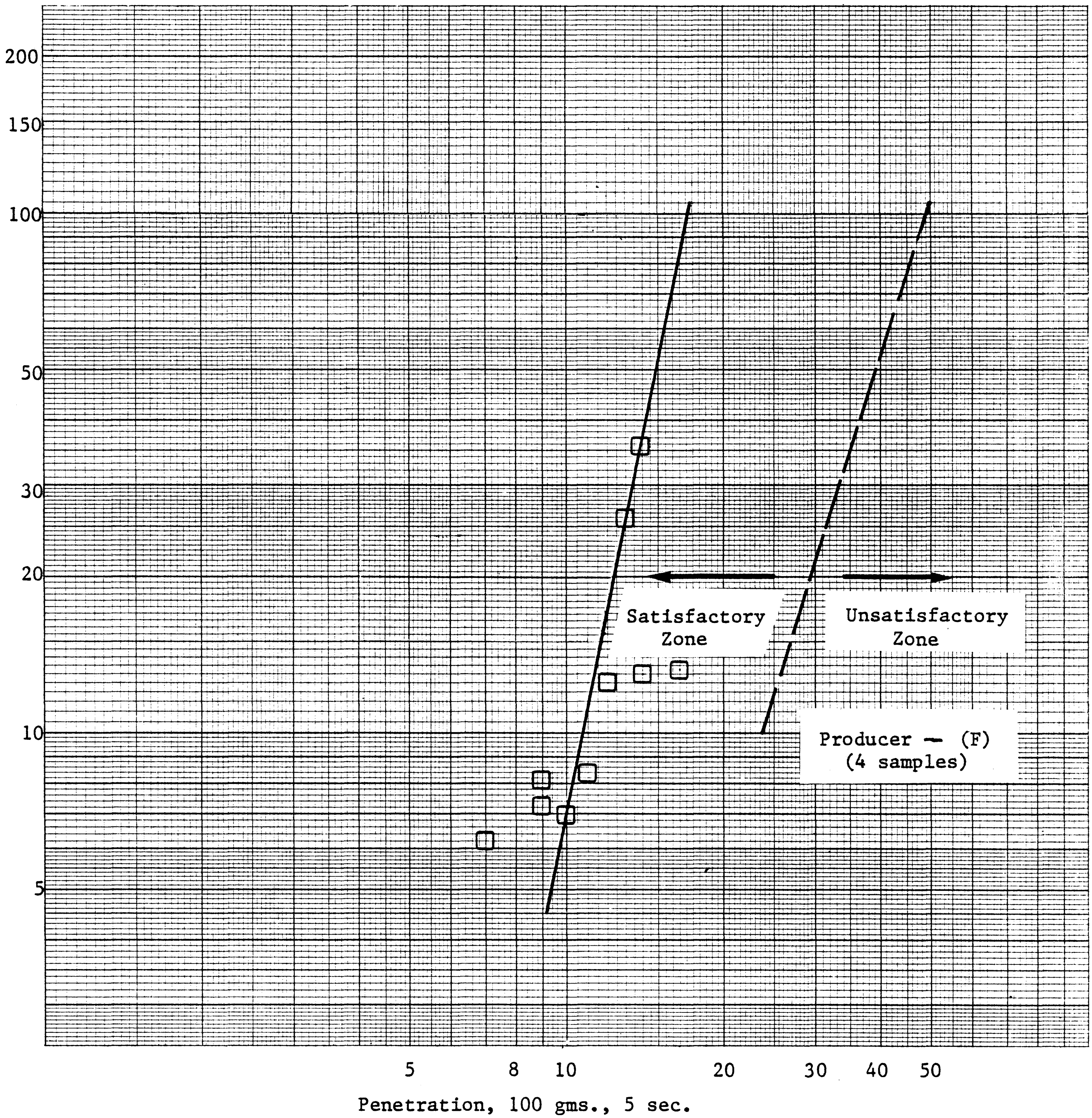

Figure 3. Ductility-penetration relationship of asphalt from Producer F.

Ash Content

All ash contents for the asphalts tested were low, ranging from zero to 0.34%. This is the range expected for asphalts produced without the addition of inorganic constituents such as sodium hydroxide or where contamination with materials such as fine sand and dusts has not occurred. This range of values suggests that a maximum limit on ash content of 0.40% would provide protection against unusual refining procedures that would leave relatively large amounts of inorganic materials in the asphalt. Such a limit would not be restrictive for asphalts derived from petroleums naturally containing small amounts of heavy metals such as nickel or vanadium.

Adhesive Characteristics

None of the specifications or special tests made to date have a direct bearing on the adhesion of the asphalts to aggregates when used in highway construction or the resistance of the asphalt-aggregate bond to deterioration in the presence of water. Thus, tests based on the Lottman procedure for selected asphalts will be made. A siliceous type aggregate with a general record of acceptable performance will be used.

The results of these tests, as well as the results of special analyses of the data, will be included in the final report.

CONCLUSIONS

The results of the tests made to date have not revealed any asphalts with unusual properties. Even though the asphalt suppliers indicated possible variations in properties (within specification tolerances) because of differences in crude sources and variable percentages of different crudes blended as the feed stock, the products from the same supplier tested in this study were relatively uniform in physical characteristics. Differences in viscosity-temperature susceptibilities of products from different suppliers were also relatively small. None of the differences noted should significantly affect the engineering properties of asphalt mixtures during construction. While the results indicate that satisfactory performance of properly designed and placed mixtures would be expected, a firm conclusion cannot be drawn until the ability of the asphalts to adhere to aggregates is determined.

APPENDIX A

Terminal (refinery) name ______________________________

Location ______________________________

Grade(s) asphalt cement stocked ______________________________

Refinery manufacturing asphalt ______________________________

Location ______________________________

Oil field(s) from which refinery feed stock(s) are obtained ______________

If blends of more than one crude are used, indicate approximate percentage of each ______________________________

(Crude 1) Field______________ Percentage______________

(Crude 2) Field______________ Percentage______________

(Crude 3) Field______________ Percentage______________

What test results are available to the asphalt purchaser from the terminal or refinery (check if available)

Viscosity-temperature chart__________

Viscosity at 140°F______________; at 275°F______________

Penetration at 77°F______________

Thin film oven loss______________

Penetration of thin film residue______

Ductility of thin film residue_______

Viscosity of thin film residue_______

Are you willing to provide the Department with two 1-gallon samples of each grade of asphalt you supply to Department contractors, along with all test data associated with each sample? Yes______________ No______________

Do you have information concerning the variability of your product from shipment to shipment over a construction season? Yes_________ No______________

If yes can these data be made available to the Virginia Department of Highways and Transportation? Yes ______________ No______________

Person to contact for further information, if needed.

Name______________________________
Address______________________________
Phone Number______________________________

Submitted by______________________