BEST TEMPERATURE TO MEASURE VISCOSITY FOR EVALUATION OF ASPHALT DURABILITY IN SERVICE

by

R. N. Traxler
Research Chemist
Texas Transportation Institute

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Research Area 8

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TEXAS TRANSPORTATION INSTITUTE
Texas A&M University
College Station, Texas 77843

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I. OBJECTIVES OF STUDY NO. 2-8-59-9 RESEARCH AREA 8

Objectives of the Study are to:

(1) Investigate the asphalt cements used by the Texas Highway Department,

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

(3) Determine how the durability of asphalt cements in service can be improved.

This report presents experimental data arranged to answer the question "What is the most suitable temperature for evaluating the hardening of asphalts during service in a pavement?" The work falls under item (3) above.

II. HISTORY

Study No. 2-8-59-9 Research Area 8 was started February 1, 1959 as Research Project No. 15.

During the past 5 years an investigation has been conducted concerning the hardening of asphalt cements during the preparation, laying and compaction of hot-mix surfacing materials and the hardening of the binder during service in the pavement. Such studies are essential to the evaluation of the durability or service life of a hot-mix surfacing. Considerable information on the hardening of asphalt cements

has been reviewed in Reports Nos. 8, 9 and 11 of the cooperative research program conducted by the Texas Transportation Institute and the Texas Highway Department.

Discussion is currently taking place among asphalt technologists concerning the relative merits of 60° or 77°F as the temperature for measuring viscosities to be used in evaluating the changes in asphalts during service or in laboratory hardening tests. The experiments discussed in the above mentioned reports have yielded information which helps in establishing the most suitable temperature to use for evaluating the hardening of asphalts during service.

III. CONCLUSIONS

It is concluded that there is no good reason for complicating the testing procedures and increasing the operational costs by using 60°F instead of 77°F for the determination of viscosities to be used in the evaluation of durability (hardening) of asphalt cements during service.

IV. RECOMMENDATIONS

It is recommended that 77°F (25°C) be used as the temperature most suitable for evaluating the hardening of asphalt cements under service conditions.

V. FUTURE WORK

No further work is planned at present.

VI. EXPERIMENTAL WORK

1. Field Program

In this study, data were obtained from 10 sites in 10 Districts of the Texas Highway Department. These locations were selected where THD, in its maintenance program for 1963, was placing 1 1/4 to 1 1/2 inch thick (about 125 lbs./sq. yd.) hot-mix surfacings. On each highway a particular location (station) was selected by District personnel.

Before the paving machine arrived, heavy aluminum foil was fastened to the base by roofing nails. This was done to facilitate removing slabs of the surfacing material and to prevent contamination of the asphalt cement by primer applied to the base. Slabs taken from the test sections by District personnel were shipped to the Transportation Institute in special wooden boxes to prevent breakage during transport.

At each site the following samples were collected:

(1) Original asphalt cement as it was supplied to the hot-mix plant (one gallon).

(2) Asphalt-aggregate mixture as it came from the plant (2 gallons).

(3) Asphalt-aggregate mixture when it was placed in the paving machine (2 gallons).

(4) A 2- x 2-foot sample of surfacing material taken one day after the pavement was laid and compacted.

(5) A 2- x 2-foot sample taken after 2 weeks.

(6) A 2- x 2-foot sample taken after 4 months

(7) A 2- x 2-foot sample taken after 1 year.

(8) A 2- x 2-foot sample taken after 2 years.

2. Extraction and Recovery of Asphalt Cements from Mixtures and Pavement Samples.

About 20-25 pounds of asphalt-aggregate mixture or surfacing removed from the road were placed in large Colorado type percolator extractors for separation of the asphalt from the stone. In order to insure, as nearly as possible, complete removal of all asphaltic components from the aggregate surface, a mixture of 6 parts benzene and 1 part 95 per cent ethyl alcohol was used to dissolve the asphalt. When the benzene-alcohol solution flowing from the bottom cone of the extrator showed a very light straw color, the heavy solution of extracted asphalt was centrifuged at 770 times gravity to remove most of the fine minerals that could have passed through the filter paper used in the extraction apparatus. The essentially mineral-free solution was distilled by the standard Abson procedure until a large portion of the benzene-alcohol was removed. This concentrated solution was then transferred to a rotary film evaporator and the remaining solvent removed at 115-150°F and 15mm of mercury pressure. By this procedure, the final removal of solvent was accomplished by exposing the asphalts to temperatures only a few degrees above their softening points.

3. Viscosity Data at Various Temperatures and Relations Established

The viscosities of the asphalts were measured promptly after recovery. Evaluations were made at the following temperatures 275°F (135°C), 140°F (60°C), 95°F (35°C), 77°F (25°C), 60°F (15.6°C) and for some samples at 50°F (10°C). Original and recovered asphalts were Newtonian liquids at 275° and essentially so at 140°F. Thus, viscosities determined at these temperatures do not reflect, as much as would be desired, the effect of handling and service on the hardening of the asphalt. Consequently, it appears that viscosities at temperatures at or below 95° would be most suitable for evaluating durability of asphalts under service conditions.

So the question given in the "objective" may now be rephrased as follows: What temperature below 95°F should be used for measuring viscosity (hardening) of asphalt cements during service?

In the field experiments mentioned above we found that most of the recovered asphalts were very viscous at 60°F and usually showed excessive non-Newtonian (shear susceptible) characteristics. The viscosities frequently had to be determined on steel plates (films of 100 to 500 microns) and several repetitive runs often were

necessary to obtain sufficient data for establishment of a sound viscosity value. The end result was the use of considerable technician time in the accumulation of data.

Log-log plots of viscosity vs temperature have been prepared for 9 different asphalts recovered at 10 sites of the 1963-67 study mentioned above. The 10 charts, shown in the appendix, cover viscosities determined at 60°, 77° and 95°F and calculated at 5 x 10^{-2} sec^{-1} rate of shear. Each chart contains a plot of the asphalt recovered early in the experiment, e.g. at the plant (6 samples) or at the paver (4 samples). Also, each chart shows a plot for the asphalt recovered after service in the pavement, e.g. after 4 months (1 sample), after 12 months (5 samples) or after 24 months (4 samples).

The 20 plots show good straight line relationships and, thus, we conclude that technically any temperature within the limits shown could be used satisfactorily for evaluating the hardening of the various asphalts during service.

However, there is another aspect of the problem to be considered. Viscosities at 95° and 77°F can be obtained with about the same ease and consumption of technician time. Measurements made at 60°F are more expensive (because of technician time) to obtain than those made at 77°F.

With a world trend toward the use of the Centigrade temperature scale, it should be advisable for us to select test temperatures that are whole numbers on both the Fahrenheit and Centigrade scales. Such a relationship is true for 77° and 95°F (25° and 35°C). However, 60°F is 15.6°C.

Studies at 77°F and below on the Fahrenheit scale should be arranged to compare in whole degrees with the Centigrade scale, i.e.

77°F	(25°C)
59°F	(15°C)
41°F	(5°C)
23°F	(-5°C)
5°F	(-15°C)

These temperatures are being considered in work we are conducting at the present time on equipment other than the sliding plate viscometer.

Exploratory studies on the thermal properties of asphalts by the Differential Thermal Analysis method show considerable thermal activity in typical road building asphalt over the range 60°F to 95°F. Thus, from this view point 60°F is no more suitable than 77° or 95°F as the temperature for making viscosity measurements.

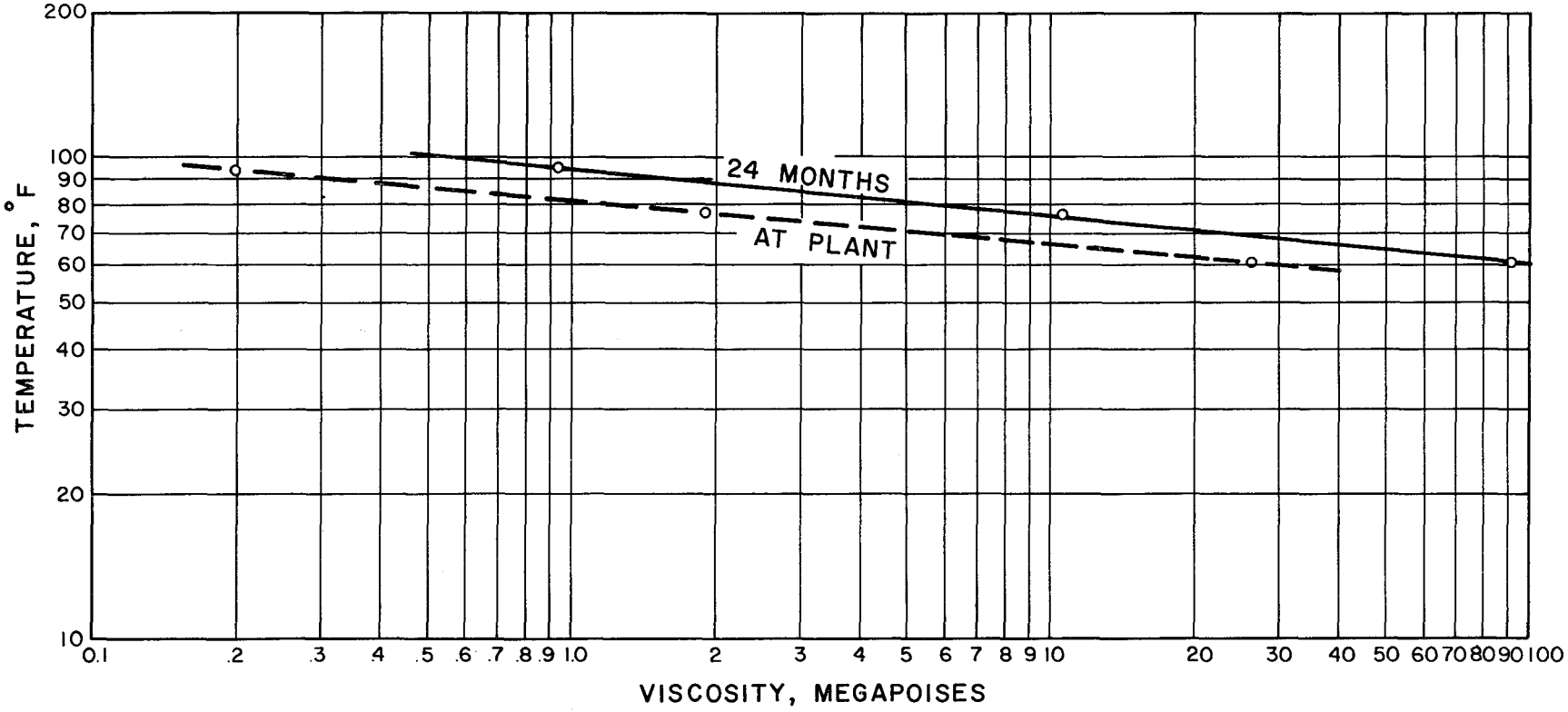
VII. APPENDIX

1. Ten Figures Showing Viscosity - Temperature Relationships of Asphalts Recovered from Paving Mixtures Shortly After Preparation and After Service for Designated Number of Months - Temperatures 95° to 60°F.

VISCOSITY—TEMPERATURE RELATIONSHIPS OF ASPHALTS RECOVERED FROM PAVING MIXTURES SHORTLY AFTER PREPARATION AND AFTER SERVICE FOR DESIGNATED NUMBER OF MONTHS

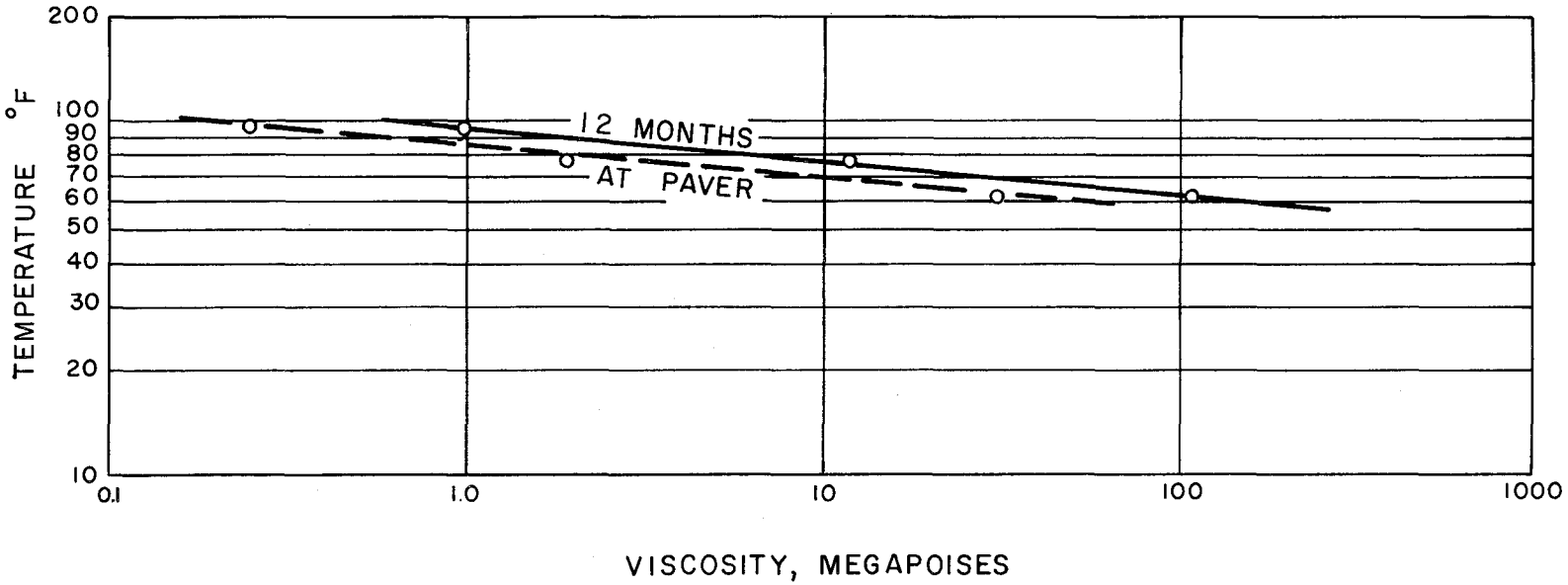
TEMPERATURES — 95 to 60° F

SITE 1 - ASPHALT 3



VISCOSITY - TEMPERATURE RELATIONSHIPS OF ASPHALTS RECOVERED FROM PAVING MIXTURES SHORTLY AFTER PREPARATION AND AFTER SERVICE FOR DESIGNATED NUMBER OF MONTHS TEMPERATURES - 95 TO 60° F

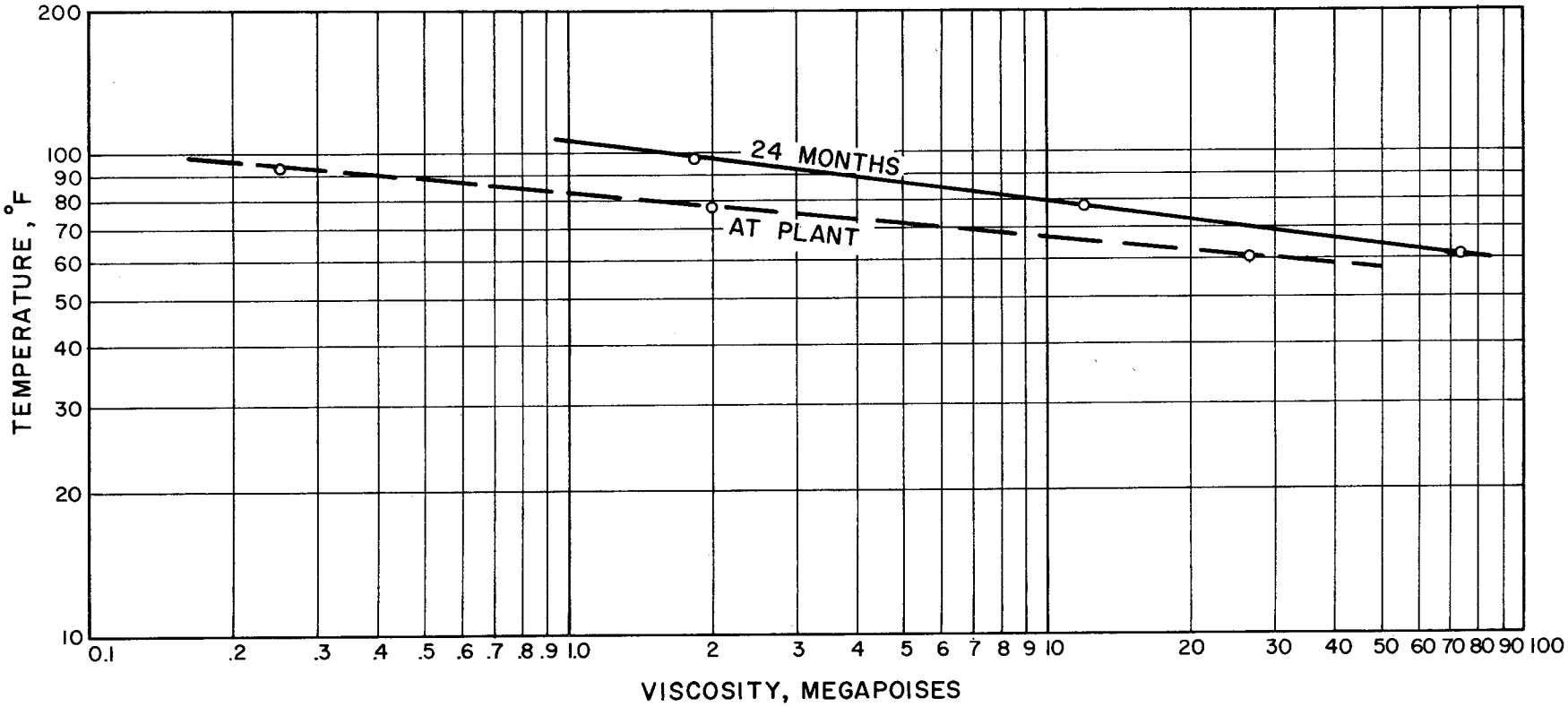
SITE 2 - ASPHALT 18



VISCOSITY — TEMPERATURE RELATIONSHIPS OF ASPHALTS RECOVERED FROM PAVING MIXTURES SHORTLY AFTER PREPARATION AND AFTER SERVICE FOR DESIGNATED NUMBER OF MONTHS

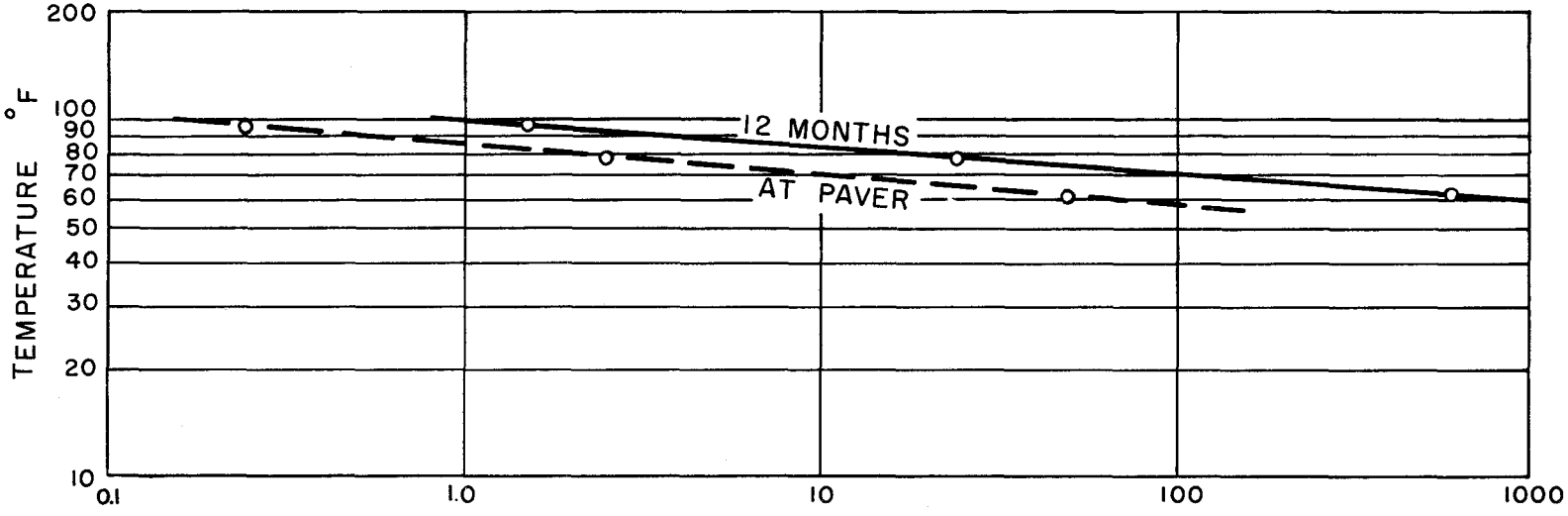
TEMPERATURES — 95 to 60° F

SITE 4 - ASPHALT II



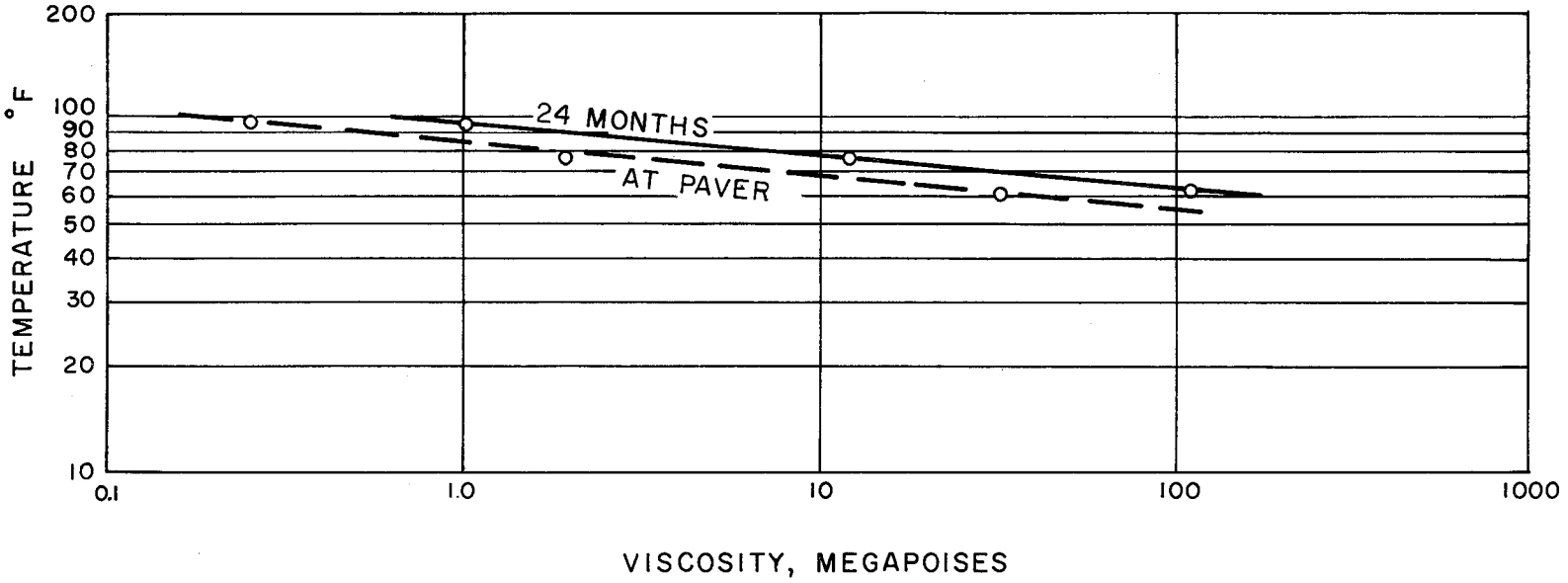
VISCOSITY - TEMPERATURE RELATIONSHIPS OF ASPHALTS RECOVERED FROM PAVING MIXTURES SHORTLY AFTER PREPARATION AND AFTER SERVICE FOR DESIGNATED NUMBER OF MONTHS TEMPERATURES - 95 TO 60° F

SITE 6 - ASPHALT 7



VISCOSITY - TEMPERATURE RELATIONSHIPS OF ASPHALTS RECOVERED FROM PAVING MIXTURES SHORTLY AFTER PREPARATION AND AFTER SERVICE FOR DESIGNATED NUMBER OF MONTHS TEMPERATURES - 95 TO 60° F

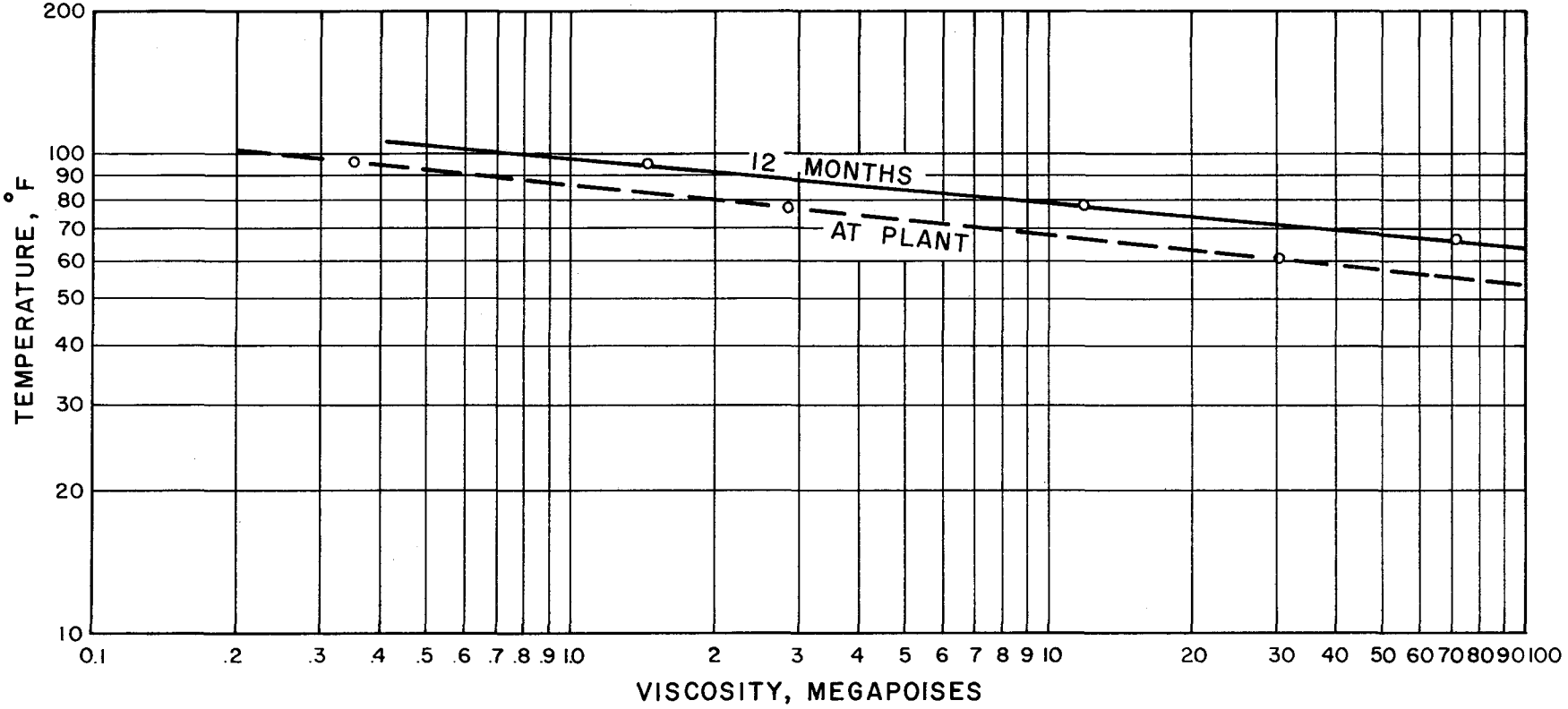
SITE 7 - ASPHALT 15



VISCOSITY — TEMPERATURE RELATIONSHIPS OF ASPHALTS RECOVERED FROM PAVING MIXTURES SHORTLY AFTER PREPARATION AND AFTER SERVICE FOR DESIGNATED NUMBER OF MONTHS

TEMPERATURES — 95 to 60° F

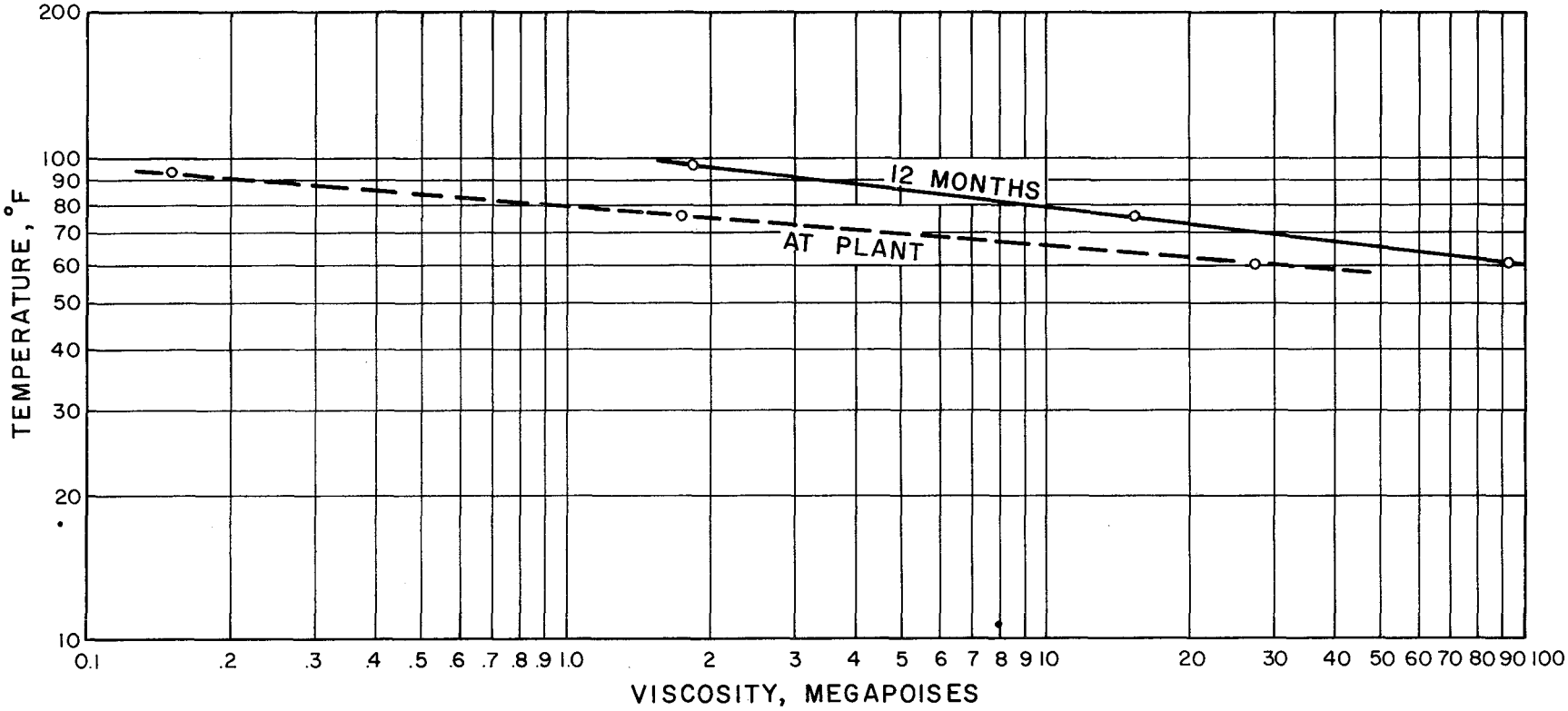
SITE 9 - ASPHALT 3



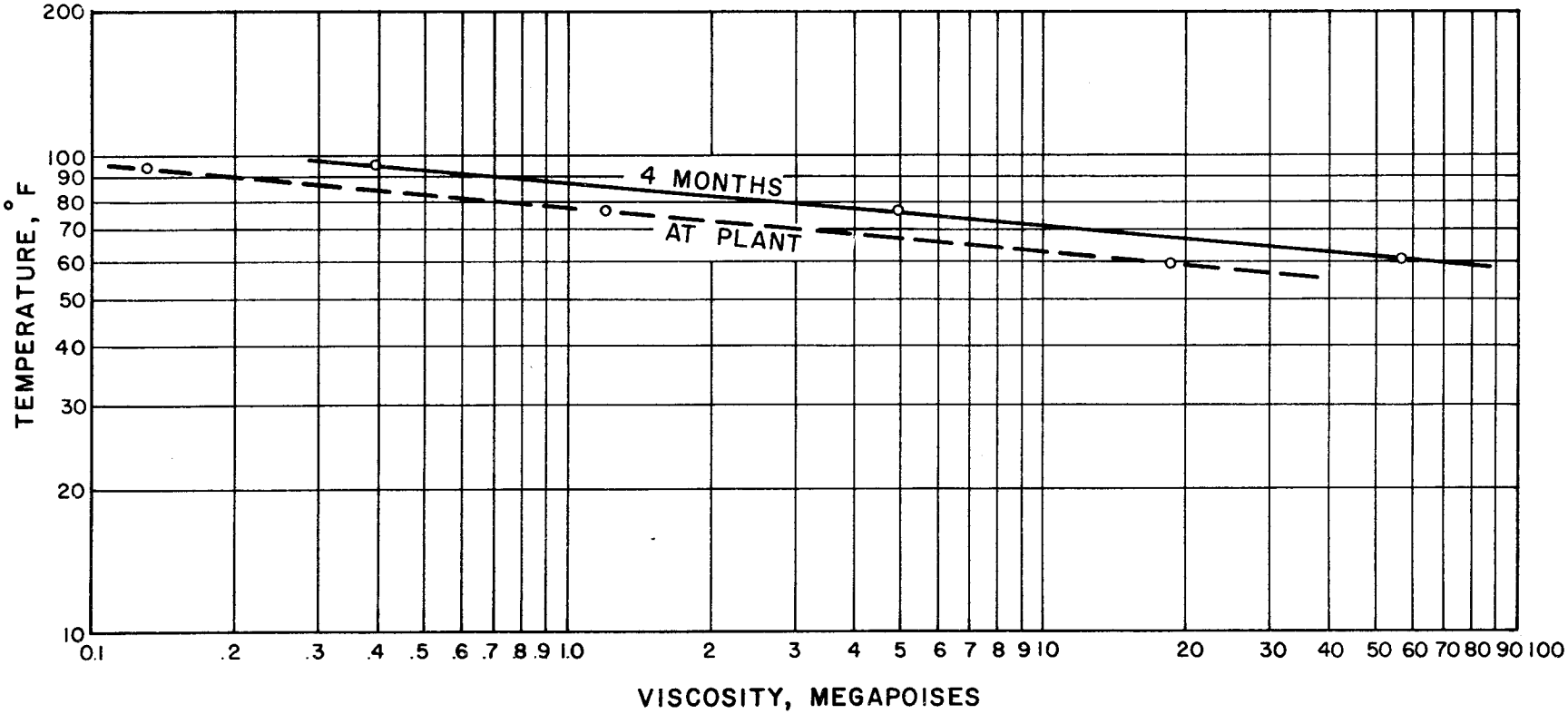
VISCOSITY — TEMPERATURE RELATIONSHIPS OF ASPHALTS RECOVERED FROM PAVING MIXTURES SHORTLY AFTER PREPARATION AND AFTER SERVICE FOR DESIGNATED NUMBER OF MONTHS

TEMPERATURES — 95 to 60° F

SITE 10 - ASPHALT 11



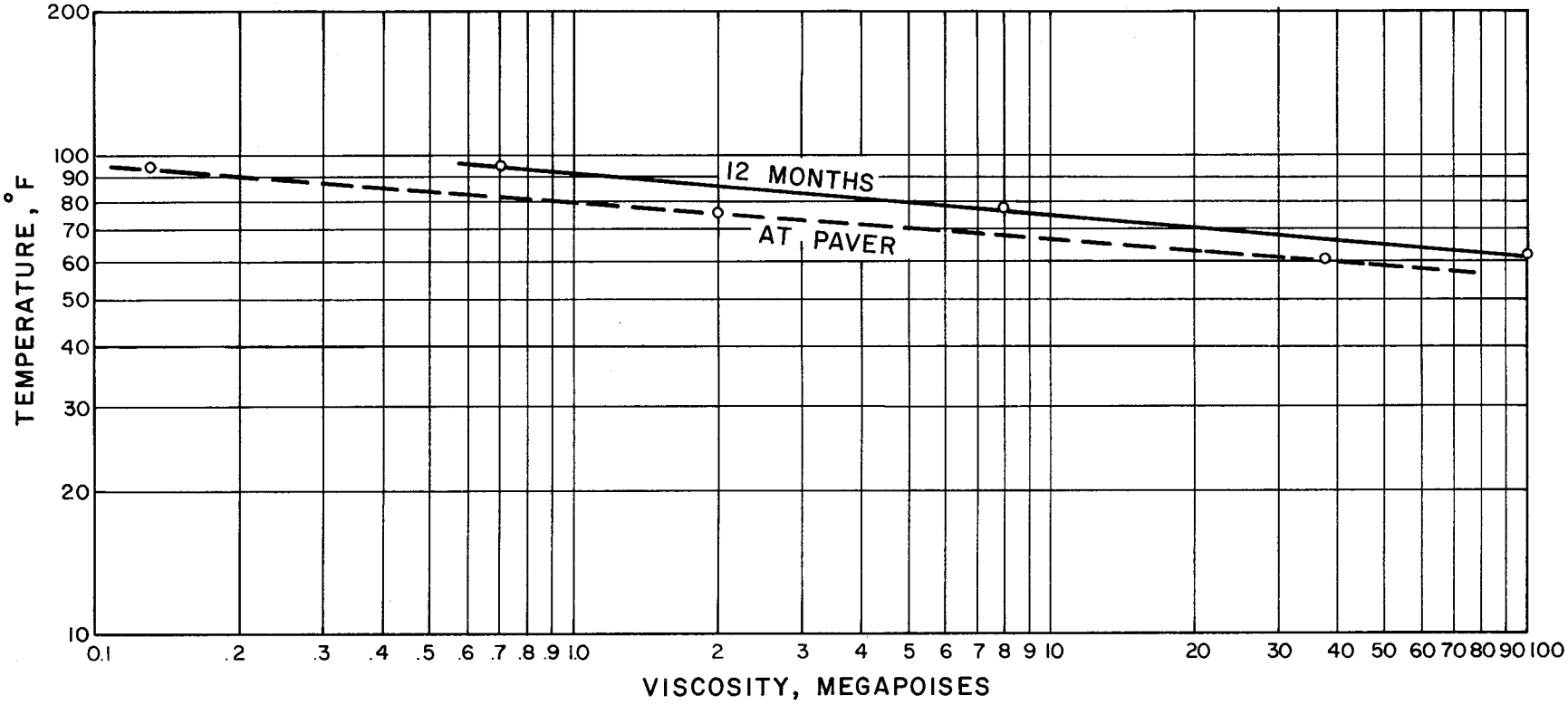
VISCOSITY—TEMPERATURE RELATIONSHIPS OF ASPHALTS RECOVERED FROM PAVING MIXTURES SHORTLY AFTER PREPARATION AND AFTER SERVICE FOR DESIGNATED NUMBER OF MONTHS
TEMPERATURES — 95 to 60° F
SITE 12 - ASPHALT 2



VISCOSITY — TEMPERATURE RELATIONSHIPS OF ASPHALTS RECOVERED FROM PAVING MIXTURES SHORTLY AFTER PREPARATION AND AFTER SERVICE FOR DESIGNATED NUMBER OF MONTHS

TEMPERATURES — 95 to 60° F

SITE 13 - ASPHALT 5



VISCOSITY — TEMPERATURE RELATIONSHIPS OF ASPHALTS RECOVERED FROM PAVING MIXTURES SHORTLY AFTER PREPARATION AND AFTER SERVICE FOR DESIGNATED NUMBER OF MONTHS

TEMPERATURES — 95 to 60° F

SITE 14 - ASPHALT 6