REPORT OF COMMITTEE ON MATERIALS AND CONSTRUCTION

H S Mattimore, *Chairman*

DETERMINATION AND CLASSIFICATION OF THE IMPORTANT CHARACTERISTICS OF BITUMEN FOR USE IN SURFACE APPLICATIONS, MIXED IN PLACE AND SIMILAR ROAD SURFACES

J E Myers, *Project Chairman*

Chief Chemist, New York State Highway Department

In order to determine and classify the important characteristics of bitumen for use in surface treatment of roads, mixed in place surfaces, etc , it is first necessary to determine what the road surfaces are with respect to the mineral aggregate and the method used in construction or the type of the road

This preliminary study of the road is necessary in order to make a proper selection of the type of bitumen to be used in the surface treatment The success of the treatment depends largely on the selection of the proper type of bitumen

A study of roads will show that they may be classified as (1) Earth roads, (2) Gravel roads, (3) Broken stone or Macadam roads, (4) Mixed type of Bituminous roads and (5) Rigid types such as concrete, brick or stone block, and wood block roads

Under the first group (earth roads) are such roads as clay, sand, sand-clay and loam In such roads the mineral aggregate is of small size, the surface is dense when dry and the voids are of small size

Under the second group (gravel roads) we find a large variation in the type of aggregate In some sections of the country the gravel surface is comparatively free from clay, loam, or other fine mineral matter and consists almost entirely of sand and pebbles In such roads the surface is porous and the voids are of appreciable size

In other sections of the country the gravel contains a considerable amount of clay, loam or other fine material in addition to the pebbles Roads constructed with such gravel are dense and the voids are of small size

Under the third group (broken stone or macadam) we find roads of two types, water bound and bitumen bound Water bound roads, if well constructed are dense and the voids small, and in the case of bitumen-bound the surface is well sealed

Under the fourth group (graded bituminous mixtures) we find a large variation in the size of mineral aggregate used This aggregate may vary from dust up to aggregate of 2 or 3 inch size Roads of this type are usually dense, well sealed and the voids are small in size

The density of the surface and relative size of voids in the various roads have been mentioned because the type of bitumen to be selected for surface treatment depends largely upon these two factors

The bitumens used for treating roads surfaces come under the general classification of (1) tar products (bitumen which yield pitches upon fractional distillation and which are produced as distillates by the destructive distillation of bitumens, pyrobitumens or organic materials) or (2) petroleum products (liquid bitumens occurring as such in nature).

The tar products may be still farther sub-divided into products with a high carbon content (low bitumen tars) or a low carbon content (high bitumen tars)

Tar products with either a high or low carbon content may be used to secure satisfactory results The pitch content (residue that is left after the volatile content has evaporated) of either high carbon or low carbon tars has a good cementing value The cementing value of a tar depends on the per cent of pitch content if the pitch is of a suitable consistency and quality

The petroleum products may be classified in two ways, first, on the basis of drying time as slow drying, medium drying or quick drying, second on the basis of cementing value, as oils having base of low cementing value, or oils having a base of high cementing value

The drying time of an oil depends upon the relation between the amount of volatile content compared to the non-volatile content and the character of these two component parts

The cementing value of the residue of an oil, the part that is left after the volatile material has evaporated, depends largely on the character of the petroleum or the residual from which the road oil was produced

The important characteristics of a tar which are to be considered as indicating suitability for surface treating roads are (1) bitumen content, (2) viscosity, (3) the amount of residue or pitch together with the volatile constituents and intermediates as shown by a distillation test, and (4) the character of the residue as indicated by the softening point test

Such requirements as tests for specific gravity, allowable amount of water, homogeneity, etc , which are usually put in specifications may be considered as being of a descriptive nature and relate indirectly to the quality of the material and are of secondary importance

The viscosity test on tars for surface treatment is usually run in an Engler Viscosimeter. The temperature at which the test is to be made should be stated in the specification This temperature is usually 40°C for surface treatment materials The result is expressed in seconds or as the specific Viscosity of the material

The distillation test on tars is usually made according to the method outlined by the American Society for Testing Materials (See Methods of Tests)

In the distillation test the distillate is usually fractioned at the following temperatures: up to 170°C, 170 to 235°C, 235 to 270°C, and 270 to 300°C These are the fractioning points usually used in the tar industry The specifications for the material should give the percentage limits (by weight) of distillate at the various temperatures

The softening point of the pitch residue that is left from the distillation test is usually a requirement of the specification This softening point can be determined by the Standard Method of Test for the Softening Point of Bituminous Materials known as the Ring and Ball Method, or Standard Method of test for Softening Point of Tar Products known as the cube method (See test methods) The specification should state the method to be followed

If the consistency of the pitch residue is controlled by both maximum and minimum limits, this requirement together with maximum and minimum distillation requirements largely controls the consistency of the original material, and its quality

The cementing value of a tar, the amount of mineral aggregate which the tar will bind together, is proportional to the amount of pitch residue which the tar contains The relative proportion of tar and mineral aggregate should be governed by the type and grading of the mineral aggregate

When the tar is to be used for the purpose of keeping down the dust, waterproofing the road surface, conserving the mineral aggregate and of acting to a slight extent as a cementing agent to bind the fine mineral aggregate, tars of low viscosity, high distillation and a corresponding low pitch content with preferably a low melting point, should be used

Such tars would be used to surface treat clay, sand-clay, loam, loam-gravel roads or for the priming treatment of waterbound macadam roads, roads in which the voids are of small size

Such road surfaces are dense hence a material must be used which has a low viscosity and a low pitch content in order to secure the proper penetration of the material

Should a material of high viscosity, high pitch content and low percentage of distillate be used, the material would not properly penetrate into the road surface but would harden and form a thin mat or crust on the road surface Such a mat breaks through under traffic, holes rapidly develop and a very rough road surface is the result

When the roads to be surface treated are of sand, sand-gravel, water-bound macadam which has been surfaced treated or bituminous macadam, tars of high viscosity and high pitch content should be used Such tars penetrate the more open surface of sand roads or sand-gravel roads The tars harden by the evaporation of the volatile constituents and leave a sufficient quantity of pitch residue to bind a wearing surface that will stand considerable traffic without breaking through and developing holes

In the case of bituminous bound macadam, water-bound macadam or concrete roads previously surface treated, the surface treating material fluxes and enlivens the bitumen on the road, seals the surface and will hold sufficient cover, pea gravel or stone screenings, to form a good wearing surface

To illustrate the types of tars to be used for the purposes outlined the following specification characteristics are given covering a light tar and a heavy tar Various intermediate grades can be called for if desired by placing the proper limits in the specifications

Light Tar would have a specific viscosity at 40°C of 5 to 8 The total distillate, by weight would be about 45 per cent, the residue after distillation about 55 per cent and the softening point (Ring and Ball) of the residue from 40 to 55°C

Heavy Tar would have a specific viscosity at 40°C of 25 to 35 The total distillate would be about 25 per cent, the residue about 75 per cent and the softening point of the residue similar to that of the light tar, 40 to 55°C

Intermediate grades of tar for surface application would have specific viscosities of approximately 8–13, 13–18 and 18–25 The amount of distillate for these various grades would likewise vary between 25 and 45 per cent

As previously mentioned, clay, sand-clay, loam-gravel, water-bound macadam or roads with non-bituminous dense surfaces require a light tar, especially for the first application The heavier grades can be used on more open surface or on bituminous treated surfaces

The tar products mentioned are not cut-back products (pitch residues softened by the addition of a volatile solvent) and require from 2 to 5 days for drying in summer weather before the material ceases to throw under traffic

The petroleum products which are used for surface treating roads may be classified according to their drying qualities and the character of their residue The quick drying materials (cut-back products), consist of an asphalt base and a volatile solvent Such products dry in a few hours, usually not more than twenty-four The Medium drying products consist of a base, intermediate oils, volatile at 260°C but not volatile at 163°C and volatile oils which are volatile at 163°C Such products require from 3 to 10 days to dry The drying time depends upon the relation between the amounts of base, intermediate and volatile constituents present The slow drying products, blended or unblended, consist of a base, together with a considerable percentage of non-volatile oils and a small percentage of volatile oils Such products require from two weeks to two months to dry.

From a study of the petroleum products used for surface treating roads it will be seen that the two main qualities relate to drying time and cementing value The laboratory tests used to determine the drying qualities are evaporation tests or distillation tests together with consistency tests (float or penetration tests) made on the residue from the evaporations or distillation The cementing value of the base of residue is determined indirectly by the ductility of the residue left from the evaporation or distillation tests

At the present time there is no acceptable direct method of measuring the cementing value of bituminous materials However we do know that materials which have good cementing values in practice have considerable ductility as measured by the ductility tests at 25°C and 5°C Materials of low cementing value are lacking in ductility Therefore, ductility tests within limits are the best methods at present for determining the relative cementing value of bituminous materials from a petroleum base

The Laboratory tests of primary importance which are used to determine the desired characteristics of a petroleum product for surface treatment are

(1) The Volatilization Test at 163°C or additional temperatures
(2) The evaporation Test at 260°C to determine the percentage of Residue of a specified penetration
(3) The character of the residue as determined by the penetration, float or ductility tests
(4) Distillation tests in the case of quick drying products (cut backs) together with penetration and Ductility tests on the residue
(5) Viscosity tests, at 25, 50 or 100°C

Tests of secondary importance which are sometimes placed in specifications for surfacing treatment are

(1) Specific gravity
(2) Solubility in carbon disulphide or benzole
(3) Solubility in Naphtha
(4) Fixed carbon
(5) Paraffine content
(6) Flash Point

The tests classified as being of primary importance are used to determine the characteristics of the material and to indicate the qualities which the residue will possess when the material has "set" or hardened

The tests listed as secondary are largely used for the purpose of identification

The Volatilization test is usually made in accordance with the A S T M "Standard Method of Test for Loss on Heating of Oil and Asphaltic Compounds" In some specifications this test is sometimes modified by using 20 grams of material rather than the 50 grams called for in the standard test; also by making the test at such temperatures as 100 or 125°C rather than or in addition to 163°C which is the standard

The tests used to determine the character of the residue from either an evaporation test or the distillation test are the float or penetration tests, and the ductility test

The distillation test for cut-back products can be made in accordance with A S T M. "Tentative Method of test for Distillation of Bituminous materials suitable for Road Treatment," or by the "Special Method for Distillation of Petroleum Products" as outlined by the asphalt Institute The principle difference in these two methods of distillation is the position of the thermometer This change in position necessitates a corresponding change in the specification requirements in regard to the distillation temperatures

The Viscosity tests may be made with either an Engler or Saybolt Furol Viscosimeter The specifications should state the instrument to be used and the temperature at which the test is to be made

The tests listed as being of secondary importance are ordinary laboratory routine work which any chemist familiar with bitumens would be able to perform with sufficient accuracy without giving the methods in detail in this paper

When the road oil is to be used as a dust preventive, to water-proof the road surface and to a slight extent act as a cementing agent to conserve the mineral aggregate, oil of low viscosity, low cementing value and slow drying qualities should be used High viscosity but slow drying oils may also be used

Such oils should be used on clay, sand-clay, loam, loam-gravel or for the first or priming treatment on water-bound macadam roads, roads in which the voids are of small size In such roads the surface is dense and the penetration will be slight unless oils of the type mentioned are used

On more open road surfaces, such as sand, sand-gravel, macadam or concrete surfaces which have been primed with low viscosity materials, oils of high viscosity, high cementing value and quick drying qualities should be used Such oils have a sufficient quantity of residue of high cementing value to bind a cover of stone chips or pea gravel and form a good wearing surface

To illustrate the specification characteristics for a slow curing oil of low cementing value, the evaporation loss at 163°C on a 50-gram sample would not exceed 15 per cent and the residue of 100 penetration would be approximately 45 to 55 per cent The specific Viscosity (Engler) at 25°C would be from 25 to 35

Medium curing oils would have an evaporation loss at 163°C on a 50-gram sample between 20 and 30 per cent, and the residue of 100 penetration would be from 55 to 65 per cent The specific Viscosity (Engler) at 50°C would be from 20 to 35

Rapid curing oils are essentially asphalts cut back with a volatile solvent The specific Viscosity (Engler) at 50°C is from 20 to 35 The volatile solvent comprises about 35 per cent of the material and an asphalt base which has a penetration at 25°C of 75 to 150 makes up the other 65 per cent of the material.

In the cases of both the medium drying oils and the rapid curing oils the ductility of the asphalt residue should be at least 25 cm at 25°C in order to insure good cementing value

There is another type of rapid curing bitumen which has but recently come into use for surface treatment These materials are asphaltic emulsions which contain about 50 per cent of water The asphalt base used in such emulsions usually has a penetration of 100–200 at 25°C

The materials classed as medium curing oils, rapid curing oils and asphaltic emulsions, provided their base has a good cementing value, may be used for the construction of mixed in place surfaces when a mineral aggregate is used that contains a relatively small amount of fine material Such surfaces are not designed for maintenance by blading

Slow curing oils of low cementing value may be used for the construction of mixed in place surfaces when the mineral aggregate contains a large percentage of fine material Such surfaces may be maintained by scarifying and blading

TEST METHODS

Total Bitumen—A S T M D 4-27
Distillation—A S T M D 20-30
Softening Point (Ring and Ball), A S T M D 36-26 or (Cube) A S T M. D 61-24
Volatilization, A S T M D 6-30
Float Test, A S T M D 139–27
Penetration, A S T M. D 5-25
Ductility, A.S T M D 113–26T
Viscosity, A S T M D 88-26 (Using Saybolt Furol Viscosimeter) The Engler Viscosimeter may also be used

DISCUSSION

ON

THE DETERMINATION AND CLASSIFICATION OF THE IMPORTANT CHARACTERISTICS OF BITUMEN FOR USE IN SURFACE APPLICATION, MIXED IN PLACE AND SIMILAR SURFACES

Mr Malcolm H Ulman, *Pennsylvania Department of Highways* Mr Myers and his Sub-Committee are to be complimented for the excellent and comprehensive manner in which they have covered this subject I was particularly gratified to note their differentiation between the essential and identification tests for bituminous materials in view of developing specifications

The producer and user of a bituminous or any other type material is particularly interested in controlling the quality for the intended use, and it is a hardship on the producer when a large number of clauses covering varying requirements are incorporated in a specification, many of which in the developed specification are not properly correlated I have always premised that the development of a specification for a bituminous material could be controlled by inserting requirements for

1 Suitable consistency
2 Adhesiveness
3 Proper bitumen content
4 (a) Change of consistency for liquid materials after use
  (b) Permanency of original consistency and durability for semi-solid and solid products after use

There have been tests developed to control these qualities as has already been explained by Mr Meyers

In many cases unsatisfactory results may be obtained with a bituminous material which is well adapted for the particular construction, if improperly handled or applied in an excessive or insufficient amount The rate of application of a bituminous material should be definitely specified As an example I can cite the case of cold surface treatment materials, which depend on the evaporation of their volatile constituents for drying It is possible that such materials may require 0 25 gallons per square yard in order to obtain successful results, but by increasing the quantity waste will occur and slower drying will be obtained It is, therefore, important to specify definitely the quantity of material under each specification used, for a particular type of construction for which the material is intended

I have been informed that considerable quantities of asphalt emulsions have been used in some of the midwestern states for the construction of mixed in place surfaces The use of asphalt emulsions for such construction, surface treatment and penetration macadam has been investigated to a considerable extent and favorable opinions have been formed due to the following

1 Uniform distribution of emulsion In the case of bituminous penetration macadam surface course uniform penetration throughout the entire depth was obtained with no puddles of excess materials

2 Moisture on road material has no detrimental effect, but on the other hand is advantageous in providing uniform distribution

3 No rich areas are obtained where overlap occurs in distribution

4 Material can be placed when air temperatures are as low as 35°F

The use of asphalt emulsions requires different methods in surface treatment and penetration macadam then is the customary practice with other types of bituminous materials, due to their consistency being thinner at time of application

We believe the correct theory covering the use of asphalt emulsions in surface treatment of macadam pavements is to apply a prime coat at the rate of 0 3 gallon per square yard This prime coat emulsion should contain approximately 45 per cent water and a base of asphaltic oil in which the residue at 100 penetration varies between 40 to 70 per cent depending on the surface conditions This prime coat after seasoning should be followed by one-half gallon per square yard application of quick breaking emulsion containing approximately 50 per cent water and having a base of asphalt cement of a penetration ranging between 100 and 200 This surface treatment is allowed to season for approximately four hours and is then covered with dustless stone chips of a maximum size of $\frac{3}{8}$ inch at the rate of 20 pounds per square yard

In consideration of penetration macadam in which emulsions are used it has been our practice on service test roads, which are still under observation, to use ballast for the specified depth ranging in size from $3\frac{1}{2}$ to $1\frac{1}{4}$ inches After thorough interlocking of the stone by the use of a three wheel twelve ton roller, it is then chinked with $\frac{1}{2}$ inch commercial size stone to within one inch of the surface This chink stone acts as a dam and prevents the emulsion from flowing to the bottom of the stone at time of distribution There is required for such chink stone approximately thirty pounds per square yard on basis of four inch loose ballast The emulsion is then applied with pressure distributor, working under an approximate twenty pound pressure, at the rate of one gallon per square yard for this depth ballast Following the first application of emulsion there is spread twenty-five pounds per square yard $\frac{3}{4}$ inch commercial size stone to key the larger stone and fill the large void spaces The pavement is again rolled and emulsion applied at the rate of one gallon per square yard and subsequently covered with $\frac{1}{2}$ inch commercial stone and rolled The seal coat is then applied, which consists of an application of one-half gallon of emulsion per square yard followed by chipping with one-half inch commercial size stone and rolling. The quantity of emulsion will of course vary with the depth of the stone course

MR E F KELLEY, *U S Bureau of Public Roads* I do not intend to discuss Mr Myers' very excellent report in any detail although it does call to mind a recent development which has a distinct bearing on the same subject Those of you who were at the Asphalt Paving Conference last week need not listen to my remarks because you have already heard them, but there is a very chaotic condition at the present time in the field of liquid asphaltic road materials, that is, road oils and cut-back asphalt The quite complete lack of agreement among the various States in the matter of the tests specified, the methods of conducting tests, and the test limits have created an unnecessarily large number of grades of material which results in needless expense It has also created a condition which makes it impossible to compare different materials on the basis of specification requirements For about two years the Bureau of Public Roads and the asphalt industry represented by the Asphalt Institute, have been carrying on a cooperative program of investigation of low cost roads and one phase of the cooperative work concerns the proposed standardization of specifications for liquid asphalt materials In connection with this work there have recently been assembled 125 specifications from 33 States for oils and cut-backs for cold, warm, and hot applications The requirements of these specifications have been analyzed and show very strikingly the great difference of opinion which exists as to the requirements of an adequate specification It is this situation that has lead to the proposed simplification program For instance, for one material, one State depends entirely on the determination of specific viscosity to control the quality of that material while other States require as many as 13 different test requirements before the material is considered acceptable

There are a great many interesting examples in the analyses of these specifications as to the differences of opinion I recall only a few—in the case of some 80 specifications for the materials for cold and warm applications, some of the specifications have no requirement as to viscosity. The balance of them specify both the Engler and Saybolt In the case of Engler there were six different temperatures specified and in the case of Saybolt there were four Examples of that kind could be cited almost indefinitely

The program which is proposed involves two distinct parts, first, the simplification of forms of specifications, and second, the standardization of specification requirements which may be expected to reduce the number of grades of material, and naturally the first part of the program is of primary importance at the present time We must reach an agreement on the tests that are to be specified before we can go to the extent of writing the specification requirements for the various tests Even before the first part of the program can be started it is necessary to reach an agreement on the methods of analysis in order that we may have some basis for comparison of the great number of specifications Consequently there has been proposed a common scheme of analysis which involves the flash point determinations for all materials, viscosity determinations at different temperatures for materials for different purposes, distillation tests and tests on the resulting residues which consist of such tests as ductility and solubility in carbon disulphide

For convenience in carrying on this proposed program, the country has been divided into five regions and it is proposed for each of these regions to hold meetings which will be attended by representatives of the State highway departments and of the principal producers of asphaltic materials The purpose of the first of these regional meetings will be to discuss this common scheme of analysis which has been proposed and to reach an agreement on this scheme or a modification of it, with the idea that during the next year each of the States will examine the materials which are purchased for construction not only to determine compliance with its own specification requirements but also in accordance with this common scheme of analysis so that we will gradually develop the basis for a comparison and I should like to emphasize that thought I believe that there has been some misconception about the purpose

The purpose of these first meetings is simply to discuss a common scheme of analysis and reach an agreement on it There is no thought that there will be any immediate change in specification requirements We must develop the basic information first before we can even make any comparison of the materials which we are using All of the State highway departments have been invited to participate in this cooperative program and I think without exception have signified their interest in it and their willingness to cooperate in this work Incidentally we hope to hold the first of these regional meetings early in 1931 in order to get started on this work, and I am sure the developments will be observed with a great deal of interest among all of those who are concerned with the use of this particular type of material in the low cost road work