

AASHTO Provisional Standard



Standard Practice for the Laboratory Evaluation of Modified Asphalt Systems

**AASHTO Designation: PP5-93
Edition 1B**

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This PS is being referred to the AASHTO Subcommittee on Materials (SCOM) for a review, ballot and approval. If the approval process produces changes, an amended version of the PS shall be published in the next edition.

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**Standard Practice for
the Laboratory Evaluation of
Modified Asphalt Systems**

AASHTO DESIGNATION: PP5-93¹

1. Scope

1.1 This practice provides procedures for evaluating the use of and the need for modified asphalt binders and paving mixes within the SUPERPAVE™ mix design system and for determining if modified asphalt binders satisfy MP1 and modified paving mixes satisfy the SUPERPAVE™ mix specification. It utilizes the performance-based asphalt binder and paving mix tests, specifications and pavement performance prediction developed in the SHRP asphalt research program.

1.2 This practice provides procedures for evaluating modified binders and modified paving mixes using performance-based tests and criteria, and for estimating their performance characteristics in pavement service.

1.3 This practice can be used for the evaluation of modified asphalt binders, meeting the requirements of MP1 Binder Specification, aggregates, paving mixes or any combination of these. It is divided into two main topics: modified asphalt binders and modified paving mixes. Distinct evaluation procedures for aggregate modifiers are not covered in this practice. Aggregate modification is covered under the topic of modified paving mixes.

1.4 This practice provides for two distinct treatments of modified asphalt binder. A modified asphalt binder proposed for use in an asphalt concrete pavement may be directly evaluated, or, a modifier can be combined with a base asphalt cement to produce a modified binder which meets MP1.

1.5 *This practice may involve hazardous materials, operations, and equipment. It does not purport to address all of the safety problems associated with its use. It is the responsibility of whomever uses this practice to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 AASHTO Standards

- MP1 Specification for Performance Graded Asphalt Binder
- MP2 Standard Specification for SUPERPAVE Volumetric Mix Design
- M92 Specification for Wire-Cloth Sieves for Testing Purposes
- PP1 Accelerated Aging of Asphalt Binder Using a Pressurized Aging Vessel (PAV)
- PP3 Preparing Hot Mix Asphalt (HMA) Specimens by Means of the Rolling Wheel Compactor
- PP6 Grading or Verifying the Performance Grade of an Asphalt Binder
- PP28 Designing SUPERPAVE HMA
- TP1 Determining the Flexural Creep Stiffness of Asphalt Binder Using the Bending Beam Rheometer (BBR)
- TP3 Determining the Fracture Properties of Asphalt Binder in Direct Tension (DT)
- TP4 Preparing and Determining the Density of Hot Mix Asphalt (HMA) Specimens by Means of the SHRP Gyratory Compactor
- TP5 Determining Rheological Properties of Asphalt Binder Using a Dynamic Shear Rheometer (DSR)
- TP7 Determining the Permanent Deformation and Fatigue Cracking Characteristics of Hot Mix Asphalt (HMA) Using the Simple Shear Test (SST) Device
- T44 Solubility of Bituminous Materials
- T48 Flash and Fire Points by Cleveland Open Cup
- T240 Effect of Heat and Air on a Moving Film of Asphalt (Rolling Thin Film Oven Test)
- T283 Resistance of Compacted Bituminous Mixture to Moisture Induced Damage

¹ This standard is based on SHRP Product P001.

3. Definitions

3.1 Modifier - a material incorporated in hot mix asphalt (HMA) or other types of asphalt paving mixes in addition to the asphalt cement, aggregate and mineral filler, in order to control the development of pavement distresses and enhance overall pavement performance. Modifiers may be any organic or inorganic material of suitable manufacture, used in virgin or recycled condition, that is dissolved, dispersed or reacted in asphalt cement or HMA or coated on aggregate particles.

3.2 Base Asphalt Binder - an unmodified asphalt cement used in the production of a modified asphalt binder. The performance grade of a base asphalt cement may be substantially different than that of a unmodified asphalt binder customarily used in a particular location.

3.3 Conventional Asphalt Binder - an unmodified asphalt cement customarily used in a particular location.

3.4 Type I Polymer Modified Asphalt Binder - a conventional asphalt cement to which styrene block copolymers have been added. [1]²

3.5 Type II Polymer Modified Asphalt Binder - a conventional asphalt cement to which styrene butadiene rubber (SBR) latex or neoprene latex has been added. [1]²

4. Summary of the Practice

4.1 This practice presents a procedure for the laboratory evaluation of modified asphalt binder and paving mixes for HMA pavements. It utilizes the SUPERPAVE™ performance-based binder and paving mix tests, specifications, mix design system and pavement performance prediction models (MP1; MP2). Materials are evaluated as a single component and/or as a multi-phase component in the final paving mix produced for roadway placement using the same SUPERPAVE™ performance criteria established for conventional (unmodified) materials.

4.2 The selected modifiers are characterized by standard physical and chemical properties used to identify them for future reference. Modified materials are then characterized according to the

SUPERPAVE™ performance-based specifications and mix design system. Any properties specifically intended for quality control of production or performance of the modified asphalt binder, aggregate, or paving mix are identified.

4.3 The final choice of materials (modifier, base asphalt cement and aggregate) is guided by reference to the criteria that led to the decision to use a modifier and to any restrictions on the availability of materials.

Note 1 -- The information required for the selection of modifiers for asphalts, aggregates or paving mixes will usually be provided by the modifier producer. However, it can also be obtained from the literature and by contacting other modifier users. The targeted pavement distress(es) should be indicated. The effect of the modifier on other pavement performance areas must also be considered in the selection process. This information and the historical pavement and laboratory performance will aid in determining if a given modifier will address the key pavement problems in the targeted climatic and traffic conditions.

Note 2 -- The results of the characterization of each modified material should be compared with MP1 criteria, historical data and the characteristics of conventional asphalt binders. Based on this comparison, if the expected pavement performance is acceptable, the evaluation should proceed to the next step (modified asphalt binder, aggregate, paving mix or pavement evaluation).

4.4 If the expected performance is unacceptable at the completion of any step in the laboratory evaluation of a modifier, the modifier is rejected or the process is repeated with another modifier, base asphalt binder or aggregate to optimize the formulation. The evaluation may also go forward to the next step, even if the properties and performance of the modified asphalt binder or paving mix are unfavorable, in order to develop additional data for making a final decision on the use of a candidate modifier.

²Number in brackets represents the reference given at the end of this procedure.

4.5 The cost of producing and placing the materials are estimated to aid in the decision on using the modified system. In addition, a simple analysis of the life-cycle cost of using the modified materials is made from the results of the SUPERPAVE™ performance-based mix tests and pavement performance prediction models, where appropriate, and compared to the use of conventional asphalt binders and paving mixes.

4.6 The modified HMA production and laydown should be completed using only the equipment and procedures recommended by the modifier producer. The pavement should be produced in accordance with the material proportions and volumetric properties developed in the SUPERPAVE™ mix design.

5. Significance and Use

5.1 This practice presents detailed procedures for evaluation of modified asphalt binder, aggregate, and paving mix, singly or in combination. The laboratory tests, used in this practice, measure fundamental properties which directly govern the response of a pavement to load. From this response, pavement performance, in terms of the development of permanent deformation (rutting), fatigue cracking and low-temperature cracking over the service life of the pavement, is estimated. The influence of aging and water sensitivity on pavement performance is also explicitly considered (PP1; T283; T240).

5.2 Use of this practice allows the evaluation and (or) selection of a modified asphalt binder, aggregate or paving mixes on the basis of a required level of pavement performance under the present and predicted traffic, environmental and structural conditions.

6. Materials Selection

6.1 Select the modifier, base asphalt cement and aggregate to satisfy the specific performance criteria that led to the decision to use a modifier. The performance criteria arise from the need to eliminate or reduce one or more pavement distresses or improve the overall performance or service life of the pavement. Consider the availability, compatibility and cost of the requisite materials in the selection process.

6.2 Modified asphalt binder or paving mix are usually used because conventional, locally available

materials do not satisfy the SUPERPAVE™ specification for the site specific traffic, environmental and structural conditions. Choose a modifier for a base asphalt binder, aggregate or paving mix after considering the recommendations of the modifier producer and historical performance data.

Note 3 -- Some conventional asphalt binders or aggregates may not be chemically or physically compatible with a modifier or may not develop the specific levels of performance expected from the use of the modifier. Any method recommended by the producer for screening asphalts or aggregates should be utilized to aid in the selection process. However, there may be cases where the objective is to improve the characteristics of a specific base asphalt cement and the evaluation of the modifier may be pursued even though the asphalt cement or aggregate is not the ideal candidate.

6.3 Table 1 presents information required for the selection of modifiers for asphalt binders, aggregates or paving mixes. Obtain this information from the modifier producer, the highway literature, and contacts with other agencies using modifiers.

6.4 Prepare "Fact Sheets" from the information called for in Table 1 to assist in the selection of modifiers that will serve their intended purpose. The "Fact Sheets" shall include the name of the modifier, any effects on material properties, restrictions, a description of the modifier, any special handling or production requirements. Identify the targeted pavement distress(es) and note the effect of the modifier on other pavement performance areas. This information and the historical pavement and laboratory performance data will aid in determining if a particular modifier will address the key pavement problems identified for the proposed application and use.

6.5 Measure the significant physical and chemical characteristics and specifications for the modifier, particularly the properties that are critical for monitoring the quality of the product. Obtain recommendations concerning the type of asphalts and aggregates that can or must be used with the modifier from the modifier producer. Also obtain unique or specialized procedures for determining asphalt or aggregate compatibility with the modifier.

Note 4 -- Chemical characterization of the modifier and the base asphalt binder may aid in determining the effect of modifier use on pavement performance. Chemical properties such as molecular weight and size, composition, association and functionality are indicators of asphalt binder performance. Size exclusion chromatography, ion exchange chromatography and infrared spectroscopy are key tools for determination of performance-related chemical properties of asphalt binder. A complete discussion and relevant experimental procedures are presented in the SHRP publication Guidelines for Asphalt Refiners and Suppliers.

6.6 Characterize the base asphalt binder with the SUPERPAVE™ performance-based conditioning procedures and tests for asphalt binders (Table 2). This information will allow comparison of the base asphalt binder with the modified asphalt binder using performance-based properties. Base selection of the modifier on improved performance, indicated by the change in the binder performance grade achieved by modification, and on the accompanying change in the costs of HMA production and laydown.

6.7 The bending beam rheometer (BBR) characterizes asphalt binders by measuring creep stiffness at low temperatures (TP1). The dynamic shear rheometer (DSR) measures the shear stiffness at various temperatures (TP5). The direct tension (DT) test characterizes the strain tolerance of the asphalt binder at low temperatures (TP3). The rolling thin film oven test (T240) simulates short term aging (HMA production). The pressurized aging vessel (PAV) test simulates long term aging which occurs in the pavement subsequent to construction (PP1).

7. Modified Asphalt Binders and Paving Mixes

7.1 General - Obtain information from the modifier producer concerning the equipment, procedures and amount necessary for the laboratory production of the modified asphalt binder, aggregates or paving mixes. This information shall include health and safety data, special conditions for handling and storage, and any unique quality control parameters recommended by the producer. Pay particular attention to procedures and equipment not common to the HMA industry. Identify any special needs or problems prior to beginning the evaluation process.

Note 5 -- For example, there are several important special handling and storage

conditions for sulfur-extended asphalt. Any tank or silo in which sulfur-extended asphalt binder or HMA is stored must be carefully vented before opening to avoid exposure of workers to toxic hydrogen sulfide (H₂S) or sulfur dioxide (SO₂) gases. If access to such storage is required, workers must wear the correct level of protective clothing. Sulfur and asphalt binder must not be contacted or stored together at temperatures above 150°C to minimize formation of toxic gases.

7.2 Modified asphalt binder - Production processes for modified asphalt binders depend greatly on the physical and chemical characteristics of the modifier and base asphalt binder. They may vary from simple, low-energy mixing to high-shear blending requiring close control of time and temperature to actual reaction of the component materials. At a minimum, achieve quality control during production by monitoring appropriate performance-based rheological properties from Table 2. Other properties recommended by the modifier producer may also be measured periodically. Use the same physical, chemical and performance-based properties (Table 3) used to characterize the base asphalt binder to evaluate and characterize the modified asphalt binder. Include any property critical to the performance of the modified asphalt binder, but not applicable to the conventional asphalt binders in the characterization.

7.3 Modified Aggregate - Modified aggregate production may vary greatly depending on the characteristics of the modifier and the aggregate. The procedure may be just simple mixing or may involve a complicated coating process. Identify quality control methods by the modifier producer or process designer.

7.4 Modified Paving Mix - Table 3 presents key information necessary for the laboratory production and characterization of modified paving mixes. Use the same physical and performance based tests used to characterize conventional paving mixes to characterize the modified paving mixes. Methods and procedures for the design of conventional and modified paving mixes are briefly presented in the Sections 10 and 11 of this practice and in detail in the SUPERPAVE™ Mix Design Manual for New Construction and Overlays.

8. Laboratory Evaluation of Modified Asphalt Binders

8.1 General - There are hundreds of potential modifiers which may change or alter asphalt binder properties. This practice is intended to provide a framework for the objective, quantitative evaluation of these candidate materials. It does not provide specific blending and preparation procedures. Develop these procedures in consultation with the producers of specific modifiers (Note 6). Use the procedures listed in Table 2 to evaluate modified asphalt binders. These procedures measure fundamental properties related to pavement performance, and they apply equally to modified and unmodified binders (Note 7).

Note 6 -- Several test procedures presented in this section apply to specific types of modified asphalt binders. These procedures may also apply to other modifiers in present use or to novel materials that may be employed in the future. However, their applicability should be decided in consultation with modifier producers.

Note 7 -- MP1 grades binders on the basis on their performance capabilities at low temperatures typically (less than -10°C) and high temperatures typically (greater than 52°C) pavement temperatures. Grading is based on the properties of the asphalt binder aged to simulate a pavement service period of nominally five to ten years. Asphalt binders must meet the same specification property limits across the entire range of pavement service temperatures.

8.2 Homogeneity:

8.2.1 Modified asphalt binders are generally multi-phase systems in which the modifiers are dispersed into the liquid asphalt cement phase. Many of these systems require a certain amount of incompatibility between the phases for the modifiers to provide any benefit, e.g., modifiers intended to disperse, not dissolve, in the base asphalt binder.

8.2.2 Excessive incompatibility is not desirable for proper storage and handling. Therefore, all modified systems should have a requirement for limiting separation of the modifier from the asphalt cement by

measurement of rheological properties after aging of the modified binder in the rolling thin film oven test.

8.2.3 Sections 8.3 and 8.4 present specific separation tests for type I and type II polymer modified asphalt binders. Actual limits should be reported when sufficient data exists to support such criteria. However, a separation test for one type of material may not provide appropriate data for other types. Consult modifier producers to determine

appropriate separation tests and test limits for their particular materials.

Note 8 -- These separation tests and the nomenclature are adapted from the Guide Specifications For Polymer Modified Asphalt. [1]²

8.3 Separation Test for Type I Polymer Modified asphalt binder:

8.3.1 Evaluate a type I polymer modifier from asphalt cement during hot storage by comparing the dynamic shear stiffness of the top and bottom samples taken from a conditioned, sealed tube of polymer modified asphalt binder. Condition the modifier by placing a sealed aluminum tube of polymer modified asphalt binder in a vertical position in a 165°C oven for a 48 hour period.

8.3.2 Place the empty aluminum tube with sealed end down in the rack and carefully heat the sample until sufficiently fluid to pour. Avoid localized overheating. Strain the fluid sample through a 0.300 mm sieve conforming to M92. After thorough stirring, pour 50.0 g into the vertically held tube. Fold the excess tube over two times, crimp and seal.

Note 9 -- Aluminum tubes (25.4 mm diameter by 139.7 mm length blind aluminum tubes) may be obtained from Sheffield Industries, P.O. Box 351, New London, CT 6320. Incidents have been reported regarding leakage of asphalt from the bottom of these tubes during the conditioning period. Other tubes may be required if this leakage is significant.

8.3.3 Place the rack containing the sealed tubes in a 163 ± 5°C oven. Allow the tubes to stand undisturbed in the oven for a period of 48 ± 1 hour.

²Number in brackets represents the reference given at the end of this procedure.