WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
MATERIALS CONTROL, SOILS AND TESTING DIVISION

MATERIALS PROCEDURE

QUALITY ASSURANCE OF BITUMINOUS PAVING MIXTURES

1.0 PURPOSE

1.1 To provide a method for daily monitoring and Quality Assurance of bituminous paving mixtures.

1.2 To provide guidelines for adequate acceptance plans.

1.3 To provide field personnel with criteria upon which to base decisions of accepting or rejecting material.

1.4 To provide field personnel with criteria upon which to base decisions of continuing or ceasing plant production.

1.5 To provide an equitable and uniform method for determining price adjustments in those instances where adequate production control has not been maintained and non-specification material has found its way into the completed work.

2.0 SCOPE

2.1 This acceptance procedure shall be applicable to hot laid bituminous concrete base, wearing, and patching and leveling courses relative to compliance with Plant Mix Formula (PMF) acceptance limits as specified in the governing specifications.

3.0 DEFINITIONS

3.1 LOT - The quantity material represented by the average of four (4) consecutive test values.

3.2 Sublot - The quantity of material represented by a test value.

3.3 Quality Control Samples and Tests - Those samples taken and tests conducted by the Producer/Contractor to monitor and control the production of this product.

3.4 Acceptance Samples and Tests - Those samples and tests conducted or utilized by the Division to determine specification compliance.

4.0 DOCUMENTATION

4.1 Forms and Distribution: All test data shall be supplied to the Division on data processing forms furnished by the Division. The original and one copy of the form will be delivered to the District Materials Supervisor, who will submit the original to this Division. One copy of each completed form is to be retained by the Contractor until the project is completed. Gradation tests and bitumen content will be recorded on Forms T-731 and T-732 in accordance with MP 700.03.01 with the following exception: The laboratory number, columns 2 thru 14, will start with the letter C for all control samples taken and tested by the Contractor. To be an effective Quality Control Program, tests must be completed in a regular and timely manner. The investigation shall determine the true quality of the material. The test results (either Contractor or Independent) which actually reflect the true quality of the material will be utilized for acceptance. The standards of acceptance will be applied to those test results in accordance with directives contained in this Materials Procedure.

5.0 ACCEPTANCE PLAN

5.1 The specifications state that acceptance sampling and testing is the responsibility of the Division. Quality Control tests by the Contractor may be obtained by the Division and used for acceptance. Therefore, acceptance may be accomplished by either conducting a sampling and testing program completely independent of the Contractor, by witnessing or reviewing tests performed by the Contractor, or by a combination of the two. In all

cases, some sampling and testing completely independent of the Contractor will be performed. The following are guidelines for a system which should result in sufficient confidence in the Contractor's documentation of his

Quality Control operations to permit acceptance of the material in accordance with the procedures set forth in the specifications.

5.1.1 Implement ML-25 for aggregate gradation.

5.1.1.1 The Division shall sample and test, and/or witness the Contractor's activities at a frequency equal to approximately 10% of the frequency for testing given in the Contractor's Quality Control Plan.

5.1.1.2 Plot the results of tests performed by the Division on the Contractor's Quality Control charts with a red circle, but do not include these values in the moving average. When the Contractor's tests are witnessed, circle his test result on the control chart with red. These values are used in the moving average calculations. Distribution of test data must be in accordance with 4.1 with the following exception: laboratory number, columns 2 thru 14 will start with an M for all independent samples taken and tested by the Division and will always start with a O for all of the Contractor's tests which are witnessed by the Division.

5.1.1.3 Evaluate the resultsa of independent tests (whether performed or witnessed by the Division) in the manner by which record samples are evaluated.

5.1.1.4 If the evaluation indicates similarity with the Quality Control test, the control chart would be considered acceptable to that point and authorization may be given to discard the samples being retained by the Contractor in accordance with ML-25.

5.1.1.5 If a dissimilarity is detected, an immediate investigation will be conducted to determine the cause. The intent of the investigation is to define and correct the problem with the Contractor's Quality Control Program. Until the situation is resolved, the samples held in accordance with ML-25 shall be retained.

6.0 PROCEDURE

6.1 General - The procedure to be used in acceptance and daily monitoring of asphaltic concrete production is a control chart procedure based upon a moving average of four (4) individual test values. The tolerance limits established by the governing specifications for sieve fractions shall fix the limits for control charts. The tolerance limits for bitumen content will be variable and established from the criteria set forth in this MP. The methods for control charting, corrective action and where necessary the adjustments of unit price, are set forth in the detailed instructions below:

6.2 Sampling Frequency

6.2.1 For the purpose of administration of this plan and the implementation of its provisions, the quantity of material represented by a sublot (individual test) shall be determined as follows:

6.2.2 The first sample taken after initiation of production under a specific formula shall represent the quantity produced from the beginning of production until the time the sample was taken.

The second sample shall represent that material produced between the time that the first and second samples were taken and so on. The last sample taken prior to a halt in production under a given formula shall represent that quantity of material produced from the time that the next to last sample was taken until production was stopped.

6.2.3 For the first day of plant operation under a specific mix formula, or the first day of production after a change in the formula, a minimum of four (4) samples shall be taken for the determination of particle size distribution and bitumen content for evaluation with the PMF.

6.2.4 For the second day of plant operation under conditions set forth by 6.2.3, a minimum of three (3) samples shall be taken for the evaluation of particle size distribution and bitumen content.

6.2.5 For the third day of plant operation under conditions set forth by 6.2.3, a minimum of two (2) samples shall be taken for the evaluation of particle size distribution and bitumen content.

6.2.6 For the fourth and subsequent days of plant operation under conditions set forth by 6.2.3, a minimum of one (1) sample per day shall be taken for evaluation of particle size distribution and bitumen content.

6.2.7 The selection of all samples shall be on a random basis utilizing randomization techniques established by Division documents.

6.3 Test Methods

6.3.1 Sampling and testing for evaluation of compliance with the PMF shall be as follows:

6.3.1.1 Determination of bitumen content will be in accordance with MP 401.02.20, with the following exception: A completely automatic plant with print-outs of bitumen and aggregate quantities which is accurately calculated, properly maintained, fully functional and operated in the automatic mode may use the print-out for determination of bitumen content. If any plant is operated in a semi-automatic or manual mode, then all provisions of this MP shall apply.

6.3.1.2 Gradation may be determined by testing the aggregate from a sample used to determine the bitumen content, or by testing samples taken from the separate, individual hot bins and recombined mathematically to determine gradation compliance. Hot bin samples shall be taken within 15 minutes of the time the bitumen content is taken. Each fifth (5th) hot bin sample shall be compared in accordance with ML-31 to a fully mixed sample from which the asphaltic content has been extracted and percentage of asphalt content and grading determined. If it is ascertained that a similarity exists, the procedure may be discontinued. If it is determined that a dissimilarity exists, hot bin samples for Quality Control shall be discontinued until the condition causing the

dissimilarity is established and corrected. Extracted and graded samples of the completed mix will be used. Each fifth (5th) hot bin sample comparison tests shall apply to all plants using that method of Quality Control. Hot bin samples shall be indicated on the control chart with the initials HB. Division acceptance may be by observation of any of the above procedures or by sampling from the truck in which material is being delivered to the project. Division record samples will, in all cases, be secured from a truck in which material is being delivered to the project.

6.4 Bitumen Content Tolerance

6.4.1 The bitumen content tolerance will be variable as established by the following formula:

$$\text{Upper Limit} = \text{PMB} + 0.6 - 0.45\ R_4$$
$$\text{Lower Limit} = \text{PMB} - 0.6 + 0.45\ R_4$$

Except that when the range is 1.3 or greater, the upper and lower limits shall be the PMF.

Where:
PMF - Plant Mix Formula in Percent

R_4 - Range in the last four (4) individual test values. Range is defined as the difference between the largest and smallest value obtained by the preceding four (4) results.

6.5 Control Charting Procedures

6.5.1 General

6.5.1.1 Control charting procedures shall apply to all samples and tests. Record samples shall be plotted as individual results, but not used in the moving averages or subsequent analysis.

6.5.2 Gradation

6.5.2.1 Control charts shall be maintained for all sieves in the PMF.

6.5.2.2 Plotting of Test Data - Individual test data shall be plotted with a blue color using the symbol "0". The moving average four (4) shall be plotted with a red color using the symbol "□". Individual values and moving averages of four (4) will be plotted on heavy vertical lines. Progress record samples shall be indicated with a green color using the symbol "▵".

District independent samples shall be indicated with a red color using the symbol "0". Hot bin samples shall be indicated by the initial HB above the appropriate symbol. Lines corresponding to the upper and lower limits of the individual screen PMB specifications shall be drawn in red across the graph. Inside the solid red lines, two green dashed lines shall be drawn. These lines shall be located parallel to the PMF lines at a distance from each specification line equal to approximately 20% of the PMF range. The band between the green dashed lines and the red specification lines shall be shaded in yellow to symbolize the caution which the Contractor should exercise to prevent the quality of his work from going outside the PMF specification limits. Individual test values and the moving average shall be rounded to the nearest whole percent point and plotted, except the 75μm sieve shall be rounded to the nearest one-tenth (0.1) of a percentage point and then plotted. At the bottom of the cross section paper and immediately to the left of the heavy vertical line on which test data is plotted, the following information shall be written:

6.5.2.2.1 The laboratory number assigned to the test.

6.5.2.2.2 The date and time sampled.

6.5.2.2.3 The quantity of material represented.

6.5.3 Bitumen Content

6.5.3.1 Control charts shall be prepared on a 10x10 cross section paper approximately 560 mm width. A chart length of approximately 760 mm shall be displayed at all times.

6.5.3.2 Scale - One division shall represent one-tenth (0.1) of a percentage point.

6.5.3.3 Plotting - The PMF shall be represented by a solid red line. Individual test values shall be plotted with a blue color using the symbol "0". The moving average of four (4) shall be plotted with a green color using the symbola"□a". Progress record samples shall be indicated with a green color using the symbol "▵".

District independent samples shall be indicated with a red color using the symbol "0". The upper and lower limits established from the formula in 6.4.1 shall be indicated with a dashed red line.

6.5.3.4 At the bottom of the chart and immediately to the left of the heavy vertical line, the following information shall be printed.

6.5.3.4.1 Laboratory number of individual test.

6.5.3.4.2 The date and time of sample.

6.5.3.4.3 The quantity of material represented.

6.5.4 Temperature

6.5.4.1 Bituminous concrete plants equipped with accepted temperature recording devices and charts or graphs, which are accurately calibrated, properly maintained, fully functional and operated in a recording mode, shall be exempt from the temperature charting requirements of this section. Plants not meeting the requirements of the above, shall prepare temperature control charts in the following manner: Temperature of the bituminous mix shall be taken from a loaded truck by the Contractor/ Producer. Minimum requirements are one (1) measurement

per hour. These measurements shall be indicated on the control chart using a blue color and the symbol "0". Average daily temperatures shall be plotted using a solid red line and the symbol "□a. The mix temperature target value and the upper and lower temperature limits shall be indicated with solid red lines. At the bottom of the chart and immediately to the left of the heavy vertical line shall be printed the date and quantity represented for the day, as well as the number of production hours.

6.5.4.2 Examples of the various control charts are included with this MP as Attachment #2.

6.5.4.3 Liquid Asphalt

Temperature control of the liquid asphalt is an important function of any Quality Assurance Program. Overheat of the liquid asphalt will cause the aggregate to have a thin film coating, an increase in absorption, an increase in viscosity, a loss of penetration with resulting decreases in the life and serviceability of the pavement. Specifications require a temperature range 121° to 163°C. While no temperature control chart will be required, the temperature of the liquid asphalt in the production tank shall be determined three times daily (a.m., noon, and p.m.) and documented in the plant diary. Temperature readings shall be taken from every load received during the production day. Should this temperature exceed 163°C, it may not be loaded into the storage tank being used for production. It shall be permissible, however, to unload it into a holding tank to cool until it has moderated to the permissible range of 121° to 163°C.

6.6 Decision Criteria - The procedures which follow apply to the general case where production is fairly uniform, beginning with the first day of operation. However, in situations where production is halted prior to the acquisition of four samples, the acceptance decision regarding the material shall be made on the test results available, unless otherwise directed by the engineer.

6.6.1 Should the moving average of four (4) individual test values for any screen in the sieve fractions or bitumen content fall outside the PMF tolerance, production shall be suspended until the producer takes necessary steps to bring production under control.

6.6.2 When the moving average of four (4) individual test values falls outside the tolerance limits, the quantity of material represented by the last individual test value in the moving average shall have its price reduced in accordance with the following schedule and procedure:

6.6.2.1 Sieve Fractions

When the moving average gradation test value is determined in accordance with the above and the average falls outside the limits of the specification, the last sublot shall have its price reduced in accordance with the schedule set forth in Table 2. In no event shall a sublot of material have its price reduced more than once, and the first reduction which is determined in accordance with this directive shall apply (except as set forth in 6.6.2.3)a

6.6.2.1.1 Degree of Non-Conformance

When a sublot of material is to have its price reduced, then the reduction shall be based on a degree of non-conformance which is calculated in the following manner:

6.6.2.1.2 The percentage point difference between the non-conforming test average of four samples (X_4) or the specification limit ($L-X_4$) or (X_4-U) shall be determined for each sieve which has its average value outside the limits of the specification, and this value shall be multiplied by its appropriate multiplication factor (M) as set forth in Table 1.

TABLE 1

Sieve Sizes	Multiplication Factor (M)
50 mm	1
37.5 mm	1
25.0 mm	1
19.0 mm	1
12.5 mm	1
9.5 mm	1
4.75 mm	1
2.36 mm	1
1.18 mm	1
600 μm	1.5
425 μm	1.5
300 μm	1.5
150 μm	2.0
75 μM	2.5

The above equation should be written thus: $M(L-X_4)$ or $M(X_4-U)$ where L is the lower limit of the specification, U is the upper limit of the specification, X is the particular average which is non-conforming and M is the multiplication factor assigned to the particular sieve on which the non-conformance occurs. The total measure of the non-conformance is the sum of the non-conformances on the various sieves which would be written thus:

$\Sigma M(L-X_4) + M(X_4-U)$ where Σ is a symbol which means summation.

6.6.2.1.3 Determination of Equitable Reduction

When the total measure of non-conformance is determined, then the corresponding equitable reduction or other specified action may be determined from Table 2.

TABLE 2

Degree of Non-Conformance $M(L-X_4)+M(X_4-U)$	Adjusted Unit Price
0 - 2.0	100
2.1 - 4.0	98
4.1 - 6.0	97
6.1 - 8.0	93
8.1 - 9.1	90
Greater than 9.1	See Note 1

Note: Make special evaluation of the material and determine appropriate action.

6.6.2.2 Bitumen Content

When the moving average falls outside the variable tolerance for bitumen content as set forth by Subsection 6.4, then the sublot of material represented is considered to be non-conforming. When a LOT of material is non-conforming, then the last sublot contained shall have its price reduced in accordance with the schedule set forth below.

In no event shall a sublot of material have its price reduced more than once, and the first reduction which is determined in accordance with this directive shall apply, (except as set forth in 6.6.2.3).

6.6.2.2.1 The degree of non-conformance shall be calculated using the following relationship:

When X_4 is greater than the PMF

$$Q_u = X_4 - UL$$

When X_4 is less than the PMF

$$Q_L = LL - X_4$$

Where UL = Upper Limit

LL = Lower Limit

X_4 = Moving average of four (4) individual test values.

If it is determined that the material is to be allowed to remain in place, then the price shall be reduced according to the following:

TABLE 3

QU or QL	Percent Contract Price to be Paid
0	100
0.1	95
0.2	90
Greater than 0.2	See Note 2

When QU or QL is equal to or greater than the value shown, then the percent of contract price shall be determined by reading across to the column labeled "Percent of Contract Price to be Paid".

Note 2: Make a special evaluation of the material and determine appropriate action.

6.6.2.3 Moving Average of Tolerance in Both Gradation and Bitumen Content.

6.6.2.3.1 Should the moving average of four (4) individual test values for both gradation and bitumen content for the same LOT fall outside of the PMF tolerance thus resulting in a reduced price for each then the following shall apply: The quantity of material of represented by the last sublot in the moving average will have an adjusted unit price which is the product of: The original price times the percent as result of gradation non-conformance times the percentage unit price as a result of bitumen content non-conformance. Expressed as a formula:

Where: AUP = OUP x PUPG x PUPB
AUP = Adjusted Unit Price
OUP = Original Unit Price
PUPG = Percent Unit Price as a result of Gradation Analysis expressed as a decimal
PUPB = Percent Unit Price as a result of Bitumen Content Analysis expressed as a decimal

6.6.3 Temperature Tolerance: The temperature of the completed mix, when measured at the plant, shall be within the tolerance as established by the PMF. The first load, which demonstrates temperatures outside of that range may be accepted provided that the temperature is within the master temperature range as established by the governing specifications. However, no additional loads of material shall be run out until necessary steps are taken to re-establish the temperature of the mix within the plant tolerance. When measured at the project site, the temperature of the mix shall not be less than the minimum tolerance established by the PMF. The first load of material which demonstrates temperatures below this minimum of any trucks in transit at that time may be accepted provided temperatures are within the master temperature range. However, the plant shall immediately be notified that no additional loads of material are to be dispatched until necessary action is taken to re-establish temperature within PMF specification limits.

6.7 Method of Accounting and Change Order Preparation

6.7.1 The matter of non-conformance will be considered to have been resolved when the reduced price has actually been applied and properly executed change order has been prepared to make the reduced price effective. These reductions in price may be processed with a single change order when the construction of the item is complete by tabulating the data and preparing the change order for the total dollar reduction shown on the tabulation.

A copy of the tabulation should accompany and be made a part of the change order. The equitable reductions shall be subtotaled for each contract pay period and the subtotaled amounts deducted from contract payments.

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Attachments

EXAMPLE

Given: The following tabulation of analysis data for a Wearing Course 1 material produced under one (1) mix design as shown. The unit bid price for this material is $12.00 per Mg.

Find: The percent (%) of contract price to be paid for the non-conforming sublot of material.

MC-14 #628635				100	85-98	56-66	36-46	27-37	5-13	1-7	Bitumen			
Sub-lot	Date	Report Number	Quantity Mg)	SIEVES							Bit	Range	LL*	UL*
				12.5	9.5	4.75	2.36	1.18	300 µm	75 µm				
1	9/16/71	M2-00001	26.8	100	86	55	36	27	7	1.1	5.5			
2	9/16/71	M2-00002	35.4	100	85	58	40	32	10	1.7	5.4			
3	9/16/71	M2-00003	30.9	100	88	59	42	33	9	1.6	5.6			
4	9/16/71	M2-00004	54.6	100	96	71	50	39	12	1.8	5.5			
	-	$\bar{X}_4$	-	100	89	61	42	33	10	1.6	5.5	0.2	5.4	6.4
5	9/17/71	M2-00005	94	100	96	71	50	38	10	1.6	5.4			
	-	$\bar{X}_4$	-	100	91	65	46	36	10	1.7	5.5	0.2	5.4	6.4
6	9/17/71	M2-00006	160.6	100	95	69	47	37	12	1.6	5			
	-	$\bar{X}_4$	-	100	94	68	47	37	11	1.6	5	0.6	5.6	6.2

* NOTE: Upper Limit (UL) and Lower Limit (LL) determined from 6.4.1.

Calculation: Review of control charts indicates acceptance criteria has been violated with the completion of sublot #6; as a result, the above tabulation has been made from which the necessary calculations may be made.

STEP 1 - Consideration of Gradation non-conformance (See 6.1.2.1.2)

4.75 mm Sieve - M (X_4-U) = 1 (68-66) = 2
2.36 mm Sieve - M (X_4-U) = 1 (47-46) = 1

M (X_4-U) + M (X_4-U) = 2+1 = 3 (total gradation non-conformance for sublot 6)

From Table 2 - PUPG = 98%

STEP II - Consideration of bitumen content non-conformance (See 6.6.2.2.1)

Q_L = 5.6 - 5.4 = 0.2 (bitumen non-conformance)

Where:

Q_L = degree of non-conformance from lower limit

From Table 3 - PUPB = 90%

STEP III - Calculation of final payment for sublot #6 (See 6.6.2.3.1)

AUP = OUP X PUPG X PUPB
= $12.00 X .98 X .90
= $10.58/Mg on sublot #6

Final payment for sublot #6 = $10.58 X 160.6 Mg = $1,699.15