

**ITEM 441 CONTRACTOR MIX DESIGN AND QUALITY CONTROL—
GENERAL**

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441.01 Description. This specification includes general requirements applicable to all types of asphalt concrete pavements where the Contractor is responsible for performing the mix design and quality control. Deviations from these general requirements will be covered in the specific requirements for each type. The requirements of Item 401 apply, except as follows.

Control all production processes to assure the Engineer that the mixture delivered to the paving site is uniform in composition, conforms to the specification requirements and that the placed mixture is free of any defect (ex. segregation, tenderness, lack of mixture and texture uniformity, raveling, flushing, rutting, holes, debris etc.) within the Contractor's control at project completion.

441.02 Composition Compose the asphalt concrete of approved aggregates, asphalt binder and, if required, other modifiers. Develop a JMF to comply with the mix design criteria and submit it to the Laboratory on approved forms at least two weeks prior to the start of production for preliminary approval. The Laboratory may perform additional tests on lab or plant produced mixtures to ensure adequate mix performance. Based on the results of these tests, the Laboratory may require the Contractor to design a new JMF. Allow time for this additional testing.

Perform the mix design and supply all required data in a manner taught in Level 2 Asphalt Technician school, Level 3 Asphalt Mix Design school and in the Asphalt Institute Manual Series No. 2. Use a 2-hour cure for all mix samples. Ensure the cure temperature and specimen compaction temperature are the same. Select the JMF asphalt binder content using the Design Air Voids and ensure the JMF meets the other requirements of Table 441.02-1. Provide a mix design with at least four asphalt binder content points, including a minimum of two points above and two points below the JMF asphalt binder content. Submit no more than two JMFs for each asphalt concrete pay item per project. Additional submittals are at the discretion of the Laboratory. Submit a 5-pound (2500 g) minimum uncompacted sample (all mixes) representing the JMF. Submit additional samples as requested by the Laboratory.

Do not start mix production without a preliminary JMF approval and 48 hour notification of the Laboratory. Final approval of a JMF will be based upon field

verification. Per 441.12 the JMF can be rejected for failure to verify in the plant or at the project.

Do not apply the gradation requirements of 703.05 for fine aggregate.

If the F/A ratio using total asphalt binder content is greater than 1.0 recalculate it using the effective asphalt binder content. Calculate the effective asphalt binder content according to Chapter 4 of the Asphalt Institute Manual Series No. 2. The value (calculated to the nearest percentage point) of the Fifty to Thirty (F-T) value, is the percent of total aggregate retained between the No. 50 (300 μm) and No. 30 (600 μm) sieves, minus the percent of total aggregate retained between the No. 30 (600 μm) and No. 16 (1.18 mm) sieves.

Identify the PG Binder supplier, as well as the polymer type if applicable, on the JMF submittal. A change in polymer asphalt binder or polymer source will require a redesign. Provide on one page neatly summarized, dated test results for the requirements of Table 702.01-1. Ensure data is no more than two months old. If SBR polymer is added at the asphalt concrete mixing plant, provide in the JMF data from the SBR polymer supplier for total solids (percent) and ash (percent) according to the 702.14. As well, provide the target amount of SBR polymer greater than or equal to 3.5 percent to achieve the properties specified. Include a letter of certification from the polymer supplier verifying percent butadiene in the SBS or SBR polymer. Report in the JMF submittal results of temperature-viscosity testing for mixing and compaction temperatures. For polymer asphalt binders supplier recommended temperatures may be used in lieu of the temperature-viscosity results, but the temperature-viscosity results must still be reported.

TABLE 441.02-1

Course	Surface Course			
	Traffic	Heavy	Medium	Light
1 1/2 inch (37.5 mm) ^[1]				
1 inch (25.0 mm) ^[1]				
3/4 inch (19.0 mm) ^[1]				
1/2 inch (12.5 mm) ^[1]		100	100	100
3/8 inch (9.5 mm) ^[1]		90 to 100	90 to 100	90 to 100
No. 4 (4.75 mm) ^[1]		50 to 72	50 to 72	50 to 72
No. 8 (2.36 mm) ^[1]		30 to 55	30 to 55	30 to 55
No. 16 (1.18 mm) ^[1]		17 to 40	17 to 40	17 to 40
No. 30 (600 μm) ^[1]		12 to 30	12 to 30	12 to 30
No. 50 (300 μm) ^[1]		5 to 20	5 to 20	5 to 20
No. 100 (150 μm) ^[1]		2 to 12	2 to 12	2 to 12
No. 200 (75 μm) ^[1]				
Asphalt Binder ^[2]		5.0 to 10.0	5.0 to 10.0	5.0 to 10.0
F/A Ratio, max. ^[3]		1.2	1.2	1.2
F-T Value ^[4]		+2	+2	
Blows ^[5]		75	50	35
Stability, min., pounds ^[5]		1800	1200	750
(N)		(8006)	(5338)	(3336)
Flow, 0.25 mm ^[5]		8 to 14	8 to 16	8 to 18
Design Air Voids ^[6]		4	3.5	3.5
VMA, min. ^[7]		16	16	16
Special Designation				
[1] Sieve, percent passing				
[2] Percent of total mix				
[3] Using effective asphalt binder content				
[4] Percentage points maximum				
[5] T 245				
[6] Percent, City Supplement 1036				
[7] Percent, City Supplement 1037				

TABLE 441.02-1 (CONTINUED)

Course	Intermediate Course	
	Heavy	Medium
1 1/2 inch (37.5 mm) ^[1]	100	100
1 inch (25.0 mm) ^[1]	95 to 100	95 to 100
3/4 inch (19.0 mm) ^[1]	85 to 100	85 to 100
1/2 inch (12.5 mm) ^[1]	65 to 85	65 to 85
3/8 inch (9.5 mm) ^[1]		
No. 4 (4.75 mm) ^[1]	35 to 60	35 to 60
No. 8 (2.36 mm) ^[1]	25 to 48	25 to 48
No. 16 (1.18 mm) ^[1]	16 to 36	16 to 36
No. 30 (600 μm) ^[1]	12 to 30	12 to 30
No. 50 (300 μm) ^[1]	5 to 18	5 to 18
No. 100 (150 μm) ^[1]	2 to 10	2 to 10
No. 200 (75 μm) ^[1]		
Asphalt Binder ^[2]	4.0 to 9.0	4.0 to 9.0
F/A Ratio, max. ^[3]	1.2	1.2
F-T Value ^[4]	+2	
Blows ^[5]	75	50
Stability, min., pounds ^[5]	1800	1200
(N)	(8006)	(5338)
Flow, 0.25 mm ^[5]	8 to 14	8 to 16
Design Air Voids ^[6]	4	4
VMA, min. ^[7]	13	13
Special Designation		
[1] Sieve, percent passing		
[2] Percent of total mix		
[3] Using effective asphalt binder content		
[4] Percentage points maximum		
[5] T 245		
[6] Percent, City Supplement 1036		
[7] Percent, City Supplement 1037		

441.03 Use of Reclaimed Pavement. Comply with the requirements of 401.04.

441.04 Antistrip Additive. If the proposed JMF contains any gravel coarse aggregate, or contains more than 25 percent natural sand, or contains more than 20 percent reclaimed asphalt concrete pavement containing gravel coarse aggregate, or is designed according to Item 442 conduct the following tests:

- A. Moisture damage potential test according to City Supplement 1051.
- B. Washed gradation according to AASHTO T 11 as modified by City Supplement 1004.
- C. Adherent fines test for each component according to ASTM D 5711.

Modify the mix with one of the following antistrip additives if the results of the moisture damage potential test show the Tensile Strength Ratio (TSR) of the asphalt concrete mix to be less than 0.80 for 442 mixes or 0.70 for all other mix types:

441.05

A. Liquid Antistrip Material. Include liquid antistrip material at a rate of 0.5 to 1.0 percent by weight of the asphalt binder. However, if 442 is specified, include liquid antistrip material at a rate of 0.50 to 1.25 percent by weight of the asphalt binder. Ensure the TSR of the asphalt concrete mix is greater than or equal to 0.80 after the addition of the liquid antistrip material.

B. Hydrated Lime. Include hydrated lime in the dry form at a rate of 1.0 percent by the dry weight of aggregate for asphalt concrete. Conform to AASHTO M 303, Type 1 for hydrated lime. Ensure the TSR of the asphalt concrete mix is greater than or equal to 0.80 after the addition of the hydrated lime. Provide the Engineer the following information for each shipment of hydrated lime: Letter of certification, Production date, Shipment date, Shipment destination, Batch or lot number and Net weight. The Laboratory may obtain samples of the hydrated lime at any time to verify quality. If the quality of the hydrated lime is in question, the Laboratory may require independent laboratory testing.

Include the antistrip additive in the mix design. Submit the following to the Laboratory with the proposed JMF:

- A. All TSR data (before and after the addition of the antistrip additive).
- B. Rate of addition of the liquid antistrip material, if used.
- C. If using liquid antistrip material submit product information, information on use by other State DOTs using the liquid antistrip material, and a letter of certification. If using hydrated lime submit certified test data showing the hydrated lime conforms to AASHTO M 303, Type 1.
- D. Results of the washed gradation test of the individual components of the mix used in determining the combined gradation.
- E. Results of the adherent fines testing for each component.

The Laboratory may perform additional tests on lab or plant produced mix according to City Supplements 1004 and 1051. If a change in the aggregate production is suspected, the City may require the Contractor to perform washed gradations on components and calculate adherent fines to determine the need for additional TSR review. Store and introduce antistrip additives into the plant according to City Supplement 1053. Obtain Laboratory approval of the antistrip additive storage and feed systems prior to the start of production.

Provide delivery tickets to the Engineer at the end of the project and at the end of each construction year on a multiple year project. The Engineer will verify the number of pounds of antistrip additive used is within 10 percent of the calculated amount of antistrip additive required for the total weight of asphalt binder, based on the JMF, used in the asphalt concrete.

441.05 JMF Field Adjustments. During production the Contractor may adjust the JMF gradation within the below limits without a redesign of the mixture. Limit adjustments of the JMF to conform to actual production, without a redesign of the mixture, to ± 3 percent passing the 1/2 inch (12.5 mm), No. 4 (4.75 mm), and No. 8 (2.36 mm) sieves and ± 1 percent passing the No. 200 (75 μ m) sieve. Do not exceed the limits in Table 441.02-1 in the adjusted JMF. The adjustment on the 1/2 inch (12.5 mm) sieve

applies only to the intermediate course mixes. Determine the need for any JMF gradation adjustments in the time specified. Should no adjustments be made, the City will base acceptance on conformance to the original JMF. After the time period specified, the City will allow no further adjustment of the JMF.

Should a redesign of the mixture become necessary, submit a new JMF according to the requirements for the initial JMF. A new acceptance lot will begin when a new JMF established by a redesign of the mixture becomes effective. Make any adjustment of this new JMF as provided for the original JMF. Record both the design JMF and the adjusted JMF in effect during production of an acceptance lot on the Quality Control Report for that lot. In the event that a new design JMF is proposed and approved, also make a notation on the ticket for the first load produced under the new design JMF.

441.06 Monitoring. The City will establish a Monitoring Team for the purpose of verifying all Contractor mixture production processes. Verification may be accomplished by obtaining split samples or independent samples from the plant or roadway. If the mixture quality verifies then production may continue. If mixture quality does not verify then the Monitoring Team and Contractor will cooperatively investigate and resolve the problem. Based on the Monitoring Team's review, the Engineer may at any time disallow production to continue.

441.07 Quality Control Program. Submit a Quality Control Program (QCP) according to 403.03. Include an example control chart per 441.10 with the QCP. Use quality control technicians working in the plant lab during all mixture production and that are approved by the City. Technician approval will be according to City Supplement 1041.

441.08 Testing Facilities. Provide testing facilities at the plant site conforming to City Supplement 1041.

441.09 Quality Control Tests. Perform quality control tests to control the asphalt concrete mix within the specifications. Ensure that these quality control tests measure the asphalt binder content, gradation, air voids, and Maximum Specific Gravity (MSG) according to the Contractor's approved QCP. Perform each quality control test a minimum of one time each half of a production day or night (two tests per production day or night), or one each 1400 tons (1300 metric tons), whichever is less.

Perform more sampling and testing than the minimum specified at the start of production. Additionally perform more sampling and testing than the minimum during production when the quality control tests show the asphalt concrete being produced is outside the warning bands as shown in the Contractor's approved QCP. Immediately resolve problems indicated by any out of warning band test and immediately retest to validate corrections have returned the materials to within the warning band limits. The Contractor may determine the method of testing of the asphalt concrete beyond the minimum specified, and will detail the methods technicians will follow in the Contractor's approved QCP.

Should additional testing as required above not be performed, the Engineer, after consultation with the Laboratory, will require the testing frequency be increased to all tests each two hours of production for the remainder of the project. If this occurs, the Engineer will request an opinion from the QCQC for action(s) against the technician

441.09

and/or Contractor including but not limited to warning, removal and/or a change of the facility to Unconditional Acceptance.

Record the results of every test performed.

Perform the required quality control tests as follows:

A. Asphalt Binder Content. Determine the asphalt binder content of a sample of asphalt concrete by performing an Asphalt Content (AC) Gauge test according to City Supplement 1043. Make all printouts available for review by the Monitoring Team at any time. Offset the AC Gauge for each JMF on each project at the project's start. Perform the offset using solvent extraction methods for every QC sample according to City Supplement 1038 and the AC Gauge Verification and Offset Record. Use solvent extraction according to City Supplement 1038 when an AC Gauge problem exists and for testing cooled samples that cannot adequately be tested in an AC Gauge test.

Total, for each day's production, the flow meter printouts for SBR polymer added at the asphalt concrete mixing plant. Calculate the percent of polymer versus neat asphalt binder in the mix each day and record on the TE-199. Hold calculation worksheets and printouts in the plant laboratory for review by the Monitoring Team. A +/- 0.2 percent tolerance from the target amount of SBR polymer will be used as a guide for an acceptable amount of SBR polymer, but will not be consistently low.

Determine the moisture content of the asphalt concrete for each AC Gauge test. Maintain the moisture content at 0.8 percent or less.

B. Gradation. Perform at least one gradation test each production day on aggregate remaining after removing the asphalt binder with a solvent from an asphalt concrete sample used in an AC Gauge test (solvent sample) or on aggregate remaining after removing the asphalt binder with a preapproved asphalt ignition oven according to City Supplement 1054 and from an asphalt concrete sample used in an AC Gauge test (ignition oven sample). Use only an asphalt ignition oven to obtain an aggregate sample from an asphalt concrete sample having a polymer modified PG Binder. The Engineer may make an exception for this for SBS polymer as long as no issues arise. Correct each solvent sample for ash. Perform all other gradations on solvent samples, ignition oven samples, or on samples obtained according to the Contractor's approved QCP.

The gradation results of all the sieves must be representative of the JMF. If the Contractor fails to control the entire gradation, the Laboratory may require a redesign according to 441.02.

When the F-T value is specified for a mix in 441.02 calculate it for each gradation analysis. Maintain the F-T value at +4 percentage points or less for these mixes.

Calculate the F/A ratio for every solvent sample or ignition oven sample analysis. Maintain the F/A ratio so no F/A ratio is greater than 1.2 for all mixes. Use the asphalt binder content determined by the AC Gauge for calculating the F/A ratio. If the F/A ratio is greater than 1.0, recalculate the F/A ratio using the effective asphalt binder content. Calculate the effective asphalt binder content on the calculation sheet using the asphalt binder content determined by the AC Gauge and attach it to the Quality Control Report. Use bulk and effective aggregate specific gravities and remaining values needed in the calculation from the approved JMF. Do not deviate from these values without the Laboratory's approval. If the F/A ratio is greater than 1.0 for ignition oven samples,

calculate the F/A ratio using the percent passing the No. 200 (75 μ m) sieve from a washed gradation of the ignition oven sample according to AASHTO T 30.

C. Air Voids and MSG. Determine the air voids of the asphalt concrete by analyzing a set of compacted specimens and a corresponding MSG determination. Use the MSG to calculate the air voids of the compacted specimens. Ensure that the cure temperature and specimen compaction temperature are the same. Use a 1-hour cure for all mix samples used in voids analysis. The Contractor may use a 2-hour cure time if voids are consistently near the low void warning band. In this case, use the 2-hour cure for all voids testing through the remainder of the project. For hot mix asphalt use the JMF lab compaction temperature. For warm mix asphalt according to 402.09 use a lab compaction temperature 30.0 °F (16.7 °C) less than the JMF lab compaction temperature for hot mix asphalt. Use a compaction temperature tolerance of +/- 5.0 °F (3.0 °C). Record on the TE-199 if the mixture produced was ran at the asphalt plant as a hot mix asphalt (HMA) or as a warm mix asphalt (WMA) produced according to 402.09 or another approved method.

Calculate the Voids in Mineral Aggregate (VMA) value for every set of compacted specimens according to City Supplement 1037.

Calculate the average of all the MSG determinations performed each production day and report this average on the Quality Control Report. When the range of three consecutive daily average MSG determinations is equal to or less than 0.020 average these three average MSG determinations to determine the Maximum Theoretical Density (MTD). After the MTD is established, compare all individual MSG determinations to the MTD

Whenever compacted specimens are to be made and an MSG determination is to be run, take a sample of sufficient size to run a corresponding AC Gauge test. When the air void and MSG test results are recorded reference them to the AC Gauge test of the sample.

D. Other Requirements. Supply proper containers and take two 1 quart (1 liter) asphalt binder samples from the first transport truck load of each different asphalt binder grade of the project before incorporation into the storage tank. Label the samples with binder grade, supplier, project number and date and retain them in the plant laboratory for future reference by the City. Discard the samples at the Project's Final Acceptance if not taken by the Monitoring Team.

Retain a split sample for each AC Gauge test and MSG test and all compacted specimens for monitoring by the City. Maintain MSG samples in the state described in ASTM D 2041, Section 9.2. The Contractor may dispose of the AC Gauge test samples after two days and all other split samples after seven days if the City does not process the split samples.

Measure the temperature of the mixture and record. Validate the results on the load tickets at least once during each hour of production.

The Contractor may conduct additional testing of any type. Record such additional testing along with all other quality control records and have these records readily available for the Monitoring Team's review. The Laboratory may observe, review, and approve the procedures at any time.

441.10

441.10 Control Charts. Maintain up to date control charts showing each individual test result and also the moving accumulative range as follows:

- A. Plot tests showing the percent passing for the 1/2 inch (12.5 mm), No. 4 (4.75 mm), No. 8 (2.36 mm), and No. 200 (75 μ m) sieves the percent asphalt binder content, the MSG and the percent air voids. Round all percentages to the nearest whole percent; except, round asphalt binder content, the No. 200 (75 μ m) sieve, and air voids to the nearest 0.1 percent.
- B. Show the out of specification limits specified in Table 441.10-1 and QCP Warning Band Limits on the control charts.
- C. Label each control chart to identify the project, mix type and producer.
- D. Record the moving accumulative range for three tests under each test point on the chart for air voids and asphalt binder content. Accumulative range is defined as the positive total of the individual ranges of two consecutive tests in three consecutive tests regardless of the up or down direction tests take. If more than the minimum required testing (i.e. two tests per production day or night, 441.09 first paragraph) is performed do not include the result in accumulative range calculations.

Stop production and immediately notify the Monitoring Team when either A or B occurs:

- A. Any two tests in a row or any two tests in two days are outside OF the specification limits of Table 441.10-1.
- B. Any four consecutive moving accumulative ranges greater than specification limits of 2.50 percent for air voids or 0.60 percent for asphalt binder content occur.

Any mixture sent to the paving site without stopping production and notifying the Monitoring Team when required by this specification will be considered non-specification material.

Do not restart production until an adequate correction to remedy problems is in place and the Monitoring Team is satisfied. Following a shutdown restart production in a manner acceptable to the Engineer. When production problems cannot be solved within one day after a plant shut down, a Contractor's representative holding a Level 3 Asphalt City approval is required to be at the asphalt plant until a full production day is achieved with results satisfactory to the Monitoring Team.

TABLE 441.10-1

Mix Characteristic	Out of Specification Limits
Asphalt Binder Content ^[1]	-0.3% to 0.3%
1/2 inch (12.5 mm) sieve ^[1]	-6.0% to 6.0%
No. 4 (4.75 mm) sieve ^[1]	-5.0% to 5.0%
No. 8 (2.36 mm) sieve ^[1]	-4.0% to 4.0%
No. 200 (75 µm) sieve ^[1]	-2.0% to 2.0%
Air Voids ^[2]	2.5 to 4.5
Air Voids ^[3]	3.0 to 5.0
MSG ^[4]	-0.012 to 0.012

[1] deviation from the JMF
[2] for Design Air Voids of 3.5%
[3] for Design Air Voids of 4.0%
[4] deviation from the MTD

441.11 Quality Control Reports. Use City Form TE-199 for the Quality Control Report. Record all test results on the Quality Control Report. Document all decisions regarding responses to test results on the Quality Control Report (referring to the particular test), including reasons why a particular problem may exist what action was taken to correct the problem (plant operation or testing), and what communication with City personnel took place. Submit one Quality Control Report to the Engineer no later than specified. Retain copies of all records documenting the quality control inspections and tests throughout the life of the Contract and furnish them to the Engineer on request.

441.12 Mixture Deficiencies. Control all production processes to assure the Engineer that the mixture delivered to the paving site is uniform in composition; within the specification requirements and limits; conforms to the JMF; and that the placed mixture is free of any defect (ex. segregation, tenderness, lack of mixture and texture uniformity, raveling, flushing, rutting, holes, debris etc.) within the Contractor's control. Correct obvious pavement problems according to 401.15. If any suspicion that other mixture composition or pavement problems exist, the Monitoring Team will conduct an initial investigation through review of data and sampling of the asphalt pavement. Should a City investigation determine that the Contractor's QCP is not controlling the mixture in a manner to achieve mixture quality as described above the Contractor quality control data may be rejected. In that case the City will conduct a thorough test investigation based on samples from the roadway and use those test results in determining disposition of the non specification material.

A mixture is not uniform in composition if multiple random non-specification individual tests or any four consecutive non-specification moving accumulative ranges exist. The mixture can be rejected, production can be stopped and/or a redesign can be called for by the City. The Laboratory will not approve any redesign it determines is unsatisfactory to provide acceptable mix performance. Submit this new design for approval according to 441.02 and at no additional cost to the City.

When any out of specification material, based on quality control tests not within the limits of Table 441.01-1, is sent to the paving site the Engineer will determine disposition of the material according to the City non specification material policy.