Kansas State University | Salina

QC/QA Asphalt Specifications Workbook

Certified Inspector Training Program

Kansas Department of Transportation

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Abbreviations Used in HOT MIX ASPHALT (HMA) CONSTRUCTION
(Quality Control/Quality Assurance (QC/QA))

	CERTIFICATIONS
NUC	Nuclear Meter Operators Certification
PO	Profilograph Operators Certification
QC/QA Asp	QC/QA Asphalt Specifications Certification
SF	Superpave Field Certification
	GENERAL
AASHTO	American Association of State Highway and Transportation Officials
JMF	Job Mix Formula
KT-Methods	Kansas Test Methods
MRC	Materials and Research Center at 2300Van Buren in Topeka, KS
QA	Quality Assurance (KDOT)
QC	Quality Control (Contractor)
RAP	Reclaimed Asphalt Pavement
RAS	Recycled Asphalt Shingles
SR	Superpave Recycle Mix
	SPECIFIC GRAVITIES
G_b	Specific Gravity of the Binder
G_{sb}	Bulk Specific Gravity of the Aggregate (smallest; includes water permeable voids)
G_{sa}	Apparent Specific Gravity of the Aggregate (largest; no permeable voids)
G_{se}	Effective Specific Gravity of the Aggregate
G_{mm}	Maximum Theoretical Specific Gravity of the Loose Hot Mix Asphalt
G_{mb}	Bulk Specific Gravity of the Compacted Mixture
$\%G_{mm}$	Mixture Bulk Density as a percentage of G_{mm}
	SUPERPAVE TERMINOLOGY
CAA	Coarse Aggregate Angularity
D/B	Dust to Effective Binder Ratio
FAA	Fine Aggregate Angularity ("U" Value)
N_{des}	Design Number of Gyrations
N_{ini}	Initial Number of Gyrations
N_{max}	Maximum Number of Gyrations
SE	Sand Equivalency
%TSR	Tensile Strength Ratio (from the Modified Lottman Test)
V_a	Percent Air Voids
VFA	Voids Filled with Asphalt
VMA	Voids in the Mineral Aggregate
	STATISTICS TERMINOLOGY
F&t test	Fisher and student t tests. Compare test results between Contractor and KDOT
LSL	Lower Specification Limit
LV	Lower Value
P_D	Density Pay Adjustment Factor
P_V	Air Voids Pay Factor
PWL	Percent Within Limits
Q	Quality Index
S	Sample Standard Deviation
USL	Upper Specification Limit

UV	Upper Value
$\overline{X}$	Average or Mean

QC/QA Asphalt Specifications

K-State Salina

Kansas Department of Transportation

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QC/QA Asphalt Specifications

Instructor:

Blair Heptig, P.E.
KDOT Bureau of Construction and Materials
Field Engineer

Kansas Department of Transportation

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QC/QA Asphalt Specifications

- Class Organization
- Ask, Tell, Help
- Test & Evaluation

➢Organization of Manual – items to tab

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APPENDIX Y (Specification Documents)

Modified Requirements – 15-MR0664

15-MR0664
Sheet 1 of 1

KANSAS DEPARTMENT OF TRANSPORTATION
SPECIAL PROVISION TO THE
STANDARD SPECIFICATIONS, EDITION 2015

SECTION 602

MODIFIED REQUIREMENTS – ASPHALT MIXTURES

Project Number: 25-77 KA-6995-01

The asphalt mix listed in **TABLE 1** has the following project mix requirements. [Reference **TABLE 602-1**, COMBINED AGGREGATE REQUIREMENTS].

TABLE 1: PROJECT MIX REQUIREMENTS

MIX CRITERIA	SR-12.5A (PG70-28)[1]
AGGREGATE:	
Coarse Angularity (min. %)	75
Uncompacted Voids-Fine (min. %)	42
Sand Equivalent (min. %)	40
Reclaimed Asphalt Pavement (RAP) (max. %)	25
RAP Bulk Specific Gravity	2.595
COMPACTION REVOLUTIONS:	
N_{ini} (level of compaction)	7 (≤91.5)
N_{des}	75
N_{max}	115
MIX:	
VFA	65 - 82

(1) Between 0 and 25% RAP may be used. Use the material milled from the project as the RAP source. The required binder and name shown below are based on the percent RAP used in the contract. The mix will be paid for at the bid price of SR-12.5A (PG70-28).

Percent RAP	Name
0	SM-12.5A (PG70-28)
1 - 15	SR-12.5A (PG70-28)
16 - 25	SR-12.5A (PG64-34)

For information only, the 20 year design lane traffic is 2.9 million ESALs.

6/5/23 C&M (BTH)

There will be test questions pertaining to this project special provision.

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APPENDIX Y (Specification Documents)

15-06007-R03 – Hot Mix Asphalt (HMA) Construction (QC/QA)

15-06007-R03
Sheet 1 of 30

KANSAS DEPARTMENT OF TRANSPORTATION
SPECIAL PROVISION TO THE
STANDARD SPECIFICATIONS, EDITION 2015

Delete SECTION 602, and replace with the following:

SECTION 602

HOT MIX ASPHALT (HMA) CONSTRUCTION
(Quality Control/Quality Assurance (QC/QA))

602.1 DESCRIPTION

Mix and place 1 or more courses of plant produced HMA mixture on a prepared surface as shown in the Contract Documents. Demonstrate quality control by providing the quality control testing.

BID ITEMS	UNITS
HMA Base (*)(**)(***)	Ton
HMA Surface (*)(**)(***)	Ton
HMA Overlay (*)(**)(***)	Ton
HMA Pavement (#) (##)	Square Yard
HMA Pavement (#) Shoulder	Square Yard
Emulsified Asphalt (****)	Ton
Asphalt Core (Set Price)	Each
Material for HMA Patching (Set Price)	Ton
Quality Control Testing (HMA)	Ton

*Mix Designation
**Grade of Asphalt Binder
***Shoulder
****Type and Grade of Emulsified Asphalt
Thickness
##Type of surface course HMA mixture

602.2 CONTRACTOR QUALITY CONTROL REQUIREMENTS

a. General. Provide qualified personnel and sufficient equipment complying with the requirements listed in Part V to conduct quality control testing that complies with Appendix B, Sampling and Testing Frequency Chart for Asphalt Construction Items for Quality Control/Quality Assurance Projects.

Allow the Engineer access to the Contractor's laboratory to observe testing procedures, calculations, test documentation and plotting of test results.

Calibrate and correlate the testing equipment with prescribed procedures, and conduct tests in compliance with specified testing procedures as listed in Part V.

Maintain a Quality Manual in the field laboratory showing the calibrations performed on all test equipment and when the next calibration is due for that equipment. As a minimum, follow the calibration/verification interval established in Table 2: HMA Materials Test Equipment in Section 5.2.7.1-HMA: Contractor's Quality Control Plan, Part V. See also, Section 5.2.7.3-Example of a Laboratory Quality Manual for HMA, Part V.

Store and retain the most recent 2 lots per mix designation of quality control samples for KDOT. KDOT will retain the most recent 2 lots per mix designation gyratory compacted air voids (Va) verification samples and the remaining material not previously used for testing (back half of sample). Do not retain more than the previous 3 lots per mix designation of quality control or verification samples. When the hot mix plant shuts down for the winter, discard the samples after 7 days.

b. Quality Control Plan (QCP). At the pre-construction conference, submit to the Engineer for approval, a QCP as outlined in Section 5.2.7-Contractor's Quality Control Plan, Part V. Follow 5.2.7.1-HMA: Contractor's Quality Control Plan in Part V as a general guideline. The Contractor's laboratory and equipment will be inspected and approved as outlined in Section 5.2.7-Contractor's Quality Control Plan, Part V.

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APPENDIX Y (Specification Documents)

15-11002-R01 – Aggregates for Hot Mix Asphalt (HMA)

15-11002-R01
Sheet 1 of 5

KANSAS DEPARTMENT OF TRANSPORTATION
SPECIAL PROVISION TO THE
STANDARD SPECIFICATIONS, 2015 EDITION

Delete the entire SECTION 1103 and replace with the following:

SECTION 1103

AGGREGATES FOR HOT MIX ASPHALT (HMA)

1103.1 DESCRIPTION

This specification covers the quality, composition and gradation requirements of aggregates for hot mix asphalt (HMA) on QC/QA projects.

1103.2 REQUIREMENTS

a. Composition Individual Aggregates. Use aggregate from each source that complies with the gradation requirements listed in **TABLE 1103-1 and 1103-2**.

(1) Crushed Aggregates. Limit crushed aggregates to the following materials.

(a) Produce Crushed Stone (CS-1) and Crushed Stone Screenings (CS-2) by crushing limestone, sandstone, porphyry, (rhyolite, basalt, granite, and Iron Mountain Trap Rock are examples of porphyry) or other types of stone.

(b) Produce Crushed Gravel (CG) by crushing siliceous gravel containing not more than 15% non-siliceous material. If 95% or more of crushed gravel is retained on the #8 (2.65 mm) sieve, then the material must have a minimum Uncompacted Void Content of Coarse Aggregate (UVA) value of 45 when tested in accordance with KT-80. Testing will be the same frequency as KT-50. Do not use material with a UVA value less than 45.

(c) Provide Chat (CH-1) obtained during the mining of lead and zinc ores in the tri-state mining district.

(d) Consider materials complying with Mineral Filler Supplements MFS-1, MFS-2, MFS-4, and MFS-7 as crushed aggregate.

(e) Produce Crushed Steel Slag (CSSL) by crushing electric furnace steel slag. Some sources of steel slag are angular when produced and may be treated the same as crushed gravel and manufactured sand. Use steel slag with an Uncompacted Void Content of the Fine Aggregate "U" Value, determined by test method KT-50, of more than 42and the Coarse Aggregate Angularity greater than the minimum specified value. The maximum allowable quantity of crushed steel slag is 50% of the total aggregate weight.

(f) Manufactured sand shall have an Uncompacted Void Content of the Fine Aggregate "U" Value, determined by test method KT-50, greater than or equal to 42. Produce manufactured sand by crushing siliceous sand and gravel (designate as crushed gravel (CG-2, CG-3, etc) in the mix design), or by washing or screening crushed stone (designate as crushed stone (CS-2, CS-3, etc) in the mix design), or by washing or screening chat (designate as chat (CH-2, CH-3, etc) in the mix design).

(2) Uncrushed Aggregates. Limit uncrushed aggregates to the following materials.

(a) Produce Sand-Gravel (SSG) by mixing natural sand and gravel formed by the disintegration of siliceous and/or calcareous materials.

(b) Provide Natural Sand consisting of particles formed by the natural disintegration of siliceous and/or calcareous materials. Use natural sand with an Uncompacted Void Content "U" value of less than 42.

(c) Provide Grizzly (Grizzly Waste) consisting of the matrix or bedding material occurring in conjunction with calcitic or dolomitic cemented sandstone "Quartzite", generally separated from the sandstone prior to crushing.

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APPENDIX Y (Specification Documents)

15-12001-R01 – General Requirements for Division 1200 – Asphalt Materials

15-12001-R01
Sheet 1 of 1

KANSAS DEPARTMENT OF TRANSPORTATION
SPECIAL PROVISION TO THE
STANDARD SPECIFICATIONS, 2015 EDITION

Delete SECTION 1201 and replace with the following:

SECTION 1201

GENERAL REQUIREMENTS FOR DIVISION 1200 – ASPHALT MATERIALS

1201.1 DESCRIPTION

This specification covers general requirements for asphalt materials specified in **DIVISION 1200**.

1201.2 REQUIREMENTS

a. Storage and Heating. Provide storage tanks, pipelines and loading facilities for asphalt materials that are equipped with adequate heating equipment that will not damage the material.

b. Shipping Facilities. Provide shipping containers that are equipped with appropriate hoses and pumps, are insulated and are equipped for heating the contents when requested by the KDOT. Do not heat asphalt materials in transit by open flame heaters on tank trucks.

Before loading, examine the shipping container and remove all remnants of previous cargoes that might contaminate the material to be loaded.

For each shipment to KDOT projects, maintain a loading log showing the following items: contract or project number, date, time, ticket number, shipping container number, contractor, grade and quantity. Mail a copy of the log to the Engineer of Tests monthly during the shipping season.

c. Weighing Equipment. For quantities measured by weight, provide a scale having a platform of adequate length to weigh the longest truck or truck-trailer combination in one operation. Calibrate the scales through the range of use by an approved scale company as often as necessary to verify their accuracy, with intervals not greater than six months. For manufacturers not operating through the winter, calibrate the scales before the production season and thereafter at intervals not greater than 6 months for the duration of the production season. Provide a copy of the calibration report to the Engineer of Tests.

d. Sampling and Inspection.

(1) General. The Engineer will perform the sampling of asphalt materials. Permit inspection of all tanks, tank cars, tank trucks, blending units, loading lines and other items relating to the production and loading of asphalt materials being shipped to KDOT work.

(2) Tests by Producer. Provide a testing laboratory with laboratory and sampling equipment complying with the appropriate AASHTO or ASTM specifications to be available to all production and terminal facilities servicing KDOT projects. The laboratory must be staffed with competent personnel who can conduct tests to verify all asphalt material intended for shipment to KDOT projects complies with the specifications before it is shipped. Perform testing necessary to maintain continuous quality control.

The minimum quality control testing and reporting requirements for each product that is shipped to KDOT projects is described in the following sections.

e. Performance Graded Asphalt Binder (PGAB).

(1) Definition of testing levels.

Complete AASHTO Specification Compliance (SC) test for PGAB:

Original Binder:

Flash Point (COC)
Brookfield Viscosity, 275°F
Dynamic Shear

APPENDIX Y (Specification Documents)

15-12002-R01 – Performance Graded Asphalt Binder

15-12002-R01
Sheet 1 of 1

KANSAS DEPARTMENT OF TRANSPORTATION
SPECIAL PROVISION TO THE
STANDARD SPECIFICATIONS, 2015 EDITION

Delete SECTION 1202 and replace with the following:

SECTION 1202

PERFORMANCE GRADED ASPHALT BINDER

1202.1 DESCRIPTION

This specification covers performance graded asphalt binder (PGAB).

1202.2 REQUIREMENTS

a. Provide material* that complies with the applicable requirements of **SECTION 1201** and AASHTO M 320. Direct tension failure strain requirements are not applicable. All binders must have $\Delta Tc \geq -5.0°C$ as defined by ASTM D 7643 after 40 hours of conditioning in the pressure aging vessel (PAV). Binders with a temperature spread of 92°C or greater and any polymer modified binder with a temperature spread of 86°C must meet the additional requirements shown in **TABLE 1202-1**.

*Perform all tests after adding 0.5% high molecular weight amine antistripping agent (by weight) to the PGAB. Contact the Chief Chemist, Bureau of Construction and Materials, for a list of acceptable high molecular weight amines.

TABLE 1202-1: ADDITIONAL REQUIREMENTS

Temperature Spread [1], °C	86	92	98	104	110
Separation, ASTM D7173, °C max. Run on Original Binder	2	2	2[2]	2	2
Elastic Recovery, ASTM D 6084, Procedure A, % min. Run on RTFO Residue	50	60	65	75	80

[1] Temperature Spread is determined by subtracting low temperature from high temperature; for example PG 64-28: 64-(-28) = 92
[2] For PG 70-28 RCI, separation test requirement no greater than 6.

b. Provide the grade of material designated in the Contract Documents. KDOT will not make changes in the grade of asphalt. The Contractor may substitute PGAB that complies with or exceeds the upper and lower grade designations for the grade specified. For example, if a maintenance overlay specifies a PG 58-22, a PG 64-22 or a PG 58-28 will also be accepted. Such substitutions require advance approval by the Engineer and a no-cost change order.

1202.3 TEST METHODS

Test according to the applicable provisions of ASTM D 7173, D 6084 and AASHTO T 48, T 240, T 313, T 315, T 316, and R 28. Use a PAV aging temperature of 90°C for binders designated PG52-xx and a temperature of 100°C for all other grade designations.

For PG 70-28 RCI prequalification, provide test data utilizing the binder in a mix that meets the criteria in Table 614-1 and passes the criteria in Table 614-5 in Section 614 (latest revision).

1202.4 PREQUALIFICATION

Prequalify material according to **SECTION 1201**.

1202.5 BASIS OF ACCEPTANCE

See applicable requirements under **SECTION 1201**.

05-07-21 C&M (RAB)/Sept-21 Letting

APPENDIX Z (Part V Documents)

Part V – 5.2.1 Statistics

Table 2 for Estimation of Lot Percent Within Limits
Variability Unknown Procedure
Standard Deviation Method

Quality Index Q_U or Q_L	Percent Within Limits for Selected Sample Sizes N=3	N=4	N=5	N=6	N=7	N=8	N=9	N=10	N=15	N=20	N=30	N=50	N=100
0.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
0.01	50.28	50.33	50.36	50.37	50.37	50.38	50.38	50.38	50.39	50.39	50.40	50.40	50.40
0.02	50.55	50.67	50.71	50.73	50.75	50.76	50.76	50.77	50.78	50.79	50.79	50.79	50.80
0.03	50.83	51.00	51.07	51.10	51.12	51.14	51.15	51.15	51.17	51.18	51.19	51.19	51.19
0.04	51.10	51.33	51.42	51.47	51.50	51.51	51.53	51.54	51.56	51.57	51.58	51.59	51.59
0.05	51.38	51.67	51.78	51.84	51.87	51.89	51.91	51.92	51.95	51.96	51.98	51.98	51.99
0.06	51.65	52.00	52.13	52.20	52.24	52.27	52.29	52.30	52.34	52.36	52.37	52.38	52.39
0.07	51.93	52.33	52.49	52.57	52.62	52.65	52.67	52.69	52.73	52.75	52.76	52.78	52.78
0.08	52.21	52.67	52.85	52.94	52.99	53.03	53.05	53.07	53.12	53.14	53.16	53.17	53.18
0.09	52.48	53.00	53.20	53.30	53.37	53.41	53.43	53.46	53.51	53.53	53.55	53.57	53.58
0.10	52.76	53.33	53.56	53.67	53.74	53.78	53.82	53.84	53.90	53.92	53.95	53.96	53.97
0.11	53.04	53.67	53.91	54.04	54.11	54.16	54.20	54.22	54.29	54.31	54.34	54.36	54.37
0.12	53.31	54.00	54.27	54.40	54.49	54.54	54.58	54.60	54.67	54.70	54.73	54.75	54.76
0.13	53.59	54.33	54.62	54.77	54.86	54.92	54.96	54.99	55.06	55.09	55.12	55.14	55.16
0.14	53.87	54.67	54.98	55.14	55.23	55.29	55.34	55.37	55.45	55.48	55.52	55.54	55.55
0.15	54.15	55.00	55.33	55.50	55.60	55.67	55.71	55.75	55.84	55.87	55.91	55.93	55.95
0.16	54.42	55.33	55.69	55.87	55.97	56.04	56.09	56.13	56.22	56.26	56.30	56.32	56.34
0.17	54.70	55.67	56.04	56.23	56.35	56.42	56.47	56.51	56.61	56.65	56.69	56.71	56.73
0.18	54.98	56.00	56.40	56.60	56.72	56.79	56.85	56.89	56.99	57.04	57.08	57.11	57.12
0.19	55.26	56.33	56.75	56.96	57.09	57.17	57.23	57.27	57.38	57.43	57.47	57.50	57.52
0.20	55.54	56.67	57.10	57.32	57.46	57.54	57.60	57.65	57.76	57.81	57.85	57.89	57.91
0.21	55.82	57.00	57.46	57.69	57.83	57.92	57.98	58.03	58.15	58.20	58.24	58.27	58.30
0.22	56.10	57.33	57.81	58.05	58.20	58.29	58.36	58.40	58.53	58.58	58.63	58.66	58.69
0.23	56.38	57.67	58.16	58.41	58.56	58.66	58.73	58.78	58.91	58.97	59.01	59.05	59.07
0.24	56.66	58.00	58.52	58.78	58.93	59.03	59.11	59.16	59.29	59.35	59.40	59.44	59.46
0.25	56.95	58.33	58.87	59.14	59.30	59.41	59.48	59.53	59.67	59.73	59.78	59.82	59.85
0.26	57.23	58.67	59.22	59.50	59.67	59.78	59.85	59.91	60.05	60.11	60.17	60.21	60.23
0.27	57.51	59.00	59.57	59.86	60.03	60.15	60.23	60.28	60.43	60.49	60.55	60.59	60.62
0.28	57.80	59.33	59.92	60.22	60.40	60.52	60.60	60.66	60.81	60.87	60.93	60.97	61.00
0.29	58.08	59.67	60.28	60.58	60.77	60.89	60.97	61.03	61.19	61.25	61.31	61.35	61.38
0.30	58.37	60.00	60.63	60.94	61.13	61.25	61.34	61.40	61.56	61.63	61.69	61.73	61.76
0.31	58.65	60.33	60.98	61.30	61.50	61.62	61.71	61.77	61.94	62.01	62.07	62.11	62.14
0.32	58.94	60.67	61.33	61.66	61.86	61.99	62.08	62.14	62.31	62.38	62.45	62.49	62.52
0.33	59.23	61.00	61.68	62.02	62.22	62.35	62.45	62.51	62.69	62.76	62.82	62.87	62.90
0.34	59.51	61.33	62.03	62.38	62.58	62.72	62.81	62.88	63.06	63.13	63.20	63.25	63.28
0.35	59.80	61.67	62.38	62.73	62.94	63.08	63.18	63.25	63.43	63.51	63.57	63.62	63.65
0.36	60.09	62.00	62.72	63.09	63.31	63.45	63.54	63.62	63.80	63.88	63.95	63.99	64.03
0.37	60.38	62.33	63.07	63.45	63.67	63.81	63.91	63.98	64.17	64.25	64.32	64.37	64.40
0.38	60.67	62.67	63.42	63.80	64.02	64.17	64.27	64.35	64.54	64.62	64.69	64.74	64.77
0.39	60.97	63.00	63.77	64.16	64.38	64.53	64.63	64.71	64.90	64.98	65.06	65.11	65.14
0.40	61.26	63.33	64.12	64.51	64.74	64.89	65.00	65.07	65.27	65.35	65.42	65.47	65.51
0.41	61.55	63.67	64.46	64.86	65.10	65.25	65.36	65.43	65.63	65.72	65.79	65.84	65.88
0.42	61.85	64.00	64.81	65.21	65.45	65.61	65.71	65.79	66.00	66.08	66.15	66.21	66.24
0.43	62.15	64.33	65.15	65.57	65.81	65.96	66.07	66.15	66.36	66.44	66.52	66.57	66.61
0.44	62.44	64.67	65.50	65.92	66.16	66.32	66.43	66.51	66.72	66.80	66.88	66.93	66.97

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PWL Table
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APPENDIX Z (Part V Documents)

Part V – 5.8.3. Segregation Check Using the Nuclear Density Gauge

5.8.3. SEGREGATION CHECK USING THE NUCLEAR DENSITY GAUGE

1. OBJECTIVE

The objective of these instructions is to give guidance on establishing a density profile behind the laydown machine. This is accomplished by taking multiple readings within a 50 foot (15 m) section. Use the nuclear density gauge results to plot a density profile. Check the profile for a drop in density caused by segregation. Check the roadway profile location for visible segregation. It is important to record the profile location to permit possible future evaluation of the segregated section. It is intended that English projects use English values and that metric projects use metric values.

2. PROJECT STARTUP

NOTE: Check gauge to verify it is in asphalt mode.

At the start of the project, allow the paving unit 1000 ft (300 m) progress with each mix designation before implementing a profile analysis.

3. SELECTION OF PROFILE LOCATIONS

It is intended that visibility identifiable segregated areas be profiled. Two basic types of segregation are encountered on the roadway. They are truck load segregation and longitudinal segregation.

- Truck load segregation (spot, chevron, or gull wing type segregation) has a visible pattern repeated with each truck load. These segregated areas are about the same longitudinal distance apart. This type of segregation will normally occur 10 to 25 ft (3 to 7.5 m) from the screed stop point when trucks dump directly into the paver. The use of a material transfer vehicle (MTV) has been known to extend this further down the paving section.

- Longitudinal segregation (streaking) is normally caused by the paver. This streaking is parallel to the centerline of the project, and may occur contimually, or may periodically start and stop.

If the laydown machine continues to progress without stops, then the engineer will establish profile starting points.

If the laydown machine periodically stops, then use the location where the screed stops as the "zero" point for the profile starting point. The Engineer should use caution on whether to run a profile if the laydown machine has been stopped for more that 10 minutes, due to cooling of the mix.

4. LOCATION OF DENSITY READINGS

Take readings approximately every 5 ft (1.5 m) along the longitudinal direction. The first reading should be located approximately 10 ft (3 m) behind the screed (zero point). If a segregated location is visible between two locations, then take an additional reading at that location.

- When checking for truck load segregation, the longitudinal distance from centerline may vary, but not the transverse distance (see **Figure 1**).

- When checking for longitudinal streaking, the longitudinal distance from centerline will vary.

This is done so the profile will cross over the longitudinal streaks. Determine the transverse distance from centerline to the longitudinal segregation. Start the profile approximately 2 ft (0.6 m) farther

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APPENDIX Z (Part V Documents)

Segregation Check Points

603.02
Sheet 1 of 5

SEGREGATION CHECK POINTS

STOCKPILES

- Avoid HIGH DRY CONES of coarse material. They guarantee segregation, it's just a question of how much..
- Low, flat piles or individual truck dumps are better.
- Visual inspection should detect stockpile segregation.

LOADING COLD BINS

- Some stockpile segregation can probably be corrected by the front end loader operation, but don't depend on it.
- The bins should be loaded evenly. Avoid the pile it high - run it dry syndrome. Cones and lop-sided loads will segregate just as they do in the stockpile.
- DO NOT allow material to slop over from one bin to the other.

COLD BIN OPERATION

- Bin openings should be high enough to prevent clogging. A large opening and a slow belt is the best combination.
- If one bin cannot properly handle the necessary material, you may have to split it into two bins.
- "Overworked" bins are prime sources of segregation.
- Gobs of wet material - for example: sand - should be smoothed out with a drag chain or other suitable means.

COLD FEED CONVEYORS

- Material coming off the end of a belt will segregate. The coarse material will be thrown out further than the fine.
- This is particularly obvious when one belt feeds another at an angle. Plates, baffles or other appropriate devices are necessary to prevent belt end segregation.
- Any segregation up to this point will show up on the cold feed belt going into the drum or dryer.
- Careful sampling at this point is very important - it can identify and/or isolate several potential sources of segregation.
- Remember, segregation can occur both along and across the belt. Proper sampling can detect either or both.

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APPENDIX Z (Part V Documents)

Part V – 5.8.4. Joint Density Evaluation Using the Nuclear Density Gauge

5.8.4. JOINT DENSITY EVALUATION USING THE NUCLEAR DENSITY GAUGE
(For English projects use English units)
(For metric projects use metric units)

1. OBJECTIVE

The objective of these instructions is to give procedures for evaluating traveled way joint density. This is accomplished by taking two or three readings in the transverse direction one paver width wide. The traveled way joint density, either one or two locations, is subtracted from the interior density and the difference in density compared to the allowable limits. It is important to record the profile location to permit possible future evaluation of this location.

2. PROJECT STARTUP

NOTE: Check gauge to verify it is in asphalt mode.

At the start of the project, allow the paving unit 1000 ft (300 m) progress with each mix designation before implementing the joint density evaluation. During this initial 1000 ft (300 m) the contractor should be establishing laydown and compaction procedures and training personnel. The contractor should make preliminary nuclear gauge evaluations of their procedures.

3. SELECTION OF JOINT DENSITY EVALUATION LOCATIONS

A lot is defined as the distance paved with each mix designation per day. Determine the number of sublots from **Table 1**. Make each sublot approximately the same length. Randomly select one longitudinal location within each sublot.

Table 1. Determination of Number of Sublots Per Day

Distance Paved		Number of Sublot
English (ft)	Metric (m)	
0 - 500	0 - 150	0
501 - 1000	151 - 300	1
1001 - 2000	301 - 600	2
2001 - 3000	601 - 900	3
3001 - 4000	901 - 1200	4
4001 and greater	1201 - and greater	5

At each sublot longitudinal test location, determine the nuclear density on the traveled way at two or three transverse locations. (See **Figures 1 and 2**) Sublot joint density evaluation will be completed before compaction is completed in the third sublot. (Second sublot evaluated before fourth sublot compaction completed. Third sublot evaluated before fifth sublot completed.)

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APPENDIX Z (Part V Documents)

Part V – Appendix B Sampling and Testing Frequency Chart

SAMPLING AND TESTING FREQUENCY CHART
CONTRACTOR QUALITY CONTROL TESTING

CONSTRUCTION OR MATERIAL TYPE 2015 Std. Spec. (SS 2015)	TESTS REQUIRED (RECORDED TO)	TEST METHOD	CODE	QUALITY CONTROL BY CONTRACTOR	CODE	VERIFICATION BY KDOT
DIVISION 600						
HMA (Plant Mix) Sec. 602, 603, 611 & 1103						
Individual Aggregates	Sieve Analysis of Aggregate (1%, 0.1% for No. 200 [75 μm] sieve, of mass)	KT-02	c	1 per 1000 TONS (1000 Mg) for each individual aggregate.		1 during the first 5000 TONS (5000 Mg) of HMA produced for each individual aggregate.
	Clay Lumps and Friable Particles in Aggregate (0.1 g or 0.01% of mass)	KT-07	c h			As required.
	Shale or Shale-Like Materials in Aggregate (0.1 g or 0.01% of mass)	KT-08	c h			As required.
	Sticks in Aggregate (0.01% of mass)	KT-35	c h			As required.
	Uncompacted Void Content of Fine Aggregate (0.1%)	KT-50	l	1 on the first lot then 1 per 10,000 TONS (10,000 Mg) of crushed gravel.		1 during the first 5000 TONS (5000 Mg) of HMA produced.

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APPENDIX Z (Part V Documents)

Part V – KT-25 Sampling and Splitting Plant Mixed Asphalt Mixtures

5.9.25 SAMPLING AND SPLITTING PLANT MIXED ASPHALT MIXTURES
(Kansas Test Method KT-25)

1. SCOPE

This method covers the procedure for sampling plant mixed asphalt mixtures from truck beds, continuous mix plants, and roadways. The procedure for sampling from trucks may be followed when sampling asphalt mixtures from other containers or in stockpiles. **KT-25** reflects testing procedures found in **AASHTO T 168**.

2. REFERENCED DOCUMENTS

2.1. AASHTO T 168; Standard Method of Test for Sampling Bituminous Paving Mixtures

2.2. AASHTO R-47; Standard Practice for Reducing Samples of Hot Mix Asphalt (HMA) to Testing Size

3. APPARATUS

3.1. Square pointed shovel or scoop.

3.2. Sampling Devices.

3.2.1. Plants shall be equipped with sampling devices capable of providing a sample of sufficient size from the full width of the mixer discharge flow. Sampling devices shall be designed so those samples may be taken while the plant is operating at normal production rates.

3.2.2. A container that will hold a minimum of 55 lb (25 kg) of loose, hot asphalt mixtures. The container should be equipped with a handle or handles that will permit it to be easily carried.

4. SAMPLING PROCEDURE

4.1. Plant Discharge.

4.1.1. Drum plants shall be capable of sampling at the discharge outlet. When a sample is taken at the discharge, the sampling container shall be of sufficient size to accommodate the entire stream uniformly. If a by-pass chute is utilized, a representative sample shall be obtained.

4.1.2. Take the sample in at least three increments to obtain the total sample. Combine the increments and mix thoroughly.

4.1.3. The combined sample size shall be at least four times the amount required for testing.

4.2. Truck Beds.

4.2.1. Divide the truck bed into at least three areas of approximately equal size.

4.2.2. Dig a hole about 1 ft (0.3 m) deep at a point that will be representative of each area.

4.2.3. Take a sample weighing 4 to 6 lb (2 to 3 kg) near the bottom of each hole, taking care to prevent segregation.

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QC/QA Asphalt Specifications
Special Provision 15-06007-R03 Outline

602.1	**Description (Sheet 1 of 30)**
602.2	Contractor QC Requirements (Sheets 1 to 4 of 30)
602.3	Materials (Sheets 4 to 8 of 30)
602.4	Construction Requirements (Sheets 8 to 14 of 30)
602.5	Process Control (Sheets 14 to 17 of 30)
602.6	Compaction Testing (Sheets 17 to 19 of 30)
602.7	Weather Limitations (Sheet 19 of 30)
602.8	Mixture Acceptance (Sheets 19 to 22 of 30)
602.9	Basis of Acceptance (Sheets 22 to 25 of 30)
602.10	HMA Paid by the Area (Sheets 25 to 29 of 30)
602.11	Measurement and Payment (Sheets 29 to 30 of 30)

Kansas Department of Transportation

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602.1 DESCRIPTION
Introduction to Superpave

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602.1 DESCRIPTION

OBJECTIVES

- Understand which HMA bid items are used on different types of construction projects
- Identify the components used in the naming conventions for Superpave Mixes
- Know what Superpave Mix volumetric properties are associated with the Tests performed in the Field

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602.1 DESCRIPTION

BID ITEMS	**UNITS**
HMA Base (*)(**)(***)	Ton
HMA Surface (*)(**)(***)	Ton
HMA Overlay (*)(**)(***)	Ton
HMA Pavement (#) (##)	Square Yard
HMA Pavement (#) Shoulder	Square Yard
Emulsified Asphalt (****)	Ton
Asphalt Core (Set Price)	Each
Material for HMA Patching (Set Price)	Ton
Quality Control Testing (HMA)	Ton

*Mix Designation
**Grade of Asphalt Binder
***Shoulder
****Type and Grade of Emulsified Asphalt
Thickness
##Type of surface course HMA mixture

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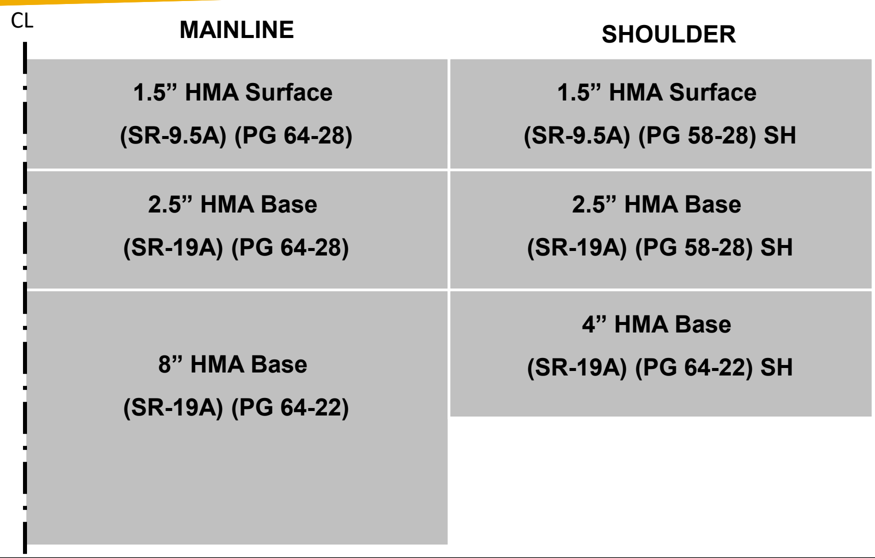
SUPERPAVE MIXES
Typical Pavement X-Section



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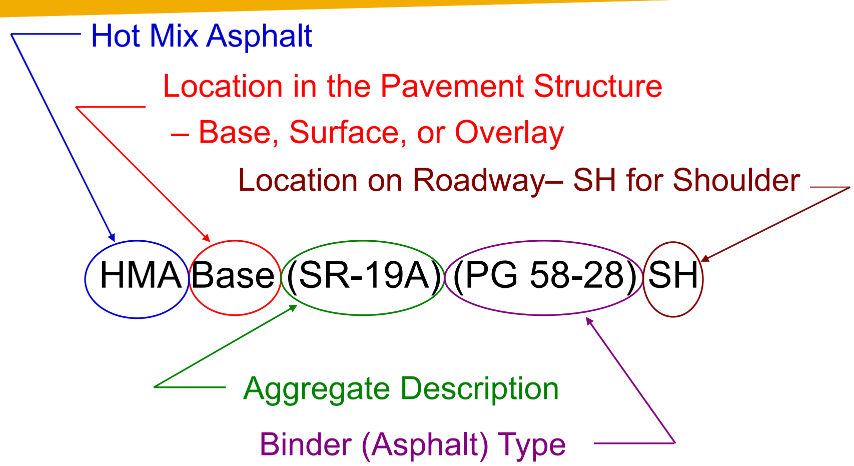
COMPONENTS OF SUPERPAVE MIXES



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COMPONENTS OF SUPERPAVE MIXES
Aggregates

HMA Base (**SR**-19A) (PG 58-28) SH

Aggregate Description

First two letters are either SM or SR

- SM – Superpave Mix
  - Virgin Aggregate and Binder
- SR – Superpave Recycled Mix
  - Used when Reclaimed Asphalt Pavement (RAP) is in the mix

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COMPONENTS OF SUPERPAVE MIXES
Aggregates

HMA Base (SR-**19**A) (PG 58-28) SH

Aggregate Description

Nominal Maximum Aggregate Size

(3 most common sizes used in Kansas)

- 9.5 mm (3/8 inch) (Surface Course)
- 12.5 mm (1/2 inch) (Surface or Base Course)
- 19 mm (3/4 inch) (Base Course)

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COMPONENTS OF SUPERPAVE MIXES
Aggregates

HMA Base (SR-19**A**) (PG 58-28) SH

Aggregate Description

Location of Aggregate Gradation Relative to the Maximum Density Line

- A - Above the Line (Fine Mixes)
- B - Below the Line (Coarse Mixes)
- T - Below the Line (Friction/Texture Course)

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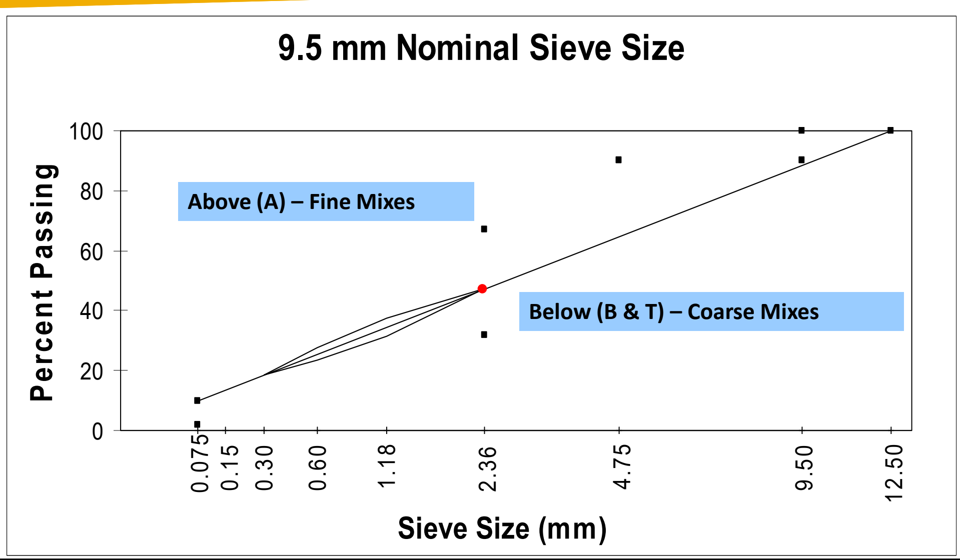
TYPICAL GRADATION CONTROL



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SUPERPAVE MIXES
Aggregate Designations Used in Kansas

• SM-4.75A	SR-4.75A
• SM-9.5A	SR-9.5A
• SM-12.5A	SR-12.5A
• SM-19A	SR-19A
• SM-9.5B	SR-9.5B
• SM-12.5B	SR-12.5B
• SM-19B	SR-19B
• SM-9.5T	SR-9.5T

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COMPONENTS OF SUPERPAVE MIXES
Performance Graded (PG) Binders

HMA Base (SR-19A) (**PG** 58-28) SH

Binder (Asphalt) Type

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COMPONENTS OF SUPERPAVE MIXES
Performance Graded (PG) Binders

HMA Base (SR-19A) (PG **58**-28) SH

Binder (Asphalt) Type

High Temperature Grade (°C)

- Correlates to the Rut Resistance of a Mix
- The larger the number, the stiffer the binder
- Kansas uses a range from 52 to 76 (incr. 6)
- PG 64 and PG 70 are typical for mainline surface mixes
- PG 58 is common with > 15% RAP or RAS
- PG 76 is used in some high volume surface mixes

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COMPONENTS OF SUPERPAVE MIXES
Performance Graded (PG) Binders

HMA Base (SR-19A) (PG **58**-28) SH

Binder (Asphalt) Type

High Temperature Grade (°C) (continued)

- PG 58 and PG 64 are used in shoulder mixes
- PG 52 is used in some high RAP or RAS shoulder mixes

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SUPERPAVE MIXES
High Temperature Reference

Water Boils:	100°C = 212°F
Water Freezes:	0°C = 32°F
°C = °F:	-40°C = -40°F
Stopped & Heavy Traffic:	76°C = 169°F
Heavy Traffic:	70°C = 158°F
Normal Traffic:	64°C = 147°F
Shoulder Traffic:	58°C = 136°F

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COMPONENTS OF SUPERPAVE MIXES
Performance Graded (PG) Binders

HMA Base (SR-19A) (PG 58-**28**) SH

Binder (Asphalt) Type

Low Temperature Grade (°C)

- Correlates to the Thermal Crack Resistance of a Mix
- The smaller the number, the more ductile the binder
- Kansas has used a range from -22 to -34 (incr. 6)

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COMPONENTS OF SUPERPAVE MIXES
Performance Graded (PG) Binders

HMA Base (SR-19A) (PG 58-**28**) SH

Binder (Asphalt) Type

Low Temperature Grade (°C) (continued)

- -28 is most common in surface mixes in Kansas
- -22 is used in base mixes and in the surface mix when reflective cracking is likely ($\leq$ 15% RAP)
- -34 used in some RAP (> 15% or > 25%) or RAS mixes

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SUPERPAVE MIXES
Low Temperature Reference

Water Boils:	100°C = 212°F
Water Freezes:	0°C = 32°F
°C = °F:	-40°C = -40°F
In Base & Some 1Rs:	-22°C = -8°F
In Surface:	-28°C = -18°F
With > 15% RAP:	-34°C = -29°F

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SUPERPAVE MIXES
Binders Used in Kansas

- PG 58-28
- PG 64-22

Neat Asphalts
Hi Side + Lo Side < 90

- PG 58-34
- PG 64-28
- PG 64-34
- PG 70-22
- PG 70-28
- PG 76-22
- PG 76-28

Modified Binders

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SUPERPAVE MIXES
Typical Mainline Mixes

- HMA Overlay (SR-12.5A) (PG 70-22)
- HMA Overlay (SR-12.5A) (PG 64-22)
- HMA Surface (SR-9.5A) (PG 64-28)
- HMA Surface (SR-9.5A) (PG 70-28)
- HMA Base (SR-19A) (PG 64-28)
- HMA Base (SR-19A) (PG 70-28)
- HMA Base (SR-19A) (PG 64-22)

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SUPERPAVE MIXES
Typical Shoulder Mixes

- HMA Overlay (SR-12.5A) (PG 64-22) SH
- HMA Surface (SR-9.5A) (PG 58-28) SH
- HMA Base (SR-19A) (PG 58-28) SH
- HMA Base (SR-19A) (PG 64-22) SH

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SUPERPAVE MIXES
Typical Pavement Section

MAINLINE	SHOULDER
1.5” HMA	1.5” HMA
2.5” HMA	2.5” HMA
8” HMA	4” HMA

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SUPERPAVE MIXES
Typical Pavement Section

MAINLINE	SHOULDER
1.5” HMA Surface	1.5” HMA Surface
2.5” HMA Base	2.5” HMA Base
8” HMA Base	4” HMA Base

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SUPERPAVE MIXES
Typical Pavement Section

MAINLINE	SHOULDER
1.5” HMA Surface (SR-9.5A)	1.5” HMA Surface (SR-9.5A)
2.5” HMA Base (SR-19A)	2.5” HMA Base (SR-19A)
8” HMA Base (SR-19A)	4” HMA Base (SR-19A)

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SUPERPAVE MIXES
Typical Pavement Section

MAINLINE	SHOULDER
1.5" HMA Surface (SR-9.5A) (PG 64-28)	1.5" HMA Surface (SR-9.5A) (PG 58-28) SH
2.5" HMA Base (SR-19A) (PG 64-28)	2.5" HMA Base (SR-19A) (PG 58-28) SH
8" HMA Base (SR-19A) (PG 64-22)	4" HMA Base (SR-19A) (PG 64-22) SH

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SUPERPAVE FOR INSPECTORS

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SUPERPAVE FOR INSPECTORS

- Introduction to Volumetrics
  - Volumetrics is a predictor of mix performance
  - Less predictive as use of recycled materials (RAP and RAS) and additives (antistripping agents, WMA additives, and rejuvenators) has become ubiquitous
    - Performance tests

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SUPERPAVE VOLUMETRIC PROPERTIES

- Voids in Mineral Aggregate (VMA)
- Voids Filled with Asphalt (VFA)
- Air Voids (V_a)
- Theoretical Maximum Specific Gravity (G_{mm})
- Mix Bulk Specific Gravity (G_{mb})
- N_{ini}, N_{des}, and N_{max}

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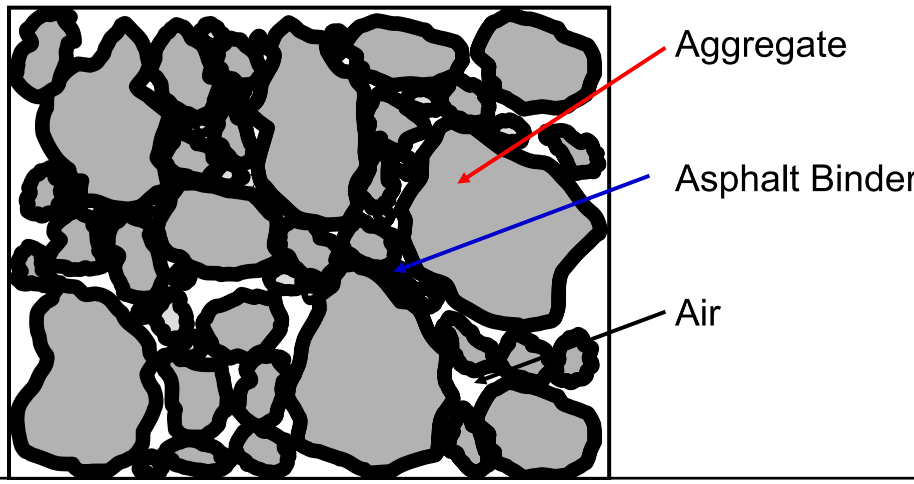
COMPOSITION OF HMA MIXTURES



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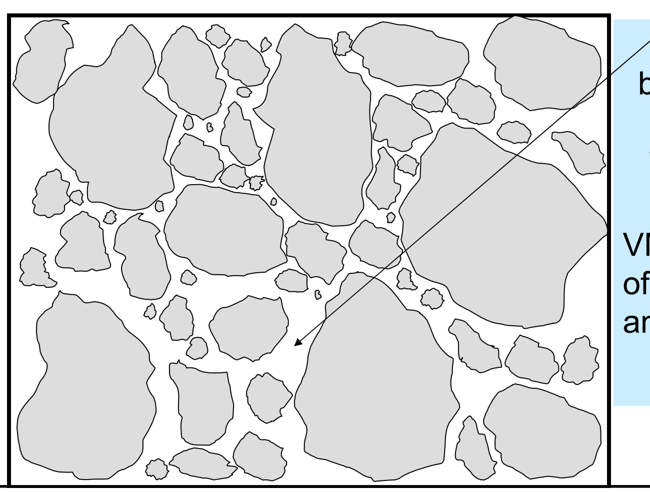
SUPERPAVE VOLUMETRIC PROPERTIES VMA



VMA is the voids between the Aggregate

$$VMA\% = \frac{V_v}{V_{mb}} \times 100$$

VMA of 14% means 14% of Total Mix Volume is Air and Binder

86% is Aggregate

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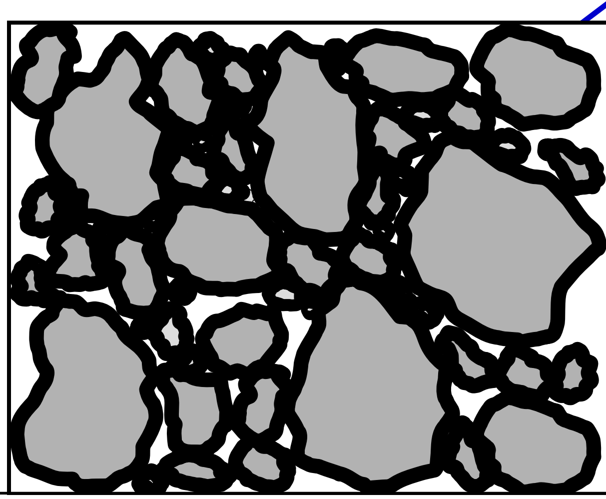
SUPERPAVE VOLUMETRIC PROPERTIES
Va and VFA



V_a are the %voids in the Aggregate that are not filled with Asphalt. % of total volume.

$$V_a\% = \frac{V_a}{V_{mb}} \times 100$$

VFA is the %voids in the Aggregate Structure that are filled with effective Asphalt

$$VFA\% = \frac{V_{be}}{V_v} \times 100$$

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SUPERPAVE VOLUMETRIC PROPERTIES
Specific Gravity

$$\text{Specific Gravity} = \frac{\text{Density of the Material}}{\text{Density of Water}}$$

Typical Specific Gravities

Styrofoam	0.04
Wood	0.45
SAE 30 Oil	0.90
Water	1.00
Asphalt	1.03
Coal	1.30
HMA	2.30
Rocks	2.65
Steel	7.85
Gold	19.3

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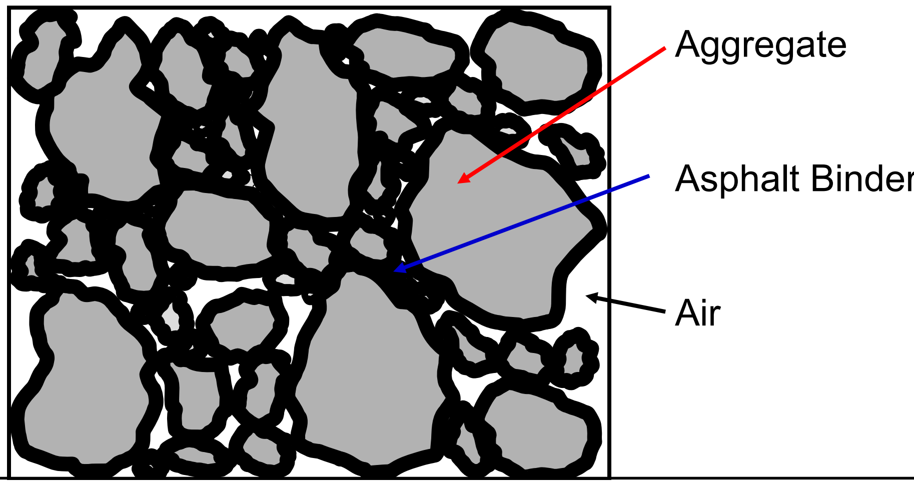
SUPERPAVE VOLUMETRIC PROPERTIES
Theoretical Maximum Specific Gravity (Gmm)



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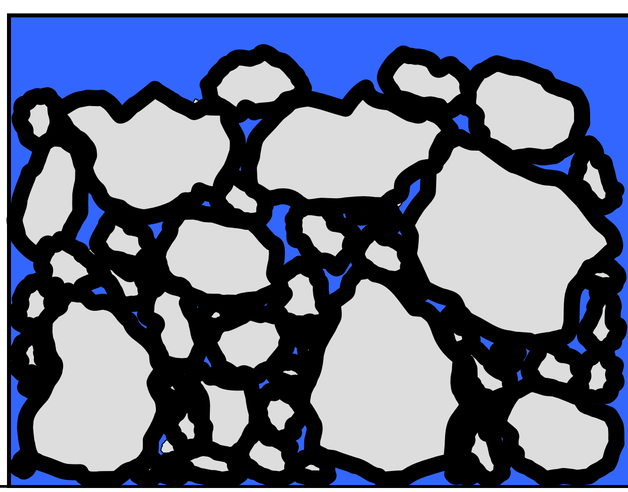
SUPERPAVE VOLUMETRIC PROPERTIES
Theoretical Maximum Specific Gravity (Gmm)



G_{mm} is the **most dense** that the Asphalt Mix can be.

We achieve it by removing all the air from the mix with a vacuum and displacing the air with water.

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SUPERPAVE VOLUMETRIC PROPERTIES
Theoretical Maximum Specific Gravity (Gmm)

Rice Test

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SUPERPAVE VOLUMETRIC PROPERTIES
Theoretical Maximum Specific Gravity (Gmm)

Rice Test

The G_{mm} value is used to compare

- In-Place Density on the Road
  - Use average value from F&t spreadsheet
- Air Voids in Gyratory Compacted Plugs
  - Value tied to individual sample

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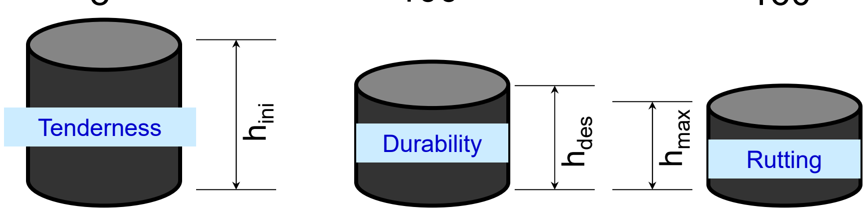
SUPERPAVE VOLUMETRIC PROPERTIES
Superpave Gyratory Compactor

N –Number of Gyrations
- ini – Initial
- des – Design
- max - Maximum

N_{ini}	N_{des}	N_{max}
6	50	75
7	75	115
8	100	160


SUPERPAVE VOLUMETRIC PROPERTIES
Superpave Gyratory Compactor

N_{ini}	N_{des}	N_{max}
6	50	75
7	75	115
8	100	160



$\leq$ 92.0% G_{mm}	$\approx$ 97% G_{mm}	$\leq$ 98.5% G_{mm}
$\leq$ 91.5% G_{mm}	3% $\approx V_a$	$V_a \geq$ 1.5%
$\leq$ 91.0% G_{mm}		

SUPERPAVE VOLUMETRIC PROPERTIES
Determining Air Voids

Compact the specimens to N_{max}

Determine the G_{mb} of the plug using KT-15

Calculate the air voids at N_{des} using the G_{mm} Value

Air Voids is a Pay Item

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SUPERPAVE VOLUMETRIC PROPERTIES
Contractor Pay Items

Air Voids
(V_a)

G_{mb} @ N_{des}

And

$\mathbf{G_{mm}}$

In-Place Density
Nuclear Gauge
And
$\mathbf{G_{mm}}$

OR

Cut Cores from the Pavement and get G_{mb}
And
$\mathbf{G_{mm}}$

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REVIEW

What Bid Item(s) are used for overlay projects?

HMA Overlay

What Bid Item(s) are generally used for heavy rehabilitation and reconstruction projects?

HMA Surface, HMA Base, HMA Pavement

What 2 Properties are necessary to determine Air Voids?

G_{mm} (Rice Test) and

G_{mb} @ N_{des} (SGC and KT-15)

What 2 Tests are usually performed to determine Field Density?

G_{mm} (Rice Test) and

Nuclear Density Gauge

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INTRODUCTION TO SUPERPAVE

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QC/QA Asphalt Specifications
Special Provision 15-06007-R03 Outline

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602.11	Measurement and Payment (Sheets 29 to 30 of 30)

Kansas Department of Transportation

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602.2 CONTRACTOR QUALITY CONTROL REQUIREMENTS

a) General

1) Provide

- Qualified Personnel
- Sufficient Equipment

Which Complies with

KDOT Construction Manual, Part V

To conduct

Quality Control Testing

Which Complies with

Appendix B – Sampling and Testing Frequency

And allow the Engineer access to the Contractor's Lab

2

PART V – MATERIALS CONTROL

5.1 GENERAL

3

BUREAU OF CONSTRUCTION & MATERIALS (C&M)

Responsible for:

Materials Portion

Of

KDOT’s QC/QA Program

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5.1.2
C&M'S Responsibility

1. Develop
   - Materials Standards
   - Materials Specifications
2. Establish
   - Sampling Procedures
   - Sampling Frequencies
3. Establish
   - Field Test Procedures
   - Lab Test Procedures

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5.2.3
Reasons for QC/QA

1. Compliance with Specifications
   - *The Primary Reason for Requiring*
     - Inspection
     - Sampling
     - Testing

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5.2.3
Reasons for QC/QA

2. Uniform Relations with Partners
   - Equitable basis for bidding
   - State receives specified product
3. Documentation of Expenditure of Public Funds
4. Compliance with Federal Regulations

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5.2.4
Procedures for Quality Assurance

1. General
   - Method Specs (Appendix A)
     - KDOT's Test Results
   - QC/QA Specs (Appendix B)
     - Contractor's QC Test Results
       - Basis of Acceptance
     - KDOT's QA Test Results
       - Verification

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5.2.4
Procedures for Quality Assurance

2. Authorized Personnel
   2) QC/QA Specs
      - Technician Certification
        - KDOT Training and Testing
        - KSU-Salina Training
        - KSU-Manhattan Training
        - ACI Certification
        - Other

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5.2.4
Procedures for Quality Assurance

- Quality Control Testing
  - Contractor
- Verification Testing
  - KDOT Construction Office
- Independent Assurance Testing
  - KDOT District Materials Lab

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5.2.4
Procedures for Quality Assurance

2. Authorized Personnel
   2) QC/QA Specs
      - Equipment Calibration and Verification
        - Contractor is Responsible
        - AASHTO Accredited Lab, Calibration Service or Equipment Manufacturer
          - Using National Institute of Standards and Technology (NIST) Traceable Equipment
        - Frequencies more often than 12 months can be done by the Contractor
        - DME can Spot Check Equipment Calibrations

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5.2.5
Quality Control/Quality Assurance (QC/QA) Tests

2. Definitions
   2.2 Assurance Sampling and Testing
      - Split or Replicate Samples
      - Independent Check
        - Sampling Procedure
        - Testing and Equipment Procedures
   - 2.3 Dispute Resolution
      - Resolve Conflicts
        - State's Verification Results
        - Contractor's QC Results

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5.2.5
Quality Control/Quality Assurance (QC/QA) Tests

2. Definitions

   2.4 Independent Assurance (IA)

   - Independent Verification of
     - QA System
     - Reliability of Field Test Results
   - Performed by KDOT District Lab
     - Specified Procedures are Followed (Witnessing)
     - Split and Replicate Sampling and Testing

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5.2.5
Quality Control/Quality Assurance (QC/QA) Tests

2. Definitions

   2.5 Quality Assurance (QA)

   - All Actions Necessary to Provide Confidence that Quality Requirements Are Satisfied

   2.6 Quality Control (QC)

   - By Contractor
   - QC Activities are Outline in QC Plan

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5.2.5
Quality Control/Quality Assurance (QC/QA) Tests

2. Definitions

2.10 Split Samples

- Portion tested by Contractor (QC), KDOT Field (Verification), and District Lab (IA)
- Tests by District Lab (IA) on Separate equipment

2.11 Verification Sampling and Testing

- By KDOT Field
- Validates QC Sampling and Testing

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5.2.5
Quality Control/Quality Assurance (QC/QA) Tests

Split Sampling
Follow KT-25

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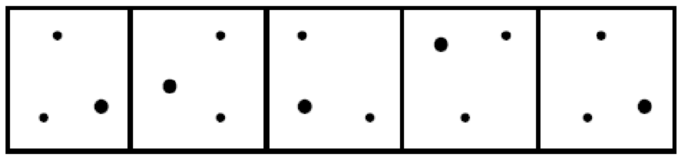
5.2.5
Quality Control/Quality Assurance (QC/QA) Tests

Random Sampling



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5.2.5
Quality Control/Quality Assurance (QC/QA) Tests

RANDOM Sampling ≠ SPLIT Sampling

Which will give you closer results?

Split Sampling

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5.2.7.1
HMA – Contractor's Quality Control Plan

- Procedures to Assure Conformance with Contract Requirements
  - Samples, Tests and Referenced Cited Specifications
  - Qualified Testing Laboratory
    - KDOT to Inspect Document Acceptability
  - Equipment Calibration and Verification
  - Technician Certification

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5.2.7.1
1. Quality Control

1. Provide and Maintain a QC Plan
2. Perform or have Performed
   a. Inspections
   b. Tests
3. Document Inspections and Tests for KDOT
4. Maintain Records of Inspections and Tests
5. Maintain
   a. Standard Equipment
   b. Qualified Personnel

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5.2.7.1
1. Quality Control

6. Prepare a QC Plan
7. Submit QC Plan to KDOT at Pre-Construction Meeting
8. QC Plan includes the following:
   a. Construction Items
   b. Tests and Test Frequency
   c. Sampling locations and techniques
   d. Documentation Procedures

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5.2.7.1
1. Quality Control

8d) Documentation Procedures
- QC Lab Identification
- QC Personnel Identification
- Inspection and Test Records
- Temperature Measurements
- Checks on Equipment
- Control Charts

9) Identify QC Personnel (consultant?)
- Liaison with KDOT
- Certified Technicians (Inspections)

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5.2.7.1

2. Samples, Tests, and Referenced Cited Specifications

1. Contractor's Responsibilities
   - Quality of Construction and Materials
   - QC Inspection, Sampling and Testing
2. KDOT's Responsibilities
   - Acceptability of Construction and Materials
   - May use Contractor's Results
     - Include Critical Information from Table 1

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5.2.7.1

3. Qualified Testing Laboratory

- MRC accredited through the AASHTO Accreditation Program (AAP)
- QC Lab Must
  - Be accredited through AAP **or**
  - Have Manufacturer Certified Technician inspect equipment and perform Calibrations and Verifications Annually

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5.2.7.1
3. Qualified Testing Laboratory

- Have Equipment/Materials for Tests
- Equipment Properly Maintained

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5.2.7.1
3. Qualified Testing Laboratory

- Annual Sampling and Testing Equipment Inspection By KDOT
  - Contractors
  - Consultants
  - Vendors
- Equipment Checks Made During Life of a Project
  - Project Sampling and Testing Personnel
  - KDOT Personnel

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5.2.7.1
3. Equipment Calibration and Verification

- Calibrate or Verify Significant Test Equipment
- Equipment Calibration Records
  - Maintained in Quality Manual
  - Stored in the Lab

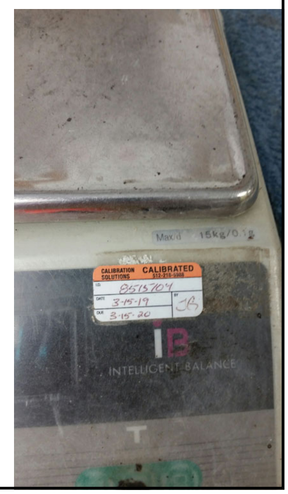

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Table 2 HMA Materials Test Equipment

Equipment –Test Method	Requirements	Interval (months)
Mechanical Shakers	Check Sieving Thoroughness	12
General Purpose Balances, Scales and Masses –**AASHTO M 231**	Calibrate	12
Test Thermometers –KT-15, KT-39, KT-56, KT-58	Standardize	12
Compression Testing Machine	Verify Load and Calibrate	12
Ovens	Standardize Thermostat	12
Vacuum System KT-39	Standardize	12
Coarse Sieves (openings ≥ No. 4 [4.75 mm]) Fine Sieves (openings < No. 4 [4.75 mm])	Check Physical Condition and Dimensions of Openings Check Physical Condition	12 12
Nuclear Density Gauge KT-32	Calibration	12
Weighted Foot Assembly KT-55	Check Mass of Assembly	12
Gyratory Compactor KT-58	Verify and/or Calibrate Ram Pressure, Angle of Gyration, Frequency of Gyration, Height	12
Gyratory Compactor Mold KT-58	Check Critical Dimensions	12

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5.2.7.1
5. Technician Certification

KDOT Requires
That All individuals who perform
sampling,
testing, and
inspection
Be Certified

Because …

Qualifications Are Ensured
Pride in Work Performed Increases
Provides Assurances that Sampling and Testing Will Be Done Correctly
Provides Assurances that Results Will Be Valid

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5.2.7.1
5. Technician Certification

- Certification programs recognized by KDOT:
  - Certified Inspector Training (CIT) Program
  - Contact CIT Program Administrator for additional information on an acceptable certification program

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5.2.7.2

- Guide for HMA QC and QA Requirements
  - Establishes minimum requirements for Contractor's QC system and KDOT's QC/QA Plan
  - Intended as a procedural guide

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5.2.7.3

- Example of a Laboratory Quality Manual
  - Guidelines for creating and maintaining a contractor's Quality Manual

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REVIEW

Who Does Quality Control?
Contractor

Who Does Quality Verification?
KDOT Construction Office

Who Does Independent Assurance?
KDOT District Office

Why do we Sample, Test, and Inspect?
Compliance with Specifications

Between Split and Random Sampling, which should give closer results?
Split Sampling

Who's Responsible for the Contractor's Equipment Calibrations?
The Contractor

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602.2 CONTRACTOR QUALITY CONTROL REQUIREMENTS

… and now back to

SECTION 602

(15-06007-R03)

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602.2 CONTRACTOR QUALITY CONTROL REQUIREMENTS

a) General

1) Provide

- Qualified Personnel
- Sufficient Equipment

Which Complies with

KDOT Construction Manual, Part V

To conduct

Quality Control Testing

Which Complies with

Appendix B – Sampling and Testing Frequency

Allow the Engineer access to Contractor's Lab

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602.2 CONTRACTOR QC REQUIREMENTS
a. General

2) Calibrate Equipment (Section 5.2.7.1)
3) Store most recent 2 lots of QC samples per mix. Do not retain more than 3 Lots of material

   KDOT will store QA Plugs & Loose Mix

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602.2 CONTRACTOR QC REQUIREMENTS
b. Quality Control Plan

1) Submit QC Plan at Precon Conference
   - Follow Section 5.2.7.1 and 5.2.7.2
   - Post Orginizational Chart in Contractor's Lab
2) Certified Technicians
   - Process Control – SF category
   - Aggregate Field – AGF category
   - Aggregate Lab – AGL category
   - QC/QA Asphalt Specifications – at Least 1 on Project
   - Profilograph – PO category
   - Nuclear Gauge – NUC Category

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602.2 CONTRACTOR QC REQUIREMENTS
c. Required Duties of Certified Technicians

1) Be on project site when HMA produced and placed
2) Perform QC tests to assure mix design requirements are met
3) Periodically inspect all equipment used to transport, proportion, mix, place and compact

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602.2 CONTRACTOR QC REQUIREMENTS
d. Contractor's Testing Facilities

1) Contractor's QC Lab at plant site
   - Engineer's approval before mix production
   - DME must approve other locations
   - Suitable Space and Test Equipment

- KDOT field lab located near QC Lab
  - Fully Functional 2 Working Days Before Pre-Production Sample

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602.2 CONTRACTOR QC REQUIREMENTS
d. Contractor's Testing Facilities

2) Contractor's QC Lab furnished with:
   - Private phone line for QC Personnel
   - Copying machine (Contractor and KDOT)
   - Broadband internet connection (1 computer)
     - If Engineer determines service not available, provide fax machine at no additional cost
   - Air conditioner (keep below 77˚F)
3) KDOT's QA Lab (Type A Lab) furnished with:
   - Air conditioner (keep below 77°F)
   - Broadband internet connection (4 computers) & telephone
   - Exhaust fan, drying oven, fire extinguisher

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602.2 CONTRACTOR QC REQUIREMENTS
e. Documentation

1) Control charts
2) Use bound field book
3) After project completion, all documentation is KDOT property
4) Test Data
   - Test results and control charts weekly
   - QC summary sheet daily when available and not later than next working day of obtaining the sample
   - Failing test results when available
   - KT-56 test results when available and not later than five working days of obtaining the sample.

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602.2 CONTRACTOR QC REQUIREMENTS
f. Testing Requirements

1) Identify test methods, procedures and equipment in QC plan
2) Follow requirements in QC plan and Sampling and Testing Frequency Chart in Appendix B, Part V

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602.2 CONTRACTOR QC REQUIREMENTS
g. Pre-Production Testing Requirements

1-4) Contractor obtains – Split 3 Ways
- Contractor
- KDOT Field Lab
- Retain sample for KDOT District Materials Lab (Hot vs Cool)

1-4) Each Sample Size
- 2 SGC Specimens (KT-58 & KT-15)
- G_{mm} (KT-39)
- Ignition Burnoff (KT-57)

5) Resolve differences, District will test if poor comparison, repeat if needed

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602.2 CONTRACTOR QC REQUIREMENTS
h. Lot 1 Testing Requirements

1) Sequence of Sampling
   - KDOT Determines Random Truckload
     - 4 Contractor QC Samples (Sublots A, B, C, D)
     - KDOT Verification Sample
   - 1 Random KDOT Verification Test in Lot
     - Sampled and Tested by KDOT
     - Different Truckload than QC Samples

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602.2 CONTRACTOR QC REQUIREMENTS
h. Lot 1 Testing Requirements

1) Sequence of Sampling
   - KDOT Field Personnel will
     - Provide Random Spots to Sample from Behind Paver (KT-25)
     - Not Supply Contractor with Random Truck's Identity Ahead of Time
     - Provide Truck's Identity
       - After aggregate has left the cold bins
       - Before truck is finished loading
     - Determine if 3-Way Split is from Sublot A or B

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602.2 CONTRACTOR QC REQUIREMENTS h. Lot 1 Testing Requirements

2) Split Samples

- Contractor shall:
  - Obtain large enough Sample to Split 3 ways
  - Retain and Test 1/3 of Sample
  - Supply 1/3 of Sample to KDOT Field Lab for testing
  - Supply 1/3 of Sample to KDOT District Lab for testing

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602.2 CONTRACTOR QC REQUIREMENTS h. Lot 1 Testing Requirements

3) Results

- Compare KDOT's and Contractor's Test Results
  - G_{mm} within 0.019
  - V_a within 0.5%
- If Comparison Fails
  - Take another Split Sample from Sublot C or D
  - Resolve Differences
  - Contractor Results are input into F&t Spreadsheet
  - KDOT's Samples are "Information Only"

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602.2 CONTRACTOR QC REQUIREMENTS
i. Testing Requirements for Lots 2 and Greater

1) Random Samples
   - Per approve QC Plan
   - At Rates in Part V, Appendix B
   - Random Number Generation is KDOT's Option
2) Obtain Sample from Behind the paver
   - Follow KT-25
   - Test Sample Quartered from larger Sample
   - Sample size is minimum of 55 lbs
     - Obtain large enough sample so back half is adequate for dispute resolution testing

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602.2 CONTRACTOR QC REQUIREMENTS
i. Testing Requirements for Lots 2 and Greater

3) Test Results
   - Record and Document
   - Use Daily Summary Sheet
   - Accuracy is listed in Part V, Appendix B
   - Document QC Actions taken
   - Post Quality Control Charts (Table 602-12)
     - Plot Single Points
     - Plot 4 Point Moving Averages
     - Random Number Generation is KDOT's Option
4) Procedures for Lot 1 may be used

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602.2 CONTRACTOR QC REQUIREMENTS
g. Corrective Action

1) In QC plan, ID procedures to notify Engineer when corrective action is taken and when production is halted

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602.2 CONTRACTOR QC REQUIREMENTS
i. Non-Conforming Materials

1) Effective and Positive System for Non-Complying Material
   - Identification
   - Isolation
   - Disposition

2) Might include removal of in-place pavement
3) Prevent Non-Complying Material from being mixed with Complying Materials

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SAMPLING AND TESTING FREQUENCY CHART (STFC)

Located in

Part V of the Construction Manual,

Appendix B (2022)

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STFC GENERAL NOTES (The 1st One)

General note:

- Sampling and testing frequencies are minimums.
- Additional testing when necessary to provide better control
- If QC, QA or IA test fails, then sample and test in next sublot.

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STFC

SAMPLING AND TESTING FREQUENCY CHART
QUALITY CONTROL/QUALITY ASSURANCE SPECIFICATIONS

CONSTRUCTION OR MATERIAL TYPE 2015 (SS 2015)	TESTS REQUIRED (RECORD TO)	TEST METHOD	QUALITY CONTROL BY CONTRACTOR	VERIFICATION BY KDOT
11 **HMA (Plant Mix)** Sec. 602, 603, 611, 1103				

602 – HOT MIX ASPHALT (HMA) CONSTRUCTION (Quality Control/Quality Assurance (QC/QA))
603 – ASPHALT PAVEMENT SMOOTHNESS
611 – HOT MIX ASPHALT (HMA)-COMMERCIAL GRADE
1103 – AGGREGATES FOR HOT MIX ASPHALT (HMA)

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STFC

SAMPLING AND TESTING FREQUENCY CHART
QUALITY CONTROL/QUALITY ASSURANCE SPECIFICATIONS

CONSTRUCTION OR MATERIAL TYPE 2015 (SS 2015)	TESTS REQUIRED (RECORD TO)	TEST METHOD		QUALITY CONTROL BY CONTRACTOR	VERIFICATION BY KDOT
Individual Aggregate	Sieve Analysis of Aggregate (1%, 0.1% for the No. 200 [75 μm] sieve, of mass)	KT-2	c	One per 1,000 Tons (1,000 Mg) of each individual aggregate	1 during the first 5000 T of HMA
	Clay Lumps and Friable Particles in Aggregate (0.1 g or 0.01% of mass)	KT-7	c h		As required
	Shale or Shale-like Materials in Aggregate (0.1 g or 0.01% of mass)	KT-8	c h		As required
	Sticks in Aggregate (0.01% of mass)	KT-35	c h		As required
	Uncompacted Void Content of Fine Aggregate (0.1%)	KT-50	l	One on the first lot, then one per 10,000 Tons (10,000 Mg) of crushed gravel	1 during the first 5000 T of HMA
	Uncompacted Void Content of Coarse Aggregate (0.01%)	KT-80	l	One on the first lot, then one per 10,000 Tons (10,000 Mg) of crushed gravel	

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INDIVIDUAL AGGREGATE

Columns 2&3 Tests Required (Record to) {Test Method}	Column 4 Quality Control by Contractor	Column 5 Verification by KDOT
Sieve Analysis of Aggregate (1%, 0.1% for the No. 200 [75 µm] sieve, of mass) {KT-2}	c **One per 1,000 Tons (1,000 Mg) of each individual aggregate**	**1 during the first 5000 T of HMA**

c The aggregate producer's tests may be used for quality control purposes if the test were performed by an appropriately certified technician. In such cases, the contractor shall perform testing as necessary to determine the degrading effects of hauling and stockpiling on the individual aggregates.

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INDIVIDUAL AGGREGATE

Columns 2&3 Tests Required (Record to) {Test Method}	Column 4 Quality Control by Contractor	Column 5 Verification by KDOT
Clay Lumps and Friable Particles in Aggregate (0.1 g or 0.01% of mass) {KT-7}	c h	**As Required**
Shale or Shale-like Materials in Aggregate (0.1 g or 0.01% of mass) {KT-8}	c h	**As Required**
Sticks in Aggregate (0.01% of mass) {KT-35}	c h	**As Required**

h If during the determination of individual aggregate gradation, clay lumps and soft or friable particles, shale or shale like particles, or sticks are found then perform KT-7, KT-8 and KT-35 respectively at such frequencies as jointly deemed necessary by the Contractor and the District Materials Engineer.

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CLAY LUMP (MUDBALL)

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INDIVIDUAL AGGREGATE

Columns 2&3 Tests Required (Record to) {Test Method}	Column 4 Quality Control by Contractor	Column 5 Verification by KDOT
Uncompacted Void Content of Fine Aggregate (0.1%) {KT-50}	**l One on the first lot, then one per 10,000 Tons (10,000 Mg) of crushed gravel**	**1 during the first 5000 T of HMA production**
Uncompacted Void Content of Coarse Aggregate (0.01%) {AASHTO KT-80}	**l One on the first lot, then one per 10,000 Tons (10,000 Mg) of crushed gravel**	

l This testing of crushed gravel is only needed to confirm that 35% or less natural sand is used in the traveled way mixes. If 95% or more of crushed gravel is retained on the #8 (2.65 mm) sieve, then the material must have a minimum Uncompacted Void Content of Coarse Aggregate (UVA) value of 45 when tested in accordance with KT-80. Testing will be the same frequency as KT- 50. Do not use material with a UVA value less than 45.

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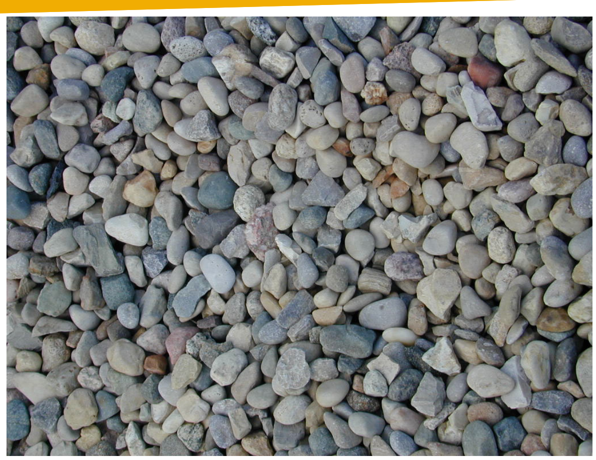
KT-50

61

KT-80



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MINERAL FILLER SUPPLEMENT

Columns 2&3 Tests Required (Record to) {Test Method}	Column 4 Quality Control by Contractor	Column 5 Verification by KDOT
Sieve Analysis of Aggregate (1%, 0.1% for the No. 200 [75 µm] sieve, of mass) {KT-2}	c h One per 250 Tons (250 Mg)	1 during the first 5000 T of HMA Produced
Plasticity Tests (0.01 g or 0.1% of mass) {KT-10}	c h One per 250 Tons (250 Mg)	1 during the first 5000 T of HMA Produced

c Can use aggregate producer's tests. Check for degrading effects.

h Test for clay lumps and soft or friable particles, shale or shale like particles, or sticks when necessary

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COMBINED AGGREGATE

Columns 2&3 Tests Required (Record to) {Test Method}	Column 4 Quality Control by Contractor	Column 5 Verification by KDOT
Coarse Aggregate Angularity (0.1% of mass) {KT-31}	c g One per Lot	One per week or per 10,000 Tons (10,000 Mg)

c Can use aggregate producers tests. Check for degrading effects.

g All aggregates except siliceous gravels and steel slag have at least two crushed faces on 100 percent of the particles.

Run KT-31 on virgin aggregates for mixes containing

- Siliceous Gravels
- Steel Slag

Reduced Testing after 3 consecutive passing tests

- 1 per 3 lots or 1 per week
- Resort to testing every lot if a test fails

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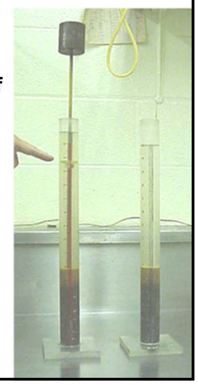
COMBINED AGGREGATE

Columns 2&3 Tests Required (Record to) {Test Method}	Column 4 Quality Control by Contractor	Column 5 Verification by KDOT
Uncompacted Void Content of Fine Aggregate (0.1%) {KT-50}	One on first lot then one per 10,000 Tons (10,000 Mg) of comb. aggregate.	1 during the first 5000 T of HMA produced
Sand Equivalent Test (1%) {KT-55}	f One per Lot	1 during the first 5000 T of HMA produced



f Determine on every lot if SE is within 5% of SE_{min}

Reduced Frequencies:

SE > SE_{min} by 5%	1 per week
SE > SE_{min} by 25%	1 per every 2 weeks

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COMBINED AGGREGATE

Columns 2&3 Tests Required (Record to) {Test Method}	Column 4 Quality Control by Contractor	Column 5 Verification by KDOT
Flat or Elongated Particles (1%) {KT-59}	One on first lot	1 during the first 5000 T of HMA
Moisture Tests (0.1 g or 0.01% of mass) {KT-11}	One per Lot	1 during the first 5000 T of HMA

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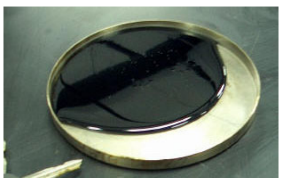
ASPHALT MATERIAL

Columns 2&3 Tests Required (Record to) {Test Method}		Column 4 Quality Control by Contractor	Column 5 Verification by KDOT
Sampling {KT-26}	e b	One Sample Every 3 Loads	



b Sampled by the district field personnel, or contractor and tested at KDOT Central Materials Laboratory (Materials and Research Center).

e Determined on a producer basis. Testing frequency is maintained in CMS. Reduced Frequencies for compliance with specifications:

1 in 6 Loads
1 in 12 Loads

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HMA MIXTURES

Columns 2&3 Tests Required (Record to) {Test Method}	Column 4 Quality Control by Contractor		Column 5 Verification by KDOT
% Moisture in Mixture (0.1 g or 0.01% of mass) {KT-11}	One Per Lot		1 during the first 5000 T of HMA produced
Air Voids (Va = 0.01%, Gmm = 0.001 & Gmb = 0.001) {KT-15, KT-39, KT-58 and Superpave Manual}	One per Sublot	j	One per Lot [Compact split sample on KDOT Gyratory; one per week or 15,000 tons (15,000 Mg)

j Provide access to Contractor owned forced air ignition furnace, ovens, and Superpave Gyratory compactor for the State inspector to perform verification tests.

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HMA MIXTURES

Columns 2&3 Tests Required (Record to) {Test Method}	Column 4 Quality Control by Contractor	Column 5 Verification by KDOT
Binder Content (by Ignition) (0.1 g or 0.01% of mass) {KT-57}	One Per Sublot	j One per Lot
Mix Gradation (by Ignition) (0.1 g or 0.01% of mass) {KT-34}	One per Sublot	One per lot

j Provide access to Contractor owned forced air ignition furnace, ovens, and Superpave Gyratory compactor for the State inspector to perform verification tests.

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BINDER CONTENT (BY IGNITION)

Before Ignition

After Ignition

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HMA MIXTURES

Columns 2&3 Tests Required (Record to) {Test Method}		Column 4 Quality Control by Contractor	Column 5 Verification by KDOT
Moisture Damage to Mix (Modified Lottman) (0.1% of mass) {KT-56}	d	One on 1st Lot then one per week or 10,000 Tons (10,000 Mg)	1 during the first 5000 T performed at District Lab

d At least one Modified Lottman test is required weekly. When more than 10,000 Tons (10,000 Mg} of production occurs in a week, then run additional tests to meet the requirements of 1 test per 10,000 Tons (10,000 Mg).

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RECLAIMED ASPHALT PAVEMENT (RAP)

Columns 2&3 Tests Required (Record to) {Test Method}	Column 4 Quality Control by Contractor		Column 5 Verification by KDOT
Binder Content in RAP (by Ignition) (0.1 g or 0.01% of mass) {KT-57}	One on first lot then one Per 1,000 Tons (1,000 Mg) of RAP	j	One per 4,000 Tons (4,000 Mg) of RAP
RAP Gradation (after Ignition) (0.1 g or 0.01% of mass) {KT-34}	One Per 1,000 Tons (1,000 Mg) of RAP		1 during the first 5000 T of HMA produced
% Moisture in RAP (0.1 g or 0.01% of mass) {KT-11}	One Per Lot		

j Provide access to Contractor owned forced air ignition furnace, ovens, and Superpave Gyratory compactor for the State inspector to perform verification tests.

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RECYCLED ASPHALT SHINGLES (RAS)

Columns 2&3 Tests Required (Record to) {Test Method}	Column 4 Quality Control by Contractor	Column 5 Verification by KDOT
Binder Content in RAS (by Ignition) (0.1 g or 0.01% of mass) {KT-57}	One on first lot then one Per 1,000 Tons (1,000 Mg) of RAP + RAS	j One per 4,000 Tons (4,000 Mg) of RAP + RAS
RAS Gradation (after Ignition) (0.1 g or 0.01% of mass) {KT-34}	One Per 1,000 Tons (1,000 Mg) of RAP + RAS	1 during the first 5000 T of HMA produced
% Moisture in RAS (0.1 g or 0.01% of mass) {KT-11}	One Per Lot	

j Provide access to Contractor owned forced air ignition furnace, ovens, and Superpave Gyratory compactor for the State inspector to perform verification tests.

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COMPLETED ROAD WORK

Columns 2&3 Tests Required (Record to) {Test Method}	Column 4 Quality Control by Contractor	Column 5 Verification by KDOT
Cores or Nuclear Density Gauge (Gmb = 0.001; 0.1 lb/ft3 (1 kg/m3) or 0.01% of optimum density) KT-15 or KT-32	i 10 Tests per Lot	i 5 Companion Tests per Lot

i For small lots (lots with less than 1,000 Tons (1,000 Mg)), the number of tests may be reduced (see Table 602-10)

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REVIEW

Who Tests the Pre-Production Sample?
Contractor & KDOT Field Lab, District optional

What Type of Sample is the Pre-Production Sample?
Split Sample

Where is the Sampling and Testing Frequency Chart?
Construction Manual, Part V, Appendix B

Can the Contractor Test more often than what is listed in the STFC?
Yes

Can KDOT Test more often than what is listed in the STFC?
Yes

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602.2 CONTRACTOR QUALITY CONTROL REQUIREMENTS

Kansas Department of Transportation

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QC/QA Asphalt Specifications
Special Provision 15-06007-R03 Outline

602.1	Description (Sheet 1 of 30)
602.2	Contractor QC Requirements (Sheets 1 to 4 of 30)
602.3	**Materials (Sheets 4 to 8 of 30)**
602.4	Construction Requirements (Sheets 8 to 14 of 30)
602.5	Process Control (Sheets 14 to 17 of 30)
602.6	Compaction Testing (Sheets 17 to 19 of 30)
602.7	Weather Limitations (Sheet 19 of 30)
602.8	Mixture Acceptance (Sheets 19 to 22 of 30)
602.9	Basis of Acceptance (Sheets 22 to 25 of 30)
602.10	HMA Paid by the Area (Sheets 25 to 29 of 30)
602.11	Measurement and Payment (Sheets 29 to 30 of 30)

Kansas Department of Transportation

1

602.3 MATERIALS

a. Asphalt Binder

b. Reclaimed Asphalt Pavement (RAP)
and Recycled Asphalt Shingles (RAS)

c. Aggregates

d. Combined Aggregates

e. Contractor Trial Mix Design

f. WMA Additives

2

602.3 MATERIALS
a. Asphalt Binder

- Bill Of Lading Near SGC
  - Mixing and Compaction Temperatures
  - Do Not Exceed 340°F
  - Higher Temps only with Field Materials Engineer Approval
  - Notify Engineer when Temperatures Change

3

602.3 MATERIALS
a. Asphalt Binder

- Division 1200
  - Section 1201 and SP 15-12001-R01
    - General Requirements
  - Section 1202 and SP 15-12002-R01
    - Performance Graded Asphalt Binder

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602.3 MATERIALS
a. Asphalt Binder

- Section 1201 and SP 15-12001-R01
  - 1201.2 – Requirements
    a. Storage and Heating
    b. Shipping Facilities
    c. Weighing Equipment
    d. Sampling and Inspection
    e. Performance Graded Asphalt Binder (PGAB)
    f. Emulsions and Rejuvenating Agents
    g. Cutbacks
    h. Reports
  - 1201.3 - Test Methods
  - 1201.4 - Prequalification
  - 1201.5 - Basis of Acceptance

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602.3 MATERIALS
a. Asphalt Binder

- Section 1202 and SP 15-12002-R01
  - Laid out similarly to 1201
  - Table 1202-1 Performance Grade (PG) - Alias Superpave Plus Specifications
    - Modified Binders used in Kansas
      - Range from PG 52-34 to PG 76-28
      - Separation (Max) is 2
      - Elastic Recovery is specified
      - ΔTc $\geq$ -5.0°C
  - Perform all tests after adding 0.5% high molecular weight amine antistripping agent to the PGAB. (Why?)

6

602.3 MATERIALS
a. Asphalt Binder

- Subsection 1202.2 b.
  - Substitutions allowed which meet or exceed
    - the upper grade designations
    - and lower grade designations
  - May upgrade asphalt *during design phase*.

  - Example: PG 58-28 and PG 64-22 upgraded to PG 64-28
  - Eliminates need to handle two asphalts
  - Expense incurred by Contractor

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602.3 MATERIALS
Shoulder Binder Substitutions

MAINLINE	**SHOULDER**
1.5" HMA Surface **(SR-9.5A) (PG 64-28)**	**1.5" HMA Surface** **(SR-9.5A) (PG 58-28) SH** **Not (PG 64-22)**
2.5" HMA Base **(SR-19A) (PG 64-28)**	**2.5" HMA Base** **(SR-19A) (PG 58-28) SH** **Not (PG 64-22)**
8" HMA Base **(SR-19A) (PG 64-22)**	**4" HMA Base** **(SR-19A) ~~(PG 64-22)~~ SH** **(PG 58-28)**

exception to the rule – will be noted in contract special provision

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602.3 MATERIALS
Example of Substituting Binders

MAINLINE	SHOULDER
1.5” HMA Surface (SR-9.5A) (PG 64-28)	1.5” HMA Surface (SR-9.5A) ~~(PG 58-28)~~ SH (PG 64-28)
2.5” HMA Base (SR-19A) (PG 64-28)	2.5” HMA Base (SR-19A) ~~(PG 58-28)~~ SH (PG 64-28)
8” HMA Base (SR-19A) ~~(PG 64-22)~~ (PG 64-28)	4” HMA Base (SR-19A) ~~(PG 64-22)~~ SH (PG 64-28)

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602.3 MATERIALS
b. RAP and RAS

- Complies with Section 1103 (15-11002-R01)
- Subsection 1103.2a(4) [RAP]
    - Only Permitted when an Option by Contract Special Provision
    - Subject to Limitations
        - Source
        - Percent in Mix
    - Screen through a 2¼” Grizzly

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602.3 MATERIALS
b. RAP and RAS

- Fractionated RAP
  - Two or more RAP stockpiles
  - Stockpiles determined by Contractor
    - Needs to be in QC Plan
- Subsection 1103.2a(5) [RAS]
  - In any mix that allows RAP
    - Max of 5% RAS and 15% total recycled material
    - 3/8" max grind size

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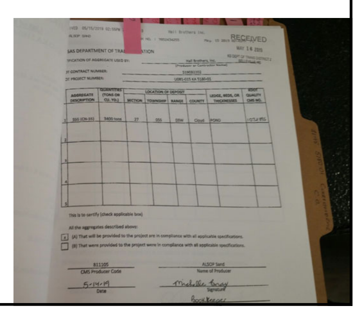
602.3 MATERIALS
c. Aggregates

- Complies with Section 1103 and 15-11002-R01
  - First, go to Section 1101
    - General Requirements for Aggregates
    - c. Certification of Aggregates (Required)
    - Frequency
      - Before initial delivery to a project
      - Upon completion of a project
      - Include quantities



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602.3 MATERIALS
c. Aggregates

- 1103.2a. (1) Crushed Aggregates
  - Limestone, Sandstone, Porphyry, Other
    - CS-1: Crushed Stone
    - CS-2: Crushed Stone Screenings
  - Gravel (CG)
  - Chat (CH-1)
  - Crushed Steel Slag (CSSL)
    - FAA “U” Value > 42
    - Maximum of 50% by weight
  - Manufactured Sand or Buckshot
    - FAA “U” value $\geq$ 42
    - Crushing sand or gravel
    - Washing Crushed Stone Screenings
    - Washing or screening Chat

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602.3 MATERIALS
c. Aggregates

- Complies with Section 1103 and 15-11002-R01
  - 1103.2a.(2) Uncrushed Aggregates
    - Sand and Gravel (SSG)
    - Natural Sand (FAA < 42)
    - Grizzly Waste (Quartzite)
    - Wet Bottom Boiler Slag (WBBS)
      - Written Approval Required
  - 1103.2a.(3) Mineral Fillers
    - Table 1103-2
    - MFS – Cement or Crushed Stone, Crushed Limestone, Silt, Hydrated Lime, Volcanic Ash, Fly Ash, Processed Chat Sludge

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602.3 MATERIALS
c. Aggregates

AGGREGATE INFORMATION

	English/Metric:	English		Mix Designation:	SM-9.5A	
Project # :	23-28 KA 0223-0	County:	FI Mix #6	Mix Use(ML/Shld)	ML	Note: Total Nat. Sd. Cannot exceed 35%
	Specs.:	1990 Std. & 90M-	272-R5			
Contractor:	Venture Corp.			Producer:	Venture Corp.	

1. Aggregate Producer Information

Aggr. Desig.	% in Mix	Producer Name	Legal Description	Producer Code	County
CG-1	5.00	ECA -1/2" Rock	S16 T23S R42W	00833301	Prowers
CG-2	5.00	ECA CF	S16 T23S R42W	00833301	Prowers
CG-4	23.00	ECA -1/2" 3A	S16 T23S R42W	00833301	Prowers
CG-5	30.00	Klotz 3A	S31 T24S R31W	00812605	Finney
SSG-1	35.00	Klotz Vib Sand	S31 T24S R31W	00812605	Finney
MFS-1	2.00	Schoeppel	SW 1/4 S16 T15S R25W	00833501	Trego
PG64-22		Sinclair, P-Burg (WYO		00002603	
Total	100.00				

Aggr. Desig.	% in Mix	1	3/4	1/2	3/8	#4	#8	#16	#30	#50	#100	#200
CG-1	5.000			0	30	96	97	98	98	99	99	99.5
CG-2	5.000				0	9	39	59	71	79	88	92.8
CG-4	23.000			0	6	38	61	74	82	86	89	92.5
CG-5	30.000			0	1	11	35	67	82	90	95	96.4
SSG-1	35.000				0	7	29	56	78	95	99	99.3
MFS-1	2.000						0	2	3	5	10	16.0
Total	100.00											

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602.3 MATERIALS
c. Aggregates

AGGREGATE INFORMATION

	English/Metric:	English		Mix Designation:	SM-12.5A	
Project # :	101 KA-0355-01	County:	Washington	Mix Use(ML/Shld)	ML	Note: Total Nat. Sd. Cannot exceed 35%
	Specs.:	1990 Std. & 90M-	272-R5			
Contractor:	Hall Brothers Const. Co. Inc.			Producer:	Hall Brothers Const. Co. Inc.	

1. Aggregate Producer Information

Aggr. Desig.	% in Mix	Producer Name	Legal Description	Producer Code	County
CS-1	13.00	Hamm Quarries	Sec. 10,T07S,R10E	00800967	Pottawatomie
CS-2	20.00	Hamm Quarries	Sec. 10,T07S,R10E	00800967	Pottawatomie
CG-1A	32.00	Blue River Sand	Sec. 25,T04S,R06E	00805404	Marshall
SSG	35.00	Blue River Sand	Sec. 25,T04S,R06E	00805404	Marshall
PG64-22		Ergon		00002202	
Total	100.00				

Aggr. Desig.	% in Mix	1	3/4	1/2	3/8	#4	#8	#16	#30	#50	#100	#200
CS-1	13.000		0	61	91	97	98	98	98	98	99	99.2
CS-2	20.000			0	5	33	54	67	74	80	84	87.0
CG-1A	32.000				0	4	35	64	78	88	93	95.2
SSG	35.000			0	1	10	28	51	73	94	99	99.7
Total	100.00											

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602.3 MATERIALS
c. Aggregates

AGGREGATE INFORMATION

	English/Metric:	Metric					
Project # :	77-57 K 7417-02		County:	Marion	Mix Designation:	SR-12.5A	%AC in Rap: 6.05
Specs.:	1990 Std. & 90M-125-R5		Class:	A	Mix Use(ML/Shld)	ML	Note: Total Nat. Sd. cannot exceed 35%
Contractor:	Ritchie Paving & Const.			Producer:	Ritchie Paving & Const.		

1. Aggregate Producer Information

Aggr. Desig.	% in Mix	Producer Name	Legal Description	Producer Code	County
CS-1	10.00	Martin Marietta	S23 T28S R11E	00802244	Elk
CS-2	15.00	Martin Marietta	S23 T28S R11E	00802244	Elk
CS-2A	10.00	Martin Marietta	S23 T28S R11E	00802244	Elk
CH-1A	5.00	Humble S & G	S24 T29N R23E	00822502	Pitcher, OK
SSG-2	10.00	Ritchie	S02 T26S R01W	00819304	Sedgwick
SSG-1	25.00	Ritchie	S02 T26S R01W	00819304	Sedgwick
RAP	25.00	Roadway	KD999905		Butler
PG64-22		Valero, Ardmore		00002802	
Total	100.00				

Aggr. Desig.	% in Mix	25.0mm	19.0mm	12.5mm	9.5mm	4.75mm	2.36mm	1.18mm	600 µm	300 µm	150 µm	75 µm
CS-1	10.15	0	0	30	54	91	96	96	96	97	97	97.0
CS-2	15.23	0	0	1	17	76	94	98	98	98	98	98.4
CS-2A	10.15	0	0	0	5	35	56	68	76	81	85	87.5
CH-1A	5.08	0	0	0	0	2	21	48	70	85	94	97.2
SSG-2	10.15	0	0	0	0	0	0	4	21	72	98	98.0
SSG-1	25.38	0	0	0	2	9	28	52	73	90	98	99.6
RAP	23.85	0	0	10	21	46	62	73	80	86	90	92.1
Total	99.99											

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602.3 MATERIALS
c. Aggregates

- 1103.2b. Quality of Individual Aggregates
  - Soundness (min) - 0.90
    - Waive if < 10% Retained on the #4
  - Wear (max) - 40%
    - Waive if < 10% Retained on the #8
  - Absorption (max) - 4.0%
- 1103.2c. Product Control of Individual Aggregates
  - Size Requirements (Tables 1103-1 and 1103-2)
  - Deleterious Substances

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602.3 MATERIALS
d. Combined Aggregates

- Table 602-1 (Mixes)
- Tables 1103-1 and 1103-2 (Individual Aggregates)
- < 0.5% Moisture in HMA
- CSSL ≤ 50% (Repeat from Section 1103)
- and …

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602.3 MATERIALS
d. Combined Aggregates

No More than <u>35%</u> Natural Sand is Permitted in Traveled Way Mixes.

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REVIEW

What's the maximum temperature a mix can be heated?

As stated by the supplier on the Bill Of Lading, but never above 340^{o}F

Is substituting a PG 64-22 for a PG 58-28 permitted?

NO

What defines a natural sand?

FAA < 42

What is the maximum percentage of sand permitted in a mainline mix?

35%

What is the maximum % moisture permitted in HMA?

0.5%

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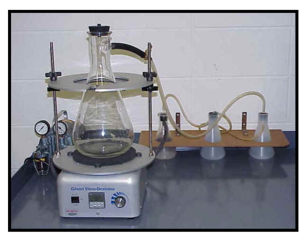
602.3 MATERIALS
e. Contractor Trial Mix Design



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602.3 MATERIALS
e. Contractor Trial Mix Design

- Submit Each Proposed Design Job Mix Formula (JMF) to the DME
  - Review and Approval
  - At least 10 working days before production
  - Test Data for Per Table 602-1 Properties @ P_{br}
  - Worksheets to include Table 602-2 Properties
  - Material as outlined in Table 602-3
  - Test Data in Table 602-4
  - Test Data in Table 602-5 if RAP or RAS in HMA
  - Submit a Mix Design as outlined in Table 602-6
  - Anti-strip required when > 25% siliceous virgin aggregate and RAP in mix

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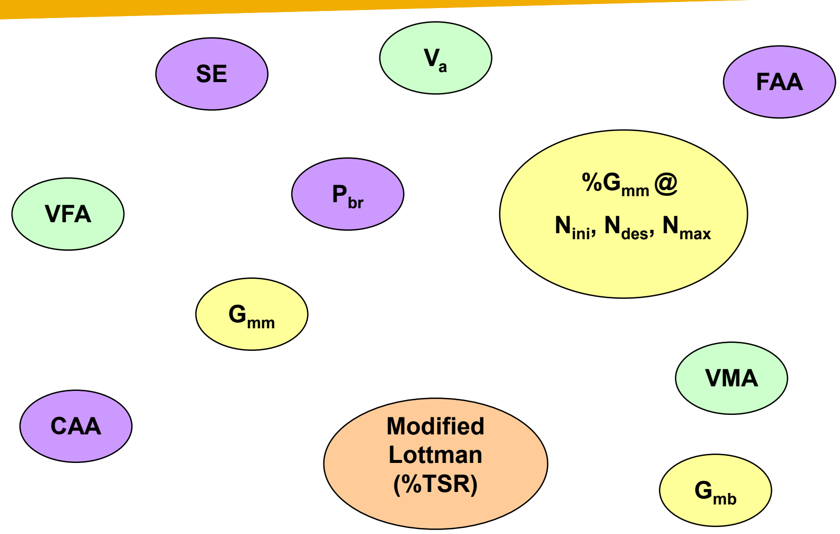
602.3 MATERIALS
Table 602-2: Mix Properties



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602.3 MATERIALS
Tables 602-3 and 602-6

- This is what we want
  - Mix Design that Meets the Specs
  - The data showing it meets the Specs
  - 2 SGC plugs so we can check them
  - 35 lbs of loose mix so we can check it
  - Some rock and oil
    - So we can mix our own samples
    - We'll run G_{mm}
    - We'll make SGC plugs
- Because we want to verify the mix meets specs

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602.3 MATERIALS
Tables 602-4 and 602-5

We also want

The Asphalt Binder (Where'd it come from?)

The Aggregates (Where'd they come from?)

The Gradation of the Aggregates

The Proportion of the Aggregates in the Mix

The Composite Gradation

The Composite Gradation Plotted

The Aggregate Tests

Information about the RAP and RAS if used.

Information about WMA additives if used.

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602.3 MATERIALS
e. Contractor Trial Mix Design

- Specific gravity
  - Each aggregate used in mix design
  - Within 12 months of construction
  - Within first 10,000 tons of HMA Produced
- Why?
  - Verify Numbers on HMA Specific Gravity List
  - Not necessarily used in current project (unless mutually agreeable)

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602.3 MATERIALS
e. Contractor Trial Mix Design

January 2023 LETTING

PROCEDURE I SPECIFIC GRAVITIES

Producer	CMS ID Producer	Legal Description	Location	Products	Bulk Dry (Gsb)	Saturated Surf Dry	Apparent	Percent Absorp	Date Modified or Verified	Chat or SSG	Latitude	Longitude
Air Capital Materials	850701	S22 T26S R01W	Segewick Co.		**2.553**	2.575	2.610	0.9	February 1, 2022			
Alsop	811105	S27 T05S R03W	Cloud Co.		**2.538**	2.563	2.603	1.0	August 1, 2020	s		
Alsop	811107	S27 T13S R01E	Dickinson Co.		**2.556**	2.611	2.705	2.2	July 1, 2017	s		
Alsop	811114	S05 T04S R04W	Republic Co.		**2.518**	2.559	2.627	1.7	September 1, 2020	s	39.73909	97.78814
American S&G	811116	S08 T15S R02W	Saline Co.		**2.541**	2.598	2.696	2.3	February 1, 2020	s		
Anchor Stone (WRSW)	836402	S34 T28N R32W	Jasper Co. MO	3/4"	**2.486**	2.558	2.680	2.9	May 1, 2021		37.10327	94.40710
APAC Kansas	826018	S24 T12S R08W	Lincoln Co.		**2.600**	2.628	2.674	1.1	November 1, 2021			
APAC-Shears	826001	S11 T12S R08W	Lincoln Co.	CS-1	**2.503**	2.556	2.642	2.1	July 1, 2021			
APAC-Shears	801934	S21 T23S R05W	Reno Co.		**2.560**	2.583	2.633	0.9	December 1, 2020	s		
Ashland Agg. (Rhoades Pit)	849303	S34 T32S R23W	Clark Co.		**2.659**	2.695	2.757	1.4	December 1 2022			
Associated	819905	S14 T26S R01W	Sedgwick County		**2.554**	2.578	2.618	1.0	October 1, 2018	s		
Bayer Const. Co.	801834	S01 T13S R04E	Dickinson Co.	CS-1	**2.505**	2.574	2.690	2.8	April 1, 2022			
Bayer Const. Co. (TRKO)	802445	S04 T11S R09E	Riley Co.	3/4" x 1/4"	**2.541**	2.604	2.716	2.6	November 1, 2021			
Bayer Const. Co. (TRKO)	802445	S04 T11S R09E	Riley Co.	Washed 3/8" Chips	**2.480**	2.563	2.695	3.3	October 1, 2020	s		
Beatrice S&G	824603	S04 T03N R01W	Thayer Co. NE	SSG	**2.569**	2.590	2.626	0.8	July 1, 2019	s		
Beyer Crushed Rock Co (BFLS)	806901	S26 T45N R33W	Cass Co. MO	-1"	**2.569**	2.618	2.700	1.9	July 1, 2022			
Big Creek Sand & Gravel	851101		Carson Co. TX		**2.613**	2.645	2.698	1.2	January 1, 2022			
Bladen	824205	S16 T02N R10W	Webster Co. NE		**2.578**	2.596	2.624	0.7	October 1, 2018	s		
Blue River Sand	805404	S25 T04S R06E	Marshall Co.		**2.559**	2.584	2.624	1.0	November 1, 2020	s		
Carthage Crushed	848001	S29 T29N R31W	Jasper Co. MO		**2.640**	2.662	2.700	0.9	June 1, 2022			
Central Sand	848601	S22 T26S R01W	Sedgwick County	MA-1 Sand	**2.556**	2.579	2.618	0.9	September 1,2022	s		
Concrete Enterprise	813403	S04 T28S R13W	Pratt Co.		**2.559**	2.590	2.641	1.2	November 1, 2018	s		
Cornejo Mtls (NW Wichita Sand)	819301	S35 T26S R01W	Sedgwick Co.	SSG	**2.554**	2.577	2.613	0.9	July 1, 2022	s		
Cornejo Stone (EVCK)	801504	S13 T31S R10E	Elk Co.		**2.555**	2.610	2.702	2.1	September 1,2022	s	37.35270	96.28578
Cornejo Mtls	820106	S07 T32S R03E	Cowley Co		**2.568**	2.592	2.630	0.9	Janurary 1, 2023			
Cornejo Mtls	820103	S23 T26S R01W	Sedgewick Co.	SSG	**2.571**	2.592	2.625	0.8	August 1, 2020	s		
Deweese	825001	S17 T01N R07W	Nuckolls Co. NE	SSG	**2.576**	2.594	2.623	0.7	November 1, 2018	s		
Dodge City Sand	813102	S32 T26S R25W	Ford Co.		**2.550**	2.580	2.630	1.0	December 1, 2019	s		
Dolese	809405	S31 T06N R15W	Cooperton, OK	CS-2	**2.676**	2.693	2.721	0.6	January 1, 2023			
Eakins Sand	817302	S08 T22S R16W	Pawnee Co.		**2.574**	2.603	2.651	1.1	May 1, 2021	s		
Flint Rock #5	822506	S20 T29N R23E	Ottawa County, OK	CME	**2.550**	2.590	2.656	1.6	July 1, 2020	c		
Flint Rock Products Pile # 2	822503	SW 1/4 S29 T29N R23E	Ottawa County, OK		**2.539**	2.587	2.668	1.9	March 1, 2020	c	36.96011	94.84968
Gravel and Concrete	832701	S15 T22S R07W	Reno Co.		**2.551**	2.580	2.620	1.1	July 1, 2018	s		
Hamm (BFLS)	842701	S07 T47N R30W	Jackson Co., MO	-3/4	**2.559**	2.612	2.703	2.1	March 1, 2022			
Hamm (CPCK)	800907	S15 T13S R21E	Eudora-Douglas Co		**2.502**	2.577	2.706	3.0	November 1, 2021			

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602.3 MATERIALS
f. WMA Additives

- WMA Additives
  - Comply with Section 1207
  - PQL 4-3
- Water Foaming Processes
  - Temperature drop of 30°F Max
- Chemical and Organic Additives
  - Temperature drop of 70°F Max
- Minimum Mixing Temperature is 220°F

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TABLE 602-1
Combined Aggregate Requirements

Nominal Max. Size Mix Designation	Percent Retained – Square Mesh Sieves								Min. VMA (%)
	1"	¾"	½"	⅜"	No. 4	No. 8	No. 16	No. 200	
SM-4.75A & SR-4.75A			0	0-5	0-10		40-70	88.0-94.0	16.0
SM-9.5A & SR-9.5A			0	0-10	10 min.	33-53		90.0-98.0	15.0
SM-9.5B & SR-9.5B			0	0-10	10 min.	53-68		90.0-98.0	15.0
SM-9.5T & SR-9.5T			0	0-10	10 min.	53-68		90.0-98.0	15.0
SM-12.5A & SR-12.5A		0	0-10	10 min.		42-61		90.0-98.0	14.0
SM-12.5B & SR-12.5B		0	0-10	10 min.		61-72		90.0-98.0	14.0
SM-19A & SR-19A	0	0-10	10 min.			51-65		92.0-98.0	13.0
SM-19B & SR-19B	0	0-10	10 min.			65-77		92.0-98.0	13.0

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TABLE 602-1
Combined Aggregate Requirements

Nominal Max. Size Mix Designation	Percent Retained – Square Mesh Sieves 1"	¾"	½"	⅜"	No. 4	No. 8	No. 16	No. 200	Min. VMA (%)
SM-4.75A & SR-4.75A			0	0-5	0-10		40-70	88.0-94.0	16.0
SM-9.5A & SR-9.5A			0	0-10	10 min.	33-53		90.0-98.0	15.0
SM-9.5B & SR-9.5B			0	0-10	10 min.	53-68		90.0-98.0	15.0
SM-9.5T & SR-9.5T			0	0-10	10 min.	53-68		90.0-98.0	15.0
SM-12.5A & SR-12.5A		0	0-10	10 min.		42-61		90.0-98.0	14.0
SM-12.5B & SR-12.5B		0	0-10	10 min.		61-72		90.0-98.0	14.0
SM-19A & SR-19A	0	0-10	10 min.			51-65		92.0-98.0	13.0
SM-19B & SR-19B	0	0-10	10 min.			65-77		92.0-98.0	13.0

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TABLE 602-1
Combined Aggregate Requirements

Mix Designation	Sieve with 0-10 Retained	Sieve with 10 min. Retained
SM/SR-4.75A	No. 4 (4.75 mm)	
SM/SR-9.5A	3/8" (9.5 mm)	No. 4 (4.75 mm)
SM/SR-9.5T	3/8" (9.5 mm)	No. 4 (4.75 mm)
SM/SR-12.5A	1/2" (12.5 mm)	3/8" (9.5 mm)
SM/SR-19A	3/4" (19.0 mm)	1/2" (12.5 mm)

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TABLE 602-1
Combined Aggregate Requirements

Mix Designation	Sieve with 0-10 Retained	Sieve with 10 min. Retained
SM/SR-4.75A	No. 4 (4.75 mm)	
SM/SR-9.5A	3/8” (9.5 mm)	No. 4 (4.75 mm)
SM/SR-9.5T	3/8” (9.5 mm)	No. 4 (4.75 mm)
SM/SR-12.5A	1/2” (12.5 mm)	3/8” (9.5 mm)
SM/SR-19A	3/4” (19.0 mm)	1/2” (12.5 mm)

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TABLE 602-1
Combined Aggregate Requirements

Mix Designation	VMA	D/B Ratio
SM/SR-4.75A	16.0%	**0.9 - 2.0**
SM/SR-9.5A	15.0%	0.6 - 1.2
SM/SR-9.5T	15.0%	0.8 - 1.6
SM/SR-12.5A	14.0%	0.6 - 1.2
SM/SR-19A	13.0%	0.6 - 1.2

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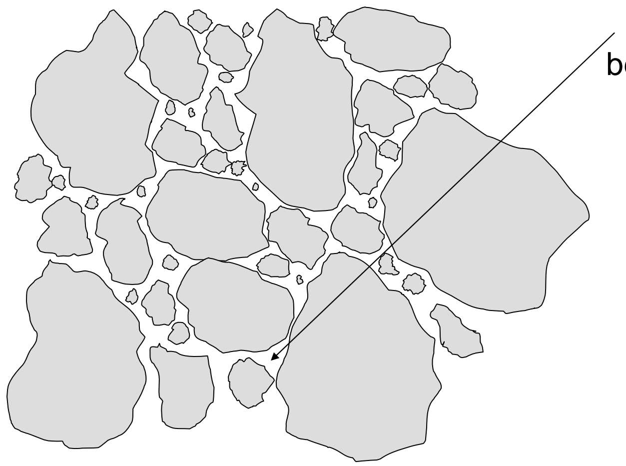
SUPERPAVE VOLUMETRIC PROPERTIES VMA



35

TABLE 602-1 Combined Aggregate Requirements

6 Notes follow Table 602-1

1. Look at Contract Special Provision for more Mix Requirements.

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SPECIAL PROVISION 15-MR0664
Table 1: Project Mix Requirements

MIX CRITERIA	SR-12.5A (PG 70-28)
AGGREGATE:	
Coarse Angularity (min. %)	75
Uncompacted Voids- Fine (min.%)	42
Sand Equivalent (min.%)	40
RAP (max.%)	25
RAP Bulk Specific Gravity	2.595
COMPACTION REVOLUTIONS:	
N_{ini} (level of compaction)	7 ($\leq$ 91.5)
N_{des}	75
N_{max}	115
MIX:	
VFA	65 - 82

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SPECIAL PROVISION 15-MR0664
Table 1: Project Mix Requirements

MIX CRITERIA	SR-12.5A (PG 70-28)
AGGREGATE:	
Coarse Angularity (min. %)	CAA ≥ 75
Uncompacted Voids- Fine (min.%)	FAA ≥ 42
Sand Equivalent (min.%)	SE ≥ 40
RAP (max.%)	25
RAP Bulk Specific Gravity	2.595
COMPACTION REVOLUTIONS:	
N_{ini} (level of compaction)	7 ($\leq$ 91.5)
N_{des}	75
N_{max}	115
MIX:	
VFA	65 - 82

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COARSE AGGREGATE ANGULARITY (CAA)

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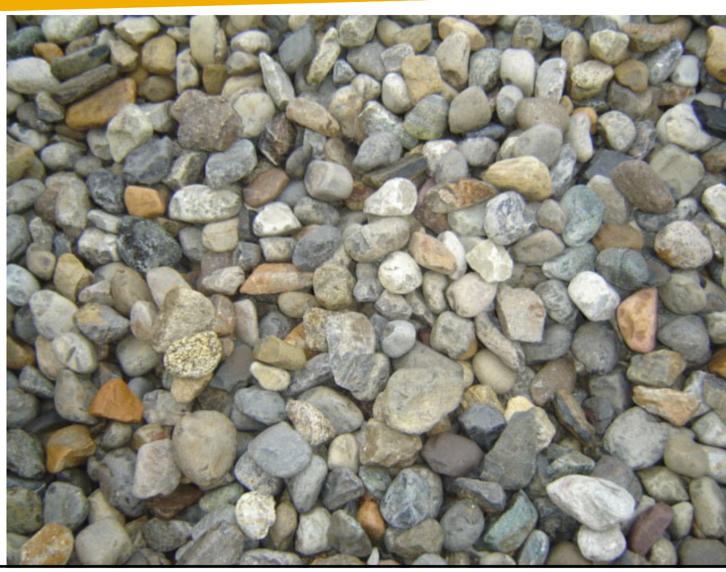
COARSE AGGREGATE ANGULARITY (CAA)



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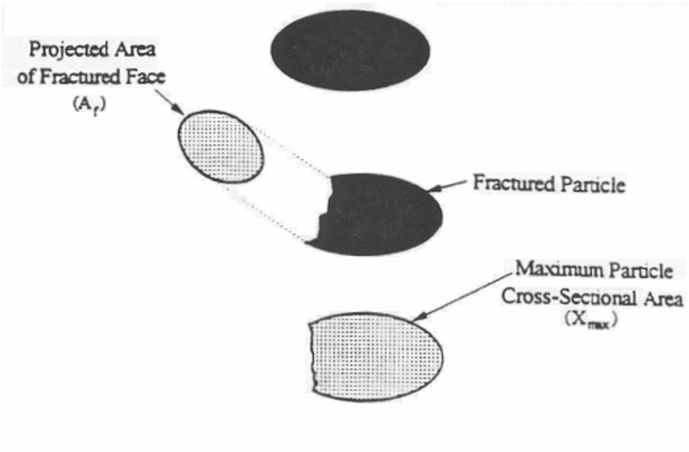
COARSE AGGREGATE ANGULARITY (CAA) KT-31



A face will be considered a "Fractured Face" only if it has : $A_f \geq 0.25\ X_{max}$

FIG. 1 Schematic of a Fractured Particle with One Fractured Face

41

FINE AGGREGATE ANGULARITY (FAA)

Remember:
Natural Sand shall have a FAA value less than 42

42

FINE AGGREGATE ANGULARITY (FAA)
KT-50

43

SAND EQUIVALENT (SE)
KT-55

Clay Reading after 20 min.

Then Sand Reading

Ratio of Sand over Clay *100

Higher the Better

44

SPECIAL PROVISION 15-MR0664
Table 1: Project Mix Requirements

MIX CRITERIA	SR-12.5A (PG 70-28)
AGGREGATE:	
Coarse Angularity (min. %)	CAA ≥ 75 (KT-31)
Uncompacted Voids- Fine (min.%)	FAA ≥ 42 (KT-50)
Sand Equivalent (min.%)	SE ≥ 40 (KT-55)
RAP (max.%)	25
RAP Bulk Specific Gravity	2.595
COMPACTION REVOLUTIONS:	
N_{ini} (level of compaction)	7 (≤ 91.5)
N_{des}	75
N_{max}	115
MIX:	
VFA	65 - 82

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SPECIAL PROVISION 15-MR0664
Table 1: Project Mix Requirements

MIX CRITERIA	SR-12.5A (PG 70-28)
AGGREGATE:	
Coarse Angularity (min. %)	75
Uncompacted Voids- Fine (min.%)	42
Sand Equivalent (min.%)	40
RAP (max.%)	**25**
RAP Bulk Specific Gravity	**2.595**
COMPACTION REVOLUTIONS:	
N_{ini} (level of compaction)	7 (≤ 91.5)
N_{des}	75
N_{max}	115
MIX:	
VFA	65 - 82

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SPECIAL PROVISION 15-MR0664
Table 1: Project Mix Requirements

MIX CRITERIA	SR-12.5A (PG 70-28)
AGGREGATE:	
Coarse Angularity (min. %)	75
Uncompacted Voids- Fine (min.%)	42
Sand Equivalent (min.%)	40
RAP (max.%)	25
RAP Bulk Specific Gravity	2.595
COMPACTION REVOLUTIONS:	
N_{ini} (level of compaction)	**7 ($\leq$ 91.5)**
N_{des}	**75**
N_{max}	**115**
MIX:	
VFA	65 - 82

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SPECIAL PROVISION 15-MR0664
Table 1: Project Mix Requirements

Compaction Revolutions

Traffic (10^6 ESALs)	N_{ini}	N_{des}	N_{max}
< 0.3	6	50	75
0.3 to < 6.0	7	75	115
$\geq$ 6.0	8	100	160

May see them written as:

6, 50, 75 7, 75, 115 8, 100, 160

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SPECIAL PROVISION 15-MR0664
Table 1: Project Mix Requirements

MIX CRITERIA	SR-12.5A (PG 70-28)
AGGREGATE:	
Coarse Angularity (min. %)	75
Uncompacted Voids- Fine (min.%)	42
Sand Equivalent (min.%)	40
RAP (max.%)	25
RAP Bulk Specific Gravity	2.595
COMPACTION REVOLUTIONS:	
N_{ini} (level of compaction)	7 ($\leq$ 91.5)
N_{des}	75
N_{max}	115
MIX:	
VFA	**65 - 82**

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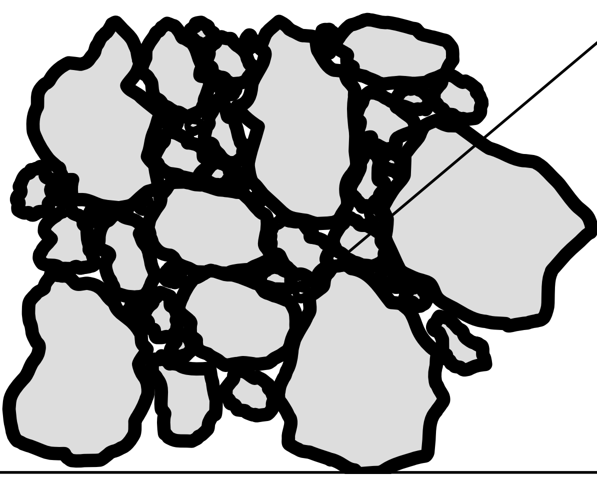
SUPERPAVE VOLUMETRIC PROPERTIES VFA



VFA is the voids in the Aggregate that are filled with Asphalt

We want 65%-82% for this project

50

TABLE 602-1
Combined Aggregate Requirements

6 Notes follow Table 602-1

1. Look at Contract Special Provision for more Mix Requirements.
2. **Flat and Elongated (KT-59) ≤ 10%**

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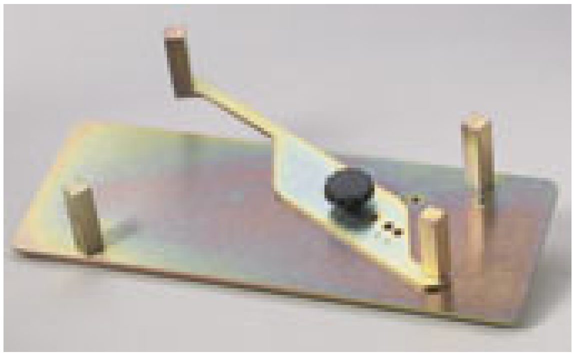
TABLE 602-1
Note 2

Flat and Elongated (KT-59) ≤ 10%



Proportional Caliper Device

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TABLE 602-1
Combined Aggregate Requirements

6 Notes follow Table 602-1

1. Look at Contract Special Provision for more Mix Requirements.
2. Flat and Elongated (KT-59) ≤ 10%
3. **Maximum Moisture in Mix (KT-11) ≤ 0.5%**

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TABLE 602-1
Combined Aggregate Requirements

6 Notes follow Table 602-1

1. Look at Contract Special Provision for more Mix Requirements.
2. Flat and Elongated (KT-59) ≤ 10%
3. Maximum Moisture in Mix (KT-11) ≤ 0.5%
4. **Target Air Voids at N_{des} = 3.0%**
5. TSR (KT-56) ≥ 80%
6. **Level of Compaction at N_{max} ≤ 98.5% G_{mm}**

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TABLE 602-1
Notes 4 and 6

Target Air Voids at N_{des} = 3.0%
Level of Compaction at $N_{max} \leq$ 98.5% G_{mm}

Compact the HMA plugs per KT-58

Weigh the plugs per KT-15

55

TABLE 602-1
Combined Aggregate Requirements

6 Notes follow Table 602-1

1. Look at Contract Special Provision for more Mix Requirements.
2. Flat and Elongated (KT-59) ≤ 10%
3. Maximum Moisture in Mix (KT-11) ≤ 0.5%
4. Target Air Voids at N_{des} = 3.0%
5. **TSR (KT-56) ≥ 80%**
6. Level of Compaction at $N_{max} \leq$ 98.5% G_{mm}

56

TABLE 602-1
Note 5

Tensile Strength Ratio (TSR) (KT-56) ≥ 80%
Lottman Test

57

TABLE 602-1
Combined Aggregate Requirements

6 Notes follow Table 602-1

1. Look at Contract Special Provision for more Mix Requirements.
2. Flat and Elongated (KT-59) ≤ 10%
3. Maximum Moisture in Mix (KT-11) ≤ 0.5%
4. Target Air Voids at N_{des} = 3.0%
5. TSR (KT-56) ≥ 80%
6. Level of Compaction at $N_{max} \leq$ 98.5% G_{mm}

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REVIEW

When is the Mix Design due to the DME?

10 working days before production

What table has gradations and the VMA requirements?

Table 602-1

Where is the max. permitted % of RAP stated?

Contract Special Provision (15-MR0664)

What is the target air voids at N_{des}?

3.0%

What is the minimum TSR% requirement?

80%

Where are the required number of SGC gyrations stated?

Contract Special Provision (15-MR0664)

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602.3 MATERIALS

AD ASTRA PER ASPERA
Kansas
Department of Transportation

60

QC/QA Asphalt Specifications Special Provision 15-06007-R03 Outline

602.1	Description (Sheet 1 of 30)
602.2	Contractor QC Requirements (Sheets 1 to 4 of 30)
602.3	Materials (Sheets 4 to 8 of 30)
602.4	**Construction Requirements (Sheets 8 to 14 of 30)**
602.5	Process Control (Sheets 14 to 17 of 30)
602.6	Compaction Testing (Sheets 17 to 19 of 30)
602.7	Weather Limitations (Sheet 19 of 30)
602.8	Mixture Acceptance (Sheets 19 to 22 of 30)
602.9	Basis of Acceptance (Sheets 22 to 25 of 30)
602.10	HMA Paid by the Area (Sheets 25 to 29 of 30)
602.11	Measurement and Payment (Sheets 29 to 30 of 30)

Kansas
Department of Transportation

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602.4 CONSTRUCTION REQUIREMENTS

a. Plant Operation
b. Road Surface Preparation
c. Weighing Operations
d. Hauling Operations
e. Paving Operations
f. Maintenance of Traffic
g. Treatment of Adjacent Areas
h. Pavement Smoothness

2

602.4 CONSTRUCTION REQUIREMENTS
a. Plant Operation

1) Preparation of the Asphalt Binder
   a) Do not Comingle Asphalt Binders
   b) Do not change Binder Sources without approval
   c) Anti-Strip Agents
      - Use totalizer if liquid anti-strip added at plant
      - Add liquid anti-strip in line with AC as it is transferred from the transit unit to storage tank
      - Mix hydrated lime with aggregates in a pug mill
   d) WMA Additives (chemical and organic)
      - Same requirements as liquid anti-strip

3

602.4 CONSTRUCTION REQUIREMENTS
a. Plant Operation

2) Preparation of Mineral Aggregate
   a) Temperature Requirements
      - Dry the Aggregates
      - No Mixing or Compacting above 340^{o}F
      - Deliver HMA to Paver at a sufficient temperature for:
        - Compaction to the specified density
        - Meet Surface Tolerance Requirement

4

602.4 CONSTRUCTION REQUIREMENTS a. Plant Operation

Exception (in 602.3a on Sheet 15-06007-R03-4)

- Air temperature (morning startup) < 70ºF.
  - May run plant 10ºF warmer than mixing temperature printed on the asphalt bill of lading
  - Temperature shall not exceed 350ºF.
- Return of a delivery truck for its 2nd load of the day
  - Reduce plant temperature to the mixing temperature shown on the bill of lading
  - Temperature shall not exceed 340ºF.

5

602.4 CONSTRUCTION REQUIREMENTS a. Plant Operation

3) Preparation of HMA

a) Basis of Rejection
- Foaming of Mixture
- Temperature outside mixing range temperatures

b) Mixing Time
- Minimum is 40 seconds
- All Aggregates are coated

c) Manufacturers Specifications (within limits)

d) Batcher Operation (Gob Hopper)
- At least ¾ full before opening gates
- Close Gates before HMA flows directly to surge bin

e) Wasted Material - Measured not for Pay

6

602.4 CONSTRUCTION REQUIREMENTS
Segregation Issues

The Gob Hopper (Correct Discharge)

Open when ≥ ¾ full

7

602.4 CONSTRUCTION REQUIREMENTS
Segregation Issues

The Gob Hopper (Flowing Partially)

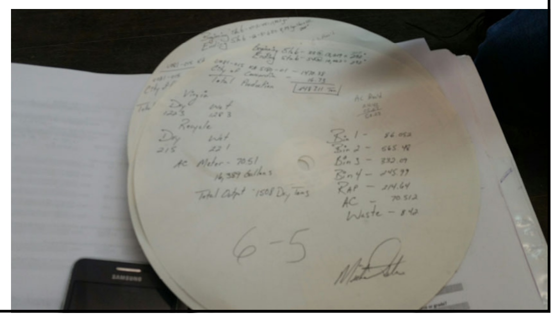
Close before material can pass directly through the Gob Hopper

8

602.4 CONSTRUCTION REQUIREMENTS
a. Plant Operation

4) End of Day Quantities

- Provide Engineer with a signed document
  - Dry Weight of Each Aggregate
  - Dry Weight of Mineral Filler
  - Dry Weight of RAP
  - Tons of Asphalt Binder
  - Tons of Anti-Strip
  - Tons of WMA Additive



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602.4 CONSTRUCTION REQUIREMENTS
e. Paving Operations

Segregation Prevention

- Equipment
  - Mobile Conveyor
  - Material Transfer Device
  - Shuttle Buggy Material Transfer Vehicle
  - Material Transfer Paver
  - Paver with Remixer Conveyor System
- SM-4.75A, SR-4.75A, SM-9.5A & SR-9.5A excluded (unless segregation is observed)

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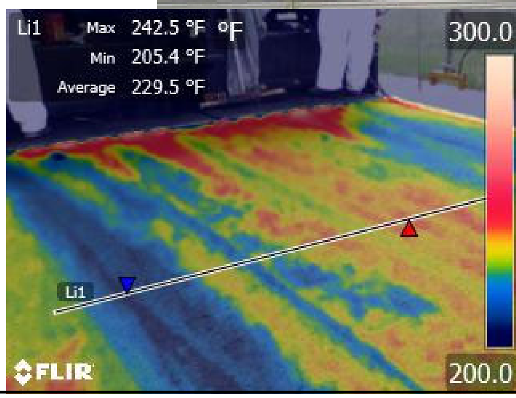
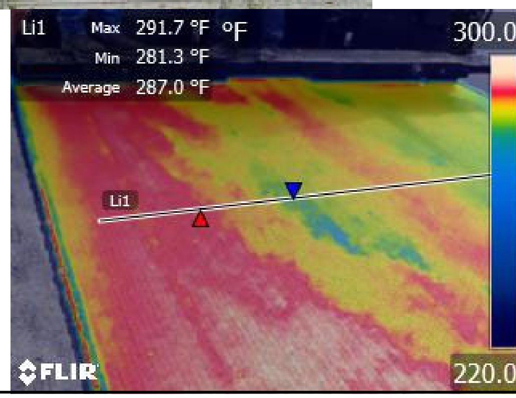
602.4 CONSTRUCTION REQUIREMENTS
e. Paving Operations





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602.4 CONSTRUCTION REQUIREMENTS
e. Paving Operations

- Segregation Prevention
  - Do not dump wings of the paver
  - Segregation Checks
  - Segregation Check Points Document

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602.4 CONSTRUCTION REQUIREMENTS
e. Paving Operations

- Segregation Checks By Engineer using the Nuclear Gauge (Section 5.8.3)
  - Multiple Readings in a 50’ Segment
  - Truckload Segregation
    - Visible Repeated Pattern with every Truck Load
    - Occurs 10’-25’ forward of where screed stops
      - MTV may extend this distance
  - Longitudinal Segregation
    - Caused by the Paver
    - Segregation Line parallel to Roadway
    - Continuous or “Start and Stop”
  - Designate Screed Stopping Location as the “zero” point provided excessive cooling hasn’t occurred

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602.4 CONSTRUCTION REQUIREMENTS
Longitudinal Segregation

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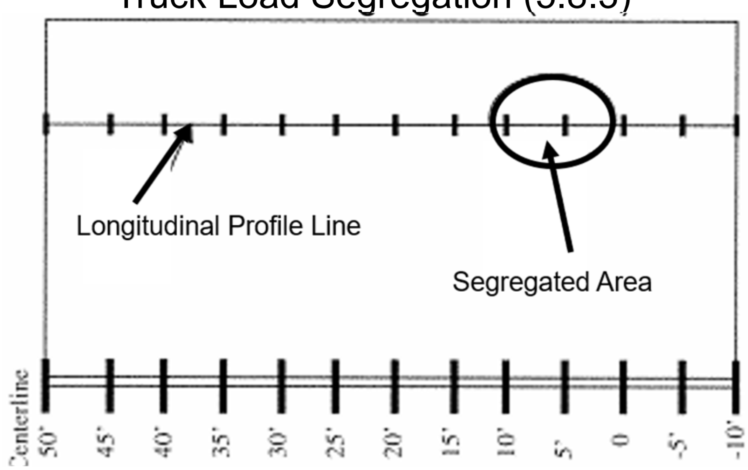
602.4 CONSTRUCTION REQUIREMENTS Segregation Issues

- Nuclear Gauge Readings
  - Truckload Segregation Checks in a Straight Line
  - Longitudinal Segregation Check will cross Segregated Line (2’ Offset)

15

602.4 CONSTRUCTION REQUIREMENTS Segregation Issues

Truck Load Segregation (5.8.3)



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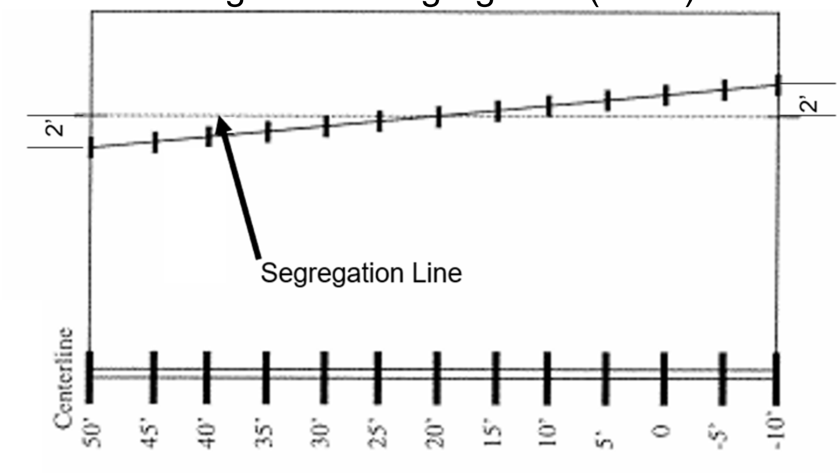
602.4 CONSTRUCTION REQUIREMENTS
Segregation Issues

Longitudinal Segregation (5.8.3)



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602.4 CONSTRUCTION REQUIREMENTS
Segregation Issues

- Procedure Summarized
  - Use Sand to fill voids in Surface
  - Avoid hot surfaces (over 160°F)
  - First Readings are 10' behind "zero" point
  - 3 Nuclear Gage Readings in Backscatter Mode
    - If a reading is more than 1.0 pcf from avg, then retake
  - Minimum of 10 locations per profile

WRONG!

18

602.4 CONSTRUCTION REQUIREMENTS Segregation Issues

- Profile Evaluation
  - Initially 4 checks per mix
  - Following a Failing test, contractor may make changes within the next hour to correct
  - Two consecutive failing tests result in stopped production
  - Start-up placement after stoppage is 2000’ long
  - 2 segregation profiles run in this segment
  - Both must pass
  - If one fails, then continue paving in 2000’ strips until both checks pass

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602.4 CONSTRUCTION REQUIREMENTS Segregation Issues

Acceptable Criteria
TABLE 602-7

Maximum Density Range (highest – lowest)	Maximum Density Drop (average – lowest)
4.4 lbs/cu. ft.	2.2 lbs/cu. ft.

If 2 Consecutive Tests Fail to Comply with **BOTH** requirements then plant production and paving will be suspended.

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602.4 CONSTRUCTION REQUIREMENTS Joint Density

- Contractor's Responsibility
- Check On Lifts > 1" Thick
- KDOT may Verify
- KDOT's Tests will be Used as acceptance when available
- Use Part V Section 5.8.4

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602.4 CONSTRUCTION REQUIREMENTS Joint Density

Table 1 (5.8.4)

Determination of Number of Sublots Per Day

Distance Paved	Number of Sublots
0' – 500'	0
501' – 1,000'	1
1,001' – 2,000'	2
2,001' – 3,000'	3
3,001' – 4,000'	4
$\geq$ 4,001'	5

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602.4 CONSTRUCTION REQUIREMENTS
Joint Density

1st sublot tested before
3rd sublot compacted

2nd sublot tested before
4th sublot compacted

3rd sublot tested before
5th sublot compacted

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Figure 1A- Traveled Way Without Hot Mix Shoulders or Shoulders Placed at The Same Time

↓ Random Longitudinal Location ↓ Interior edge of mat

• 8" from edge of mat

↑ 2' from edge of mat

TRAVELED WAY
Direction of Travel →

■ Random Transverse Distance

↓ 2' from edge of mat

(drawing not to scale) ↑ Exterior edge of mat

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Figure 1A- Traveled Way Without Hot Mix Shoulders or Shoulders Placed at The Same Time

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JOINT DENSITY – Where?

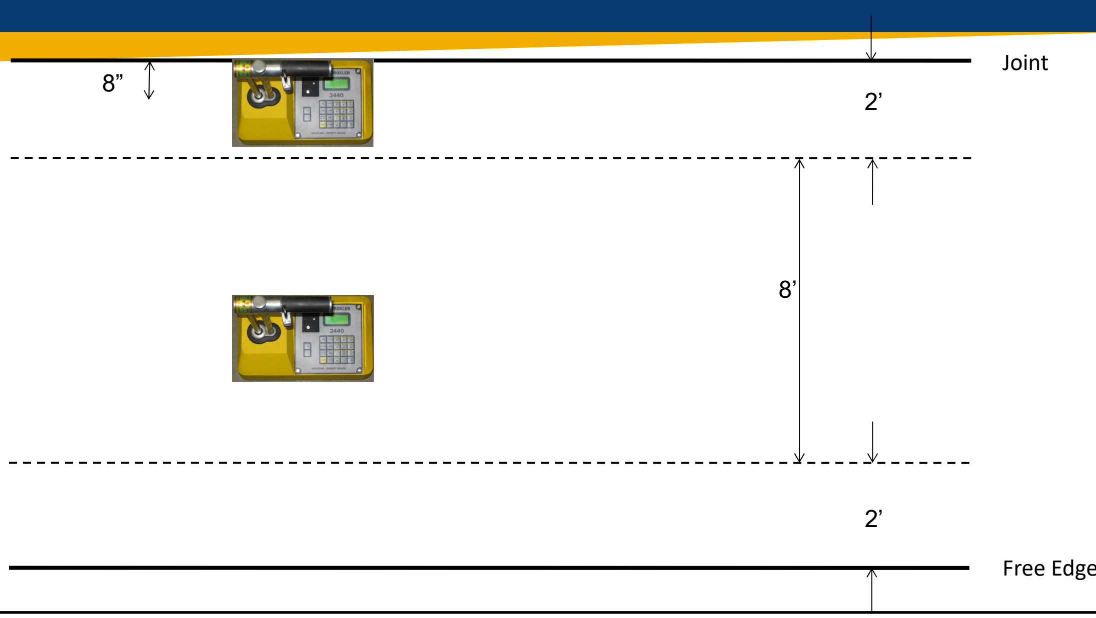

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Figure 1B- Traveled Way With Hot Mix Shoulders or Shoulders Not Placed at the Same Time

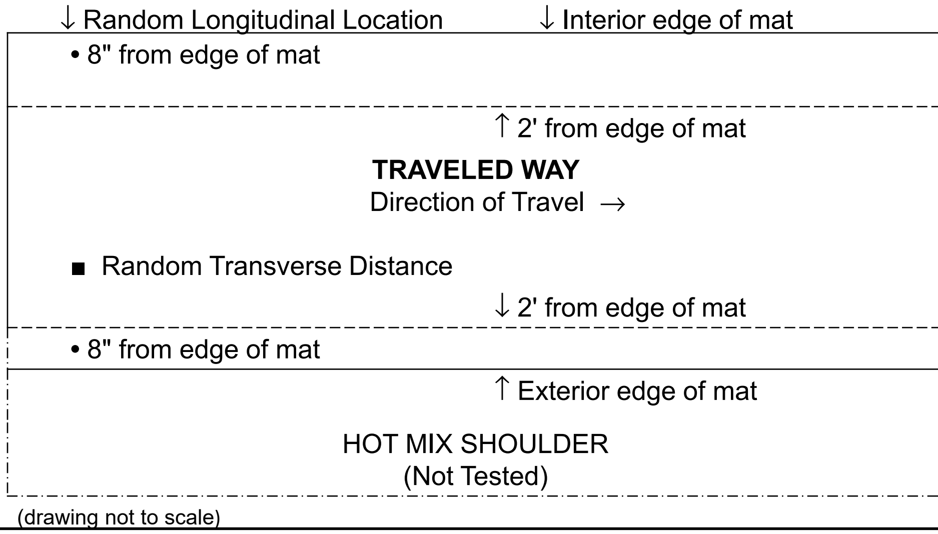

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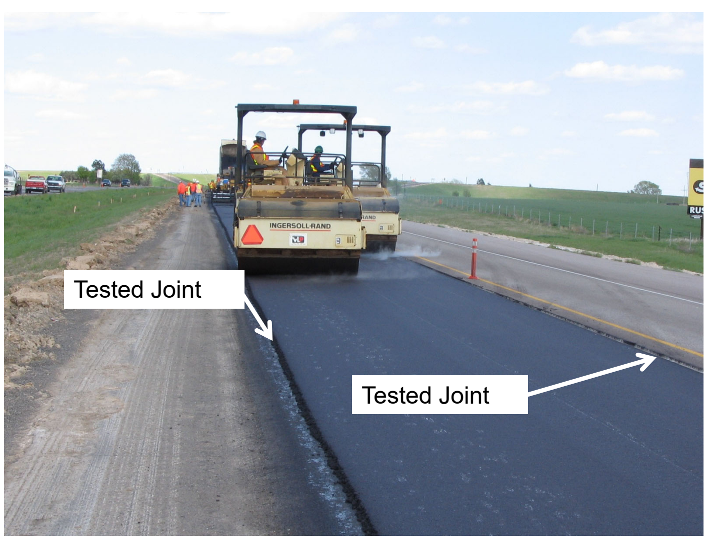
Figure 1B- Traveled Way With Hot Mix Shoulders or Shoulders Not Placed at the Same Time



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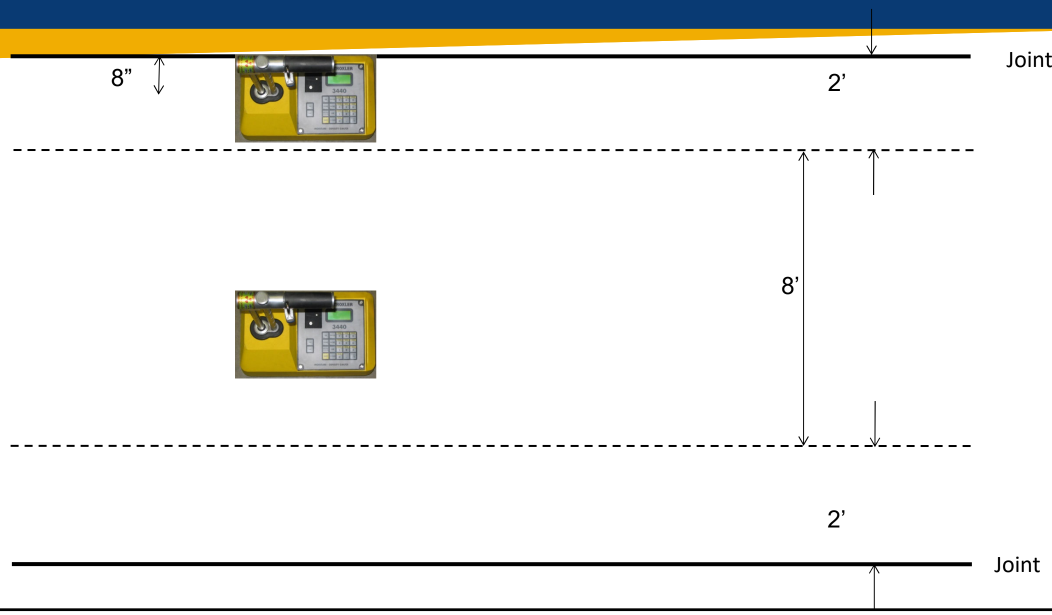
JOINT DENSITY – Where?



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602.4 CONSTRUCTION REQUIREMENTS
Joint Density

Acceptable Criteria

TABLE 602-8

Interior Density – Joint Density $\leq$ 3.0 lbs/cu.ft.

OR

Joint Density $\geq$ 91.00% of G_{mm}

Each Joint must pass.

30

602.4 CONSTRUCTION REQUIREMENTS Joint Density

- Suspend paving if 2 consecutive failures.
- Contractor must make changes.
- Pave 2000 ft.
- 2 joint densities must pass.
- Repeat as needed.

31

602.4 CONSTRUCTION REQUIREMENTS e.(3) Lift Thickness

The **minimum** lift thickness for any HMA mixture is **3 times** the nominal maximum aggregate size (NMAS)

- unless otherwise designated in the Contract Documents
- or approved by the Engineer.

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TABLE 602-1
Combined Aggregate Requirements

Mix Designation	Sieve with 0-10 Retained	NMAS
SM/SR-4.75A	No. 4 (4.75 mm)	3/16”
SM/SR-9.5A	3/8” (9.5 mm)	⅜”
SM/SR-9.5T	3/8” (9.5 mm)	⅜”
SM/SR-12.5A	1/2” (12.5 mm)	½”
SM/SR-19A	3/4” (19.0 mm)	¾”

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602.4 CONSTRUCTION REQUIREMENTS
e.(3) Lift Thickness

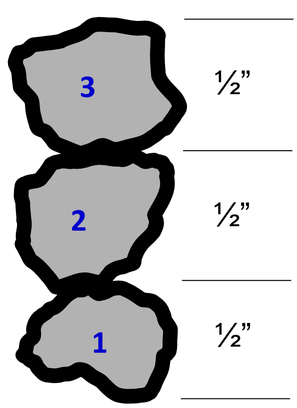
Min. lift thickness ≥ 3 x {NMAS}

SM-4.75A: 3/16” * 3 = 9/16”

SM-9.5T or SM-9.5A: ⅜” * 3 = 1⅛”

SM-12.5A: ½” * 3 = 1½”

SM-19A: ¾” * 3 = 2¼”



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602.4 CONSTRUCTION REQUIREMENTS e.(6) Density Requirements

a) Specified Mix Thickness ≥ 1½"

- Lots 1 and 2
  - Density controlled by an approved rolling procedure
  - Minimum of 10 random nuclear density gauge determinations
  - The contractor may accept pay adjustments for Lots 1 and 2, or Lot 2 prior to beginning production

35

602.4 CONSTRUCTION REQUIREMENTS e.(6) Density Requirements

a) Specified Mix Thickness ≥ 1½"

- Lots 3 and Greater
  - Densities are subjected to pay adjustments
  - Densities are typically compared to G_{mm} values obtained the same day as the paving.
  - Number of Sublots based on Table 602-10

36

602.4 CONSTRUCTION REQUIREMENTS e.(6) Density Requirements

b) Specified Mix Thickness < 1½”

- Density controlled by an approved rolling procedure
- Minimum of 10 random nuclear density gauge determinations
- No density pay adjustment

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602.4 CONSTRUCTION REQUIREMENTS e.(6) Density Requirements

c) All Mixes

- Complete Rolling before mat temperature reaches 175°F for HMA, 165°F for WMA
- Only final roller (Static steel wheel or oscillating) permitted on mat at temperatures cooler than 175°F for HMA, 165°F for WMA
- Do not crush the aggregate

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602.4 CONSTRUCTION REQUIREMENTS e.(6) Density Requirements

TABLE 602-10: DAILY PRODUCTION VS NUMBER OF SUBLOTS AND TEST REQUIREMENTS			
Daily Production (tons)	**Number of Sublots**	**No. of Cores or Nuclear Density Tests****	**No. of Verification Cores or Nuclear Density Tests****
0-599	3*	6*	3*
600-999	4*	8*	4*
1000 or more	5	10	5

*Min # for mixes ≥ 1½" thick: Contractor may choose to obtain 10 tests. If so, KDOT will obtain 5 verification tests.

**For mixes < 1½" thick: Verification testing may be performed, but is not required. Additional testing may be performed by the Contractor. A minimum of 10 tests are required.

DENSITY TEST LOCATIONS Normal Daily Production Rates

≥ 1000 tons Daily

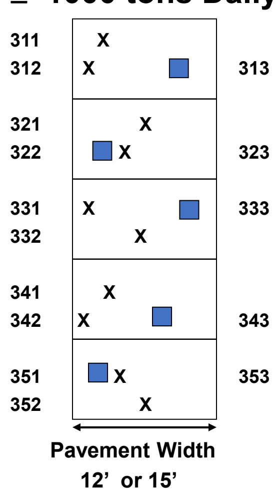

Chart Key:

Sample Number (Your Choice)

Example : **352**

3 = Lot Number

5 = Sublot Number

2 = Sample Number

X - Quality Control Tests by Contractor

- Verification Tests by KDOT

DENSITY TEST LOCATIONS
Normal Daily Production Rates

≥ 1000 tons Daily

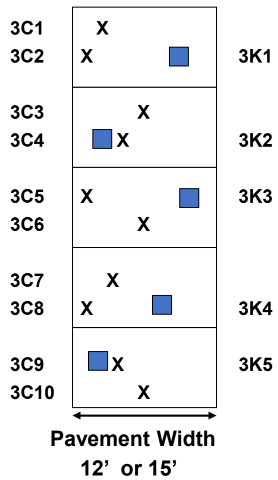

Chart Key:

Sample Number (Your Choice)

Example : **3C2**

3 = Lot Number

C = Contractor (K for KDOT)

2 = Sample Number

X - Quality Control Tests by Contractor

■ - Verification Tests by KDOT

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REVIEW

Describe the Correct Operation of a Gob Hopper (Batcher)?

Open when it's 3/4th full: Close before HMA goes directly to surge bin

When can the Wings of the Paver Receiving Hopper be raised (dumped)?

Never, unless Engineer determines it will not result in detrimental segregation

Who performs segregation checks?

KDOT

What's causes longitudinal segregation?

Paver

42

REVIEW

Does sand need to be used when doing a segregation profile?

Yes

What's the criteria for a passing segregation check?

Density Range (high minus low) of 4.4 lbs/cu. ft. or less

and

Density Drop (average minus low) of 2.2 lbs/cu. ft. or less

When is a joint density reading taken?

When the edge of mainline paving is a joint or will be a joint

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REVIEW

Who performs joint density checks?

Contractor, unless KDOT chooses to

What's the criteria for a passing joint density?

Within 3.0 pcf of interior reading, or at least 91.00% G_{mm}

What's the minimum lift thickness for a mix?

3 times the nominal max aggregate size

What's the minimum number of density tests the contractor must make when paving a 1" thick lift?

10

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602.4 CONSTRUCTION REQUIREMENTS

Kansas
Department of Transportation

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QC/QA Asphalt Specifications
Special Provision 15-06007-R03 Outline

602.1 Description (Sheet 1 of 30)
602.2 Contractor QC Requirements (Sheets 1 to 4 of 30)
602.3 Materials (Sheets 4 to 8 of 30)
602.4 Construction Requirements (Sheets 8 to 14 of 30)
602.5 Process Control (Sheets 14 to 17 of 30)
602.6 Compaction Testing (Sheets 17 to 19 of 30)
602.7 Weather Limitations (Sheet 19 of 30)
602.8 Mixture Acceptance (Sheets 19 to 22 of 30)
602.9 Basis of Acceptance (Sheets 22 to 25 of 30)
602.10 HMA Paid by the Area (Sheets 25 to 29 of 30)
602.11 Measurement and Payment (Sheets 29 to 30 of 30)

Kansas Department of Transportation

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602.5 PROCESS CONTROL

a) General
- Contractor is Responsible for Process Control
- KDOT is responsible for
  - Verification Testing
  - Assurance Testing
  - Inspection

b) JMF Adjustments
- Contractor makes
- Single point gradation
- Binder Content
- Must still meet Table 602-1 properties

c) Specification Working Ranges
- Table 602-12
- Apply to Tolerances to JMF or Table 602-1

2

602.5 PROCESS CONTROL
602.8 MIXTURE ACCEPTANCE

Sheet 15-06007-R03-22

Section j. Suspension of Mix Production

- 2 consecutive single test values
- Any 4 point moving average

3

TABLE 602-12

Mix Characteristic	Tolerance from JMF			
	Single Test Value	Plot	4 Point Moving Average Value	Plot
Binder Content	±0.6%	*	±0.3%	*

Mix Characteristic	Tolerance for Specification Limits			
	Single Test Value	Plot	4 Point Moving Average Value	Plot
Gradation (applicable. sieves in **Table 602-1**)	N/A	*	zero tolerance	*
Air Voids @ N_{des} gyrations	-1.0%, +1.5%	*	N/A	
Voids in Mineral Aggregate (VMA)	1.0% below min.	*	zero tolerance	*
Voids Filled with Asphalt (VFA)	N/A		zero tolerance	*
Course Agg. Angularity (CAA)	zero tolerance		N/A	
Sand Equivalent (SE)	zero tolerance		N/A	
Fine Aggregate Angularity (FAA)	zero tolerance		N/A	
Tensile Strength Ratio (%TSR)	zero tolerance	*	N/A	
Density @ N_{ini} and N_{max}	N/A		zero tolerance	
Dust to Eff. Binder (D/B) Ratio	zero tolerance	*	zero tolerance	*

* Values to plot.
For gradations, as a minimum, plot the No. 4, 8, 30, and 200 sieves.

4

602.5 PROCESS CONTROL
Binder Content

Single Test Value Range = **±0.6%**

Assume Target Binder Content = **5.0%**

The Lower Single Test Value = 5.0% - 0.6% = **4.4%**

The Upper Single Test Value = 5.0% + 0.6% = **5.6%**

4-Point Moving Average Value Range = **±0.3%**

Assume Target Binder Content = **5.0%**

The Lower 4-Pt Moving Avg Value = 5.0% - 0.3% = **4.7%**

The Upper 4-Pt Moving Avg Value = 5.0% + 0.3% = **5.3%**

5

TABLE 602-12

Mix Characteristic	**Tolerance from JMF**			
	Single Test Value	**Plot**	**4 Point Moving Average Value**	**Plot**
Binder Content	±0.6%	*	±0.3%	*
Mix Characteristic	**Tolerance for Specification Limits**			
	Single Test Value	**Plot**	**4 Point Moving Average Value**	**Plot**
Gradation (applicable. sieves in **Table 602-1**)	N/A	*	zero tolerance	*
Air Voids @ N_{des} gyrations	-1.0%, +1.5%	*	N/A	
Voids in Mineral Aggregate (VMA)	1.0% below min.	*	zero tolerance	*
Voids Filled with Asphalt (VFA)	N/A		zero tolerance	*
Course Agg. Angularity (CAA)	zero tolerance		N/A	
Sand Equivalent (SE)	zero tolerance		N/A	
Fine Aggregate Angularity (FAA)	zero tolerance		N/A	
Tensile Strength Ratio (%TSR)	zero tolerance	*	N/A	
Density @ N_{ini} and N_{max}	N/A		zero tolerance	
Dust to Eff. Binder (D/B) Ratio	zero tolerance	*	zero tolerance	*

* Values to plot.
For gradations, as a minimum, plot the No. 4, 8, 30, and 200 sieves.

6

602.5 PROCESS CONTROL Gradations

Single Test Value Range = **N/A**

N/A means not applicable

Therefore, there is no criteria on the single point

4-Point Moving Average Value Range = **zero tolerance**

Zero tolerance means that the established criteria must be met.

For gradations, we go back to Table 602-1.

The gradation for the applicable sieves must meet the limits in Table 602-1.

7

TABLE 602-12

Mix Characteristic	Tolerance from JMF			
	Single Test Value	Plot	4 Point Moving Average Value	Plot
Binder Content	±0.6%	*	±0.3%	*
Mix Characteristic	**Tolerance for Specification Limits**			
	Single Test Value	**Plot**	**4 Point Moving Average Value**	**Plot**
Gradation (applicable. sieves in **Table 602-1**)	N/A	*	zero tolerance	*
Air Voids @ N_{des} gyrations	-1.0%, +1.5%	*	N/A	
Voids in Mineral Aggregate (VMA)	1.0% below min.	*	zero tolerance	*
Voids Filled with Asphalt (VFA)	N/A		zero tolerance	*
Course Agg. Angularity (CAA)	zero tolerance		N/A	
Sand Equivalent (SE)	zero tolerance		N/A	
Fine Aggregate Angularity (FAA)	zero tolerance		N/A	
Tensile Strength Ratio (%TSR)	zero tolerance	*	N/A	
Density @ N_{ini} and N_{max}	N/A		zero tolerance	
Dust to Eff. Binder (D/B) Ratio	zero tolerance	*	zero tolerance	*

* Values to plot.
For gradations, as a minimum, plot the No. 4, 8, 30, and 200 sieves.

8

602.5 PROCESS CONTROL
Air Voids

Single Test Value Range = **-1.0%, +1.5%**

The Target Air Voids is Generally = **3.0%**

The Lower Single Test Value = 3.0% - 1.0% = **2.0%**

The Upper Single Test Value = 3.0% + 2.0% = **4.5%**

4-Point Moving Average Value Range = **n/a**

N/A means not applicable

Therefore, there is no criteria on the 4-Pt Moving Avg

9

TABLE 602-12

Mix Characteristic	**Tolerance from JMF**			
	Single Test Value	**Plot**	**4 Point Moving Average Value**	**Plot**
Binder Content	±0.6%	*	±0.3%	*
Mix Characteristic	**Tolerance for Specification Limits**			
	Single Test Value	**Plot**	**4 Point Moving Average Value**	**Plot**
Gradation (applicable. sieves in **Table 602-1**)	N/A	*	zero tolerance	*
Air Voids @ N_{des} gyrations	-1.0%, +1.5%	*	N/A	
Voids in Mineral Aggregate (VMA)	1.0% below min.	*	zero tolerance	*
Voids Filled with Asphalt (VFA)	N/A		zero tolerance	*
Course Agg. Angularity (CAA)	zero tolerance		N/A	
Sand Equivalent (SE)	zero tolerance		N/A	
Fine Aggregate Angularity (FAA)	zero tolerance		N/A	
Tensile Strength Ratio (%TSR)	zero tolerance	*	N/A	
Density @ N_{ini} and N_{max}	N/A		zero tolerance	
Dust to Eff. Binder (D/B) Ratio	zero tolerance	*	zero tolerance	*

* Values to plot.
For gradations, as a minimum, plot the No. 4, 8, 30, and 200 sieves.

10

602.5 PROCESS CONTROL VMA

Single Test Value Range = **1.0% below min**

Assume the Specified minimum VMA is = **14.0%**

The Lower Single Test Value = 14.0% - 1.0% = **13.0%**

There is no Upper Single Test Value Criteria

4-Point Moving Average Value Range = **zero tolerance**

Zero tolerance means that the established criteria must be met.

Assume the Specified minimum VMA is = **14.0%**

The Lower 4-Pt Moving Avg Value = **14.0%**

There is no Upper 4-Pt Moving Avg Test Value Criteria

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TABLE 602-12

Mix Characteristic	**Tolerance from JMF**			
	Single Test Value	**Plot**	**4 Point Moving Average Value**	**Plot**
Binder Content	±0.6%	*	±0.3%	*
Mix Characteristic	**Tolerance for Specification Limits**			
	Single Test Value	**Plot**	**4 Point Moving Average Value**	**Plot**
Gradation (applicable. sieves in **Table 602-1**)	N/A	*	zero tolerance	*
Air Voids @ N_{des} gyrations	-1.0%, +1.5%	*	N/A	
Voids in Mineral Aggregate (VMA)	1.0% below min.	*	zero tolerance	*
Voids Filled with Asphalt (VFA)	N/A		zero tolerance	*
Course Agg. Angularity (CAA)	zero tolerance		N/A	
Sand Equivalent (SE)	zero tolerance		N/A	
Fine Aggregate Angularity (FAA)	zero tolerance		N/A	
Tensile Strength Ratio (%TSR)	zero tolerance	*	N/A	
Density @ N_{ini} and N_{max}	N/A		zero tolerance	
Dust to Eff. Binder (D/B) Ratio	zero tolerance	*	zero tolerance	*

* Values to plot.
For gradations, as a minimum, plot the No. 4, 8, 30, and 200 sieves.

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602.5 PROCESS CONTROL VFA

Single Test Value Range = **N/A**

N/A means not applicable

Therefore, there is no criteria on the single point

4-Point Moving Average Value Range = **zero tolerance**

Zero tolerance means that the established criteria must be met.

Assume the VFA Range is **65% - 82%.**

The Lower 4-Pt Moving Avg Value = **65%**

The Upper 4-Pt Moving Avg Value = **82%**

13

TABLE 602-12

Mix Characteristic	Tolerance from JMF			
	Single Test Value	Plot	4 Point Moving Average Value	Plot
Binder Content	±0.6%	*	±0.3%	*
Mix Characteristic	**Tolerance for Specification Limits**			
	Single Test Value	**Plot**	**4 Point Moving Average Value**	**Plot**
Gradation (applicable. sieves in **Table 602-1**)	N/A	*	zero tolerance	*
Air Voids @ N_{des} gyrations	-1.0%, +1.5%	*	N/A	
Voids in Mineral Aggregate (VMA)	1.0% below min.	*	zero tolerance	*
Voids Filled with Asphalt (VFA)	N/A		zero tolerance	*
Course Agg. Angularity (CAA)	zero tolerance		N/A	
Sand Equivalent (SE)	zero tolerance		N/A	
Fine Aggregate Angularity (FAA)	zero tolerance		N/A	
Tensile Strength Ratio (%TSR)	zero tolerance	*	N/A	
Density @ N_{ini} and N_{max}	N/A		zero tolerance	
Dust to Eff. Binder (D/B) Ratio	zero tolerance	*	zero tolerance	*

* Values to plot.
For gradations, as a minimum, plot the No. 4, 8, 30, and 200 sieves.

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602.5 PROCESS CONTROL CAA, SE, FAA and %TSR

Single Point Value = **zero tolerance**

Zero tolerance means that the established criteria must be met.

CAA minimum = **75%**
SE minimum = **40%**
FAA minimum = **42%**
%TSR minimum = **80%**

These Values must be met or exceeded (refer to Project Specific Mix Requirements and Table 602-1)

4-Point Moving Average Value Range = **N/A**

N/A means not applicable

Therefore, there is no criteria on the 4-Pt Moving Avg

15

TABLE 602-12

Mix Characteristic	**Tolerance from JMF**			
	Single Test Value	**Plot**	**4 Point Moving Average Value**	**Plot**
Binder Content	±0.6%	*	±0.3%	*
Mix Characteristic	**Tolerance for Specification Limits**			
	Single Test Value	**Plot**	**4 Point Moving Average Value**	**Plot**
Gradation (applicable. sieves in **Table 602-1**)	N/A	*	zero tolerance	*
Air Voids @ N_{des} gyrations	-1.0%, +1.5%	*	N/A	
Voids in Mineral Aggregate (VMA)	1.0% below min.	*	zero tolerance	*
Voids Filled with Asphalt (VFA)	N/A		zero tolerance	*
Course Agg. Angularity (CAA)	zero tolerance		N/A	
Sand Equivalent (SE)	zero tolerance		N/A	
Fine Aggregate Angularity (FAA)	zero tolerance		N/A	
Tensile Strength Ratio (%TSR)	zero tolerance	*	N/A	
Density @ N_{ini} and N_{max}	N/A		zero tolerance	
Dust to Eff. Binder (D/B) Ratio	zero tolerance	*	zero tolerance	*

* Values to plot.
For gradations, as a minimum, plot the No. 4, 8, 30, and 200 sieves.

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602.5 PROCESS CONTROL Density at Nini and Nmax

Single Test Value Range = **N/A**

N/A means not applicable

Therefore, there is no criteria on the single point

4-Point Moving Average Value Range = **zero tolerance**

Zero tolerance means that the established criteria must be met.

Assume Density @ $N_{ini} \leq$ **91.5%.** (project specific mix req)

Density @ $N_{max} \leq$ **98.5%.** (Table 602-1)

The 4-Pt Moving Avg Value must meet these values.

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TABLE 602-12

Mix Characteristic	Tolerance from JMF			
	Single Test Value	Plot	4 Point Moving Average Value	Plot
Binder Content	±0.6%	*	±0.3%	*
Mix Characteristic	**Tolerance for Specification Limits**			
	Single Test Value	**Plot**	**4 Point Moving Average Value**	**Plot**
Gradation (applicable. sieves in **Table 602-1**)	N/A	*	zero tolerance	*
Air Voids @ N_{des} gyrations	-1.0%, +1.5%	*	N/A	
Voids in Mineral Aggregate (VMA)	1.0% below min.	*	zero tolerance	*
Voids Filled with Asphalt (VFA)	N/A		zero tolerance	*
Course Agg. Angularity (CAA)	zero tolerance		N/A	
Sand Equivalent (SE)	zero tolerance		N/A	
Fine Aggregate Angularity (FAA)	zero tolerance		N/A	
Tensile Strength Ratio (%TSR)	zero tolerance	*	N/A	
Density @ N_{ini} and N_{max}	N/A		zero tolerance	
Dust to Eff. Binder (D/B) Ratio	zero tolerance	*	zero tolerance	*

* Values to plot.
For gradations, as a minimum, plot the No. 4, 8, 30, and 200 sieves.

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602.5 PROCESS CONTROL
Dust to Effective Binder Ratio

Single Point Value = **zero tolerance**

Zero tolerance means that the established criteria must be met.

Assume D/B Ratio Range = **0.6 to 1.2**

Each test must have a value in this range

4-Point Moving Average Value Range = **zero tolerance**

Zero tolerance means that the established criteria must be met.

Assume D/B Ratio Range = **0.6 to 1.2**

The 4-Pt Moving Avg Value must be in this range.

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602.5 PROCESS CONTROL
602.8 MIXTURE ACCEPTANCE

Sheet 15-06007-R03-22

Section j. Suspension of Mix Production

- 2 consecutive single test values
- Any 4 point moving average

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602.5 PROCESS CONTROL

Plotting Example

Binder Content

21

TABLE 602-12

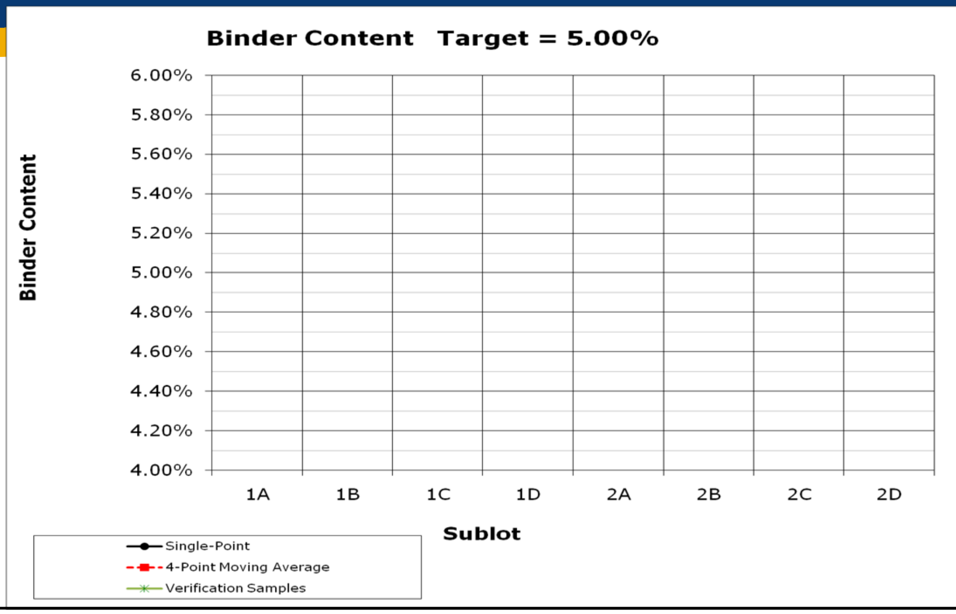
Mix Characteristic	Tolerance from JMF			
	Single Test Value	Plot	4 Point Moving Average Value	Plot
Binder Content	±0.6%	*	±0.3%	*

Mix Characteristic	Tolerance for Specification Limits			
	Single Test Value	Plot	4 Point Moving Average Value	Plot
Gradation (applicable. sieves in **Table 602-1**)	N/A	*	zero tolerance	*
Air Voids @ N_{des} gyrations	-1.0%, +1.5%	*	N/A	
Voids in Mineral Aggregate (VMA)	1.0% below min.	*	zero tolerance	*
Voids Filled with Asphalt (VFA)	N/A		zero tolerance	*
Course Agg. Angularity (CAA)	zero tolerance		N/A	
Sand Equivalent (SE)	zero tolerance		N/A	
Fine Aggregate Angularity (FAA)	zero tolerance		N/A	
Tensile Strength Ratio (%TSR)	zero tolerance	*	N/A	
Density @ N_{ini} and N_{max}	N/A		zero tolerance	
Dust to Eff. Binder (D/B) Ratio	zero tolerance	*	zero tolerance	*

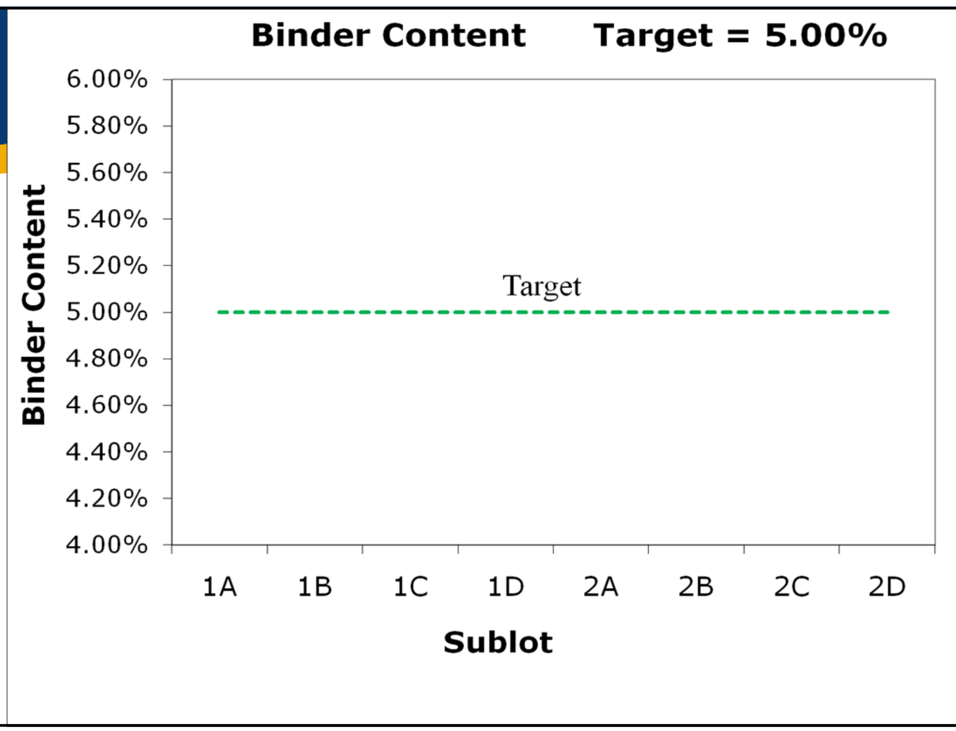
* Values to plot.
For gradations, as a minimum, plot the No. 4, 8, 30, and 200 sieves.

22

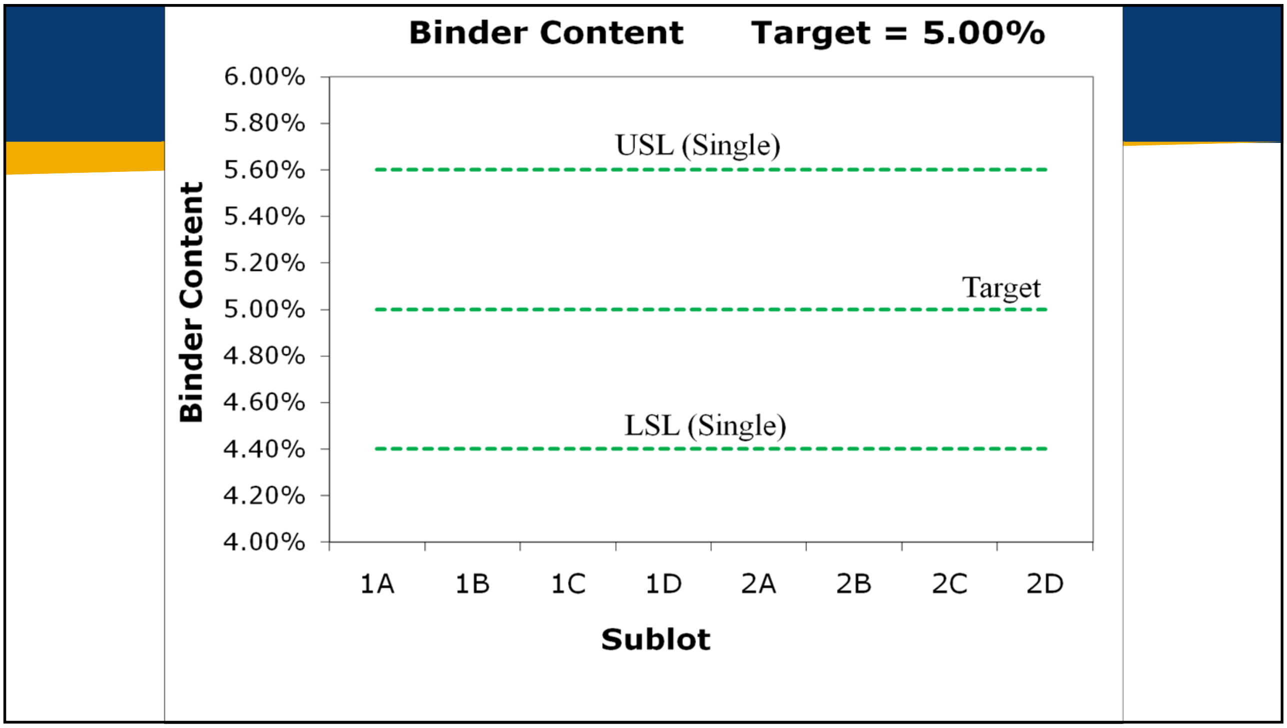
PROCESS CONTROL
Plotting



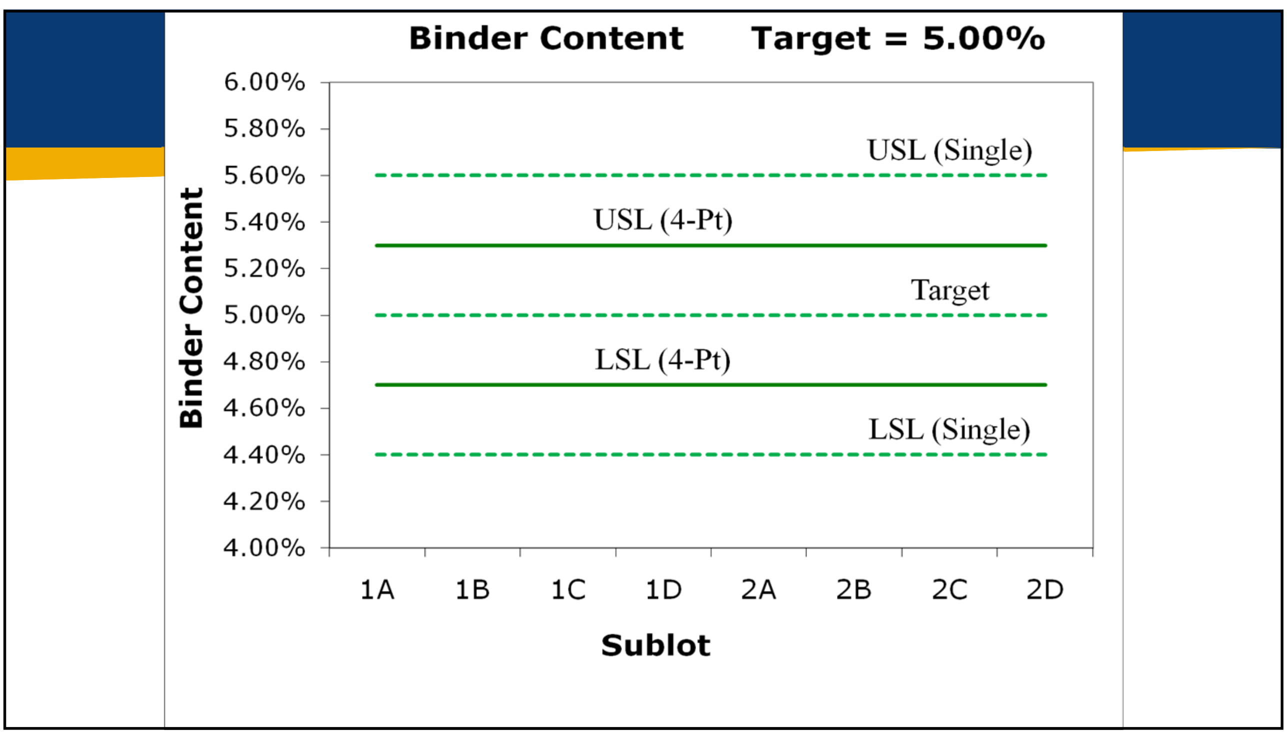
23



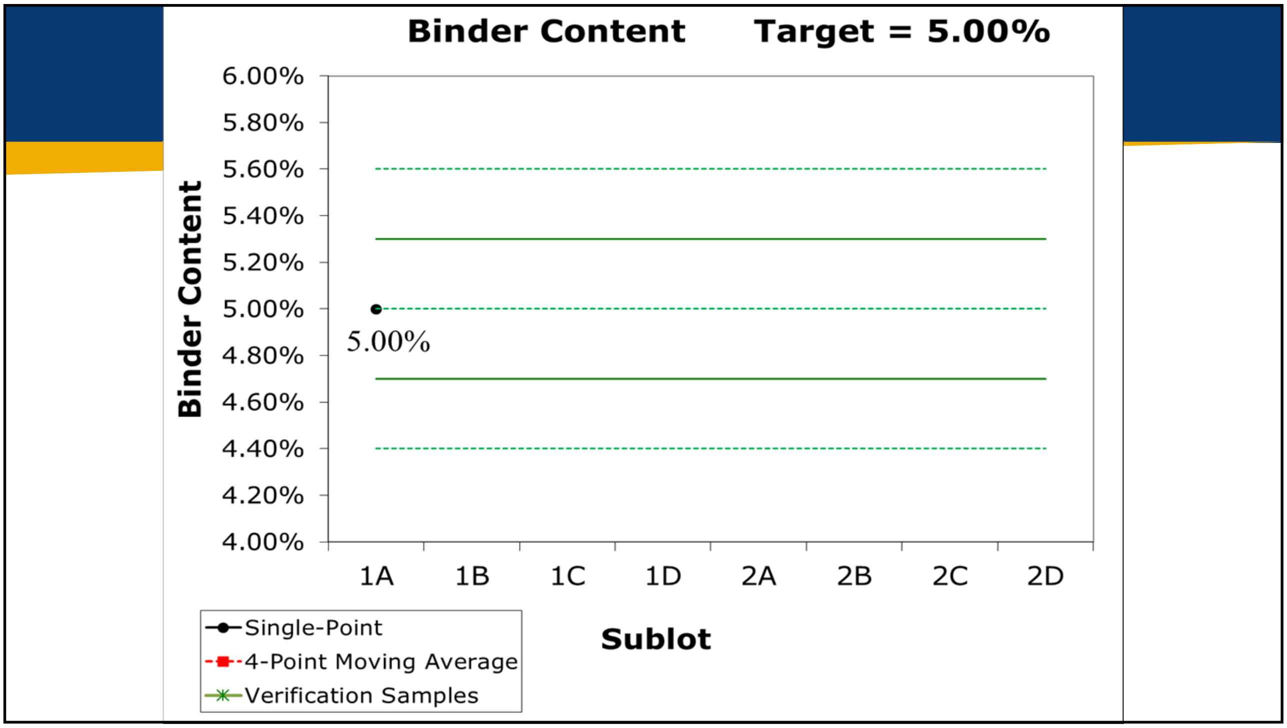
24


Binder Content Target = 5.00%
6.00%
5.80%
5.60%
5.40%
5.20%
5.00%
4.80%
4.60%
4.40%
4.20%
4.00%
Binder Content
USL (Single)
Target
LSL (Single)
1A 1B 1C 1D 2A 2B 2C 2D
Sublot

25


Binder Content Target = 5.00%
6.00%
5.80%
5.60%
5.40%
5.20%
5.00%
4.80%
4.60%
4.40%
4.20%
4.00%
Binder Content
USL (Single)
USL (4-Pt)
Target
LSL (4-Pt)
LSL (Single)
1A 1B 1C 1D 2A 2B 2C 2D
Sublot

26


Binder Content Target = 5.00%
Binder Content
6.00%
5.80%
5.60%
5.40%
5.20%
5.00%
4.80%
4.60%
4.40%
4.20%
4.00%
5.00%
1A
1B
1C
1D
2A
2B
2C
2D
Sublot
Single-Point
4-Point Moving Average
Verification Samples

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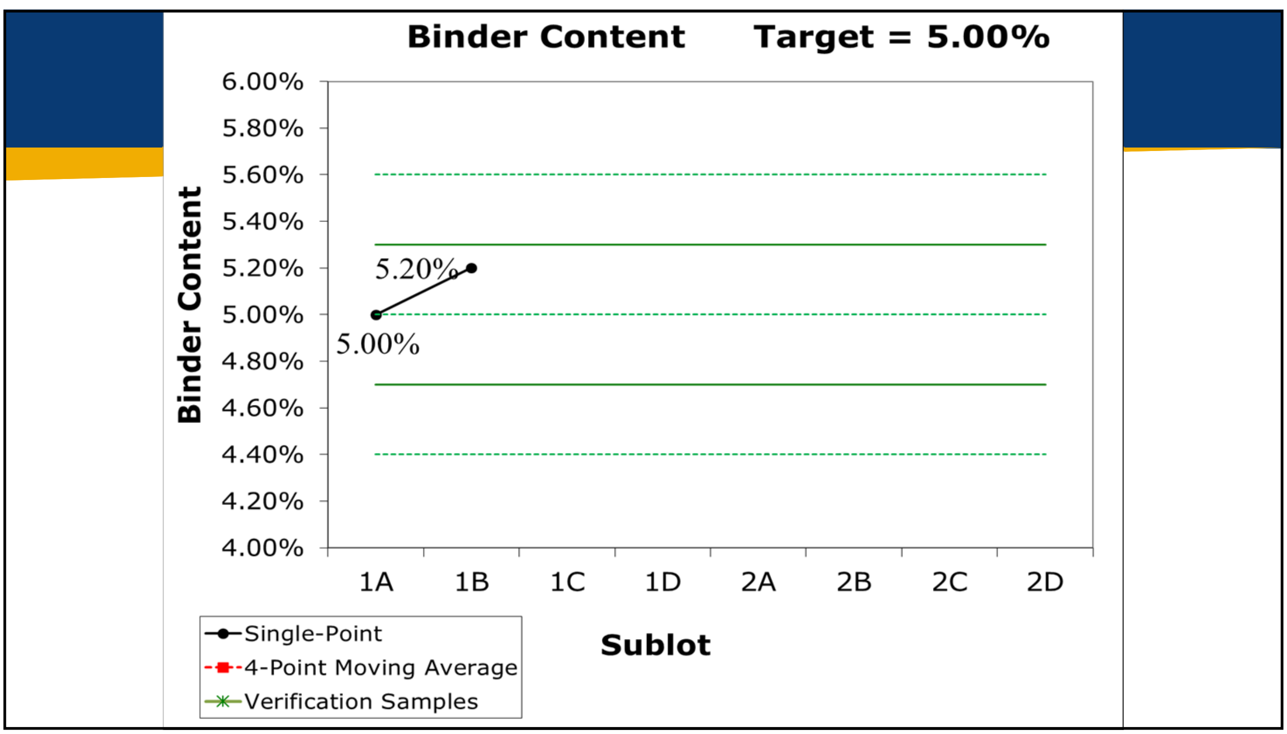
Binder Content Target = 5.00%
Binder Content
6.00%
5.80%
5.60%
5.40%
5.20%
5.00%
4.80%
4.60%
4.40%
4.20%
4.00%
5.20%
5.00%
1A
1B
1C
1D
2A
2B
2C
2D
Sublot
Single-Point
4-Point Moving Average
Verification Samples

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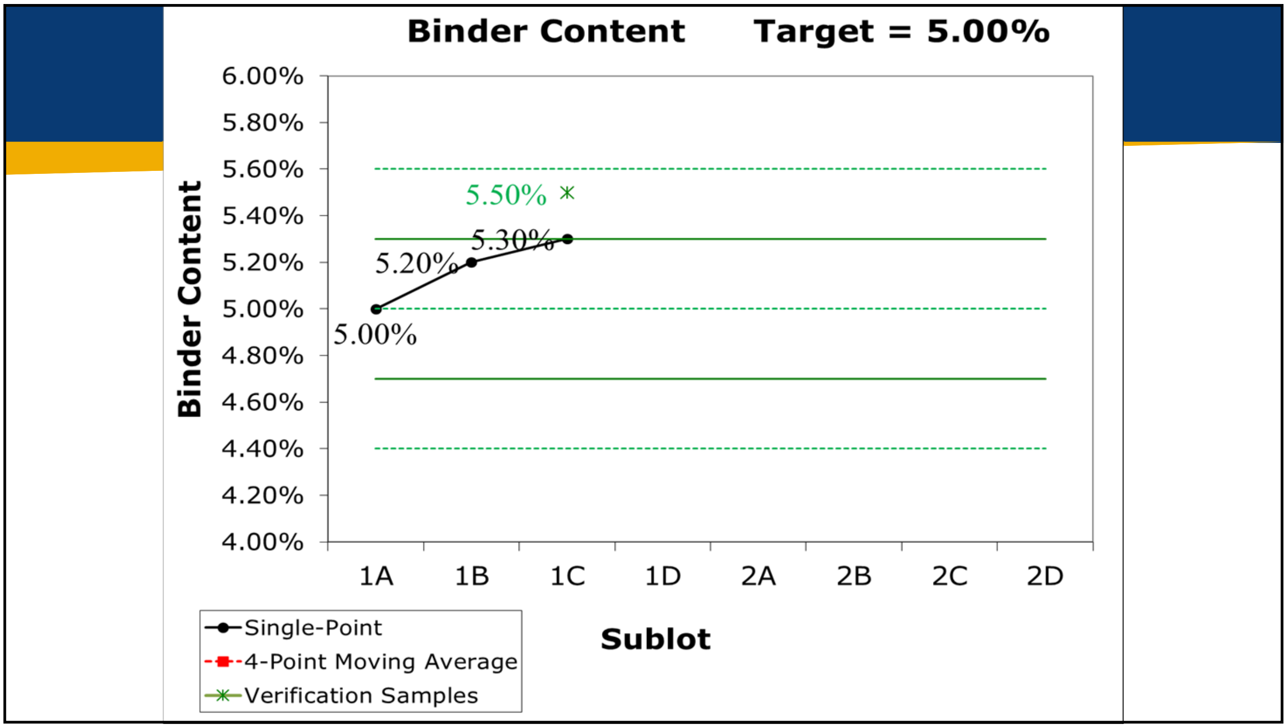
Binder Content
Target = 5.00%
6.00%
5.80%
5.60%
5.40%
5.20%
5.00%
4.80%
4.60%
4.40%
4.20%
4.00%
Binder Content
5.50%
5.30%
5.20%
5.00%
1A
1B
1C
1D
2A
2B
2C
2D
Sublot
Single-Point
4-Point Moving Average
Verification Samples

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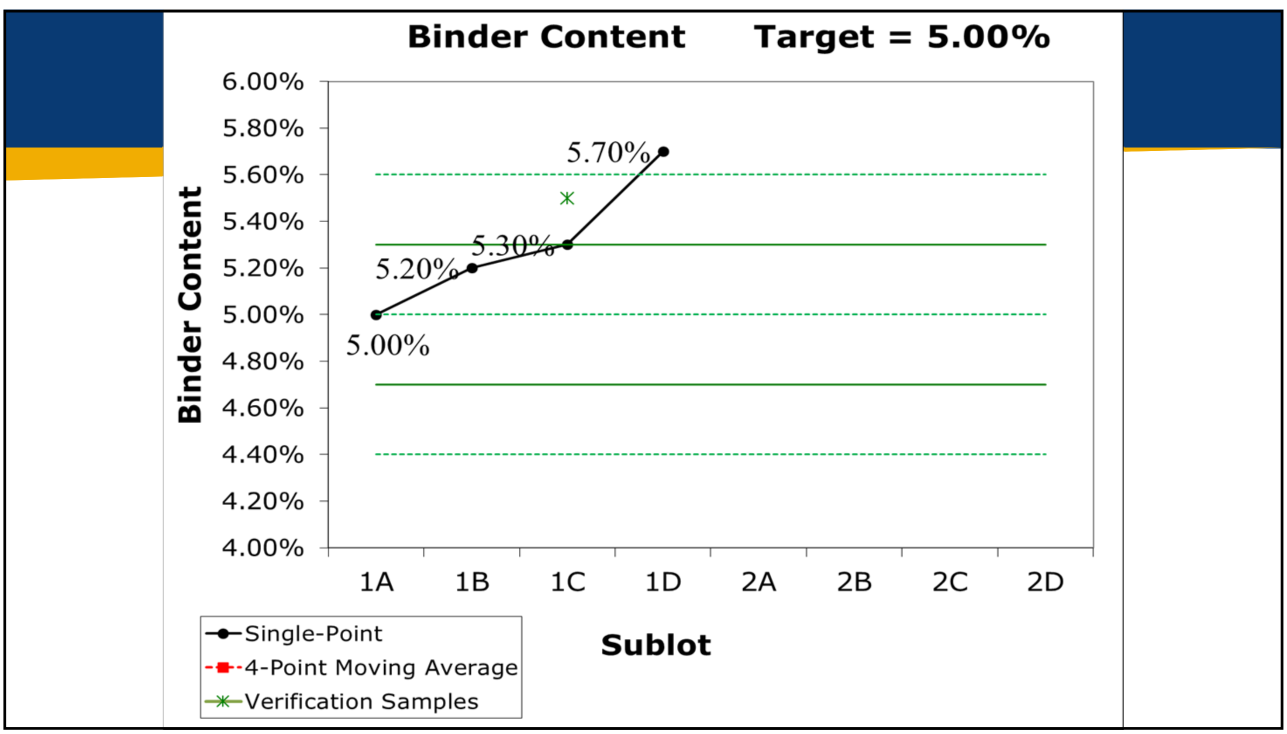
Binder Content
Target = 5.00%
6.00%
5.80%
5.60%
5.40%
5.20%
5.00%
4.80%
4.60%
4.40%
4.20%
4.00%
Binder Content
5.70%
5.30%
5.20%
5.00%
1A
1B
1C
1D
2A
2B
2C
2D
Sublot
Single-Point
4-Point Moving Average
Verification Samples

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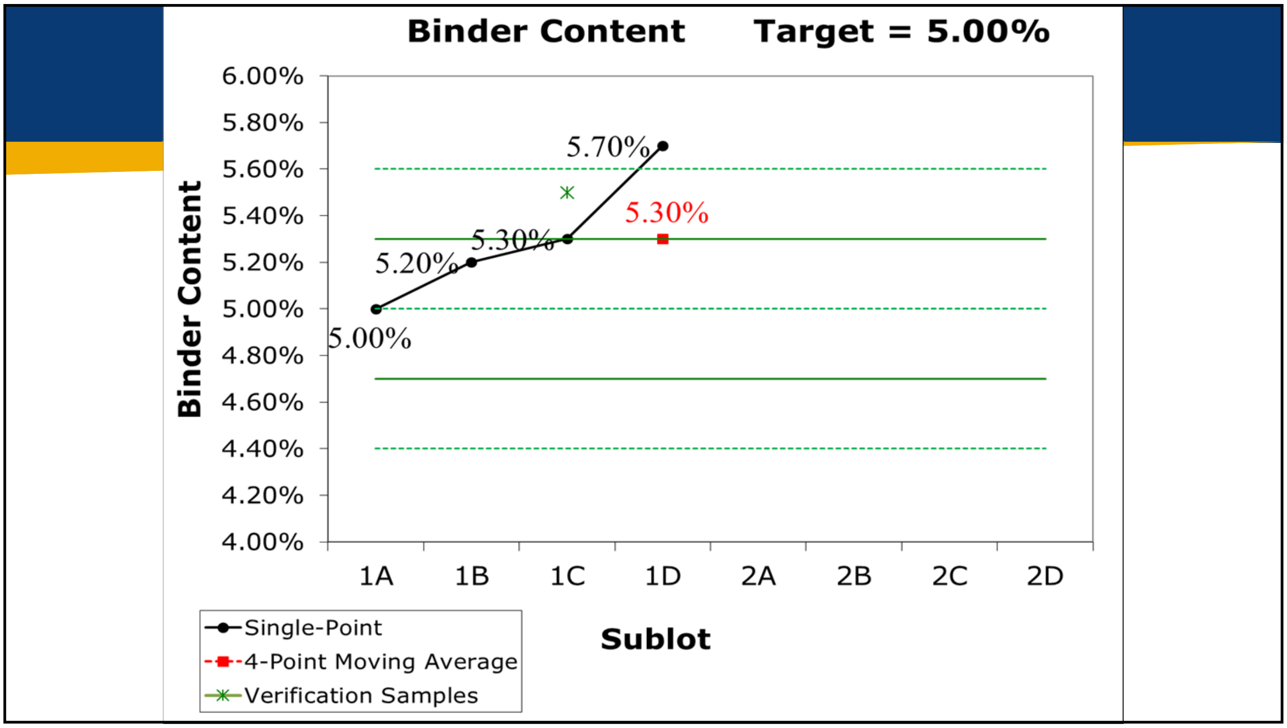
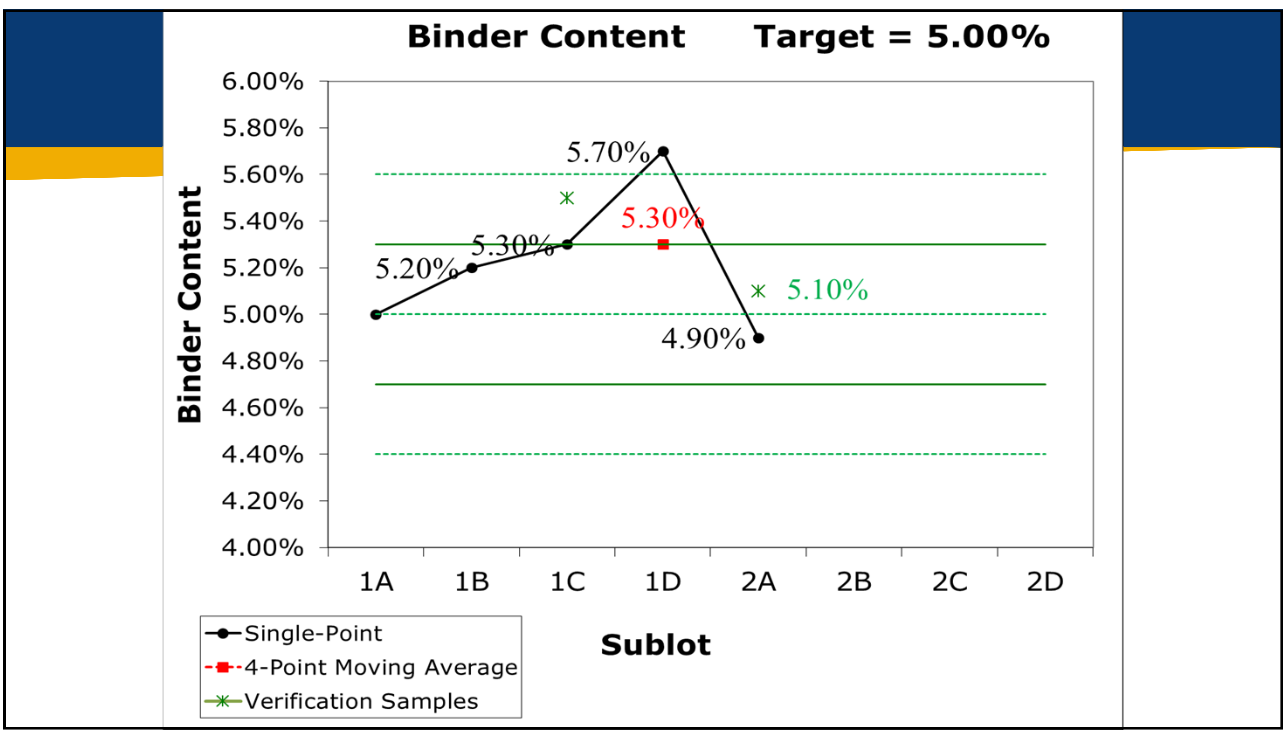


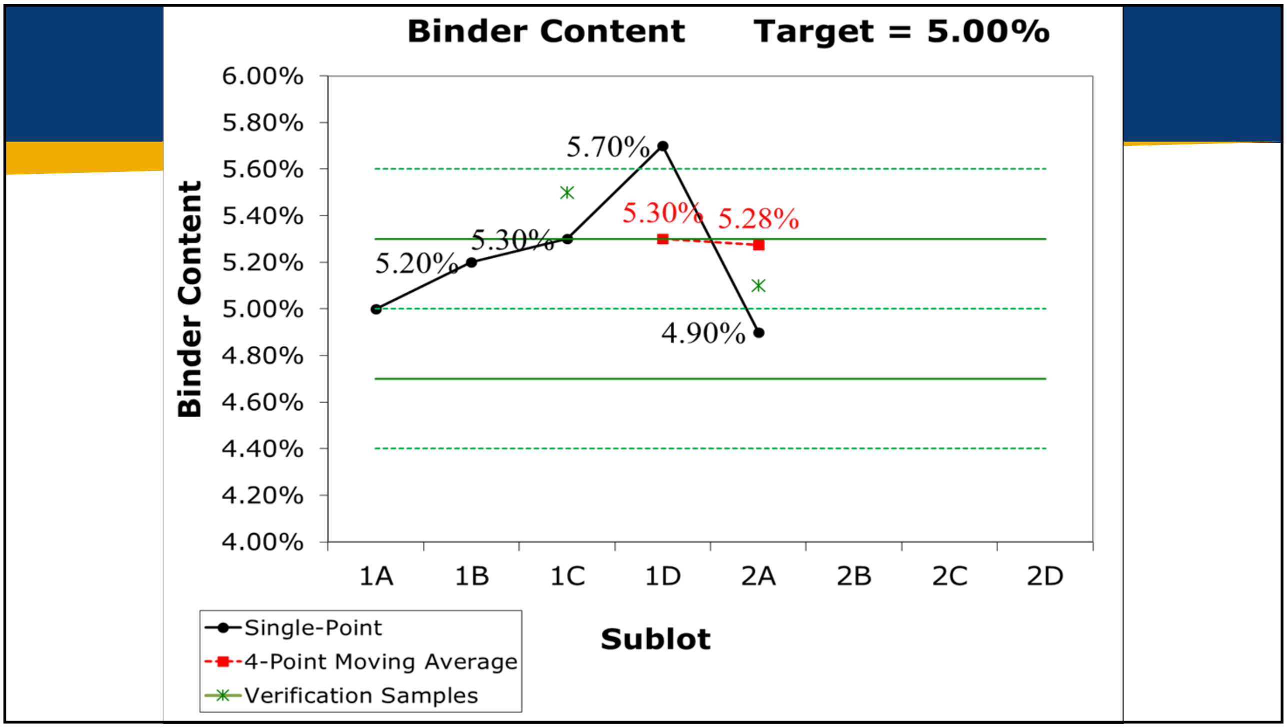
Binder Content Target = 5.00%
6.00%
5.80%
5.60%
5.40%
5.20%
5.00%
4.80%
4.60%
4.40%
4.20%
4.00%
Binder Content
5.70%
5.30%
5.30%
5.20%
5.00%
1A 1B 1C 1D 2A 2B 2C 2D
Sublot
Single-Point
4-Point Moving Average
Verification Samples

31



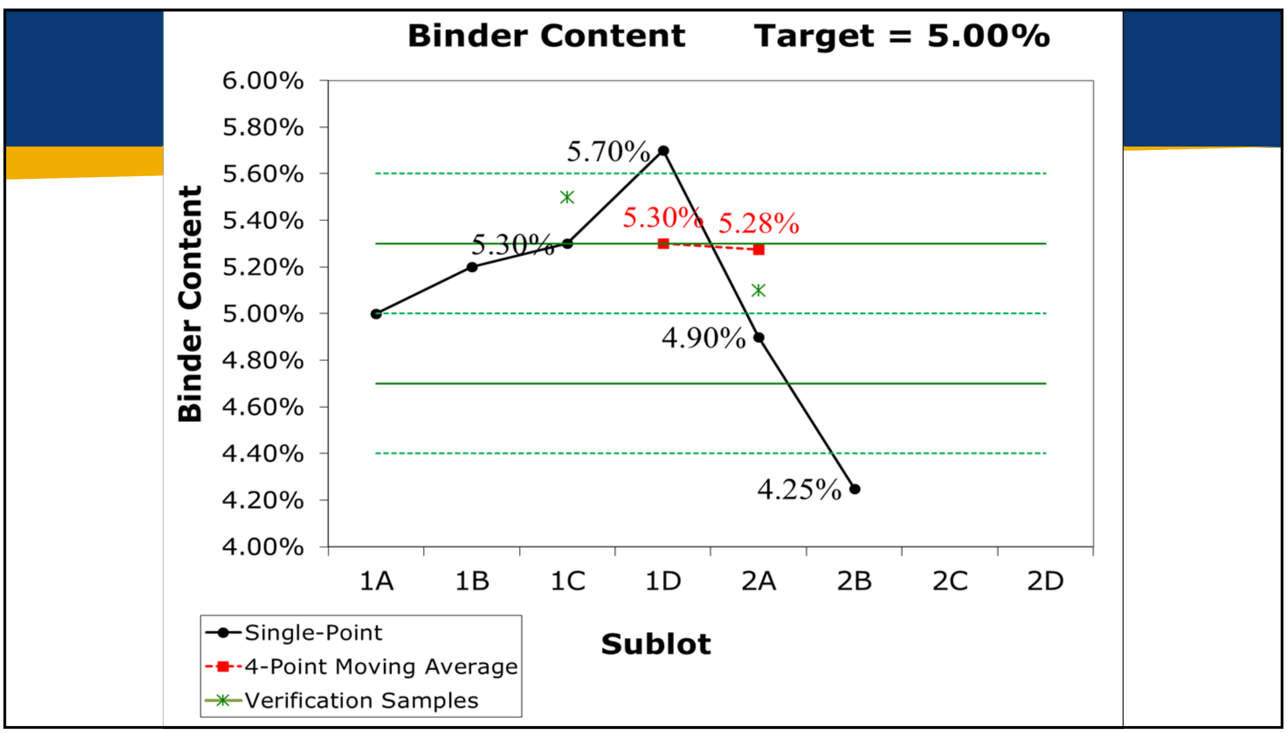
Binder Content Target = 5.00%
6.00%
5.80%
5.60%
5.40%
5.20%
5.00%
4.80%
4.60%
4.40%
4.20%
4.00%
Binder Content
5.70%
5.30%
5.30%
5.20%
5.10%
4.90%
1A 1B 1C 1D 2A 2B 2C 2D
Sublot
Single-Point
4-Point Moving Average
Verification Samples

32



Binder Content Target = 5.00%
6.00%
5.80%
5.60%
5.40%
5.20%
5.00%
4.80%
4.60%
4.40%
4.20%
4.00%
Binder Content
5.70%
5.30%
5.20%
5.30%
5.28%
4.90%
1A
1B
1C
1D
2A
2B
2C
2D
Sublot
Single-Point
4-Point Moving Average
Verification Samples

33



Binder Content Target = 5.00%
6.00%
5.80%
5.60%
5.40%
5.20%
5.00%
4.80%
4.60%
4.40%
4.20%
4.00%
Binder Content
5.70%
5.30%
5.30%
5.28%
4.90%
4.25%
1A
1B
1C
1D
2A
2B
2C
2D
Sublot
Single-Point
4-Point Moving Average
Verification Samples

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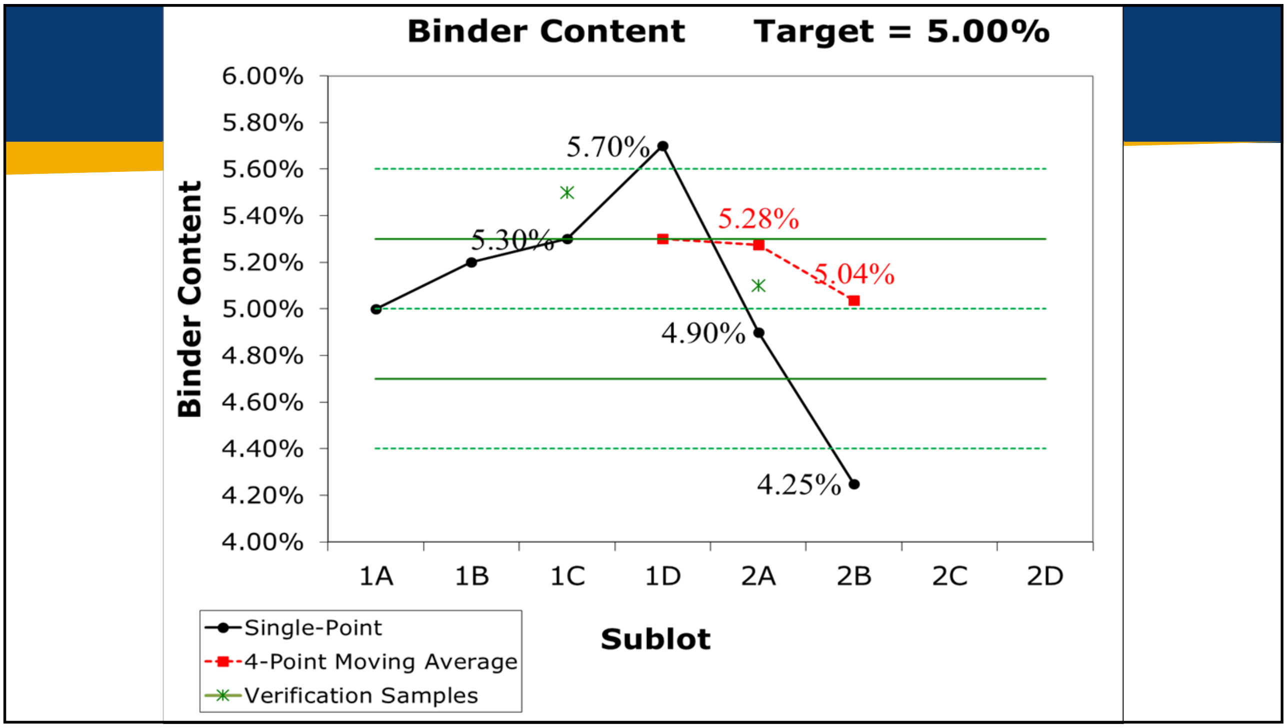
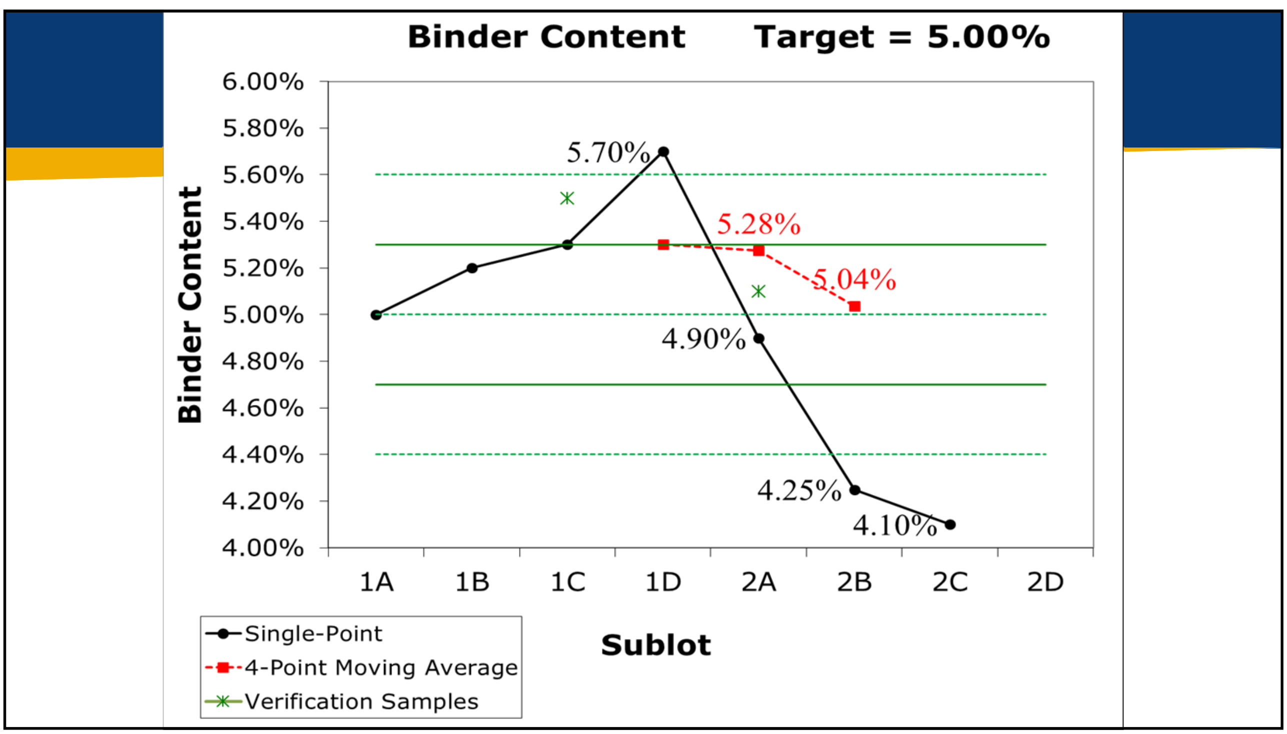
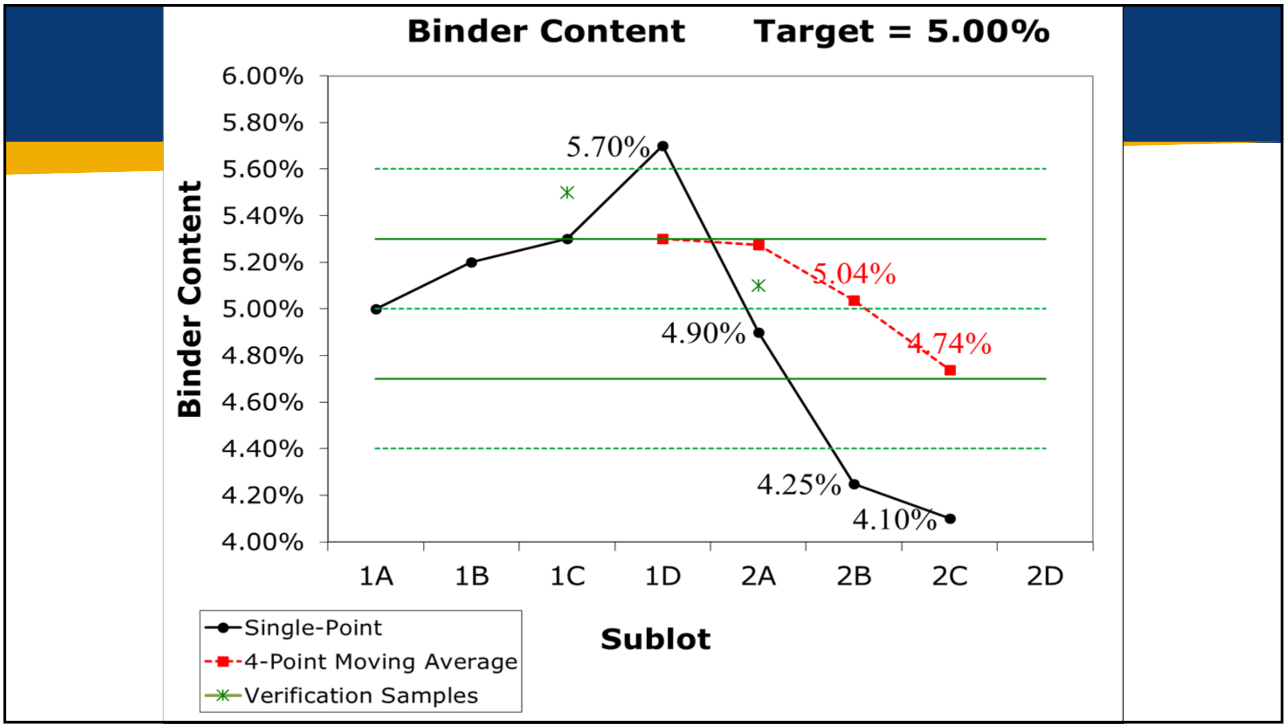

Binder Content Target = 5.00%
Binder Content
6.00%
5.80%
5.60%
5.40%
5.20%
5.00%
4.80%
4.60%
4.40%
4.20%
4.00%
5.70%
5.30%
5.28%
5.04%
4.90%
4.25%
1A
1B
1C
1D
2A
2B
2C
2D
Sublot
Single-Point
4-Point Moving Average
Verification Samples

35


Binder Content Target = 5.00%
Binder Content
6.00%
5.80%
5.60%
5.40%
5.20%
5.00%
4.80%
4.60%
4.40%
4.20%
4.00%
5.70%
5.28%
5.04%
4.90%
4.25%
4.10%
1A
1B
1C
1D
2A
2B
2C
2D
Sublot
Single-Point
4-Point Moving Average
Verification Samples

36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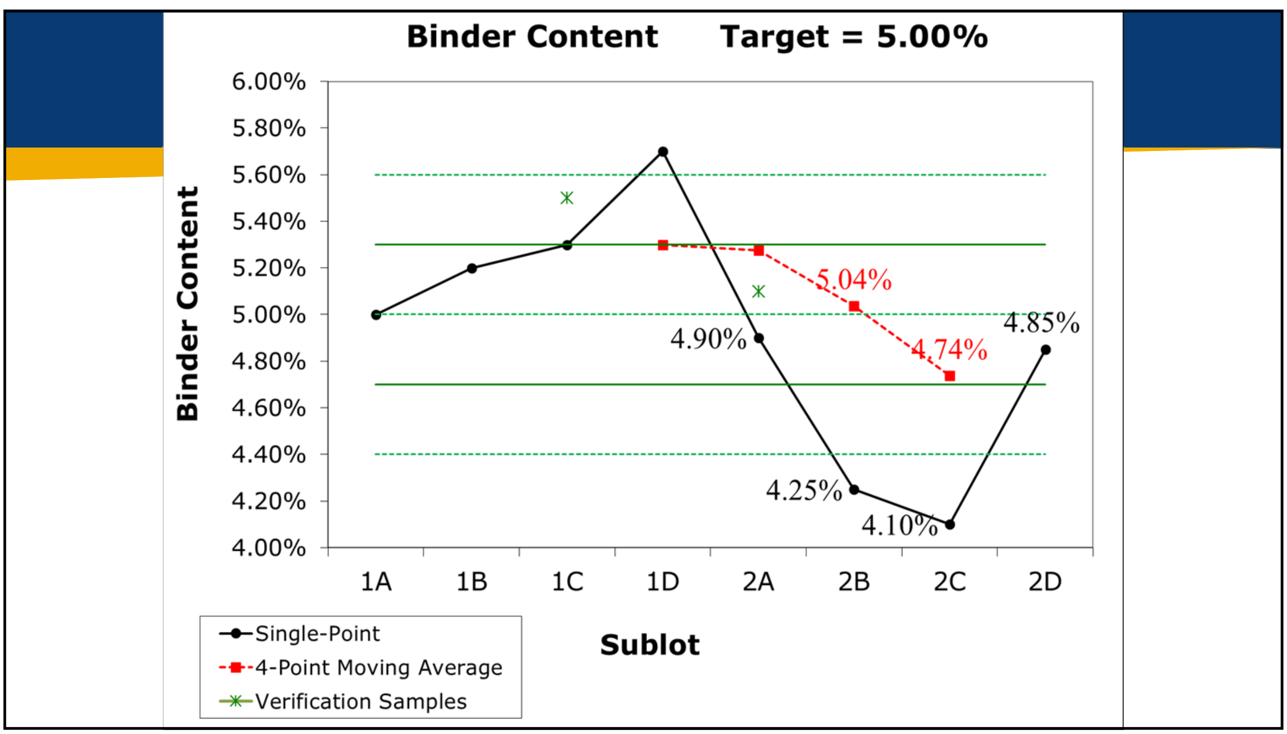
6.00%
5.80%
5.60%
5.40%
5.20%
5.00%
4.80%
4.60%
4.40%
4.20%
4.00%
Binder Content
5.70%
5.04%
4.90%
4.74%
4.25%
4.10%
1A
1B
1C
1D
2A
2B
2C
2D
Sublot
Single-Point
4-Point Moving Average
Verification Samples

37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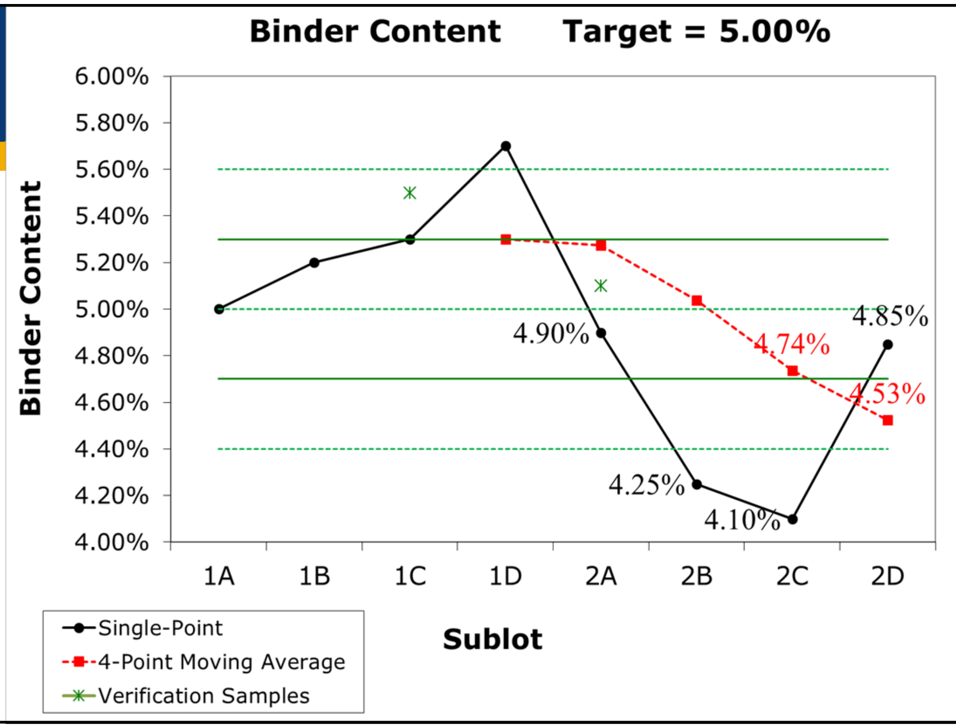
6.00%
5.80%
5.60%
5.40%
5.20%
5.00%
4.80%
4.60%
4.40%
4.20%
4.00%
Binder Content
5.04%
4.85%
4.90%
4.74%
4.25%
4.10%
1A
1B
1C
1D
2A
2B
2C
2D
Sublot
Single-Point
4-Point Moving Average
Verification Samples

38



39

602.5 PROCESS CONTROL

Plotting Example

VMA

40

TABLE 602-12

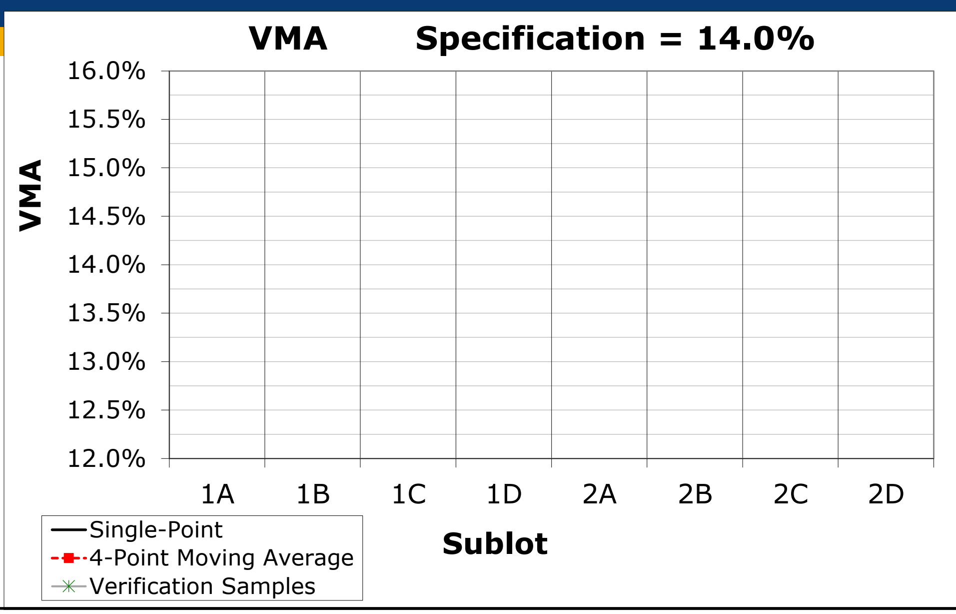
Mix Characteristic	Tolerance from JMF			
	Single Test Value	Plot	4 Point Moving Average Value	Plot
Binder Content	±0.6%	*	±0.3%	*

Mix Characteristic	Tolerance for Specification Limits			
	Single Test Value	Plot	4 Point Moving Average Value	Plot
Gradation (applicable. sieves in **Table 602-1**)	N/A	*	zero tolerance	*
Air Voids @ N_{des} gyrations	-1.0%, +1.5%	*	N/A	
Voids in Mineral Aggregate (VMA)	1.0% below min.	*	zero tolerance	*
Voids Filled with Asphalt (VFA)	N/A		zero tolerance	*
Course Agg. Angularity (CAA)	zero tolerance		N/A	
Sand Equivalent (SE)	zero tolerance		N/A	
Fine Aggregate Angularity (FAA)	zero tolerance		N/A	
Tensile Strength Ratio (%TSR)	zero tolerance	*	N/A	
Density @ N_{ini} and N_{max}	N/A		zero tolerance	
Dust to Eff. Binder (D/B) Ratio	zero tolerance	*	zero tolerance	*

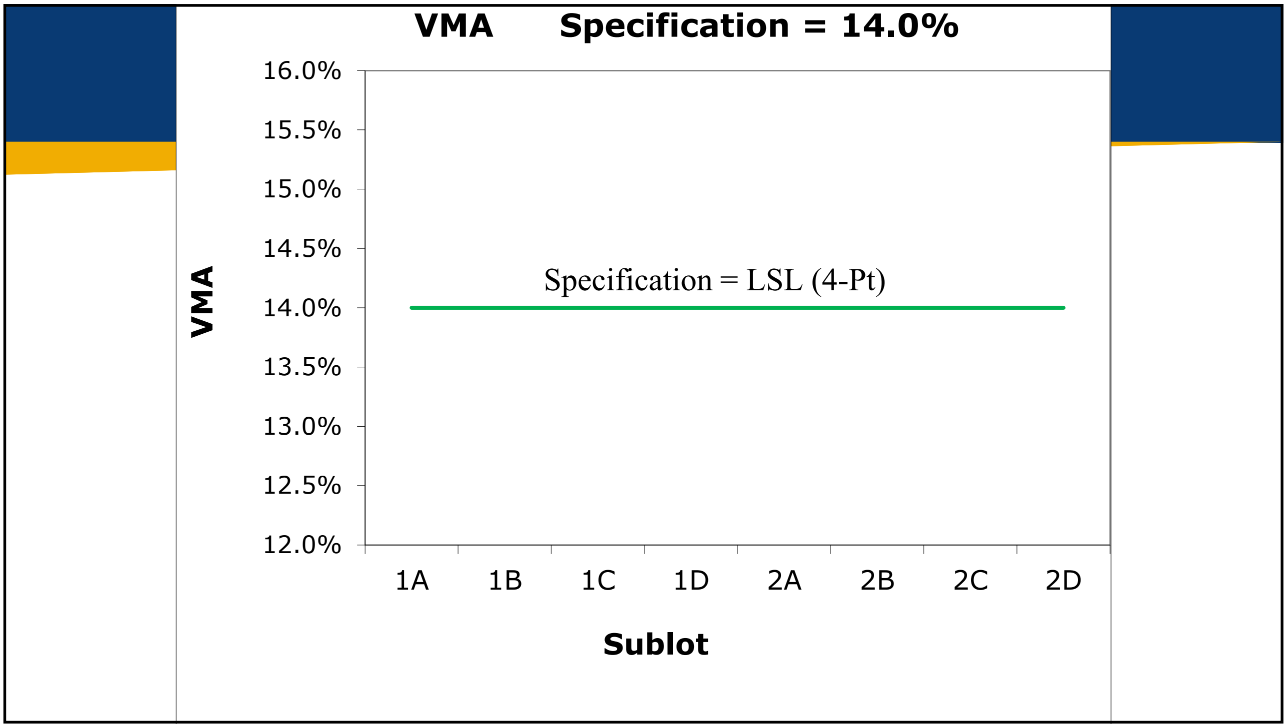
* Values to plot.
For gradations, as a minimum, plot the No. 4, 8, 30, and 200 sieves.

41

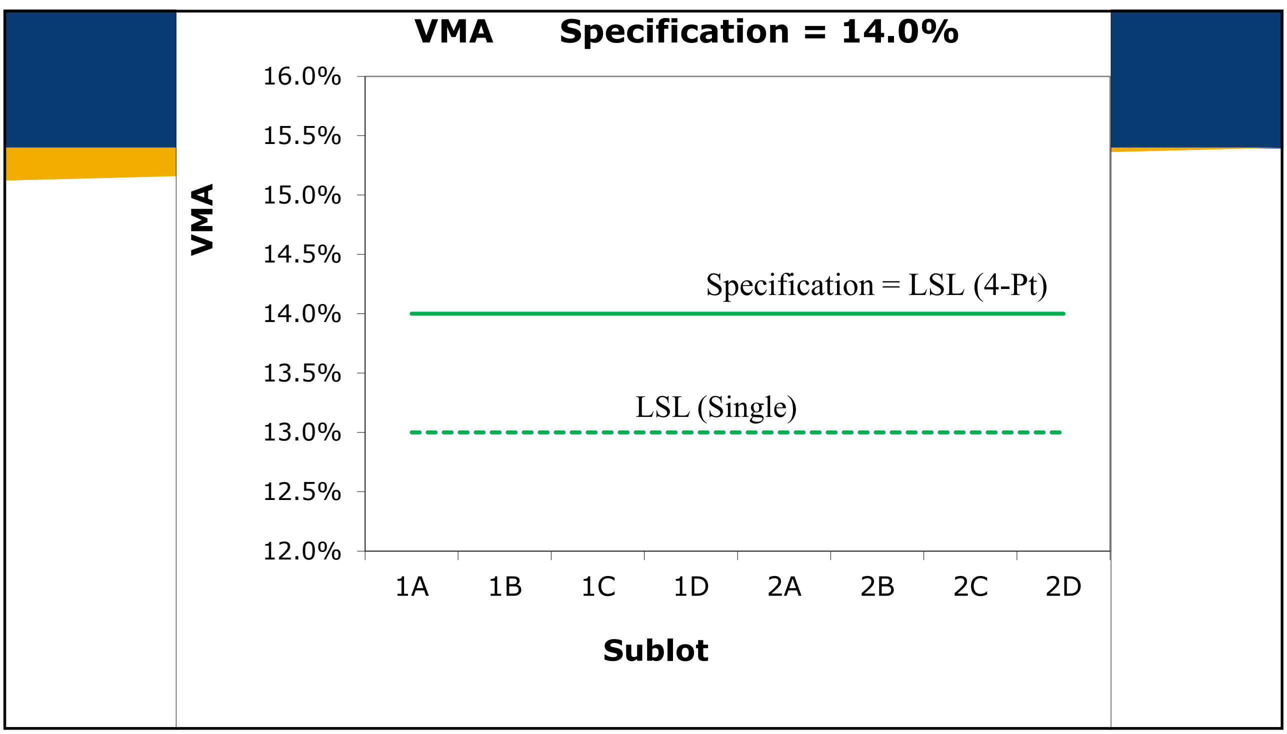
PROCESS CONTROL Plotting



42


VMA Specification = 14.0%
16.0%
15.5%
15.0%
14.5%
14.0%
13.5%
13.0%
12.5%
12.0%
VMA
Specification = LSL (4-Pt)
1A
1B
1C
1D
2A
2B
2C
2D
Sublot

43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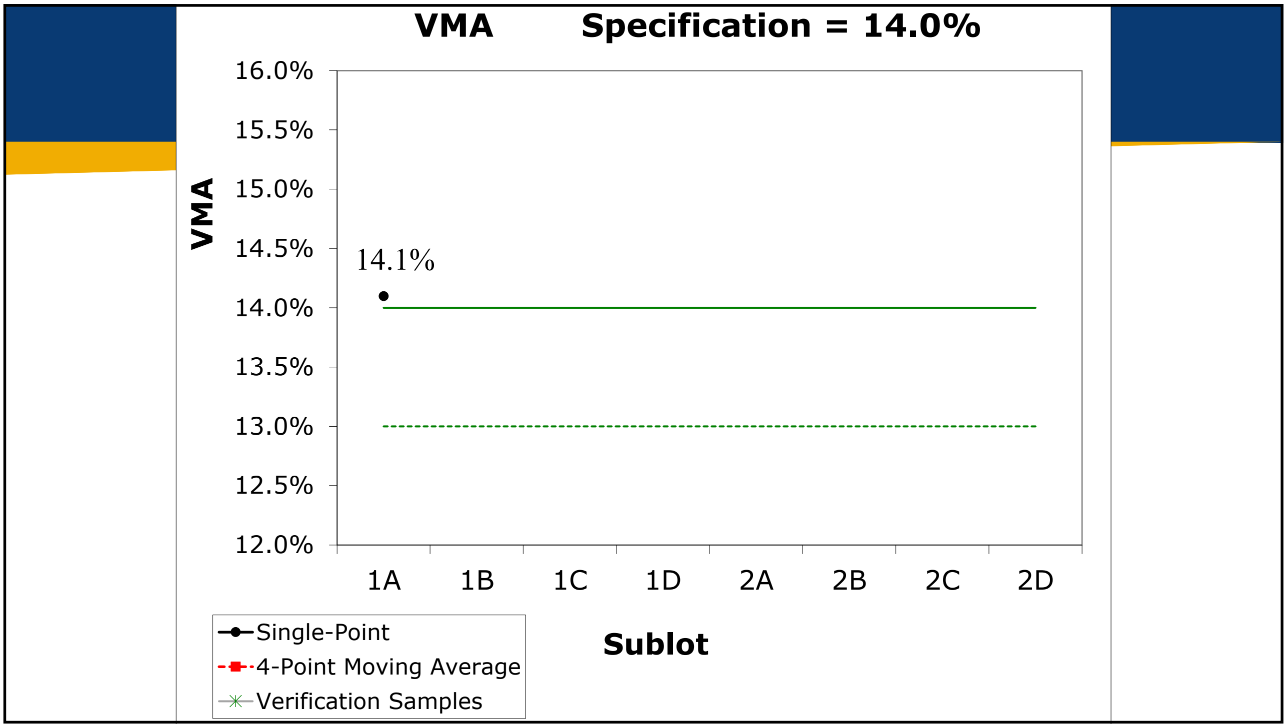
16.0%
15.5%
15.0%
14.5%
14.0%
13.5%
13.0%
12.5%
12.0%
VMA
Specification = LSL (4-Pt)
LSL (Single)
1A
1B
1C
1D
2A
2B
2C
2D
Sublot

44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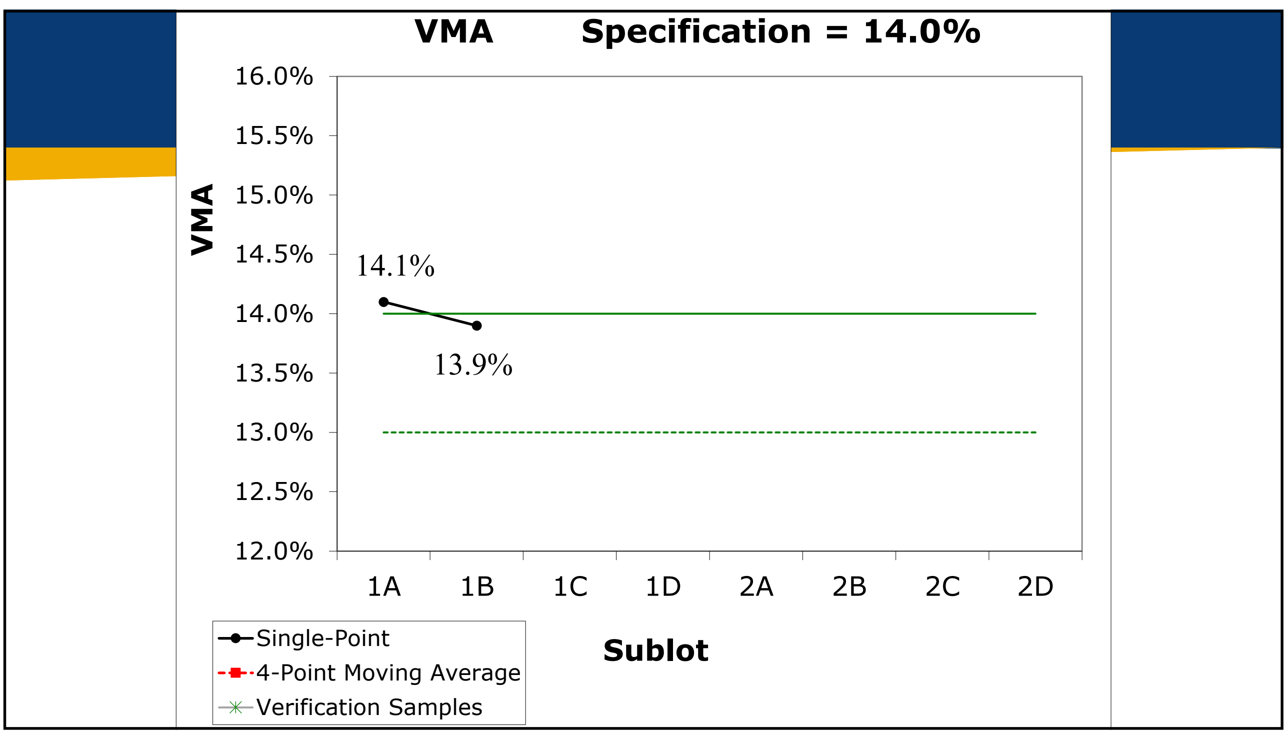
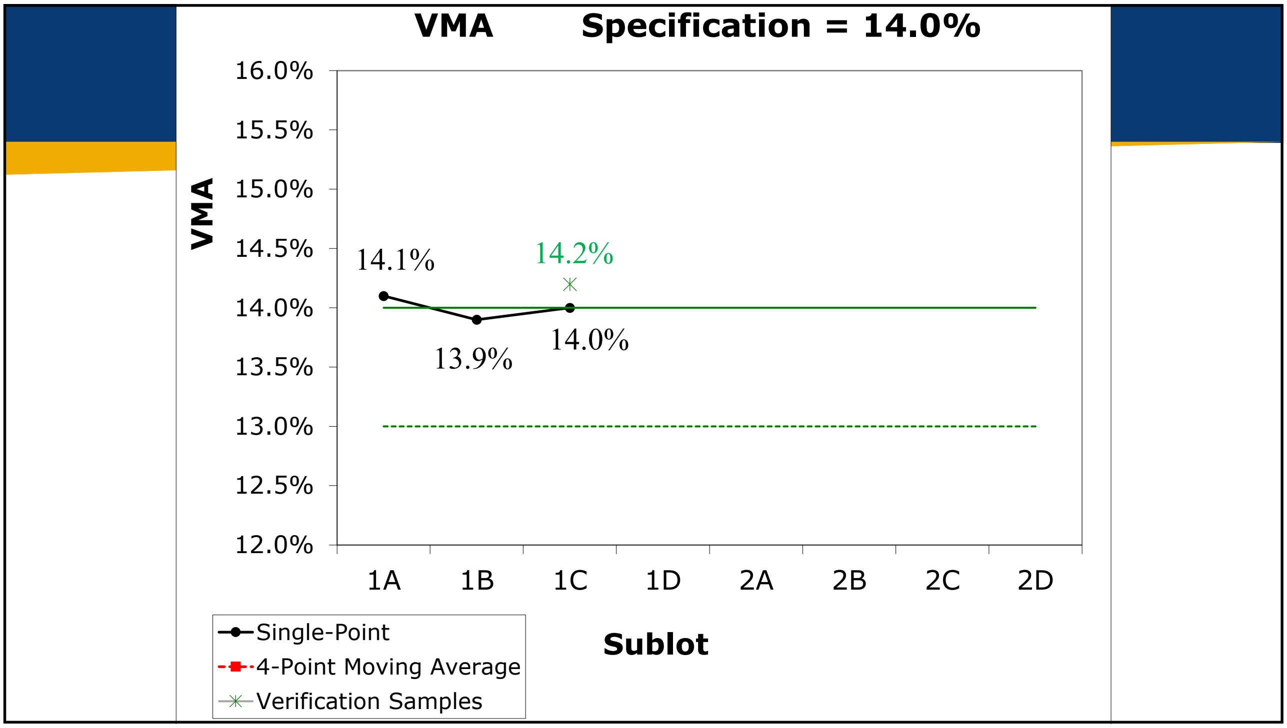
VMA
16.0%
15.5%
15.0%
14.5%
14.0%
13.5%
13.0%
12.5%
12.0%
14.1%
1A
1B
1C
1D
2A
2B
2C
2D
Sublot
Single-Point
4-Point Moving Average
Verification Samples

45

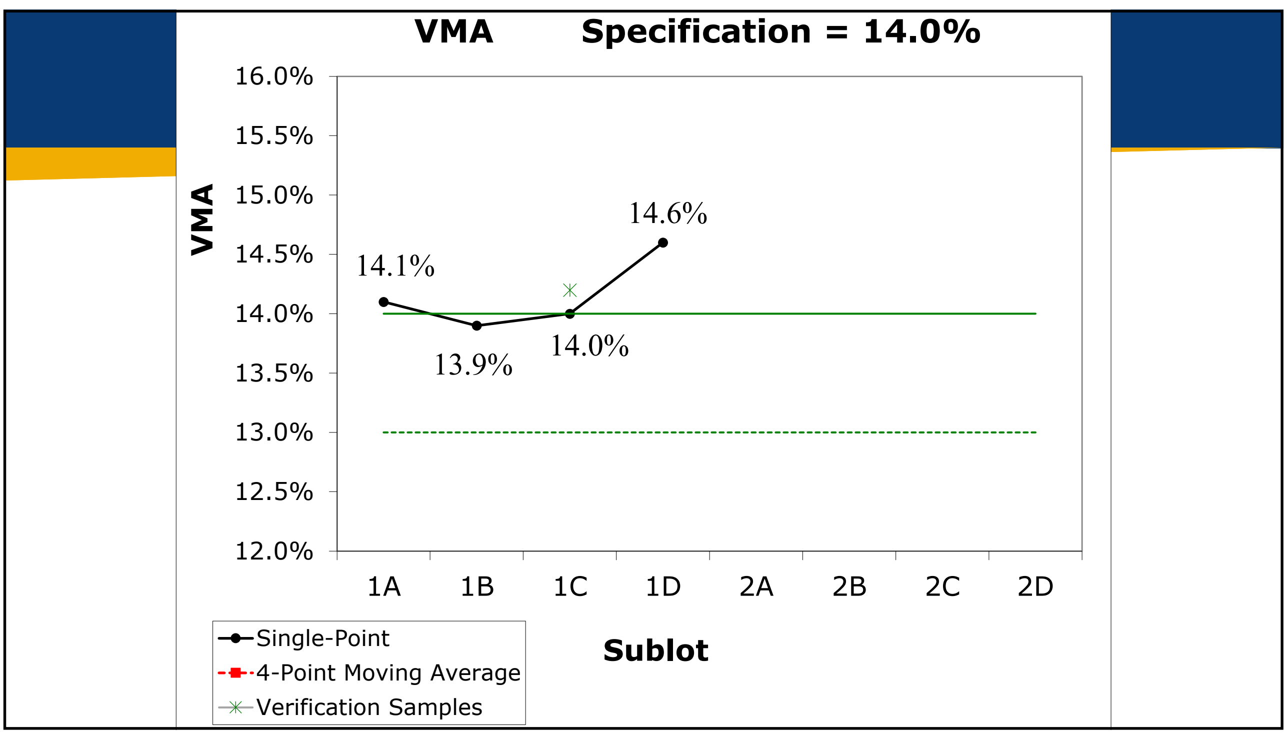

VMA Specification = 14.0%
VMA
16.0%
15.5%
15.0%
14.5%
14.0%
13.5%
13.0%
12.5%
12.0%
14.1%
13.9%
1A
1B
1C
1D
2A
2B
2C
2D
Sublot
Single-Point
4-Point Moving Average
Verification Samples

46



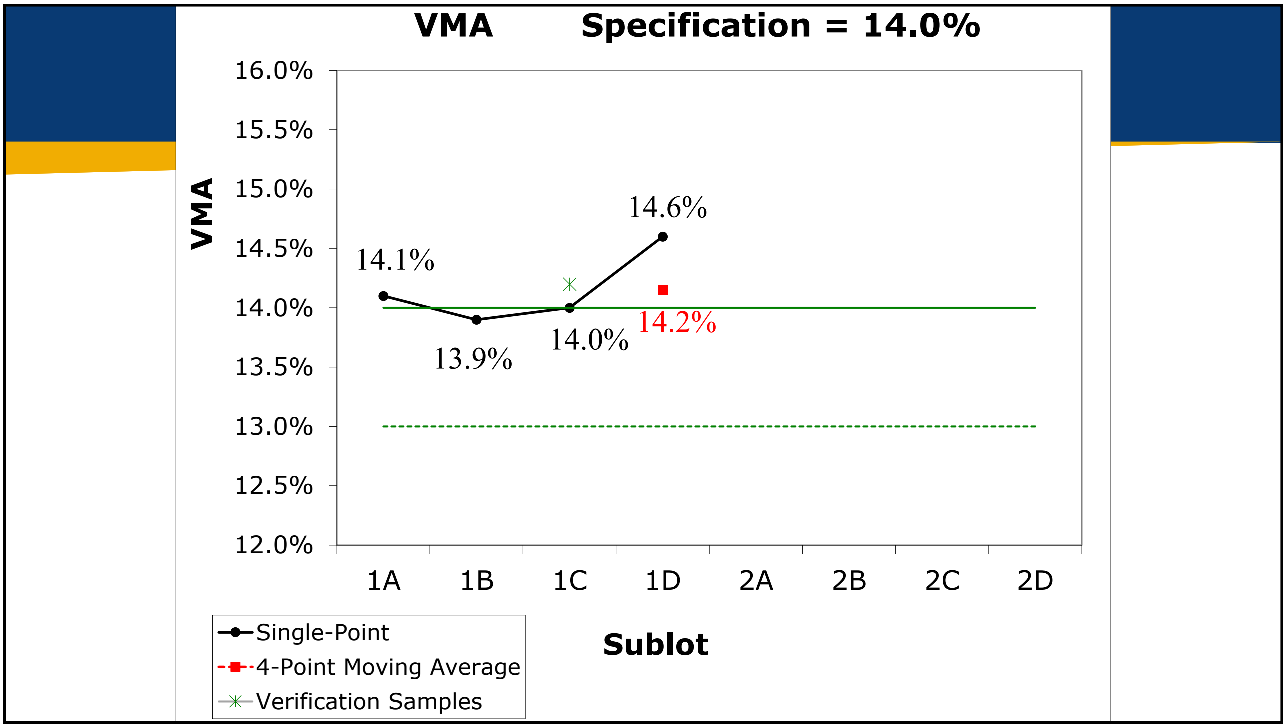
VMA Specification = 14.0%
16.0%
15.5%
15.0%
14.5%
14.0%
13.5%
13.0%
12.5%
12.0%
VMA
14.1%
14.2%
13.9%
14.0%
1A
1B
1C
1D
2A
2B
2C
2D
Sublot
Single-Point
4-Point Moving Average
Verification Samples

47

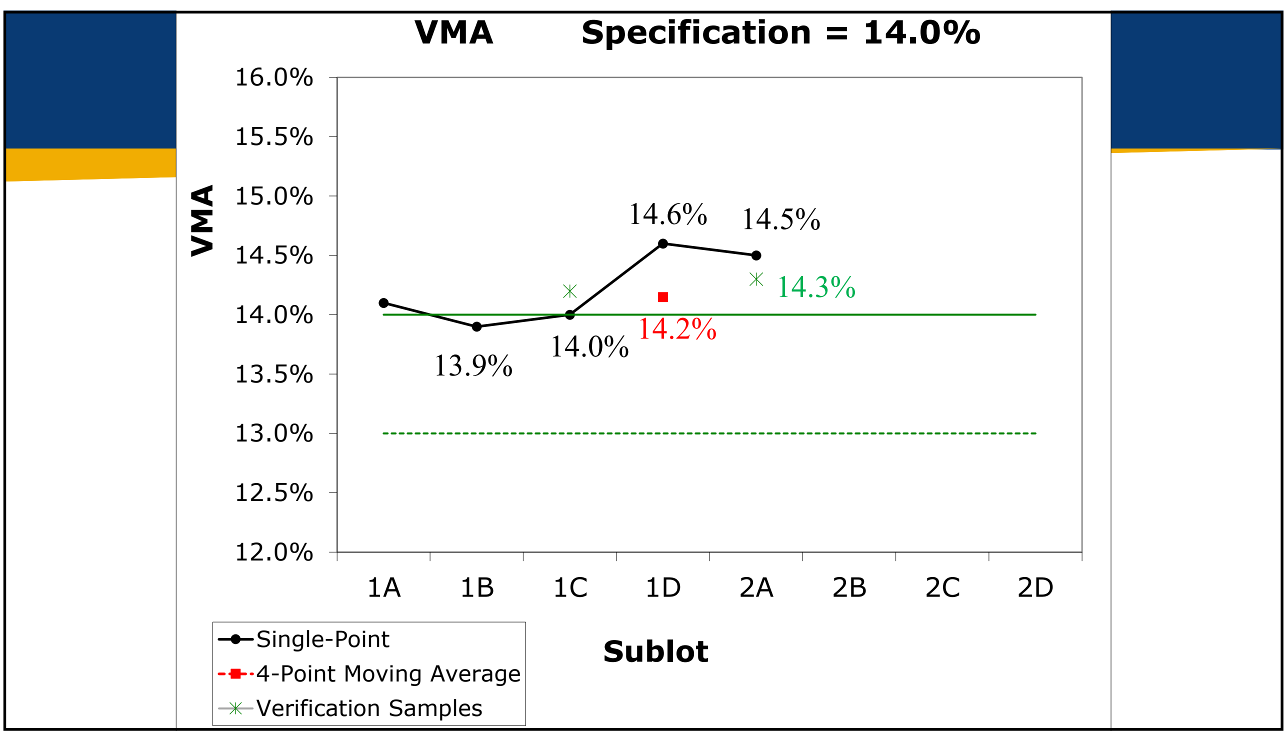


VMA Specification = 14.0%
16.0%
15.5%
15.0%
14.5%
14.0%
13.5%
13.0%
12.5%
12.0%
VMA
14.6%
14.1%
13.9%
14.0%
1A
1B
1C
1D
2A
2B
2C
2D
Sublot
Single-Point
4-Point Moving Average
Verification Samples

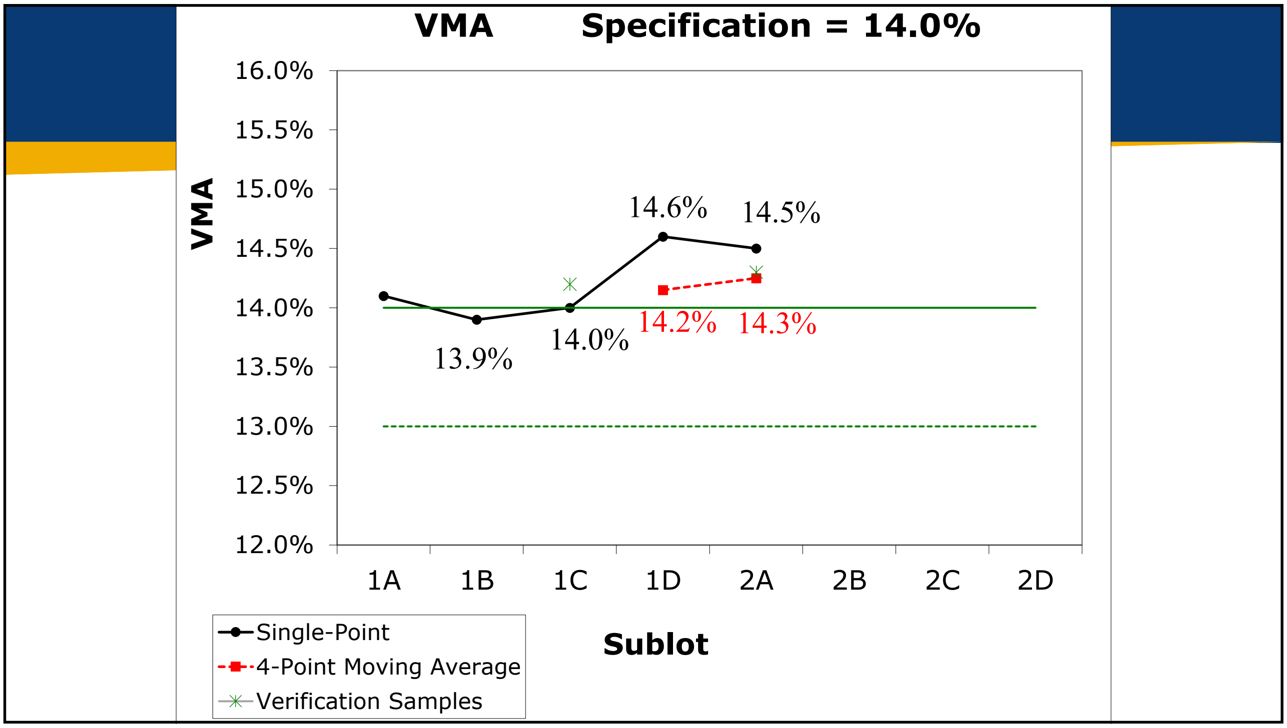
48


VMA
Specification = 14.0%
16.0%
15.5%
15.0%
14.5%
14.0%
13.5%
13.0%
12.5%
12.0%
VMA
14.1%
13.9%
14.0%
14.6%
14.2%
1A
1B
1C
1D
2A
2B
2C
2D
Sublot
Single-Point
4-Point Moving Average
Verification Samples

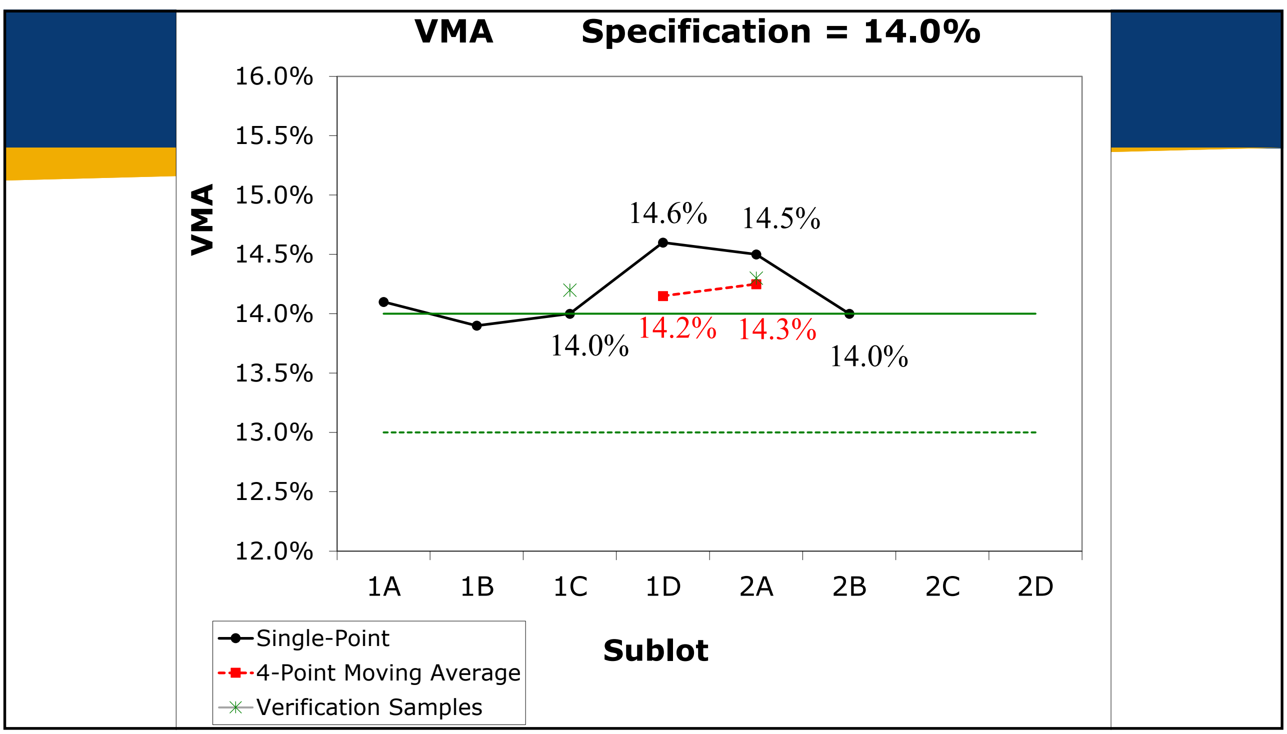
49


VMA
Specification = 14.0%
16.0%
15.5%
15.0%
14.5%
14.0%
13.5%
13.0%
12.5%
12.0%
VMA
13.9%
14.0%
14.6%
14.5%
14.3%
14.2%
1A
1B
1C
1D
2A
2B
2C
2D
Sublot
Single-Point
4-Point Moving Average
Verification Samples

50


VMA Specification = 14.0%
16.0%
15.5%
15.0%
14.5%
14.0%
13.5%
13.0%
12.5%
12.0%
VMA
14.6%
14.5%
14.2%
14.3%
14.0%
13.9%
1A
1B
1C
1D
2A
2B
2C
2D
Single-Point
4-Point Moving Average
Verification Samples
Sublot

51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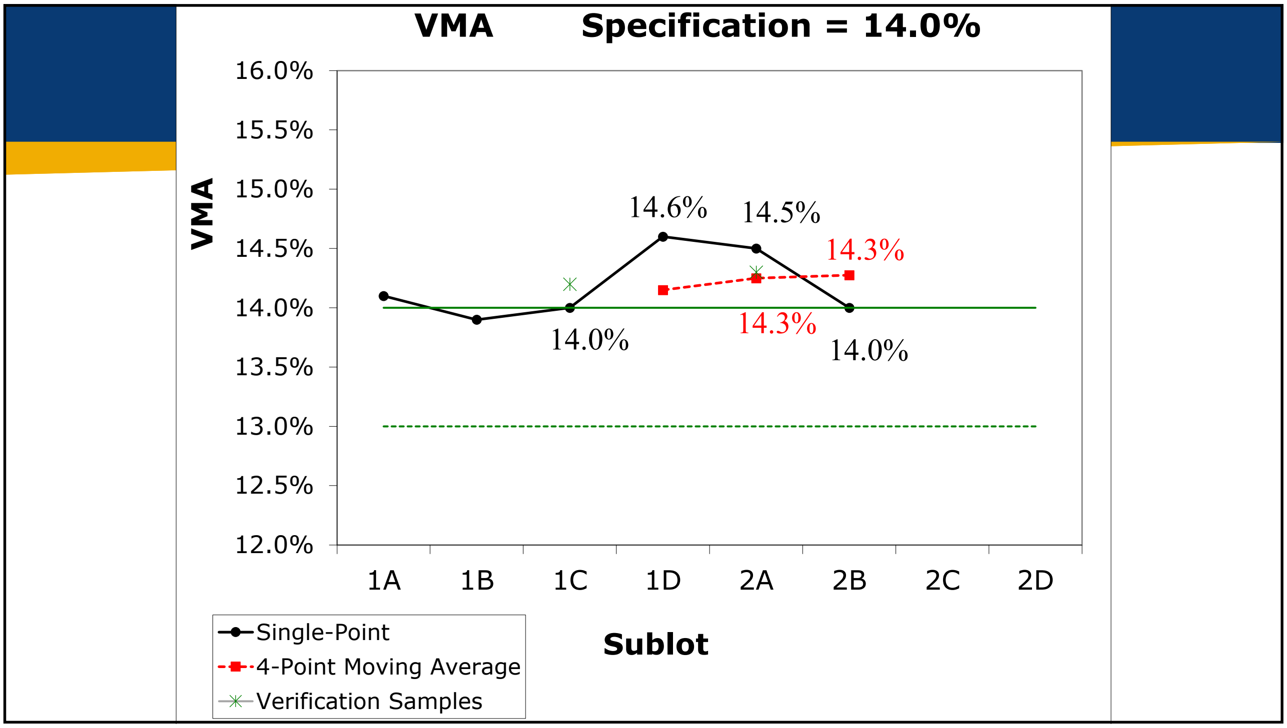
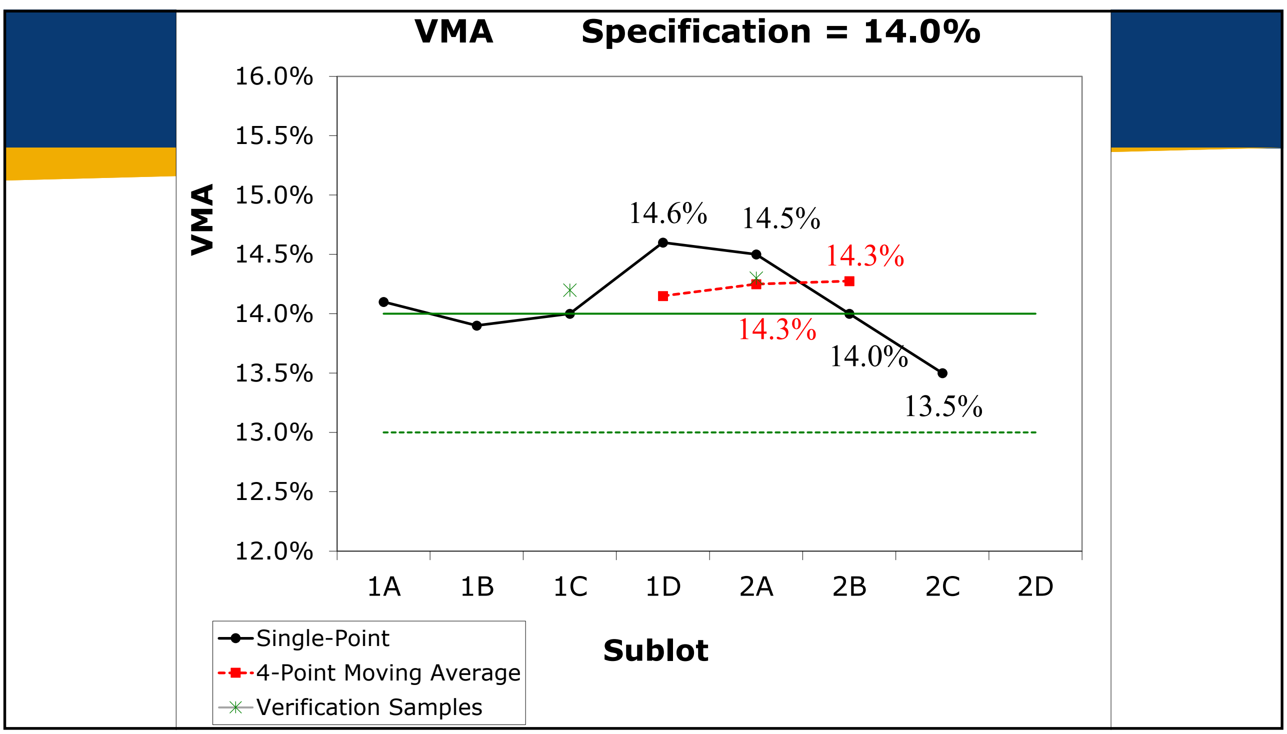
16.0%
15.5%
15.0%
14.5%
14.0%
13.5%
13.0%
12.5%
12.0%
VMA
14.6%
14.5%
14.2%
14.3%
14.0%
14.0%
1A
1B
1C
1D
2A
2B
2C
2D
Single-Point
4-Point Moving Average
Verification Samples
Sublot

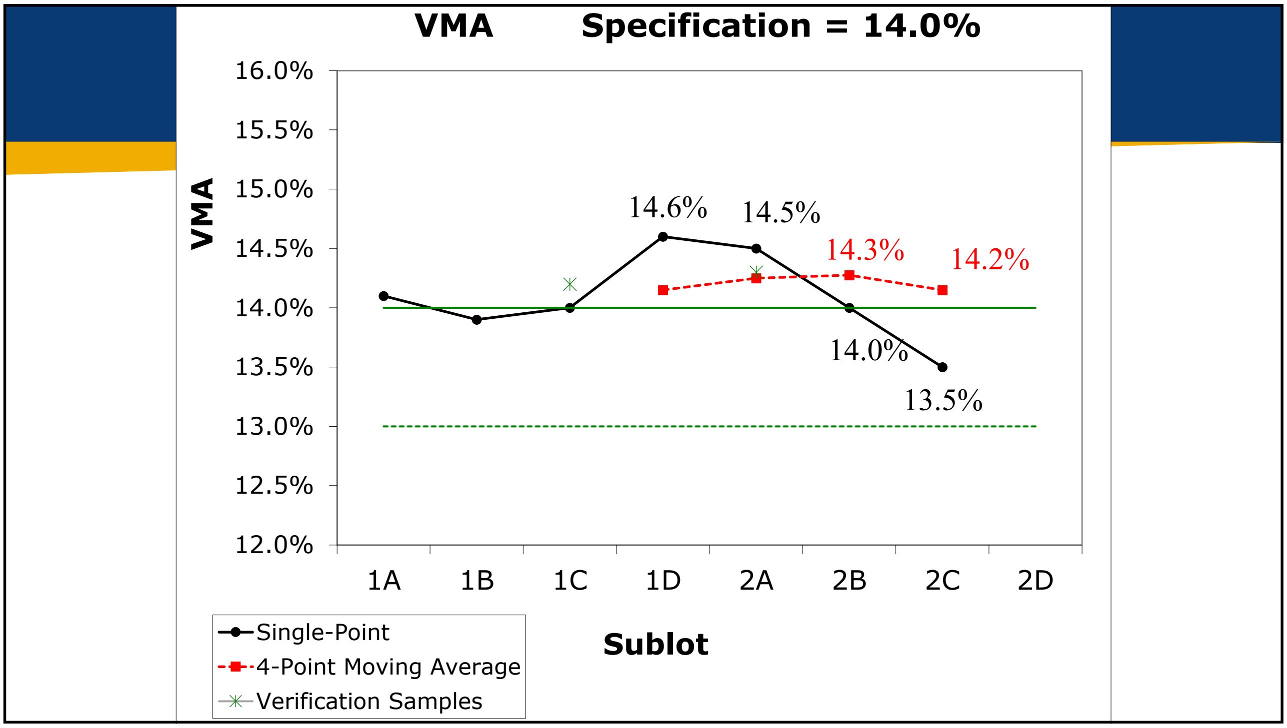
52


VMA Specification = 14.0%
16.0%
15.5%
15.0%
14.5%
14.0%
13.5%
13.0%
12.5%
12.0%
VMA
14.6%
14.5%
14.3%
14.3%
14.0%
14.0%
1A
1B
1C
1D
2A
2B
2C
2D
Sublot
Single-Point
4-Point Moving Average
Verification Samples

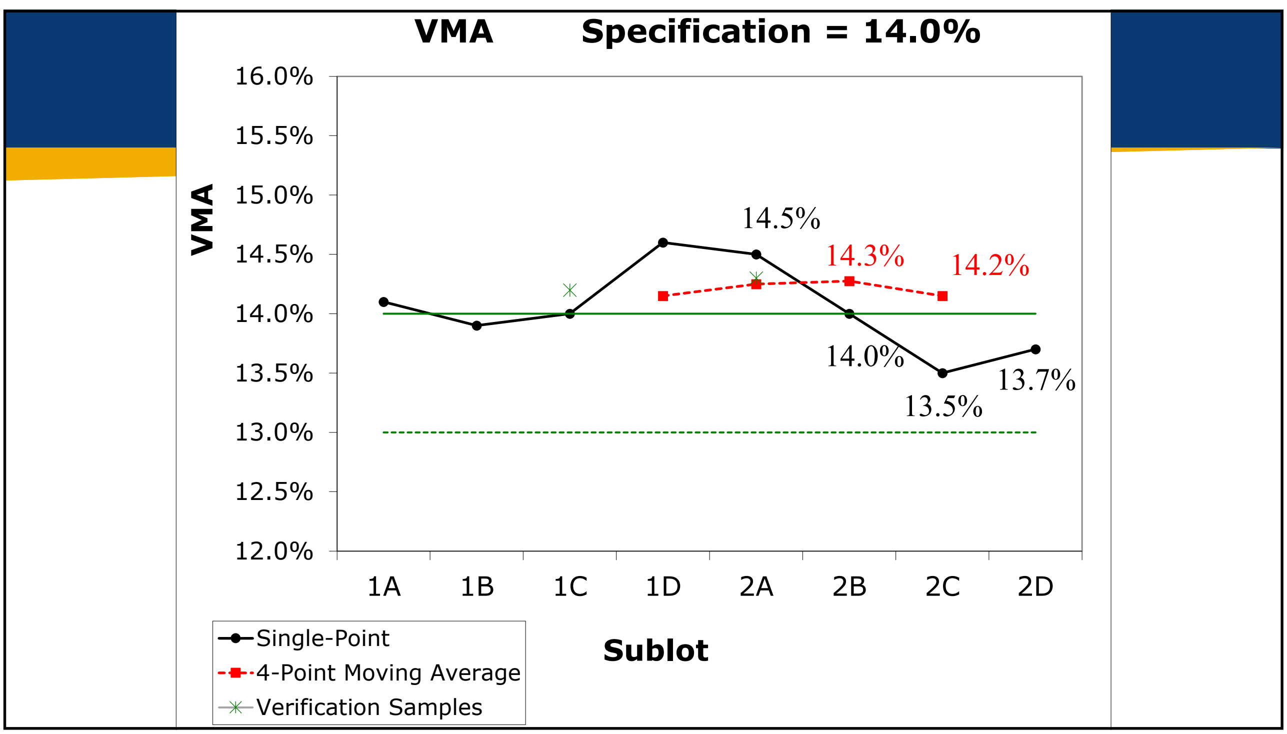
53


VMA Specification = 14.0%
16.0%
15.5%
15.0%
14.5%
14.0%
13.5%
13.0%
12.5%
12.0%
VMA
14.6%
14.5%
14.3%
14.3%
14.0%
13.5%
1A
1B
1C
1D
2A
2B
2C
2D
Sublot
Single-Point
4-Point Moving Average
Verification Samples

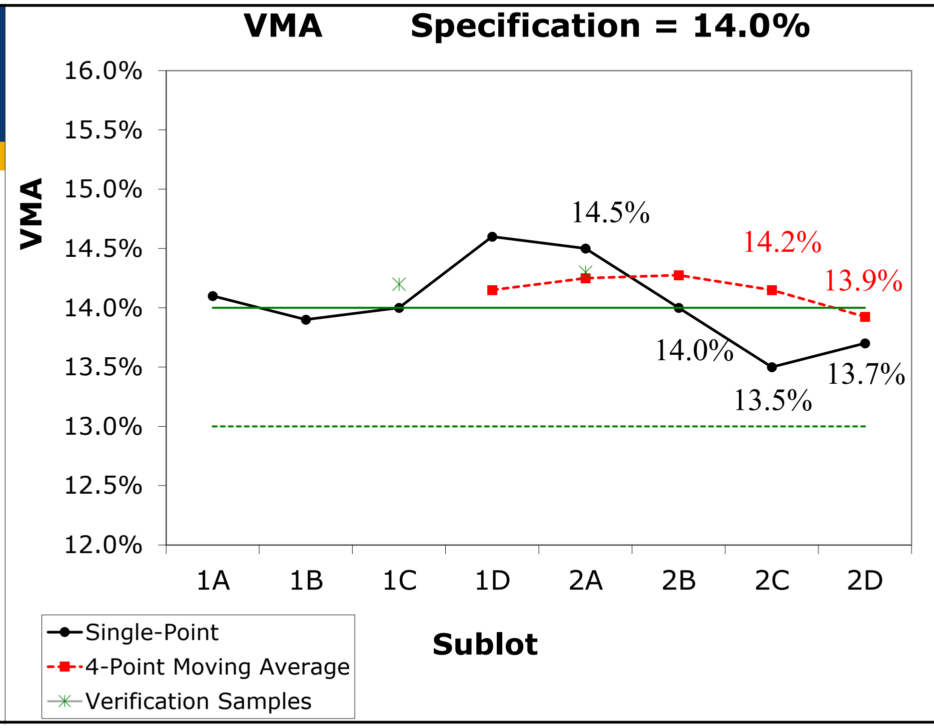
54


VMA Specification = 14.0%
16.0%
15.5%
15.0%
14.5%
14.0%
13.5%
13.0%
12.5%
12.0%
VMA
14.6%
14.5%
14.3%
14.2%
14.0%
13.5%
1A
1B
1C
1D
2A
2B
2C
2D
Sublot
Single-Point
4-Point Moving Average
Verification Samples

55


VMA Specification = 14.0%
16.0%
15.5%
15.0%
14.5%
14.0%
13.5%
13.0%
12.5%
12.0%
VMA
14.5%
14.3%
14.2%
14.0%
13.7%
13.5%
1A
1B
1C
1D
2A
2B
2C
2D
Sublot
Single-Point
4-Point Moving Average
Verification Samples

56



57

TABLE 602-12

Mix Characteristic	Tolerance from JMF			
	Single Test Value	Plot	4 Point Moving Average Value	Plot
Binder Content	±0.6%	*	±0.3%	*
Mix Characteristic	**Tolerance for Specification Limits**			
	Single Test Value	**Plot**	**4 Point Moving Average Value**	**Plot**
Gradation (applicable. sieves in **Table 602-1**)	N/A	*	zero tolerance	*
Air Voids @ N_{des} gyrations	-1.0%, +1.5%	*	N/A	
Voids in Mineral Aggregate (VMA)	1.0% below min.	*	zero tolerance	*
Voids Filled with Asphalt (VFA)	N/A		zero tolerance	*
Course Agg. Angularity (CAA)	zero tolerance		N/A	
Sand Equivalent (SE)	zero tolerance		N/A	
Fine Aggregate Angularity (FAA)	zero tolerance		N/A	
Tensile Strength Ratio (%TSR)	zero tolerance	*	N/A	
Density @ N_{ini} and N_{max}	N/A		zero tolerance	
Dust to Eff. Binder (D/B) Ratio	zero tolerance	*	zero tolerance	*

* Values to plot.
For gradations, as a minimum, plot the No. 4, 8, 30, and 200 sieves.

58

602.5 PROCESS CONTROL
d. Mixes with RAP

- Objective:
  - Prevent the maximum %RAP specified in the Project Special Provision (15-MR0664) from being exceeded.
- Accomplish this by
  - Using the Totalizer Readings (dry weights) to calculate %RAP
  - Take Readings
    - at least twice a day
    - at least 2 hours apart
    - and not more than 6 hours apart

TABLE 1: PROJECT MIX REQUIREMENTS

MIX CRITERIA	SR-12.5A (PG70-28)[1]
AGGREGATE:	
Coarse Angularity (min. %)	75
Uncompacted Voids-Fine (min. %)	42
Sand Equivalent (min. %)	40
Reclaimed Asphalt Pavement (RAP) (max. %)	25
RAP Bulk Specific Gravity	2.595
COMPACTION REVOLUTIONS:	
N_{ini} (level of compaction)	7 (≤91.5)
N_{des}	75
N_{max}	115
MIX:	
VFA	65 - 82

(1) Between 0 and 25% RAP may be used. Use the material milled from the project as the RAP source. The required binder and name shown below are based on the percent RAP used in the contract. The mix will be paid for at the bid price of SR-12.5A (PG70-28).

Percent RAP	Name
0	SM-12.5A (PG70-28)
1 - 15	SR-12.5A (PG70-28)
16 - 25	SR-12.5A (PG64-34)

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602.5 PROCESS CONTROL
d. Mixes with RAP

Equation A:

$$\%RAP = \frac{RAP * 100}{RAP + AGGv}$$

- %RAP is the percent RAP in the total aggregates (Virgin and RAP) rounded to the nearest tenth.
- RAP is the difference between the current and last reading of the RAP totalizer in tons.
- AGGv is the difference between the current and last reading of the Virgin Aggregate totalizer in tons.

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602.5 PROCESS CONTROL
d. Mixes with RAP

- Actions to be taken if out of compliance:
  - If any single test > 3.0% of maximum or if 4-point moving average > maximum 3 consecutive times
    - stop production, perform the “0 check run”, and make adjustments to correct.
  - If the 4-point moving average > maximum by more than 1.0% then the Contractor will be assessed a penalty.

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602.5 PROCESS CONTROL
d. Mixes with RAP

Equation B:

$$\text{Recycled Asphalt Materials Deduct} = \frac{BP * Q * (\%RAP_4 - \%RAP_{max})}{100}$$

- Recycled Asphalt Materials Deduct is the Dollar amount to be subtracted from the contract.
- BP is the Bid Price of the mix.
- Q is the Quantity, in tons, of material represented by the 4-point moving average.
  - This value shall be based on the weigh tickets taken from the time of the 1st test of the 4-point moving average through the time of 4^{th} test.
- $\%RAP_4$ is the 4-point moving average of %RAP.
- $\%RAP_{max}$ is the Maximum %RAP from the Project Special Provision.

62

602.5 PROCESS CONTROL
e. Mixes with RAP and RAS

- Objective:
  - Prevent the maximum % of RAP and % of RAS in JMF from being exceeded
- Accomplish this by
  - Using the Totalizer Readings to calculate %RAP and %RAS

Equation C: $\%RAP = \dfrac{RAP * 100}{RAP + RAS + AGGv}$

Equation E: $\%RAS = \dfrac{RAS * 100}{RAP + RAS + AGGv}$

63

602.5 PROCESS CONTROL
e. Mixes with RAP and RAS (2)

- Actions to be taken if out of compliance:
  - RAP
    - If any single test > 2.0% of JMF target or if 4-point moving average > JMF target 3 consecutive times
      - stop production, perform the "0 check run", and make adjustments to correct.
    - If the 4-point moving average > JMF target by more than 1.0% then the Contractor will be assessed a penalty.

Equation D: $\text{Recycled Asphalt Materials Deduct} = \dfrac{BP * Q * (\%RAP_4 - \%RAP_{max})}{100}$

64

602.5 PROCESS CONTROL
e. Mixes with RAP and RAS

- Actions to be taken if out of compliance:
  - RAS
    - If any single test > 2.0% of JMF target or if 4-point moving average > JMF target 3 consecutive times
      - stop production, perform the “0 check run”, and make adjustments to correct.
    - If the 4-point moving average > JMF target by more than 0.5% then the Contractor will be assessed a penalty.

Equation F:

$$\text{Recycled Asphalt Materials Deduct} = \frac{BP * Q * 4 * (\%RAS_4 - \%RAS_{max})}{100}$$

65

602.5 PROCESS CONTROL

Kansas Department of Transportation

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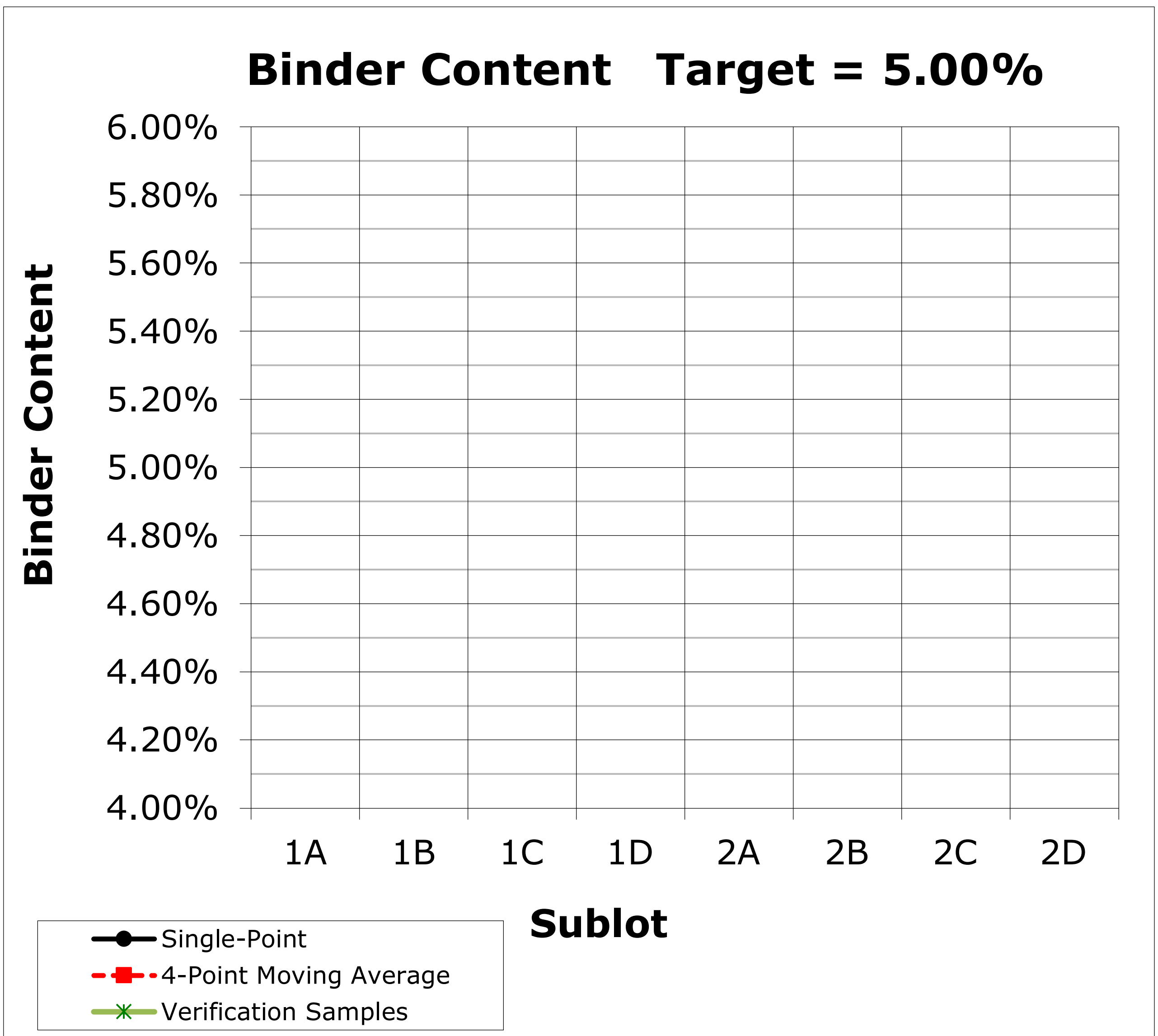
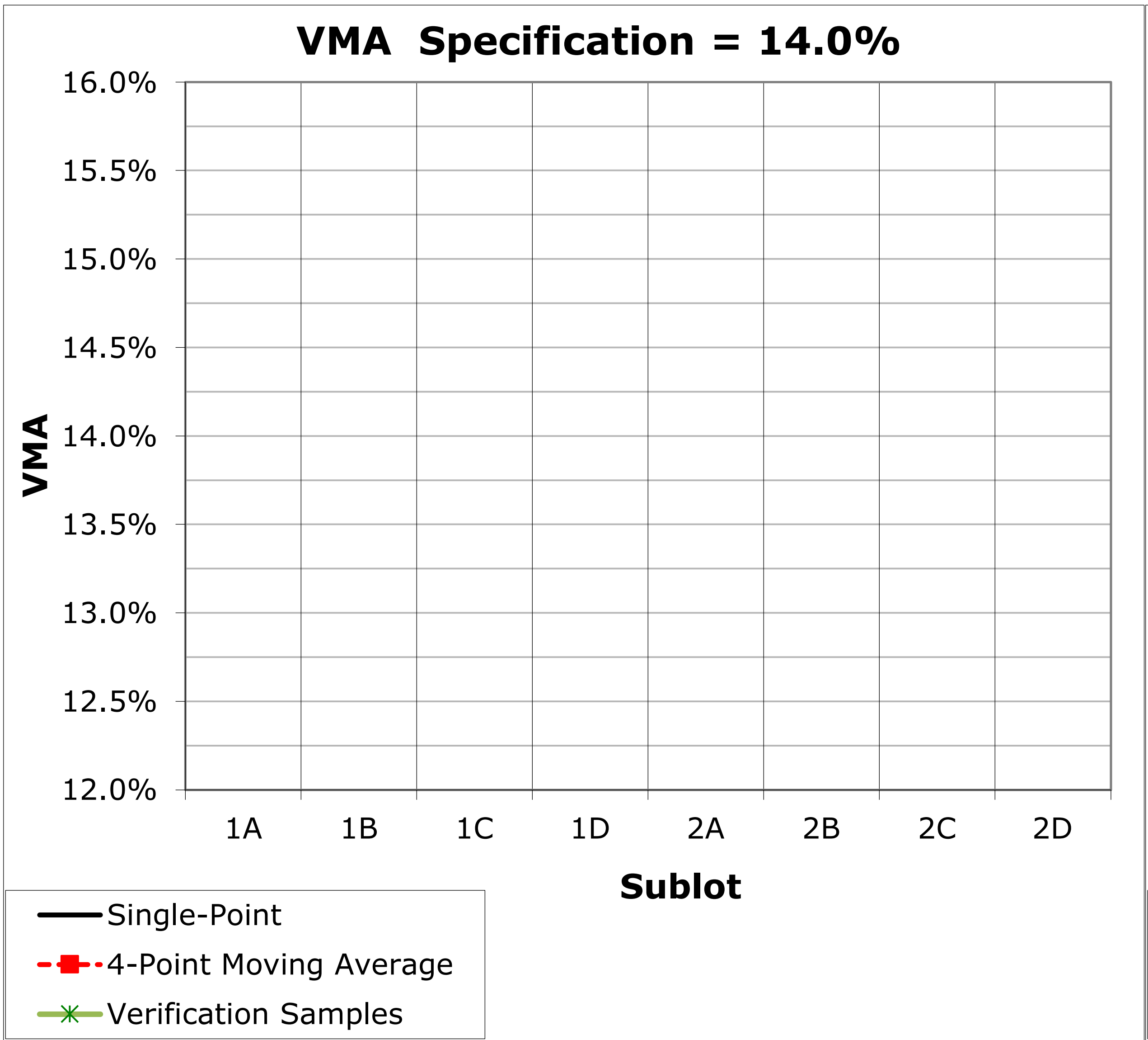
602.5 PROCESS CONTROL PLOTTING BINDER CONTENT				
Target Binder Content = 5.00%				
QC Test		4-pt Moving Average	QA Test	
Sublot	AC%		Sublot	AC%
01A	5.00%			
01B	5.20%			
01C	5.30%		01	5.50%
01D	5.70%			
02A	4.90%		02	5.10%
02B	4.25%			
02C	4.10%			
02D	4.85%			



602.5 PROCESS CONTROL PLOTTING VMA				
		VMA Specification (Min) =		14.0%
QC Test		4-pt Moving Average	QA Test	
Sublot	VMA		Sublot	VMA
01A	14.1%			
01B	13.9%			
01C	14.0%		01	14.2%
01D	14.6%			
02A	14.5%		02	14.3%
02B	14.0%			
02C	13.5%			
02D	13.7%			



QC/QA Asphalt Specifications
Special Provision 15-06007-R03 Outline

602.1	Description (Sheet 1 of 30)
602.2	Contractor QC Requirements (Sheets 1 to 4 of 30)
602.3	Materials (Sheets 4 to 8 of 30)
602.4	Construction Requirements (Sheets 8 to 14 of 30)
602.5	Process Control (Sheets 14 to 17 of 30)
602.6	**Compaction Testing (Sheets 17 to 19 of 30)**
602.7	Weather Limitations (Sheet 19 of 30)
602.8	Mixture Acceptance (Sheets 19 to 22 of 30)
602.9	Basis of Acceptance (Sheets 22 to 25 of 30)
602.10	HMA Paid by the Area (Sheets 25 to 29 of 30)
602.11	Measurement and Payment (Sheets 29 to 30 of 30)

Kansas Department of Transportation

1

602.6 COMPACTION TESTING

Objectives

- Describe when, where, and by whom nuclear density testing is accomplished
- Identify situations when re-evaluation of nuclear density testing is permitted
- Explain the process for taking cores to determine the roadway density

2

602.6 COMPACTION TESTING
a. General

- Density Determination using Test Results
  - Randomly Selected
  - Nuclear Density Gauge or
  - Core Samples
- Before Next Lift is Placed
- Before opening to
  - Construction Traffic
  - Public Traffic
- No later than the next working day after placement

3

602.6 COMPACTION TESTING
a. General

- Exception to Coring After Traffic on Overlay
- Used not more than twice on a Contract without Engineer's Approval
- Contractor requests Re-evaluation by Coring
- Follow Steps (1) through (5)

4

602.6 COMPACTION TESTING
a. Genera

1) Retake QC Nuclear Density Tests
   - Performed by Contractor in Engineer's Presence
   - Same Locations as Original
   - Average Density Determined
   - Contractor Density Correction Factor determined
     - Avg Density After Traffic – Avg Density Before Traffic
     - Value cannot be negative (use zero if negative)
2) Do the same for QA Nuclear Density Tests
3) Traffic Density Correction Factor
   - Larger of those determined in (1) and (2)

5

602.6 COMPACTION TESTING
a. General

4) Contractor obtains one core from each density location
   - Together, Contractor and Engineer will determine core densities using KT-15
   - Subtract the Traffic Density Correction Factor from the Core Density to get the Corrected Core Density
5) Use Corrected Core Densities to determine new pay factors

6

602.6 COMPACTION TESTING
a. General

Shoulder Information

Plan Width ≤ 3' and placed with Traveled Way

Density Pay factors for Traveled Way apply

Plan Width > 3' and **not** placed with Traveled Way

Density Controlled by different criteria

7

602.6 COMPACTION TESTING
a. General

- **Lot Definition**

- Day's Production for each lift placed
- Lot Acceptance
  - Based on Contractor's 2 QC Tests per Sublot
  - Unless the Engineer's Tests are Used (Failing F&t Test) (1 QA Test per Sublot)
- Density Lots and Air Void Lots are Different

8

602.6 COMPACTION TESTING
a. General

Opening to Traffic on Same Day

May Predetermine the Sublot Size

Adjust the Size as Warranted by Production

Density Pay Factors do not apply

Sideroads

Entrances

Crossover

Incidental Surfacing

9

602.6 COMPACTION TESTING
b. Nuclear Density Tests (T $\geq$ 1.5”)

- Contractor takes 2 QC tests per Sublot
- KDOT takes 1 Verification test per Sublot
- Used for:
  - Traveled Way Pay Adjustment
  - Control of Shoulder Density
- For A mixes (e.g. SR-12.5A) sand vs. no sand test not performed
  - Sand still required for segregation checks

10

602.6 COMPACTION TESTING
b. Nuclear Density Tests (T $\geq$ 1.5”)

- Do not take within 1’ of Longitudinal Joint or edge
- Do not take with 20’ of Transverse Joint
- Do not take on shoulders 3’ wide or less and placed with traveled way unless pavement section uniform across entire roadway
- Mark the outline of the Gauge (24 hours)
- Do not move Gauge to change results
- Contractor may choose to core if accuracy is doubted
  - All Nuclear Density Test Results are Void
  - Entire lot will be Cored

11

602.6 COMPACTION TESTING
b. Nuclear Density Tests (T $\geq$ 1.5”)

Calibration

- KDOT determines all calibration factors for nuclear gauges
- Contractor may observe the Calibration Procedure
  - At District Lab or Field Lab
- KDOT District Office Provides Calibration Factors
  - By end of next working day when cores are collected
  - If not possible, advance agreement to no price adjustment for affected lot(s)

12

602.6 COMPACTION TESTING
b. Nuclear Density Tests (T $\geq$ 1.5")

- KDOT and Contractor will compare nuclear density test results before traffic is on roadway
- If any values are suspect, Engineer may approve re-testing questionable areas
- Substitute new readings for the old ones
- Contractor must decide to core before traffic is allowed on roadway

13

602.6 COMPACTION TESTING
c. Cores (T $\geq$ 1.5")

- Same frequency and location restrictions as Nuclear Density Test
- May need to cool the mix before coring
- 4" diameter Core Barrel (6" dia. if approved)
- Transport cores to labs quickly

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602.6 COMPACTION TESTING
c. Cores (T $\geq$ 1.5")

- Contractor not reimbursed for coring
  - Reimbursed if associated with Gauge Calibration
  - Reimbursed if associated with dispute resolution (Contractor's results are used)
- Use KT-15 to determine the density
  - Contractor tests QC Samples in QC Lab
  - KDOT tests Verification Samples in QA Lab
- Fill in Core Holes **BY NEXT WORKING DAY**

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602.6 COMPACTION TESTING
c. Cores (T $\geq$ 1.5")

KT-15, Procedure III

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QC/QA Asphalt Specifications Special Provision 15-06007-R03 Outline

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Kansas Department of Transportation

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602.7 WEATHER LIMITATIONS

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602.7 WEATHER LIMITATIONS

- Do not place HMA on
  - Wet Surfaces
  - Frozen Surfaces
  - When Weather Conditions Prevent Proper Handling and Finishing the HMA

3

602.7 WEATHER LIMITATIONS

Either Ambient Air Temperature **or** Road Surface Temperature must be met.

TABLE 602-13: MINIMUM HMA PLACEMENT TEMPERATURES							
Paving Course	**Thickness (inches)**	**Air Temperature (ºF)**			**Surface Temperature (ºF)**		
		HMA	**WMA Foam**	**WMA Chem**	**HMA**	**WMA Foam**	**WMA Chem**
Surface	All	50	45	40	55	50	45
Subsurface	<1.5	50	45	40	55	50	45
Subsurface	≥1.5 and < 3	40	35	30	45	40	35
Subsurface	≥ 3	30	30	30	35	32	32

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602.7 WEATHER LIMITATIONS

Kansas Department of Transportation

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602.8 MIXTURE ACCEPTANCE

Kansas Department of Transportation

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602.8 MIXTURE ACCEPTANCE

Objectives

- Describe the different types of dispute resolution
- Explain how lot size can be increased and decreased
- Explain the purpose of the Pre-Production Sample
- Describe the circumstances which result in suspension of mix production

3

602.8 MIXTURE ACCEPTANCE
a. General

- Test each mix designation (each plant)
- Acceptance on a lot basis
- Obtain samples from behind paver before compaction
- Use Kansas Test Method KT-25
- **Obtain the mix from 3 locations**
- Contractor Repairs areas
- Sampled Material will be used to determine Air Void Pay Adjustment (Traveled Way and Shoulders

4

602.8 MIXTURE ACCEPTANCE
a. General

5

602.8 MIXTURE ACCEPTANCE
a. General

6

602.8 MIXTURE ACCEPTANCE
a. General

7

602.8 MIXTURE ACCEPTANCE
a. General

8

602.8 MIXTURE ACCEPTANCE
b. Lot Definition for Mix Production Sampling and Testing

- Isolated Quantity of as specified Material produced from a single source or operation
- Represented by 4 contiguous test results
- Can be from tests spanning multiple days

9

602.8 MIXTURE ACCEPTANCE
c. Lot Investigation

- Engineer may examine materials beyond the QC/QA Samples taken for Pay Adjustment
  - Define Unacceptable Work
  - Apply Appropriate Price Reductions
  - Initiate Corrective Actions
- Disputes will be handled through referee testing (Density and Air Voids are excluded)
  - KDOT District Materials Lab
  - Materials and Research Center (MRC)
  - Independent Laboratory
- "Unsupported Results" Pays for Testing

10

602.8 MIXTURE ACCEPTANCE
c. Lot Investigation

- Engineer decides on the disposition of each Lot when any Discrepancy exists (other than Density and Air Voids).
  - Acceptance
  - Rejection
  - Accepted with Adjusted Pay
  - Engineer's Decision is Final

11

602.8 MIXTURE ACCEPTANCE
c.(1) Nuclear Density Dispute Resolution

- Use when:
  - Statistical Comparison Fails
  - Contractor questions Department's Results
- Discard Previous Pay Factors
- Core each Nuclear Gauge Location (normally 15)
- Determine Core Densities using KT-15
- F&t test determines which values to use for pay

12

602.8 MIXTURE ACCEPTANCE
c.(2) Air Void Dispute Resolution

- Use when:
  - Statistical Comparison Fails
  - Contractor questions Department's Results
- Dispute lot previous to current production
- Discard previous Air Void Tests and Pay Factors
- Take the following to District Materials Lab
  - Gyratory Compacted QC and QA Samples
  - Back Halves of HMA (min of 35 lbs)
  - All Paper Work and Calculations

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602.8 MIXTURE ACCEPTANCE
c.(2) Air Void Dispute Resolution

- KDOT District Lab will Retest
- Retest Gyratory Compacted Plugs and Compare
- Determine G_{mm} for all 5 back halves
- Compact Back Halves to N_{max} and determine G_{mb} @ N_{des}
- Calculate Air Voids at N_{des}
- Plug new data into the F&t Spreadsheet

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602.8 MIXTURE ACCEPTANCE

(d) Resampling of Lots - not permitted

(e) Multiple Projects - If a plant is producing the same mix for more than one project, the lots will carry over between projects.

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602.8 MIXTURE ACCEPTANCE

(f) Lot Size = 3,000 tons

- 750 tons per sublot
- Contractor may redefine with Engineer's concurrence
  - Change in quantities
  - Interruption of Work

(g) Increased Lot Size = 4,000 tons

- 1,000 tons per sublot
  - Produce 8 consecutive sublots
  - Mix meets Table 602-12 Tolerances
  - No Air Void Penalty
  - Plant Production Rate ≥ 250 tons/Hr
  - Notification of Engineer

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602.8 MIXTURE ACCEPTANCE
g. Increased Lot Size

- Increased Lot Size = 5,000 tons
  - 1,250 tons per sublot
  - Produce 8 consecutive sublots @ 1,000 tons
    - Mix meets Table 602-12 Tolerances
    - No Air Void Penalty
    - Plant Production Rate for Previous 2 days > 3,750 tons/day
    - 2 out of 3 Segregation Profiles Meet:

Criteria	Maximum Density Range (Highest to Lowest)	Maximum Density Drop (Average – Lowest)
New	3.1 lbs/cf	1.9 lbs/cf
Previous	4.4 lbs/cf	2.2 lbs/cf

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602.8 MIXTURE ACCEPTANCE
g. Increased Lot Size

- 5,000 Tons (1,250 tons per sublot)
  - Reduce to 750 ton sublots
    - Do not meet mix tolerances in Table 602-12
    - Incur an Air Void Penalty
  - Reduce to 1,000 ton sublots
    - Production Rate for 2 consecutive days < 3,750 tons/day
    - 2 out of 3 Segregation Profiles fail to meet stricter criteria.

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602.8 MIXTURE ACCEPTANCE
h. Decreased Lot Size for Small Quantities

- Quantities < 3,000 tons
- Lot Size = Plan Quantity
- Sublot Size Reduced accordingly
- Before Production, Contractor Provides Engineer with Sublot size and number

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602.8 MIXTURE ACCEPTANCE
i. Pre-Production Mix (Test Strip)

- Maximum of 200 tons
- Initial Start-up
- Suspended Production from failing tests
- No Air Void Pay Adjustments
- Meet Mix Criteria
- Use Single Test Criteria (Table 602-12) for:
  - Binder Content
  - Air Voids
  - VMA
- Use Table 602-1 Criteria for other Tests
- Multiple Test Strips may be required

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602.8 MIXTURE ACCEPTANCE
i. Pre-Production Mix (Test Strip)

When HMA is Paid by the Ton (HMA Overlay, Surface, Base)

- Place in non-critical areas when possible
  - Sideroads
  - Entrances
  - Shoulders
  - Deep in the Base
- Paid for as the Material Produced
- Do not place an *excessive* number of “higher cost” mixes on shoulders, entrances, etc.

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602.8 MIXTURE ACCEPTANCE
i. Pre-Production Mix (Test Strip)

When HMA is Paid by the Square Yard (HMA Pavement)

- Place where required by contract documents
- High quality mixes (Top 4” of Pavement)
  - Should be placed in the top 4”
  - Contractor may choose to place in shoulders or deep in base
    - No additional cost to KDOT
    - Does not replace the need for the higher quality HMA in the top 4”

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602.8 MIXTURE ACCEPTANCE
i. Pre-Production Mix (Test Strip)

CL

MAINLINE	SHOULDER
1.5” HMA Surface (SR-9.5A) (PG 64-28)	1.5” HMA Surface (SR-9.5A) (PG 58-28) SH
2.5” HMA Base (SR-19A) (PG 64-28)	2.5” HMA Base (SR-19A) (PG 58-28) SH
8” HMA Base (SR-19A) (PG 64-22)	4” HMA Base (SR-19A) (PG 64-22) SH

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602.8 MIXTURE ACCEPTANCE
i. Pre-Production Mix (Test Strip)

- KDOT will pay for replacement of 1 test strip per mix provided its not removed:
  - Due to poor workmanship
  - Due to equipment malfunction
- Decision to remove Failed Test Strip Lies with
  - District Construction Engineer or
  - District Materials Engineer
  - Input from Contractor
- Remove Test Strip if:
  - Out of Specification
  - Reduce Pavement Life
  - Change Intended Function

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602.8 MIXTURE ACCEPTANCE
j. Suspension of Mix Production

- Suspend Production until Corrective Actions are Taken if
  - 2 Consecutive single test values fail criteria in Table 602-12
  - Any 4-point moving average value fails criteria in Table 602-12
- Production remains suspended
  - Pending successful Pre-Production Sample
  - District Materials Engineer can Waive Pre-Production
- Engineer can cease production any time HMA is unsatisfactory

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602.8 MIXTURE ACCEPTANCE

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QC/QA Asphalt Specifications
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602.9 BASIS OF ACCEPTANCE

OBJECTIVE

- Calculate pay adjustments for roadway compaction on projects with “HMA Overlay” bid items

2

602.9 BASIS OF ACCEPTANCE

Density pay Adjustment – "HMA Overlay" $\geq$ 1.5"

- By **lot**
  - Day's Paving (same mix; same lift)
  - Based on % G_{mm}
  - Average the % G_{mm} values to 0.01%aaaaaaaa
- Calculate Density Pay Factor to 0.001
- Density Pay Adjustment

  = P_D * Tons in lot * $75 per Ton

  Where: P_D = Density Pay Adjustment Factor

3

602.9 BASIS OF ACCEPTANCE

Density pay Adjustment – "HMA Overlay" $\geq$ 1.5"

LOT SIZE

- Typically 10 tests
- Single Day's Placement
- Table 602-10 Defines Lot Size for Low Production Days

4

602.4 CONSTRUCTION REQUIREMENTS e.(6) Density Requirements

TABLE 602-10: DAILY PRODUCTION VS NUMBER OF SUBLOTS AND TEST REQUIREMENTS			
Daily Production (tons)	**Number of Sublots**	**No. of Cores or Nuclear Density Tests****	**No. of Verification Cores or Nuclear Density Tests****
0-599	3*	6*	3*
600-999	4*	8*	4*
1000 or more	5	10	5

*Min # for mixes ≥ 1½" thick: Contractor may choose to obtain 10 tests. If so, KDOT will obtain 5 verification tests.

**For mixes < 1½" thick: Verification testing may be performed, but is not required. Additional testing may be performed by the Contractor. A minimum of 10 tests are required.

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602.9 BASIS OF ACCEPTANCE a. General

- F&t tests
  - Determine if Material came from the same population
  - F-test Compares Variances (s^2)
  - t-test compares Means ($\overline{X}$)
- Compare Contractor's QC and KDOT's QA Test Results
  - Air Voids
  - G_{mm}
  - Density

6

602.9 BASIS OF ACCEPTANCE
a. General

- Passing F&t test
  - Use Contractor's QC data
- Failing F&t test
  - Use KDOT's QA data (verification test data)
- KDOT Construction Manual Section 5.2.6

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602.9 BASIS OF ACCEPTANCE
KDOT Construction Manual – Section 5.2.6

Level of Significance

- Probability of rejecting the null hypothesis when the null hypothesis is true (Type I error)
- KDOT uses $\alpha = 1\%$
  - 1% chance that contractor's test results are valid and we reject them

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602.9 BASIS OF ACCEPTANCE
KDOT Construction Manual – Section 5.2.6

F-Test

- Determines if the variances (s^2) in the QC and verification (QA) tests are statistically equal
- Determines what formulae are used to conduct the t-test

t-Test

- Determine if the sample means ($\bar{X}$) in the QC and verification (QA) tests are equal
- **If the sample means are statistically equal, the materials came from the same population**

9

602.9 BASIS OF ACCEPTANCE
a. General

- **Passing t-Test – Use Contractor's Test Results**
- **Failing t-Test – Use KDOT's Test Results**

to

Accept or Reject Material

and

Determine Pay Adjustment

10

602.9 BASIS OF ACCEPTANCE
b. Density Pay Adjustment for "HMA Overlay"

- Mixes with Specified Thickness < 1½ inches
  - No Density Pay Adjustments
- Plan thickness of $\geq$ 1½ inches
- By **lot**
  - Based on % G_{mm}
  - Average the % G_{mm} values to 0.01%

11

602.9 BASIS OF ACCEPTANCE
b. Density Pay Adjustment for "HMA Overlay"

- Calculate Pay Adjustment Factor to 0.001
- Density Pay Adjustment

= P_D * Tons in lot * $75 per Ton

Where: P_D = Density Pay Adjustment Factor

P_D = Density Pay Factor – 1.000

Pay Factor from Table 602-15

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602.9 BASIS OF ACCEPTANCE
b. Density Pay Adjustment for "HMA Overlay"

TABLE 602-15: DENSITY PAY FACTORS FOR SPECIFIED THICKNESS[4]			
Specified Thickness →	≥ 2"	≥ 1½"	
	All	Continuous Action[5]	No Continuous Action[6]
% of G_{mm} Average of 10 Density Tests[1]	Pay Factor[2]		Pay Factor[2]
94.00% or greater	1.040		1.040
93.00 to 93.99%	A1		A2
92.00 to 92.99%	1.000		A2
91.00 to 91.99%	A3		1.000
90.00 to 90.99%	A3		A4
89.00% to 89.99%	0.840 or Remove[3]		A4
less than 89.00%	0.840 or Remove[3]		0.840 or Remove[3]

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602.9 BASIS OF ACCEPTANCE
b. Density Pay Adjustment for "HMA Overlay"

Notes to Table 602-15

1) If < 1000 tons, then may only be 6 or 8 tests.
2) Shoulders > 3': $\%G_{mm} \geq 91.00\%$ (if T $\geq$2") or $\%G_{mm} \geq 90.00\%$ (if T is between 1½" and 1⅞").

   Otherwise either remove or use density pay factor ≤ 0.950.
3) Remove or use a pay factor of 0.840.
4) Specified thickness is total thickness shown for mix.
5) Use Left Table for T ≥1½" when another continuous action is completed ahead of this overlay.
6) Use Right Table for T ≥1½" when another continuous action is not completed before the overlay

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602.9 BASIS OF ACCEPTANCE

b. Density Pay Adjustment for “HMA Overlay”

Continuous Actions

Overlay

Cold Recycle

Surface Recycle

Milling

15

602.9 BASIS OF ACCEPTANCE

b. Density Pay Adjustment for “HMA Overlay”

Calculations for Density Pay Factors
A1, A2, A3 and A4:

$A1 = [100 + 4 (\%G_{mm} - 93.00)] \div 100$

$A2 = [100 + 2 (\%G_{mm} - 92.00)] \div 100$

$A3 = [84 + 8 (\%G_{mm} - 90.00)] \div 100$

$A4 = [84 + 8 (\%G_{mm} - 89.00)] \div 100$

P_D = Density Pay Factor - 1.000

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COMPUTATION OF DENSITY PAY FACTORS

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DENSITY PAY FACTOR EXAMPLE (HMA Overlay (SR-12.5A)(PG 64-22)) (1.5" LIFT) (Lot 4)

No Continuous Action

602.9b. (Sheet 15-06007-R03-23)

Date	Test	Lift	Station	Lane	Dist from CL (ft)	Nuclear Gauge (pcf)	Maximum (Rice) Specific Gravity	% G_{mm}	Tons
8/21/2024	411	First	154+30	NB	3.4	131.3	2.385	89.45	364
8/21/2024	412	First	181+76	NB	10.8	132.8	2.385	90.46	
8/21/2024	421	First	198+65	NB	1.1	135.8	2.385	92.48	364
8/21/2024	422	First	201+62	NB	8.9	134.0	2.385	91.27	
8/21/2024	431	First	221+77	NB	2.8	131.7	2.385	89.72	364
8/21/2024	432	First	241+13	NB	4.4	132.7	2.385	90.39	
8/21/2024	441	First	258+33	NB	5.9	134.7	2.385	91.74	364
8/21/2024	442	First	272+61	NB	6.9	131.7	2.385	89.72	
8/21/2024	451	First	293+79	NB	9.9	135.7	2.385	92.41	364
8/21/2024	452	First	304+39	NB	3.1	133.1	2.385	90.66	

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	Mean	**90.83**	Average of %G_{mm} Values

Which Side of the Table 602-15 (602.9b. sheet 15-06007-R03-23)?

1. What is the Thickness? ______
2. Is it ≥ 2"? ______ If "YES" then use Left Side of Table; go to Step 4, If "NO" go to step 3
3. Was there a Continuous Action? ______ If "YES" then Left Side of Table, If "NO" then Right Side of Table ______
4. Based on the Mean Density, Determine the Pay Factor to be used ______
5. Pay Factor from equation or table: ______
6. Density Pay Adjustment Factor, P_D ______ Pay Factor - 1.000

Number of Tons in the Lot	TONS	**1,820**	
Price per Ton for Pay Adjustment	COST		602.9b. Sheet 15-06007-R03-23
Density Pay Adjustment	DPA		DPA = P_D * TONS * COST

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	Mean	**90.83**	Average of %G_{mm} Values

Which Side of the Table 602-15 (602.9b. sheet 15-06007-R03-23)?

1. What is the Thickness? **1.5**
2. Is it ≥ 2"? ______ If "YES" then use Left Side of Table; go to Step 4, If "NO" go to step 3
3. Was there a Continuous Action? ______ If "YES" then Left Side of Table, If "NO" then Right Side of Table ______
4. Based on the Mean Density, Determine the Pay Factor to be used ______
5. Pay Factor from equation or table: ______
6. Density Pay Adjustment Factor, P_D ______ Pay Factor - 1.000

Number of Tons in the Lot	TONS	**1,820**	
Price per Ton for Pay Adjustment	COST		602.9b. Sheet 15-06007-R03-23
Density Pay Adjustment	DPA		DPA = P_D * TONS * COST

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Mean		**90.83**	Average of $\%G_{mm}$ Values

Which Side of the Table 602-15 (602.9b. sheet 15-06007-R03-23)?

1. What is the Thickness?	**1.5**		
2. Is it $\geq$ 2"?	**NO**	If "YES" then use Left Side of Table; go to Step 4, If "NO" go to step 3	
3. Was there a Continuous Action?		If "YES" then Left Side of Table, If "NO" then Right Side of Table	
4. Based on the Mean Density, Determine the Pay Factor to be used			
5. Pay Factor from equation or table:			
6. Density Pay Adjustment Factor, P_D		Pay Factor - 1.000	
Number of Tons in the Lot	TONS	**1,820**	
Price per Ton for Pay Adjustment	COST		602.9b. Sheet 15-06007-R03-23
Density Pay Adjustment	DPA		DPA = P_D * TONS * COST

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Mean		**90.83**	Average of $\%G_{mm}$ Values

Which Side of the Table 602-15 (602.9b. sheet 15-06007-R03-23)?

1. What is the Thickness?	**1.5**		
2. Is it $\geq$ 2"?	**NO**	If "YES" then use Left Side of Table; go to Step 4, If "NO" go to step 3	
3. Was there a Continuous Action?	**NO**	If "YES" then Left Side of Table, If "NO" then Right Side of Table	
4. Based on the Mean Density, Determine the Pay Factor to be used			
5. Pay Factor from equation or table:			
6. Density Pay Adjustment Factor, P_D		Pay Factor - 1.000	
Number of Tons in the Lot	TONS	**1,820**	
Price per Ton for Pay Adjustment	COST		602.9b. Sheet 15-06007-R03-23
Density Pay Adjustment	DPA		DPA = P_D * TONS * COST

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Mean		**90.83**	Average of %G_{mm} Values

Which Side of the Table 602-15 (602.9b. sheet 15-06007-R03-23)?

1. What is the Thickness?	**1.5**		
2. Is it ≥ 2"?	**NO**	If "YES" then use Left Side of Table; go to Step 4, If "NO" go to step 3	
3. Was there a Continuous Action?	**NO**	If "YES" then Left Side of Table, If "NO" then Right Side of Table	**Right**
4. Based on the Mean Density, Determine the Pay Factor to be used			
5. Pay Factor from equation or table:			
6. Density Pay Adjustment Factor, P_D		Pay Factor - 1.000	
Number of Tons in the Lot	TONS	**1,820**	
Price per Ton for Pay Adjustment	COST		602.9b. Sheet 15-06007-R03-23
Density Pay Adjustment	DPA		DPA = P_D * TONS * COST

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602.9b.
Sheet 15-06007-R03-23

b. Asphalt Density Pay Adjustment for "HMA Overlay" Bid Items. Mixes with specified thickness of less than 1½ inches are not subject to the asphalt density pay adjustments.

For mixes with specified thickness of 1½ inches or greater: Asphalt density pay adjustment for compaction of the completed pavement shall be by lot, based on the percentage of G_{mm} obtained. Compute the asphalt density pay adjustment (incentive or disincentive) by multiplying the density pay adjustment factor (P_D) times the number of tons included in the lot times $75 per ton. (Air voids lots and density lots are normally of different sizes.) This adjustment will be paid for under the bid item Asphalt Density Pay Adjustment.

Density pay factors will be determined from **TABLE 602-15**. (For **TABLE 602-15**, average the percent of G_{mm} values to 0.01% and calculate the density pay adjustment factors rounded to the thousandths).

TABLE 602-15: DENSITY PAY FACTORS FOR SPECIFIED THICKNESS[4]

Specified Thickness →	≥ 2"	≥ 1½"	
	All	Continuous Action[5]	No Continuous Action[6]
% of G_{mm} Average of 10 Density Tests[1]	Pay Factor[2]		Pay Factor[2]
94.00% or greater	1.040		1.040
93.00 to 93.99%	A1		A2
92.00 to 92.99%	1.000		A2
91.00 to 91.99%	A3		1.000
90.00 to 90.99%	A3		A4
89.00% to 89.99%	0.840 or Remove[3]		A4
less than 89.00%	0.840 or Remove[3]		0.840 or Remove[3]

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602.9b.
Sheet 15-06007-R03-23

[1]For low daily production rates less than 1000 tons, or when the Engineer's verification tests are to be used for asphalt density pay determination, the lot sample size is as determined in **TABLE 602-10**.
[2]Shoulders: For shoulders with a plan width greater than 3 feet and any shoulder not placed at the same time as the traveled way, compact the HMA in the lot to a minimum of 91.00% (if specified thickness is ≥2") or 90.00% (if the specified thickness is from 1½" to 1⅞") of the G_{mm}. Otherwise, the Engineer will determine whether the HMA in the lot may remain in place or be removed. Any such material left in place shall have a density pay factor of 0.950 or less.
[3]Low Density: The Engineer will determine if the traveled way, shoulders with a plan width of 3 feet or less and placed with the traveled way, ramps, acceleration and deceleration lanes may remain in place or be removed. The Engineer will notify the Contractor before 11:00 AM of the next working day if the area is to be removed. Any such material left in place shall have a density pay factor of 0.840.
[4]Specified thickness is the total thickness shown in the Contract Documents for the mix being placed.
[5]Use for ≥1½" when another continuous action, such as milling, surface recycling, cold recycling or overlay is completed ahead of this overlay.
[6]Use for ≥1½" when another continuous action is not completed before the overlay.

Calculations for Density Pay Factors A1, A2, A3 and A4:

A1 = [100 + 4 (% of lot G_{mm} - 93.00)] ÷ 100
A2 = [100 + 2 (% of lot G_{mm} - 92.00)] ÷ 100
A3 = [84 + 8 (% of lot G_{mm} - 90.00)] ÷ 100
A4 = [84 + 8 (% of lot G_{mm} - 89.00)] ÷ 100

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Mean **90.83** Average of %G_{mm} Values

Which Side of the Table 602-15 (602.9b. sheet 15-06007-R03-23)?

1. What is the Thickness?	**1.5**		
2. Is it ≥ 2"?	**NO**	If "YES" then use Left Side of Table; go to Step 4, If "NO" go to step 3	
3. Was there a Continuous Action?	**NO**	If "YES" then Left Side of Table, If "NO" then Right Side of Table	**Right**
4. Based on the Mean Density, Determine the Pay Factor to be used	**A4 = [84 + 8 (%Gmm - 89.00)] ÷ 100**		
5. Pay Factor from equation or table:			
6. Density Pay Adjustment Factor, P_D		Pay Factor - 1.000	
Number of Tons in the Lot	TONS	**1,820**	
Price per Ton for Pay Adjustment	COST		602.9b. Sheet 15-06007-R03-23
Density Pay Adjustment	DPA		DPA = P_D * TONS * COST

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$$A4 = [84 + 8\ (\%Gmm - 89.00)] / 100$$

$$A4 = [84 + 8\ (90.83 - 89.00)] / 100$$

$$A4 = [84 + 8\ (1.83)] / 100$$

$$A4 = [84 + 14.64] / 100$$

$$A4 = [98.64] / 100$$

$$A4 = 0.986$$

Order of Operation

- Parenthesis
- Exponents
- Multiplication and Division
- Addition and Subtraction

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Mean		**90.83**	Average of $\%G_{mm}$ Values

Which Side of the Table 602-15 (602.9b. sheet 15-06007-R03-23)?

1. What is the Thickness?	**1.5**		
2. Is it $\geq$ 2"?	**NO**	If "YES" then use Left Side of Table; go to Step 4, If "NO" go to step 3	
3. Was there a Continuous Action?	**NO**	If "YES" then Left Side of Table, If "NO" then Right Side of Table	**Right**
4. Based on the Mean Density, Determine the Pay Factor to be used	**A4 = [84 + 8 (%Gmm - 89.00)] ÷ 100**		
5. Pay Factor from equation or table:	**0.986**		
6. Density Pay Adjustment Factor, P_D		Pay Factor - 1.000	
Number of Tons in the Lot	TONS	**1,820**	
Price per Ton for Pay Adjustment	COST		602.9b. Sheet 15-06007-R03-23
Density Pay Adjustment	DPA		DPA = P_D * TONS * COST

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602.9b.
Sheet 15-06007-R03-23

[1]For low daily production rates less than 1000 tons, or when the Engineer's verification tests are to be used for asphalt density pay determination, the lot sample size is as determined in **TABLE 602-10**.
[2]Shoulders: For shoulders with a plan width greater than 3 feet and any shoulder not placed at the same time as the traveled way, compact the HMA in the lot to a minimum of 91.00% (if specified thickness is ≥2") or 90.00% (if the specified thickness is from 1½" to 1⅞") of the G_{mm}. Otherwise, the Engineer will determine whether the HMA in the lot may remain in place or be removed. Any such material left in place shall have a density pay factor of 0.950 or less.
[3]Low Density: The Engineer will determine if the traveled way, shoulders with a plan width of 3 feet or less and placed with the traveled way, ramps, acceleration and deceleration lanes may remain in place or be removed. The Engineer will notify the Contractor before 11:00 AM of the next working day if the area is to be removed. Any such material left in place shall have a density pay factor of 0.840.
[4]Specified thickness is the total thickness shown in the Contract Documents for the mix being placed.
[5]Use for ≥1½" when another continuous action, such as milling, surface recycling, cold recycling or overlay is completed ahead of this overlay.
[6]Use for ≥1½" when another continuous action is not completed before the overlay.

Calculations for Density Pay Factors A1, A2, A3 and A4:

A1 = [100 + 4 (% of lot G_{mm} - 93.00)] ÷ 100
A2 = [100 + 2 (% of lot G_{mm} - 92.00)] ÷ 100
A3 = [84 + 8 (% of lot G_{mm} - 90.00)] ÷ 100
A4 = [84 + 8 (% of lot G_{mm} - 89.00)] ÷ 100

Density Pay Adjustment Factor Calculation:

Density Pay Adjustment Factor (P_D)* = Density Pay Factor - 1.000
*P_D rounded to the nearest thousandth

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P_D = Pay Factor - 1.000

P_D = 0.986 - 1.000

P_D = -0.014

Order of Operation

- Parenthesis
- Exponents
- Multiplication and Division
- Addition and Subtraction

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Mean		**90.83**	Average of %G_{mm} Values

Which Side of the Table 602-15 (602.9b. sheet 15-06007-R03-23)?

1. What is the Thickness?	**1.5**		
2. Is it ≥ 2"?	**NO**	If "YES" then use Left Side of Table; go to Step 4, If "NO" go to step 3	
3. Was there a Continuous Action?	**NO**	If "YES" then Left Side of Table, If "NO" then Right Side of Table	**Right**
4. Based on the Mean Density, Determine the Pay Factor to be used	**A4 = [84 + 8 (%Gmm - 89.00)] ÷ 100**		
5. Pay Factor from equation or table:	**0.986**		
6. Density Pay Adjustment Factor, P_D	**-0.014**	Pay Factor - 1.000	
Number of Tons in the Lot	TONS	**1,820**	
Price per Ton for Pay Adjustment	COST		602.9b. Sheet 15-06007-R03-23
Density Pay Adjustment	DPA		DPA = P_D * TONS * COST

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602.9b.
Sheet 15-06007-R03-23

b. Asphalt Density Pay Adjustment for "HMA Overlay" Bid Items. Mixes with specified thickness of less than 1½ inches are not subject to the asphalt density pay adjustments.

For mixes with specified thickness of 1½ inches or greater: Asphalt density pay adjustment for compaction of the completed pavement shall be by lot, based on the percentage of G_{mm} obtained. Compute the asphalt density pay adjustment (incentive or disincentive) by multiplying the density pay adjustment factor (P_D) times the number of tons included in the lot times $75 per ton. (Air voids lots and density lots are normally of different sizes.) This adjustment will be paid for under the bid item Asphalt Density Pay Adjustment.

Density pay factors will be determined from **TABLE 602-15**. (For **TABLE 602-15**, average the percent of G_{mm} values to 0.01% and calculate the density pay adjustment factors rounded to the thousandths).

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Mean	90.83	Average of %G_{mm} Values	

Which Side of the Table 602-15 (602.9b. sheet 15-06007-R03-23)?

1. What is the Thickness?	**1.5**		
2. Is it ≥ 2"?	**NO**	If "YES" then use Left Side of Table; go to Step 4, If "NO" go to step 3	
3. Was there a Continuous Action?	**NO**	If "YES" then Left Side of Table, If "NO" then Right Side of Table	**Right**
4. Based on the Mean Density, Determine the Pay Factor to be used	**A4 = [84 + 8 (%Gmm - 89.00)] ÷ 100**		
5. Pay Factor from equation or table:	**0.986**		
6. Density Pay Adjustment Factor, P_D	**-0.014**	Pay Factor - 1.000	
Number of Tons in the Lot	TONS	**1,820**	
Price per Ton for Pay Adjustment	COST	**$ 75.00**	602.9b. Sheet 15-06007-R03-23
Density Pay Adjustment	DPA		DPA = P_D * TONS * COST

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602.9b.
Sheet 15-06007-R03-23

b. Asphalt Density Pay Adjustment for "HMA Overlay" Bid Items. Mixes with specified thickness of less than 1½ inches are not subject to the asphalt density pay adjustments.

For mixes with specified thickness of 1½ inches or greater: Asphalt density pay adjustment for compaction of the completed pavement shall be by lot, based on the percentage of G_{mm} obtained. Compute the asphalt density pay adjustment (incentive or disincentive) by multiplying the density pay adjustment factor (P_D) times the number of tons included in the lot times $75 per ton. (Air voids lots and density lots are normally of different sizes.) This adjustment will be paid for under the bid item Asphalt Density Pay Adjustment.

Density pay factors will be determined from **TABLE 602-15**. (For **TABLE 602-15**, average the percent of G_{mm} values to 0.01% and calculate the density pay adjustment factors rounded to the thousandths).

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Density Pay Adjustment

$= P_D * \text{Tons per Lot} * \text{Cost per Ton}$

$= -0.014 * (1{,}820 * \$75.00)$

$= -0.014 * 136{,}500$

$= -\$1{,}911.00$ or $ (1,911.00)

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Mean		**90.83**	Average of $\%G_{mm}$ Values

Which Side of the Table 602-15 (602.9b. sheet 15-06007-R03-23)?

1. What is the Thickness?	**1.5**		
2. Is it ≥ 2"?	**NO**	If "YES" then use Left Side of Table; go to Step 4, If "NO" go to step 3	
3. Was there a Continuous Action?	**NO**	If "YES" then Left Side of Table, If "NO" then Right Side of Table	**Right**
4. Based on the Mean Density, Determine the Pay Factor to be used	**A4 = [84 + 8 (%Gmm - 89.00)] ÷ 100**		
5. Pay Factor from equation or table:	**0.986**		
6. Density Pay Adjustment Factor, P_D	**-0.014**	Pay Factor - 1.000	
Number of Tons in the Lot	TONS	**1,820**	
Price per Ton for Pay Adjustment	COST	**$ 75.00**	602.9b. Sheet 15-06007-R03-23
Density Pay Adjustment	DPA	**$ (1,911.00)**	DPA = P_D * TONS * COST

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DENSITY PAY FACTOR EXAMPLE (HMA Overlay (SR-12.5A)(PG 64-22)) (1.5" LIFT) (Lot 5)

Continuous Action

602.9b. (Sheet 15-06007-R03-23)

Date	Test	Lift	Station	Lane	Dist from CL (ft)	Nuclear Gauge (pcf)	Maximum (Rice) Specific Gravity	% G_{mm}	Tons
8/21/2024	511	First	154+94	NB	8.8	139.0	2.388	94.52	364
8/21/2024	512	First	173+98	NB	3.0	137.3	2.388	93.37	
8/21/2024	521	First	193+78	NB	2.9	136.4	2.388	92.77	364
8/21/2024	522	First	205+65	NB	10.0	138.7	2.388	94.32	
8/21/2024	531	First	227+75	NB	3.5	138.9	2.388	94.45	364
8/21/2024	532	First	235+97	NB	10.3	136.4	2.388	92.77	
8/21/2024	541	First	260+15	NB	9.4	138.6	2.388	94.25	364
8/21/2024	542	First	272+59	NB	4.1	137.2	2.388	93.31	
8/21/2024	551	First	297+55	NB	5.8	136.4	2.388	92.77	364
8/21/2024	552	First	312+23	NB	5.8	135.5	2.388	92.16	

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Mean X **93.47** Average of %G_{mm} Values

Which Side of the Table 602-15 (602.9b. sheet 15-06007-R03-23)?

1. What is the Thickness? ________

2. Is it ≥ 2"? ________ If "YES" then use Left Side of Table; go to Step 4, If "NO" go to step 3

3. Was there a Continuous Action? ________ If "YES" then Left Side of Table, If "NO" then Right Side of Table ________

4. Based on the Mean Density, Determine the Pay Factor to be used ________

5. Pay Factor from equation or table: ________

6. Density Pay Adjustment Factor, P_D ________ Pay Factor - 1.000

Number of Tons in the Lot TONS **1,820**

Price per Ton for Pay Adjustment COST ________ 602.9b. Sheet 15-06007-R03-23

Density Pay Adjustment DPA ________ $DPA = P_D * TONS * COST$

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Mean $\bar{X}$ **93.47** Average of $\%G_{mm}$ Values

Which Side of the Table 602-15 (602.9b. sheet 15-06007-R03-23)?

1. What is the Thickness? **1.5**

2. Is it $\geq$ 2"? ______ If "YES" then use Left Side of Table; go to Step 4, If "NO" go to step 3

3. Was there a Continuous Action? ______ If "YES" then Left Side of Table, If "NO" then Right Side of Table ______

4. Based on the Mean Density, Determine the Pay Factor to be used ______

5. Pay Factor from equation or table: ______

6. Density Pay Adjustment Factor, P_D ______ Pay Factor - 1.000

Number of Tons in the Lot	TONS	**1,820**	
Price per Ton for Pay Adjustment	COST		602.9b. Sheet 15-06007-R03-23
Density Pay Adjustment	DPA		DPA = P_D * TONS * COST

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Mean $\bar{X}$ **93.47** Average of $\%G_{mm}$ Values

Which Side of the Table 602-15 (602.9b. sheet 15-06007-R03-23)?

1. What is the Thickness? **1.5**

2. Is it $\geq$ 2"? **NO** If "YES" then use Left Side of Table; go to Step 4, If "NO" go to step 3

3. Was there a Continuous Action? ______ If "YES" then Left Side of Table, If "NO" then Right Side of Table ______

4. Based on the Mean Density, Determine the Pay Factor to be used ______

5. Pay Factor from equation or table: ______

6. Density Pay Adjustment Factor, P_D ______ Pay Factor - 1.000

Number of Tons in the Lot	TONS	**1,820**	
Price per Ton for Pay Adjustment	COST		602.9b. Sheet 15-06007-R03-23
Density Pay Adjustment	DPA		DPA = P_D * TONS * COST

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Mean	$\bar{X}$	**93.47**	Average of %G_{mm} Values

Which Side of the Table 602-15 (602.9b. sheet 15-06007-R03-23)?

1. What is the Thickness?	**1.5**		
2. Is it ≥ 2"?	**NO**	If "YES" then use Left Side of Table; go to Step 4, If "NO" go to step 3	
3. Was there a Continuous Action?	**YES**	If "YES" then Left Side of Table, If "NO" then Right Side of Table	
4. Based on the Mean Density, Determine the Pay Factor to be used			
5. Pay Factor from equation or table:			
6. Density Pay Adjustment Factor, P_D		Pay Factor - 1.000	
Number of Tons in the Lot	TONS	**1,820**	
Price per Ton for Pay Adjustment	COST		602.9b. Sheet 15-06007-R03-23
Density Pay Adjustment	DPA		DPA = P_D * TONS * COST

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Mean	$\bar{X}$	**93.47**	Average of %G_{mm} Values

Which Side of the Table 602-15 (602.9b. sheet 15-06007-R03-23)?

1. What is the Thickness?	**1.5**		
2. Is it ≥ 2"?	**NO**	If "YES" then use Left Side of Table; go to Step 4, If "NO" go to step 3	
3. Was there a Continuous Action?	**YES**	If "YES" then Left Side of Table, If "NO" then Right Side of Table	**Left**
4. Based on the Mean Density, Determine the Pay Factor to be used			
5. Pay Factor from equation or table:			
6. Density Pay Adjustment Factor, P_D		Pay Factor - 1.000	
Number of Tons in the Lot	TONS	**1,820**	
Price per Ton for Pay Adjustment	COST		602.9b. Sheet 15-06007-R03-23
Density Pay Adjustment	DPA		DPA = P_D * TONS * COST

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602.9b.
Sheet 15-06007-R03-23

b. Asphalt Density Pay Adjustment for "HMA Overlay" Bid Items. Mixes with specified thickness of less than 1½ inches are not subject to the asphalt density pay adjustments.

For mixes with specified thickness of 1½ inches or greater: Asphalt density pay adjustment for compaction of the completed pavement shall be by lot, based on the percentage of G_{mm} obtained. Compute the asphalt density pay adjustment (incentive or disincentive) by multiplying the density pay adjustment factor (P_D) times the number of tons included in the lot times $75 per ton. (Air voids lots and density lots are normally of different sizes.) This adjustment will be paid for under the bid item Asphalt Density Pay Adjustment.

Density pay factors will be determined from **TABLE 602-15**. (For **TABLE 602-15**, average the percent of G_{mm} values to 0.01% and calculate the density pay adjustment factors rounded to the thousandths).

TABLE 602-15: DENSITY PAY FACTORS FOR SPECIFIED THICKNESS[4]

Specified Thickness →	≥ 2"	≥ 1½"	
	All	Continuous Action[5]	No Continuous Action[6]
% of G_{mm} Average of 10 Density Tests[1]	Pay Factor[2]		Pay Factor[2]
94.00% or greater	1.040		1.040
93.00 to 93.99%	A1		A2
92.00 to 92.99%	1.000		A2
91.00 to 91.99%	A3		1.000
90.00 to 90.99%	A3		A4
89.00% to 89.99%	0.840 or Remove[3]		A4
less than 89.00%	0.840 or Remove[3]		0.840 or Remove[3]

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602.9b.
Sheet 15-06007-R03-23

[1]For low daily production rates less than 1000 tons, or when the Engineer's verification tests are to be used for asphalt density pay determination, the lot sample size is as determined in **TABLE 602-10**.

[2]Shoulders: For shoulders with a plan width greater than 3 feet and any shoulder not placed at the same time as the traveled way, compact the HMA in the lot to a minimum of 91.00% (if specified thickness is ≥2") or 90.00% (if the specified thickness is from 1½" to 1⅞") of the G_{mm}. Otherwise, the Engineer will determine whether the HMA in the lot may remain in place or be removed. Any such material left in place shall have a density pay factor of 0.950 or less.

[3]Low Density: The Engineer will determine if the traveled way, shoulders with a plan width of 3 feet or less and placed with the traveled way, ramps, acceleration and deceleration lanes may remain in place or be removed. The Engineer will notify the Contractor before 11:00 AM of the next working day if the area is to be removed. Any such material left in place shall have a density pay factor of 0.840.

[4]Specified thickness is the total thickness shown in the Contract Documents for the mix being placed.

[5]Use for ≥1½" when another continuous action, such as milling, surface recycling, cold recycling or overlay is completed ahead of this overlay.

[6]Use for ≥1½" when another continuous action is not completed before the overlay.

Calculations for Density Pay Factors A1, A2, A3 and A4:

A1 = [100 + 4 (% of lot G_{mm} - 93.00)] ÷ 100

A2 = [100 + 2 (% of lot G_{mm} - 92.00)] ÷ 100

A3 = [84 + 8 (% of lot G_{mm} - 90.00)] ÷ 100

A4 = [84 + 8 (% of lot G_{mm} - 89.00)] ÷ 100

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Mean	$\bar{X}$	**93.47**	Average of $\%G_{mm}$ Values

Which Side of the Table 602-15 (602.9b. sheet 15-06007-R03-23)?

1. What is the Thickness?	**1.5**		
2. Is it $\geq$ 2"?	**NO**	If "YES" then use Left Side of Table; go to Step 4, If "NO" go to step 3	
3. Was there a Continuous Action?	**YES**	If "YES" then Left Side of Table, If "NO" then Right Side of Table	**Left**
4. Based on the Mean Density, Determine the Pay Factor to be used	**A1 = [100 + 4 (%Gmm - 93.00)] ÷ 100**		
5. Pay Factor from equation or table:			
6. Density Pay Adjustment Factor, P_D		Pay Factor - 1.000	
Number of Tons in the Lot	TONS	**1,820**	
Price per Ton for Pay Adjustment	COST		602.9b. Sheet 15-06007-R03-23
Density Pay Adjustment	DPA		DPA = P_D * TONS * COST

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A1 = [100 + 4 (%Gmm – 93.00)] / 100

A1 = [100 + 4 (93.47 – 93.00)] / 100

A1 = [100 + 4 (0.47)] / 100

A1 = [100 + 1.88] / 100

A1 = [101.88] / 100

A1 = 1.019

Order of Operation

- Parenthesis
- Exponents
- Multiplication and Division
- Addition and Subtraction

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Mean	$\bar{X}$	**93.47**	Average of %G_{mm} Values	

Which Side of the Table 602-15 (602.9b. sheet 15-06007-R03-23)?

1. What is the Thickness?	**1.5**		
2. Is it ≥ 2"?	**NO**	If "YES" then use Left Side of Table; go to Step 4, If "NO" go to step 3	
3. Was there a Continuous Action?	**YES**	If "YES" then Left Side of Table, If "NO" then Right Side of Table	**Left**
4. Based on the Mean Density, Determine the Pay Factor to be used	**A1 = [100 + 4 (%Gmm - 93.00)] ÷ 100**		
5. Pay Factor from equation or table:	**1.019**		
6. Density Pay Adjustment Factor, P_D		Pay Factor - 1.000	
Number of Tons in the Lot	TONS	**1,820**	
Price per Ton for Pay Adjustment	COST		602.9b. Sheet 15-06007-R03-23
Density Pay Adjustment	DPA		DPA = P_D * TONS * COST

47

602.9b.
Sheet 15-06007-R03-23

[1]For low daily production rates less than 1000 tons, or when the Engineer's verification tests are to be used for asphalt density pay determination, the lot sample size is as determined in **TABLE 602-10**.
[2]Shoulders: For shoulders with a plan width greater than 3 feet and any shoulder not placed at the same time as the traveled way, compact the HMA in the lot to a minimum of 91.00% (if specified thickness is ≥2") or 90.00% (if the specified thickness is from 1½" to 1⅞") of the G_{mm}. Otherwise, the Engineer will determine whether the HMA in the lot may remain in place or be removed. Any such material left in place shall have a density pay factor of 0.950 or less.
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[4]Specified thickness is the total thickness shown in the Contract Documents for the mix being placed.
[5]Use for ≥1½" when another continuous action, such as milling, surface recycling, cold recycling or overlay is completed ahead of this overlay.
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Calculations for Density Pay Factors A1, A2, A3 and A4:

A1 = [100 + 4 (% of lot G_{mm} - 93.00)] ÷ 100
A2 = [100 + 2 (% of lot G_{mm} - 92.00)] ÷ 100
A3 = [84 + 8 (% of lot G_{mm} - 90.00)] ÷ 100
A4 = [84 + 8 (% of lot G_{mm} - 89.00)] ÷ 100

Density Pay Adjustment Factor Calculation:

Density Pay Adjustment Factor (P_D)* = Density Pay Factor - 1.000
*P_D rounded to the nearest thousandth

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P_D = Pay Factor - 1.000

P_D = 1.019 - 1.000

P_D = 0.019

Order of Operation

- Parenthesis
- Exponents
- Multiplication and Division
- Addition and Subtraction

49

Mean	X	**93.47**	Average of %G_{mm} Values	

Which Side of the Table 602-15 (602.9b. sheet 15-06007-R03-23)?

1. What is the Thickness?	**1.5**		
2. Is it ≥ 2"?	**NO**	If "YES" then use Left Side of Table; go to Step 4, If "NO" go to step 3	
3. Was there a Continuous Action?	**YES**	If "YES" then Left Side of Table, If "NO" then Right Side of Table	**Left**
4. Based on the Mean Density, Determine the Pay Factor to be used	**A1 = [100 + 4 (%Gmm - 93.00)] ÷ 100**		
5. Pay Factor from equation or table:	**1.019**		
6. Density Pay Adjustment Factor, P_D	**0.019**	Pay Factor - 1.000	
Number of Tons in the Lot	TONS	**1,820**	
Price per Ton for Pay Adjustment	COST		602.9b. Sheet 15-06007-R03-23
Density Pay Adjustment	DPA		DPA = P_D * TONS * COST

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602.9b.
Sheet 15-06007-R03-23

b. Asphalt Density Pay Adjustment for "HMA Overlay" Bid Items. Mixes with specified thickness of less than 1½ inches are not subject to the asphalt density pay adjustments.

For mixes with specified thickness of 1½ inches or greater: Asphalt density pay adjustment for compaction of the completed pavement shall be by lot, based on the percentage of G_{mm} obtained. Compute the asphalt density pay adjustment (incentive or disincentive) by multiplying the density pay adjustment factor (P_D) times the number of tons included in the lot times $75 per ton. (Air voids lots and density lots are normally of different sizes.) This adjustment will be paid for under the bid item Asphalt Density Pay Adjustment.

Density pay factors will be determined from **TABLE 602-15**. (For **TABLE 602-15**, average the percent of G_{mm} values to 0.01% and calculate the density pay adjustment factors rounded to the thousandths).

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Mean	X	**93.47**	Average of %G_{mm} Values	

Which Side of the Table 602-15 (602.9b. sheet 15-06007-R03-23)?

1. What is the Thickness?	**1.5**		
2. Is it ≥ 2"?	**NO**	If "YES" then use Left Side of Table; go to Step 4, If "NO" go to step 3	
3. Was there a Continuous Action?	**YES**	If "YES" then Left Side of Table, If "NO" then Right Side of Table	**Left**
4. Based on the Mean Density, Determine the Pay Factor to be used	**A1 = [100 + 4 (%Gmm - 93.00)] ÷ 100**		
5. Pay Factor from equation or table:	**1.019**		
6. Density Pay Adjustment Factor, P_D	**0.019**	Pay Factor - 1.000	

Number of Tons in the Lot	TONS	**1,820**	
Price per Ton for Pay Adjustment	COST	**$ 75.00**	602.9b. Sheet 15-06007-R03-23
Density Pay Adjustment	DPA		DPA = P_D * TONS * COST

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602.9b.
Sheet 15-06007-R03-23

b. Asphalt Density Pay Adjustment for "HMA Overlay" Bid Items. Mixes with specified thickness of less than 1½ inches are not subject to the asphalt density pay adjustments.

For mixes with specified thickness of 1½ inches or greater: Asphalt density pay adjustment for compaction of the completed pavement shall be by lot, based on the percentage of G_{mm} obtained. Compute the asphalt density pay adjustment (incentive or disincentive) by multiplying the density pay adjustment factor (P_D) times the number of tons included in the lot times $75 per ton. (Air voids lots and density lots are normally of different sizes.) This adjustment will be paid for under the bid item Asphalt Density Pay Adjustment.

Density pay factors will be determined from **TABLE 602-15**. (For **TABLE 602-15**, average the percent of G_{mm} values to 0.01% and calculate the density pay adjustment factors rounded to the thousandths).

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Density Pay Adjustment

= P_D* Tons per Lot * Cost per Ton

= 0.019 * (1,820 * $75.00)

= 0.019 * 136,500

= $ 2,593.50

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Mean	$\overline{X}$	**93.47**	Average of %G_{mm} Values

Which Side of the Table 602-15 (602.9b. sheet 15-06007-R03-23)?

1. What is the Thickness?	**1.5**		
2. Is it $\geq$ 2"?	**NO**	If "YES" then use Left Side of Table; go to Step 4, If "NO" go to step 3	
3. Was there a Continuous Action?	**YES**	If "YES" then Left Side of Table, If "NO" then Right Side of Table	**Left**
4. Based on the Mean Density, Determine the Pay Factor to be used	**A1 = [100 + 4 (%Gmm - 93.00)] ÷ 100**		
5. Pay Factor from equation or table:	**1.019**		
6. Density Pay Adjustment Factor	**0.019**	Pay Factor - 1.000	
Number of Tons in the Lot	TONS	**1,820**	
Price per Ton for Pay Adjustment, P_D	COST	**$ 75.00**	602.9b. Sheet 15-06007-R03-23
Density Pay Adjustment	DPA	**$ 2,593.50**	DPA = P_D * TONS * COST

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602.9 BASIS OF ACCEPTANCE
b. Density Pay Adjustment for "HMA Overlay"

Keys

- "HMA Overlay" bid items
- No Density Pay Adjustment for
  - Specified Thickness less than 1 ½"
  - Lots 1 and 2, unless contractor accepts the pay adjustments for Lots 1 and 2, or Lot 2 prior to mix production
- Shoulders with a width greater than 3' have:
  - Different %G_{mm} Criteria than Traveled Way
  - Have no Incentive for Density (only Disincentive)
- Know if you have a Continuous Action

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602.9 BASIS OF ACCEPTANCE

b. Density Pay Adjustment for "HMA Overlay"

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Department of Transportation

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DENSITY PAY FACTOR EXAMPLE (HMA Overlay (SR-12.5A)(PG 64-22)) (1.5" LIFT) (Lot 4)
No Continuous Action
602.9b. (Sheet 15-06007-R03-23)

Date	Test	Lift	Station	Lane	Dist from CL (ft)	Nuclear Gauge (pcf)	Maximum (Rice) Specific Gravity	% G_{mm}	Tons
8/21/2024	411	First	154+30	NB	3.4	131.3	2.385	89.45	364
8/21/2024	412	First	181+76	NB	10.8	132.8	2.385	90.46	
8/21/2024	421	First	198+65	NB	1.1	135.8	2.385	92.48	364
8/21/2024	422	First	201+62	NB	8.9	134.0	2.385	91.27	
8/21/2024	431	First	221+77	NB	2.8	131.7	2.385	89.72	364
8/21/2024	432	First	241+13	NB	4.4	132.7	2.385	90.39	
8/21/2024	441	First	258+33	NB	5.9	134.7	2.385	91.74	364
8/21/2024	442	First	272+61	NB	6.9	131.7	2.385	89.72	
8/21/2024	451	First	293+79	NB	9.9	135.7	2.385	92.41	364
8/21/2024	452	First	304+39	NB	3.1	133.1	2.385	90.66	

Mean $\overline{X}$ 90.83 Average of %G_{mm} Values

Which Side of the Table 602-15 (602.9b. sheet 15-06007-R03-23)?

1. What is the Thickness? ____________

2. Is it ≥ 2"? ____________ If "YES" then use Left Side of Table; go to Step 4, If "NO" go to step 3

3. Was there a Continuous Action? ____________ If "YES" then Left Side of Table, If "NO" then Right Side of Table ____________

4. Based on the Mean Density, Determine the Pay Factor to be used ______________________________

5. Pay Factor from equation or table: ____________

6. Density Pay Adjustment Factor, P_D ____________ Pay Factor - 1.000

Number of Tons in the Lot TONS 1,820

Price per Ton for Pay Adjustment COST ____________ 602.9b. Sheet 15-06007-R03-23

Density Pay Adjustment DPA ____________ DPA = P_D * TONS * COST

DENSITY PAY FACTOR EXAMPLE (HMA Overlay (SR-12.5A)(PG 64-22)) (1.5" LIFT) (Lot 5)
Continuous Action
602.9b. (Sheet 15-06007-R03-23)

Date	Test	Lift	Station	Lane	Dist from CL (ft)	Nuclear Gauge (pcf)	Maximum (Rice) Specific Gravity	% G_{mm}	Tons
8/21/2024	511	First	154+94	NB	8.8	139.0	2.388	94.52	364
8/21/2024	512	First	173+98	NB	3.0	137.3	2.388	93.37	
8/21/2024	521	First	193+78	NB	2.9	136.4	2.388	92.77	364
8/21/2024	522	First	205+65	NB	10.0	138.7	2.388	94.32	
8/21/2024	531	First	227+75	NB	3.5	138.9	2.388	94.45	364
8/21/2024	532	First	235+97	NB	10.3	136.4	2.388	92.77	
8/21/2024	541	First	260+15	NB	9.4	138.6	2.388	94.25	364
8/21/2024	542	First	272+59	NB	4.1	137.2	2.388	93.31	
8/21/2024	551	First	297+55	NB	5.8	136.4	2.388	92.77	364
8/21/2024	552	First	312+23	NB	5.8	135.5	2.388	92.16	

Mean $\overline{X}$ 93.47 Average of %G_{mm} Values

Which Side of the Table 602-15 (602.9b. sheet 15-06007-R03-23)?

1. What is the Thickness? ____________

2. Is it ≥ 2"? ____________ If "YES" then use Left Side of Table; go to Step 4, If "NO" go to step 3

3. Was there a Continuous Action? ____________ If "YES" then Left Side of Table, If "NO" then Right Side of Table ____________

4. Based on the Mean Density, Determine the Pay Factor to be used ____________________________

5. Pay Factor from equation or table: ____________

6. Density Pay Adjustment Factor, P_D ____________ Pay Factor - 1.000

Number of Tons in the Lot TONS 1,820

Price per Ton for Pay Adjustment COST ____________ 602.9b. Sheet 15-06007-R03-23

Density Pay Adjustment DPA ____________ $DPA = P_D * TONS * COST$

DENSITY PAY FACTOR ( ) (" LIFT) (Lot) (*HMA OVERLAY*)

Continuous Action?

602.9b. (Sheet 15-06007-R03-23)

Mean $\overline{X}$ ________ Average of %G_{mm} Values

Which Side of the Table 602-15 (602.9b. sheet 15-06007-R03-23)?

1. What is the Thickness? ________
2. Is it ≥ 2"? ________ If "YES" then use Left Side of Table; go to Step 4, If "NO" go to step 3
3. Was there a Continuous Action? ________ If "YES" then Left Side of Table, If "NO" then Right Side of Table ________
4. Based on the Mean Density, Determine the Pay Factor to be used ________________________
5. Pay Factor from equation or table: ________
6. Density Pay Adjustment Factor, P_D ________ Pay Factor - 1.000

Number of Tons in the Lot TONS ________

Price per Ton for Pay Adjustment COST ________ 602.9b. Sheet 15-06007-R03-23

Density Pay Adjustment DPA ________ DPA = P_D * TONS * COST

QC/QA Asphalt Specifications
Special Provision 15-06007-R03 Outline

602.1	Description (Sheet 1 of 30)
602.2	Contractor QC Requirements (Sheets 1 to 4 of 30)
602.3	Materials (Sheets 4 to 8 of 30)
602.4	Construction Requirements (Sheets 8 to 14 of 30)
602.5	Process Control (Sheets 14 to 17 of 30)
602.6	Compaction Testing (Sheets 17 to 19 of 30)
602.7	Weather Limitations (Sheet 19 of 30)
602.8	Mixture Acceptance (Sheets 19 to 22 of 30)
602.9	**Basis of Acceptance (Sheets 22 to 25 of 30)**
602.10	HMA Paid by the Area (Sheets 25 to 29 of 30)
602.11	Measurement and Payment (Sheets 29 to 30 of 30)

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602.9 BASIS OF ACCEPTANCE

OBJECTIVE

- Calculate pay adjustments for roadway compaction on projects with the following bid items
  - HMA Surface
  - HMA Base
  - HMA Pavement

2

602.9 BASIS OF ACCEPTANCE

c. Density Pay Adjustment for "HMA Surface", "HMA Base" and "HMA Pavement"

- By **lot**
  - Day's Paving (same mix; same lift)
  - Based on % G_{mm}
  - Average the % G_{mm} values to 0.01%
- Calculate Density Pay Adjustment Factor to 0.001
- Density Pay Adjustment

  = P_D * Tons in lot * $75 per Ton

  Where: P_D = Density Pay Adjustment Factor

3

602.9 BASIS OF ACCEPTANCE

c. Density Pay Adjustment for "HMA Surface", "HMA Base" and "HMA Pavement"

- Shoulders ≤ 3' and placed with Traveled Way - P_D of Traveled Way Applies
- P_D Does not apply to sideroads, entrances, crossovers, and other incidental surfacing
- Use KDOT's Tests to determine P_D for the Lot if F&t Fails

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602.9 BASIS OF ACCEPTANCE

c. Density Pay Adjustment for "HMA Surface", "HMA Base" and "HMA Pavement"

LOT SIZE

- Typically 10 tests
- Single Day's Placement
- Table 602-10 Defines Lot Size for Low Production Days

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602.4 CONSTRUCTION REQUIREMENTS e.(6) Density Requirements

TABLE 602-10: DAILY PRODUCTION VS NUMBER OF SUBLOTS AND TEST REQUIREMENTS			
Daily Production (tons)	**Number of Sublots**	**No. of Cores or Nuclear Density Tests****	**No. of Verification Cores or Nuclear Density Tests****
0-599	3*	6*	3*
600-999	4*	8*	4*
1000 or more	5	10	5

*Min # for mixes ≥ 1½" thick: Contractor may choose to obtain 10 tests. If so, KDOT will obtain 5 verification tests.

**For mixes < 1½" thick: Verification testing may be performed, but is not required. Additional testing may be performed by the Contractor. A minimum of 10 tests are required.

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602.9 BASIS OF ACCEPTANCE

QUALITY LEVEL ANALYSIS

KDOT Construction Manual

Section 5.2.1

Pages 12-26

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602.9 BASIS OF ACCEPTANCE

QUALITY LEVEL ANALYSIS

Definition:

A statistical procedure that provides a method for estimating the percentage of each lot of material, product, item of construction, or completed construction that may be expected within *specified tolerances.*

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602.9 BASIS OF ACCEPTANCE

PERCENT WITHIN LIMITS

Definition:

Amount of material or workmanship that has been determined by statistical method, to be within the pre-established characteristic boundary(ies)

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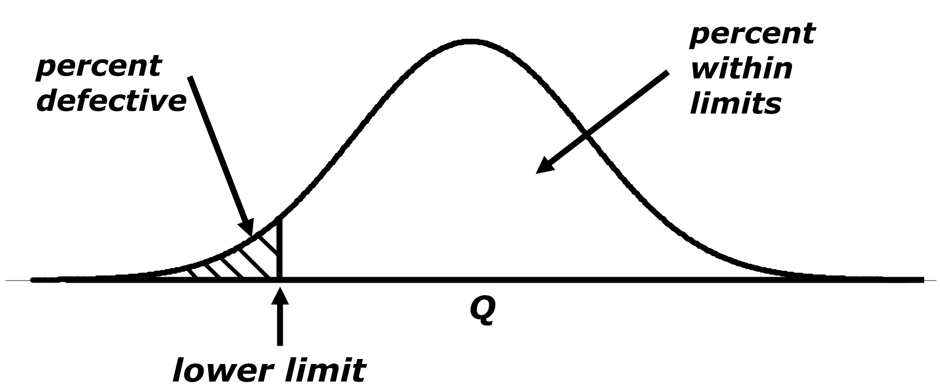
602.9 BASIS OF ACCEPTANCE
Percent Within Limits (PWL)

SINGLE-LIMIT SPECIFICATION



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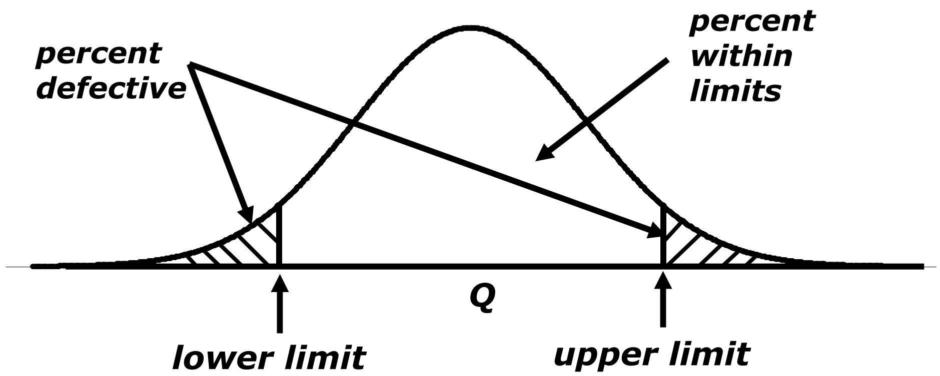
602.9 BASIS OF ACCEPTANCE
Percent Within Limits (PWL)

DOUBLE-LIMIT SPECIFICATION



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602.9 BASIS OF ACCEPTANCE

LOWER QUALITY INDEX (Q_L)

Definition:

Subtract the lower specification limit from the average and divide by the sample standard deviation

$$Q_L = \frac{(\bar{X} - LSL)}{S}$$

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602.9 BASIS OF ACCEPTANCE

UPPER QUALITY INDEX (Q_U)

Definition:

Subtract the average from the upper specification limit and divide by the sample standard deviation

$$Q_U = \frac{(USL - \bar{X})}{S}$$

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602.9 BASIS OF ACCEPTANCE

QUALITY LEVEL ANALYSIS

- PWL is determined from Table 5.2.1-2 after computing the Quality Index(es)
- If Quality Index is a negative number, the Percent Within Limits is equal to 100% - (Value looked up in Table 5.2.1-2)

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602.9 BASIS OF ACCEPTANCE

c. Density Pay Adjustment for “HMA Surface”, “HMA Base” and “HMA Pavement”

Shoulders > 3’

- LSL = 90.00% G_{mm}
- PWL ≥ 50.00%, Pay Factor (P_D) = 0
- PWL < 50.00%, then Engineer Decides:
  - Complete Removal
  - Left in Place
    - P_D of -0.050
    - P_D of a lower value (-0.100, -0.200, etc)

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602.9 BASIS OF ACCEPTANCE

c. Density Pay Adjustment for "HMA Surface", "HMA Base" and "HMA Pavement"

Determination of $\boldsymbol{P_D}$ and $\boldsymbol{PWL_{LD}}$

1. Calculate Q_{LD} using Equation 1
2. Locate Q_{LD} in left Column of PWL Table (Table 5.2.1-2)
3. Select PWL_{LD} (N=10 usually)
4. If Q_{LD} is > than largest value in Table 5.2.1-2, then PWL_{LD} = 100.00

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602.9 BASIS OF ACCEPTANCE

c. Density Pay Adjustment for "HMA Surface", "HMA Base" and "HMA Pavement"

Determination of $\boldsymbol{P_D}$ and $\boldsymbol{PWL_{LD}}$

- PWL_{LD} < 50.00%, then Engineer Decides:
  - Complete Removal
  - Left in Place
    - P_D of -0.160
    - P_D of a lower value (-0.200, -0.300, etc)
- PWL_{LD} ≥ 50.00%, then Equation 2

P_D - Rounded to nearest thousandths (0.000)

Q_{LD} - Rounded to nearest hundredths (0.00)

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602.9 BASIS OF ACCEPTANCE

c. Density Pay Adjustment for "HMA Surface", "HMA Base" and "HMA Pavement"

Equation 1: $$Q_{LD} = \frac{\overline{X} - LSL}{S}$$

$\overline{X}$ - Avg. measured $\%G_{mm}$ of all samples in a lot (rounded to 0.01)

LSL - lower specification limit for density
91.00% G_{mm} for plan thickness ≤ 2"
92.00% G_{mm} for plan thickness > 2"

S - standard deviation of the measured $\%G_{mm}$ of all samples in a lot (rounded to 0.01)

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602.9 BASIS OF ACCEPTANCE

c. Density Pay Adjustment for "HMA Surface", "HMA Base" and "HMA Pavement"

Equation 2:

$$P_D = \left(PWL_{LD} * 0.004\right) - 0.360$$

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COMPUTATION OF DENSITY PAY FACTORS

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DENSITY PAY FACTOR EXAMPLE (HMA Base (SR-19A)(PG 64-22)) (4" LIFT) (Lot 5)

602.9c. (Sheets 15-06007-R03-23 and 15-06007-R03-24)

Date	Test	Lift	Station	Lane	Dist from CL (ft)	Nuclear Gauge (pcf)	Maximum (Rice) Specific Gravity	% Gmm	Tons
5/21/2024	511	First	751+29	WB	2.6	137.6	2.385	92.69	500
5/21/2024	512	First	759+96	WB	4.4	137.8	2.385	92.83	
5/21/2024	521	First	775+33	WB	4.7	135.3	2.385	91.14	500
5/21/2024	522	First	777+53	WB	1.2	139.1	2.385	93.70	
5/21/2024	531	First	791+88	WB	3.2	138.3	2.385	93.16	500
5/21/2024	532	First	800+76	WB	1.4	137.6	2.385	92.69	
5/21/2024	541	First	808+41	WB	9.7	139.3	2.385	93.84	500
5/21/2024	542	First	816+32	WB	2.4	137.5	2.385	92.62	
5/21/2024	551	First	819+10	WB	3.2	136.9	2.385	92.22	500
5/21/2024	552	First	831+72	WB	6.5	137.5	2.385	92.62	

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Mean	$\overline{X}$	**92.75**	Average of %G_{mm} Values
Standard Deviation	S	**0.76**	Standard Deviation of %G_{mm} Values
Number of Samples	n		Number of %G_{mm} Values
Lower Specification Limit	LSL		602.9c. Sheet 15-06007-R03-24
Lower Density Quality Index	Q_{LD}		$Q_{LD} = \frac{\overline{X} - LSL}{S}$
Lower Percent Within Limits (Density)	PWL_{LD}		Table 5.2.1-2: Page 5.2.1-18
Density Pay Adjustment Factor	P_D		$P_D = (PWL_{LD} * 0.004) - 0.360$
Number of Tons in the Lot	TONS	**2,500**	
Price per Ton for Pay Adjustment	COST		602.9c. Sheet 15-06007-R03-23
Density Pay Adjustment	DPA		DPA = P_D * TONS * COST

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Mean	$\overline{X}$	**92.75**	Average of %G_{mm} Values
Standard Deviation	S	**0.76**	Standard Deviation of %G_{mm} Values
Number of Samples	n	**10**	Number of %G_{mm} Values
Lower Specification Limit	LSL		602.9c. Sheet 15-06007-R03-24
Lower Density Quality Index	Q_{LD}		$Q_{LD} = \frac{\overline{X} - LSL}{S}$
Lower Percent Within Limits (Density)	PWL_{LD}		Table 5.2.1-2: Page 5.2.1-18
Density Pay Adjustment Factor	P_D		$P_D = (PWL_{LD} * 0.004) - 0.360$
Number of Tons in the Lot	TONS	**2,500**	
Price per Ton for Pay Adjustment	COST		602.9c. Sheet 15-06007-R03-23
Density Pay Adjustment	DPA		DPA = P_D * TONS * COST

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602.9c.
Sheet 15-06007-R03-24

Determination of P_D and PWL_{LD}: Calculate the lower density quality index (Q_{LD}) for each lot using Equation 1 and round to hundredths. Locate the Q_{LD} value in the left column of the Percent Within Limits (PWL) Table in Section 5.2.1 - Statistics, Part V. Select the appropriate PWL_{LD} value by moving across the selected quality index row to the column representing the number of samples in the lot.

If Q_{LD} is greater than the largest quality index value shown in the table, use 100.00 as the value for PWL_{LD}.

If PWL_{LD} is less than 50.00% for the lot, the Engineer will determine if the material in the lot may remain in place. If the material is left in place, the value of P_D for the lot will be equal to -0.160, unless the Engineer establishes lower values for P_D (-0.200, -0.300, etc.) as a condition of leaving the material in place. Otherwise, calculate P_D using Equation 2 and round to thousandths.

Equation 1: $$Q_{LD} = \frac{\overline{X} - LSL}{S}$$

$\overline{X}$ is the average measured percent of G_{mm} of all samples within a lot rounded to hundredths.

LSL is the lower specification limit for density and is defined as 91.00% of G_{mm} for traveled way plan thickness 2 inches and less and 92.00% of G_{mm} for traveled way plan thickness greater than 2 inches.

S is the standard deviation of the measured density of all samples within a lot and is calculated using equation (4) in Section 5.2.1, Part V, rounded to hundredths.

Equation 2: $$P_D = (PWL_{LD} * 0.004) - 0.360$$

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Mean	$\overline{X}$	**92.75**	Average of %G_{mm} Values
Standard Deviation	S	**0.76**	Standard Deviation of %G_{mm} Values
Number of Samples	n	**10**	Number of %G_{mm} Values
Lower Specification Limit	LSL	**92.00**	602.9c. Sheet 15-06007-R03-24
Lower Density Quality Index	Q_{LD}		$Q_{LD} = \frac{\overline{X} - LSL}{S}$
Lower Percent Within Limits (Density)	PWL_{LD}		Table 5.2.1-2: Page 5.2.1-18
Density Pay Adjustment Factor	P_D		$P_D = (PWL_{LD} * 0.004) - 0.360$
Number of Tons in the Lot	TONS	**2,500**	
Price per Ton for Pay Adjustment	COST		602.9c. Sheet 15-06007-R03-23
Density Pay Adjustment	DPA		DPA = P_D * TONS * COST

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$$Q_{LD} = \frac{\bar{X} - LSL}{S}$$

$$Q_{LD} = \frac{92.75 - 92.00}{0.76}$$

$$Q_{LD} = \frac{0.75}{0.76}$$

$$Q_{LD} = 0.9868 = 0.99$$

Order of Operation

- Parenthesis
- Exponents
- Multiplication and Division
- Addition and Subtraction

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Mean	$\bar{X}$	**92.75**	Average of $\%G_{mm}$ Values
Standard Deviation	S	**0.76**	Standard Deviation of $\%G_{mm}$ Values
Number of Samples	n	**10**	Number of $\%G_{mm}$ Values
Lower Specification Limit	LSL	**92.00**	602.9c. Sheet 15-06007-R03-24
Lower Density Quality Index	Q_{LD}	**0.99**	$Q_{LD} = \frac{\bar{X} - LSL}{S}$
Lower Percent Within Limits (Density)	PWL_{LD}		Table 5.2.1-2: Page 5.2.1-18
Density Pay Adjustment Factor	P_D		$P_D = (PWL_{LD} * 0.004) - 0.360$
Number of Tons in the Lot	TONS	**2,500**	
Price per Ton for Pay Adjustment	COST		602.9c. Sheet 15-06007-R03-23
Density Pay Adjustment	DPA		DPA = P_D * TONS * COST

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Table 5.17.09-2 for Estimation of Lot Percent Within Limits													
Variability Unknown Procedure													
Standard Deviation Method													
Quality													
Index	Percent Within Limits for Selected Sample Sizes												
Q_U or	N=3	N=4	N=5	N=6	N=7	N=8	N=9	N=10	N=15	N=20	N=30	N=50	N=100
0.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
0.01	50.28	50.33	50.36	50.37	50.37	50.38	50.38	50.38	50.39	50.39	50.40	50.40	50.40
0.02	50.55	50.67	50.71	50.73	50.75	50.76	50.76	50.77	50.78	50.79	50.79	50.79	50.80
0.03	50.83	51.00	51.07	51.10	51.12	51.14	51.15	51.15	51.17	51.18	51.19	51.19	51.19
0.04	51.10	51.33	51.42	51.47	51.50	51.51	51.53	51.54	51.56	51.57	51.58	51.59	51.59
0.05	51.38	51.67	51.78	51.84	51.87	51.89	51.91	51.92	51.95	51.96	51.98	51.98	51.99
0.06	51.65	52.00	52.13	52.20	52.24	52.27	52.29	52.30	52.34	52.36	52.37	52.38	52.39
0.07	51.93	52.33	52.49	52.57	52.62	52.65	52.67	52.69	52.73	52.75	52.76	52.78	52.78
0.08	52.21	52.67	52.85	52.94	52.99	53.03	53.05	53.07	53.12	53.14	53.16	53.17	53.18
0.09	52.48	53.00	53.20	53.30	53.37	53.41	53.43	53.46	53.51	53.53	53.55	53.57	53.58
0.10	52.76	53.33	53.56	53.67	53.74	53.78	53.82	53.84	53.90	53.92	53.95	53.96	53.97
0.11	53.04	53.67	53.91	54.04	54.11	54.16	54.20	54.22	54.29	54.31	54.34	54.36	54.37
0.12	53.31	54.00	54.27	54.40	54.49	54.54	54.58	54.60	54.67	54.70	54.73	54.75	54.76
0.13	53.59	54.33	54.62	54.77	54.86	54.92	54.96	54.99	55.06	55.09	55.12	55.14	55.16
0.14	53.87	54.67	54.98	55.14	55.23	55.29	55.34	55.37	55.45	55.48	55.52	55.54	55.55
0.15	54.15	55.00	55.33	55.50	55.60	55.67	55.71	55.75	55.84	55.87	55.91	55.93	55.95
0.16	54.42	55.33	55.69	55.87	55.97	56.04	56.09	56.13	56.22	56.26	56.30	56.32	56.34
0.17	54.70	55.67	56.04	56.23	56.35	56.42	56.47	56.51	56.61	56.65	56.69	56.71	56.73
0.18	54.98	56.00	56.40	56.60	56.72	56.79	56.85	56.89	56.99	57.04	57.08	57.11	57.12
0.19	55.26	56.33	56.75	56.96	57.09	57.17	57.23	57.27	57.38	57.43	57.47	57.50	57.52
0.20	55.54	56.67	57.10	57.32	57.46	57.54	57.60	57.65	57.76	57.81	57.85	57.89	57.91
0.21	55.82	57.00	57.46	57.69	57.83	57.92	57.98	58.03	58.15	58.20	58.24	58.27	58.30
0.22	56.10	57.33	57.81	58.05	58.20	58.29	58.36	58.40	58.53	58.58	58.63	58.66	58.69
0.23	56.38	57.67	58.16	58.41	58.56	58.66	58.73	58.78	58.91	58.97	59.01	59.05	59.07
0.24	56.66	58.00	58.52	58.78	58.93	59.03	59.11	59.16	59.29	59.35	59.40	59.44	59.46
0.25	56.95	58.33	58.87	59.14	59.30	59.41	59.48	59.53	59.67	59.73	59.78	59.82	59.85
0.26	57.23	58.67	59.22	59.50	59.67	59.78	59.85	59.91	60.05	60.11	60.17	60.21	60.23
0.27	57.51	59.00	59.57	59.86	60.03	60.15	60.23	60.28	60.43	60.49	60.55	60.59	60.62
0.28	57.80	59.33	59.92	60.22	60.40	60.52	60.60	60.66	60.81	60.87	60.93	60.97	61.00
0.29	58.08	59.67	60.28	60.58	60.77	60.89	60.97	61.03	61.19	61.25	61.31	61.35	61.38
0.30	58.37	60.00	60.63	60.94	61.13	61.25	61.34	61.40	61.56	61.63	61.69	61.73	61.76
0.31	58.65	60.33	60.98	61.30	61.50	61.62	61.71	61.77	61.94	62.01	62.07	62.11	62.14
0.32	58.94	60.67	61.33	61.66	61.86	61.99	62.08	62.14	62.31	62.38	62.45	62.49	62.52
0.33	59.23	61.00	61.68	62.02	62.22	62.35	62.45	62.51	62.69	62.76	62.82	62.87	62.90
0.34	59.51	61.33	62.03	62.38	62.58	62.72	62.81	62.88	63.06	63.13	63.20	63.25	63.28
0.35	59.80	61.67	62.38	62.73	62.94	63.08	63.18	63.25	63.43	63.51	63.57	63.62	63.65
0.36	60.09	62.00	62.72	63.09	63.31	63.45	63.54	63.62	63.80	63.88	63.95	63.99	64.03
0.37	60.38	62.33	63.07	63.45	63.67	63.81	63.91	63.98	64.17	64.25	64.32	64.37	64.40
0.38	60.67	62.67	63.42	63.80	64.02	64.17	64.27	64.35	64.54	64.62	64.69	64.74	64.77
0.39	60.97	63.00	63.77	64.16	64.38	64.53	64.63	64.71	64.90	64.98	65.06	65.11	65.14
0.40	61.26	63.33	64.12	64.51	64.74	64.89	65.00	65.07	65.27	65.35	65.42	65.47	65.51
0.41	61.55	63.67	64.46	64.86	65.10	65.25	65.36	65.43	65.63	65.72	65.79	65.84	65.88
0.42	61.85	64.00	64.81	65.21	65.45	65.61	65.71	65.79	66.00	66.08	66.15	66.21	66.24
0.43	62.15	64.33	65.15	65.57	65.81	65.96	66.07	66.15	66.36	66.44	66.52	66.57	66.61
0.44	62.44	64.67	65.50	65.92	66.16	66.32	66.43	66.51	66.72	66.80	66.88	66.93	66.97
0.45	62.74	65.00	65.84	66.27	66.51	66.67	66.79	66.87	67.08	67.16	67.24	67.29	67.33

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Q_U or Q_L	N=3	N=4	N=5	N=6	N=7	N=8	N=9	N=10	N=15
0.90	78.45	80.00	80.62	80.93	81.10	81.21	81.28	81.33	81.46
0.91	78.89	80.33	80.93	81.22	81.39	81.49	81.56	81.61	81.73
0.92	79.34	80.67	81.23	81.51	81.67	81.77	81.84	81.89	82.00
0.93	79.81	81.00	81.54	81.81	81.96	82.05	82.12	82.16	82.27
0.94	80.27	81.33	81.84	82.10	82.24	82.33	82.39	82.44	82.54
0.95	80.75	81.67	82.14	82.39	82.52	82.61	82.67	82.71	82.80
0.96	81.25	82.00	82.45	82.67	82.80	82.88	82.94	82.97	83.06
0.97	81.75	82.33	82.75	82.96	83.08	83.15	83.21	83.24	83.32
0.98	82.26	82.67	83.04	83.24	83.35	83.43	83.47	83.51	83.58
0.99	82.79	83.00	83.34	83.52	83.63	83.69	83.74	$\boxed{83.77}$	83.84
1.00	83.33	83.33	83.64	83.80	83.90	83.96	84.00	84.03	84.09
1.01	83.89	83.67	83.93	84.08	84.17	84.22	84.26	84.28	84.34
1.02	84.47	84.00	84.22	84.36	84.44	84.49	84.52	84.54	84.59

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Mean	$\overline{X}$	**92.75**	Average of %G_{mm} Values
Standard Deviation	S	**0.76**	Standard Deviation of %G_{mm} Values
Number of Samples	n	**10**	Number of %G_{mm} Values
Lower Specification Limit	LSL	**92.00**	602.9c. Sheet 15-06007-R03-24
Lower Density Quality Index	Q_{LD}	**0.99**	$Q_{LD} = \frac{\overline{X} - LSL}{S}$
Lower Percent Within Limits (Density)	PWL_{LD}	**83.77**	Table 5.2.1-2: Page 5.2.1-18
Density Pay Adjustment Factor	P_D		$P_D = (PWL_{LD} * 0.004) - 0.360$
Number of Tons in the Lot	TONS	**2,500**	
Price per Ton for Pay Adjustment	COST		602.9c. Sheet 15-06007-R03-23
Density Pay Adjustment	DPA		DPA = P_D * TONS * COST

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602.9c.
Sheet 15-06007-R03-24

Equation 1: $Q_{LD} = \frac{X - LSL}{S}$

$\overline{X}$ is the average measured percent of G_{mm} of all samples within a lot rounded to hundredths.
LSL is the lower specification limit for density and is defined as 91.00% of G_{mm} for traveled way plan thickness 2 inches and less and 92.00% of G_{mm} for traveled way plan thickness greater than 2 inches.
S is the standard deviation of the measured density of all samples within a lot and is calculated using equation (4) in Section 5.2.1, Part V, rounded to hundredths.

Equation 2: $P_D = (PWL_{LD} * 0.004) - 0.360$

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$$P_D = (PWL_{LD} * 0.004) – 0.360$$

$$P_D = (83.77 * 0.004) – 0.360$$

$$P_D = (0.3351) – 0.360$$

$$P_D = -0.02492 = -0.025$$

Order of Operation

- Parenthesis
- Exponents
- Multiplication and Division
- Addition and Subtraction

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Mean	$\overline{X}$	**92.75**	Average of %G_{mm} Values
Standard Deviation	S	**0.76**	Standard Deviation of %G_{mm} Values
Number of Samples	n	**10**	Number of %G_{mm} Values
Lower Specification Limit	LSL	**92.00**	602.9c. Sheet 15-06007-R03-24
Lower Density Quality Index	Q_{LD}	**0.99**	$Q_{LD} = \frac{\overline{X} - LSL}{S}$
Lower Percent Within Limits (Density)	PWL_{LD}	**83.77**	Table 5.2.1-2: Page 5.2.1-18
Density Pay Adjustment Factor	P_D	**-0.025**	$P_D = (PWL_{LD} * 0.004) - 0.360$
Number of Tons in the Lot	TONS	**2,500**	
Price per Ton for Pay Adjustment	COST		602.9c. Sheet 15-06007-R03-23
Density Pay Adjustment	DPA		DPA = P_D * TONS * COST

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602.9c.
Sheet 15-06007-R03-23

c. Asphalt Density Pay Adjustment for "HMA Surface", "HMA Base" and "HMA Pavement" Bid Items. Asphalt Density Pay Adjustment for compaction of the completed pavement shall be by lot, based on the percentage of G_{mm} obtained. This adjustment will be paid for under the bid item Asphalt Density Pay Adjustment. Compute the Asphalt Density Pay Adjustment (positive or negative) by multiplying the Density Pay Adjustment factor (***P_D***) times the number of tons included in the lot times $75 per ton. The Asphalt Density Pay Adjustment will be added or subtracted on the pay estimate. For shoulders with a plan width of less than or equal to 3 feet, and placed at the same time as the traveled way, the ***P_D*** for the traveled way will apply. The ***P_D*** does not apply to sideroads, entrances, crossovers and other incidental surfacing. Use KDOT test results for the lot to determine the ***P_D*** when the statistical comparison between the quality control and the verification tests fail (see **subsection 602.9a.**).

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Mean	$\overline{X}$	**92.75**	Average of %G_{mm} Values
Standard Deviation	S	**0.76**	Standard Deviation of %G_{mm} Values
Number of Samples	n	**10**	Number of %G_{mm} Values
Lower Specification Limit	LSL	**92.00**	602.9c. Sheet 15-06007-R03-24
Lower Density Quality Index	Q_{LD}	**0.99**	$Q_{LD} = \frac{\overline{X} - LSL}{S}$
Lower Percent Within Limits (Density)	PWL_{LD}	**83.77**	Table 5.2.1-2: Page 5.2.1-18
Density Pay Adjustment Factor	P_D	**-0.025**	$P_D = (PWL_{LD} * 0.004) - 0.360$
Number of Tons in the Lot	TONS	**2,500**	
Price per Ton for Pay Adjustment	COST	**$ 75.00**	602.9c. Sheet 15-06007-R03-23
Density Pay Adjustment	DPA		DPA = P_D * TONS * COST

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602.9c.
Sheet 15-06007-R03-23

c. Asphalt Density Pay Adjustment for "HMA Surface", "HMA Base" and "HMA Pavement" Bid Items. Asphalt Density Pay Adjustment for compaction of the completed pavement shall be by lot, based on the percentage of G_{mm} obtained. This adjustment will be paid for under the bid item Asphalt Density Pay Adjustment. Compute the Asphalt Density Pay Adjustment (positive or negative) by multiplying the Density Pay Adjustment factor (***P***P_D) times the number of tons included in the lot times $75 per ton. The Asphalt Density Pay Adjustment will be added or subtracted on the pay estimate. For shoulders with a plan width of less than or equal to 3 feet, and placed at the same time as the traveled way, the P_D for the traveled way will apply. The P_D does not apply to sideroads, entrances, crossovers and other incidental surfacing. Use KDOT test results for the lot to determine the P_D when the statistical comparison between the quality control and the verification tests fail (see **subsection 602.9a.**).

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Density Pay Adjustment

= P_D* Tons per Lot * Cost per Ton

= -0.025 * (2,500 * $75.00)

= -0.025 * 187,500

= -$ 4,687.50 or $(4,687.50)

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Mean	$\overline{X}$	**92.75**	Average of %G_{mm} Values
Standard Deviation	S	**0.76**	Standard Deviation of %G_{mm} Values
Number of Samples	n	**10**	Number of %G_{mm} Values
Lower Specification Limit	LSL	**92.00**	602.9c. Sheet 15-06007-R03-24
Lower Density Quality Index	Q_{LD}	**0.99**	$Q_{LD} = \frac{\overline{X} - LSL}{S}$
Lower Percent Within Limits (Density)	PWL_{LD}	**83.77**	Table 5.2.1-2: Page 5.2.1-18
Density Pay Adjustment Factor	P_D	**-0.025**	$P_D = (PWL_{LD} * 0.004) - 0.360$
Number of Tons in the Lot	TONS	**2,500**	
Price per Ton for Pay Adjustment	COST	**$ 75.00**	602.9c. Sheet 15-06007-R03-23
Density Pay Adjustment	DPA	**$ -4687.50**	DPA = P_D * TONS * COST

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DENSITY PAY FACTOR EXAMPLE (HMA Surface (SR-9.5A)(PG 64-28)) (1.5" LIFT) (Lot 6)

602.9c. (Sheets 15-06007-R03-23 and 15-06007-R03-24)

Date	Test	Lift	Station	Lane	Dist from CL (ft)	Nuclear Gauge (pcf)	Maximum (Rice) Specific Gravity	% Gmm	Tons
6/18/2024	611	First	648+15	WB	3.2	136.4	2.379	92.11	225
6/18/2024	612	First	660+57	WB	9.9	138.7	2.379	93.67	
6/18/2024	621	First	669+16	WB	6.6	135.8	2.379	91.71	225
6/18/2024	622	First	675+94	WB	8.9	137.8	2.379	93.06	
6/18/2024	631	First	686+09	WB	3.3	138.2	2.379	93.33	225
6/18/2024	632	First	694+85	WB	5.0	138.5	2.379	93.53	
6/18/2024	641	First	697+34	WB	5.7	137.1	2.379	92.59	225
6/18/2024	642	First	705+75	WB	3.5	136.5	2.379	92.18	
6/18/2024	651	First	716+55	WB	9.4	137.5	2.379	92.86	225
6/18/2024	652	First	729+59	WB	8.9	137.9	2.379	93.13	

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Mean	$\overline{X}$	**92.82**	Average of %G_{mm} Values
Standard Deviation	S	**0.65**	Standard Deviation of %G_{mm} Values
Number of Samples	n		Number of %G_{mm} Values
Lower Specification Limit	LSL		602.9c. Sheet 15-06007-R03-24
Lower Density Quality Index	Q_{LD}		$Q_{LD} = \frac{\overline{X} - LSL}{S}$
Lower Percent Within Limits (Density)	PWL_{LD}		Table 5.2.1-2: Page 5.2.1-18
Density Pay Adjustment Factor	P_D		$P_D = (PWL_{LD} * 0.004) - 0.360$
Number of Tons in the Lot	TONS	**1,125**	
Price per Ton for Pay Adjustment	COST		602.9c. Sheet 15-06007-R03-23
Density Pay Adjustment	DPA		DPA = P_D * TONS * COST

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Mean	$\overline{X}$	**92.82**	Average of %G_{mm} Values
Standard Deviation	S	**0.65**	Standard Deviation of %G_{mm} Values
Number of Samples	n	**10**	Number of %G_{mm} Values
Lower Specification Limit	LSL		602.9c. Sheet 15-06007-R03-24
Lower Density Quality Index	Q_{LD}		$Q_{LD} = \frac{\overline{X} - LSL}{S}$
Lower Percent Within Limits (Density)	PWL_{LD}		Table 5.2.1-2: Page 5.2.1-18
Density Pay Adjustment Factor	P_D		$P_D = (PWL_{LD} * 0.004) - 0.360$
Number of Tons in the Lot	TONS	**1,125**	
Price per Ton for Pay Adjustment	COST		602.9c. Sheet 15-06007-R03-23
Density Pay Adjustment	DPA		DPA = P_D * TONS * COST

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602.9c.
Sheet 15-06007-R03-23

Determination of P_D and PWL_{LD}: Calculate the lower density quality index (Q_{LD}) for each lot using Equation 1 and round to hundredths. Locate the Q_{LD} value in the left column of the Percent Within Limits (PWL) Table in Section 5.2.1 - Statistics, Part V. Select the appropriate PWL_{LD} value by moving across the selected quality index row to the column representing the number of samples in the lot.

If Q_{LD} is greater than the largest quality index value shown in the table, use 100.00 as the value for PWL_{LD}.

If PWL_{LD} is less than 50.00% for the lot, the Engineer will determine if the material in the lot may remain in place. If the material is left in place, the value of P_D for the lot will be equal to -0.160, unless the Engineer establishes lower values for P_D (-0.200, -0.300, etc.) as a condition of leaving the material in place. Otherwise, calculate P_D using Equation 2 and round to thousandths.

Equation 1: $$Q_{LD} = \frac{\overline{X} - LSL}{S}$$

$\overline{X}$ is the average measured percent of G_{mm} of all samples within a lot rounded to hundredths.

LSL is the lower specification limit for density and is defined as 91.00% of G_{mm} for traveled way plan thickness 2 inches and less and 92.00% of G_{mm} for traveled way plan thickness greater than 2 inches.

S is the standard deviation of the measured density of all samples within a lot and is calculated using equation (4) in Section 5.2.1, Part V, rounded to hundredths.

Equation 2: $$P_D = (PWL_{LD} * 0.004) - 0.360$$

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Mean	$\overline{X}$	**92.82**	Average of %G_{mm} Values
Standard Deviation	S	**0.65**	Standard Deviation of %G_{mm} Values
Number of Samples	n	**10**	Number of %G_{mm} Values
Lower Specification Limit	LSL	**91.00**	602.9c. Sheet 15-06007-R03-24
Lower Density Quality Index	Q_{LD}		$Q_{LD} = \frac{\overline{X} - LSL}{S}$
Lower Percent Within Limits (Density)	PWL_{LD}		Table 5.2.1-2: Page 5.2.1-18
Density Pay Adjustment Factor	P_D		$P_D = (PWL_{LD} * 0.004) - 0.360$
Number of Tons in the Lot	TONS	**1,125**	
Price per Ton for Pay Adjustment	COST		602.9c. Sheet 15-06007-R03-23
Density Pay Adjustment	DPA		DPA = P_D * TONS * COST

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$$Q_{LD} = \frac{\overline{X} - LSL}{S}$$

$$Q_{LD} = \frac{92.82 - 91.00}{0.65}$$

$$Q_{LD} = \frac{1.82}{0.65}$$

$$Q_{LD} = 2.80$$

Order of Operation

- Parenthesis
- Exponents
- Multiplication and Division
- Addition and Subtraction

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Mean	$\overline{X}$	**92.82**	Average of %G_{mm} Values
Standard Deviation	S	**0.65**	Standard Deviation of %G_{mm} Values
Number of Samples	n	**10**	Number of %G_{mm} Values
Lower Specification Limit	LSL	**91.00**	602.9c. Sheet 15-06007-R03-24
Lower Density Quality Index	Q_{LD}	**2.80**	$Q_{LD} = \frac{\overline{X} - LSL}{S}$
Lower Percent Within Limits (Density)	PWL_{LD}		Table 5.2.1-2: Page 5.2.1-18
Density Pay Adjustment Factor	P_D		$P_D = (PWL_{LD} * 0.004) - 0.360$
Number of Tons in the Lot	TONS	**1,125**	
Price per Ton for Pay Adjustment	COST		602.9c. Sheet 15-06007-R03-23
Density Pay Adjustment	DPA		DPA = P_D * TONS * COST

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Q_U or Q_L	N=3	N=4	N=5	N=6	N=7	N=8	N=9	N=10	N=15
2.71	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.94
2.72	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.94
2.73	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.94
2.74	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.95
2.75	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.95
2.76	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.95
2.77	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.96
2.78	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.96
2.79	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.96
2.80	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.97
2.81	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.97
2.82	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.97
2.83	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.97

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Mean	$\overline{X}$	**92.82**	Average of $\%G_{mm}$ Values
Standard Deviation	S	**0.65**	Standard Deviation of $\%G_{mm}$ Values
Number of Samples	n	**10**	Number of $\%G_{mm}$ Values
Lower Specification Limit	LSL	**91.00**	602.9c. Sheet 15-06007-R03-24
Lower Density Quality Index	Q_{LD}	**2.80**	$Q_{LD} = \frac{\overline{X} - LSL}{S}$
Lower Percent Within Limits (Density)	PWL_{LD}	**100.00**	Table 5.2.1-2: Page 5.2.1-18
Density Pay Adjustment Factor	P_D		$P_D = (PWL_{LD} * 0.004) - 0.360$
Number of Tons in the Lot	TONS	**1,125**	
Price per Ton for Pay Adjustment	COST		602.9c. Sheet 15-06007-R03-23
Density Pay Adjustment	DPA		DPA = P_D * TONS * COST

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602.9c.
Sheet 15-06007-R03-24

Equation 1: $$Q_{LD} = \frac{\bar{X} - LSL}{S}$$

$\bar{X}$ is the average measured percent of G_{mm} of all samples within a lot rounded to hundredths.
LSL is the lower specification limit for density and is defined as 91.00% of G_{mm} for traveled way plan thickness 2 inches and less and 92.00% of G_{mm} for traveled way plan thickness greater than 2 inches.
S is the standard deviation of the measured density of all samples within a lot and is calculated using equation (4) in Section 5.2.1, Part V, rounded to hundredths.

Equation 2: $$P_D = (PWL_{LD} * 0.004) - 0.360$$

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$$P_D = (PWL_{LD} * 0.004) - 0.360$$

$$P_D = (100.00 * 0.004) - 0.360$$

$$P_D = (0.400) - 0.360$$

$$P_D = 0.040$$

Order of Operation

- Parenthesis
- Exponents
- Multiplication and Division
- Addition and Subtraction

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Mean	$\overline{X}$	**92.82**	Average of %G_{mm} Values
Standard Deviation	S	**0.65**	Standard Deviation of %G_{mm} Values
Number of Samples	n	**10**	Number of %G_{mm} Values
Lower Specification Limit	LSL	**91.00**	602.9c. Sheet 15-06007-R03-24
Lower Density Quality Index	Q_{LD}	**2.80**	$Q_{LD} = \frac{\overline{X} - LSL}{S}$
Lower Percent Within Limits (Density)	PWL_{LD}	**100.00**	Table 5.2.1-2: Page 5.2.1-18
Density Pay Adjustment Factor	P_D	**0.040**	$P_D = (PWL_{LD} * 0.004) - 0.360$
Number of Tons in the Lot	TONS	**1,125**	
Price per Ton for Pay Adjustment	COST		602.9c. Sheet 15-06007-R03-23
Density Pay Adjustment	DPA		DPA = P_D * TONS * COST

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602.9c.
Sheet 15-06007-R03-23

c. Asphalt Density Pay Adjustment for "HMA Surface", "HMA Base" and "HMA Pavement" Bid Items. Asphalt Density Pay Adjustment for compaction of the completed pavement shall be by lot, based on the percentage of G_{mm} obtained. This adjustment will be paid for under the bid item Asphalt Density Pay Adjustment. Compute the Asphalt Density Pay Adjustment (positive or negative) by multiplying the Density Pay Adjustment factor (***P**$_D$*) times the number of tons included in the lot times $75 per ton. The Asphalt Density Pay Adjustment will be added or subtracted on the pay estimate. For shoulders with a plan width of less than or equal to 3 feet, and placed at the same time as the traveled way, the P_D for the traveled way will apply. The P_D does not apply to sideroads, entrances, crossovers and other incidental surfacing. Use KDOT test results for the lot to determine the P_D when the statistical comparison between the quality control and the verification tests fail (see **subsection 602.9a.**).

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Mean	$\overline{X}$	92.82	Average of %G_{mm} Values
Standard Deviation	S	0.65	Standard Deviation of %G_{mm} Values
Number of Samples	n	10	Number of %G_{mm} Values
Lower Specification Limit	LSL	91.00	602.9c. Sheet 15-06007-R03-24
Lower Density Quality Index	Q_{LD}	2.80	$Q_{LD} = \frac{\overline{X} - LSL}{S}$
Lower Percent Within Limits (Density)	PWL_{LD}	100.00	Table 5.2.1-2: Page 5.2.1-18
Density Pay Adjustment Factor	P_D	0.040	$P_D = (PWL_{LD} * 0.004) - 0.360$
Number of Tons in the Lot	TONS	1,125	
Price per Ton for Pay Adjustment	COST	$ 75.00	602.9c. Sheet 15-06007-R03-23
Density Pay Adjustment	DPA		DPA = P_D * TONS * COST

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602.9c. Sheet 15-06007-R03-23

c. Asphalt Density Pay Adjustment for "HMA Surface", "HMA Base" and "HMA Pavement" Bid Items. Asphalt Density Pay Adjustment for compaction of the completed pavement shall be by lot, based on the percentage of G_{mm} obtained. This adjustment will be paid for under the bid item Asphalt Density Pay Adjustment. Compute the Asphalt Density Pay Adjustment (positive or negative) by multiplying the Density Pay Adjustment factor (***P_D***) times the number of tons included in the lot times $75 per ton. The Asphalt Density Pay Adjustment will be added or subtracted on the pay estimate. For shoulders with a plan width of less than or equal to 3 feet, and placed at the same time as the traveled way, the ***P_D*** for the traveled way will apply. The ***P_D*** does not apply to sideroads, entrances, crossovers and other incidental surfacing. Use KDOT test results for the lot to determine the ***P_D*** when the statistical comparison between the quality control and the verification tests fail (see **subsection 602.9a.**).

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Density Pay Adjustment

$= P_D$ * Tons per Lot * Cost per Ton

= 0.040 * (1,125 * $75.00)

= 0.040 * 84,375

= $ 3,375.00

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Mean	$\overline{X}$	**92.82**	Average of %G_{mm} Values
Standard Deviation	S	**0.65**	Standard Deviation of %G_{mm} Values
Number of Samples	n	**10**	Number of %G_{mm} Values
Lower Specification Limit	LSL	**91.00**	602.9c. Sheet 15-06007-R03-24
Lower Density Quality Index	Q_{LD}	**2.80**	$Q_{LD} = \frac{\overline{X} - LSL}{S}$
Lower Percent Within Limits (Density)	PWL_{LD}	**100.00**	Table 5.2.1-2: Page 5.2.1-18
Density Pay Adjustment Factor	P_D	**0.040**	$P_D = (PWL_{LD} * 0.004) - 0.360$
Number of Tons in the Lot	TONS	**1,125**	
Price per Ton for Pay Adjustment	COST	**$ 75.00**	602.9c. Sheet 15-06007-R03-23
Density Pay Adjustment	DPA	**$ 3,375.00**	DPA = P_D * TONS * COST

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602.9 BASIS OF ACCEPTANCE

c. Density Pay Adjustment for “HMA Surface”, “HMA Base” and “HMA Pavement”

- Keys
  - “HMA Surface,” “HMA Base,” and “HMA Pavement” bid items
  - No Density Pay Adjustment for Lots 1 and 2
    - Contractor may accept density pay adjustments for Lots 1 & 2, or Lot 2 if specified before production.
  - LSL varies
    - 91.00% G_{mm} for travelway plan thickness 2” and less
    - 92.00% G_{mm} for travelway plan thickness greater than 2”
    - 90.00% of G_{mm} for shoulders
  - Shoulders have no Incentive for Density (only Disincentive)

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602.9 BASIS OF ACCEPTANCE

c. Density Pay Adjustment for “HMA Surface”, “HMA Base” and “HMA Pavement”

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THICKNESS PAY FACTOR (*HMA PAVEMENT*)
602.10 (Sheets 15-06007-R03-25 to 15-06007-R03-29)

Mean	$\overline{X}$	______	Average of Core Lengths
Standard Deviation	S	______	Standard Deviation of Core Lengths
Number of Samples	n	______	Number of Cores
Plan Thickness	in	______	Typical Section
Amount to Subtract from Plan Thickness to get LSL	Adj	______	602.10f: Sheet 15-06007-R03-28 (DL = 0.5" : SH = 0.8")
Lower Specification Limit	LSL	______	(Plan Thickness - Adjustment)
Lower Thickness Quality Index	Q_T	______	$Q_T = \frac{\overline{X} - LSL}{S}$
Lower Percent Within Limits (Thickness)	PWL_T	______	Table 5.2.1-2: Page 5.2.1-18
Thickness Pay Factor	P_T	______	$P_T = \left(\frac{(PWL_T)*0.3}{100}\right) - 0.270$
Pay Driving Lane Area in Lot	yd^2	______	$\sum$PDLA or $\sum$PSA
Price Adjustment per inch	$	______	$3.50 for Driving Lane: $3.20 for Shoulder
Thickness Pay Adjustment per Lot	TPA	______	TPA = P_T ($\sum$P**)($)(Plan Thickness)

DENSITY PAY FACTOR EXAMPLE (HMA Base (SR-19A)(PG 64-22)) (4" LIFT) (Lot 5)
602.9c. (Sheets 15-06007-R01-22 and 15-06007-R01-23)

Date	Test	Lift	Station	Lane	Dist from CL (ft)	Nuclear Gauge (pcf)	Maximum (Rice) Specific Gravity	% Gmm	Tons
5/21/2024	511	First	751+29	WB	2.6	137.6	2.385	92.69	500
5/21/2024	512	First	759+96	WB	4.4	137.8	2.385	92.83	
5/21/2024	521	First	775+33	WB	4.7	135.3	2.385	91.14	500
5/21/2024	522	First	777+53	WB	1.2	139.1	2.385	93.70	
5/21/2024	531	First	791+88	WB	3.2	138.3	2.385	93.16	500
5/21/2024	532	First	800+76	WB	1.4	137.6	2.385	92.69	
5/21/2024	541	First	808+41	WB	9.7	139.3	2.385	93.84	500
5/21/2024	542	First	816+32	WB	2.4	137.5	2.385	92.62	
5/21/2024	551	First	819+10	WB	3.2	136.9	2.385	92.22	500
5/21/2024	552	First	831+72	WB	6.5	137.5	2.385	92.62	

Mean	$\overline{X}$	92.75	Average of %G_{mm} Values
Standard Deviation	S	0.76	Standard Deviation of %G_{mm} Values
Number of Samples	n		Number of %G_{mm} Values
Lower Specification Limit	LSL		602.9c. Sheet 15-06007-R01-23
Lower Density Quality Index	Q_{LD}		$Q_{LD} = \frac{\overline{X} - LSL}{S}$
Lower Percent Within Limits (Densit	PWL_{LD}		Table 5.2.1-2: Page 5.2.1-18
Density Pay Adjustment Factor	P_D		$P_D = (PWL_{LD} * 0.004) - 0.360$
Number of Tons in the Lot	TONS	2,500	
Price per Ton for Pay Adjustment	COST		602.9c. Sheet 15-06007-R01-22
Density Pay Adjustment	DPA		DPA = P_D * TONS * COST

DENSITY PAY FACTOR EXAMPLE (HMA Surface (SM-9.5A)(PG 64-28)) (1.5" LIFT) (Lot 6)
602.9c. (Sheets 15-06007-R01-22 and 15-06007-R01-23)

Date	Test	Lift	Station	Lane	Dist from CL (ft)	Nuclear Gauge (pcf)	Maximum (Rice) Specific Gravity	% Gmm	Tons
6/18/2024	611	First	648+15	WB	3.2	136.4	2.379	92.11	225
6/18/2024	612	First	660+57	WB	9.9	138.7	2.379	93.67	
6/18/2024	621	First	669+16	WB	6.6	135.8	2.379	91.71	225
6/18/2024	622	First	675+94	WB	8.9	137.8	2.379	93.06	
6/18/2024	631	First	686+09	WB	3.3	138.2	2.379	93.33	225
6/18/2024	632	First	694+85	WB	5.0	138.5	2.379	93.53	
6/18/2024	641	First	697+34	WB	5.7	137.1	2.379	92.59	225
6/18/2024	642	First	705+75	WB	3.5	136.5	2.379	92.18	
6/18/2024	651	First	716+55	WB	9.4	137.5	2.379	92.86	225
6/18/2024	652	First	729+59	WB	8.9	137.9	2.379	93.13	

Mean	$\overline{X}$	92.82	Average of %G_{mm} Values
Standard Deviation	S	0.65	Standard Deviation of %G_{mm} Values
Number of Samples	n		Number of %G_{mm} Values
Lower Specification Limit	LSL		602.9c. Sheet 15-06007-R01-23
Lower Density Quality Index	Q_{LD}		$Q_{LD} = \frac{\overline{X} - LSL}{S}$
Lower Percent Within Limits (Densit	PWL_{LD}		Table 5.2.1-2: Page 5.2.1-18
Density Pay Adjustment Factor	P_D		$P_D = (PWL_{LD} * 0.004) - 0.360$
Number of Tons in the Lot	TONS	1,125	
Price per Ton for Pay Adjustment	COST		602.9c. Sheet 15-06007-R01-22
Density Pay Adjustment	DPA		DPA = P_D * TONS * COST

DENSITY PAY FACTOR ( ) (" LIFT) (Lot) (*HMA SURFACE & HMA BASE*)

602.9c. (Sheets 15-06007-R03-23 and 15-06007-R03-24)

Mean	$\overline{X}$	________	Average of $\%G_{mm}$ Values
Standard Deviation	S	________	Standard Deviation of $\%G_{mm}$
Number of Samples	n	________	Number of $\%G_{mm}$ Values
Lower Specification Limit	LSL	________	602.9c. Sheet 15-06007-R03-24
Lower Density Quality Index	Q_{LD}	________	$Q_{LD} = \dfrac{\overline{X} - LSL}{S}$
Lower Percent Within Limits (Density)	PWL_{LD}	________	Table 5.2.1-2: Page 5.2.1-18
Density Pay Adjustment Factor	P_D	________	$P_D = (PWL_{LD} * 0.004) - 0.360$
Number of Tons in the Lot	TONS	________	
Price per Ton for Pay Adjustment	COST	________	602.9c. Sheet 15-06007-R03-23
Density Pay Adjustment	DPA	________	DPA = P_D * TONS * COST

QC/QA Asphalt Specifications Special Provision 15-06007-R03 Outline

602.1 Description (Sheet 1 of 30)
602.2 Contractor QC Requirements (Sheets 1 to 4 of 30)
602.3 Materials (Sheets 4 to 8 of 30)
602.4 Construction Requirements (Sheets 8 to 14 of 30)
602.5 Process Control (Sheets 14 to 17 of 30)
602.6 Compaction Testing (Sheets 17 to 19 of 30)
602.7 Weather Limitations (Sheet 19 of 30)
602.8 Mixture Acceptance (Sheets 19 to 22 of 30)
602.9 Basis of Acceptance (Sheets 22 to 25 of 30)
602.10 HMA Paid by the Area (Sheets 25 to 29 of 30)
602.11 Measurement and Payment (Sheets 29 to 30 of 30)

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602.9 BASIS OF ACCEPTANCE

OBJECTIVE

- Calculate pay adjustments for air voids – same for all HMA bid items, mainline and shoulder
  - HMA Overlay
  - HMA Surface
  - HMA Base
  - HMA Pavement

2

602.9 BASIS OF ACCEPTANCE
d. Air Void Pay Adjustment

- By **lot**
  - 4 Contiguous V_a Tests (same mix design and plant)
  - Measured V_a of plant produced material
- Calculate Air Voids Pay Adjustment Factor to 0.001
- Air Void Pay Adjustment

  = P_V * Tons in lot * $75 per Ton

  Where: P_V = Air Voids Pay Adjustment Factor
- Two Scenarios
  - Passing "t" test – Use Paragraph **602.9d(1)**
  - Failing "t" test – Use Paragraph **602.9d(2)**

3

602.9 BASIS OF ACCEPTANCE
d. Air Void Pay Adjustment

Lot Size Defined: 602.8f, 602.8g & 602.8h

- Normal Lot
  - 4 contiguous individual air void tests
  - Tests performed on Superpave gyratory compacted samples of a given mix design
- Abnormal Lots
  - When 1 or 2 tests remain, combine with previous 4 tests
  - When 3 tests remain, combine the 3 tests into a lot.

4

602.8 MIXTURE ACCEPTANCE

(f) Lot Size = 3,000 tons

- 4 Equal Sublots
- 750 tons per sublot
- Contractor may redefine with Engineer's concurrence
  - Change in quantities
  - Interruption of Work

(g) Increased Lot Size

- 4,000 Tons (4-1,000 Ton Sublots)
  - Produce 8 consecutive sublots
    - Mix meets Table 602-12 Tolerances
    - No Air Void Penalty
    - Plant Production Rate > 250 tons/Hr
    - Notification of Engineer

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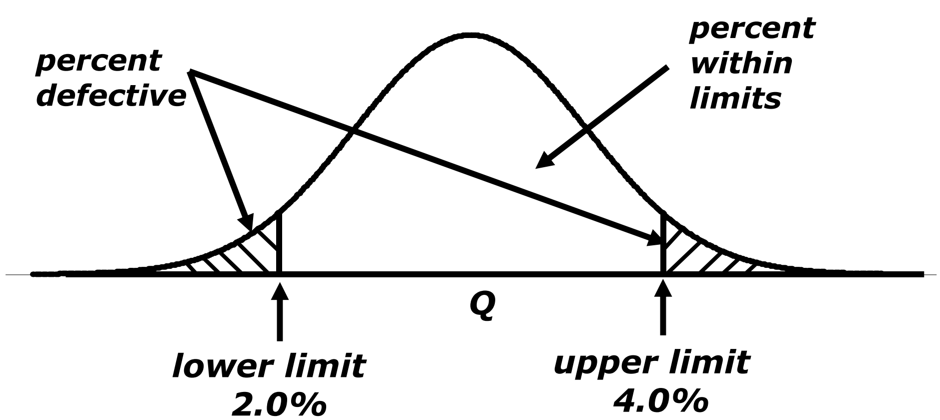
602.9 BASIS OF ACCEPTANCE Percent Within Limits (PWL)

DOUBLE-LIMIT SPECIFICATION



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602.9 BASIS OF ACCEPTANCE
d.(1) Air Void Pay Adjustment (Passing t-Test)

Equation 3

$$Q_{UV} = \frac{USL - \overline{X}}{S}$$

USL = 4.00%

Equation 4

$$Q_{LV} = \frac{\overline{X} - LSL}{S}$$

LSL = 2.00%

$\overline{X}$ - Mean of Air Voids in Lot

S - Standard Deviation of Air Voids in Lot

Equation 5

$$P_V = ((PWL_{UV} + PWL_{LV} \text{ -}100) * 0.0030) - 0.270$$

- If Q is > than largest value in Table 5.2.1-2, then PWL = 100.00

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602.9 BASIS OF ACCEPTANCE
d.(1) Air Void Pay Adjustment (Passing t-Test)

Low Quality Material

- If either $\boldsymbol{Q_{UV}}$ or $\boldsymbol{Q_{LV}}$ is a negative value or
- If $\boldsymbol{PWL_{UV}}$ + $\boldsymbol{PWL_{LV}}$ is less than 150.00
- Engineer determines disposition of material
- If it remains in place then the **maximum P_V** value for the lot will be equal to –0.120
- The Engineer may choose to establish lower **P_V** values for (-0.200, -0.300, etc.)

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602.9 BASIS OF ACCEPTANCE
d.(2) Air Void Pay Adjustment (Failing t-Test)

Table 602-16

TABLE 602-16: Statistical Values for Air Voids Pay Adjustment for Failing t-Test		
Term	**Definition**	**Value**
$\overline{X}$	Average or Mean	KDOT's test result for the lot
S	Standard Deviation	0.50
USL	Upper Specification Limit	4.50%
LSL	Lower Specification Limit	1.50%
N	Sample Size	3

Use Equations 3, 4 and 5 to calculate Q_{UV}, Q_{LV}, and P_V

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602.9 BASIS OF ACCEPTANCE
d. Air Void Pay Adjustment

Determination of PWL

- Locate Q value in Table 5.2.1-2 of KDOT Construction Manual (Section 5.2.1)
- Select PWL value by moving to the column representing the number of samples in the lot
- To find the PWL for a negative Q value, first get the PWL for the positive value of the Q value from PWL Table and subtract the result from 100

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COMPUTATION OF AIR VOID PAY FACTORS

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AIR VOID PAY FACTOR EXAMPLE

HMA Overlay (SR-12.5A)(PG 64-22)
(1.5" LIFT) (Lot 1)
602.9d (Sheets 15-06007-R03-24 and 15-06007-R03-25)

Date	Test	Lift	Station	Lane	Air Void (%)	$\overline{X}$ (%)	S (%)	Quantity (Tons)
8/18/2024	1A	First	34+83	NB	3.30	3.23	0.44	750
8/18/2024	1B	First	87+69	NB	2.77			750
8/18/2024	1C	First	216+47	NB	3.05			750
8/19/2024	1D	First	223+70	NB	3.80			750

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Date	Test	Lift	Station	Lane	Air Void (%)	$\overline{X}$ (%)	S (%)	Quantity (Tons)
8/18/2024	1A	First	34+83	NB	3.30			750
8/18/2024	1B	First	87+69	NB	2.77	3.23	0.44	750
8/18/2024	1C	First	216+47	NB	3.05			750
8/19/2024	1D	First	223+70	NB	3.80			750

Number of Samples	n		Number of V_a Samples
Upper Specification Limit	*USL*		602.9d: Sheet 15-06007-R03-25
Lower Specification Limit	*LSL*		602.9d: Sheet 15-06007-R03-25
Upper Air Void Quality Limit	Q_{UV}		$Q_{UV} = \frac{USL - \overline{X}}{S}$
Lower Air Void Quality Limit	Q_{LV}		$Q_{LV} = \frac{\overline{X} - LSL}{S}$
Upper Percent Within Limits	PWL_{UV}		Table 5.2.1-2
Lower Percent Within Limits	PWL_{LV}		Table 5.2.1-2
Air Void Pay Factor	P_V		$((PWL_{UV} + PWL_{LV} - 100.00)*0.003)-0.270$
Number of Tons in Lot	TONS	**3,000**	
Price per Ton	COST		602.9d: Sheet 15-06007-R03-24
Air Void Pay Adjustment	V_aPA		$V_aPA = P_v$ * TONS * COST

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Date	Test	Lift	Station	Lane	Air Void (%)	$\overline{X}$ (%)	S (%)	Quantity (Tons)
8/18/2024	1A	First	34+83	NB	3.30			750
8/18/2024	1B	First	87+69	NB	2.77	3.23	0.44	750
8/18/2024	1C	First	216+47	NB	3.05			750
8/19/2024	1D	First	223+70	NB	3.80			750

Number of Samples	n	**4**	Number of V_a Samples
Upper Specification Limit	*USL*		602.9d: Sheet 15-06007-R03-25
Lower Specification Limit	*LSL*		602.9d: Sheet 15-06007-R03-25
Upper Air Void Quality Limit	Q_{UV}		$Q_{UV} = \frac{USL - \overline{X}}{S}$
Lower Air Void Quality Limit	Q_{LV}		$Q_{LV} = \frac{\overline{X} - LSL}{S}$
Upper Percent Within Limits	PWL_{UV}		Table 5.2.1-2
Lower Percent Within Limits	PWL_{LV}		Table 5.2.1-2
Air Void Pay Factor	P_V		$((PWL_{UV} + PWL_{LV} - 100.00)*0.003)-0.270$
Number of Tons in Lot	TONS	**3,000**	
Price per Ton	COST		602.9d: Sheet 15-06007-R03-24
Air Void Pay Adjustment	V_aPA		$V_aPA = P_v$ * TONS * COST

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602.9d(1)
Sheet 15-06007-R03-25

Equation 3: $$Q_{UV} = \frac{USL - \overline{X}}{S}$$

Equation 4: $$Q_{LV} = \frac{\overline{X} - LSL}{S}$$

$\overline{X}$ is the average measured V_a of all samples within a lot rounded to hundredths.
USL is the upper specification limit for V_a and is defined as 4.00%.
LSL is the lower specification limit for V_a and is defined as 2.00%.
S is the standard deviation of the measured V_a for all samples within a lot and is calculated using equation (4) in Section 5.2.1 - Statistics, Part V, rounded to hundredths.

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Date	Test	Lift	Station	Lane	Air Void (%)	$\overline{X}$ (%)	S (%)	Quantity (Tons)
8/18/2024	1A	First	34+83	NB	3.30	3.23	0.44	750
8/18/2024	1B	First	87+69	NB	2.77			750
8/18/2024	1C	First	216+47	NB	3.05			750
8/19/2024	1D	First	223+70	NB	3.80			750

Number of Samples	n	**4**	Number of V_a Samples
Upper Specification Limit	*USL*	**4.00**	602.9d: Sheet 15-06007-R03-25
Lower Specification Limit	*LSL*		602.9d: Sheet 15-06007-R03-25
Upper Air Void Quality Limit	Q_{UV}		$Q_{UV} = \frac{USL - \overline{X}}{S}$
Lower Air Void Quality Limit	Q_{LV}		$Q_{LV} = \frac{\overline{X} - LSL}{S}$
Upper Percent Within Limits	PWL_{UV}		Table 5.2.1-2
Lower Percent Within Limits	PWL_{LV}		Table 5.2.1-2
Air Void Pay Factor	P_V		$((PWL_{UV} + PWL_{LV} - 100.00)*0.003)-0.270$
Number of Tons in Lot	TONS	**3,000**	
Price per Ton	COST		602.9d: Sheet 15-06007-R03-24
Air Void Pay Adjustment	V_aPA		$V_aPA = P_v$ * TONS * COST

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602.9d(1)
Sheet 15-06007-R03-25

Equation 3: $$Q_{UV} = \frac{USL - \overline{X}}{S}$$

Equation 4: $$Q_{LV} = \frac{\overline{X} - LSL}{S}$$

$\overline{X}$ is the average measured V_a of all samples within a lot rounded to hundredths.
USL is the upper specification limit for V_a and is defined as 4.00%.
LSL is the lower specification limit for V_a and is defined as 2.00%.
S is the standard deviation of the measured V_a for all samples within a lot and is calculated using equation (4) in Section 5.2.1 - Statistics, Part V, rounded to hundredths.

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Date	Test	Lift	Station	Lane	Air Void (%)	$\overline{X}$ (%)	S (%)	Quantity (Tons)
8/18/2024	1A	First	34+83	NB	3.30	3.23	0.44	750
8/18/2024	1B	First	87+69	NB	2.77			750
8/18/2024	1C	First	216+47	NB	3.05			750
8/19/2024	1D	First	223+70	NB	3.80			750

Number of Samples	n	**4**	Number of V_a Samples
Upper Specification Limit	*USL*	**4.00**	602.9d: Sheet 15-06007-R03-25
Lower Specification Limit	*LSL*	**2.00**	602.9d: Sheet 15-06007-R03-25
Upper Air Void Quality Limit	Q_{UV}		$Q_{UV} = \frac{USL - \overline{X}}{S}$
Lower Air Void Quality Limit	Q_{LV}		$Q_{LV} = \frac{\overline{X} - LSL}{S}$
Upper Percent Within Limits	PWL_{UV}		Table 5.2.1-2
Lower Percent Within Limits	PWL_{LV}		Table 5.2.1-2
Air Void Pay Factor	P_V		$((PWL_{UV} + PWL_{LV} - 100.00)*0.003)-0.270$
Number of Tons in Lot	TONS	**3,000**	
Price per Ton	COST		602.9d: Sheet 15-06007-R03-24
Air Void Pay Adjustment	V_aPA		$V_aPA = P_v$ * TONS * COST

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AIR VOID PAY ADJUSTMENT
Lot 1

USL = 4.00%

$\overline{X}$ = 3.23

$$Q_{UV} = \frac{USL - \overline{X}}{S}$$

$$Q_{UV} = \frac{4.00 - 3.23}{0.44}$$

$$Q_{UV} = \frac{0.77}{0.44}$$

$$Q_{UV} = 1.75$$

LSL = 2.00%

S = 0.44

$$Q_{LV} = \frac{\overline{X} - LSL}{S}$$

$$Q_{LV} = \frac{3.23 - 2.00}{0.44}$$

$$Q_{LV} = \frac{1.23}{0.44}$$

$$Q_{LV} = 2.80$$

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Date	Test	Lift	Station	Lane	Air Void (%)	$\overline{X}$ (%)	S (%)	Quantity (Tons)
8/18/2024	1A	First	34+83	NB	3.30			750
8/18/2024	1B	First	87+69	NB	2.77	3.23	0.44	750
8/18/2024	1C	First	216+47	NB	3.05			750
8/19/2024	1D	First	223+70	NB	3.80			750

Number of Samples	n	**4**	Number of V_a Samples
Upper Specification Limit	USL	**4.00**	602.9d: Sheet 15-06007-R03-25
Lower Specification Limit	LSL	**2.00**	602.9d: Sheet 15-06007-R03-25
Upper Air Void Quality Limit	Q_{UV}	**1.75**	$Q_{UV} = \frac{USL - \overline{X}}{S}$
Lower Air Void Quality Limit	Q_{LV}	**2.80**	$Q_{LV} = \frac{\overline{X} - LSL}{S}$
Upper Percent Within Limits	PWL_{UV}		Table 5.2.1-2
Lower Percent Within Limits	PWL_{LV}		Table 5.2.1-2
Air Void Pay Factor	P_V		$((PWL_{UV} + PWL_{LV} - 100.00)*0.003)-0.270$
Number of Tons in Lot	TONS	**3,000**	
Price per Ton	COST		602.9d: Sheet 15-06007-R03-24
Air Void Pay Adjustment	V_aPA		$V_aPA = P_v$ * TONS * COST

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Q_U or Q_L	N=3	N=4	N=5	N=6	N=7
1.70	100.00	100.00	99.34	98.02	97.38
1.71	100.00	100.00	99.45	98.13	97.49
1.72	100.00	100.00	99.55	98.24	97.59
1.73	100.00	100.00	99.64	98.34	97.70
1.74	100.00	100.00	99.73	98.45	97.80
1.75	100.00	**100.00**	99.81	98.55	97.89
1.76	100.00	100.00	99.88	98.64	97.99
1.77	100.00	100.00	99.94	98.73	98.08
1.78	100.00	100.00	99.98	98.82	98.17
1.79	100.00	100.00	100.00	98.91	98.26
1.80	100.00	100.00	100.00	98.99	98.35

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Q_U or Q_L	N=3	N=4	N=5	N=6	N=7
2.75	100.00	100.00	100.00	100.00	100.00
2.76	100.00	100.00	100.00	100.00	100.00
2.77	100.00	100.00	100.00	100.00	100.00
2.78	100.00	100.00	100.00	100.00	100.00
2.79	100.00	100.00	100.00	100.00	100.00
2.80	100.00	**100.00**	100.00	100.00	100.00
2.81	100.00	100.00	100.00	100.00	100.00
2.82	100.00	100.00	100.00	100.00	100.00
2.83	100.00	100.00	100.00	100.00	100.00
2.84	100.00	100.00	100.00	100.00	100.00
2.85	100.00	100.00	100.00	100.00	100.00

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Date	Test	Lift	Station	Lane	Air Void (%)	$\bar{X}$ (%)	S (%)	Quantity (Tons)
8/18/2024	1A	First	34+83	NB	3.30	3.23	0.44	750
8/18/2024	1B	First	87+69	NB	2.77			750
8/18/2024	1C	First	216+47	NB	3.05			750
8/19/2024	1D	First	223+70	NB	3.80			750

Number of Samples	n	**4**	Number of V_a Samples
Upper Specification Limit	*USL*	**4.00**	602.9d: Sheet 15-06007-R03-25
Lower Specification Limit	*LSL*	**2.00**	602.9d: Sheet 15-06007-R03-25
Upper Air Void Quality Limit	Q_{UV}	**1.75**	$Q_{UV} = \frac{USL - \bar{X}}{S}$
Lower Air Void Quality Limit	Q_{LV}	**2.80**	$Q_{LV} = \frac{\bar{X} - LSL}{S}$
Upper Percent Within Limits	PWL_{UV}	**100.00**	Table 5.2.1-2
Lower Percent Within Limits	PWL_{LV}	**100.00**	Table 5.2.1-2
Air Void Pay Factor	P_V		$((PWL_{UV} + PWL_{LV} - 100.00)*0.003)-0.270$
Number of Tons in Lot	TONS	**3,000**	
Price per Ton	COST		602.9d: Sheet 15-06007-R03-24
Air Void Pay Adjustment	V_aPA		$V_aPA = P_v$ * TONS * COST

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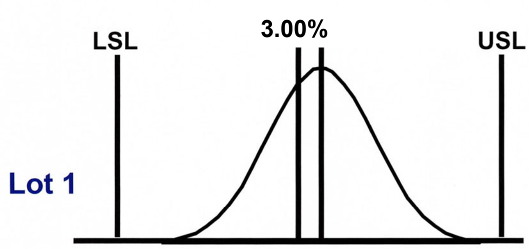
AIR VOID PAY ADJUSTMENT
Lot 1

$$Q_{UV} = 1.75 \qquad Q_{LV} = 2.80$$

N = 4

PWL_{UV} = 100.00 PWL_{LV} = 100.00



$\bar{X}$ = 3.23 & S = 0.44

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602.9d(1)
Sheet 15-06007-R03-24

Equation 3: $Q_{UV} = \dfrac{USL - \overline{X}}{S}$

Equation 4: $Q_{LV} = \dfrac{\overline{X} - LSL}{S}$

$\overline{X}$ is the average measured V_a of all samples within a lot rounded to hundredths.
USL is the upper specification limit for V_a and is defined as 4.00%.
LSL is the lower specification limit for V_a and is defined as 2.00%.
S is the standard deviation of the measured V_a for all samples within a lot and is calculated using equation (4) in Section 5.2.1 - Statistics, Part V, rounded to hundredths.

Equation 5: $P_V = ((PWL_{UV} + PWL_{LV} - 100.00)(0.003)) - 0.270$

PWL_{UV} is the upper percent within limits value for V_a.
PWL_{LV} is the lower percent within limits value for V_a.

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AIR VOID PAY ADJUSTMENT
Lot 1

$PWL_{UV} = 100.00$ $PWL_{LV} = 100.00$

$P_V = ((PWL_{UV}+PWL_{LV} - 100.00) * 0.003) - 0.270$

$P_V = ((100.00+100.00-100.00) * 0.003) - 0.270$

$P_V = ((100.00) * 0.003) - 0.270$

$P_V = (0.300) - 0.270$

$P_V = 0.030$

Order of Operation

- Parenthesis
- Exponents
- Multiplication and Division
- Addition and Subtraction

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Date	Test	Lift	Station	Lane	Air Void (%)	$\overline{X}$ (%)	S (%)	Quantity (Tons)
8/18/2024	1A	First	34+83	NB	3.30	3.23	0.44	750
8/18/2024	1B	First	87+69	NB	2.77			750
8/18/2024	1C	First	216+47	NB	3.05			750
8/19/2024	1D	First	223+70	NB	3.80			750

Number of Samples	n	**4**	Number of V_a Samples
Upper Specification Limit	*USL*	**4.00**	602.9d: Sheet 15-06007-R03-25
Lower Specification Limit	*LSL*	**2.00**	602.9d: Sheet 15-06007-R03-25
Upper Air Void Quality Limit	Q_{UV}	**1.75**	$Q_{UV} = \frac{USL - \overline{X}}{S}$
Lower Air Void Quality Limit	Q_{LV}	**2.80**	$Q_{LV} = \frac{\overline{X} - LSL}{S}$
Upper Percent Within Limits	PWL_{UV}	**100.00**	Table 5.2.1-2
Lower Percent Within Limits	PWL_{LV}	**100.00**	Table 5.2.1-2
Air Void Pay Factor	P_V	**0.030**	$((PWL_{UV} + PWL_{LV} - 100.00)*0.003)-0.270$
Number of Tons in Lot	TONS	**3,000**	
Price per Ton	COST		602.9d: Sheet 15-06007-R03-24
Air Void Pay Adjustment	V_aPA		$V_aPA = P_v$ * TONS * COST

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602.9d(1)
Sheet 15-06007-R03-24

d. Asphalt Air Void Pay Adjustment. Asphalt Air Void (V_a) Pay Adjustment will be made on a lot basis and based on measured V_a from samples of plant produced material. This adjustment will be paid for under the bid item Asphalt Air Void Pay Adjustment. The V_a pay adjustment factor (P_V) (positive or negative) will be determined and used to compute the V_a Pay Adjustment by multiplying P_V times the number of tons included in the lot times $75 per ton. The V_a Pay Adjustment will be added or subtracted on the pay estimate. When the statistical comparison between the quality control and the verification tests pass, use the procedures in **subsection 602.9d.(1)** to compute P_V. When the statistical comparison fails, calculate P_V using procedures in **subsection 602.9d.(2)**.

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Date	Test	Lift	Station	Lane	Air Void (%)	$\overline{X}$ (%)	S (%)	Quantity (Tons)
8/18/2024	1A	First	34+83	NB	3.30			750
8/18/2024	1B	First	87+69	NB	2.77	3.23	0.44	750
8/18/2024	1C	First	216+47	NB	3.05			750
8/19/2024	1D	First	223+70	NB	3.80			750

Number of Samples	n	**4**	Number of V_a Samples
Upper Specification Limit	*USL*	**4.00**	602.9d: Sheet 15-06007-R03-25
Lower Specification Limit	*LSL*	**2.00**	602.9d: Sheet 15-06007-R03-25
Upper Air Void Quality Limit	Q_{UV}	**1.75**	$Q_{UV} = \frac{USL - \overline{X}}{S}$
Lower Air Void Quality Limit	Q_{LV}	**2.80**	$Q_{LV} = \frac{\overline{X} - LSL}{S}$
Upper Percent Within Limits	PWL_{UV}	**100.00**	Table 5.2.1-2
Lower Percent Within Limits	PWL_{LV}	**100.00**	Table 5.2.1-2
Air Void Pay Factor	P_V	**0.030**	$((PWL_{UV} + PWL_{LV} - 100.00)*0.003)-0.270$
Number of Tons in Lot	TONS	**3,000**	
Price per Ton	COST	**$75.00**	602.9d: Sheet 15-06007-R03-24
Air Void Pay Adjustment	V_aPA		$V_aPA = P_v$ * TONS * COST

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602.9d(1)
Sheet 15-06007-R03-24

d. Asphalt Air Void Pay Adjustment. Asphalt Air Void (V_a) Pay Adjustment will be made on a lot basis and based on measured V_a from samples of plant produced material. This adjustment will be paid for under the bid item Asphalt Air Void Pay Adjustment. The V_a pay adjustment factor (***P****V*) (positive or negative) will be determined and used to compute the V_a Pay Adjustment by multiplying ***P****V* times the number of tons included in the lot times $75 per ton. The V_a Pay Adjustment will be added or subtracted on the pay estimate. When the statistical comparison between the quality control and the verification tests pass, use the procedures in **subsection 602.9d.(1)** to compute ***P****V*. When the statistical comparison fails, calculate ***P****V* using procedures in **subsection 602.9d.(2)**.

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AIR VOID PAY ADJUSTMENT
Lot 1

$P_V = 0.030$

Air Void Payment Adjustment =

P_V * tons in lot * $75.00 per ton

= 0.030 * (3,000 * $75.00)

= 0.030 * (225,000)

= $ 6,750.00

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Date	Test	Lift	Station	Lane	Air Void (%)	$\overline{X}$ (%)	S (%)	Quantity (Tons)
8/18/2024	1A	First	34+83	NB	3.30	3.23	0.44	750
8/18/2024	1B	First	87+69	NB	2.77			750
8/18/2024	1C	First	216+47	NB	3.05			750
8/19/2024	1D	First	223+70	NB	3.80			750

Number of Samples	n	**4**	Number of V_a Samples
Upper Specification Limit	*USL*	**4.00**	602.9d: Sheet 15-06007-R03-25
Lower Specification Limit	*LSL*	**2.00**	602.9d: Sheet 15-06007-R03-25
Upper Air Void Quality Limit	Q_{UV}	**1.75**	$Q_{UV} = \frac{USL - \overline{X}}{S}$
Lower Air Void Quality Limit	Q_{LV}	**2.80**	$Q_{LV} = \frac{\overline{X} - LSL}{S}$
Upper Percent Within Limits	PWL_{UV}	**100.00**	Table 5.2.1-2
Lower Percent Within Limits	PWL_{LV}	**100.00**	Table 5.2.1-2
Air Void Pay Factor	P_V	**0.030**	$((PWL_{UV} + PWL_{LV} - 100.00)*0.003)-0.270$
Number of Tons in Lot	TONS	**3,000**	
Price per Ton	COST	**$75.00**	602.9d: Sheet 15-06007-R03-24
Air Void Pay Adjustment	V_aPA	**$6,750.00**	$V_aPA = P_v$ * TONS * COST

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AIR VOID PAY FACTOR EXAMPLE

HMA Overlay (SR-12.5A)(PG 64-22)
(1.5" LIFT) (Lot 2)
602.9d. (Sheets 15-06007-R01-24 and 15-06007-R01-25)

Date	Test	Lift	Station	Lane	Air Void (%)	$\overline{X}$ (%)	S (%)	Quantity (Tons)
8/19/2024	2A	First	337+71	NB	1.65			750
8/19/2024	2B	First	398+86	NB	1.94	1.57	0.35	750
8/20/2024	2C	First	482+99	NB	1.57			750
8/20/2024	2D	First	511+21	NB	1.10			750

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Date	Test	Lift	Station	Lane	Air Void (%)	$\overline{X}$ (%)	S (%)	Quantity (Tons)
8/19/2024	2A	First	337+71	NB	1.65			750
8/19/2024	2B	First	398+86	NB	1.94	1.57	0.35	750
8/20/2024	2C	First	482+99	NB	1.57			750
8/20/2024	2D	First	511+21	NB	1.10			750

Number of Samples	n	**4**	Number of V_a Samples
Upper Specification Limit	*USL*		602.9d: Sheet 15-06007-R03-25
Lower Specification Limit	*LSL*		602.9d: Sheet 15-06007-R03-25
Upper Air Void Quality Limit	Q_{UV}		$Q_{UV} = \frac{USL - \overline{X}}{S}$
Lower Air Void Quality Limit	Q_{LV}		$Q_{LV} = \frac{\overline{X} - LSL}{S}$
Upper Percent Within Limits	PWL_{UV}		Table 5.2.1-2
Lower Percent Within Limits	PWL_{LV}		Table 5.2.1-2
Air Void Pay Factor	P_V		$((PWL_{UV} + PWL_{LV} - 100.00)*0.003)-0.270$
Number of Tons in Lot	TONS	**3,000**	
Price per Ton	COST		602.9d: Sheet 15-06007-R03-24
Air Void Pay Adjustment	V_aPA		$V_aPA = P_v$ * TONS * COST

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602.9d(1)
Sheet 15-06007-R03-25

Equation 3: $$Q_{UV} = \frac{USL - \overline{X}}{S}$$

Equation 4: $$Q_{LV} = \frac{\overline{X} - LSL}{S}$$

$\overline{X}$ is the average measured V_a of all samples within a lot rounded to hundredths.
USL is the upper specification limit for V_a and is defined as 4.00%.
LSL is the lower specification limit for V_a and is defined as 2.00%.
S is the standard deviation of the measured V_a for all samples within a lot and is calculated using equation (4) in Section 5.2.1 - Statistics, Part V, rounded to hundredths.

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Date	Test	Lift	Station	Lane	Air Void (%)	$\overline{X}$ (%)	S (%)	Quantity (Tons)
8/19/2024	2A	First	337+71	NB	1.65			750
8/19/2024	2B	First	398+86	NB	1.94	1.57	0.35	750
8/20/2024	2C	First	482+99	NB	1.57			750
8/20/2024	2D	First	511+21	NB	1.10			750

Number of Samples	n	4	Number of V_a Samples
Upper Specification Limit	*USL*	**4.00**	602.9d: Sheet 15-06007-R03-25
Lower Specification Limit	*LSL*		602.9d: Sheet 15-06007-R03-25
Upper Air Void Quality Limit	Q_{UV}		$Q_{UV} = \frac{USL - \overline{X}}{S}$
Lower Air Void Quality Limit	Q_{LV}		$Q_{LV} = \frac{\overline{X} - LSL}{S}$
Upper Percent Within Limits	PWL_{UV}		Table 5.2.1-2
Lower Percent Within Limits	PWL_{LV}		Table 5.2.1-2
Air Void Pay Factor	P_V		$((PWL_{UV} + PWL_{LV} - 100.00)*0.003)-0.270$
Number of Tons in Lot	TONS	**3,000**	
Price per Ton	COST		602.9d: Sheet 15-06007-R03-24
Air Void Pay Adjustment	V_aPA		$V_aPA = P_v * TONS * COST$

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602.9d(1)
Sheet 15-06007-R03-25

Equation 3: $$Q_{UV} = \frac{USL - \overline{X}}{S}$$

Equation 4: $$Q_{LV} = \frac{\overline{X} - LSL}{S}$$

$\overline{X}$ is the average measured V_a of all samples within a lot rounded to hundredths.
USL is the upper specification limit for V_a and is defined as 4.00%.
LSL is the lower specification limit for V_a and is defined as 2.00%.
S is the standard deviation of the measured V_a for all samples within a lot and is calculated using equation (4) in Section 5.2.1 - Statistics, Part V, rounded to hundredths.

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Date	Test	Lift	Station	Lane	Air Void (%)	$\overline{X}$ (%)	S (%)	Quantity (Tons)
8/19/2024	2A	First	337+71	NB	1.65	1.57	0.35	750
8/19/2024	2B	First	398+86	NB	1.94			750
8/20/2024	2C	First	482+99	NB	1.57			750
8/20/2024	2D	First	511+21	NB	1.10			750

Number of Samples	n	**4**	Number of V_a Samples
Upper Specification Limit	*USL*	**4.00**	602.9d: Sheet 15-06007-R03-25
Lower Specification Limit	*LSL*	**2.00**	602.9d: Sheet 15-06007-R03-25
Upper Air Void Quality Limit	Q_{UV}		$Q_{UV} = \frac{USL - \overline{X}}{S}$
Lower Air Void Quality Limit	Q_{LV}		$Q_{LV} = \frac{\overline{X} - LSL}{S}$
Upper Percent Within Limits	PWL_{UV}		Table 5.2.1-2
Lower Percent Within Limits	PWL_{LV}		Table 5.2.1-2
Air Void Pay Factor	P_V		$((PWL_{UV} + PWL_{LV} - 100.00)*0.003)-0.270$
Number of Tons in Lot	TONS	**3,000**	
Price per Ton	COST		602.9d: Sheet 15-06007-R03-24
Air Void Pay Adjustment	V_aPA		$V_aPA = P_v$ * TONS * COST

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AIR VOID PAY ADJUSTMENT
Lot 2

USL = 4.00% LSL = 2.00%

$\bar{X}$ = 1.57 S = 0.35

$$Q_{UV} = \frac{USL - \bar{X}}{S} \qquad Q_{LV} = \frac{\bar{X} - LSL}{S}$$

$$Q_{UV} = \frac{4.00 - 1.57}{0.35} \qquad Q_{LV} = \frac{1.57 - 2.00}{0.35}$$

$$Q_{UV} = \frac{2.43}{0.35} \qquad Q_{LV} = \frac{-0.43}{0.35}$$

$$Q_{UV} = 6.94 \qquad Q_{LV} = -1.23$$

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Date	Test	Lift	Station	Lane	Air Void (%)	$\bar{X}$ (%)	S (%)	Quantity (Tons)
8/19/2024	2A	First	337+71	NB	1.65			750
8/19/2024	2B	First	398+86	NB	1.94	1.57	0.35	750
8/20/2024	2C	First	482+99	NB	1.57			750
8/20/2024	2D	First	511+21	NB	1.10			750

Number of Samples	n	**4**	Number of V_a Samples
Upper Specification Limit	*USL*	**4.00**	602.9d: Sheet 15-06007-R03-25
Lower Specification Limit	*LSL*	**2.00**	602.9d: Sheet 15-06007-R03-25
Upper Air Void Quality Limit	Q_{UV}	**6.94**	$Q_{UV} = \frac{USL - \bar{X}}{S}$
Lower Air Void Quality Limit	Q_{LV}	**-1.23**	$Q_{LV} = \frac{\bar{X} - LSL}{S}$
Upper Percent Within Limits	PWL_{UV}		Table 5.2.1-2
Lower Percent Within Limits	PWL_{LV}		Table 5.1.1-2
Air Void Pay Factor	P_V		$((PWL_{UV} + PWL_{LV} - 100.00)*0.003)-0.270$
Number of Tons in Lot	TONS	**3,000**	
Price per Ton	COST		602.9d: Sheet 15-06007-R03-24
Air Void Pay Adjustment	V_aPA		$V_aPA = P_v$ * TONS * COST

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Q_U or Q_L	N=3	N=4	N=5	N=6	N=7
3.66	100.00	100.00	100.00	100.00	100.00
3.67	100.00	100.00	100.00	100.00	100.00
3.68	100.00	100.00	100.00	100.00	100.00
3.69	100.00	100.00	100.00	100.00	100.00
3.70	100.00	100.00	100.00	100.00	100.00
3.71	100.00	100.00	100.00	100.00	100.00
3.72	100.00	100.00	100.00	100.00	100.00
3.73	100.00	100.00	100.00	100.00	100.00
3.74	100.00	100.00	100.00	100.00	100.00
3.75	100.00	100.00	100.00	100.00	100.00
3.76	100.00	**100.00**	100.00	100.00	100.00

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602.9d(1)
Sheet 15-06007-R03-24

(1) Air Voids Pay Adjustment Factor (Passing t-test). Calculate the upper and lower V_a quality indices (Q_{UV} and Q_{LV}) for each lot using Equations 3 and 4, respectively and round to hundredths. Locate the Q_{UV} value in the left column of the Percent Within Limits (PWL) Table in Section 5.2.1 – Statistics, Part V. Select the appropriate upper percent within limit value (PWL_{UV}) by moving across the selected quality index row to the column representing the number of samples (N) in the lot. Repeat the process using the Q_{LV} value and select the appropriate value for the lower percent within limits (PWL_{LV}). If the Q_{UV} or Q_{LV} value is greater than the largest quality index value shown in the table, then a value of 100.00 is assigned as the value for PWL_{UV} or PWL_{LV}, respectively. If both Q_{UV} and Q_{LV} exceed the values shown in the table, a value of 100.00 is assigned as the value for both PWL_{UV} and PWL_{LV}. If either Q_{UV} or Q_{LV} is a negative value or $PWL_{UV} + PWL_{LV}$ is less than 150.00, the Engineer will determine if the material in the lot may remain in place. If the Engineer determines that the material may remain in place then the maximum value of P_V for the lot will be equal to –0.120. The Engineer may establish lower values for P_V (-0.200, -0.300, etc.) in such instances. Otherwise, calculate P_V using Equation 5 and round to thousandths.

Equation 3: $$Q_{UV} = \frac{USL - \overline{X}}{S}$$

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602.9d(1)
Sheet 15-06007-R03-24

(1) Air Voids Pay Adjustment Factor (Passing t-test). Calculate the upper and lower V_a quality indices (Q_{UV} and Q_{LV}) for each lot using Equations 3 and 4, respectively and round to hundredths. Locate the Q_{UV} value in the left column of the Percent Within Limits (PWL) Table in Section 5.2.1 – Statistics, Part V. Select the appropriate upper percent within limit value (PWL_{UV}) by moving across the selected quality index row to the column representing the number of samples (N) in the lot. Repeat the process using the Q_{LV} value and select the appropriate value for the lower percent within limits (PWL_{LV}). If the Q_{UV} or Q_{LV} value is greater than the largest quality index value shown in the table, then a value of 100.00 is assigned as the value for PWL_{UV} or PWL_{LV}, respectively. If both Q_{UV} and Q_{LV} exceed the values shown in the table, a value of 100.00 is assigned as the value for both PWL_{UV} and PWL_{LV}. If either Q_{UV} or Q_{LV} is a negative value or $PWL_{UV} + PWL_{LV}$ is less than 150.00, the Engineer will determine if the material in the lot may remain in place. If the Engineer determines that the material may remain in place then the maximum value of P_V for the lot will be equal to –0.120. The Engineer may establish lower values for P_V (-0.200, -0.300, etc.) in such instances. Otherwise, calculate P_V using Equation 5 and round to thousandths.

Equation 3: $$Q_{UV} = \frac{USL - \overline{X}}{S}$$

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TABLE 5.2.1
Page 26

3.65	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
3.66	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
3.67	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
3.68	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
3.69	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
3.70	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
3.71	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
3.72	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
3.73	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
3.74	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
3.75	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
3.76	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

The estimates of lot percent within limits (PWL) provided in the tables are obtained by numerically intergrating the beta distribution function corresponding to Quality Index (Q) and Sample Size (N).

To find PWL from the tables, compute Q from the sample mean and sample standard deviation with unknown population variability, and the lower or upper specification limits.

To find the PWL for a negative Quality Index, first get the PWL for the positive value of the Quality Index from the tables and subtract the result from 100.

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Q_U or Q_L	N=3	N=4	N=5	N=6	N=7
1.19	100.00	89.67	88.98	88.77	88.67
1.20	100.00	90.00	89.24	89.01	88.90
1.21	100.00	90.33	89.50	89.25	89.13
1.22	100.00	90.67	89.77	89.49	89.35
1.23	100.00	**91.00**	90.03	89.72	89.58
1.24	100.00	91.33	90.28	89.96	89.80
1.25	100.00	91.67	90.54	90.19	90.02
1.26	100.00	92.00	90.79	90.42	90.23
1.27	100.00	92.33	91.04	90.64	90.45
1.28	100.00	92.67	91.29	90.87	90.66
1.29	100.00	93.00	91.54	91.09	90.87

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$$PWL_{LV} = 100 - PWL|Q_{LV}|$$

$$PWL_{LV} = 100 – 91.00$$

$$PWL_{LV} = 9.00$$

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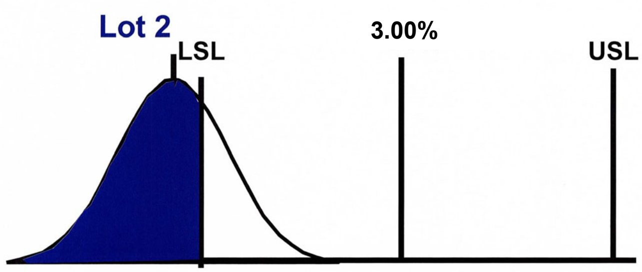
AIR VOID PAY ADJUSTMENT
Lot 2

$$Q_{UV} = 6.94 \qquad Q_{LV} = -1.23$$

PWL_{UV} = 100.00

PWL_{LV} = 100.00 – 91.00

PWL_{LV} = 9.00



$\bar{X}$ = 1.57 & S = 0.35

47

Date	Test	Lift	Station	Lane	Air Void (%)	$\bar{X}$ (%)	S (%)	Quantity (Tons)
8/19/2024	2A	First	337+71	NB	1.65	1.57	0.35	750
8/19/2024	2B	First	398+86	NB	1.94			750
8/20/2024	2C	First	482+99	NB	1.57			750
8/20/2024	2D	First	511+21	NB	1.10			750

Number of Samples	n	**4**	Number of V_a Samples
Upper Specification Limit	*USL*	**4.00**	602.9d: Sheet 15-06007-R03-25
Lower Specification Limit	*LSL*	**2.00**	602.9d: Sheet 15-06007-R03-25
Upper Air Void Quality Limit	Q_{UV}	**6.94**	$Q_{UV} = \frac{USL - \bar{X}}{S}$
Lower Air Void Quality Limit	Q_{LV}	**-1.23**	$Q_{LV} = \frac{\bar{X} - LSL}{S}$
Upper Percent Within Limits	PWL_{UV}	**100.00**	Table 5.2.1-2
Lower Percent Within Limits	PWL_{LV}	**9.00**	Table 5.2.1-2
Air Void Pay Factor	P_V		$((PWL_{UV} + PWL_{LV} - 100.00)*0.003)-0.270$
Number of Tons in Lot	TONS	**3,000**	
Price per Ton	COST		602.9d: Sheet 15-06007-R03-24
Air Void Pay Adjustment	V_aPA		$V_aPA = P_v$ * TONS * COST

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602.9d(1)
Sheet 15-06007-R03-25

Equation 4: $Q_{LV} = \dfrac{\overline{X} - LSL}{S}$

$\overline{X}$ is the average measured V_a of all samples within a lot rounded to hundredths.
USL is the upper specification limit for V_a and is defined as 4.00%.
LSL is the lower specification limit for V_a and is defined as 2.00%.
S is the standard deviation of the measured V_a for all samples within a lot and is calculated using equation (4) in Section 5.2.1 - Statistics, Part V, rounded to hundredths.

Equation 5: $P_V = ((PWL_{UV} + PWL_{LV} - 100.00)(0.003)) - 0.270$

PWL_{UV} is the upper percent within limits value for V_a.
PWL_{LV} is the lower percent within limits value for V_a.

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AIR VOID PAY ADJUSTMENT
Lot 2

$PWL_{UV} = 100.00$ $PWL_{LV} = 9.00$

$P_V = ((PWL_{UV} + PWL_{LV} - 100.00) * 0.003) - 0.270$

$P_V = ((100.00+9.00 - 100.00) * 0.003) - 0.270$

$P_V = ((9) * 0.003) - 0.270$

$P_V = (0.027) - 0.270$

$P_V = -0.243$ or $P_V = -0.120$ or $P_V = \ldots$

Order of Operation

- Parenthesis
- Exponents
- Multiplication and Division
- Addition and Subtraction

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Date	Test	Lift	Station	Lane	Air Void (%)	$\overline{X}$ (%)	S (%)	Quantity (Tons)
8/19/2024	2A	First	337+71	NB	1.65	1.57	0.35	750
8/19/2024	2B	First	398+86	NB	1.94			750
8/20/2024	2C	First	482+99	NB	1.57			750
8/20/2024	2D	First	511+21	NB	1.10			750

Number of Samples	n	**4**	Number of V_a Samples
Upper Specification Limit	*USL*	**4.00**	602.9d: Sheet 15-06007-R03-25
Lower Specification Limit	*LSL*	**2.00**	602.9d: Sheet 15-06007-R03-25
Upper Air Void Quality Limit	Q_{UV}	**6.94**	$Q_{UV} = \frac{USL - \overline{X}}{S}$
Lower Air Void Quality Limit	Q_{LV}	**-1.23**	$Q_{LV} = \frac{\overline{X} - LSL}{S}$
Upper Percent Within Limits	PWL_{UV}	**100.00**	Table 5.2.1-2
Lower Percent Within Limits	PWL_{LV}	**9.00**	Table 5.2.1-2
Air Void Pay Factor	P_V	**-0.120**	$((PWL_{UV} + PWL_{LV} - 100.00)*0.003)-0.270$
Number of Tons in Lot	TONS	**3,000**	
Price per Ton	COST		602.9d: Sheet 15-06007-R03-24
Air Void Pay Adjustment	V_aPA		$V_aPA = P_v * TONS * COST$

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602.9d(1)
Sheet 15-06007-R03-24

d. Asphalt Air Void Pay Adjustment. Asphalt Air Void (V_a) Pay Adjustment will be made on a lot basis and based on measured V_a from samples of plant produced material. This adjustment will be paid for under the bid item Asphalt Air Void Pay Adjustment. The V_a pay adjustment factor (***P_V***) (positive or negative) will be determined and used to compute the V_a Pay Adjustment by multiplying ***P_V*** times the number of tons included in the lot times $75 per ton. The V_a Pay Adjustment will be added or subtracted on the pay estimate. When the statistical comparison between the quality control and the verification tests pass, use the procedures in **subsection 602.9d.(1)** to compute ***P_V***. When the statistical comparison fails, calculate ***P_V*** using procedures in **subsection 602.9d.(2)**.

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Date	Test	Lift	Station	Lane	Air Void (%)	$\overline{X}$ (%)	S (%)	Quantity (Tons)
8/19/2024	2A	First	337+71	NB	1.65	1.57	0.35	750
8/19/2024	2B	First	398+86	NB	1.94			750
8/20/2024	2C	First	482+99	NB	1.57			750
8/20/2024	2D	First	511+21	NB	1.10			750

Number of Samples	n	**4**	Number of V_a Samples
Upper Specification Limit	*USL*	**4.00**	602.9d: Sheet 15-06007-R03-25
Lower Specification Limit	*LSL*	**2.00**	602.9d: Sheet 15-06007-R03-25
Upper Air Void Quality Limit	Q_{UV}	**6.94**	$Q_{UV} = \frac{USL - \overline{X}}{S}$
Lower Air Void Quality Limit	Q_{LV}	**-1.23**	$Q_{LV} = \frac{\overline{X} - LSL}{S}$
Upper Percent Within Limits	PWL_{UV}	**100.00**	Table 5.2.1-2
Lower Percent Within Limits	PWL_{LV}	**9.00**	Table 5.2.1-2
Air Void Pay Factor	P_V	**-0.120**	$((PWL_{UV} + PWL_{LV} - 100.00)*0.003)-0.270$
Number of Tons in Lot	TONS	**3,000**	
Price per Ton	COST	**$75.00**	602.9d: Sheet 15-06007-R03-24
Air Void Pay Adjustment	V_aPA		$V_aPA = P_v$ * TONS * COST

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602.9d(1)
Sheet 15-06007-R03-24

d. Asphalt Air Void Pay Adjustment. Asphalt Air Void (V_a) Pay Adjustment will be made on a lot basis and based on measured V_a from samples of plant produced material. This adjustment will be paid for under the bid item Asphalt Air Void Pay Adjustment. The V_a pay adjustment factor (***P_V***) (positive or negative) will be determined and used to compute the V_a Pay Adjustment by multiplying ***P_V*** times the number of tons included in the lot times $75 per ton. The V_a Pay Adjustment will be added or subtracted on the pay estimate. When the statistical comparison between the quality control and the verification tests pass, use the procedures in **subsection 602.9d.(1)** to compute ***P_V***. When the statistical comparison fails, calculate ***P_V*** using procedures in **subsection 602.9d.(2)**.

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AIR VOID PAY ADJUSTMENT
Lot 2

P_V = -0.243

P_V = -0.120 max value

Air Void Payment Adjustment =

***P_V* * tons in lot * $75.00 per ton**

= -0.120 * (3,000 * $75.00)

= -0.120 * (225,000)

= -$27,000.00

55

AIR VOID PAY ADJUSTMENT
Lot 2

P_V = -0.243

P_V = -0.120 max value

Air Void Payment Adjustment =

***P_V* * tons in lot * $75.00 per ton**

= -0.243 * (3,000 * $75.00)

= -0.243 * (225,000)

= -$54,675.00

56

AIR VOID PAY ADJUSTMENT
Lot 2

P_V = -0.243

P_V = -0.120 max value

Air Void Payment Adjustment =

***P_V* * tons in lot * $75.00 per ton**

= -0.200 * (3,000 * $75.00)

= -0.200 * (225,000)

= -$45,000.00

57

Date	Test	Lift	Station	Lane	Air Void (%)	$\overline{X}$ (%)	S (%)	Quantity (Tons)
8/19/2024	2A	First	337+71	NB	1.65	1.57	0.35	750
8/19/2024	2B	First	398+86	NB	1.94			750
8/20/2024	2C	First	482+99	NB	1.57			750
8/20/2024	2D	First	511+21	NB	1.10			750

Number of Samples	n	**4**	Number of V_a Samples
Upper Specification Limit	*USL*	**4.00**	602.9d: Sheet 15-06007-R03-25
Lower Specification Limit	*LSL*	**2.00**	602.9d: Sheet 15-06007-R03-25
Upper Air Void Quality Limit	Q_{UV}	**6.94**	$Q_{UV} = \frac{USL - \overline{X}}{S}$
Lower Air Void Quality Limit	Q_{LV}	**-1.23**	$Q_{LV} = \frac{\overline{X} - LSL}{S}$
Upper Percent Within Limits	PWL_{UV}	**100.00**	Table 5.2.1-2
Lower Percent Within Limits	PWL_{LV}	**9.00**	Table 5.2.1-2
Air Void Pay Factor	P_V	**-0.200**	$((PWL_{UV} + PWL_{LV} - 100)*0.0030)-0.270$
Number of Tons in Lot	TONS	**3,000**	
Price per Ton	COST	**$75.00**	602.9d: Sheet 15-06007-R03-24
Air Void Pay Adjustment	V_aPA	**- $ 45,000.00**	$V_aPA = P_v$ * TONS * COST

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AIR VOID PAY FACTOR EXAMPLE

HMA Overlay (SR-12.5A)(PG 64-22)
(1.5" LIFT) (Lot 3)
602.9d. (Sheets 15-06007-R03-24 and 15-06007-R03-25)

Date	Test	Lift	Station	Lane	Air Void (%)	$\overline{X}$ (%)	S (%)	Quantity (Tons)
8/21/2024	3A	First	597+48	NB	1.64			750
8/21/2024	3B	First	667+45	NB	2.14	2.89	1.22	750
8/22/2024	3C	First	719+75	NB	4.29			750
8/22/2024	3D	First	801+09	NB	3.49			750

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Date	Test	Lift	Station	Lane	Air Void (%)	$\overline{X}$ (%)	S (%)	Quantity (Tons)
8/21/2024	3A	First	597+48	NB	1.64			750
8/21/2024	3B	First	667+45	NB	2.14	2.89	1.22	750
8/22/2024	3C	First	719+75	NB	4.29			750
8/22/2024	3D	First	801+09	NB	3.49			750

Number of Samples	n	**4**	Number of V_a Samples
Upper Specification Limit	*USL*	**4.00**	602.9d: Sheet 15-06007-R03-25
Lower Specification Limit	*LSL*	**2.00**	602.9d: Sheet 15-06007-R03-25
Upper Air Void Quality Limit	Q_{UV}		$Q_{UV} = \frac{USL - \overline{X}}{S}$
Lower Air Void Quality Limit	Q_{LV}		$Q_{LV} = \frac{\overline{X} - LSL}{S}$
Upper Percent Within Limits	PWL_{UV}		Table 5.2.1-2
Lower Percent Within Limits	PWL_{LV}		Table 5.2.1-2
Air Void Pay Factor	P_V		$((PWL_{UV} + PWL_{LV} - 100.00)*0.003)-0.270$
Number of Tons in Lot	TONS	**3,000**	
Price per Ton	COST		602.9d: Sheet 15-06007-R03-24
Air Void Pay Adjustment	V_aPA		$V_aPA = P_v * TONS * COST$

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AIR VOID PAY ADJUSTMENT
Lot 3

USL = 4.00%

$\bar{X}$ = 2.89

LSL = 2.00%

S = 1.22

$$Q_{UV} = \frac{USL - \bar{X}}{S}$$

$$Q_{UV} = \frac{4.00 - 2.89}{1.22}$$

$$Q_{UV} = \frac{1.11}{1.22}$$

$$Q_{UV} = 0.91$$

$$Q_{LV} = \frac{\bar{X} - LSL}{S}$$

$$Q_{LV} = \frac{2.89 - 2.00}{1.22}$$

$$Q_{LV} = \frac{0.89}{1.22}$$

$$Q_{LV} = 0.73$$

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Date	Test	Lift	Station	Lane	Air Void (%)	$\bar{X}$ (%)	S (%)	Quantity (Tons)
8/21/2024	3A	First	597+48	NB	1.64	2.89	1.22	750
8/21/2024	3B	First	667+45	NB	2.14			750
8/22/2024	3C	First	719+75	NB	4.29			750
8/22/2024	3D	First	801+09	NB	3.49			750

Number of Samples	n	**4**	Number of V_a Samples
Upper Specification Limit	*USL*	**4.00**	602.9d: Sheet 15-06007-R03-25
Lower Specification Limit	*LSL*	**2.00**	602.9d: Sheet 15-06007-R03-25
Upper Air Void Quality Limit	Q_{UV}	**0.91**	$Q_{UV} = \frac{USL - \bar{X}}{S}$
Lower Air Void Quality Limit	Q_{LV}	**0.73**	$Q_{LV} = \frac{\bar{X} - LSL}{S}$
Upper Percent Within Limits	PWL_{UV}		Table 5.2.1-2
Lower Percent Within Limits	PWL_{LV}		Table 5.2.1-2
Air Void Pay Factor	P_V		$((PWL_{UV} + PWL_{LV} - 100.00)*0.003)-0.270$
Number of Tons in Lot	TONS	**3,000**	
Price per Ton	COST		602.9d: Sheet 15-06007-R03-24
Air Void Pay Adjustment	V_aPA		$V_aPA = P_v$ * TONS * COST

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Q_U or Q_L	N=3	N=4	N=5	N=6	N=7
0.86	76.74	78.67	79.38	79.73	79.93
0.87	77.16	79.00	79.69	80.03	80.22
0.88	77.58	79.33	80.00	80.33	80.52
0.89	78.01	79.67	80.31	80.63	80.81
0.90	78.45	80.00	80.62	80.93	81.10
0.91	78.89	**80.33**	80.93	81.22	81.39
0.92	79.34	80.67	81.23	81.51	81.67
0.93	79.81	81.00	81.54	81.81	81.96
0.94	80.27	81.33	81.84	82.10	82.24
0.95	80.75	81.67	82.14	82.39	82.52
0.96	81.25	82.00	82.45	82.67	82.80
0.97	81.75	82.33	82.75	82.96	83.08

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Q_U or Q_L	N=3	N=4	N=5	N=6	N=7
0.68	70.04	72.67	73.60	74.06	74.32
0.69	70.39	73.00	73.93	74.39	74.65
0.70	70.73	73.33	74.26	74.71	74.97
0.71	71.08	73.67	74.59	75.04	75.29
0.72	71.43	74.00	74.91	75.36	75.61
0.73	71.78	**74.33**	75.24	75.68	75.93
0.74	72.14	74.67	75.56	76.00	76.25
0.75	72.50	75.00	75.89	76.32	76.56
0.76	72.87	75.33	76.21	76.63	76.88
0.77	73.24	75.67	76.53	76.95	77.19

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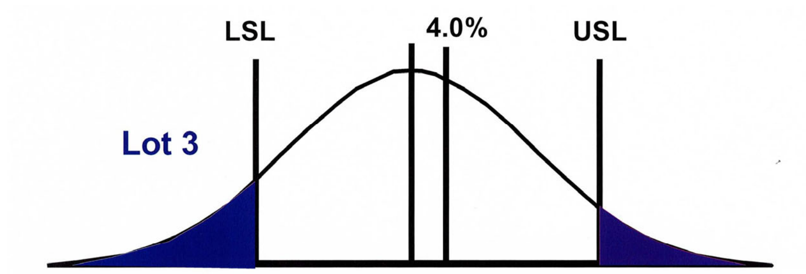
AIR VOID PAY ADJUSTMENT
Lot 3

$Q_{UV} = 0.91$ $Q_{LV} = 0.73$

$PWL_{UV} = 80.33$ $PWL_{LV} = 74.33$



$\bar{X} = 3.89$ & $S = 1.22$

Date	Test	Lift	Station	Lane	Air Void (%)	$\bar{X}$ (%)	S (%)	Quantity (Tons)
8/21/2024	3A	First	597+48	NB	1.64	2.89	1.22	750
8/21/2024	3B	First	667+45	NB	2.14			750
8/22/2024	3C	First	719+75	NB	4.29			750
8/22/2024	3D	First	801+09	NB	3.49			750

Number of Samples	n	**4**	Number of V_a Samples
Upper Specification Limit	*USL*	**4.00**	602.9d: Sheet 15-06007-R03-25
Lower Specification Limit	*LSL*	**2.00**	602.9d: Sheet 15-06007-R03-25
Upper Air Void Quality Limit	Q_{UV}	**0.91**	$Q_{UV} = \frac{USL - \bar{X}}{S}$
Lower Air Void Quality Limit	Q_{LV}	**0.73**	$Q_{LV} = \frac{\bar{X} - LSL}{S}$
Upper Percent Within Limits	PWL_{UV}	**80.33**	Table 5.2.1-2
Lower Percent Within Limits	PWL_{LV}	**74.33**	Table 5.2.1-2
Air Void Pay Factor	P_V		$((PWL_{UV} + PWL_{LV} – 100.00)*0.003)-0.270$
Number of Tons in Lot	TONS	**3,000**	
Price per Ton	COST		602.9d: Sheet 15-06007-R03-24
Air Void Pay Adjustment	V_aPA		$V_aPA = P_v$ * TONS * COST

AIR VOID PAY ADJUSTMENT
Lot 3

PWL_{UV} = 80.33 PWL_{LV} = 74.33

$$P_V = ((PWL_{UV} + PWL_{LV} - 100.00) * 0.003) - 0.270$$

$$P_V = ((80.33 + 74.33 - 100.00) * 0.003) - 0.270$$

$$P_V = ((54.66) * 0.003) - 0.270$$

$$P_V = (0.164) - 0.270$$

$$P_V = -0.106$$

Order of Operation

- Parenthesis
- Exponents
- Multiplication and Division
- Addition and Subtraction

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Date	Test	Lift	Station	Lane	Air Void (%)	$\bar{X}$ (%)	S (%)	Quantity (Tons)
8/21/2024	3A	First	597+48	NB	1.64	2.89	1.22	750
8/21/2024	3B	First	667+45	NB	2.14			750
8/22/2024	3C	First	719+75	NB	4.29			750
8/22/2024	3D	First	801+09	NB	3.49			750

Number of Samples	n	**4**	Number of V_a Samples
Upper Specification Limit	*USL*	**4.00**	602.9d: Sheet 15-06007-R03-25
Lower Specification Limit	*LSL*	**2.00**	602.9d: Sheet 15-06007-R03-25
Upper Air Void Quality Limit	Q_{UV}	**0.91**	$Q_{UV} = \frac{USL - \bar{X}}{S}$
Lower Air Void Quality Limit	Q_{LV}	**0.73**	$Q_{LV} = \frac{\bar{X} - LSL}{S}$
Upper Percent Within Limits	PWL_{UV}	**80.33**	Table 5.2.1-2
Lower Percent Within Limits	PWL_{LV}	**74.33**	Table 5.2.1-2
Air Void Pay Factor	P_V	**-0.106**	$((PWL_{UV} + PWL_{LV} - 100.00)*0.003)-0.270$
Number of Tons in Lot	TONS	**3,000**	
Price per Ton	COST		602.9d: Sheet 15-06007-R03-24
Air Void Pay Adjustment	V_aPA		$V_aPA = P_v * TONS * COST$

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Date	Test	Lift	Station	Lane	Air Void (%)	$\overline{X}$ (%)	S (%)	Quantity (Tons)
8/21/2024	3A	First	597+48	NB	1.64	2.89	1.22	750
8/21/2024	3B	First	667+45	NB	2.14			750
8/22/2024	3C	First	719+75	NB	4.29			750
8/22/2024	3D	First	801+09	NB	3.49			750

Number of Samples	n	**4**	Number of V_a Samples
Upper Specification Limit	*USL*	**4.00**	602.9d: Sheet 15-06007-R03-25
Lower Specification Limit	*LSL*	**2.00**	602.9d: Sheet 15-06007-R03-25
Upper Air Void Quality Limit	Q_{UV}	**0.91**	$Q_{UV} = \frac{USL - \overline{X}}{S}$
Lower Air Void Quality Limit	Q_{LV}	**0.73**	$Q_{LV} = \frac{\overline{X} - LSL}{S}$
Upper Percent Within Limits	PWL_{UV}	**80.33**	Table 5.2.1-2
Lower Percent Within Limits	PWL_{LV}	**74.33**	Table 5.2.1-2
Air Void Pay Factor	P_V	**-0.106**	$((PWL_{UV} + PWL_{LV} - 100.00)*0.003)-0.270$
Number of Tons in Lot	TONS	**3,000**	
Price per Ton	COST	**$75.00**	602.9d: Sheet 15-06007-R03-24
Air Void Pay Adjustment	V_aPA		$V_aPA = P_v$ * TONS * COST

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AIR VOID PAY ADJUSTMENT
Lot 3

P_V = -0.106

Air Void Payment Adjustment =

P_V * tons in lot * $75.00 per ton

= -0.106 * (3,000 * $75.00)

= -0.106 * (225,000)

= -$23,850.00

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Date	Test	Lift	Station	Lane	Air Void (%)	$\overline{X}$ (%)	S (%)	Quantity (Tons)
8/21/2024	3A	First	597+48	NB	1.64	2.89	1.22	750
8/21/2024	3B	First	667+45	NB	2.14			750
8/22/2024	3C	First	719+75	NB	4.29			750
8/22/2024	3D	First	801+09	NB	3.49			750

Number of Samples	n	**4**	Number of V_a Samples
Upper Specification Limit	*USL*	**4.00**	602.9d: Sheet 15-06007-R03-25
Lower Specification Limit	*LSL*	**2.00**	602.9d: Sheet 15-06007-R03-25
Upper Air Void Quality Limit	Q_{UV}	**0.91**	$Q_{UV} = \frac{USL - \overline{X}}{S}$
Lower Air Void Quality Limit	Q_{LV}	**0.73**	$Q_{LV} = \frac{\overline{X} - LSL}{S}$
Upper Percent Within Limits	PWL_{UV}	**80.33**	Table 5.2.1-2
Lower Percent Within Limits	PWL_{LV}	**74.33**	Table 5.2.1-2
Air Void Pay Factor	P_V	**-0.106**	$((PWL_{UV} + PWL_{LV} - 100.00)*0.003)-0.270$
Number of Tons in Lot	TONS	**3,000**	
Price per Ton	COST	**$75.00**	602.9d: Sheet 15-06007-R03-24
Air Void Pay Adjustment	V_aPA	**- $ 23,850.00**	$V_aPA = P_v$ * TONS * COST

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602.9 BASIS OF ACCEPTANCE
d. Air Void Pay Adjustment

- Keys
  - Air Voids Pay Adjustment for all Lots (shoulders, too)
  - Different procedure for Failing t-Test (different LSL and USL and set Standard Deviation value)
  - LSL = 2.00% and USL = 4.00% for passing t-Test
  - Must calculate a lower and upper Quality Index

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602.9 BASIS OF ACCEPTANCE
d. Air Void Pay Adjustment

Kansas Department of Transportation

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AIR VOIDS PAY FACTOR EXAMPLE (HMA Overlay (SR-12.5A)(PG 64-22)) (1.5" LIFT) (Lot 1)
602.9d. (Sheets 15-06007-R03-24 and 15-06007-R03-25)

Date	Test	Lift	Station	Lane	Air Void (%)	$\overline{X}$ (%)	S (%)	Quantity (Tons)
8/18/2024	1A	First	34+83	NB	3.30	3.23	0.44	750
8/18/2024	1B	First	87+69	NB	2.77			750
8/18/2024	1C	First	216+47	NB	3.05			750
8/19/2024	1D	First	223+70	NB	3.80			750

Number of Samples	n	______	Number of %Air Void Values
Upper Specification Limit	USL	______	602.9d. Sheet 15-06007-R03-25
Lower Specification Limit	LSL	______	602.9d. Sheet 15-06007-R03-25
Upper Air Void Quality Index	Q_{UV}	______	$Q_{UV} = \frac{USL - \overline{X}}{S}$
Lower Air Void Quality Index	Q_{LV}	______	$Q_{LV} = \frac{\overline{X} - LSL}{S}$
Upper Percent Within Limits (V_a)	PWL_{UV}	______	Table 5.2.1-2: Page 5.2.1-18
Lower Percent Within Limits (V_a)	PWL_{LV}	______	Table 5.2.1-2: Page 5.2.1-18
Air Void Pay Factor	P_V	______	$P_V = ((PWL_{UV} + PWL_{LV} - 100) * 0.003) - 0.270$
Number of Tons in the Lot	TONS	3,000	
Price per Ton for Pay Adjustment	COST	______	602.9d. Sheet 15-06007-R03-24
Air Void Pay Adjustment	V_aPA	______	$V_aPD = P_v$ * TONS * COST

AIR VOIDS PAY FACTOR EXAMPLE (HMA Overlay (SR-12.5A)(PG 64-22)) (1.5" LIFT) (Lot 2) 602.9d. (Sheets 15-06007-R03-24 and 15-06007-R03-25)

Date	Test	Lift	Station	Lane	Air Void (%)	$\overline{X}$ (%)	S (%)	Quantity (Tons)
8/19/2024	2A	First	337+71	NB	1.65	1.57	0.35	750
8/19/2024	2B	First	398+86	NB	1.94			750
8/20/2024	2C	First	482+99	NB	1.57			750
8/20/2024	2D	First	511+21	NB	1.10			750

Number of Samples	n	________	Number of %Air Void Values
Upper Specification Limit	USL	________	602.9d. Sheet 15-06007-R03-25
Lower Specification Limit	LSL	________	602.9d. Sheet 15-06007-R03-25
Upper Air Void Quality Index	Q_{UV}	________	$Q_{UV} = \frac{USL - \overline{X}}{S}$
Lower Air Void Quality Index	Q_{LV}	________	$Q_{LV} = \frac{\overline{X} - LSL}{S}$
Upper Percent Within Limits (V_a)	PWL_{UV}	________	Table 5.2.1-2: Page 5.2.1-18
Lower Percent Within Limits (V_a)	PWL_{LV}	________	Table 5.2.1-2: Page 5.2.1-18
Air Void Pay Factor	P_V	________	$P_V = ((PWL_{UV} + PWL_{LV} - 100) * 0.003) - 0.270$
Number of Tons in the Lot	TONS	3,000	
Price per Ton for Pay Adjustment	COST	________	602.9d. Sheet 15-06007-R03-24
Air Void Pay Adjustment	V_aPA	________	$V_aPD = P_v$ * TONS * COST

AIR VOIDS PAY FACTOR EXAMPLE (HMA Overlay (SR-12.5A)(PG 64-22)) (1.5" LIFT) (Lot 3) 602.9d. (Sheets 15-06007-R03-24 and 15-06007-R03-25)

Date	Test	Lift	Station	Lane	Air Void (%)	$\overline{X}$ (%)	S (%)	Quantity (Tons)
8/21/2024	3A	First	597+48	NB	1.64	2.89	1.22	750
8/21/2024	3B	First	667+45	NB	2.14			750
8/22/2024	3C	First	719+75	NB	4.29			750
8/22/2024	3D	First	801+09	NB	3.49			750

Number of Samples	n		Number of %Air Void Values
Upper Specification Limit	USL		602.9d. Sheet 15-06007-R03-25
Lower Specification Limit	LSL		602.9d. Sheet 15-06007-R03-25
Upper Air Void Quality Index	Q_{UV}		$Q_{UV} = \frac{USL - \overline{X}}{S}$
Lower Air Void Quality Index	Q_{LV}		$Q_{LV} = \frac{\overline{X} - LSL}{S}$
Upper Percent Within Limits (V_a)	PWL_{UV}		Table 5.2.1-2: Page 5.2.1-18
Lower Percent Within Limits (V_a)	PWL_{LV}		Table 5.2.1-2: Page 5.2.1-18
Air Void Pay Factor	P_V		$P_V = ((PWL_{UV} + PWL_{LV} - 100) * 0.003) - 0.270$
Number of Tons in the Lot	TONS	3,000	
Price per Ton for Pay Adjustment	COST		602.9d. Sheet 15-06007-R03-24
Air Void Pay Adjustment	V_aPA		$V_aPD = P_v * TONS * COST$

AIR VOIDS PAY FACTOR ( ) (" LIFT) (Lot)

602.9d. (Sheets 15-06007-R03-24 and 15-06007-R03-25)

Mean	$\overline{X}$	________	Average of %Air Voids
Standard Deviation	S	________	Standard Deviation of %Air Voids
Number of Samples	n	________	Number of %Air Void Values
Upper Specification Limit	USL	________	602.9d: Sheet 15-06007-R03-25
Lower Specification Limit	LSL	________	602.9d: Sheet 15-06007-R03-25
Upper Air Void Quality Index	Q_{UV}	________	$Q_{UV} = \frac{USL - \overline{X}}{S}$
Lower Air Void Quality Index	Q_{LV}	________	$Q_{LV} = \frac{\overline{X} - LSL}{S}$
Upper Percent Within Limits (V_a)	PWL_{UV}	________	Table 5.2.1-2: Page 5.2.1-18
Lower Percent Within Limits (V_a)	PWL_{LV}	________	Table 5.2.1-2: Page 5.2.1-18
Air Void Pay Factor	P_V	________	$P_V = ((PWL_{UV} + PWL_{LV} - 100.00) * 0.003) - 0.270$
Number of Tons in the Lot	TONS	________	
Price per Ton for Pay Adjustment	COST	________	602.9d: Sheet 15-06007-R01-24
Air Void Pay Adjustment	V_aPA		$V_aPD = P_v * TONS * COST$

QC/QA Asphalt Specifications Special Provision 15-06007-R03 Outline

602.1	Description (Sheet 1 of 30)
602.2	Contractor QC Requirements (Sheets 1 to 4 of 30)
602.3	Materials (Sheets 4 to 8 of 30)
602.4	Construction Requirements (Sheets 8 to 14 of 30)
602.5	Process Control (Sheets 14 to 17 of 30)
602.6	Compaction Testing (Sheets 17 to 19 of 30)
602.7	Weather Limitations (Sheet 19 of 30)
602.8	Mixture Acceptance (Sheets 19 to 22 of 30)
602.9	Basis of Acceptance (Sheets 22 to 25 of 30)
602.10	**HMA Paid by the Area (Sheets 25 to 29 of 30)**
602.11	Measurement and Payment (Sheets 29 to 30 of 30)

Kansas Department of Transportation

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602.10: DETERMINATION OF THICKNESS, THICKNESS PAY ADJUSTMENT AND AREA PAY ADJUSTMENTS FOR "HMA PAVEMENT"

aka: Uniform Thickness Specification

But we'll call it

"HMA Paid by the Area"

2

602.10 HMA PAID BY THE AREA

OBJECTIVES

- Demonstrate basic knowledge in:
  - Calculating pay adjustments for uniform thickness on new construction and reconstruction projects (HMA Pavement bid items - full depth, significant length)
  - Calculating pay for areas placed and not placed

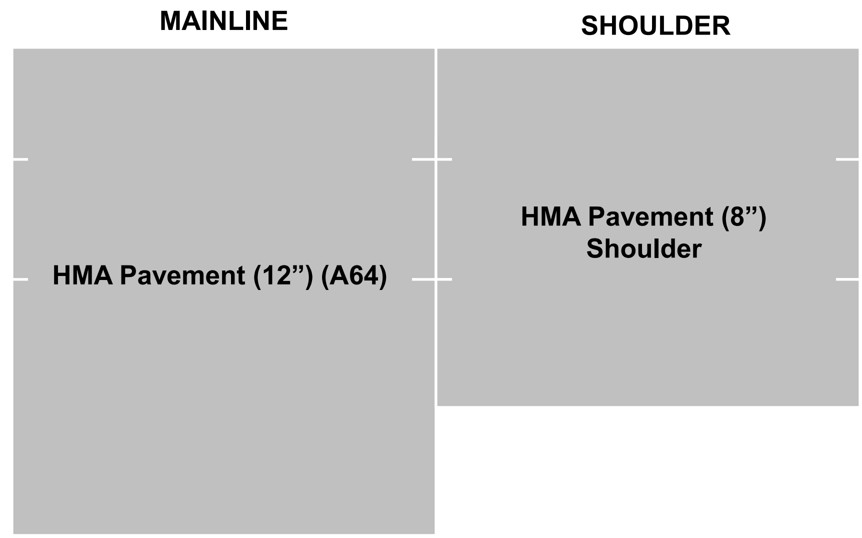
3

602.10 HMA PAID BY THE AREA Mixes

MAINLINE	SHOULDER
1.5” HMA Surface (SR-9.5A) (PG 64-28)	1.5” HMA Surface (SR-9.5A) (PG 58-28) SH
2.5” HMA Base (SR-19A) (PG 64-28)	2.5” HMA Base (SR-19A) (PG 58-28) SH
8” HMA Base (SR-19A) (PG 64-22)	4” HMA Base (SR-19A) (PG 64-22) SH

4

602.10 HMA PAID BY THE AREA
Bid Items



5

602.10 HMA PAID BY THE AREA
a. General

BID ITEMS

HMA Pavement (#) (##)

HMA Pavement (#) Shoulder

Thickness

Type of surface course HMA mixture

Examples:

HMA Pavement (12”) (A64*)

HMA Pavement (8”) Shoulder

*Likely values: A64, A70, A76

6

602.10 HMA PAID BY THE AREA
a. General

- Pave Entire "Connected" Width before Measuring and Coring
- Driving lane defined as:
  - Mainline Lanes
  - Accel/Decel Lanes (including Tapers)
  - Auxiliary Lanes
  - Ramps
- Include Shoulders and other Widenings with Adjacent Driving Lane if:
  - There is not a separate bid item for Shoulders
  - Paved at the same time as Driving Lane

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602.10 HMA PAID BY THE AREA
b. Measurements

- A Lot = 5-1000 ft. long sublots
  - Single Driving Lane or Single Shoulder (1000 ft)
  - Same thickness
  - If last lot has ≤ 2 sublots, combine with previous
  - Last lot can have 3 or 4 sublots

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602.10 HMA PAID BY THE AREA
b. Measurements

- Engineer generates 1 random core location per sublot
  - At least 1 foot from longitudinal joint or edge
  - Contractor obtains 4” diameter core
  - Engineer will measure thickness
    - Determine thickness of each mixture (FYI)
    - Thickness of total base in core (e.g. SR-19A) (FYI)
    - Determine total core thickness for pay adjustment
    - 3 measurements taken 120° apart and average
    - Measure to nearest 0.1”
  - Provide data to Contractor before end of following working day

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602.10 HMA PAID BY THE AREA
b. Measurements

- Areas trimmed without automatic equipment may be designated as a lot.
  - Divide into 5 sublots
  - Obtain 1 core/sublot
- Thick Cores > 1.0” thicker than plan thickness
  - Will calculate as 1.0” thicker than plan thickness
  - Keep standard deviation low
- Fill Core Holes by end of next working day
  - Dry the hole
  - Tack the sides & bottom
  - Fill and compact mix into the hole

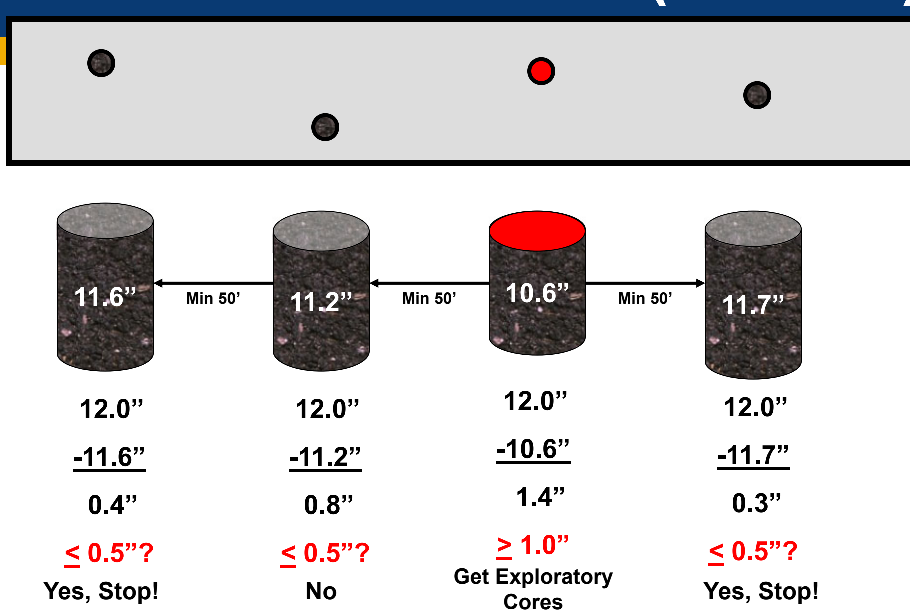
10

602.10 HMA PAID BY THE AREA
c. Deficient Measurements for Driving Lanes

- Deficient by 1.0” or greater
- Exploratory Cores not less than 50’ intervals
  - Continue until deficiency is ≤ 0.5”
  - Defines minimum length of overlay required
- Overlay width is full roadway width
- Overlay thickness ≥ 3 x {Nom Max Agg Size}
- Engineer must approve the overlay
- Mill Butt joints at ends
- Randomly select another core outside overlaid area to represent the sublot for pay

11

Plan Thickness = 12.0” (Mainline)



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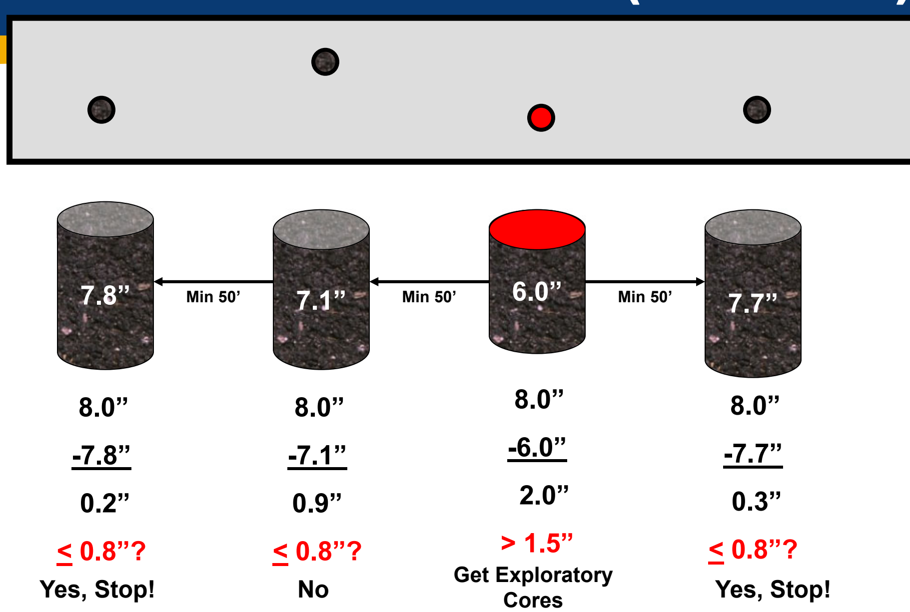
602.10 HMA PAID BY THE AREA
d. Deficient Measurements for Shoulders

- Deficient by greater than 1.5”
- Exploratory Cores not less than 50’ intervals
  - Continue until deficiency is < 0.8”
  - Defines minimum length of:
    - Removal and replacement, left in place at a reduced price, overlay
- Full Depth Repair is full shoulder width
- Rework, restabilize (if required), & regrade Subgrade & Base
- Mill Butt joints at ends of overlay
- Randomly select another core outside overlaid area to represent the sublot for pay

13

Plan Thickness = 8.0” (Shoulder)



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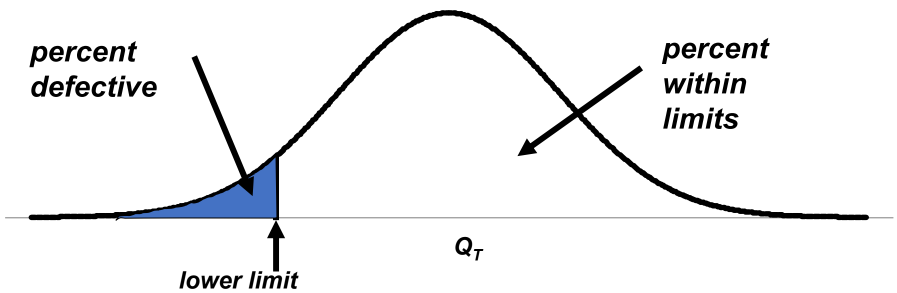
602.10 HMA PAID BY THE AREA
f. Thickness Pay Adjustments

- PWL for a single limit specification
- Pay Adjustment is calculated using Eq 6 or Eq 7

Eq 6: $TPA_{DL} = P_T(\sum PDLA)(\$3.50)(\text{Plan Thickness})$

Eq 7: $TPA_{SH} = P_T(\sum PSA)(\$3.20)(\text{Plan Thickness})$



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602.10 HMA PAID BY THE AREA
f. Thickness Pay Adjustments

- 1st must calculate P_T for Eq 6 and Eq 7
- P_T requires PWL_T per Eq 9
- To get a PWL_T, we first need a Q_T

(Equation 8)
$$Q_T = \frac{\overline{X} - LSL}{S}$$

(Q_T will be rounded to the nearest 0.01)

$\overline{X}$ = Avg of all cores in lot rounded to 0.1”

LSL = Plan Thickness of Driving Lane minus 0.5”
Plan Thickness of Shoulder minus 0.8”

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602.10 HMA PAID BY THE AREA
f. Thickness Pay Adjustments

Negative Q values

- Entire Lot and all adjacent areas (full width of roadway) will be overlaid
- After overlaying, randomly select another core for each sublot, and calculate a new pay factor.
- For lots that have been entirely overlaid, the maximum pay factor is zero.

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602.10 HMA PAID BY THE AREA
f. Thickness Pay Adjustments

Determination of P_T

(Equation 9)

$$P_T = \left(\frac{(PWL_T) * 0.3}{100} \right) - 0.270$$

(P_T will be rounded to the nearest 0.001)

No Incentive Paid for Shoulders
Maximum P_T = 0.000
However Disincentive is a Possibility

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602.10 HMA PAID BY THE AREA
f. Thickness Pay Adjustments

We can now calculate P_T In Equations 6 and 7

Eq 6: $TPA_{DL} = P_T(\sum PDLA)(\$3.50)(\text{Plan Thickness})$

Eq 7: $TPA_{SH} = P_T(\sum PSA)(\$3.20)(\text{Plan Thickness})$

We still need to determine ∑PDLA and ∑PSA

∑PDLA = Pay Driving Lane Area per Lot

∑PSA = Pay Shoulder Area per Lot

But 1st We'll compute P_T for a lot or 2

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COMPUTATION OF THICKNESS PAY FACTORS

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MAINLINE EXAMPLE

THICKNESS PAY FACTOR EXAMPLE								
Mainline		**602.10 (Sheets 15-06007-R03-25 to 15-06007-R03-29)**						
Date	**Test**	**Station**	**Lane**	**Dist from CL**	**Core Length**	**Adjusted Core Length**	**Plan Thickness**	**Pay Driving Lane Area in Lot**
				(ft)	**(in)**	**(in)**	**(in)**	**(yd^2)**
10/12/2024	1A	8+58	NB	2.6	11.6	11.6	12.0	6,666.67
10/12/2024	1B	15+24	NB	6.0	11.2	11.2		
10/12/2024	1C	26+37	NB	8.5	13.2	**13.0**		
10/12/2024	1D	39+21	NB	10.7	12.4	12.4		
10/12/2024	1E	47+53	NB	7.9	11.4	11.4		

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Mean	$\overline{X}$	11.9	Average of Core Lengths
Standard Deviation	S	0.76	Standard Deviation of Core Lengths
Number of Samples	n		Number of Cores
Plan Thickness	in		Typical Section
Amount to Subtract from Plan Thickness to get LSL	Adj		602.10f. Sheet 15-06007-R03-28 (DL=0.5": SH=0.8")
Lower Specification Limit	LSL		(Plan Thickness - Adjustment)
Lower Thickness Quality Index	Q_T		$Q_T = \frac{\overline{X} - LSL}{S}$
Lower Percent Within Limits (Thickness)	PWL_T		Table 5.2.1-2: Page 5.2.1-18
Thickness Pay Factor	P_T		$P_T = \left(\frac{(PWL_T) * 0.3}{100}\right) - 0.270$
Pay Driving Lane Area in Lot	yd^2	6,666.67	∑PDLA or ∑PSA
Price Adjustment per in	$		$3.50 for Driving Lane: $3.20 for Shoulder
Thickness Pay Adjustment per Lot for Driving Lane	TPA_{DL}		TPA=P_T(∑PDLA)($3.50)(Plan Thickness)

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Mean	$\overline{X}$	11.9	Average of Core Lengths
Standard Deviation	S	0.76	Standard Deviation of Core Lengths
Number of Samples	n	5	Number of Cores
Plan Thickness	in		Typical Section
Amount to Subtract from Plan Thickness to get LSL	Adj		602.10f. Sheet 15-06007-R03-28 (DL=0.5": SH=0.8")
Lower Specification Limit	LSL		(Plan Thickness - Adjustment)
Lower Thickness Quality Index	Q_T		$Q_T = \frac{\overline{X} - LSL}{S}$
Lower Percent Within Limits (Thickness)	PWL_T		Table 5.2.1-2: Page 5.2.1-18
Thickness Pay Factor	P_T		$P_T = \left(\frac{(PWL_T)*0.3}{100}\right) - 0.270$
Pay Driving Lane Area in Lot	yd^2	6,666.67	∑PDLA or ∑PSA
Price Adjustment per in	$		$3.50 for Driving Lane: $3.20 for Shoulder
Thickness Pay Adjustment per Lot for Driving Lane	TPA_{DL}		$TPA=P_T(\sum PDLA)(\$3.50)(Plan\ Thickness)$

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Mean	$\overline{X}$	11.9	Average of Core Lengths
Standard Deviation	S	0.76	Standard Deviation of Core Lengths
Number of Samples	n	5	Number of Cores
Plan Thickness	in	12.0	Typical Section
Amount to Subtract from Plan Thickness to get LSL	Adj		602.10f. Sheet 15-06007-R03-28 (DL=0.5": SH=0.8")
Lower Specification Limit	LSL		(Plan Thickness - Adjustment)
Lower Thickness Quality Index	Q_T		$Q_T = \frac{\overline{X} - LSL}{S}$
Lower Percent Within Limits (Thickness)	PWL_T		Table 5.2.1-2: Page 5.2.1-18
Thickness Pay Factor	P_T		$P_T = \left(\frac{(PWL_T)*0.3}{100}\right) - 0.270$
Pay Driving Lane Area in Lot	yd^2	6,666.67	∑PDLA or ∑PSA
Price Adjustment per in	$		$3.50 for Driving Lane: $3.20 for Shoulder
Thickness Pay Adjustment per Lot for Driving Lane	TPA_{DL}		$TPA=P_T(\sum PDLA)(\$3.50)(Plan\ Thickness)$

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602.10f
Sheet 15-06007-R03-28

$\overline{X}$ = Average total core length of all samples representing a lot, rounded to the nearest 0.1 inch. (Adjust core length before averaging, as shown in **subsection 602.10b.**)

LSL = Lower specification limit for thickness. For driving lanes use 0.5 inch less than the total plan driving lane thickness shown on the typical section. For shoulders, use 0.8 inch less than the total plan shoulder thickness shown on the typical section.

S = Sample standard deviation of the measured core lengths of all samples representing a lot and is calculated using equation (4) in Section 5.2.1 – Statistics, Part V, rounded to hundredths.

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Mean	$\overline{X}$	11.9	Average of Core Lengths		
Standard Deviation	S	0.76	Standard Deviation of Core Lengths		
Number of Samples	n	5	Number of Cores		
Plan Thickness	in	12.0	Typical Section		
Amount to Subtract from Plan Thickness to get LSL	Adj	0.5	602.10f. Sheet 15-06007-R03-28 (DL=0.5": SH=0.8")		
Lower Specification Limit	LSL		(Plan Thickness - Adjustment)		
Lower Thickness Quality Index	Q_T		$Q_T = \frac{\overline{X} - LSL}{S}$		
Lower Percent Within Limits (Thickness)	PWL_T		Table 5.2.1-2: Page 5.2.1-18		
Thickness Pay Factor	P_T		$P_T = \left(\frac{(PWL_T)*0.3}{100}\right) - 0.270$		
Pay Driving Lane Area in Lot	yd^2	6,666.67	∑PDLA or ∑PSA		
Price Adjustment per in	$		$3.50 for Driving Lane: $3.20 for Shoulder		
Thickness Pay Adjustment per Lot for Driving Lane	TPA_{DL}		$TPA=P_T(\sum PDLA)(\$3.50)(Plan\ Thickness)$		

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LSL = Plan Thickness - Adjustment

LSL = 12.0 - 0.5

LSL = 11.5

Order of Operation

- Parenthesis
- Exponents
- Multiplication and Division
- Addition and Subtraction

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Mean	$\overline{X}$	11.9	Average of Core Lengths
Standard Deviation	S	0.76	Standard Deviation of Core Lengths
Number of Samples	n	5	Number of Cores
Plan Thickness	in	12.0	Typical Section
Amount to Subtract from Plan Thickness to get LSL	Adj	0.5	602.10f. Sheet 15-06007-R03-28 (DL=0.5": SH=0.8")
Lower Specification Limit	LSL	11.5	(Plan Thickness - Adjustment)
Lower Thickness Quality Index	Q_T		$Q_T = \frac{\overline{X} - LSL}{S}$
Lower Percent Within Limits (Thickness)	PWL_T		Table 5.2.1-2: Page 5.2.1-18
Thickness Pay Factor	P_T		$P_T = \left(\frac{(PWL_T) * 0.3}{100}\right) - 0.270$
Pay Driving Lane Area in Lot	yd^2	6,666.67	∑PDLA or ∑PSA
Price Adjustment per in	$		$3.50 for Driving Lane: $3.20 for Shoulder
Thickness Pay Adjustment per Lot for Driving Lane	TPA_{DL}		$TPA=P_T(\sum PDLA)(\$3.50)(\text{Plan Thickness})$

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$$Q_T = \frac{\overline{X} - LSL}{S}$$

$$Q_T = \frac{11.9 - 11.5}{0.76}$$

$$Q_T = \frac{0.4}{0.76}$$

$$Q_T = 0.53$$

Order of Operation

- Parenthesis
- Exponents
- Multiplication and Division
- Addition and Subtraction

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Mean	$\overline{X}$	11.9	Average of Core Lengths
Standard Deviation	S	0.76	Standard Deviation of Core Lengths
Number of Samples	n	5	Number of Cores
Plan Thickness	in	12.0	Typical Section
Amount to Subtract from Plan Thickness to get LSL	Adj	0.5	602.10f. Sheet 15-06007-R03-28 (DL=0.5": SH=0.8")
Lower Specification Limit	LSL	11.5	(Plan Thickness - Adjustment)
Lower Thickness Quality Index	Q_T	0.53	$Q_T = \frac{\overline{X} - LSL}{S}$
Lower Percent Within Limits (Thickness)	PWL_T		Table 5.2.1-2: Page 5.2.1-18
Thickness Pay Factor	P_T		$P_T = \left(\frac{(PWL_T) * 0.3}{100}\right) - 0.270$
Pay Driving Lane Area in Lot	yd^2	6,666.67	∑PDLA or ∑PSA
Price Adjustment per in	$		$3.50 for Driving Lane: $3.20 for Shoulder
Thickness Pay Adjustment per Lot for Driving Lane	TPA_{DL}		TPA=P_T(∑PDLA)($3.50)(Plan Thickness)

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Q_U or Q_L	N=3	N=4	N=5	N=6	N=7	N=8	N=9	N=10
0.44	62.44	64.67	65.50	65.92	66.16	66.32	66.43	66.51
0.45	62.74	65.00	65.84	66.27	66.51	66.67	66.79	66.87
0.46	63.04	65.33	66.19	66.62	66.87	67.03	67.14	67.22
0.47	63.34	65.67	66.53	66.96	67.22	67.38	67.49	67.58
0.48	63.65	66.00	66.88	67.31	67.57	67.73	67.85	67.93
0.49	63.95	66.33	67.22	67.66	67.92	68.08	68.20	68.28
0.50	64.25	66.67	67.56	68.00	68.26	68.43	68.55	68.63
0.51	64.56	67.00	67.90	68.35	68.61	68.78	68.90	68.98
0.52	64.87	67.33	68.24	68.69	68.96	69.13	69.24	69.33
0.53	65.18	67.67	68.58	69.04	69.30	69.47	69.59	69.68
0.54	65.49	68.00	68.92	69.38	69.64	69.82	69.93	70.02
0.55	65.80	68.33	69.26	69.72	69.99	70.16	70.28	70.36
0.56	66.12	68.67	69.60	70.06	70.33	70.50	70.62	70.71
0.57	66.43	69.00	69.94	70.40	70.67	70.84	70.96	71.05
0.58	66.75	69.33	70.27	70.74	71.01	71.18	71.30	71.39
0.59	67.07	69.67	70.61	71.07	71.34	71.52	71.64	71.72
0.60	67.39	70.00	70.95	71.41	71.68	71.85	71.97	72.06
0.61	67.72	70.33	71.28	71.75	72.02	72.19	72.31	72.40
0.62	68.04	70.67	71.61	72.08	72.35	72.52	72.64	72.73
0.63	68.37	71.00	71.95	72.41	72.68	72.85	72.97	73.06
0.64	68.70	71.33	72.28	72.74	73.01	73.18	73.30	73.39
0.65	69.03	71.67	72.61	73.08	73.34	73.51	73.63	73.72

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Mean	$\overline{X}$	11.9	Average of Core Lengths
Standard Deviation	S	0.76	Standard Deviation of Core Lengths
Number of Samples	n	5	Number of Cores
Plan Thickness	in	12.0	Typical Section
Amount to Subtract from Plan Thickness to get LSL	Adj	0.5	602.10f. Sheet 15-06007-R03-28 (DL=0.5": SH=0.8")
Lower Specification Limit	LSL	11.5	(Plan Thickness - Adjustment)
Lower Thickness Quality Index	Q_T	0.53	$Q_T = \frac{\overline{X} - LSL}{S}$
Lower Percent Within Limits (Thickness)	PWL_T	68.58	Table 5.2.1-2: Page 5.2.1-18
Thickness Pay Factor	P_T		$P_T = \left(\frac{(PWL_T)*0.3}{100}\right) - 0.270$
Pay Driving Lane Area in Lot	yd^2	6,666.67	∑PDLA or ∑PSA
Price Adjustment per in	$		$3.50 for Driving Lane: $3.20 for Shoulder
Thickness Pay Adjustment per Lot for Driving Lane	TPA_{DL}		$TPA=P_T(\sum PDLA)(\$3.50)(Plan Thickness)$

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$$P_T = \left(\frac{(PWL_T) * 0.3}{100} \right) - 0.270$$

$$P_T = \left(\frac{(68.58) * 0.3}{100} \right) - 0.270$$

$$P_T = \left(\frac{(20.574)}{100} \right) - 0.270$$

$$P_T = (0.20574) - 0.270$$

$$P_T = -0.064$$

Order of Operation

- Parenthesis
- Exponents
- Multiplication and Division
- Addition and Subtraction

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Mean	$\overline{X}$	11.9	Average of Core Lengths
Standard Deviation	S	0.76	Standard Deviation of Core Lengths
Number of Samples	n	5	Number of Cores
Plan Thickness	in	12.0	Typical Section
Amount to Subtract from Plan Thickness to get LSL	Adj	0.5	602.10f. Sheet 15-06007-R03-28 (DL=0.5": SH=0.8")
Lower Specification Limit	LSL	11.5	(Plan Thickness - Adjustment)
Lower Thickness Quality Index	Q_T	0.53	$Q_T = \frac{\overline{X} - LSL}{S}$
Lower Percent Within Limits (Thickness)	PWL_T	68.58	Table 5.2.1-2: Page 5.2.1-18
Thickness Pay Factor	P_T	-0.064	$P_T = \left(\frac{(PWL_T) * 0.3}{100} \right) - 0.270$
Pay Driving Lane Area in Lot	yd^2	6,666.67	∑PDLA or ∑PSA
Price Adjustment per in	$		$3.50 for Driving Lane: $3.20 for Shoulder
Thickness Pay Adjustment per Lot for Driving Lane	TPA_{DL}		$TPA=P_T$(∑PDLA)($3.50)(Plan Thickness)

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602.10f
Sheet 15-06007-R03-27

f. Asphalt Pavement Thickness Pay Adjustment. Compute the Asphalt Thickness Pay Adjustment for the driving lanes (TPA_{DL}) and shoulders (TPA_{SH}) using Equation 6 or 7, respectively. Compute the Asphalt Thickness Pay Adjustment factor (P_T) as shown in Equation 9. Determine area calculations for the driving lanes and shoulders as shown in **TABLE 602-18**. **TABLE 602-17** provides the definition for the abbreviations used in **TABLE 602-18**. Enter the measured values into the spreadsheet program to determine PDLA and PSA.

This adjustment will be paid for under the bid item Asphalt Pavement Thickness Adjustment.

Equation 6: $TPA_{DL} = P_T\ (\sum PDLA)(\$3.50)(\text{Plan Thickness})$

Equation 7: $TPA_{SH} = P_T\ (\sum PSA)(\$3.20)(\text{Plan Thickness})$

TPA_{DL} = Thickness Pay Adjustment per Lot for Driving Lane

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Mean	$\overline{X}$	11.9	Average of Core Lengths
Standard Deviation	S	0.76	Standard Deviation of Core Lengths
Number of Samples	n	5	Number of Cores
Plan Thickness	in	12.0	Typical Section
Amount to Subtract from Plan Thickness to get LSL	Adj	0.5	602.10f. Sheet 15-06007-R03-28 (DL=0.5": SH=0.8")
Lower Specification Limit	LSL	11.5	(Plan Thickness - Adjustment)
Lower Thickness Quality Index	Q_T	0.53	$Q_T = \frac{\overline{X} - LSL}{S}$
Lower Percent Within Limits (Thickness)	PWL_T	68.58	Table 5.2.1-2: Page 5.2.1-18
Thickness Pay Factor	P_T	-0.064	$P_T = \left(\frac{(PWL_T)*0.3}{100}\right) - 0.270$
Pay Driving Lane Area in Lot	yd^2	6,666.67	$\sum PDLA$ or $\sum PSA$
Price Adjustment per in	\$	\$3.50	\$3.50 for Driving Lane: \$3.20 for Shoulder
Thickness Pay Adjustment per Lot for Driving Lane	TPA_{DL}		$TPA = P_T(\sum PDLA)(\$3.50)(\text{Plan Thickness})$

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Thickness Pay Adjustment

TPA = P_T(∑PDLA)($3.50)(Plan Thickness)

TPA = (-0.064)(6,666.67)[($3.50)(12.0)]

TPA = (-0.064){(6,666.67)[42]}

TPA = (-0.064){280,000.1}

TPA = -$17,920.00

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Mean	$\overline{X}$	11.9	Average of Core Lengths
Standard Deviation	S	0.76	Standard Deviation of Core Lengths
Number of Samples	n	5	Number of Cores
Plan Thickness	in	12.0	Typical Section
Amount to Subtract from Plan Thickness to get LSL	Adj	0.5	602.10f. Sheet 15-06007-R03-28 (DL=0.5": SH=0.8
Lower Specification Limit	LSL	11.5	(Plan Thickness - Adjustment)
Lower Thickness Quality Index	Q_T	0.53	$Q_T = \frac{\overline{X} - LSL}{S}$
Lower Percent Within Limits (Thickness)	PWL_T	68.58	Table 5.2.1-2: Page 5.2.1-18
Thickness Pay Factor	P_T	-0.064	$P_T = \left(\frac{(PWL_T)*0.3}{100}\right) - 0.270$
Pay Driving Lane Area in Lot	yd^2	6,666.67	∑PDLA or ∑PSA
Price Adjustment per in	$	$3.50	$3.50 for Driving Lane: $3.20 for Shoulder
Thickness Pay Adjustment per Lot for Driving Lane	TPA_{DL}	$17,920.00	TPA=P_T(∑PDLA)($3.50)(Plan Thickness)

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SHOULDER EXAMPLE

THICKNESS PAY FACTOR EXAMPLE								
Shoulder	602.10 (Sheets 15-06007-R03-25 to 15-06007-R03-29)							
Date	Test	Station	Lane	Dist from CL	Core Length	Adjusted Core Length	Plan Thickness	Pay Shoulder Area in Lot
				(ft)	(in)	(in)	(in)	(yd^2)
10/12/2024	1A	6+44	NB	16.7	8.0	8.0	8.0	5,555.56
10/12/2024	1B	12+93	NB	14.8	8.3	8.3		
10/12/2024	1C	28+14	NB	18.2	8.5	8.5		
10/12/2024	1D	33+27	NB	18.1	7.9	7.9		
10/12/2024	1E	43+85	NB	17.5	8.1	8.1		

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Mean	$\overline{X}$	8.2	Average of Core Lengths
Standard Deviation	S	0.24	Standard Deviation of Core Lengths
Number of Samples	n		Number of Cores
Plan Thickness	in		Typical Section
Amount to Subtract from Plan Thickness to get LSL	Adj		602.10f. Sheet 15-06007-R03-28 (DL=0.5": SH=0.8")
Lower Specification Limit	LSL		(Plan Thickness - Adjustment)
Lower Thickness Quality Index	Q_T		$Q_T = \frac{\overline{X} - LSL}{S}$
Lower Percent Within Limits (Thickness)	PWL_T		Table 5.2.1-2: Page 5.2.1-18
Thickness Pay Factor	P_T		$P_T = \left(\frac{(PWL_T)*0.3}{100}\right) - 0.270$
Pay Shoulder Area in Lot	yd^2	5,555.56	∑PDLA or ∑PSA
Price Adjustment per in	$		$3.50 for Driving Lane: $3.20 for Shoulder
Thickness Pay Adjustment per Lot for Shoulder	TPA_{SH}		$TPA=P_T$(∑PSA)($3.20)(Plan Thickness)

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Mean	$\overline{X}$	8.2	Average of Core Lengths
Standard Deviation	S	0.24	Standard Deviation of Core Lengths
Number of Samples	n	5	Number of Cores
Plan Thickness	in		Typical Section
Amount to Subtract from Plan Thickness to get LSL	Adj		602.10f. Sheet 15-06007-R03-28 (DL=0.5": SH=0.8")
Lower Specification Limit	LSL		(Plan Thickness - Adjustment)
Lower Thickness Quality Index	Q_T		$Q_T = \frac{\overline{X} - LSL}{S}$
Lower Percent Within Limits (Thickness)	PWL_T		Table 5.2.1-2: Page 5.2.1-18
Thickness Pay Factor	P_T		$P_T = \left(\frac{(PWL_T)*0.3}{100}\right) - 0.270$
Pay Shoulder Area in Lot	yd^2	5,555.56	∑PDLA or ∑PSA
Price Adjustment per in	$		$3.50 for Driving Lane: $3.20 for Shoulder
Thickness Pay Adjustment per Lot for Shoulder	TPA_{SH}		$TPA=P_T$(∑PSA)($3.20)(Plan Thickness)

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Mean	$\overline{X}$	8.2	Average of Core Lengths
Standard Deviation	S	0.24	Standard Deviation of Core Lengths
Number of Samples	n	5	Number of Cores
Plan Thickness	in	8.0	Typical Section
Amount to Subtract from Plan Thickness to get LSL	Adj		602.10f. Sheet 15-06007-R03-28 (DL=0.5": SH=0.8")
Lower Specification Limit	LSL		(Plan Thickness - Adjustment)
Lower Thickness Quality Index	Q_T		$Q_T = \frac{\overline{X} - LSL}{S}$
Lower Percent Within Limits (Thickness)	PWL_T		Table 5.2.1-2: Page 5.2.1-18
Thickness Pay Factor	P_T		$P_T = \left(\frac{(PWL_T)*0.3}{100}\right) - 0.270$
Pay Shoulder Area in Lot	yd^2	5,555.56	∑PDLA or ∑PSA
Price Adjustment per in	$		$3.50 for Driving Lane: $3.20 for Shoulder
Thickness Pay Adjustment per Lot for Shoulder	TPA_{SH}		$TPA=P_T$(∑PSA)($3.20)(Plan Thickness)

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602.10f
Sheet 15-06007-R03-28

$\overline{X}$ = Average total core length of all samples representing a lot, rounded to the nearest 0.1 inch. (Adjust core length before averaging, as shown in **subsection 602.10b.**)
LSL = Lower specification limit for thickness. For driving lanes use 0.5 inch less than the total plan driving lane thickness shown on the typical section. For shoulders, use 0.8 inch less than the total plan shoulder thickness shown on the typical section.
S = Sample standard deviation of the measured core lengths of all samples representing a lot and is calculated using equation (4) in Section 5.2.1 – Statistics, Part V, rounded to hundredths.

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Mean	$\overline{X}$	8.2	Average of Core Lengths
Standard Deviation	S	0.24	Standard Deviation of Core Lengths
Number of Samples	n	5	Number of Cores
Plan Thickness	in	8.0	Typical Section
Amount to Subtract from Plan Thickness to get LSL	Adj	0.8	602.10f. Sheet 15-06007-R03-28 (DL=0.5": SH=0.8")
Lower Specification Limit	LSL		(Plan Thickness - Adjustment)
Lower Thickness Quality Index	Q_T		$Q_T = \frac{\overline{X} - LSL}{S}$
Lower Percent Within Limits (Thickness)	PWL_T		Table 5.2.1-2: Page 5.2.1-18
Thickness Pay Factor	P_T		$P_T = \left(\frac{(PWL_T)*0.3}{100}\right) - 0.270$
Pay Shoulder Area in Lot	yd^2	5,555.56	∑PDLA or ∑PSA
Price Adjustment per in	$		$3.50 for Driving Lane: $3.20 for Shoulder
Thickness Pay Adjustment per Lot for Shoulder	TPA_{SH}		$TPA=P_T(\sum PSA)(\$3.20)(Plan\ Thickness)$

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LSL = Plan Thickness – Adjustment

LSL = 8.0 - 0.8

LSL = 7.2

Order of Operation

- Parenthesis
- Exponents
- Multiplication and Division
- Addition and Subtraction

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Mean	$\overline{X}$	8.2	Average of Core Lengths
Standard Deviation	S	0.24	Standard Deviation of Core Lengths
Number of Samples	n	5	Number of Cores
Plan Thickness	in	8.0	Typical Section
Amount to Subtract from Plan Thickness to get LSL	Adj	0.8	602.10f. Sheet 15-06007-R03-28 (DL=0.5": SH=0.8")
Lower Specification Limit	LSL	7.2	(Plan Thickness - Adjustment)
Lower Thickness Quality Index	Q_T		$Q_T = \frac{\overline{X} - LSL}{S}$
Lower Percent Within Limits (Thickness)	PWL_T		Table 5.2.1-2: Page 5.2.1-18
Thickness Pay Factor	P_T		$P_T = \left(\frac{(PWL_T) * 0.3}{100}\right) - 0.270$
Pay Shoulder Area in Lot	yd^2	5,555.56	∑PDLA or ∑PSA
Price Adjustment per in	$		$3.50 for Driving Lane: $3.20 for Shoulder
Thickness Pay Adjustment per Lot for Shoulder	TPA_{SH}		$TPA=P_T(\sum PSA)(\$3.20)(\text{Plan Thickness})$

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$$Q_T = \frac{\bar{X} - LSL}{S}$$

$$Q_T = \frac{8.2 - 7.2}{0.24}$$

$$Q_T = \frac{1.0}{0.24}$$

$$Q_T = 4.17$$

Order of Operation

- Parenthesis
- Exponents
- Multiplication and Division
- Addition and Subtraction

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Mean	$\bar{X}$	8.2	Average of Core Lengths
Standard Deviation	S	0.24	Standard Deviation of Core Lengths
Number of Samples	n	5	Number of Cores
Plan Thickness	in	8.0	Typical Section
Amount to Subtract from Plan Thickness to get LSL	Adj	0.8	602.10f. Sheet 15-06007-R03-28 (DL=0.5": SH=0.8")
Lower Specification Limit	LSL	7.2	(Plan Thickness - Adjustment)
Lower Thickness Quality Index	Q_T	4.17	$Q_T = \frac{\bar{X} - LSL}{S}$
Lower Percent Within Limits (Thickness)	PWL_T		Table 5.2.1-2: Page 5.2.1-18
Thickness Pay Factor	P_T		$P_T = \left(\frac{(PWL_T) * 0.3}{100}\right) - 0.270$
Pay Shoulder Area in Lot	yd^2	5,555.56	∑PDLA or ∑PSA
Price Adjustment per in	$		$3.50 for Driving Lane: $3.20 for Shoulder
Thickness Pay Adjustment per Lot for Shoulder	TPA_{SH}		$TPA = P_T(\sum PSA)(\$3.20)(\text{Plan Thickness})$

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Q_U or Q_L	N=3	N=4	N=5	N=6	N=7	N=8	N=9	N=10
3.55	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
3.56	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
3.57	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
3.58	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
3.59	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
3.60	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
3.61	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
3.62	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
3.63	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
3.64	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
3.65	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
3.66	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
3.67	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
3.68	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
3.69	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
3.70	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
3.71	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
3.72	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
3.73	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
3.74	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
3.75	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
3.76	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

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Mean	$\overline{X}$	8.2	Average of Core Lengths
Standard Deviation	S	0.24	Standard Deviation of Core Lengths
Number of Samples	n	5	Number of Cores
Plan Thickness	in	8.0	Typical Section
Amount to Subtract from Plan Thickness to get LSL	Adj	0.8	602.10f. Sheet 15-06007-R03-28 (DL=0.5": SH=0.8")
Lower Specification Limit	LSL	7.2	(Plan Thickness - Adjustment)
Lower Thickness Quality Index	Q_T	4.17	$Q_T = \frac{\overline{X} - LSL}{S}$
Lower Percent Within Limits (Thickness)	PWL_T	100.00	Table 5.2.1-2: Page 5.2.1-18
Thickness Pay Factor	P_T		$P_T = \left(\frac{(PWL_T) * 0.3}{100}\right) - 0.270$
Pay Shoulder Area in Lot	yd^2	5,555.56	∑PDLA or ∑PSA
Price Adjustment per in	$		$3.50 for Driving Lane: $3.20 for Shoulder
Thickness Pay Adjustment per Lot for Shoulder	TPA_{SH}		$TPA=P_T$(∑PSA)($3.20)(Plan Thickness)

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$$P_T = \left(\frac{(PWL_T) * 0.3}{100}\right) - 0.270$$

$$P_T = \left(\frac{(100.00) * 0.3}{100}\right) - 0.270$$

$$P_T = \left(\frac{(30.000)}{100}\right) - 0.270$$

$$P_T = (0.300) - 0.270$$

$$P_T = 0.030$$

For Shoulders However:
P_T is never greater than 0.000
Therefore, P_T = 0.000

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Mean	$\overline{X}$	8.2	Average of Core Lengths		
Standard Deviation	S	0.24	Standard Deviation of Core Lengths		
Number of Samples	n	5	Number of Cores		
Plan Thickness	in	8.0	Typical Section		
Amount to Subtract from Plan Thickness to get LSL	Adj	0.8	602.10f. Sheet 15-06007-R03-28 (DL=0.5": SH=0.8")		
Lower Specification Limit	LSL	7.2	(Plan Thickness - Adjustment)		
Lower Thickness Quality Index	Q_T	4.17	$Q_T = \frac{\overline{X} - LSL}{S}$		
Lower Percent Within Limits (Thickness)	PWL_T	100.00	Table 5.2.1-2: Page 5.2.1-18		
Thickness Pay Factor	P_T	0.000	$P_T = \left(\frac{(PWL_T) * 0.3}{100}\right) - 0.270$		
Pay Shoulder Area in Lot	yd^2	5,555.56	∑PDLA or ∑PSA		
Price Adjustment per in	$		$3.50 for Driving Lane: $3.20 for Shoulder		
Thickness Pay Adjustment per Lot for Shoulder	TPA_{SH}		TPA=P_T(∑PSA)($3.20)(Plan Thickness)		

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602.10f
Sheet 15-06007-R03-27

f. Asphalt Pavement Thickness Pay Adjustment. Compute the Asphalt Thickness Pay Adjustment for the driving lanes (TPA_{DL}) and shoulders (TPA_{SH}) using Equation 6 or 7, respectively. Compute the Asphalt Thickness Pay Adjustment factor (P_T) as shown in Equation 9. Determine area calculations for the driving lanes and shoulders as shown in **TABLE 602-18**. **TABLE 602-17** provides the definition for the abbreviations used in **TABLE 602-18**. Enter the measured values into the spreadsheet program to determine PDLA and PSA.

This adjustment will be paid for under the bid item Asphalt Pavement Thickness Adjustment.

Equation 6: $TPA_{DL} = P_T\,(\sum PDLA)(\$3.50)(\text{Plan Thickness})$

Equation 7: $TPA_{SH} = P_T\,(\sum PSA)(\$3.20)(\text{Plan Thickness})$

TPA_{DL} = Thickness Pay Adjustment per Lot for Driving Lane

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Mean	$\overline{X}$	8.2	Average of Core Lengths		
Standard Deviation	S	0.24	Standard Deviation of Core Lengths		
Number of Samples	n	5	Number of Cores		
Plan Thickness	in	8.0	Typical Section		
Amount to Subtract from Plan Thickness to get LSL	Adj	0.8	602.10f. Sheet 15-06007-R03-28 (DL=0.5": SH=0.8")		
Lower Specification Limit	LSL	7.2	(Plan Thickness - Adjustment)		
Lower Thickness Quality Index	Q_T	4.17	$Q_T = \dfrac{\overline{X} - LSL}{S}$		
Lower Percent Within Limits (Thickness)	PWL_T	100.00	Table 5.2.1-2: Page 5.2.1-18		
Thickness Pay Factor	P_T	0.000	$P_T = \left(\dfrac{(PWL_T)*0.3}{100}\right) - 0.270$		
Pay Shoulder Area in Lot	yd^2	5,555.56	∑PDLA or ∑PSA		
Price Adjustment per in	$	$3.20	$3.50 for Driving Lane: $3.20 for Shoulder		
Thickness Pay Adjustment per Lot for Shoulder	TPA_{SH}		$TPA=P_T(\sum PSA)(\$3.20)(\text{Plan Thickness})$		

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Mean	$\overline{X}$	8.2	Average of Core Lengths
Standard Deviation	S	0.24	Standard Deviation of Core Lengths
Number of Samples	n	5	Number of Cores
Plan Thickness	in	8.0	Typical Section
Amount to Subtract from Plan Thickness to get LSL	Adj	0.8	602.10f. Sheet 15-06007-R03-28 (DL=0.5": SH=0.8")
Lower Specification Limit	LSL	7.2	(Plan Thickness - Adjustment)
Lower Thickness Quality Index	Q_T	4.17	$Q_T = \frac{\overline{X} - LSL}{S}$
Lower Percent Within Limits (Thickness)	PWL_T	100.00	Table 5.2.1-2: Page 5.2.1-18
Thickness Pay Factor	P_T	0.000	$P_T = \left(\frac{(PWL_T)*0.3}{100}\right) - 0.270$
Pay Shoulder Area in Lot	yd^2	5,555.56	∑PDLA or ∑PSA
Price Adjustment per in	$	$3.20	$3.50 for Driving Lane: $3.20 for Shoulder
Thickness Pay Adjustment per Lot for Shoulder	TPA_{SH}	$0.00	TPA=P_T(∑PSA)($3.20)(Plan Thickness)

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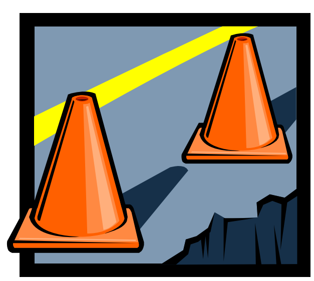
PAY PER LOT FOR AREAS PLACED AND NOT PLACED



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602.10 HMA PAID BY THE AREA
e. Area Pay Adjustments

Pay Equations per Lot for **Driving Lane** Areas

Placed

Equation 10:

Pay for Driving Lane = (∑PDLA)(BP)

Not Placed (Deducted)

Equation 11:

Pay Deduct for Driving Lanes = 2(∑PDLDA)(BP)

∑PDLA = **P**ay **D**riving **L**ane **A**rea per Lot

∑PDLDA = **P**ay **D**riving **L**ane **D**educt **A**rea per Lot

BP = **B**id **P**rice

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602.10 HMA PAID BY THE AREA
e. Area Pay Adjustments

Pay Equations per Lot for **Shoulder** Areas

Placed

Equation 12:

Pay for Shoulder = (∑PSA)(BP)

Not Placed (Deducted)

Equation 13:

Pay Deduct for Shoulder = 2(∑PSDA)(BP)

∑PSA = **P**ay **S**houlder **A**rea per Lot

∑PSDA = **P**ay **S**houlder **D**educt **A**rea per Lot

BP = **B**id **P**rice

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602.10 HMA PAID BY THE AREA
e. Area Pay Adjustments

TABLE 602-18

HMA UNIFORM THICKNESS SUBLOT CALCULATIONS

EQUATIONS FOR AREA CALCULATIONS

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602.10 HMA PAID BY THE AREA
Area Calculations

I. – Separate Bid Item for Shoulders
- A - Narrow Driving Lane
  - 1) - Measured Shoulder Width < Plan Width
  - 2) - Measured Shoulder Width ≥ Plan Width
- B - Wide Driving Lane
  - 1) - Measured Shoulder Width + Excess Driving Lane Width < Plan Width
  - 2) - Measured Shoulder Width + Excess Driving Lane Width ≥ Plan Width

II. – No Separate Bid Item for Shoulders
- A - Narrow Driving Lane and Shoulder
- B - Wide Driving Lane and Shoulder

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I. – Separate Bid Item for Shoulders

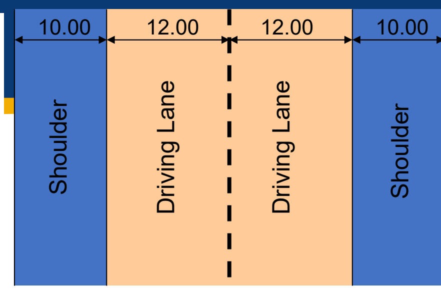
MDLW = **Measured Driving Lane Width**

PDLW = **Plan Driving Lane Width**

MSW = **Measured Shoulder Width**

PSW = **Plan Shoulder Width**

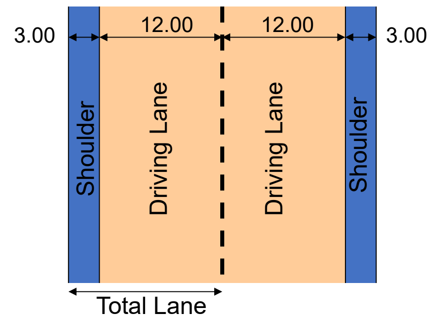
EDLW = **Excess Driving Lane Width**



II. – No Separate Bid Item for Shoulders

MTLW = **Measured Total Lane Width**

PTLW = **Plan Total Lane Width**



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Determining Pay Widths

TABLE 602-18: HMA UNIFORM THICKNESS SUBLOT CALCULATIONS[1]				
Condition	**PDLA[2] (Sq Yd)**	**PDLDA[2] (Sq Yd)**	**PSA[2] (Sq Yd)**	**PSDA[2] (Sq Yd)**
Projects with a Separate Bid Item for Shoulder				
Narrow Driving Lane				
MSW is less than PSW	(SL)(MDLW)	(SL)(PDLW–MDLW)	(SL)(MSW)	(SL)(PSW–MSW)
MSW is greater than PSW	(SL)(MDLW)	(SL)(PDLW–MDLW)	(SL)(MSW[3])	0
Wide Driving Lane				
MSW + EDLW is less than PSW	(SL)(PDLW)	0	(SL)(MSW+EDLW)	(SL)(PSW–MSW-EDLW)
MSW + EDLW is greater than PSW	(SL)(PDLW)	0	(SL)(MSW+EDLW[4])	0
Projects without a Separate Bid Item for Shoulder[5]				
Narrow Driving Lane and Shoulder	(SL)(MTLW)	(SL)(PTLW–MTLW)	N/A	N/A
Wide Driving Lane and Shoulder	(SL)(MTLW[6])	0	N/A	N/A

[1]Deductions will be made for unplaced areas.
[2]Calculate the areas to the nearest 0.01 square yards. Measure the lengths and widths to the nearest 0.01 feet. Divide the result of all equations in this table by 9 so that the resulting units are square yards.
[3]MSW shall be between PSW and PSW + 0.25 feet. Any excess width over 0.25 feet will not be included in PSW.
[4]MSW+ EDLW shall be between PSW and PSW + 0.25 feet. Any excess width over 0.25 feet will not be included in PSW.
[5]Shoulder is normally 0.00 feet to 3.00 feet wide and placed at the same time as the driving lane. PTLW = PDLW + PSW
[6]MSTLW shall be between PTLW and PTLW + 0.25 feet. Any excess width over 0.25 feet will not be included for pay.

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Determining Pay Widths

TABLE 602-18: HMA UNIFORM THICKNESS SUBLOT CALCULATIONS[1]				
Condition	PDLA[2]	PDLDA[2]	PSA[2]	PSDA[2]
	(Sq Yd)	(Sq Yd)	(Sq Yd)	(Sq Yd)
Projects with a Separate Bid Item for Shoulder				
Narrow Driving Lane				
MSW is less than PSW	~~(SL)~~(MDLW)	~~(SL)~~(PDLW–MDLW)	~~(SL)~~(MSW)	~~(SL)~~(PSW–MSW)
MSW is greater than PSW	~~(SL)~~(MDLW)	~~(SL)~~(PDLW–MDLW)	~~(SL)~~(MSW[3])	0
Wide Driving Lane				
MSW + EDLW is less than PSW	~~(SL)~~(PDLW)	0	~~(SL)~~(MSW+EDLW)	~~(SL)~~(PSW–MSW-EDLW)
MSW + EDLW is greater than PSW	~~(SL)~~(PDLW)	0	~~(SL)~~(MSW+EDLW[4])	0
Projects without a Separate Bid Item for Shoulder[5]				
Narrow Driving Lane and Shoulder	~~(SL)~~(MTLW)	~~(SL)~~(PTLW–MTLW)	N/A	N/A
Wide Driving Lane and Shoulder	~~(SL)~~(MTLW[6])	0	N/A	N/A

[1]Deductions will be made for unplaced areas.
[2]Calculate the areas to the nearest 0.01 square yards. Measure the lengths and widths to the nearest 0.01 feet. Divide the result of all equations in this table by 9 so that the resulting units are square yards.
[3]MSW shall be between PSW and PSW + 0.25 feet. Any excess width over 0.25 feet will not be included in PSW.
[4]MSW+ EDLW shall be between PSW and PSW + 0.25 feet. Any excess width over 0.25 feet will not be included in PSW.
[5]Shoulder is normally 0.00 feet to 3.00 feet wide and placed at the same time as the driving lane. PTLW = PDLW + PSW
[6]MSTLW shall be between PTLW and PTLW + 0.25 feet. Any excess width over 0.25 feet will not be included for pay.

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Determining Pay Widths

TABLE 602-18: HMA UNIFORM THICKNESS SUBLOT CALCULATIONS~~[1]~~				
Condition	PDL~~A[2]~~Width	PDLD~~A[2]~~Width	PS~~A[2]~~Width	PSD~~A[2]~~Width
	~~(Sq Yd)~~	~~(Sq Yd)~~	~~(Sq Yd)~~	~~(Sq Yd)~~
Projects with a Separate Bid Item for Shoulder				
Narrow Driving Lane				
MSW is less than PSW	(MDLW)	(PDLW–MDLW)	(MSW)	(PSW–MSW)
MSW is greater than PSW	(MDLW)	(PDLW–MDLW)	(MSW[3])	0
Wide Driving Lane				
MSW + EDLW is less than PSW	(PDLW)	0	(MSW+EDLW)	(PSW–MSW-EDLW)
MSW + EDLW is greater than PSW	(PDLW)	0	(MSW+EDLW[4])	0
Projects without a Separate Bid Item for Shoulder[5]				
Narrow Driving Lane and Shoulder	(MTLW)	(PTLW–MTLW)	N/A	N/A
Wide Driving Lane and Shoulder	(MTLW[6])	0	N/A	N/A

~~[1]Deductions will be made for unplaced areas.~~
~~[2]Calculate the areas to the nearest 0.01 square yards. Measure the lengths and widths to the nearest 0.01 feet. Divide the result of all equations in this table by 9 so that the resulting units are square yards.~~
[3]MSW shall be between PSW and PSW + 0.25 feet. Any excess width over 0.25 feet will not be included in PSW.
[4]MSW+ EDLW shall be between PSW and PSW + 0.25 feet. Any excess width over 0.25 feet will not be included in PSW.
[5]Shoulder is normally 0.00 feet to 3.00 feet wide and placed at the same time as the driving lane. PTLW = PDLW + PSW
[6]M~~S~~TLW shall be between PTLW and PTLW + 0.25 feet. Any excess width over 0.25 feet will not be included for pay.

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Determining Pay Widths

TABLE 602-18: HMA UNIFORM THICKNESS SUBLOT CALCULATIONS				
Condition	PDLWidth	PDLDWidth	PSWidth	PSDWidth
Projects with a Separate Bid Item for Shoulder				
Narrow Driving Lane				
MSW is less than PSW	(MDLW)	(PDLW–MDLW)	(MSW)	(PSW–MSW)
MSW is greater than PSW	(MDLW)	(PDLW–MDLW)	Min(MSW, PSW+0.25)	0
Wide Driving Lane				
MSW + EDLW is less than PSW	(PDLW)	0	(MSW+EDLW)	(PSW–MSW-EDLW)
MSW + EDLW is greater than PSW	(PDLW)	0	Min (MSW+EDLW, PSW+0.25)	0
Projects without a Separate Bid Item for Shoulder[5]				
Narrow Driving Lane and Shoulder	(MTLW)	(PTLW–MTLW)	N/A	N/A
Wide Driving Lane and Shoulder	Min(MTLW, PTLW+0.25)	0	N/A	N/A

[3]MSW shall be between PSW and PSW + 0.25 feet. Any excess width over 0.25 feet will not be included in PSW.
[4]MSW+ EDLW shall be between PSW and PSW + 0.25 feet. Any excess width over 0.25 feet will not be included in PSW.
[5]Shoulder is normally 0.00 feet to 3.00 feet wide and placed at the same time as the driving lane. PTLW = PDLW + PSW
[6]MTLW shall be between PTLW and PTLW + 0.25 feet. Any excess width over 0.25 feet will not be included for pay.

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Determining Pay Widths

TABLE 602-18: HMA UNIFORM THICKNESS SUBLOT CALCULATIONS				
Condition	PDL Width Pay Driving Lane Width	PDLD Width Pay Driving Lane Deduct Width	PS Width Pay Shoulder Width	PSD Width Pay Shoulder Deduct Width
Projects with a Separate Bid Item for Shoulder				
Narrow Driving Lane				
MSW<PSW	MDLW	PDLW–MDLW	MSW	PSW–MSW
MSW>PSW	MDLW	PDLW–MDLW	Min (MSW, PSW+0.25)	0
Wide Driving Lane				
MSW+EDLW<PSW	PDLW	0	MSW+EDLW	PSW–MSW-EDLW
MSW+EDLW>PSW	PDLW	0	Min (MSW+EDLW, PSW+0.25)	0
Projects without a Separate Bid Item for Shoulder				
Narrow Driving Lane and Shoulder	MTLW	PTLW–MTLW	N/A	N/A
Wide Driving Lane and Shoulder	Min (MTLW, PTLW+0.25)	0	N/A	N/A

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Ask Youself These Questions:

	YES	NO
1) Is the Shoulder a Separate Bid Item?	Top Table (I.)	Bottom Table (II.)
2) Is the Measured Driving Lane Width less than the Plan Driving Lane Width	Narrow Rows (A.)	Wide Rows (B.)
3) If a Separate Shoulder then is it narrow?	Upper Row (1))	Lower Row (2))

Find the Column Corresponding to your Answers

1)	YES	YES	YES	YES	NO	NO
2)	YES	YES	NO	NO	YES	NO
3)	YES	NO	YES	NO	---	---
	I.A.1)	I.A.2)	I.B.1)	I.B.2)	II.A.	II.B.

This Row tells which Section to Use for Pay Width(s) determination(s).

TABLE 602-18: HMA UNIFORM THICKNESS SUBLOT CALCULATIONS

Row	Condition	PDL Width Pay Driving Lane Width	PDLD Width Pay Driving Lane Deduct Width	PS Width Pay Shoulder Width	PSD Width Pay Shoulder Deduct Width
	I. Projects with a Separate Bid Item for Shoulder				
	A. Narrow Driving Lane				
I.A.1)	MSW<PSW	MDLW	PDLW–MDLW	MSW	PSW–MSW
I.A.2)	MSW>PSW	MDLW	PDLW–MDLW	Min (MSW, PSW+0.25)	0
	B. Wide Driving Lane				
I.B.1)	MSW+EDLW<PSW	PDLW	0	MSW+EDLW	PSW–MSW-EDLW
I.B.2)	MSW+EDLW>PSW	PDLW	0	Min (MSW+EDLW, PSW+0.25)	0
	II. Projects without a Separate Bid Item for Shoulder				
II.A.	Narrow Driving Lane and Shoulder	MTLW	PTLW–MTLW	N/A	N/A
II.B.	Wide Driving Lane and Shoulder	Min (MTLW, PTLW+0.25)	0	N/A	N/A

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602.10 HMA PAID BY THE AREA Area Calculations

3 Golden Rules when Shoulder is paved separately from the Mainline

1. Never Pay More than the Plan DL Width
2. Can Carry Excess DL Width to SH
3. Never Pay more than Plan SH width + 0.25 ft

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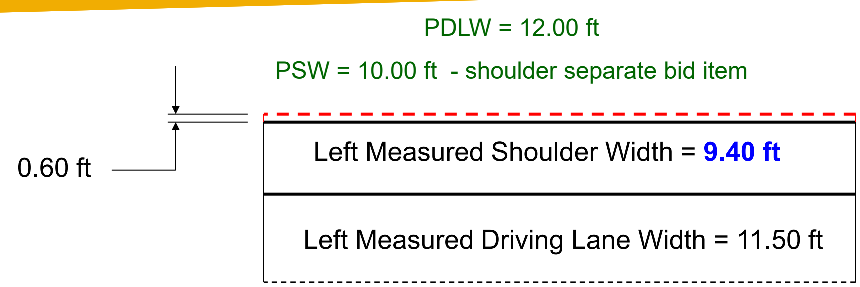

69

Ask Youself These Questions:	YES	NO
1) Is the Shoulder a Separate Bid Item?	Top Table (I.)	Bottom Table (II.)
2) Is the Measured Driving Lane Width less than the Plan Driving Lane Width?	Narrow Rows (A.)	Wide Rows (B.)
3) If a Separate Shoulder then is it narrow?	Upper Row (1))	Lower Row (2))

Find the Column Corresponding to your Answers

1)	YES	YES	YES	YES	NO	NO
2)	YES	YES	NO	NO	YES	NO
3)	YES	NO	YES	NO	---	---
	I.A.1)	I.A.2)	I.B.1)	I.B.2)	II.A.	II.B.

This Row tells which Section to Use for Pay Width(s) determination(s).

TABLE 602-18: HMA UNIFORM THICKNESS SUBLOT CALCULATIONS

		DRIVING LANE		SHOULDER	
Row	Condition	PDL Width Pay Driving Lane Width	PDLD Width Pay Driving Lane Deduct Width	PS Width Pay Shoulder Width	PSD Width Pay Shoulder Deduct Width
	I. Projects with a Separate Bid Item for Shoulder				
	A. Narrow Driving Lane				
I.A.1)	MSW<PSW	MDLW	PDLW–MDLW	MSW	PSW–MSW
I.A.2)	MSW>PSW	MDLW	PDLW–MDLW	Min (MSW, PSW+0.25)	0
	B. Wide Driving Lane				
I.B.1)	MSW+EDLW<PSW	PDLW	0	MSW+EDLW	PSW–MSW-EDLW
I.B.2)	MSW+EDLW>PSW	PDLW	0	Min (MSW+EDLW, PSW+0.25)	0
	II. Projects without a Separate Bid Item for Shoulder				
II.A.	**Narrow** Driving Lane and Shoulder	MTLW	PTLW–MTLW	N/A	N/A
II.B.	**Wide** Driving Lane and Shoulder	Min (MTLW, PTLW+0.25)	0	N/A	N/A

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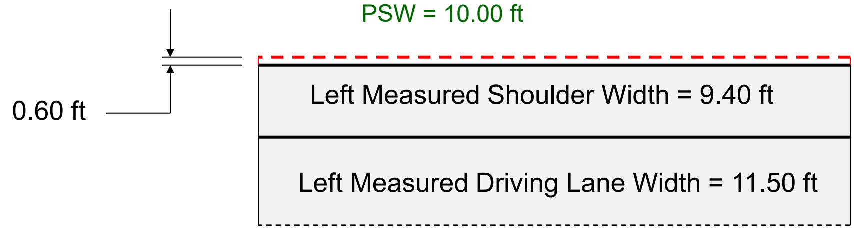
PDLW = 12.00 ft

PSW = 10.00 ft



Left Driving Lane:

MDLW < PDLW: (11.50 < 12.00)

Pay Driving Lane Width = MDLW = 11.50 ft

Pay Driving Lane Deduct Width = PDLW – MDLW

= 12.00 ft – 11.50 ft

= 0.50 ft

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Ask Youself These Questions:	YES	NO
1) Is the Shoulder a Separate Bid Item?	Top Table (I.)	Bottom Table (II.)
2) Is the Measured Driving Lane Width less than the Plan Driving Lane Width?	Narrow Rows (A.)	Wide Rows (B.)
3) If a Separate Shoulder then is it narrow?	Upper Row (1))	Lower Row (2))

Find the Column Corresponding to your Answers

1)	YES	YES	YES	YES	NO	NO
2)	YES	YES	NO	NO	YES	NO
3)	YES	NO	YES	NO	---	---
	I.A.1)	I.A.2)	I.B.1)	I.B.2)	II.A.	II.B.

This Row tells which Section to Use for Pay Width(s) determination(s).

		DRIVING LANE		SHOULDER	
	TABLE 602-18: HMA UNIFORM THICKNESS SUBLOT CALCULATIONS				
	Condition	**PDL Width** Pay Driving Lane Width	**PDLD Width** Pay Driving Lane Deduct Width	**PS Width** Pay Shoulder Width	**PSD Width** Pay Shoulder Deduct Width
Row	**I. Projects with a Separate Bid Item for Shoulder**				
	A. Narrow Driving Lane				
I.A.1)	MSW<PSW	MDLW	PDLW–MDLW	MSW	PSW–MSW
I.A.2)	MSW>PSW	MDLW	PDLW–MDLW	Min (MSW, PSW+0.25)	0
	B. Wide Driving Lane				
I.B.1)	MSW+EDLW<PSW	PDLW	0	MSW+EDLW	PSW–MSW-EDLW
I.B.2)	MSW+EDLW>PSW	PDLW	0	Min (MSW+EDLW, PSW+0.25)	0
	II. Projects without a Separate Bid Item for Shoulder				
II.A.	**Narrow** Driving Lane and Shoulder	MTLW	PTLW–MTLW	N/A	N/A
II.B.	**Wide** Driving Lane and Shoulder	Min (MTLW, PTLW+0.25)	0	N/A	N/A

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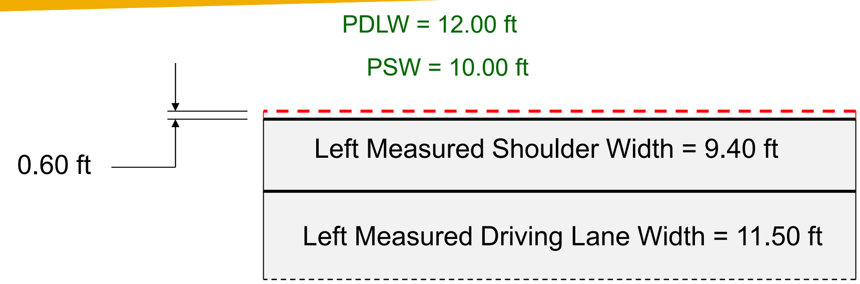

Left MSW < PSW

Pay Shoulder Width = Left MSW = 9.40 ft

Pay Shoulder Deduct Width = PSW – MSW

= 10.00 ft – 9.40 ft

= 0.60 ft

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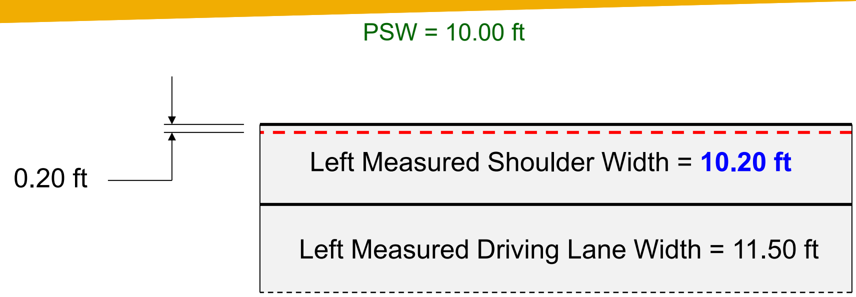

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Ask Youself These Questions:	YES	NO
1) Is the Shoulder a Separate Bid Item?	Top Table (I.)	Bottom Table (II.)
2) Is the Measured Driving Lane Width less than the Plan Driving Lane Width?	Narrow Rows (A.)	Wide Rows (B.)
3) If a Separate Shoulder then is it narrow?	Upper Row (1))	Lower Row (2))

Find the Column Corresponding to your Answers						
1)	YES	YES	YES	YES	NO	NO
2)	YES	YES	NO	NO	YES	NO
3)	YES	NO	YES	NO	---	---
	I.A.1)	I.A.2)	I.B.1)	I.B.2)	II.A.	II.B.

This Row tells which Section to Use for Pay Width(s) determination(s).

TABLE 602-18: HMA UNIFORM THICKNESS SUBLOT CALCULATIONS

		DRIVING LANE		SHOULDER	
Row	Condition	PDL Width Pay Driving Lane Width	PDLD Width Pay Driving Lane Deduct Width	PS Width Pay Shoulder Width	PSD Width Pay Shoulder Deduct Width
	I. Projects with a Separate Bid Item for Shoulder				
	A. Narrow Driving Lane				
I.A.1)	MSW<PSW	MDLW	PDLW–MDLW	MSW	PSW–MSW
I.A.2)	MSW>PSW	MDLW	PDLW–MDLW	Min (MSW, PSW+0.25)	0
	B. Wide Driving Lane				
I.B.1)	MSW+EDLW<PSW	PDLW	0	MSW+EDLW	PSW–MSW-EDLW
I.B.2)	MSW+EDLW>PSW	PDLW	0	Min (MSW+EDLW, PSW+0.25)	0
	II. Projects without a Separate Bid Item for Shoulder				
II.A.	**Narrow** Driving Lane and Shoulder	MTLW	PTLW–MTLW	N/A	N/A
II.B.	**Wide** Driving Lane and Shoulder	Min (MTLW, PTLW+0.25)	0	N/A	N/A

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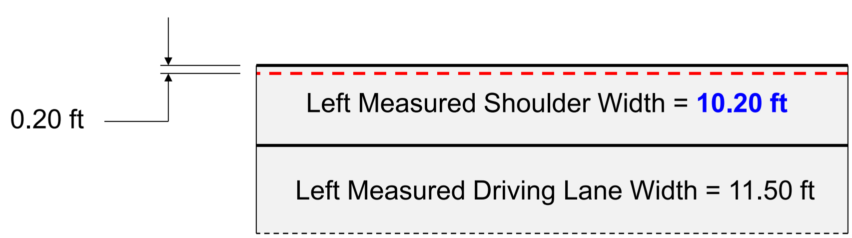
PSW = 10.00 ft



Left MSW ≥ PSW

Pay Shoulder Width = MSW*

= 10.20 ft < 10.25 ft*

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PSW = 10.00 ft

0.40 ft

Left Measured Shoulder Width = **10.40 ft**

Left Measured Driving Lane Width = 11.50 ft

Left MSW ≥ PSW

Pay Shoulder Width = MSW*

= 10.40 ft > 10.25 ft*

= 10.25 ft

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PDLW = 12.00 ft

PSW = 10.00 ft

Left Measured Shoulder Width = **9.85 ft**

Left Measured Driving Lane Width = **12.10 ft**

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Ask Youself These Questions:	YES	NO
1) Is the Shoulder a Separate Bid Item?	Top Table (I.)	Bottom Table (II.)
2) Is the Measured Driving Lane Width less than the Plan Driving Lane Width?	Narrow Rows (A.)	Wide Rows (B.)
3) If a Separate Shoulder then is it narrow?	Upper Row (1))	Lower Row (2))

Find the Column Corresponding to your Answers

1)	YES	YES	YES	YES	NO	NO
2)	YES	YES	NO	NO	YES	NO
3)	YES	NO	YES	NO	---	---
	I.A.1)	I.A.2)	I.B.1)	I.B.2)	II.A.	II.B.

This Row tells which Section to Use for Pay Width(s) determination(s).

		DRIVING LANE		SHOULDER	
TABLE 602-18: HMA UNIFORM THICKNESS SUBLOT CALCULATIONS					
	Condition	**PDL Width** Pay Driving Lane Width	**PDLD Width** Pay Driving Lane Deduct Width	**PS Width** Pay Shoulder Width	**PSD Width** Pay Shoulder Deduct Width
Row	**I. Projects with a Separate Bid Item for Shoulder**				
	A. Narrow Driving Lane				
I.A.1)	MSW<PSW	MDLW	PDLW–MDLW	MSW	PSW–MSW
I.A.2)	MSW>PSW	MDLW	PDLW–MDLW	Min (MSW, PSW+0.25)	0
	B. Wide Driving Lane				
I.B.1)	MSW+EDLW<PSW	PDLW	0	MSW+EDLW	PSW–MSW-EDLW
I.B.2)	MSW+EDLW>PSW	PDLW	0	Min (MSW+EDLW, PSW+0.25)	0
	II. Projects without a Separate Bid Item for Shoulder				
II.A.	**Narrow** Driving Lane and Shoulder	MTLW	PTLW–MTLW	N/A	N/A
II.B.	**Wide** Driving Lane and Shoulder	Min (MTLW, PTLW+0.25)	0	N/A	N/A

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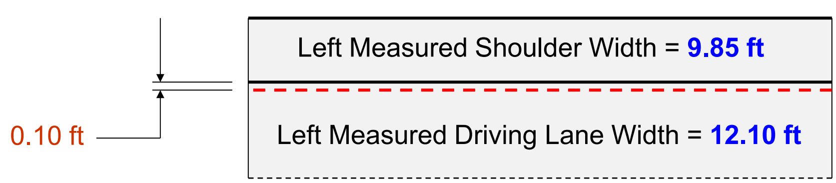
PSW = 10.00 ft



Left MDLW ≥ PDLW

Pay Driving Lane Width = PDLW

= 12.00 ft

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Ask Youself These Questions:	YES	NO
1) Is the Shoulder a Separate Bid Item?	Top Table (I.)	Bottom Table (II.)
2) Is the Measured Driving Lane Width less than the Plan Driving Lane Width?	Narrow Rows (A.)	Wide Rows (B.)
3) If a Separate Shoulder then is it narrow?	Upper Row (1))	Lower Row (2))

Find the Column Corresponding to your Answers

1)	YES	YES	YES	YES	NO	NO
2)	YES	YES	NO	NO	YES	NO
3)	YES	NO	YES	NO	---	---
	I.A.1)	I.A.2)	I.B.1)	I.B.2)	II.A.	II.B.

This Row tells which Section to Use for Pay Width(s) determination(s).

		DRIVING LANE		SHOULDER	
TABLE 602-18: HMA UNIFORM THICKNESS SUBLOT CALCULATIONS					
	Condition	**PDL Width** Pay Driving Lane Width	**PDLD Width** Pay Driving Lane Deduct Width	**PS Width** Pay Shoulder Width	**PSD Width** Pay Shoulder Deduct Width
Row	**I. Projects with a Separate Bid Item for Shoulder**				
	A. Narrow Driving Lane				
I.A.1)	MSW<PSW	MDLW	PDLW–MDLW	MSW	PSW–MSW
I.A.2)	MSW>PSW	MDLW	PDLW–MDLW	Min (MSW, PSW+0.25)	0
	B. Wide Driving Lane				
I.B.1)	MSW+EDLW<PSW	PDLW	0	MSW+EDLW	PSW–MSW-EDLW
I.B.2)	MSW+EDLW>PSW	PDLW	0	Min (MSW+EDLW, PSW+0.25)	0
	II. Projects without a Separate Bid Item for Shoulder				
II.A.	**Narrow** Driving Lane and Shoulder	MTLW	PTLW–MTLW	N/A	N/A
II.B.	**Wide** Driving Lane and Shoulder	Min (MTLW, PTLW+0.25)	0	N/A	N/A

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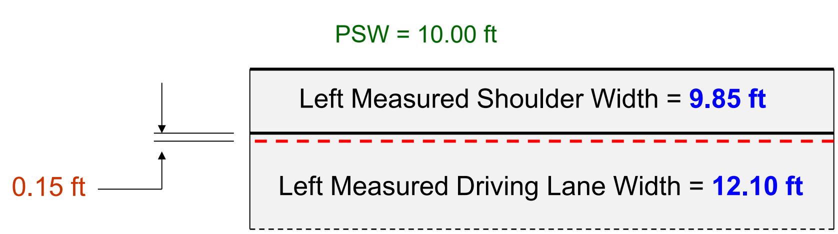

MSW + EDLW < PSW

Pay Shoulder Width = MSW + EDLW
= 9.85 ft + (12.10 ft – 12.00 ft)
= 9.85 ft + (0.10 ft)
= 9.95 ft

Pay Shoulder Deduct Width = PSW – MSW – EDLW
= 10.00 ft - 9.85 ft - 0.10 ft
= 0.05 ft

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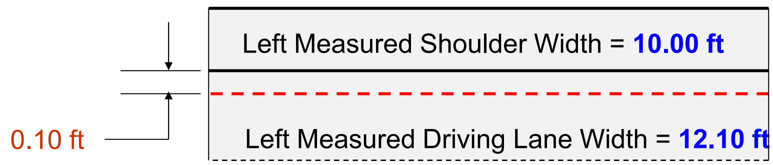
PSW = 10.00 ft

PDLW = 12.00 ft



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Ask Youself These Questions:	YES	NO
1) Is the Shoulder a Separate Bid Item?	Top Table (I.)	Bottom Table (II.)
2) Is the Measured Driving Lane Width less than the Plan Driving Lane Width?	Narrow Rows (A.)	Wide Rows (B.)
3) If a Separate Shoulder then is it narrow?	Upper Row (1))	Lower Row (2))

Find the Column Corresponding to your Answers

1)	YES	YES	YES	YES	NO	NO
2)	YES	YES	NO	NO	YES	NO
3)	YES	NO	YES	NO	---	---
	I.A.1)	I.A.2)	I.B.1)	I.B.2)	II.A.	II.B.

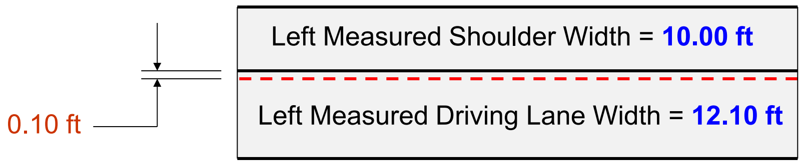
This Row tells which Section to Use for Pay Width(s) determination(s).

TABLE 602-18: HMA UNIFORM THICKNESS SUBLOT CALCULATIONS

		DRIVING LANE		**SHOULDER**	
Row	**Condition**	**PDL Width** Pay Driving Lane Width	**PDLD Width** Pay Driving Lane Deduct Width	**PS Width** Pay Shoulder Width	**PSD Width** Pay Shoulder Deduct Width
	I. Projects with a Separate Bid Item for Shoulder				
	A. Narrow Driving Lane				
I.A.1)	MSW<PSW	MDLW	PDLW–MDLW	MSW	PSW–MSW
I.A.2)	MSW>PSW	MDLW	PDLW–MDLW	Min (MSW, PSW+0.25)	0
	B. Wide Driving Lane				
I.B.1)	MSW+EDLW<PSW	PDLW	0	MSW+EDLW	PSW–MSW-EDLW
I.B.2)	MSW+EDLW>PSW	PDLW	0	Min (MSW+EDLW, PSW+0.25)	0
	II. Projects without a Separate Bid Item for Shoulder				
II.A.	**Narrow** Driving Lane and Shoulder	MTLW	PTLW–MTLW	N/A	N/A
II.B.	**Wide** Driving Lane and Shoulder	Min (MTLW, PTLW+0.25)	0	N/A	N/A

84

PSW = 10.00 ft



<u>MSW + EDLW ≥ PSW</u>

Pay Shoulder Width = MSW + EDLW**

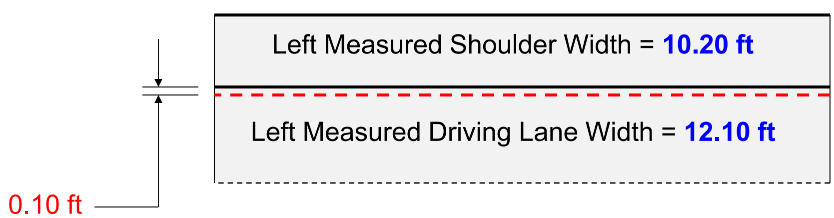
= 10.00 ft + (12.10 ft – 12.00 ft)

= 10.00 ft + (0.10 ft)

= <u>10.10 ft</u> < 10.25 ft**

85

PSW = 10.00 ft



86

Ask Youself These Questions:	YES	NO
1) Is the Shoulder a Separate Bid Item?	Top Table (I.)	Bottom Table (II.)
2) Is the Measured Driving Lane Width less than the Plan Driving Lane Width?	Narrow Rows (A.)	Wide Rows (B.)
3) If a Separate Shoulder then is it narrow?	Upper Row (1))	Lower Row (2))

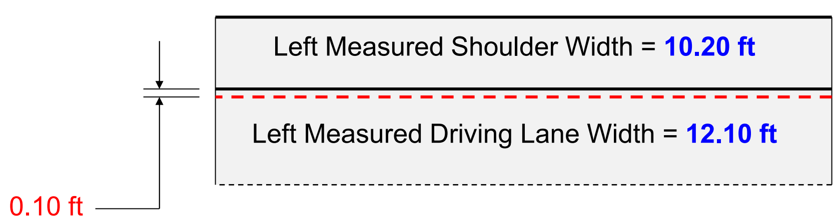
Find the Column Corresponding to your Answers						
1)	YES	YES	YES	YES	NO	NO
2)	YES	YES	NO	NO	YES	NO
3)	YES	NO	YES	NO	---	---
	I.A.1)	I.A.2)	I.B.1)	I.B.2)	II.A.	II.B.

This Row tells which Section to Use for Pay Width(s) determination(s).

		DRIVING LANE		SHOULDER	
	TABLE 602-18: HMA UNIFORM THICKNESS SUBLOT CALCULATIONS				
	Condition	**PDL Width** Pay Driving Lane Width	**PDLD Width** Pay Driving Lane Deduct Width	**PS Width** Pay Shoulder Width	**PSD Width** Pay Shoulder Deduct Width
Row	**I. Projects with a Separate Bid Item for Shoulder**				
	A. Narrow Driving Lane				
I.A.1)	MSW<PSW	MDLW	PDLW–MDLW	MSW	PSW–MSW
I.A.2)	MSW>PSW	MDLW	PDLW–MDLW	Min (MSW, PSW+0.25)	0
	B. Wide Driving Lane				
I.B.1)	MSW+EDLW<PSW	PDLW	0	MSW+EDLW	PSW–MSW-EDLW
I.B.2)	MSW+EDLW>PSW	PDLW	0	Min (MSW+EDLW, PSW+0.25)	0
	II. Projects without a Separate Bid Item for Shoulder				
II.A.	**Narrow** Driving Lane and Shoulder	MTLW	PTLW–MTLW	N/A	N/A
II.B.	**Wide** Driving Lane and Shoulder	Min (MTLW, PTLW+0.25)	0	N/A	N/A

87

PSW = 10.00 ft



MSW + EDLW ≥ PSW

Pay Shoulder Width = MSW + EDLW**

= 10.20 ft + (12.10 ft – 12.00 ft)

= 10.20 ft + (0.10 ft)

= 10.30 ft > 10.25 ft**

= 10.25 ft

88

No Shoulder Bid Item

Plan Total Lane Width = 15.00 ft

Left Measured Total Lane Width = **15.50 ft**

Right Measured Total Lane Width = **14.8 ft**

89

Ask Youself These Questions:	YES	NO
1) Is the Shoulder a Separate Bid Item?	Top Table (I.)	Bottom Table (II.)
2) Is the Measured Driving Lane Width less than the Plan Driving Lane Width?	Narrow Rows (A.)	Wide Rows (B.)
3) If a Separate Shoulder then is it narrow?	Upper Row (1))	Lower Row (2))

Find the Column Corresponding to your Answers

1)	YES	YES	YES	YES	NO	NO
2)	YES	YES	NO	NO	YES	NO
3)	YES	NO	YES	NO	---	---
	I.A.1)	I.A.2)	I.B.1)	I.B.2)	II.A.	II.B.

This Row tells which Section to Use for Pay Width(s) determination(s).

		DRIVING LANE		**SHOULDER**	
	TABLE 602-18: HMA UNIFORM THICKNESS SUBLOT CALCULATIONS				
Row	**Condition**	**PDL Width** Pay Driving Lane Width	**PDLD Width** Pay Driving Lane Deduct Width	**PS Width** Pay Shoulder Width	**PSD Width** Pay Shoulder Deduct Width
	I. Projects with a Separate Bid Item for Shoulder				
	A. Narrow Driving Lane				
I.A.1)	MSW<PSW	MDLW	PDLW–MDLW	MSW	PSW–MSW
I.A.2)	MSW>PSW	MDLW	PDLW–MDLW	Min (MSW, PSW+0.25)	0
	B. Wide Driving Lane				
I.B.1)	MSW+EDLW<PSW	PDLW	0	MSW+EDLW	PSW–MSW-EDLW
I.B.2)	MSW+EDLW>PSW	PDLW	0	Min (MSW+EDLW, PSW+0.25)	0
	II. Projects without a Separate Bid Item for Shoulder				
II.A.	**Narrow** Driving Lane and Shoulder	MTLW	PTLW–MTLW	N/A	N/A
II.B.	**Wide** Driving Lane and Shoulder	Min (MTLW, PTLW+0.25)	0	N/A	N/A

90

No Shoulder Bid Item

Plan Total Lane Width = 15.00 ft

Left Measured Total Lane Width = **15.50 ft**
Right Measured Total Lane Width = **14.8 ft**

Left Lane

PDLW = Min (MILW, PDLW + .25 ft)

MILW = 15.5, > 15 + .25 = 15.25

PDLW = 15.25 ft

91

Ask Youself These Questions:	YES	NO
1) Is the Shoulder a Separate Bid Item?	Top Table (I.)	Bottom Table (II.)
2) Is the Measured Driving Lane Width less than the Plan Driving Lane Width?	Narrow Rows (A.)	Wide Rows (B.)
3) If a Separate Shoulder then is it narrow?	Upper Row (1))	Lower Row (2))

Find the Column Corresponding to your Answers

1)	YES	YES	YES	YES	NO	NO
2)	YES	YES	NO	NO	YES	NO
3)	YES	NO	YES	NO	---	---
	I.A.1)	I.A.2)	I.B.1)	I.B.2)	II.A.	II.B.

This Row tells which Section to Use for Pay Width(s) determination(s).

TABLE 602-18: HMA UNIFORM THICKNESS SUBLOT CALCULATIONS

Row	Condition	DRIVING LANE: PDL Width (Pay Driving Lane Width)	DRIVING LANE: PDLD Width (Pay Driving Lane Deduct Width)	SHOULDER: PS Width (Pay Shoulder Width)	SHOULDER: PSD Width (Pay Shoulder Deduct Width)
	I. Projects with a Separate Bid Item for Shoulder				
	A. Narrow Driving Lane				
I.A.1)	MSW<PSW	MDLW	PDLW–MDLW	MSW	PSW–MSW
I.A.2)	MSW>PSW	MDLW	PDLW–MDLW	Min (MSW, PSW+0.25)	0
	B. Wide Driving Lane				
I.B.1)	MSW+EDLW<PSW	PDLW	0	MSW+EDLW	PSW–MSW-EDLW
I.B.2)	MSW+EDLW>PSW	PDLW	0	Min (MSW+EDLW, PSW+0.25)	0
	II. Projects without a Separate Bid Item for Shoulder				
II.A.	**Narrow** Driving Lane and Shoulder	MTLW	PTLW–MTLW	N/A	N/A
II.B.	**Wide** Driving Lane and Shoulder	Min (MTLW, PTLW+0.25)	0	N/A	N/A

92

No Shoulder Bid Item

Plan Total Lane Width = 15.00 ft

Left Measured Total Lane Width = **15.50 ft**
Right Measured Total Lane Width = **14.8 ft**

Right Lane

PDLW = MTLW

MTLW = 14.8 ft

PDLD = PTLW – MTLW

15.0 ft – 14.8 ft = 0.2 ft

93

602.10 HMA PAID BY THE AREA

Pay Equations per Lot for Driving Lane Areas

Placed

Equation 10:

Pay for Driving Lane = (∑PDLA)(BP)

Not Placed (Deducted)

Equation 11:

Pay Deduct for Driving Lanes = 2(∑PDLDA)(BP)

∑PDLA = **P**ay **D**riving **L**ane **A**rea per Lot

∑PDLDA = **P**ay **D**riving **L**ane **D**educt **A**rea per Lot

BP = **B**id **P**rice

94

602.10 HMA PAID BY THE AREA

Pay Equations per Lot for Shoulder Areas

Placed

Equation 12:

Pay for Shoulder = (∑PSA)(BP)

Not Placed (Deducted)

Equation 13:

Pay Deduct for Shoulder = 2(∑PSDA)(BP)

∑PSA = **P**ay **S**houlder **A**rea per Lot

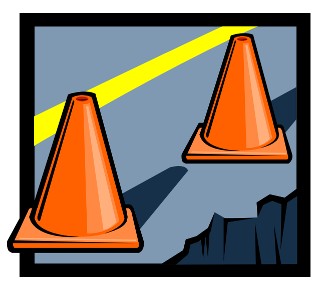
∑PSDA = **P**ay **S**houlder **D**educt **A**rea per Lot

BP = **B**id **P**rice

95

COMPUTATIONS FOR

PAY PER LOT FOR AREAS PLACED AND NOT PLACED



96

Pay per Lot for Lanes & Shoulders

Shoulders are Placed Separately

Sublot Length (SL) = 1000 ft
Bid Price (BP) = $50.00 per yd^2 (same for ML and SH)

9.90 ft Shoulder

11.85 ft Driving Lane

12.10 ft Driving Lane

10.00 ft Shoulder

Location	(A) Plan Width (ft)	(B) Measured Width (ft)	(C) Pay Width (ft)	(D) Deduct Width (ft)
Left Shoulder	10.00	9.90		
Left Driving Lane	12.00	11.85		
Right Driving Lane	12.00	12.10		
Right Shoulder	10.00	10.00		

97

Ask Youself These Questions:	YES	NO
1) Is the Shoulder a Separate Bid Item?	Top Table (I.)	Bottom Table (II.)
2) Is the Measured Driving Lane Width less than the Plan Driving Lane Width?	Narrow Rows (A.)	Wide Rows (B.)
3) If a Separate Shoulder then is it narrow?	Upper Row (1))	Lower Row (2))

Find the Column Corresponding to your Answers

1)	YES	YES	YES	YES	NO	NO
2)	YES	YES	NO	NO	YES	NO
3)	YES	NO	YES	NO	---	---
	I.A.1)	I.A.2)	I.B.1)	I.B.2)	II.A.	II.B.

This Row tells which Section to Use for Pay Width(s) determination(s).

		DRIVING LANE		SHOULDER	
	TABLE 602-18: HMA UNIFORM THICKNESS SUBLOT CALCULATIONS				
	Condition	**PDL Width** Pay Driving Lane Width	**PDLD Width** Pay Driving Lane Deduct Width	**PS Width** Pay Shoulder Width	**PSD Width** Pay Shoulder Deduct Width
Row	**I. Projects with a Separate Bid Item for Shoulder**				
	A. Narrow Driving Lane				
I.A.1)	MSW<PSW	MDLW	PDLW–MDLW	MSW	PSW–MSW
I.A.2)	MSW>PSW	MDLW	PDLW–MDLW	Min (MSW, PSW+0.25)	0
	B. Wide Driving Lane				
I.B.1)	MSW+EDLW<PSW	PDLW	0	MSW+EDLW	PSW–MSW-EDLW
I.B.2)	MSW+EDLW>PSW	PDLW	0	Min (MSW+EDLW, PSW+0.25)	0
	II. Projects without a Separate Bid Item for Shoulder				
II.A.	**Narrow** Driving Lane and Shoulder	MTLW	PTLW–MTLW	N/A	N/A
II.B.	**Wide** Driving Lane and Shoulder	Min (MTLW, PTLW+0.25)	0	N/A	N/A

98

Pay per Lot for Lanes & Shoulders

Shoulders are Placed Separately

Sublot Length (SL) = 1000 ft

Bid Price (BP) = $50.00 per yd^2 (same for ML and SH)

9.90 ft Shoulder

11.85 ft Driving Lane

12.10 ft Driving Lane

10.00 ft Shoulder

Location	(A) Plan Width (ft)	(B) Measured Width (ft)	(C) Pay Width (ft)	(D) Deduct Width (ft)
Left Shoulder	10.00	9.90	9.90	0.10
Left Driving Lane	12.00	11.85	11.85	0.15
Right Driving Lane	12.00	12.10		
Right Shoulder	10.00	10.00		

99

Ask Youself These Questions:	YES	NO
1) Is the Shoulder a Separate Bid Item?	Top Table (I.)	Bottom Table (II.)
2) Is the Measured Driving Lane Width less than the Plan Driving Lane Width?	Narrow Rows (A.)	Wide Rows (B.)
3) If a Separate Shoulder then is it narrow?	Upper Row (1))	Lower Row (2))

Find the Column Corresponding to your Answers

1)	YES	YES	YES	YES	NO	NO
2)	YES	YES	NO	NO	YES	NO
3)	YES	NO	YES	NO	---	---
	I.A.1)	I.A.2)	I.B.1)	I.B.2)	II.A.	II.B.

This Row tells which Section to Use for Pay Width(s) determination(s).

TABLE 602-18: HMA UNIFORM THICKNESS SUBLOT CALCULATIONS

Row	Condition	DRIVING LANE: PDL Width Pay Driving Lane Width	DRIVING LANE: PDLD Width Pay Driving Lane Deduct Width	SHOULDER: PS Width Pay Shoulder Width	SHOULDER: PSD Width Pay Shoulder Deduct Width
	I. Projects with a Separate Bid Item for Shoulder				
	A. Narrow Driving Lane				
I.A.1)	MSW<PSW	MDLW	PDLW–MDLW	MSW	PSW–MSW
I.A.2)	MSW>PSW	MDLW	PDLW–MDLW	Min (MSW, PSW+0.25)	0
	B. Wide Driving Lane				
I.B.1)	MSW+EDLW<PSW	PDLW	0	MSW+EDLW	PSW–MSW-EDLW
I.B.2)	MSW+EDLW>PSW	PDLW	0	Min (MSW+EDLW, PSW+0.25)	0
	II. Projects without a Separate Bid Item for Shoulder				
II.A.	**Narrow** Driving Lane and Shoulder	MTLW	PTLW–MTLW	N/A	N/A
II.B.	**Wide** Driving Lane and Shoulder	Min (MTLW, PTLW+0.25)	0	N/A	N/A

100

Pay per Lot for Lanes & Shoulders
Shoulders are Placed Separately

Sublot Length (SL) = 1000 ft
Bid Price (BP) = $50.00 per yd^2 (same for ML and SH)

9.90 ft Shoulder

11.85 ft Driving Lane

12.10 ft Driving Lane

10.00 ft Shoulder

Location	(A) Plan Width (ft)	(B) Measured Width (ft)	(C) Pay Width (ft)	(D) Deduct Width (ft)
Left Shoulder	10.00	9.90	9.90	0.10
Left Driving Lane	12.00	11.85	11.85	0.15
Right Driving Lane	12.00	12.10	12.00	0.00
Right Shoulder	10.00	10.00	10.10	0.00

101

Pay per Lot for Lanes & Shoulders
Shoulders are Placed Separately

Sublot Length (SL) = 1000 ft
Bid Price (BP) = $50.00 per yd^2 (same for ML and SH)

9.90 ft Shoulder

11.85 ft Driving Lane

12.10 ft Driving Lane

10.00 ft Shoulder

Location	(A) Plan Width (ft)	(B) Measured Width (ft)	(C) Pay Width (ft)	(D) Deduct Width (ft)	(E) Pay Area (yd^2)
Left Shoulder	10.00	9.90	9.90	0.10	1,100.00
Left Driving Lane	12.00	11.85	11.85	0.15	1,316.67
Right Driving Lane	12.00	12.10	12.00	0.00	1,333.33
Right Shoulder	10.00	10.00	10.10	0.00	1,122.22

102

Pay per Lot for Lanes & Shoulders
Shoulders are Placed Separately

Sublot Length (SL) = 1000 ft
Bid Price (BP) = $50.00 per yd^2 (same for ML and SH)

9.90 ft Shoulder

11.85 ft Driving Lane

12.10 ft Driving Lane

10.00 ft Shoulder

Location	(A) Plan Width (ft)	(B) Measured Width (ft)	(C) Pay Width (ft)	(D) Deduct Width (ft)	(E) Pay Area (yd^2)	(F) Pay Deduct Area (yd^2)
Left Shoulder	10.00	9.90	9.90	0.10	1,100.00	11.11
Left Driving Lane	12.00	11.85	11.85	0.15	1,316.67	16.67
Right Driving Lane	12.00	12.10	12.00	0.00	1,333.33	-
Right Shoulder	10.00	10.00	10.10	0.00	1,122.22	-

103

Pay per Lot for Lanes & Shoulders
Shoulders are Placed Separately

Sublot Length (SL) = 1000 ft
Bid Price (BP) = $50.00 per yd^2 (same for ML and SH)

9.90 ft Shoulder

11.85 ft Driving Lane

12.10 ft Driving Lane

10.00 ft Shoulder

Location	(E) Pay Area (yd^2)	(F) Pay Deduct Area (yd^2)	(G) Pay	(H) Pay Deduct
Left Shoulder	1,100.00	11.11	$ 55,000.00	$ (1,111.11)
Left Driving Lane	1,316.67	16.67	$ 65,833.33	$ (1,666.67)
Right Driving Lane	1,333.33	-	$ 66,666.67	$ -
Right Shoulder	1,122.22	-	$ 56,111.11	$ -
			$243,611.11	$ (2,777.78)

104

602.10 HMA PAID BY THE AREA

Equation 14:

$$\text{Minimum Quantity (Tons)} = \frac{0.93 * A * T * G_{mm}}{42.7}$$

A - Area of the mixes (square yards)

T - Plan Thickness of Last two HMA Courses (inches)

G_{mm} - G_{mm} for the 4 mixes listed in “T”

- Average for first 5 lots or
- Average for ½ the project

  (whichever is less)

Penalty is $75 per Ton

105

602.10 HMA PAID BY THE AREA

3 Golden Rules when Shoulder is paved separately from the Mainline

1. Never Pay More than the Plan DL Width
2. Can Carry Excess DL Width to SH
3. Never Pay more than

   Plan SH width + 0.25 ft

106

602.10 HMA PAID BY THE AREA

Kansas
Department of Transportation

107

THICKNESS PAY FACTOR EXAMPLE								
Mainline		**602.10 (Sheets 15-06007-R03-25 to 15-06007-R03-29)**						
Date	**Test**	**Station**	**Lane**	**Dist from CL (ft)**	**Core Length (in)**	**Adjusted Core Length (in)**	**Plan Thicknes (in)**	**Pay Driving Lane Area in Lot (yd^2)**
10/12/2024	1A	8+58	NB	2.6	11.6	11.6	12.0	6,666.67
10/12/2024	1B	15+24	NB	6.0	11.2	11.2		
10/12/2024	1C	26+37	NB	8.5	13.2	**13.0**		
10/12/2024	1D	39+21	NB	10.7	12.4	12.4		
10/12/2024	1E	47+53	NB	7.9	11.4	11.4		

Mean	$\overline{X}$	11.9	Average of Core Lengths
Standard Deviation	S	0.76	Standard Deviation of Core Len
Number of Samples	n		Number of Cores
Plan Thickness	in		Typical Section
Amount to Subtract from Plan Thickness to get LSL	Adj		602.10f. Sheet 15-06007-R03-2
Lower Specification Limit	LSL		(Plan Thickness - Adjustment)
Lower Thickness Quality Index	Q_T		$Q_T = \frac{\overline{X} - LSL}{S}$
Lower Percent Within Limits (Thickness)	PWL_T		Table 5.2.1-2: Page 5.2.1
Thickness Pay Factor	P_T		$P_T = \left(\frac{(PWL_T)*0.3}{100}\right) - 0.270$
Pay Driving Lane Area in Lot	yd^2	6,666.67	∑PDLA or ∑PSA
Price Adjustment per in	$		$3.50 for Driving Lane, $3.20 fo
Thickness Pay Adjustment per Lot for Driving Lane	TPA_{DL}		TPA = P_T (∑PDLA)($3.50)(Pla

1

THICKNESS PAY FACTOR EXAMPLE								
Shoulder		**602.10 (Sheets 15-06007-R03-25 to 15-06007-R03-29)**						
Date	**Test**	**Station**	**Lane**	**Dist from CL (ft)**	**Core Length (in)**	**Adjusted Core Length (in)**	**Plan Thicknes (in)**	**Pay Shoulder Area in Lot (yd^2)**
10/12/2024	1A	6+44	NB	16.7	8.0	8.0	8.0	5,555.56
10/12/2024	1B	12+93	NB	14.8	8.3	8.3		
10/12/2024	1C	28+14	NB	18.2	8.5	8.5		
10/12/2024	1D	33+27	NB	18.1	7.9	7.9		
10/12/2024	1E	43+85	NB	17.5	8.1	8.1		

Mean	$\overline{X}$	8.2	Average of Core Lengths
Standard Deviation	S	0.24	Standard Deviation of Core Len
Number of Samples	n		Number of Cores
Plan Thickness	in		Typical Section
Amount to Subtract from Plan Thickness to get LSL	Adj		602.10f. Sheet 15-06007-R03-2
Lower Specification Limit	LSL		(Plan Thickness - Adjustment)
Lower Thickness Quality Index	Q_T		$Q_T = \frac{\overline{X} - LSL}{S}$
Lower Percent Within Limits (Thickness)	PWL_T		Table 5.2.1-2: Page 5.2.1
Thickness Pay Factor	P_T		$P_T = \left(\frac{(PWL_T) * 0.3}{100}\right) - 0.270$
Pay Shoulder Area in Lot	yd^2	5,555.56	∑PDLA or ∑PSA
Price Adjustment per in	$		$3.50 for Driving Lane, $3.20 fc
Thickness Pay Adjustment per Lot for Shoulder	TPA_{SH}		TPA = P_T (∑PSA)($3.20)(Plan

2

Ask Youself These Questions:

1) Is the Shoulder a Separate Bid Item?
2) Is the Measured Driving Lane Width less than the Plan Driving Lane Width
3) If a Separate Shoulder then is it narrow?

YES	NO
Top Table (I.)	Bottom Table (II.)
Narrow Rows (A.)	Wide Rows (B.)
Upper Row (1))	Lower Row (2))

Find the Column Corresponding to your Answers

1)	YES	YES	YES	YES	NO	NO
2)	YES	YES	NO	NO	YES	NO
3)	YES	NO	YES	NO	---	---
	I.A.1)	I.A.2)	I.B.1)	I.B.2)	II.A.	II.B.

This Row tells which Section to Use for Pay Width(s) determination(s).

		DRIVING LANE		SHOULDER	
TABLE 602-18: HMA UNIFORM THICKNESS SUBLOT CALCULATIONS					
	Condition	**PDL Width** Pay Driving Lane Width	**PDLD Width** Pay Driving Lane Deduct Width	**PS Width** Pay Shoulder Width	**PSD Width** Pay Shoulder Deduct Width
Row	**I. Projects with a Separate Bid Item for Shoulder**				
	A. Narrow Driving Lane				
I.A.1)	MSW<PSW	MDLW	PDLW–MDLW	MSW	PSW–MSW
I.A.2)	MSW>PSW	MDLW	PDLW–MDLW	Min (MSW, PSW+0.25)	0
	B. Wide Driving Lane				
I.B.1)	MSW+EDLW<PSW	PDLW	0	MSW+EDLW	PSW–MSW-EDLW
I.B.2)	MSW+EDLW>PSW	PDLW	0	Min (MSW+EDLW, PSW+0.25)	0
	II. Projects without a Separate Bid Item for Shoulder				
II.A.	**Narrow** Driving Lane and Shoulder	MTLW	PTLW–MTLW	N/A	N/A
II.B.	**Wide** Driving Lane and Shoulder	Min (MTLW, PTLW+0.25)	0	N/A	N/A

PAY AREA CALCULATION EXAMPLE

9.90 ft Shoulder
11.85 ft Driving Lane
12.10 ft Driving Lane
10.00 ft Shoulder

Shoulders are laid separately

Location	(A) Plan Width (ft)	(B) Measured Width (ft)	(C) Pay Width (ft)	(D) Deduct Width (ft)
Left Shoulder	10.00	9.90		
Left Driving Lane	12.00	11.85		
Right Driving Lane	12.00	12.10		
Right Shoulder	10.00	10.00		

QC/QA Asphalt Specifications
Special Provision 15-06007-R03 Outline

602.1	Description (Sheet 1 of 30)
602.2	Contractor QC Requirements (Sheets 1 to 4 of 30)
602.3	Materials (Sheets 4 to 8 of 30)
602.4	Construction Requirements (Sheets 8 to 14 of 30)
602.5	Process Control (Sheets 14 to 17 of 30)
602.6	Compaction Testing (Sheets 17 to 19 of 30)
602.7	Weather Limitations (Sheet 19 of 30)
602.8	Mixture Acceptance (Sheets 19 to 22 of 30)
602.9	Basis of Acceptance (Sheets 22 to 25 of 30)
602.10	HMA Paid by the Area (Sheets 25 to 29 of 30)
602.11	**Measurement and Payment (Sheets 29 to 30 of 30)**

Kansas
Department of Transportation

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602.11 MEASUREMENT AND PAYMENT

OBJECTIVE

- Identify the bid items for payment and how they are measured

2

602.11 MEASUREMENT AND PAYMENT
a. HMA Base, HMA Surface and HMA Overlay

- Measured by the Ton (Delivered to the Road)
- Batch weights permitted if all the following conditions are met:
  - Plant equipped with an automatic printer system approved by the Engineer;
    - Prints the weights of material delivered; and
    - is used in conjunction with an automatic batching and mixing control system approved by the Engineer.
- Weigh ticket for each load

3

602.11 MEASUREMENT AND PAYMENT
a. HMA Base, HMA Surface and HMA Overlay

- Pay adjustments from both the air voids pay adjustment factor and the density pay adjustment factor will both be applied and the payment adjusted accordingly.
- Items not shown on the Contract Documents and require paving will be paid at 1.5 times the unit price for "HMA Surface", "HMA Base" or "HMA Overlay."
  - Sideroads
  - Entrances
  - Mailbox Turnouts

4

602.11 MEASUREMENT AND PAYMENT
b. HMA Pavement and HMA Pavement Shoulder

- Measured by the square yard of the in-place material
- Contractor will measure all lifts except the surface (Engineer verifies)
- Engineer will measure the surface course
- Measure each shoulder width, each driving lane width and sublot length separately
- Measure the lengths (to the nearest 0.01 ft) a minimum of once per sublot
- The location of the width measurements will be the same location as the mainline cores

5

602.11 MEASUREMENT AND PAYMENT
b. HMA Pavement and HMA Pavement Shoulder

- If the driving lane and shoulder (measured from centerline) is less than 0.25 ft (per side) deficient, a deduction will be assessed
- If the roadway is greater than 0.25 ft (per side) deficient, correction will be required.
  - Proposed by the Contractor and must be approved by the Engineer.
  - After satisfactory correction by the Contractor, the deduction for the narrow roadway will be eliminated for the areas corrected.
- Excessive grinding may result in cutting cores after grinding for thickness pay

6

602.11 MEASUREMENT AND PAYMENT
f. Quality Control Testing (HMA)

- The Engineer will measure Quality Control Testing (HMA) performed by the Contractor on a per ton basis of HMA Surface, HMA Base, HMA Overlay and HMA Pavement placed on the project.
- No adjustment in the bid price will be made for overruns or underruns in the contract quantity.
- The bid price will constitute payment for all necessary mix design testing, field process control testing, the testing laboratory and all necessary test equipment.

7

Sometimes things just go wrong

8

Appendix Y

KANSAS DEPARTMENT OF TRANSPORTATION
SPECIAL PROVISION TO THE
STANDARD SPECIFICATIONS, EDITION 2015

SECTION 602

MODIFIED REQUIREMENTS – ASPHALT MIXTURES

Project Number: 25-77 KA-6995-01

The asphalt mix listed in **TABLE 1** has the following project mix requirements. [Reference **TABLE 602-1**, COMBINED AGGREGATE REQUIREMENTS].

TABLE 1: PROJECT MIX REQUIREMENTS

MIX CRITERIA	**SR-12.5A (PG70-28)[(1)]**
AGGREGATE:	
Coarse Angularity (min. %)	75
Uncompacted Voids-Fine (min. %)	42
Sand Equivalent (min. %)	40
Reclaimed Asphalt Pavement (RAP) (max. %)	25
RAP Bulk Specific Gravity	2.595
COMPACTION REVOLUTIONS:	
N_{ini} (level of compaction)	7 ($\leq$91.5)
N_{des}	75
N_{max}	115
MIX:	
VFA	65 - 82

(1) Between 0 and 25% RAP may be used. Use the material milled from the project as the RAP source. The required binder and name shown below are based on the percent RAP used in the contract. The mix will be paid for at the bid price of SR-12.5A (PG70-28).

Percent RAP	**Name**
0	SM-12.5A (PG70-28)
1 - 15	SR-12.5A (PG70-28)
16 - 25	SR-12.5A (PG64-34)

For information only, the 20 year design lane traffic is 2.9 million ESALs.

6/5/23 C&M (BTH)

KANSAS DEPARTMENT OF TRANSPORTATION
SPECIAL PROVISION TO THE
STANDARD SPECIFICATIONS, EDITION 2015

Delete SECTION 602, and replace with the following:

SECTION 602

HOT MIX ASPHALT (HMA) CONSTRUCTION
(Quality Control/Quality Assurance (QC/QA))

602.1 DESCRIPTION

Mix and place 1 or more courses of plant produced HMA mixture on a prepared surface as shown in the Contract Documents. Demonstrate quality control by providing the quality control testing.

BID ITEMS	UNITS
HMA Base (*)(**)(***)	Ton
HMA Surface (*)(**)(***)	Ton
HMA Overlay (*)(**)(***)	Ton
HMA Pavement (#) (##)	Square Yard
HMA Pavement (#) Shoulder	Square Yard
Emulsified Asphalt (****)	Ton
Asphalt Core (Set Price)	Each
Material for HMA Patching (Set Price)	Ton
Quality Control Testing (HMA)	Ton

*Mix Designation
**Grade of Asphalt Binder
***Shoulder
****Type and Grade of Emulsified Asphalt
Thickness
##Type of surface course HMA mixture

602.2 CONTRACTOR QUALITY CONTROL REQUIREMENTS

a. General. Provide qualified personnel and sufficient equipment complying with the requirements listed in Part V to conduct quality control testing that complies with Appendix B, Sampling and Testing Frequency Chart for Asphalt Construction Items for Quality Control/Quality Assurance Projects.

Allow the Engineer access to the Contractor's laboratory to observe testing procedures, calculations, test documentation and plotting of test results.

Calibrate and correlate the testing equipment with prescribed procedures, and conduct tests in compliance with specified testing procedures as listed in Part V.

Maintain a Quality Manual in the field laboratory showing the calibrations performed on all test equipment and when the next calibration is due for that equipment. As a minimum, follow the calibration/verification interval established in Table 2: HMA Materials Test Equipment in Section 5.2.7.1-HMA: Contractor's Quality Control Plan, Part V. See also, Section 5.2.7.3-Example of a Laboratory Quality Manual for HMA, Part V.

Store and retain the most recent 2 lots per mix designation of quality control samples for KDOT. KDOT will retain the most recent 2 lots per mix designation gyratory compacted air voids (Va) verification samples and the remaining material not previously used for testing (back half of sample). Do not retain more than the previous 3 lots per mix designation of quality control or verification samples. When the hot mix plant shuts down for the winter, discard the samples after 7 days.

b. Quality Control Plan (QCP). At the pre-construction conference, submit to the Engineer for approval, a QCP as outlined in Section 5.2.7-Contractor's Quality Control Plan, Part V. Follow 5.2.7.1-HMA: Contractor's Quality Control Plan in Part V as a general guideline. The Contractor's laboratory and equipment will be inspected and approved as outlined in Section 5.2.7-Contractor's Quality Control Plan, Part V.

Include a listing of the names and phone numbers of individuals and alternates responsible for quality control administration and inspection. On the Contractor's organizational chart, show the specified lines of authority relating both to mix design and quality control operations during production. Post the organizational chart in the Contractor's test facility.

Provide a quality control organization or private testing firm having personnel certified according to the Policy and Procedures Manual for The Certified Inspection and Testing (CIT) Training Program. The testing for this type of construction will require personnel certified in Aggregate Field Tester (AGF), Aggregate Lab Technician (AGL), Superpave Field (SF), Profilograph (PO) and Nuclear Moisture Density Gauge Tester (NUC) classifications. Provide a minimum of 1 employee on the project certified in the QC/QA Asphalt Specs (QCA) classification.

Only persons certified in the appropriate classifications covering the specific tests required shall perform such testing. At the beginning of the project, provide the Engineer with the list of certified technicians and alternates, phone numbers and tests/inspection they will be performing. Include certification expiration dates for all certified technicians. As personnel changes and certifications may expire, continue to provide the Engineer with an accurate list.

Provide an organizational chart showing the specified lines of authority relating to both mix design and quality control operations during production. Identify the company official acting as liaison with KDOT, and the Certified Technician who will direct inspection and testing. Post the chart in the test facility.

c. Required Duties of Certified Inspectors. Be available on the project site whenever HMA is being produced and being placed on the project site. Perform and utilize quality control tests and other quality control practices to assure that delivered materials and proportioning meet the requirements of the mix designs.

Periodically inspect all equipment utilized in transporting, proportioning, mixing, placing and compacting to assure it is operating properly and that placement and compaction comply with the contract requirements.

d. Contractor's Testing Facilities. Describe the testing facility and its accreditation in the QCP.

Locate the testing facility either at the plant site or at the project. Obtain approval of the testing facilities and location from the DME before the commencement of mixture production.

Provide suitable space for the required testing equipment. Also, equip the testing facility with these items for the exclusive use of the testing facility's quality control personnel and the Engineer:

A telephone with a private line for the exclusive use of the testing facility's quality control personnel; and

A copying machine for use by the Contractor's personnel and the Engineer.

Broadband internet connection (for 1 computer). If the Engineer determines that broadband internet service is not available, provide a fax machine, at no additional cost.

An air conditioner capable of maintaining a temperature below 77°F in the main part of the Field Office and Laboratory.

Locate the KDOT field laboratory near the Contractor's testing facility and have it fully functional 2 working days before placement of the pre-production mix.

e. Documentation. Include in the QCP procedures, charts and forms to be used to provide the required documentation.

Record all original documentation in a bound field book or other KDOT approved bound record and turn over to KDOT at the end of the project.

At all times, have complete records of all inspections and tests available on site for the Engineer. All records documenting the Contractor's quality control inspections and tests become the property of KDOT upon completion of the work.

Indicate the nature and number of observations made, the number and type of deficiencies found, the quantities approved and rejected, and the corrective action taken in the records. Examples of quality control forms and charts are available in Part V, or Contractors may design their own. Documentation procedures are subject to approval by the Engineer before the start of the work and to compliance checks during the progress of the work.

Maintain control charts on an ongoing basis.

Provide the following test data to the KDOT Project Representative:

- Copies of all test results and control charts on a weekly basis, representing the prior week's production;
- Copies of the quality control summary sheet when available and not later than the next working day of obtaining the sample. Include, as a minimum, mix gradation, binder content, theoretical maximum

specific gravity (G_{mm}), air voids (V_a) at N_{des}, percent G_{mm} at N_{ini} and N_{max}, voids in mineral aggregate (VMA), voids filled with asphalt (VFA) and dust to effective binder content (D/B) ratio;
- Copies of all failing test results when available (based on a moving average of 4 tests, when appropriate). Include all applicable sieves, VMA, VFA, density at N_{ini} and N_{max}, and D/B ratio; and
- Copies of KT-56 test results when available and not later than five working days of obtaining the sample.

f. Testing Requirements. In the QCP, identify test methods, procedures and equipment proposed for use. Use standard KDOT test methods and properly calibrated measuring and testing equipment as outlined in Part V. Detail any alternative sampling method, procedure or inspection equipment proposed to be used. Such alternatives are subject to review and approval by the DME.

Take all samples for tests and perform in-place tests at random locations, selected according to the Contractor's QCP and at the rates specified in the Sampling and Testing Frequency Chart for Hot Mix Asphalt for Quality Control/Quality Assurance Projects in Appendix B, Part V.

g. Pre-Production Testing Requirements.

(1) The Engineer will observe the Contractor obtaining and splitting the pre-production test section sample into 3 representative portions. Each sample set shall consist of enough material for 2 gyratory specimens, theoretical G_{mm} and ignition burnoff.

(2) Mold 2 gyratory specimens from the 1st sample set immediately, while still hot. Additional heating may be required to raise the temperature of the sample to compaction temperature. Determine G_{mm}, perform ignition burnoff and complete calculations.

(3) Provide the KDOT Field Representative with the 2nd sample set. The KDOT Field Representative will mold 2 gyratory specimens, determine G_{mm}, perform ignition burnoff and complete calculations.

(4) Retain or provide the 3rd sample set to the KDOT District Materials Representative.

(5) The results of the testing will be compared. If Contractor and KDOT field laboratory test results do not compare favorably, the District Materials Laboratory will test their ⅓ of the sample. This sample will be transported to the District Materials Laboratory, after it has cooled to ambient air temperature. KDOT personnel will reheat the sample to compaction temperature, mold 2 gyratory specimens, determine G_{mm}, perform ignition burnoff and complete calculations. If the 3rd sample set is collected, transported while hot to the District Materials Laboratory and compacted in less than 2 hours, then, at the DME's discretion, the requirement to cool the sample may be waived.

If results are not acceptable to either party, repeat the above steps in **subsections 602.2g.(1)** through **(5)** for the Contractor's Field Laboratory, KDOT's Field Laboratory, and District Materials Laboratory until the issues may be resolved satisfactorily by all parties.

h. Lot 1 Testing Requirements.

(1) Sequence of Sampling. KDOT field personnel will determine the random truckload for the Contractor for sublots A, B, C and D, and the KDOT verification test.

The verification sample will be sampled and tested by KDOT field personnel. The verification sample shall be randomly taken within the lot and shall not be the same truckload as selected for the Contractor's sublot A, B, C or D.

KDOT field personnel will:
- provide the random spots to sample from behind the paving operations before compaction (KT-25);
- not supply the Contractor the identity of the truckload to be sampled ahead of time;
- notify the Contractor's laboratory of which truck to sample after the aggregate has left the cold feeds, and before the truck is finished loading; and
- determine whether the split sample will be taken from sublot A or B and notify the Contractor.

(2) Split Samples. The Contractor shall:
- obtain a sample large enough to split 3 ways for testing;
- retain and test ⅓ of the sample;
- supply ⅓ of the sample to the KDOT field laboratory for testing; and
- supply ⅓ of the sample to the KDOT District Materials Laboratory for testing.

(3) Results. At a minimum, compare G_{mm} and V_a results. The acceptable differences are 0.019 and 0.5%, respectively. If the results exceed these differences, take an additional split sample in Lot 1 from sublot C or D, as time permits.

If test results do not compare favorably, KDOT and the Contractor will investigate the differences in test results together and take appropriate action. The Contractor's test results will be used for quality control. KDOT Field Laboratory test results and District Materials Laboratory test results will be reported as "information only" samples.

i. Testing Requirements for Lots 2 and Greater.

(1) Take all samples for tests at random locations as designated in the approved QCP at the rates specified in Appendix B, Part V.

Provide the Engineer with the random locations before going to the roadway to determine density or sample the HMA. The Engineer reserves the right to generate the random locations. If the Engineer generates the random locations, the Contractor will be notified before going to the roadway to sample the HMA or determine density.

(2) Conduct the tests for mixture properties, aggregate gradation and binder content on representative portions of the HMA, quartered from the larger sample of HMA. Take a random sample weighing a minimum of 55 pounds from behind the paver and transport it to the test facility, using a method to retain heat to facilitate sample quartering procedures.

(3) Record and document all test results and calculations on data sheets provided by KDOT. Record specific test results on a daily summary sheet provided by KDOT to facilitate the computation of moving test averages. Base moving averages on 4 consecutive test results. Calculations are to be based on the precision displayed on the data sheets. Use "precision displayed" when calculating within Excel. Appendix B, Part V shows the accuracy to "record to" for the tests listed. Include a description of quality control actions taken (adjustment of cold feed percentages, changes in Job Mix Formulas (JMF), etc.) in the Daily Quality Control Summary Sheet. In addition, post and keep current quality control charts, showing both individual test results and moving average values. As a minimum, plot the single test values and the 4 test moving average values, as applicable, on KDOT approved control charts for the mix characteristics shown in **TABLE 602-12**.

(4) If the Contractor and Engineer agree, the procedures shown for sampling, testing and evaluation of Lot 1 in **subsection 602.2h.** may be used for any other Lot produced on the project.

j. Corrective Action. In the QCP, identify procedures for notifying the Engineer when corrective measures must be implemented, and for halting production.

k. Non-Conforming Materials. In the QCP, specifically address how non-conforming materials will be controlled and identified. Establish and maintain an effective and positive system for controlling non-complying material, including procedures for its identification, isolation and disposition. Reclaim or rework non-complying materials according to procedures acceptable to the Engineer. This could include removal and replacement of in-place pavement.

Positively identify all non-conforming materials and products to prevent use, shipment and intermingling with complying materials and products. Provide holding areas, mutually agreeable to the Engineer and Contractor.

602.3 MATERIALS

a. Asphalt Binder. Provide Asphalt Binder that complies with **DIVISION 1200**. Post a legible copy of the latest bill of lading for the Asphalt Binder on or near the gyratory compactor. Use the mixing and compaction temperatures shown on the bill of lading; however, the maximum mixing or compaction temperature is 340°F, unless otherwise approved by the Field Materials Engineer. Notify the Engineer if the mixing or compaction temperature changes.

Exception: The mixing temperature may be increased no more than 10°F above the maximum mixing temperature shown on the bill of lading provided all the following are met:

- The air temperature is below 70°F.
- The plant has not produced mix earlier in the day.
- Do not exceed a mix temperature of 350°F.
- No truck has returned for its second load of the day.

Once a previously loaded truck returns for its next load, reduce the temperature to not higher than the maximum mix temperature shown on the bill of lading, not to exceed 340°F.

b. Reclaimed Asphalt Pavement (RAP) and Recycled Asphalt Shingles (RAS). Provide RAP and RAS that comply with **SECTION 1103**.

c. Aggregates. Provide aggregates that comply with **SECTION 1103**.

d. Combined Aggregates. Provide combined aggregates for the mixes required in the Contract Documents as shown in **TABLE 602-1**.

Mixes may use any combination of aggregate and mineral filler supplements complying with the applicable requirements in **TABLES 1103-1** and **1103-2**.

Provide materials with less than 0.5% moisture in the final mixture.

The maximum quantity of crushed steel slag used in the mix is 50% of the total aggregate weight.

For all mixes used on the traveled way, the maximum quantity of natural sand is 35%.

Natural sand shall be called SSG-1, SSG-2, etc. in the mix design.

Additional requirements for SM-9.5T and SR-9.5T:

- Traveled way mixes shall include a minimum of 40% primary aggregate based on total aggregate weight;
- A minimum of 50% of the plus No. 4 mesh sieve material in the mixture shall be from the primary aggregate;
- A minimum of 45% of the plus No. 8 mesh sieve material in the mixture shall be from the primary aggregate; and
- Primary aggregates are designated as CS-1 (excluding limestone), CS-2 (excluding limestone), CG, CH-1 and CSSL as described in **subsection 1103.2a.(1)**. Primary aggregate requirements do not apply to the mixture used on the shoulder.

e. Contractor Trial Mix Design. A minimum of 10 working days before the start of HMA production, submit in writing to the DME for review and approval, a proposed JMF for each combination of aggregates. For each JMF submitted, include test data to demonstrate that mixtures complying with each proposed JMF shall have properties specified in **TABLE 602-1** for the designated mix type at the Recommended Percent Asphalt (P_{br}). Submit the proposed JMF on forms provided by KDOT. Submit the worksheets used in the design process to include at a minimum the mix properties listed in **TABLE 602-2**. Contact the DME to determine if additional information should be submitted. Provide sufficient material as identified in **TABLE 602-3**. Contact the DME to determine if additional material is needed for additional design checks such as the modified Lottman test (KT-56).

When more than 25% of the mix is comprised of siliceous virgin aggregates and/or RAP, add anti-strip to the mix. The minimum amount of anti-strip required in the mix is 0.01% for every percent of natural sand and RAP in the mix. Thus, if 25% natural sand and 10% RAP is in a mix, then 0.35% anti-strip by weight of virgin asphalt binder is required in the mix.

If during production, the Tensile Strength Ratio (TSR) values (both KDOT and Contractor) exceed 85%, then the Contractor and the DME, working together, may decide on a lower amount of anti-strip.

Submit for the Engineer's review and approval, the test data listed in **TABLE 602-4** for each blend and the proposed JMF. In addition, for mixes containing RAP or RAS, submit for the Engineer's review and approval, the test data listed in **TABLE 602-5** for each blend and the proposed JMF. Submit a mix design for each blend and the proposed JMF as outlined in **TABLE 602-6**.

For each aggregate used in the mix design, determine the specific gravity using KT-06. This may be accomplished while the project is being constructed or anytime during the 12 months preceding the start of construction on a project. If construction has not yet begun, notify the DME 5 working days prior to obtaining the material for the specific gravity test so that companion samples may be obtained at the same time. If construction has already begun on the project, then determine the specific gravity values of the individual aggregates before 10,000 tons of HMA is produced. Provide the test results to the DME within 14 days of sampling the material. If the producer of the aggregate has been required to submit material to KDOT for a new Official Quality test, since the time the Contractor ran the specific gravity tests, then perform KT-06 on the aggregate currently produced. Do not use the specific gravity values obtained from these tests in the mix design calculations for current projects, unless mutually agreeable to both parties. Use the information, as soon as it becomes available, as part of the process to verify and update the "Monthly Hot Mix Aggregate Specific Gravity Values" posted on KDOT's Internet site.

TABLE 602-1: COMBINED AGGREGATE REQUIREMENTS											
Nom. Max. Size Mix Designation	Percent Retained – Square Mesh Sieves									Min. VMA (%)	D/B Ratio
	$1^1/_2$"	1"	$^3/_4$"	$^1/_2$"	$^3/_8$"	No. 4	No. 8	No. 16	No. 200		
SM-4.75A SR-4.75A			 0	0 0-2	0-5 0-5	0-10 0-10		40-70 40-70	88.0-94.0 88.0-94.0	16.0 16.0	0.9 – 2.0 0.9 – 2.0
SM-9.5A SR-9.5A			 0	0 0-2	0-10 0-10	10 min. 10 min.	33-53 33-53		90.0-98.0 90.0-98.0	15.0 15.0	0.6 – 1.2 0.6 – 1.2
SM-9.5B SR-9.5B			 0	0 0-2	0-10 0-10	10 min. 10 min.	53-68 53-68		90.0-98.0 90.0-98.0	15.0 15.0	0.8 – 1.6 0.8 – 1.6
SM-9.5T SR-9.5T			 0	0 0-2	0-10 0-10	10 min. 10 min.	53-68 53-68		90.0-98.0 90.0-98.0	15.0 15.0	0.8 – 1.6 0.8 – 1.6
SM-12.5A SR-12.5A		 0	0 0-2	0-10 0-10	10 min. 10 min.		42-61 42-61		90.0-98.0 90.0-98.0	14.0 14.0	0.6 – 1.2 0.6 – 1.2
SM-12.5B SR-12.5B		 0	0 0-2	0-10 0-10	10 min. 10 min.		61-72 61-72		90.0-98.0 90.0-98.0	14.0 14.0	0.8 – 1.6 0.8 – 1.6
SM-19A SR-19A	 0	0 0-2	0-10 0-10	10 min. 10 min.			51-65 51-65		92.0-98.0 92.0-98.0	13.0 13.0	0.6 – 1.2 0.6 – 1.2
SM-19B SR-19B	 0	0 0-2	0-10 0-10	10 min. 10 min.			65-77 65-77		92.0-98.0 92.0-98.0	13.0 13.0	0.8 – 1.6 0.8 – 1.6

1. The requirements for Coarse Aggregate Angularity (CAA); Fine Aggregate Angularity (FAA); Sand Equivalent (SE); percent RAP; binder grade; Gyratory compaction revolutions N_{ini}, N_{des}, N_{max}, N_{ini} level of compaction and VFA shall be as shown in the Contract Special Provisions for each mix designation.
2. The flat and elongated particles in the combined coarse aggregate shall not exceed 10% for the total sample.
3. The maximum percent moisture in the final mixture shall not exceed 0.5 for any mix designation.
4. The target air voids (V_a) for any mix designation shall be 3.0% at N_{des} gyrations.
5. The minimum tensile strength ratio (%TSR) shall be 80% for any mix designation.
6. The level of compaction of the mix when compacted to N_{ini} gyrations shall be less than the percent of the G_{mm} shown in the Contract Special Provision, and when compacted to N_{max} gyrations shall be a maximum of 98.5% of the G_{mm}.
7. For mixes containing recycled asphalt shingles (RAS), increase the minimum VMA requirement in **TABLE 602-1** by 0.1 percent for every 1 percent RAS (by weight of aggregate) in the JMF.

TABLE 602-2: MIX PROPERTIES			
Property	**Abbreviation**	**Test Method**	**Additional Information**
Air Voids	V_a	KT-15 & KT-58	Calculated from G_{mm} and G_{mb}. Run at the P_{br}.
Recommended Percent Asphalt	P_{br}		Produce a mix with a V_a of 2.5% to 3.5%.
Theoretical Maximum Specific Gravity	G_{mm}	KT-39	Rice Test.
Percent Tensile Strength Ratio	%TSR	KT-56	Run test at P_{br} or at 0.3% to 0.5% less than P_{br}
Sand Equivalent	SE	KT-55	
Bulk Specific Gravity of HMA	G_{mb}	KT-15	Compacted Mix Property.
Percent G_{mm} at N_{ini} and N_{des} and N_{max}	%G_{mm} @ N_{ini} %G_{mm} @ N_{des} %G_{mm} @ N_{max}	KT-15	Use G_{mm} value from KT-39. Calculated from Gyratory Compaction height data, G_{mm}, and G_{mb}.
Voids in Mineral Aggregate	VMA	KT-15 & KT-06	Calculated from G_{mb}, G_{sb}, P_b.
Voids Filled with Asphalt	VFA		Calculated from VMA and V_a @ N_{des}.
Coarse Aggregate Angularity	CAA	KT-31	
Fine Aggregate Angularity	FAA	KT-50	

Formulas for calculations are in the Superpave Volumetric Mixture Design and Analysis Handbook.

TABLE 602-3: MATERIAL SUBMITTALS			
Submittal	**Quantity**	**Description**	**Additional Information**
Aggregate for KT-15	3 Samples	Sized for 6 inch Plugs	Comply with Job Mix Gradation.
Aggregate for KT-39	2 Samples	Sized for G_{mm} Testing	Comply with Job Mix Gradation.
Binder for KT-15	As Needed	Sized for 3 Plugs at P_{br}	
Binder for KT-39	As Needed	Sized for 2 G_{mm} Tests	
Each Aggregate for KT-06	As Needed	Specific Gravity Test	
Uncompacted HMA Sample	35 lbs	Cool sample to room temperature	If transported hot and compacted within 2 hours, then requirement to cool sample may be waived by the DME.
Gyratory Plugs at N_{max}	2 Plugs	Compacted at P_{br}	Compacted to N_{max}.

TABLE 602-4: TEST DATA SUBMITTALS	
Submittal	**Information**
Asphalt Binder	Source, Grade, Specific Gravity, Mixing and Compaction Temperature from the Producer of the asphalt binder.
Each Aggregate	Source and Producer, including Legal Description.
Gradation of Each Aggregate	Percentage Retained to nearest 1% (except nearest 0.1% for No. 200 sieve) Derive RAP gradation after residual binder is removed. Derive RAS gradation after residual binder is removed or from the Shingle Aggregate Gradation table in **SECTION 1103**.
Material Proportioning	Proportion of each material is shown in percentage of aggregate.
Composite Gradation	Based on Gradation of Each Aggregate and Material Proportioning.
Composite Gradation Plot	Plotted on KDOT Form 712 (0.45 power graph paper).
Asphalt Binder Added	Percentage to nearest 0.01% based on total weight of the mixture.
Aggregate	Percentage of flat and elongated particles in the coarse aggregate, CAA and FAA.
%TSR	Percent Tensile Strength Ratio of the Mixture (Modified Lottman Test).
Sand Equivalent	SE for the combined virgin aggregates.

TABLE 602-5: RAP AND RAS TEST DATA SUBMITTALS	
Submittal	**Information**
RAP and RAS	Source and location where RAP will be obtained. Source and location where RAS will be obtained.
RAP Aggregate	Bulk Specific Gravity (G_{sb}). Use the G_{sb} provided on the Contract Special Provision. If no value is provided, the Effective Specific Gravity (G_{se}) shall be calculated as shown in subsection 5.10.4, Part V and used as the G_{sb}.
RAS Aggregate	Bulk Specific Gravity (G_{sb}). The Effective Specific Gravity (G_{se}) shall be calculated as shown in subsection 5.10.4, Part V and used as the G_{sb}.
Asphalt Binder Content of RAP Asphalt Binder Content of RAS	Determined from ignition oven analysis using KT-57.
RAP G_{mm} RAS G_{mm}	Determined by KT-39.
Asphalt Binder Specific Gravity	Specific Gravity of the asphalt binder in the RAP and RAS (G_b) shall be set equal to 1.035.
Corrected Asphalt Binder Content of the total recycled mixture	Determined from ignition oven analysis using KT-57.

TABLE 602-6: MIX DESIGN TEST DATA SUBMITTALS	
Submittal	**Information**
Minimum of 2 Mix Designs	As a minimum, 1 mix design at the P_{br} and 1 mix design at 0.3% to 0.5% below the P_{br}
G_{mm}	Determined at each binder content.
Individual and Bulk Specific Gravity Tests	Provide results for a minimum of 2 specimens at each binder content.
Percent Air Voids	Provide % V_a in the mixture for each binder content when compacted to N_{ini}, N_{des} and N_{max} gyratory revolutions along with copies of the Gyratory graphs.
Percent VMA	Provide %VMA at each binder content. (Note: The Contractor is cautioned that plant produced material generally yields a mixture with less VMA than predicted by the design. In such case, the design VMA should be increased above the specified minimum accordingly.)
D/B Ratio	Calculate to the nearest 0.1% at each binder content.

f. Additives. Provide Warm Mix Asphalt (WMA) additives or processes that comply with **SECTION 1207**. The Contractor is permitted to use WMA, unless otherwise shown in the Contract Documents.

For mixes containing Warm Mix Asphalt (WMA) additives, submit for the Engineer's review and approval, the additive or process used, the recommended rate of application, and the temperature ranges for mixing and compaction.

Mixing temperature range is provided by the Asphalt Binder Supplier. When using WMA, the mixing temperature may be reduced no more than 30°F for WMA water foaming processes, and no more than 70°F for WMA chemical and organic additives. The minimum mixing temperature for WMA is 220°F.

602.4 CONSTRUCTION REQUIREMENTS

a. Plant Operation. Adjust all plant operations to operate continuously.

(1) Preparation of the Asphalt Binder. Heat the asphalt binder to within a range as specified in **SECTION 601**. When heating the asphalt binder to the specified temperature, avoid local overheating. At all times, provide a continuous supply of the asphalt binder to the mixer at a uniform temperature. Asphalt binder received from the refinery at temperatures less than 375°F may be used as received, if the requirements regarding the reheating of asphalt binder in **SECTION 601** are met.

(a) Commingling of Asphalt Binders. Do not add or commingle asphalt binders from 2 or more sources into a storage tank. If this occurs, the contents of the storage tank are considered contaminated. Do not use the contents of the storage tank on the project, except as follows: It is permissible, at the Contractor's option, to thoroughly mix the contents of the tank and request sampling of the mixture. Submit the sample to the MRC for testing. Do not use the asphalt binder until approved, and when needed, a new mix design evaluation is completed.

(b) Asphalt Binder Sources. Before changing asphalt binder sources on a project, obtain approval from the DME. A new JMF may be required.

(c) Anti-Strip Additives. If liquid anti-strip additives are added at the Contractor's plant, install a "totalizer" to monitor the quantity of anti-strip additive being added. The Engineer may approve alternative methods for including anti-strip additives in a batch plant. If added at the plant, the anti-strip will be added in line with the asphalt binder as it is being transferred from the transit unit to the asphalt binder storage tank. Provide a method for the Engineer to monitor the percent of additive being added.

If hydrated lime is added, mix it in an approved pug mill to coat the combined aggregates. Moisten the combined virgin aggregate to a minimum of 3% above the saturated surface dry condition prior to, or during the addition of the hydrated lime.

(d) WMA Additives. If WMA additives are added at the Contractor's plant, install a "totalizer" to monitor the quantity of WMA additive being added. The Engineer may approve alternative methods for including chemical and organic WMA additives in a batch plant. If added at the plant, chemical and organic WMA additives will be added in line with the asphalt binder as it is being transferred from the transit unit to the asphalt binder storage tank. Provide a method for the Engineer to monitor the percent of additive being added.

(2) Preparation of Mineral Aggregate. When the mineral aggregate is composed of 2 or more ingredients, combine as shown in the approved JMF.

(a) Temperature Requirements. Dry the aggregate for the mixture and heat to a temperature to obtain an asphalt-aggregate mixture temperature immediately after mixing within the 75 to 150 second Saybolt viscosity range of the asphalt binder used. Obtain the temperature for this viscosity range from the MRC or the Asphalt Binder Producer. No mixing or compaction temperatures are to exceed 340ºF without approval from the Field Materials Engineer. The minimum temperature may be revised by the DME provided it is demonstrated that satisfactory results may be obtained at a lower temperature. In such event, deliver the HMA to the paver at a temperature sufficient to allow the material to be satisfactorily placed and compacted to the specified density and surface tolerance requirements.

(3) Preparation of HMA. Introduce asphalt binder into the prepared aggregate in the proportionate amount determined by the P_{br} in the JMF.

(a) Basis of Rejection. HMA will be rejected if the aggregate, as it is discharged from the drum or the pugmill, contains sufficient moisture to cause foaming of the mixture, or if the temperature of the aggregate is such that the asphalt-aggregate mixture temperature is outside the range specified in **SECTION 601**.

(b) Mixing Time. Operate drum mixers at a rate to provide uniform aggregate coating in a continuous operation. For batch and continuous type plants, the minimum wet mixing time is 40 seconds. In all cases, mix a sufficient time to produce a uniform mixture in which all the aggregate particles are thoroughly coated. On batch plants, begin the timing at the start of the asphalt binder introduction into the pugmill, and end upon the opening of the discharge gate. For continuous flow plants, mixing time in seconds shall equal:

[pugmill dead capacity in pounds] divided by [pugmill output in pounds per second].

(c) Manufacturer's Specifications. Operate all drying, pumping and mixing equipment within the limits specified by the manufacturer, unless it can be demonstrated to the satisfaction of the Engineer that such limits may be exceeded without detriment to the HMA.

(d) Batcher Operation. Coordinate HMA batchers (Gob Hoppers) with the plant production rate at all times so the hopper is more than ¾ full before the gates open, and the gates close before material can drop through the gob hopper directly into the surge bin, weigh hopper or truck.

(e) Wasted Material. Wasted material is not measured for pay.

If after an interruption of production, the drum-mixer contains cold, uncoated or otherwise unsuitable material, waste material through a diversion chute. In a continuous or batch plant drier, waste unsuitable material through the pugmill.

At the end of a production run, waste any segregated material in the cone of the storage bin.

(4) End of Day Quantities. At the end of each day of production provide the Engineer with a document signed by the Plant Foreman or the Project Manager listing the dry weight of each aggregate, mineral filler, RAP, RAS and WMA chemical or organic additive; the tons of asphalt binder, the tons of anti-strip agent used for the project during the day, and the tons of water used in the WMA foaming process. The dry weight is the tons of the material less the water content.

b. Road Surface Preparation.

(1) Preparation of Earth Subgrade. Do not place any surfacing material on any section, until the ditches and drains along that section are constructed to effectively drain the highway, and the base or subgrade is trimmed to the line, grade and typical cross-section as shown in the Contract Documents.

Do not deposit any material until the subgrade or base has been checked and approved by the Engineer.

Maintain the subgrade as prepared until it is covered with the base course. Repair any defects which may develop, at the Contractor's expense, to the satisfaction of the Engineer.

Protect the subgrade from damage when handling materials, tools and equipment. Do not store or stockpile materials on the subgrade. Do not place material or lay pavement on a frozen or muddy subgrade, or when it is raining or snowing.

Lightly spray the subgrade or base with water to obtain a thoroughly moistened condition when the HMA is deposited on it. Lightly scarify, where necessary. Do not puddle water on the grade. Disturb the originally compacted crust or top portion of the subgrade as little as possible.

(2) Preparation of an Existing Asphalt Pavement. Clean the surface to remove all foreign material and broom to remove dust. Excavate areas shown in the Contract Documents to be patched to a depth directed by the Engineer. Fill with HMA and compact.

(3) Preparation of an Existing Concrete or Brick Pavement. Clean all foreign material and broom to remove dust. Clean and fill cracks and joints, and construct surface leveling as shown in the Contract Documents.

(4) Tack Coat. Prior to placing the HMA, apply a tack coat to the existing surface, as shown in the Contract Documents. When warranted by weather conditions, the Engineer may authorize a change in the asphalt for tack coat. When such changes are made, the price per ton of material being used will be the unit price bid for the material designated in the contract plus or minus the difference in the invoice price per ton of the 2 materials at the refinery as determined at the time of application.

c. Weighing Operations. See **SECTION 109** for details regarding weighing operations.

d. Hauling Operations. Schedule operations to minimize hauling over a surface course.

Deliver HMA to the paver at a temperature sufficient to allow the material to be placed and compacted to the specified density and surface tolerance.

e. Paving Operations. Except when placing SM-4.75A, SM-9.5A or SR-9.5A asphalt mixtures, remix the material transferred from the hauling unit, prior to placement. Use equipment such as a mobile conveyor, material transfer device, shuttle buggy material transfer vehicle, material transfer paver or paver with remixer conveyor system. After starting the project with the equipment listed above, and after producing HMA pavement density within the limits specified in **TABLE 602-7**, the Engineer will consider other types of equipment or modifications to pavers that will produce less segregation. The use of equipment as noted above shall not relieve the Contractor of the responsibility to comply with **TABLE 602-7**. The Engineer will check the pavement for longitudinal streaks and other irregularities. Make every effort to prevent or correct any irregularities in the pavement, such as changing pavers or using different and additional equipment.

Do not raise (dump) the wings of the paver receiving hopper at any time during the paving operation. The Engineer may waive this requirement if it is determined that raising (dumping) the wings will not produce detrimental segregation. If segregation or irregularities in the pavement surface or density are noted, review the plant, hauling and paving operations and take corrective action. The recommendations made in KDOT's "Segregation Check Points" should reduce the segregation and irregularities to an acceptable level. Copies of KDOT's "Segregation Check Points" may be obtained from the KDOT District Office or Field Engineer.

Spread the HMA and finish to the specified crown and grade using an automatically controlled HMA paver. Operate the paver at a speed to provide a uniform rate of placement without undue interruption. At all times, keep the paver hopper sufficiently full to prevent non-uniform flow of the HMA to the augers and screed.

If the automatic grade control devices break down, the Engineer may allow the paver to operate to the close of the working day, provided the surface is satisfactory. Do not operate the paver without working automatic control devices upon another lift that was laid without automatic controls.

(1) Surface Quality. Spread the HMA without tearing the surface. Strike a finish that is smooth, free of segregation, true to cross section, uniform in density and texture and free from surface irregularities. If the pavement does not comply with all of these requirements, plant production and paving will be suspended until the deficiency is corrected.

The Engineer will check segregation and uniformity of density using methods outlined in Section 5.8.3 - Segregation Check Using the Nuclear Density Gauge, Part V. For shoulders with a plan width of less than or equal to 3 feet, and placed at the same time as the traveled way, do not take nuclear density readings on the shoulder nor within 1 foot of the shoulder unless the pavement section is uniform across the entire roadway. The acceptable criteria for density uniformity are in **TABLE 602-7**.

TABLE 602-7: SEGREGATION AND UNIFORMITY OF DENSITY CHECK		
Mix Designation	**Maximum Density Range (highest minus lowest)**	**Maximum Density Drop (average minus lowest)**
All	4.4 lbs./cu. ft.	2.2 lbs./cu. ft.

Whenever the results from 2 consecutive density profiles fail to comply with both of the requirements listed in **TABLE 602-7**, plant production and paving will be suspended. Follow the procedures listed in the Profile Evaluation

Subsection of Section 5.8.3-Segregation Check Using the Nuclear Density Gauge, Part V until production may be resumed.

Joint density testing and the associated requirements listed below do not apply for HMA lift thicknesses less than or equal to 1 inch.

Evaluate the longitudinal joint density using methods outlined in Section 5.8.4-Joint Density Evaluation Using the Nuclear Density Gauge, Part V. Although it is the Contractor's responsibility to perform the joint density evaluation, the Engineer may make as many independent joint density verifications as deemed necessary at the random sample locations. The Engineer's results will be used for acceptance for joint density, whenever available. The acceptable criteria for joint density are in **TABLE 602-8**.

TABLE 602-8: JOINT DENSITY REQUIREMENTS	
Nuclear Gauge Readings	**Requirement**
Interior Density minus Joint Density	≤ 3.0 lbs./cu. ft.
OR	
Joint Density	≥ 91.00% of G_{mm}

If the results of 2 consecutive density profiles fail to comply with **TABLE 602-8**, the plant production and paving operations will be suspended. Follow the procedures listed in the Joint Evaluation Subsection of Section 5.8.4-Joint Density Evaluation Using the Nuclear Density Gauge, Part V, until production may be resumed.

(2) Leveling Courses. In general, spread leveling course mixtures by the method to produce the best results under prevailing conditions to secure a smooth base of uniform grade and cross section. The leveling course may be spread with a properly equipped paver or motor grader.

(3) Lift Thickness. Except for leveling courses or when shown otherwise in the Contract Documents, **TABLE 602-9** applies. The Engineer may adjust lift thickness to utilize the most efficient method of acquiring specified density and surface quality. The minimum lift thickness for any HMA mixture is 3 times the nominal maximum aggregate size, unless otherwise designated in the Contract Documents or approved by the Engineer.

TABLE 602-9: NOMINAL COMPACTED THICKNESS	
Lift	**Maximum Nominal Compacted Thickness**
Surface	2 inches
Base	4 inches

(4) Grade Control. Achieve grade control by use of 1 or more of the following grade reference devices. Approval of any of these devices will be based upon satisfactory performance.

(a) Traveling Stringline. Attach a traveling stringline or ski type attachment, a minimum length of 30 feet, to the paver and operate parallel with its line of travel.

(b) Reference Shoe. Attach a short reference shoe or joint matching device to the paver for control in matching surface grades along longitudinal joints.

(c) Erect Stringline. Use an erected stringline consisting of a tightly stretched wire or string offset from and parallel to the pavement edge on 1 or both sides. Erect the stringline parallel to the established pavement surface grade and support at intervals as necessary to maintain the established grade and alignment.

(d) Stringless Paving. Control line, grade and pavement cross-section as shown in the Contract Documents. Use electronic guidance systems that meet the requirements and tolerances listed in **SECTION 802**. Horizontal control is guided by GPS. Vertical control is guided by Total Stations. GPS will not be allowed for Vertical control.

When paving on a fresh subgrade that has not been trimmed by an automatically controlled machine, use an erected stringline or stringless paving to establish grade. Use either of these options on the first or second lift. When directed by the Engineer, use an erected stringline or stringless paving to match grade control points such as bridges.

(5) Compaction of Mixtures. Uniformly compact the HMA as soon after spreading and strike-off as possible without shoving or tearing. Use self-propelled rollers operated at speeds slow enough to avoid displacement of the HMA. Equipment and rolling procedures which result in excessive crushing of the aggregate are prohibited. Use a sufficient number and weight of rollers to compact the HMA to the required density, using a minimum of 2 rollers. If the hot mix plant is operating at over 275 tons per hour, use a minimum of 3 rollers. See **subsections 602.4e.(6)** for

exceptions to the minimum number of rollers. Perform final rolling with a steel roller unless otherwise specified. On the final pass, operate finish rollers in the static or oscillating mode.

Coordinate the frequency, amplitude and forward speed of the vibratory roller to achieve satisfactory compaction without objectionable undulations. For HMA lifts with a compacted thickness less than 1¼ inch, operate vibratory rollers in the static mode.

Keep rollers in operation as necessary so all parts of the pavement receive substantially equal compaction at the proper time. The Engineer will suspend HMA delivery to the project at any time proper compaction is not being performed.

Remove, replace with suitable material and finish according to these specifications any mixture that becomes loose, broken, mixed with foreign material or which does not comply in all respects with the specifications.

(6) Density Requirements.

(a) For mixes with a specified thickness greater than or equal to 1 ½ inches:

For lots 1 and 2, control density as shown in **subsection 602.4e.(6)(b)**. Before beginning production, the Contractor has the option to accept the pay adjustment for density on both Lots 1 and 2, or only Lot 2. If the Contractor chooses to accept the pay adjustments for density on both Lots 1 and 2, or only Lot 2, control the density as shown in **subsections 602.4e.(6)(a)(i-ii)**. If the Contractor chooses to accept pay adjustment for density on Lot 1, the pay adjustment can not be rejected on Lot 2.

(i) HMA Overlay. For lots 3 and greater, the lot density requirements and appropriate density pay adjustment factors are shown in **subsection 602.9b.** as the percent of the G_{mm} value based on the average of the density tests. The standard lot size is 10 density tests. Smaller lot sizes may result as outlined in **TABLE 602-10**. Normally, the G_{mm} value used to calculate the density percentage is the average value of all G_{mm} tests conducted the same day the lot was placed and compacted. If less than 3 G_{mm} values were obtained that day, use the moving average value (last 4 tests prior to the end of the day). When starting a mix and less than 4 G_{mm} values have been determined, use the average value of those available at the end of each day.

(ii) HMA Surface, HMA Base and HMA Pavement. For lots 3 and greater, the lower specification limit (LSL) value for density is given in **subsection 602.9c.** along with the appropriate density pay adjustment factor equations. The LSL value is given as a percentage of G_{mm}. Lot density is determined using the measured density values for all sublots in a lot. The standard lot size is 10 density tests. Smaller lot sizes may result as outlined in **TABLE 602-10**. Normally, the G_{mm} value used to calculate the density percentage is the average value of all G_{mm} tests conducted the same day the lot was placed and compacted. If less than 3 G_{mm} values were obtained that day, use the moving average value (last 4 tests prior to the end of the day). When starting a mix and less than 4 G_{mm} values have been determined, use the average value of those available at the end of each day.

(b) For mixes with a specified thickness less than 1½ inches:

These mixes will not have a density pay adjustment. Control density using an approved rolling procedure with random nuclear gauge density determinations. Include a method for controlling density in the QCP.

Designate a "Compaction Foreman". This person shall control compaction procedures, review nuclear gauge results as they are obtained, adjust compaction procedures as needed to optimize compaction and report any changes in the compaction process and results of nuclear gauge testing to the Engineer. The compaction foreman may also be the nuclear gauge operator. The nuclear gauge operator shall continuously monitor compaction procedures. As a minimum, take 10 random nuclear gauge density determinations per day and report results to the Engineer. Throughout the day, nuclear gauge results shall be available for review by the Engineer. The compaction foreman shall document at a minimum of once every 2 hours that the approved rolling sequence is being followed. Documentation includes roller passes, the mat temperature at each pass, amplitude setting of rollers and roller speed. Provide the documentation to the Engineer.

Determine and periodically update an approved rolling procedure, as outlined in this section. As a minimum, evaluate the initial rolling procedure using 3 rollers. If the hot mix plant is operating at over 275 tons per hour, use a minimum of 4 rollers in the initial evaluation. Operate vibratory rollers according to **SECTION 151**. Evaluate HMA paver screed operation with the nuclear gauge at various vibration settings. For screed evaluation, take the nuclear gauge readings directly behind the screed and before rolling. The Compaction Foreman and Engineer will evaluate the densities obtained with the various roller combinations and screed settings to determine the initial approved rolling procedure.

Together, the Compaction Foreman and Engineer will determine when new rolling procedures are required. HMA production may be stopped by the Compaction Foreman or Engineer whenever rolling is not being performed according to the approved rolling procedure.

(c) For all lots, achieve the maximum density before the temperature of the HMA falls below 175°F. When using WMA, achieve the maximum density before the temperature of the WMA falls below 165ºF. Do not crush the aggregate. When the mat temperature falls below 175°F or 165°F for WMA, roller marks may be removed from the mat with a self-propelled static steel roller or an oscillating roller operating in either the static mode or in the oscillating mode.

TABLE 602-10: DAILY PRODUCTION VS NUMBER OF SUBLOTS AND TEST REQUIREMENTS

Daily Production (tons)	Number of Sublots	No. of Cores or Nuclear Density Tests**	No. of Verification Cores or Nuclear Density Tests**
0-599	3*	6*	3*
600-999	4*	8*	4*
1000 or more	5	10	5

*Minimum number for mixes with a specified thickness of 1½ inches or greater: The Contractor may choose to obtain the number required for 1000 or more tons. If the Contractor chooses to test 5 sublots (10 tests), KDOT will obtain 5 verification tests.

**For mixes with a specified thickness less than 1½ inch: Verification testing may be performed, but is not required. Additional testing may be performed by the Contractor. A minimum of 10 tests are required.

(7) Contact Surfaces. Coat contact surfaces of curbing, gutters, manholes and similar structures with a thin uniform coating of asphalt material. Place the HMA uniformly high near the contact surfaces so that after compaction it shall be approximately ¼ inch above the edge of such structures.

(8) Adjustment of Manholes (Set Price). When required, this work will be performed and paid for under **SECTION 816**.

(9) Construction Joints.

(a) Transverse Construction Joints. Use a method of making transverse construction joints to provide a thorough and continuous bond, provide an acceptable surface texture and meet density requirements. Do not vary the surface elevation more than 3/16 inch in 10 feet, when tested longitudinally across the joint. When required, repair the joints or paving operations will be suspended.

(b) Longitudinal Joints. Construct well bonded and sealed longitudinal joints to obtain maximum compaction at the joint. If deemed necessary by the Engineer to properly seal the joint, apply a light coat of asphalt emulsion or asphalt binder to the exposed edge before the joint is made.

Before placing the fresh HMA against a cut joint or against old pavement, spray or paint the contact surface with a thin uniform coat of asphalt emulsion or asphalt binder. Where a finishing machine is used, make the longitudinal joint by depositing a sufficient amount of HMA to form a smooth and tight joint.

Offset the longitudinal joint in successive courses by 6 to 12 inches. Comply with traffic lane edges for the width of the surface of top course placement.

(10) Shoulder Surfacing and Widening. When the placement width of shoulders or uniform width widenings is less than can be accomplished with a regular paver, spread each course with a mechanical spreading device.

(11) Rumble Strips. When designated, construct rumble strips according to the Contract Documents.

f. Treatment of Adjacent Areas. Pave sideroads, entrances and turnouts for mailboxes as shown in the Contract Documents. Overlay all widening areas designated in the Contract Documents or ordered by the Engineer.

g. Pavement Smoothness. Evaluate pavement smoothness according to **SECTION 603** and the following:

TABLE 602-11: MAXIMUM VARIATION OF THE SURFACE	
Length (feet)	**Maximum Variation of the Surface (inches)**
10	3/16
25	5/16

Correct all humps or depressions exceeding the specified tolerance by removing the defective work and overlaying with new material, or by other means approved by the Engineer. All necessary corrections are at the Contractor's expense.

602.5 PROCESS CONTROL

a. General. Establish gradation limits and proportions for each individual aggregate, mineral filler and RAP and RAS, when applicable. Specify the limits and proportions such that the material produced complies with the applicable requirements of the designated mix type. The Contractor is responsible for all process control operations including testing. At no time will KDOT's representative issue instructions to the Contractor or producer as to setting of dials, gauges, scales and meters. KDOT will collect and test verification samples and assurance samples and inspect the Contractor's quality control operations.

b. JMF Adjustments. Produce a mixture of uniform composition closely complying with approved design JMF to obtain the specified properties when compacted. If, during production, results from quality control tests demonstrate a need to make adjustments to the mix design, then make adjustments to the design JMF single point gradation and binder content to achieve the specified properties. The JMF adjustments shall produce a mix that complies with **TABLE 602-1** for the specified mix designation. When necessary, adjust on a sublot basis. Report the new JMF to KDOT's field representative and the DME before making such changes, and submit a new mix design for review and approval if required by the DME.

c. Specification Working Ranges. Establish acceptable limits for field test results by applying the tolerances shown in **TABLE 602-12** to the JMF or adjusted JMF for binder content. Establish acceptable limits for the other listed mix characteristics by applying the tolerances shown in **TABLE 602-12** to the requirements of **TABLE 602-1**.

TABLE 602-12: SPECIFICATION WORKING RANGES (QC/QA)				
Mix Characteristic	**Tolerance from JMF**			
	Single Test Value	**Plot**	**4 Point Moving Average Value**	**Plot**
Binder Content	±0.6%	*	±0.3%	*
Mix Characteristic	**Tolerance for Specification Limits**			
	Single Test Value	**Plot**	**4 Point Moving Average Value**	**Plot**
Gradation (applicable sieves in **TABLE 602-1**)	N/A	*	zero tolerance	*
Air Voids @ N_{des} gyrations	-1.0%, +1.5%	*	N/A	
Voids in Mineral Aggregate (VMA)	1.0% below min.	*	zero tolerance	*
Voids Filled with Asphalt (VFA)	N/A		zero tolerance	*
Course Aggregate Angularity (CAA)	zero tolerance		N/A	
Sand Equivalent (SE)	zero tolerance		N/A	
Fine Aggregate Uncompacted Voids (FAA)	zero tolerance		N/A	
%Tensile Strength Ratio (%TSR)	zero tolerance	*	N/A	
Density @ N_{ini} and N_{max}	N/A		zero tolerance	
Dust to Effective Binder (D/B) Ratio	zero tolerance	*	zero tolerance	*

* Plot data according to **subsection 106.4**.
For gradations, as a minimum, plot the No. 4, 8, 30 and 200 sieves.

Plot G_{mm} to third decimal point.
Indicate Job Mix Formula (JMF) and specification working range limits for single test results on the control charts using a green ink dotted line.
Indicate the specification working range limits for the 4-point moving average results with a green ink solid line.

d. Mixes with Reclaimed Asphalt Pavement (RAP). The intent of this section is to prevent more RAP going into a mix than is allowed in the Contract Documents. Totalizers are used to determine the %RAP in a mix; however, this does not preclude the Engineer from using other methods for determining the %RAP in a mix.

Provide the Engineer with the totalizer readings at the end of each day of production. These shall include the final daily readings for the RAP, virgin aggregates and asphalt binder.

The %RAP will be checked a minimum of twice a day by the Engineer. The readings will be taken a minimum of 2 hours apart and a maximum of 6 hours apart. The readings will not be taken within the first hour of start-up as adjustments to the plant are most frequent within this time frame.

Calculate RAP percentages using the plant totalizers for the virgin aggregates (AGG_v), and the RAP as follows:

Equation A: $$\%RAP = \frac{RAP * 100}{RAP + AGGv}$$

%RAP is the percent RAP in the total aggregates (Virgin and RAP) rounded to the nearest tenth.
RAP is the difference between the current and last reading of the RAP totalizer in tons.
AGG_v is the difference between the current and last reading of the Virgin Aggregate totalizer in tons.

%RAP is considered out of compliance when any of the following occurs:

- Any single test exceeds the maximum percentage allowed by specs by more than 3.0%.
- The 4-point moving average exceeds the maximum percentage allowed by specifications.

Actions to be taken if the %RAP is out of compliance:

- If any single test exceeds the maximum allowed %RAP by more than 3.0% stop production, perform the "0 check run" on the belts in the presence of the Engineer, and make adjustments to correct the discrepancy.
- If the 4-point moving average exceeds the maximum allowed %RAP three consecutive times, stop production, perform the "0 check run" on the belts in the presence of the Engineer, and make adjustments to correct the discrepancy.
- If the 4-point moving average exceeds the maximum allowed %RAP by more than 1.0% then the Contractor will be assessed the following penalty.

Equation B: $$\text{Recycled Asphalt Materials Deduct} = \frac{BP * Q * (\%RAP_4 - \%RAP_{max})}{100}$$

Recycled Asphalt Materials Deduct is the Dollar amount to be subtracted from the contract.
BP is the Bid Price of the mix.
Q is the Quantity, in tons, of material represented by the 4-point moving average. This value shall be based on the weigh tickets taken from the time of the 1st test of the 4-point moving average through the time of 4th test.
$\%RAP_4$ is the 4-point moving average of %RAP.
$\%RAP_{max}$ is the Maximum %RAP from the Project Special Provision.

Recycled Asphalt Materials Deduct for RAP will be an item added to the contract.

Any time production is stopped due to non-compliant %RAP, restart the 4-point moving average provided the belt had the "0 check run" performed in the presence of the Engineer, and adjustments were made to the mix proportioning to correct previous discrepancies. The initial start-up at the beginning of each work day does not constitute a stop in production due to non-compliant %RAP.

If at any time the Contractor chooses to stop production in order to correct discrepancies in the mix proportioning concerning the %RAP, the most recent data (not to exceed 4 points) will be averaged. If the average exceeds the maximum allowed %RAP by more than 1% then a Recycled Asphalt Materials Deduct will be assessed as calculated above with the following substitutions:

In the case where less than 4-points are available for the 4-point moving average, the most recent test is substituted for the 4th test, and the $\%RAP_4$ may be a single test, a 2-point moving average or a 3-point moving average.

e. Mixes with RAP and RAS. The intent of this section is to prevent more RAP or RAS going into a mix than is allowed in the Contract Documents. Totalizers are used to determine the %RAP and %RAS in a mix; however, this does not preclude the Engineer from using other methods for determining the %RAP and %RAS in a mix.

Provide the Engineer with the totalizer readings at the end of each day of production. These shall include the final daily readings for the RAP, RAS, virgin aggregates and asphalt binder. Readings for the RAP and RAS may be obtained from individual RAP and RAS measurements or may be calculated from measurements on the combined recycled material and either the RAP or RAS.

The %RAP and %RAS will be checked a minimum of twice a day by the Engineer. The readings will be taken a minimum of 2 hours apart and a maximum of 6 hours apart. The readings will not be taken within the first hour of start-up as adjustments to the plant are most frequent within this time frame.

Calculate RAP percentages using the plant totalizers for the virgin aggregates (AGG_v), RAP and RAS as follows:

Equation C: $$\%RAP = \frac{RAP * 100}{RAP + RAS + AGGv}$$

%RAP is the percent RAP in the total aggregates (Virgin, RAP and RAS) rounded to the nearest tenth.
RAP is the difference between the current and last reading of the RAP totalizer in tons.
RAS is the difference between the current and last reading of the RAS totalizer in tons.
AGG_v is the difference between the current and last reading of the Virgin Aggregate totalizer in tons.

%RAP is considered out of compliance when any of the following occurs:

- Any single test exceeds the target percentage in the JMF by more than 2.0%.
- The 4-point moving average exceeds the target percentage in the JMF.

Actions to be taken if the %RAP is out of compliance:

- If any single test exceeds the target %RAP in the JMF by more than 2.0% stop production, perform the “0 check run” on the belts in the presence of the Engineer, and make adjustments to correct the discrepancy.
- If the 4-point moving average exceeds the target %RAP in the JMF three consecutive times, stop production, perform the “0 check run” on the belts in the presence of the Engineer, and make adjustments to correct the discrepancy.
- If the 4-point moving average exceeds the target %RAP in the JMF by more than 1.0% then the Contractor will be assessed the following penalty.

Equation D: $$\text{Recycled Asphalt Materials Deduct} = \frac{BP * Q * (\%RAP_4 - \%RAP_{max})}{100}$$

Recycled Asphalt Materials Deduct is the Dollar amount to be subtracted from the contract.
BP is the Bid Price of the mix.
Q is the Quantity, in tons, of material represented by the 4-point moving average. This value shall be based on the weigh tickets taken from the time of the 1st test of the 4-point moving average through the time of 4th test.
$\%RAP_4$ is the 4-point moving average of %RAP.
$\%RAP_{max}$ is the target %RAP in the JMF.

Calculate RAS percentages using the plant totalizers for the virgin aggregates (AGG_v), RAP and RAS as follows:

Equation E: $$\%RAS = \frac{RAS * 100}{RAP + RAS + AGGv}$$

%RAS is the percent RAS in the total aggregates (Virgin, RAP and RAS) rounded to the nearest tenth.
RAP is the difference between the current and last reading of the RAP totalizer in tons.
RAS is the difference between the current and last reading of the RAS totalizer in tons.
AGG_v is the difference between the current and last reading of the Virgin Aggregate totalizer in tons.

%RAS is considered out of compliance when any of the following occurs:

- Any single test exceeds the target percentage in the JMF more than 1.0%.
- The 4-point moving average exceeds the target percentage in the JMF.

Actions to be taken if the %RAS is out of compliance:

- If any single test exceeds the target %RAS in the JMF by more than 1.0% stop production, perform the "0 check run" on the belts in the presence of the Engineer, and make adjustments to correct the discrepancy.
- If the 4-point moving average exceeds the target %RAS in the JMF three consecutive times, stop production, perform the "0 check run" on the belts in the presence of the Engineer, and make adjustments to correct the discrepancy.
- If the 4-point moving average exceeds the target %RAS in the JMF by more than 0.5% then the Contractor will be assessed the following penalty.

Equation F: $$\text{Recycled Asphalt Materials Deduct} = \frac{BP * Q * 4 * (\%RAS_4 - \%RAS_{max})}{100}$$

Recycled Asphalt Materials Deduct is the Dollar amount to be subtracted from the contract.
BP is the Bid Price of the mix.
Q is the Quantity, in tons, of material represented by the 4-point moving average. This value shall be based on the weigh tickets taken from the time of the 1st test of the 4-point moving average through the time of 4th test.
$\%RAS_4$ is the 4-point moving average of %RAS.
$\%RAS_{max}$ is the target %RAS in the JMF.

Recycled Asphalt Materials Deduct for RAP or RAS will be an item added to the contract.

Any time production is stopped due to non-compliant %RAP or %RAS, restart both 4-point moving averages provided the belt had the "0 check run" performed in the presence of the Engineer, and adjustments were made to the mix proportioning to correct previous discrepancies. The initial start-up at the beginning of each work day does not constitute a stop in production due to non-compliant %RAP or %RAS.

If at any time the Contractor chooses to stop production in order to correct discrepancies in the mix proportioning concerning the %RAP or %RAS, the most recent data (not to exceed 4 points) will be averaged. If the average exceeds the target %RAP in the JMF by more than 1.0% or exceeds the target %RAS in the JMF by more than 0.5% then a Recycled Asphalt Materials Deduct will be assessed as calculated above with the following substitutions:

In the case where less than 4-points are available for the 4-point moving average, the most recent test is substituted for the 4th test, and the $\%RAP_4$ or $\%RAS_4$ may be a single test, a 2-point moving average or a 3-point moving average.

602.6 COMPACTION TESTING

a. General. Make the density determination of the compacted mixture using test results on random samples selected by the Contractor or Engineer (see **subsection 602.2i.(1)**) from each lift placed. Select sites according to the approved QCP. Take the nuclear density tests or core samples before placement of the next lift and before opening to construction or public traffic, and no later than the next working day following the date of placement.

Exception to coring after any traffic on the overlay. Do not use this procedure more than twice on any one project or tied projects, unless approved by the Engineer. The Contractor may request re-evaluation by coring.

(Testing and coring shall be subsidiary items.) When coring is requested, follow these procedures for the lot under re-evaluation.

(1) Immediately prior to coring, determine nuclear gauge densities in the presence of the Engineer in the locations previously tested. The average nuclear gauge density after traffic will be determined. A Contractor density correction factor will be calculated as follows: the average nuclear gauge density after traffic minus the average nuclear gauge density before traffic. If the calculated Contractor density correction factor is a negative value, the Contractor's density correction factor will be set equal to zero (normally the density correction factor will be a positive number).

(2) Immediately before coring, nuclear gauge densities will be determined by the Engineer in the presence of the Contractor in the locations previously tested. The average nuclear density after traffic will be determined. A KDOT density correction factor will be calculated as follows, the average nuclear gauge density after traffic minus the average nuclear gauge density before traffic. If the calculated KDOT density correction factor is a negative number, KDOT's density correction factor will be set equal to zero.

(3) Determine the Traffic Density Correction Factor. It will be the larger of the Contractor's density correction factor or KDOT's density correction factor determined in **subsections 602.6a.(1)** and **(2)**.

(4) With the Engineer present, obtain 1 core from each of the Contractor and KDOT nuclear gauge locations. Mark each core as they are taken. Take the cores to KDOT's field laboratory for drying and evaluation. Together, the Contractor and Engineer will determine the density of each core. Determine the corrected core density for each Contractor and KDOT core as follows: the core density minus the Traffic Density Correction Factor.

(5) Using the corrected Contractor core densities and the corrected KDOT core densities, the Engineer will re-evaluate this lot using the procedures outlined in **subsection 602.9**. Based on this re-evaluation, the Engineer will inform the Contractor of the lots disposition and density pay adjustment factor.

For shoulders with a plan width of less than or equal to 3 feet and placed at the same time as the traveled way, the density pay adjustment factors for the traveled way applies. Acceptance of or pay adjustment for density on all shoulders with a plan width greater than 3 feet and any shoulder not placed at the same time as the traveled way shall be according to **subsection 602.9**.

A lot consists of a day's production for each lift placed and contains the number of density locations as outlined in **TABLE 602-10**. Base lot acceptance on 2 test results from each sublot unless the Engineer's results (1 test per sublot) are used. V_a lots and density lots are normally of different sizes.

If the lane being placed is to be opened to traffic that day, the Engineer and the Contractor may predetermine the sublot size based on anticipated production. If actual production does not meet anticipated production, the sublot size will be adjusted. The number of tests shall be as outlined in **TABLE 602-10**.

The minimum number of density tests is as listed in **TABLE 602-10**. The Contractor has the option to take additional tests to provide 10 test results to determine payment. The density pay adjustment factors are computed using formulas in **subsection 602.9**. The density pay adjustment factors do not apply to sideroads, entrances, crossovers and other incidental surfacing.

b. Nuclear Density Tests (For mixes with a specified thickness of 1½ inches or greater.). Take 2 nuclear density tests at random within each sublot. The Engineer will take 1 random nuclear density verification test per sublot. Perform nuclear density testing to be used in the determination of the traveled way pay adjustment factors and control of shoulder density. Do not take nuclear gauge readings within 1 foot of a longitudinal joint or edge, nor within 20 feet of a transverse joint. For shoulders with a plan width of less than or equal to 3 feet, and placed at the same time as the traveled way, do not take nuclear density readings on the shoulder nor within 1 foot of the shoulder unless the pavement section is uniform across the entire roadway. Mark the outline of the nuclear gauge on the pavement at each location tested with a method of marking that shall last a minimum of 24 hours. Take the nuclear density test at the random location. Do not move the gauge from this location to maximize or minimize the density results. If the Contractor doubts the accuracy of any of the nuclear density test results, the pavement may be cored at the nuclear gauge test locations. If coring is chosen to determine the density for pay adjustment purposes, then all nuclear density test results representing the lot shall be voided and cores taken as prescribed in **subsection 602.6c**.

Take verification nuclear density tests, 1 per sublot, at random locations selected by the Engineer. Payment factors will be based on the Contractor's nuclear density test results, provided those results are validated by KDOT's nuclear density tests.

The Engineer will determine a calibration factor for the Contractor's nuclear density device at the same time as a calibration factor is determined for KDOT's device. The Contractor will be afforded the opportunity to observe the calibration procedure whether it is performed at the district laboratory or on the project site. The Engineer should provide calibration factors by the end of the working day following the date of collecting the cores. In cases where this is not possible, the Contractor and the Engineer may agree in advance to accept a zero pay adjustment for the concerned lots.

The Engineer and Contractor will compare nuclear density test results before any traffic is allowed on the roadway. If the Contractor or KDOT density values are suspect, the Engineer may approve re-testing the locations in question. When re-testing is approved, substitute the new nuclear density values for the values in question. Before traffic is allowed on the roadway, the Contractor needs to determine if cores will be taken.

c. Cores (For mixes with a specified thickness of 1½ inches or greater.) Take 2 cores at random locations within each sublot. It may be necessary to chill the compacted mixture before coring so that the samples may be removed intact without distortion. Cut the samples using a 4-inch coring device, unless a 6-inch coring device is approved by the Engineer. Mark all samples with the lot number, sublot number and core number.

Transport the cores to the laboratory as soon as possible to prevent damage due to improper handling or exposure to heat. Cut all cores including the Engineer's verification cores. The Contractor will be paid only for cores cut to calibrate the nuclear gauge, when requested by the Engineer. Use KT-15 Procedure III to determine core density.

Do not take cores within 1 foot of a longitudinal joint or edge, nor within 20 feet of a transverse joint. For shoulders with a plan width of less than or equal to 3 feet, and placed at the same time as the traveled way, do not take cores on the shoulder nor within 1 foot of the shoulder unless the pavement section is uniform across the entire roadway.

Take 1 verification core per sublot (at locations selected by the Engineer) for testing at KDOT's laboratory. Density pay adjustment factors and control of shoulder density are based on the core results, provided those results are validated by the verification cores sent to KDOT's laboratory.

Dry the core holes, tack the sides and bottom, fill with the same type of material and properly compact it by the next working day.

602.7 WEATHER LIMITATIONS

Do not place HMA on any wet or frozen surface or when weather conditions otherwise prevent the proper handling and finishing of the mixture.

Only place HMA when either the minimum ambient air temperature or the road surface temperature shown in **TABLE 602-13** is met.

TABLE 602-13: MINIMUM HMA PLACEMENT TEMPERATURES

Paving Course	Thickness (inches)	Air Temperature (ºF)			Surface Temperature (ºF)		
		HMA	WMA Foam	WMA Chem	HMA	WMA Foam	WMA Chem
Surface	All	50	45	40	55	50	45
Subsurface	<1.5	50	45	40	55	50	45
Subsurface	≥1.5 and < 3	40	35	30	45	40	35
Subsurface	≥ 3	30	30	30	35	32	32

602.8 MIXTURE ACCEPTANCE

a. General. Test each mix designation at each plant for compliance with **TABLE 602-1**. Acceptance will be made on a lot by lot basis contingent upon satisfactory test results. Obtain test samples of the mix designation from the roadway behind the paving operation before compaction. The sampling device and procedures used to obtain the samples must be approved by the Engineer. Use KT-25 for obtaining HMA from the roadway and splitting of the sample. The Contractor's quality control tests will be used for acceptance provided those results are verified by KDOT.

A load or loads of mixture which, in the opinion of the Engineer, are unacceptable for reasons such as being segregated, aggregate being improperly coated, foaming aggregate or being outside the mixing temperature range may be rejected. Verification samples will be taken by the Engineer at randomly selected locations from behind the paver. Fill all sample locations before compaction.

The V_a test values will also be used to determine V_a pay adjustments according to **subsection 602.9d**. V_a pay adjustments apply to the HMA placed on the traveled way and shoulders (including ramps and acceleration and deceleration lanes).

b. Lot Definition for Mix Production Sampling and Testing. A lot is defined as an isolated quantity of a specified material produced from a single source or operation. Each lot shall normally be represented by 4 contiguous test results. A lot may be represented by test results on samples taken from 1 or more day's production.

c. Lot Investigation. The Engineer may examine materials represented by individual test results which lie beyond the Contractor's normal quality control testing variation. The investigation may be based on either Contractor or KDOT test results. The information from additional testing (including testing of in-place HMA) may be used to define unacceptable work according to **SECTION 105**. The Engineer may apply appropriate price reductions or initiate corrective action.

For any test, if a dispute exists between the Engineer and Contractor about the validity of the other's test results, the KDOT District Materials Laboratory or the MRC will perform referee testing, except for nuclear density dispute resolution and V_a dispute resolution. If the disputed KDOT test results were generated at the District Laboratory, the MRC will perform the referee tests. If the disputed KDOT test result was generated at the MRC, an independent laboratory agreeable to both parties will be selected. The Laboratory shall be accredited by the AASHTO Accreditation Program in the appropriate testing category.

If referee testing indicates that KDOT test results are correct, the Contractor pays for the additional testing, including referee testing performed at the MRC. This will be paid using the bid item Contract Deduct which will be an item added to the contract.

If the referee testing indicates that Contractor test results are correct, KDOT pays for the additional testing. Pay the independent lab for the testing and submit the paid invoice to KDOT. The Engineer will reimburse the Contractor (based on the invoice price) as Extra Work, **SECTION 104**.

(1) For nuclear density dispute resolution (the statistical comparison fails and the Contractor questions KDOT's results), the following procedure applies:

- Discard pay factors previously established with the nuclear gauge, and use the core results to establish the pay factors.
- With the Engineer present, take 1 core from each of the locations previously tested with the Contractor's nuclear gauge and KDOT's nuclear gauge (normally 15 cores). Mark all cores with the lot number, sublot number and core number.
- Take the cores to the field laboratory and dry to a constant weight before testing. The Contractor and the Engineer, working together, will determine the core densities (KT-15, Procedure III).
- A statistical comparison will be made between Contractor and KDOT core results. If the t-test passes, KDOT will pay for all cores. The Contractor's test results will be used to calculate the density pay factors. If the t-test fails, KDOT will not pay for the cores. KDOT test results will be used to calculate the density pay factors.

(2) For V_a dispute resolution (the statistical comparison fails and the Contractor questions KDOT results), the following procedure applies for the lots in question:

- Determine which lots to dispute. Only dispute the lot produced immediately prior to the lot currently under production and being tested. Notify the Engineer, prior to the completion of all Contractor V_a testing for this lot. (When production is completed for any mix, the last lot may be challenged the day production is completed). When the hot mix plant shuts down for the winter, the Contractor has a maximum of 7 calendar days to dispute the last lot produced prior to winter shut down.
- Discard V_a and V_a pay adjustment factors previously determined within the lots being questioned.
- All saved gyratory compacted V_a quality control and verification samples and back half of samples within the lots in question will be taken by KDOT to the District Materials Laboratory. All back half of samples shall be a minimum of 35 pounds. Failing to obtain enough material removes the right to dispute resolution. Copies of all paperwork, including work sheets, associated with previous V_a calculations for the disputed lots will also be taken to the District Materials Laboratory.

The following retesting will be completed by KDOT:

- Check the samples to be sure they are dry before retesting. Reweigh the original gyratory compacted V_a quality control and verification samples. Determine the G_{mb} at N_{des} revolutions for all saved gyratory plugs. Compare retest results with original test results. Use this information to isolate potential testing errors, but continue with the remainder of the retesting steps.

- Determine the G_{mm} using the back half of all samples within each lot being questioned. Normally, there will be 5 back halves (4 Contractor's and 1 KDOT) to test within each lot.
- Compact the back halves to N_{max} revolutions and determine the G_{mb} at N_{des} revolutions.
- Use G_{mm} determined above and the G_{mb} determined from the recompacted samples to calculate V_a at N_{des} revolutions for the lots in question.
- Using the retest V_a results, a statistical comparison will be made. If the t-test passes, the Contractor's retest results will be used to calculate the pay factor and KDOT will pay for all retesting. Use the procedures shown in **subsection 602.9d**. If the t-test fails, KDOT's retest results will be used to calculate the pay factor, and the Contractor will pay for all retesting.

d. Resampling of Lots. Take no samples for retest for pay adjustment purposes except as noted in **subsections 602.6b.** and **602.8c**.

e. Multiple Projects. If multiple projects are supplied from 1 or more plants using the same mix, carry over the lots at each hot mix plant from project to project.

f. Lot Size. A standard size mix production lot (density test lots are defined in **subsection 602.6a.(5)**) consists of 4 equal sublots of 750 tons each of HMA (lot size is 3,000 tons).

It is anticipated that lot size shall be as specified. However, with the Engineer's approval, the Contractor may re-define lot size for reasons such as, but not limited to, change in contract quantities or interruption of the work. Take 1 sample during production of each sublot and utilize it to determine disposition of the lot in which it occurs.

g. Increased Lot Size. After 8 consecutive sublots have been produced within the tolerances shown for all mix characteristics listed in **TABLE 602-12** and without a V_a penalty, the sublot size may be increased to 1,000 tons (lot size of 4,000 tons), provided the normal production rate of the plant is greater than 250 tons per hour. Provide immediate notification of lot size changes to the Engineer any time a change is made.

After 8 additional consecutive sublots have been produced at the 1,000 ton sublot size, the sublot size may again be increased to 1,250 tons per sublot (lot size of 5,000 tons), provided all 8 consecutive 1,000 ton sublots have been produced within the tolerances shown for all mix characteristics listed in **TABLE 602-12**, without a V_a penalty, production rates for the previous 2 days have been greater than 3,750 tons per day, and a minimum of 2 of the last 3 segregation profile checks comply with **TABLE 602-14**.

TABLE 602-14: SEGREGATION PROFILE CHECKS FOR INCREASED SUBLOT SIZE		
Mix Designation	**Maximum Density Range (highest minus lowest)**	**Maximum Density Drop (average minus lowest)**
All	3.1 lbs./cu. ft.	1.9 lbs./cu. ft.

If subsequent test results fall outside the tolerances shown for any mix characteristic listed in **TABLE 602-12** or a V_a penalty is incurred, decrease the sublot size to 750 tons. If the production rates fall below 3,750 tons per day for 2 consecutive days or a minimum of 2 of the last 3 segregation profile checks fail the above requirements, then reduce the 1,250 ton sublots size to 1,000 ton per sublot provided the **TABLE 602-12** criteria is met and no V_a penalty is incurred.

When the increased lot size criteria are again met for 4 consecutive sublots, the sublot may be increased as the limits given above.

h. Decreased Lot Size for Small Quantities. This is to be used when a small quantity (less than 3,000 tons) of a particular mix will be used. Use the plan quantity for the lot size. Reduce the sublot size below 750 tons by dividing the lot into 3 or 4 equal sublots. Before beginning production, provide the Engineer with the number and size of the sublots.

i. Pre-Production Mix. Test and evaluate a pre-production mix, limited to a maximum of 200 tons from each plant and type of mix before production of that mix. Evaluate the pre-production mix at initial start-up and after suspension of production resulting from failing test results. Do not adjust V_a payment for pre-production mixes. Provide a pre-production mix that complies with the gradation, D/B ratio, binder content, VMA, level of compaction for N_{ini}, N_{des}, N_{max} and laboratory V_a requirements prior to starting or resuming production. For binder content, V_a at

N_{des} and VMA, use the "Single Test Value" listed in **TABLE 602-12** for comparison. For the other tests listed, use the values listed in **TABLE 602-1** for each mix. Except for initial start-up, normal delivery of material to the project before completion of certain test results on pre-production mixes may be authorized by the DME.

Place the material produced for the pre-production mix in locations approved by the DME. On projects where HMA is paid by the ton, consider placing the pre-production mix in non-critical areas such as side roads, entrances, shoulders or deep in the base. The Engineer will pay for material as the material produced, not in the location placed. However to prevent potential cost overruns, do not run an excessive number of "higher cost" pre-production mixes (as determined by the Engineer) on shoulders or entrances.

On projects in which the HMA is paid by the square yard, place pre-production mixes where required by the Contract Documents. A higher quality pre-production mix may be placed at no additional expense to KDOT. If HMA materials which are designated to be placed in the top 4 inches of the pavement structure are placed deeper than 4 inches as a pre-production mix, do not count the material toward the requirement to place the material in the top 4 inches of the pavement section.

At the direction of the Engineer, remove the pre-production mix if it is both out of specification and the material shortens the pavement life or changes the intended function. The Engineer will pay for the replacement of one pre-production mix at 100% of the contract unit price for each mix in the contract (not each mix design). If the HMA is paid by the square yard, then the removed material will be paid for at a rate of $75 per ton. The Engineer will create a change order (**SECTION 104**) adding the item of work with a unit price of $75 per ton. The payment will be full compensation to the Contractor for the placement and removal of that pre-production mix. KDOT will not be financially responsible for any subsequent failed pre-production mixes (that require removal) for that mix. The removed material is the property of the Contractor.

The Engineer will not pay for pre-production mixes that are required to be replaced due to poor workmanship or equipment failure. The Engineer will make the final decision to remove a failed pre-production mix with input from the Contractor.

j. Suspension of Mix Production. Suspend production of the mix until appropriate corrections have been made, if 2 consecutive test results for any single mix characteristic fail to fall within the limits established by the tolerances shown in the single test value column of **TABLE 602-12**. Additionally, suspend production of the mix until appropriate corrections have been made, if any 4-point moving average value for any single mix characteristic fails to fall within the limits established by the tolerances shown in the 4-point moving average value column of **TABLE 602-12**. Production remains suspended pending the satisfactory results of a pre-production mix, unless waived by the DME.

The Engineer may stop production of HMA at any time the mix or process is determined to be unsatisfactory. Make the necessary corrections before production will be allowed to resume. Failure to stop production of HMA subjects all subsequent material to rejection by the Engineer, or acceptance at a reduced price, as determined by the Engineer.

602.9 BASIS OF ACCEPTANCE

a. General. Acceptance of the mixture will be contingent upon test results from both the Contractor and KDOT. The Engineer will routinely compare the variances (F-test) and the means (t-test) of the verification test results with the quality control test results for V_a, G_{mm} and density using a spreadsheet provided by KDOT. If KDOT verification test results do not show favorable comparison with the Contractor's quality control test results, then KDOT test results will be used for material acceptance, material rejection and the determination of any pay adjustment on the V_a and roadway density. Disputed test results will be handled according to **subsection 602.8c**.

KDOT will use a spreadsheet program to calculate pay adjustments for density and V_a, and to compare Contractor QC and KDOT QA test results (including G_{mm}). KDOT will provide a copy of this program to the Contractor, when requested. Microsoft Excel software is required to run this program; it is the Contractor's responsibility to obtain the correct software. Values computed using equations referenced in this specification may vary slightly from the spreadsheet values due to rounding of numbers. In such cases, the numbers computed by the spreadsheet will govern.

The comparison of quality control and verification tests will be completed using the t-tests to compare their population means and the F-test to compare their variances. The F & t tests, along with the Excel Spreadsheet used to compare the Contractor's QC results and KDOT's QA results, are described in Section 5.2.6 – Comparison of Quality Control and Verification Tests, Part V. (Examples of Air Voids F & t tests, along with Density F & t tests are shown in this section.) Additional information on the program may be obtained from the Bureau of Construction and Materials.

b. Asphalt Density Pay Adjustment for "HMA Overlay" Bid Items. Mixes with specified thickness of less than 1½ inches are not subject to the asphalt density pay adjustments.

For mixes with specified thickness of 1½ inches or greater: Asphalt density pay adjustment for compaction of the completed pavement shall be by lot, based on the percentage of G_{mm} obtained. Compute the asphalt density pay adjustment (incentive or disincentive) by multiplying the density pay adjustment factor (P_D) times the number of tons included in the lot times $75 per ton. (Air voids lots and density lots are normally of different sizes.) This adjustment will be paid for under the bid item Asphalt Density Pay Adjustment.

Density pay factors will be determined from **TABLE 602-15**. (For **TABLE 602-15**, average the percent of G_{mm} values to 0.01% and calculate the density pay adjustment factors rounded to the thousandths).

TABLE 602-15: DENSITY PAY FACTORS FOR SPECIFIED THICKNESS[4]		
Specified Thickness →	**≥ 2"**	**≥ 1½"**	
	All	**Continuous Action[5]**	**No Continuous Action[6]**
% of G_{mm} Average of 10 Density Tests[1]	**Pay Factor[2]**		**Pay Factor[2]**
94.00% or greater	1.040		1.040
93.00 to 93.99%	A1		A2
92.00 to 92.99%	1.000		A2
91.00 to 91.99%	A3		1.000
90.00 to 90.99%	A3		A4
89.00% to 89.99%	0.840 or Remove[3]		A4
less than 89.00%	0.840 or Remove[3]		0.840 or Remove[3]

[1]For low daily production rates less than 1000 tons, or when the Engineer's verification tests are to be used for asphalt density pay determination, the lot sample size is as determined in **TABLE 602-10**.

[2]Shoulders: For shoulders with a plan width greater than 3 feet and any shoulder not placed at the same time as the traveled way, compact the HMA in the lot to a minimum of 91.00% (if specified thickness is ≥2") or 90.00% (if the specified thickness is from 1½" to 1⅞") of the G_{mm}. Otherwise, the Engineer will determine whether the HMA in the lot may remain in place or be removed. Any such material left in place shall have a density pay factor of 0.950 or less.

[3]Low Density: The Engineer will determine if the traveled way, shoulders with a plan width of 3 feet or less and placed with the traveled way, ramps, acceleration and deceleration lanes may remain in place or be removed. The Engineer will notify the Contractor before 11:00 AM of the next working day if the area is to be removed. Any such material left in place shall have a density pay factor of 0.840.

[4]Specified thickness is the total thickness shown in the Contract Documents for the mix being placed.

[5]Use for ≥1½" when another continuous action, such as milling, surface recycling, cold recycling or overlay is completed ahead of this overlay.

[6]Use for ≥1½" when another continuous action is not completed before the overlay.

Calculations for Density Pay Factors A1, A2, A3 and A4:

$A1 = [100 + 4 (\% \text{ of lot } G_{mm} - 93.00)] \div 100$

$A2 = [100 + 2 (\% \text{ of lot } G_{mm} - 92.00)] \div 100$

$A3 = [84 + 8 (\% \text{ of lot } G_{mm} - 90.00)] \div 100$

$A4 = [84 + 8 (\% \text{ of lot } G_{mm} - 89.00)] \div 100$

Density Pay Adjustment Factor Calculation:

Density Pay Adjustment Factor (P_D)* = Density Pay Factor - 1.000

*P_D rounded to the nearest thousandth

c. Asphalt Density Pay Adjustment for "HMA Surface", "HMA Base" and "HMA Pavement" Bid Items. Asphalt Density Pay Adjustment for compaction of the completed pavement shall be by lot, based on the percentage of G_{mm} obtained. This adjustment will be paid for under the bid item Asphalt Density Pay Adjustment. Compute the Asphalt Density Pay Adjustment (positive or negative) by multiplying the Density Pay Adjustment factor (***P_D***) times the number of tons included in the lot times $75 per ton. The Asphalt Density Pay Adjustment will be added or subtracted on the pay estimate. For shoulders with a plan width of less than or equal to 3 feet, and placed at the same time as the traveled way, the ***P_D*** for the traveled way will apply. The ***P_D*** does not apply to sideroads, entrances, crossovers and other incidental surfacing. Use KDOT test results for the lot to determine the ***P_D*** when the statistical comparison between the quality control and the verification tests fail (see **subsection 602.9a.**).

Lot Size: A lot shall normally be comprised of the results of 10 tests performed on a day's placement of a given mix placed in a given lift. Lot size is defined in **subsection 602.6**. (Air void lots and density lots are normally of different sizes).

Shoulders: For all shoulders with a plan width greater than 3 feet and any shoulder not placed at the same time as the traveled way, the lower specification limit (LSL) is 90.00%. When the lower percent within limits (PWL_{LD}) is 50.00% or more for the lot, P_D is zero. When the PWL_{LD} is less than 50.00% for the lot, the Engineer will determine whether the HMA in the lot may remain in place or be removed. Any such material left in place will have a P_D of -0.050, unless the Engineer establishes lower values for P_D (-0.100, -0.200, -0.300, etc.) as a condition of leaving the material in place.

Determination of P_D and PWL_{LD}: Calculate the lower density quality index (Q_{LD}) for each lot using Equation 1 and round to hundredths. Locate the Q_{LD} value in the left column of the Percent Within Limits (PWL) Table in Section 5.2.1 - Statistics, Part V. Select the appropriate PWL_{LD} value by moving across the selected quality index row to the column representing the number of samples in the lot.

If Q_{LD} is greater than the largest quality index value shown in the table, use 100.00 as the value for PWL_{LD}.

If PWL_{LD} is less than 50.00% for the lot, the Engineer will determine if the material in the lot may remain in place. If the material is left in place, the value of P_D for the lot will be equal to -0.160, unless the Engineer establishes lower values for P_D (-0.200, -0.300, etc.) as a condition of leaving the material in place. Otherwise, calculate P_D using Equation 2 and round to thousandths.

Equation 1: $$Q_{LD} = \frac{\overline{X} - LSL}{S}$$

$\overline{X}$ is the average measured percent of G_{mm} of all samples within a lot rounded to hundredths.

LSL is the lower specification limit for density and is defined as 91.00% of G_{mm} for traveled way plan thickness 2 inches and less and 92.00% of G_{mm} for traveled way plan thickness greater than 2 inches.

S is the standard deviation of the measured density of all samples within a lot and is calculated using equation (4) in Section 5.2.1, Part V, rounded to hundredths.

Equation 2: $$P_D = (PWL_{LD} * 0.004) - 0.360$$

d. Asphalt Air Void Pay Adjustment. Asphalt Air Void (V_a) Pay Adjustment will be made on a lot basis and based on measured V_a from samples of plant produced material. This adjustment will be paid for under the bid item Asphalt Air Void Pay Adjustment. The V_a pay adjustment factor (P_V) (positive or negative) will be determined and used to compute the V_a Pay Adjustment by multiplying P_V times the number of tons included in the lot times $75 per ton. The V_a Pay Adjustment will be added or subtracted on the pay estimate. When the statistical comparison between the quality control and the verification tests pass, use the procedures in **subsection 602.9d.(1)** to compute P_V. When the statistical comparison fails, calculate P_V using procedures in **subsection 602.9d.(2)**.

Lot Size: A lot shall normally be comprised of the results of 4 contiguous individual V_a tests performed on gyratory compacted samples of a given mix design. Lot size is defined in **subsections 602.8f.**, **602.8g.** and **602.8h**. When there are 1 or 2 tests remaining, such as at the end of a project or season, combine them with the previous 4 tests to create a 5 or 6 test lot, respectively. When there are 3 tests remaining, combine the 3 tests into a lot. (Air voids lots and density lots are normally of different sizes).

(1) Air Voids Pay Adjustment Factor (Passing t-test). Calculate the upper and lower V_a quality indices (Q_{UV} and Q_{LV}) for each lot using Equations 3 and 4, respectively and round to hundredths. Locate the Q_{UV} value in the left column of the Percent Within Limits (PWL) Table in Section 5.2.1 – Statistics, Part V. Select the appropriate upper percent within limit value (PWL_{UV}) by moving across the selected quality index row to the column representing the number of samples (N) in the lot. Repeat the process using the Q_{LV} value and select the appropriate value for the lower percent within limits (PWL_{LV}). If the Q_{UV} or Q_{LV} value is greater than the largest quality index value shown in the table, then a value of 100.00 is assigned as the value for PWL_{UV} or PWL_{LV}, respectively. If both Q_{UV} and Q_{LV} exceed the values shown in the table, a value of 100.00 is assigned as the value for both PWL_{UV} and PWL_{LV}. If either Q_{UV} or Q_{LV} is a negative value or PWL_{UV} + PWL_{LV} is less than 150.00, the Engineer will determine if the material in the lot may remain in place. If the Engineer determines that the material may remain in place then the maximum value of P_V for the lot will be equal to –0.120. The Engineer may establish lower values for P_V (-0.200, -0.300, etc.) in such instances. Otherwise, calculate P_V using Equation 5 and round to thousandths.

Equation 3: $$Q_{UV} = \frac{USL - \overline{X}}{S}$$

Equation 4: $$\boldsymbol{Q_{LV}} = \frac{\overline{X} - LSL}{S}$$

$\overline{X}$ is the average measured V_a of all samples within a lot rounded to hundredths.
USL is the upper specification limit for V_a and is defined as 4.00%.
LSL is the lower specification limit for V_a and is defined as 2.00%.
S is the standard deviation of the measured V_a for all samples within a lot and is calculated using equation (4) in Section 5.2.1 - Statistics, Part V, rounded to hundredths.

Equation 5: $$\boldsymbol{P_V} = ((\boldsymbol{PWL_{UV}} + \boldsymbol{PWL_{LV}} - 100.00)(0.003)) - 0.270$$

$\boldsymbol{PWL_{UV}}$ is the upper percent within limits value for V_a.
$\boldsymbol{PWL_{LV}}$ is the lower percent within limits value for V_a.

(2) Air Voids Pay Adjustment (Failing t-Test). If the t-test fails, KDOT's test result will be used to calculate the $\boldsymbol{P_V}$ for the lot. Follow the procedures given in **subsection 602.9d.(1)** to determine the $\boldsymbol{P_V}$ or disposition of the lot. Use the values from **TABLE 602-16** to calculate $\boldsymbol{Q_{UV}}$, $\boldsymbol{Q_{LV}}$, $\boldsymbol{PWL_{UV}}$ and $\boldsymbol{PWL_{LV}}$ in Equations 3, 4 and 5 in **subsection 602.9d.(1)**.

TABLE 602-16: Statistical Values for Air Voids Pay Adjustment for Failing t-Test

Term	**Definition**	**Value**
$\overline{X}$	Average or Mean	KDOT's test result for the lot
S	Standard Deviation	0.50
USL	Upper Specification Limit	4.50%
LSL	Lower Specification Limit	1.50%
N	Sample Size	3

602.10 DETERMINATION OF THICKNESS, THICKNESS PAY ADJUSTMENT AND AREA PAY ADJUSTMENTS FOR "HMA PAVEMENT" AND "HMA PAVEMENT SHOULDER" BID ITEMS

a. General. Construct the pavement to the dimensions shown in the Contract Documents. Inform the Engineer when a section is ready for coring and measurement of width and length. Complete all paving of the shoulder and driving lanes within this section, unless otherwise approved by the Engineer.

A driving lane is defined as mainline lanes, acceleration lanes (including tapers), deceleration lanes (including tapers), auxiliary lanes, ramp lanes or combination thereof.

When shoulders, medians and widenings are placed monolithically with the adjacent driving lane, and there is not a separate bid item for shoulders, then the shoulders are considered as part of the driving lane, and are subjected to the same unit price adjustment as the driving lane.

b. Measurements. The Engineer will divide the projects into lots. A lot is comprised of 5 sublots with the same plan thickness. A sublot is defined as a single driving lane or a single shoulder, with an accumulative length of 1000 feet. If the last lot has 1 or 2 sublots (such as at the end of a project or season), combine them with the previous lot to create a lot with 6 or 7 sublots, respectively. Consider as a single lot if there are 3 or 4 sublots in the final lot.

The Engineer will generate 1 random location for coring within each sublot. Do not take a core within 1 foot of a longitudinal joint or edge. Obtain the cores with the Engineer present.

Take a 4-inch diameter core from the selected sites. Mark each core with its lot and sublot number, and transport to the KDOT field lab.

For information only, the Engineer will determine the thickness of each HMA mixture and the total HMA base for each core.

The Engineer will determine the total core thickness for pay by taking 3 caliper measurements at approximately 120° apart and record each to the nearest 0.1 inch. The average of the 3 caliper measurements rounded to the nearest 0.1 inch shall represent the average measured thickness. The Engineer will use the total pavement thickness measurements to determine thickness pay adjustment factors.

The Engineer will provide a copy of the results to the Contractor before the end of the following working day.

Prior to coring, the Contractor may request that areas trimmed without automatically controlled equipment be handled separately. (This would require the Contractor to designate the area as a lot before knowing the actual core thickness.) When requested and approved by the Engineer, each area will be considered a lot. Divide the area into 5 sublots and obtain 1 core from each sublot.

For Percent Within Limits (PWL) thickness analysis, if any sublot thickness exceeds the design thickness by more than 1.0 inch, the Excel spreadsheet will automatically consider that sublot thickness to be 1.0 inch more than the design thickness. The spreadsheet will recalculate a new lot mean and sample standard deviation based on the adjusted value.

Dry the core holes, tack the sides and bottom, fill them with a HMA mixture (approved for the project) and properly compact it by the end of the next working day.

c. Deficient Measurements for Driving Lanes. When any full depth core for driving lanes is deficient by 1.0 inch or greater from the specified thickness, take exploratory cores at intervals a minimum of 50 feet in each direction (parallel to the centerline) from the deficient core.

Continue to take exploratory cores in each direction until a core is taken that is deficient a maximum of 0.5 inch. Exploratory cores are used only to determine the length of pavement in a lot that is to be overlaid, as approved by the Engineer.

The minimum overlay length (with surface mix) shall be equal to the distance between the cores that are deficient by a maximum of 0.5 inch, and the width to be paved shall be full width of the roadway (driving lanes and shoulders) when this occurs.

The minimum overlay thickness is 3 times the nominal maximum aggregate size.

Complete the overlay to the satisfaction of the Engineer. Mill butt joints on the ends of the overlay area. The Engineer will not pay for any milling costs.

The exploratory cores are not used to determine thickness pay adjustment factors. Randomly select another core (outside the overlay area) to represent the sublot.

d. Deficient Measurements for Shoulders. When any full depth core taken from the shoulders is deficient by greater than 1.5 inches, take exploratory cores at intervals a minimum of 50 feet in each direction (parallel to the centerline) from the deficient core.

Continue to take exploratory cores in each direction until a core is only deficient a maximum of 0.8 inches.

Exploratory cores are used only to determine the length of pavement in a lot that is to be removed and replaced, or accepted at a reduced price (in addition to any disincentive assessed on that lot), as approved by the Engineer.

The minimum repair length is equal to the distance between the cores that are deficient a maximum of 0.8 inches, and the full width of the shoulder.

Mill butt joints on the ends of the overlay area. The Engineer will not pay for any milling costs. Unless approved by the Engineer, replacing includes complete removal of all HMA within the area defined by the results of the exploratory cores. Rework, stabilize (if required) and regrade the subgrade. When required, reconstruct the base and replace all HMA mixes shown in the Contract Documents. Obtain 1 random core within this sublot and use its core length to determine the thickness pay adjustment factor.

e. Asphalt Pavement Area Pay Adjustment. Determine the areas for pay and pay adjustment as shown in **TABLE 602-18**. The KDOT spreadsheet program will calculate these areas. This adjustment will be paid for under the bid item Asphalt Pavement Area Pay Adjustment.

Irregularly shaped areas may have to be calculated outside the program and the area entered into the program. Compute pay per lot for areas placed and not placed (deducted) as shown in Equations 10, 11, 12 and 13.

Equation 10: Pay for Driving Lane = $(\sum PDLA)(BP)$
Equation 11: Pay Deduct for Driving Lanes = $2(\sum PDLDA)(BP)$
Equation 12: Pay for Shoulder = $(\sum PSA)(BP)$
Equation 13: Pay Deduct for Shoulder = $2(\sum PSDA)(BP)$

$\sum PDLA$ = Pay Driving Lane Area per Lot, Square Yard
$\sum PDLDA$ = Pay Driving Lane Deduct Area per Lot, Square Yard
$\sum PSA$ = Pay Shoulder Area per Lot, Square Yard
$\sum PSDA$ = Pay Shoulder Deduct Area per Lot, Square Yard

BP = Bid Price for either the driving lanes or the shoulder, as applicable

TABLE 602-17: HMA AREA ABBREVIATIONS			
Abbreviation		**Definition**	**Units**
PDLA	=	Pay Driving Lane Area per Sublot	Sq Yd
PDLDA	=	Pay Driving Lane Deduct Area per Sublot,	Sq Yd
PSA	=	Pay Shoulder Area per Sublot	Sq Yd
PSDA	=	Pay Shoulder Deduct Area per Sublot	Sq Yd
MDLW	=	Measured Driving Lane Width	Ft
MSW	=	Measured Shoulder Width	Ft
MTLW	=	Measured Total Lane Width (includes shoulder, if any)	Ft
PDLW	=	Plan Driving Lane Width	Ft
PSW	=	Plan Shoulder Width	Ft
PTLW	=	Plan Total Lane Width (includes shoulder, if any)	Ft
EDLW	=	Excess Driving Lane Width	Ft
SL	=	Sublot Length	Ft

TABLE 602-18: HMA AREA SUBLOT CALCULATIONS[1]				
Condition	**PDLA[2]**	**PDLDA[2]**	**PSA[2]**	**PSDA[2]**
	(Sq Yd)	**(Sq Yd)**	**(Sq Yd)**	**(Sq Yd)**
Projects with a Separate Bid Item for Shoulder				
Narrow Driving Lane				
MSW is less than PSW	(SL)(MDLW)	(SL)(PDLW–MDLW)	(SL)(MSW)	(SL)(PSW–MSW)
MSW is greater than PSW	(SL)(MDLW)	(SL)(PDLW–MDLW)	(SL)(MSW[3])	0
Wide Driving Lane				
MSW + EDLW is less than PSW	(SL)(PDLW)	0	(SL)(MSW+EDLW)	(SL)(PSW–MSW-EDLW)
MSW + EDLW is greater than PSW	(SL)(PDLW)	0	(SL)(MSW+EDLW[4])	0
Projects without a Separate Bid Item for Shoulder[5]				
Narrow Driving Lane and Shoulder	(SL)(MTLW)	(SL)(PTLW–MTLW)	N/A	N/A
Wide Driving Lane and Shoulder	(SL)(MTLW[6])	0	N/A	N/A

[1]Deductions will be made for unplaced areas.
[2]Calculate the areas to the nearest 0.01 square yards. Measure the lengths and widths to the nearest 0.01 feet. Divide the result of all equations in this table by 9 so that the resulting units are square yards.
[3]MSW shall be between PSW and PSW + 0.25 feet. Any excess width over 0.25 feet will not be included in PSW.
[4]MSW+ EDLW shall be between PSW and PSW + 0.25 feet. Any excess width over 0.25 feet will not be included in PSW.
[5]Shoulder is normally 0.00 feet to 3.00 feet wide and placed at the same time as the driving lane. PTLW = PDLW + PSW
[6]MSTLW shall be between PTLW and PTLW + 0.25 feet. Any excess width over 0.25 feet will not be included for pay.

f. Asphalt Pavement Thickness Pay Adjustment. Compute the Asphalt Thickness Pay Adjustment for the driving lanes (TPA_{DL}) and shoulders (TPA_{SH}) using Equation 6 or 7, respectively. Compute the Asphalt Thickness Pay Adjustment factor (P_T) as shown in Equation 9. Determine area calculations for the driving lanes and shoulders as shown in **TABLE 602-18**. **TABLE 602-17** provides the definition for the abbreviations used in **TABLE 602-18**. Enter the measured values into the spreadsheet program to determine PDLA and PSA.

This adjustment will be paid for under the bid item Asphalt Pavement Thickness Adjustment.

Equation 6: $TPA_{DL} = P_T\,(\sum PDLA)(\$3.50)(\text{Plan Thickness})$
Equation 7: $TPA_{SH} = P_T\,(\sum PSA)(\$3.20)(\text{Plan Thickness})$

TPA_{DL} = Thickness Pay Adjustment per Lot for Driving Lane

TPA_{SH} = Thickness Pay Adjustment per Lot for Shoulder
∑PDLA = Pay Driving Lane Area per Lot, Square Yard
∑PSA = Pay Shoulder Area per Lot, Square Yard
Plan Thickness = HMA Thickness shown on Plans, Inches

KDOT will use a spreadsheet program to calculate thickness pay adjustments. KDOT will provide a copy of this program to the Contractor, when requested. It is the Contractor's responsibility to obtain the Microsoft Excel software required to run this program. Values computed using equations referenced in this specification may vary slightly from the spreadsheet values due to rounding of numbers. In such cases the numbers computed by the spreadsheet take precedence.

Thickness Quality Index ($\boldsymbol{Q_T}$) Computation. In each lot, calculate $\boldsymbol{Q_T}$ for the total pavement thickness using Equation 8 and round to hundredths.

Equation 8:

$$\boldsymbol{Q_T} = \frac{\overline{X} - LSL}{S}$$

$\overline{X}$ = Average total core length of all samples representing a lot, rounded to the nearest 0.1 inch. (Adjust core length before averaging, as shown in **subsection 602.10b.**)
LSL = Lower specification limit for thickness. For driving lanes use 0.5 inch less than the total plan driving lane thickness shown on the typical section. For shoulders, use 0.8 inch less than the total plan shoulder thickness shown on the typical section.
S = Sample standard deviation of the measured core lengths of all samples representing a lot and is calculated using equation (4) in Section 5.2.1 – Statistics, Part V, rounded to hundredths.

Use the computed $\boldsymbol{Q_T}$ to determine the thickness Percent Within Limits value ($\boldsymbol{PWL_T}$) by locating the $\boldsymbol{Q_T}$ in the left column of the Percent Within Limits (PWL) Table in Section 5.2.1 - Statistics, Part V. Select the appropriate $\boldsymbol{PWL_T}$ by moving across the selected $\boldsymbol{Q_T}$ row to the column representing the number of samples in the lot.

If the computed $\boldsymbol{Q_T}$ is a negative value, then the lot and all adjacent areas (full width of roadway) shall be overlaid as determined by the Engineer. After the lot has been overlaid, randomly select another core for each sublot, and calculate a new pay factor. For lots that have been entirely overlaid, the maximum pay factor is zero.

If the computed $\boldsymbol{Q_T}$ is greater than the largest $\boldsymbol{Q_T}$ shown in the PWL Table, a value of 100.00 is assigned as the $\boldsymbol{PWL_T}$ for thickness.

For each lot and all lanes and shoulders, compute the thickness pay factor ($\boldsymbol{P_T}$) for the total pavement thickness using Equation 9 and round to nearest thousandth. No bonus will be paid for shoulders, thus use $\boldsymbol{P_T}$ = 0.000 whenever $\boldsymbol{P_T}$ calculates greater than 0.000 for shoulders.

Equation 9:

$$\boldsymbol{P_T} = \left(\frac{(\boldsymbol{PWL_T}) * 0.3}{100}\right) - 0.270$$

g. Minimum Quantity of HMA for Square Yard Projects with "HMA Pavement" and HMA Pavement Shoulder" Bid Items. For the total project, supply a minimum of 93% of G_{mm} required by the surface course of driving lanes and shoulders and the top base course of driving lanes and shoulder. Calculate the minimum quantity of those 2 mixes, individually as follows:

Equation 14:

$$\text{Minimum Quantity (Tons)} = \frac{0.93\ (A)\ (T)\ (G_{mm})}{42.7}$$

A = Area in square yards for each of the mixes.
T = Plan thickness in inches of surface course and the top base course of driving lanes and shoulders.
G_{mm} = Theoretical maximum specific gravity equals the average G_{mm} value used in the first 5 lots or the average G_{mm} for ½ of the project (whichever is less) for the 4 mixes listed in "T" in Equation 14. Determine the average G_{mm} from the Excel worksheet titled "Density F & T Test Worksheet".

If this minimum quantity of surface course or base course is not placed, a deduction of $75 per ton will apply to the quantity not placed for each mix. This will be paid using the bid item Contract Deduct which will be an item added to the contract.

602.11 MEASUREMENT AND PAYMENT

a. "HMA Base", "HMA Surface" and "HMA Overlay" Bid Items. The Engineer will measure HMA Base, HMA Surface and HMA Overlay by the ton of material at the time of delivery to the road. Batch weights will not be allowed as a method of measurement unless all the following conditions are met:

- the plant is equipped with an automatic printer system approved by the Engineer;
- the automatic printer system prints the weights of material delivered; and
- the automatic printer system is used in conjunction with an automatic batching and mixing control system approved by the Engineer.

Provide a weigh ticket for each load. Due to possible variations in the specific gravity or weight per cubic foot of the aggregates, the tonnage used may vary from the proposal quantities and no adjustment in contract unit price will be made because of such variances.

Payment for "HMA Base (*)(**)(***)", "HMA Surface (*)(**)(***)" and "HMA Overlay (*)(**)(***)" at the contract unit prices is full compensation for the specified work. Any pay adjustments will both be applied and the payment adjusted accordingly.

Sideroads, entrances and mailbox turnouts that are not shown in the Contract Documents that are to be surfaced shall be paid for at 1½ times the unit price for "HMA Surface (*)(**)(***)", "HMA Base(*)(**)(***)" or "HMA Overlay (*)(**)(***)".

b. "HMA Pavement" and "HMA Shoulder" Bid Items. The Engineer will measure HMA Pavement and HMA Pavement Shoulder by the square yard of the measured in-place material. All lifts, except the surface course, will be measured by the Contractor and verified by the Engineer. The Engineer will measure the surface course.

Measure each shoulder width, each driving lane width and sublot length separately. Measure the lengths (to the nearest 0.01 feet) a minimum of once per sublot. The location of the width measurements will be the same location as the mainline cores which were established using random numbers. Before the end of the next working day, type and submit to the Engineer, the Contractor's individual measurements and the sum of the 2 driving lanes. Likewise, when the surface course is completed the Engineer will provide a typed copy of the surface course measurements to the Contractor before the end of the next working day.

If the driving lane and shoulder (measured from centerline) is less than 0.25 feet (per side) deficient, a deduction will be assessed. If the roadway is greater than 0.25 feet (per side) deficient, correction will be required. The correction will be proposed by the Contractor and must be approved by the Engineer. After satisfactory correction by the Contractor, the deduction for the narrow roadway will be eliminated for the areas corrected.

The Engineer will measure the sublot length and width (to the nearest 0.01 feet). Measure the width from the construction joint to the top of the slope of HMA pavement. Calculate the pay area for each lot to the nearest square yard. Unless the Engineer authorizes in writing to increase the area of HMA pavement, the Engineer will use dimensions shown in the Contract Documents and as measured in the field to calculate the final pay quantity. If the Engineer authorizes in writing to increase the area of HMA pavement or shoulder, the additional area will be measured and paid for as "HMA Pavement (#) (##)" or "HMA Pavement (#) Shoulder", respectively. The length will be measured horizontally along the centerline of each roadway or ramp.

Payment for "HMA Pavement (#) (##)" and "HMA Pavement (#) Shoulder" at the contract unit prices is full compensation for the specified work.

The Asphalt Pavement Thickness Adjustment and Asphalt Pavement Area Pay Adjustment will be entered on the Contractor's Payment Vouchers (intermediates and final) after each lot of the surface course (driving lanes and shoulders) has been completed.

The Contractor will receive no additional compensation for overlaying or for removing and replacing areas of deficient thickness. Exploratory cores and cores taken to determine pavement thickness will not be measured for payment. The Engineer will apply a Contract Deduct for surface course (driving lanes and shoulders) and top base course (driving lanes and shoulders) mix not placed on the project as determined using Equation 14. The Contract Deduct will be computed by the spreadsheet and be an item added to the contract.

If the project has a large amount of grinding required for pavement smoothness, the Engineer may require the Contractor to cut cores after the grinding is complete. These cores will be used in the spreadsheet in place of the cores originally cut.

c. Emulsified Asphalt. The Engineer will measure emulsified asphalt used for tack by the ton. Payment for "Emulsified Asphalt" at the contract unit price is full compensation for the specified work.

d. Asphalt Core (Set Price).

(1) Nuclear Density Gauge Calibration. The Engineer will measure each asphalt core required by the Engineer to calibrate the nuclear density gauges. No payment will be made for cores deemed unsuitable for calibrating the nuclear density gauges. No payment will be made for cores taken at the Contractor's option to determine density.

(2) Nuclear Density Dispute Resolution. If during nuclear density dispute resolution, the Contractor's test results are used for payment, the Engineer will measure each core taken for payment at the Asphalt Core (Set Price). If KDOT's test results are used for payment, then no payment for cores will be made for nuclear density dispute resolution.

(3) Payment for "Asphalt Core (Set Price)" at the contract set unit price is full compensation for the specified work.

e. Material for HMA Patching (Set Price). When the Contractor is required to remove any existing base course, subgrade or surface course (unless damaged by the Contractor) and provisions are not made in the Contract Documents, the Engineer will measure the material used for repair and patching (either HMA-Commercial Grade or a specified mix on the project) separately, by the ton at the time of delivery to the road. The Engineer will not measure the quantity of material used in the repair of damage due to the Contractor's negligence. The Engineer will measure HMA materials by the ton. Use cold feed virgin gradation test results for acceptance as described in **SECTION 611** or combined gradation results for acceptance in accordance with **TABLE 602-1**.

Payment for "Material for HMA Patching (Set Price)" at the contract set unit price includes all excavation, compaction of subgrade or subbase if required, disposal of waste material and all material (including emulsified asphalt for tack), all labor, equipment, tools, supplies, incidentals and mobilization necessary to complete the work. Pay adjustments will not be applied to this material.

f. Quality Control Testing (HMA). The Engineer will measure Quality Control Testing (HMA) performed by the Contractor on a per ton basis of HMA Surface, HMA Base, HMA Overlay and HMA Pavement placed on the project. No adjustment in the bid price will be made for overruns or underruns in the contract quantity. The bid price will constitute payment for all necessary mix design testing, field process control testing, the testing laboratory and all necessary test equipment.

The Engineer will not measure for payment Quality Control Testing (HMA) for the bid item Material for HMA Patching (Set Price).

Payment for "Quality Control Testing (HMA)" at the contract unit price is full compensation for the specified work.

04-19-23 C&M (BTH)
Jul-2023 Letting

KANSAS DEPARTMENT OF TRANSPORTATION
SPECIAL PROVISION TO THE
STANDARD SPECIFICATIONS, 2015 EDITION

Delete the entire SECTION 1103 and replace with the following:

SECTION 1103

AGGREGATES FOR HOT MIX ASPHALT (HMA)

1103.1 DESCRIPTION

This specification covers the quality, composition and gradation requirements of aggregates for hot mix asphalt (HMA) on QC/QA projects.

1103.2 REQUIREMENTS

a. Composition Individual Aggregates. Use aggregate from each source that complies with the gradation requirements listed in **TABLE 1103-1 and 1103-2**.

(1) Crushed Aggregates. Limit crushed aggregates to the following materials.

(a) Produce Crushed Stone (CS-1) and Crushed Stone Screenings (CS-2) by crushing limestone, sandstone, porphyry, (rhyolite, basalt, granite, and Iron Mountain Trap Rock are examples of porphyry) or other types of stone.

(b) Produce Crushed Gravel (CG) by crushing siliceous gravel containing not more than 15% non-siliceous material. If 95% or more of crushed gravel is retained on the #8 (2.65 mm) sieve, then the material must have a minimum Uncompacted Void Content of Coarse Aggregate (UVA) value of 45 when tested in accordance with KT-80. Testing will be the same frequency as KT-50. Do not use material with a UVA value less than 45.

(c) Provide Chat (CH-1) obtained during the mining of lead and zinc ores in the tri-state mining district.

(d) Consider materials complying with Mineral Filler Supplements MFS-1, MFS-2, MFS-4, and MFS-7 as crushed aggregate.

(e) Produce Crushed Steel Slag (CSSL) by crushing electric furnace steel slag. Some sources of steel slag are angular when produced and may be treated the same as crushed gravel and manufactured sand. Use steel slag with an Uncompacted Void Content of the Fine Aggregate "U" Value, determined by test method KT-50, of more than 42and the Coarse Aggregate Angularity greater than the minimum specified value. The maximum allowable quantity of crushed steel slag is 50% of the total aggregate weight.

(f) Manufactured sand shall have an Uncompacted Void Content of the Fine Aggregate "U" Value, determined by test method KT-50, greater than or equal to 42. Produce manufactured sand by crushing siliceous sand and gravel (designate as crushed gravel (CG-2, CG-3, etc) in the mix design), or by washing or screening crushed stone (designate as crushed stone (CS-2, CS-3, etc) in the mix design), or by washing or screening chat (designate as chat (CH-2, CH-3, etc) in the mix design).

(2) Uncrushed Aggregates. Limit uncrushed aggregates to the following materials.

(a) Produce Sand-Gravel (SSG) by mixing natural sand and gravel formed by the disintegration of siliceous and/or calcareous materials.

(b) Provide Natural Sand consisting of particles formed by the natural disintegration of siliceous and/or calcareous materials. Use natural sand with an Uncompacted Void Content "U" value of less than 42.

(c) Provide Grizzly (Grizzly Waste) consisting of the matrix or bedding material occurring in conjunction with calcitic or dolomitic cemented sandstone "Quartzite", generally separated from the sandstone prior to crushing.

(d) Provide Wet Bottom Boiler Slag (WBBS) consisting of a hard angular by-product of the combustion of coal in wet-bottom boilers. Quality requirements do not exist for this material. Obtain written approval by the Chief of Construction and Materials for use in HMA. The use of WBBS does not modify the requirements for minimum contents of either crushed stone or natural sand.

(3) Mineral Filler Supplement. Provide a mineral filler supplement that is easily pulverized and free of cemented lumps, mudballs, and organic materials that complies with the following and the general requirements in **subsection 1103.2c**. Do not blend 2 or more materials to produce mineral filler supplement. Provide only 1 mineral filler supplement in each HMA design.

(a) Mineral Filler Supplement designation MFS-1 is Portland cement, blended hydraulic cements, or crushed stone.

(b) Mineral Filler Supplement designation MFS-2 is crushed limestone.

(c) Mineral Filler Supplement designation MFS-3 is water or wind deposited silty soil material.

(d) Mineral Filler Supplement designation MFS-4 is Hydrated lime. The minimum allowable quantity of MFS-4 or Hydrated Lime is 1% of the total aggregate weight when required as a supplement on the Contract Documents.

(e) Mineral Filler Supplement designation MFS-5 is volcanic ash containing a minimum of 70% glass shard. The maximum allowable quantity of MFS-5 is 5% of the total aggregate weight when specified as acceptable mineral filler supplement.

(f) Mineral Filler Supplement designation MFS-6 is fly ash. Fly ash is the finely divided residue resulting from the combustion of ground or powdered coal and is transported from the boiler by flue gasses. The maximum allowable quantity of MFS-6 is 3% of the total aggregate weight when specified as acceptable mineral filler supplement.

(g) Mineral Filler Supplement designation MFS-7 is processed chat sludge that has been dewatered at the source of supply, and does not exceed 15% moisture content by weight at the time of shipping.

(4) Reclaimed Asphaltic Pavement (RAP). Use RAP in HMA only when such an option is permitted by Contract Special Provision. Subject the RAP to the limitations (i.e. source, max. percent allowed in mix, etc.) shown on the Contract Documents and contained in the appropriate Contract Special Provisions. Screen the RAP through a 2 ¼ inch screen or grizzly before it enters the HMA plant.

Fractionated Reclaimed Asphaltic Pavement (FRAP) is defined as having two or more RAP stockpiles, where the RAP is divided into a minimum of two fractions consisting of coarse and fine fractions. Subject the FRAP to the same limitations shown on the Contract Documents and contained in the appropriate Contract Special Provisions for RAP. Comprise the maximum percentage of FRAP of coarse or fine FRAP or a combination of coarse and fine FRAP, unless otherwise stated in the Contract Documents. Utilize a separate cold feed bin for each stockpile of FRAP used. Add FRAP to the mix through the RAP collar. Include the processing requirements for each FRAP stockpile within the Quality Control Plan.

(5) Recycled Asphalt Shingles**.** Recycled Asphalt Shingles (RAS) are allowed in any mixture specified to use RAP. The Contractor may use the %RAP as shown in the Contract Special Provision **or** a maximum of 5% RAS and 15% total recycled material.

Drop the grade of the virgin binder one grade from both the top and the bottom grade specified for 0% RAP. For example, if a PG 64-22 is specified for 0% RAP, then the virgin grade of the binder for up to 5% RAS and 15% total recycled material is PG 58-28.

Comply with the Kansas Department of Health and Environment's Bureau of waste Management Policy 2011-P3 or current version and other regulations pertaining to the recycling of shingles.

Grind the shingles to a minus 3/8-inch size. Remove deleterious materials from waste, manufacturer, or new shingles. Use post-consumer RAS that contains less than 0.5% wood by weight or less than 1.0% total deleterious by weight. Determine the gradation of the aggregate by extraction of the binder or by using **TABLE 1103-A** as a standard gradation:

TABLE 1103-A: SHINGLE AGGREGATE GRADATION	
Sieve Size	**Percent Retained**
3/8 in.	0
No. 4	5
No. 8	15
No. 16	30
No. 30	50
No. 50	55
No. 100	65
No. 200	75

b. Quality of Individual Aggregates.

- Soundness, minimum (KTMR-21) 0.90
  Soundness requirements do not apply to aggregates having less than 10% material retained on the No. 4 mesh sieve.
- Wear, maximum (AASHTO T 96)...40%
  Wear requirements do not apply to aggregates having less than 10% retained on the No. 8 sieve.
- Absorption, maximum (KT-6) 4.0%
  Test aggregates for absorption as follows:
  - Crushed Stone (CS-1) ....Test Method KT-6, Procedure I
  - Screenings (CS-2)..Test Method KT-6, Procedure II
  - Sand Gravel (SSG)/Crushed Gravel (CG) ....Test Method KT-6, Procedures I & II

  Apply the specified maximum absorption to both the fraction retained on the No. 4 sieve and the fraction passing the No. 4. Screenings produced concurrently with CS-1 will be accepted without tests for absorption.
  Crushed aggregates with less than 10% materials retained on the No. 4 sieve (excluding mineral filler supplements) must be produced from a source complying with the official quality requirements of this Section prior to crushing.
- Plasticity Index, the maximum P.I. for MFS-1, MFS-2, MFS-3, MFS-5, and MFS-7 is 6.

c. Product Control of Individual Aggregates

(1) Size Requirements. Produce each individual aggregate that complies with **TABLE 1103-1 and 1103-2.**

(2) Deleterious Substances. Provide combined aggregates free from alkali, acids, organic matter, or injurious quantities of other foreign substances that does not exceed the following maximum percentages by weight.

- Shale or Shale-like (KT-8) 1.0%
- Clay lumps and friable particles (KT-7) 1.0%
- Sticks (wet) (KT-35) 0.1%
- Coal (AASHTO T-113) 0.5%

TABLE 1103-1: REQUIREMENTS FOR INDIVIDUAL AGGREGATES

Designation	**Material**	**Percent Retained – Square Mesh Sieves**						
		1”	**½”**	**3/8”**	**No. 4**	**No. 8**	**No. 30**	**No. 200**
CS-1	Crushed Stone	0						95.5-100.0
CS-2	Crushed Stone Screenings		0	0 - 5				60-100
CG	Crushed Gravel	Blend gradation with other aggregates in the mix.						
CH-1	Chat	Blend gradation with other aggregates in the mix						
SSG	Sand & Sand Gravel	0						80-100
WBBS	Wet Bottom Boiler Slag		0	Blend gradation with other aggregates in the mix.				
CSSL	Crushed Steel Slag	Blend gradation with other aggregate in the mix.						

TABLE 1103-2: REQUIREMENTS FOR MINERAL FILLER SUPPLEMENTS								
Designation	**Material**	**Percent Retained – Square Mesh Sieves**						
		1”	**½”**	**3/8”**	**No. 4**	No. 8	No. 30	No. 200
MFS-1	Cement or Crushed Stone			0		0-5	0-8	0-40
MFS-2	Crushed Limestone			0		1-10		60-80
MFS-3	Silt			0	0-5			0-40
MFS-4	Hydrated Lime	Blend gradation with other aggregate in the mix						
MFS-5	Volcanic Ash			0		0-5	0-8	0-40
MFS-6	Fly Ash	Blend gradation with other aggregate in the mix						
MFS-7	Processed Chat Sludge			0		0-5	0-8	0-40

d. Stockpiling. Stockpile and handle aggregates in such a manner to prevent detrimental degradation and segregation, the incorporation of appreciable amounts of foreign material, and the intermingling of stockpiled materials.

e. Special Requirements for aggregates used in ultrathin bonded asphalt surface (UBAS). Produce each individual aggregate that complies with the gradation requirements in **TABLE 1103-1 and 1103-2** and the requirements listed in **TABLE 1103-3 and 1103-4.**

TABLE 1103-3: INDIVIDUAL COARSE AGGREGATE PROPERTIES		
Property	**Test Method**	**Limits**
Coarse Aggregate Angularity (% min.)	KT-31	95/90 [a]
Los Angeles Abrasion (% max.) [b]	AASHTO T 96	35 [c]
Micro-Deval,(% max.) [b]	AASHTO T 327	18[d]
Soundness (% min.)	KTMR-21	0.90 [d]
Absorption (% max.)	KT-6	4.0 [d]
Methylene Blue (% max.)	AASHTO T 330	10 [e]
An individual aggregate will be considered a coarse aggregate source if it contributes more than 5% of the total plus No. 4 sieve material of the combined aggregate (individual aggregate contribution No. 4 / total JMF retained No. 4 > 5%). a – 95% of the coarse aggregate has one fractured face & 90% has two or more fractured faces. b – Sample from stockpiled material with top size aggregate not larger than the maximum aggregate size for the mix designation type from **TABLE 613-1**. c - For calcitic or dolometic cemented sandstone “quartzite”, the maximum percent is 40. d - May use KDOT’s Official Quality results e – Perform this test on all individual aggregates that contribute more than 1.0% to the JMF for the material passing the No. 200 sieve.		

TABLE 1103-4: INDIVIDUAL FINE AGGREGATE PROPERTIES		
Property	**Test Method**	**Limits**
Methylene Blue (% max.)	AASHTO T 330	10
Soundness (% min.)	KTMR-21	0.90 [a]
Los Angeles Abrasion (% max.)	AASHTO T 96	40 [a]
Absorption (% max.)	KT-6	4.0 [a]
a –May use KDOT’s Official Quality results. • The above requirements for wear do not apply for aggregates having less than 10% material retained on the No. 8 sieve. • The above requirements for soundness do not apply for aggregates having less than 10% material retained on the No. 4 sieve.		

1103.3 TEST METHODS

Test aggregates according to the applicable provisions of **SECTIONS 1115 and 2501**.

1103.4 PREQUALIFICATION

Prequalify aggregate sources according to **subsection 1101.4**.

1103.5 BASIS OF ACCEPTANCE

Aggregates covered by this subsection are accepted based on the procedure described in **subsection 1101.5.**

06-22-16 C&M (BTH)
Oct-16 Letting

KANSAS DEPARTMENT OF TRANSPORTATION
SPECIAL PROVISION TO THE
STANDARD SPECIFICATIONS, 2015 EDITION

Delete SECTION 1201 and replace with the following:

SECTION 1201

GENERAL REQUIREMENTS FOR DIVISION 1200 – ASPHALT MATERIALS

1201.1 DESCRIPTION

This specification covers general requirements for asphalt materials specified in **DIVISION 1200**.

1201.2 REQUIREMENTS

a. Storage and Heating. Provide storage tanks, pipelines and loading facilities for asphalt materials that are equipped with adequate heating equipment that will not damage the material.

b. Shipping Facilities. Provide shipping containers that are equipped with appropriate hoses and pumps, are insulated and are equipped for heating the contents when requested by the KDOT. Do not heat asphalt materials in transit by open flame heaters on tank trucks.

Before loading, examine the shipping container and remove all remnants of previous cargoes that might contaminate the material to be loaded.

For each shipment to KDOT projects, maintain a loading log showing the following items: contract or project number, date, time, ticket number, shipping container number, contractor, grade and quantity. Mail a copy of the log to the Engineer of Tests monthly during the shipping season.

c. Weighing Equipment. For quantities measured by weight, provide a scale having a platform of adequate length to weigh the longest truck or truck-trailer combination in one operation. Calibrate the scales through the range of use by an approved scale company as often as necessary to verify their accuracy, with intervals not greater than six months. For manufacturers not operating through the winter, calibrate the scales before the production season and thereafter at intervals not greater than 6 months for the duration of the production season. Provide a copy of the calibration report to the Engineer of Tests.

d. Sampling and Inspection.

(1) General. The Engineer will perform the sampling of asphalt materials. Permit inspection of all tanks, tank cars, tank trucks, blending units, loading lines and other items relating to the production and loading of asphalt materials being shipped to KDOT work.

(2) Tests by Producer. Provide a testing laboratory with laboratory and sampling equipment complying with the appropriate AASHTO or ASTM specifications to be available to all production and terminal facilities servicing KDOT projects. The laboratory must be staffed with competent personnel who can conduct tests to verify all asphalt material intended for shipment to KDOT projects complies with the specifications before it is shipped. Perform testing necessary to maintain continuous quality control.

The minimum quality control testing and reporting requirements for each product that is shipped to KDOT projects is described in the following sections.

e. Performance Graded Asphalt Binder (PGAB).

(1) Definition of testing levels.

Complete AASHTO Specification Compliance (SC) test for PGAB:

Original Binder:

Flash Point (COC)

Brookfield Viscosity, 275°F

Dynamic Shear

Separation Test, 325°F, 48 hours-**WHEN REQUIRED**

Rolling Thin Film Oven Residue:

Mass Loss

Dynamic Shear

Elastic Recovery, 77°F-**WHEN REQUIRED**

Pressure Aging Vessel Residue:

Dynamic Shear

Creep Stiffness, S, 60s

Slope, m

Pressure Aging Vessel Residue (total conditioning time of 40 hours):

ΔTc-evaluate at least 1 time per month if AASHTO SC tests are more frequent than 1 per month

Quality Control (QC) Tests for PGAB:

DSR on Original Binder

DSR after RTFO

Any other short-term test(s) the producer has found to provide useful information for quality control of the product.

(2) When shipping from Refineries and Blending Facilities, use the following guidelines:

(a) For a tank which is filled before beginning shipping, and then emptied before more material is added, perform 1 complete AASHTO SC test per tank when filled, and weekly QC tests.

(b) For a tank being continually filled while continuous shipping is made from the tank, perform 1 complete AASHTO SC test every 2 weeks, and daily QC tests

(c) When blending directly into a tanker, sample every third truck for QC tests, and perform 1 complete AASHTO SC test every 2 weeks.

(d) Under any of the operations described above, if the results of any of the QC tests indicate the product may be out of specification, stop shipment from that source immediately. Perform a complete AASHTO SC test to ascertain the product status and re-certify the source.

(3) When shipping from Terminals, use the following guidelines:

(a) For operations where a tank is filled before beginning shipping, and then emptied before more material is added, perform a complete AASHTO SC test at the refinery on the material being shipped. When the shipment arrives at the terminal, run the QC tests to verify the material as it is being unloaded. After that, perform the QC tests every 2 weeks until the tank is emptied.

(b) For operations where a tank is being continually filled while continuous shipping is being made from the tank, perform a complete AASHTO SC test at the refinery on the material being shipped. When the shipment arrives at the terminal, run the QC tests to verify the material as it is being unloaded. Perform the QC tests on the contents in the tank every 2 weeks. Perform a complete AASHTO SC test on the contents in the tank once per month.

(c) Under any of the operations described above, if the results of any of the QC tests indicate the product may be out of specification, stop shipment from that source immediately. Perform a complete AASHTO SC test to ascertain the product status and re-certify the source.

f. Emulsions and Asphalt Rejuvenating Agents.

(1) Perform 1 complete AASHTO test each time a batch of material is produced. A tank must be tested each time new material is added to it.

(2) A complete AASHTO test for Emulsions is defined as follows:

Saybolt Furol Viscosity, 77°F or 122°F

Residue by Distillation

Oil Distillate-**WHEN REQUIRED**

Storage Stability, 1 day-**WHEN REQUIRED**

Sieve Test

Demulsibility-**WHEN REQUIRED**

Tests on Distillation Residue:

Penetration, 77°F

Solubility-**WHEN REQUIRED**

Ductility, 39°F or 77°F-**WHEN REQUIRED**

Elastic Recovery - **EMULSIONS with a "P" DESIGNATION**

(3) A complete AASHTO test for asphalt rejuvenating agents is defined as follows:

Viscosity, Saybolt-Furol, 77°F
Residue by Distillation
Oil Distillate
Sieve Test
Storage Stability
Tests on Residue:
Penetration @39°F, 50g, 5 sec.
Asphaltenes
Elastic Recovery

g. Cutbacks.

(1) For a tank being filled and emptied before more material is added, perform 1 complete AASHTO test per tank, and weekly tests for 140°F viscosity.

(2) For a tank being continually filled while continuous shipping is made from the tank, perform 1 complete AASHTO test per week, and daily tests for 140°F viscosity.

(3) When blending directly into a tanker, sample every third truck for 140°F viscosity, and perform 1 complete AASHTO test per week.

(4) A complete AASHTO test for cutback asphalt is defined as follows:

Kinematic Viscosity, 140°F
Flash Point, TOC
Distillation Test:
Distillates
Residue
Tests on Distillation Residue:
Vacuum Viscosity, 140°F and/or Penetration, 77°F
Ductility, 77°F or 60°F

h. Reports. For all types of products discussed above, prepare quarterly summary reports for all quality control and specification compliance testing performed during that period, including any statistical analysis associated with process control. Retain the reports for a minimum of 1 year. Submit them to KDOT if requested.

1201.3 TEST METHODS

As described in the specification for each type of asphalt material.

1201.4 PREQUALIFICATION

a. Producers are required to submit qualification samples of any type or grade of material provided under this specification that has not previously been produced by them, or which has not been used on KDOT projects within the last 12 months. PGAB producers will also be required to submit material that complies with **SECTION 1202.** For each material being qualified or re-qualified, submit samples taken from a production batch, along with a copy of the producer's complete AASHTO test results on the same material and a copy of the Material Safety Data Sheet (MSDS) to the Engineer of Tests. The Engineer will test the sample and compare the results. The producer will be notified of the results in writing.

b. Any change in formulation will require requalification. Changes in base stock or major components may require requalification. Contact the Engineer of Tests' Chief Chemist to determine if requalification is necessary.

c. All producers supplying material to KDOT projects must have a written quality control plan addressing the requirements of this specification. Producers of performance graded asphalt binder must also address any requirements in the latest edition of AASHTO R 26 that are not specifically covered here.

Submit a copy of the written quality control plan to the Bureau of Construction and Materials for review and approval. Quality control plans and the testing information contained therein will be maintained as confidential by KDOT. An approved plan is a required prerequisite to prequalification of any product.

In addition to the requirements specified in AASHTO R 26, include provisions in the QC plan for maintaining the mixing and compaction temperature ranges using the following guidelines:

(1) Unmodified PGAB Suppliers: Record the initial mixing and compaction temperature ranges on the certificate. Once 3 sets of tests for temperature ranges have been accumulated, then maintain a 3-point moving average. Maintain the mixing and compaction temperature ranges constant unless there is a change to any component (example: upper compaction temperature) of the 3-point moving averages by more than 40ºF. If this occurs, then replace all of the old temperature ranges with the 3-point moving average temperature ranges.

Provide a monthly copy of all individual and 3-point moving average temperature ranges to the Chief Chemist at the Materials and Research Center. Provide the Contractor with the most current mixing and compaction temperature ranges as outlined above.

(2) Modified PGAB Suppliers: In additional to the requirements stated in (1) above, include a detailed description of the method used by your laboratory to determine the modified PGAB mixing and compaction temperature ranges in the QC Plan.

d. The Bureau of Construction and Materials will maintain a list of producers that are qualified to supply specific types and grades of materials. Qualified producers will be permitted to supply qualified materials on a certification basis. Monthly loading logs and results of the producer's quality control testing are required to be forwarded to the Engineer of Tests to maintain status on the prequalified list. In addition, suppliers of CRS-1HP and EBL are to submit up to two samples per year to the Engineer of Tests at the Materials and Research Center at the request of the Chief Chemist to maintain status on the prequalified list.

e. An annual split-sample testing program will be conducted for each producer on the Prequalified List. Producers must participate in this program for each type of material they have prequalified. When notified by KDOT, producers will be required to split a sample, test the material according to specifications, and send KDOT a portion to test along with their test results. The 2 sets of test results will be compared using the precision and bias guidelines outlined by AASHTO. If there are any discrepancies in the test results that cannot be resolved, a laboratory inspection may be necessary. Producer laboratories that are AMRL certified will be exempt from this program.

f. Results of the split sample testing program, producer quality control testing required by **subsection 1201.2d.(2)** and verification testing conducted by the KDOT will be used to determine the reliability of the producer's certifications. If any of these data indicate that the certifications are not reliable, permission granted to the producer to supply asphalt materials on the basis of certification will be withdrawn. The producer may still supply asphalt materials, but the contents of each shipping container must be sampled and tested by KDOT before acceptance for use. This procedure will be followed until the producer has provided to the Bureau Chief of Construction and Materials, adequate indication that future certifications will be reliable.

1201.5 BASIS OF ACCEPTANCE

a. For producers prequalified as required by **subsection 1201.4** above, asphalt materials covered by this specification will be accepted upon receipt and approval by the Field Engineer of a certification prepared by the producer to cover the quality and quantity of material in each shipping container. Certifications must be based on the results of the producer's quality control testing as required in **subsection 1201.2d.(2)**.

b. For producers who are not prequalified, asphalt materials covered by this specification will be accepted based on the results of tests by the Materials and Research Center on samples from each shipping container. Testing must be completed before incorporation of the product into the project.

03-18-19 C&M (KJS)
Aug-19 Letting

KANSAS DEPARTMENT OF TRANSPORTATION
SPECIAL PROVISION TO THE
STANDARD SPECIFICATIONS, 2015 EDITION

Delete SECTION 1202 and replace with the following:

SECTION 1202

PERFORMANCE GRADED ASPHALT BINDER

1202.1 DESCRIPTION

This specification covers performance graded asphalt binder (PGAB).

1202.2 REQUIREMENTS

a. Provide material* that complies with the applicable requirements of **SECTION 1201** and AASHTO M 320. Direct tension failure strain requirements are not applicable. All binders must have ΔTc ≥ -5.0°C as defined by ASTM D 7643 after 40 hours of conditioning in the pressure aging vessel (PAV). Binders with a temperature spread of 92°C or greater and any polymer modified binder with a temperature spread of 86°C must meet the additional requirements shown in **TABLE 1202-1**.

*Perform all tests after adding 0.5% high molecular weight amine antistripping agent (by weight) to the PGAB. Contact the Chief Chemist, Bureau of Construction and Materials, for a list of acceptable high molecular weight amines.

TABLE 1202-1: ADDITIONAL REQUIREMENTS

Temperature Spread [1], °C	**86**	**92**	**98**	**104**	**110**
Separation, ASTM D7173, ºC max. Run on Original Binder	2	2	2[2]	2	2
Elastic Recovery, ASTM D 6084, Procedure A, % min. Run on RTFO Residue	50	60	65	75	80

[1] Temperature Spread is determined by subtracting low temperature from high temperature; for example PG 64-28: 64-(-28) = 92
[2] For PG 70-28 RCI, separation test requirement no greater than 6.

b. Provide the grade of material designated in the Contract Documents. KDOT will not make changes in the grade of asphalt. The Contractor may substitute PGAB that complies with or exceeds the upper and lower grade designations for the grade specified. For example, if a maintenance overlay specifies a PG 58-22, a PG 64-22 or a PG 58-28 will also be accepted. Such substitutions require advance approval by the Engineer and a no-cost change order.

1202.3 TEST METHODS

Test according to the applicable provisions of ASTM D 7173, D 6084 and AASHTO T 48, T 240, T 313, T 315, T 316, and R 28. Use a PAV aging temperature of 90°C for binders designated PG52-xx and a temperature of 100°C for all other grade designations.

For PG 70-28 RCI prequalification, provide test data utilizing the binder in a mix that meets the criteria in Table 614-1 and passes the criteria in Table 614-5 in Section 614 (latest revision).

1202.4 PREQUALIFICATION

Prequalify material according to **SECTION 1201**.

1202.5 BASIS OF ACCEPTANCE

See applicable requirements under **SECTION 1201**.

05-07-21 C&M (RAB)/Sept-21 Letting

APPENDIX Z

5.2. QUALITY CONTROL /QUALITY ASSURANCE

5.2.1. STATISTICS

1. ACKNOWLEDGEMENT

This paper has been copied directly from the HMA Manual with a few modifications from the original version. The original version was prepared by Dr. Mustaque Hossain. Ph. D., P.E., Kansas State University.

2. BACKGROUND

2.1. American industries have defined the Quality Control/Quality Assurance (QC/QA) concept to fit within their particular application and there is no doubt that the "working" definition differs from industry to industry. In the highway community those Contractors, suppliers, and Public Agencies (Agency) that have implemented a QC/QA program probably have their own definition as well. It is important that a concise and logical definition of QC/QA be adopted and be supported by all members within a single industry. For the highway community the QC/QA concept must be defined so that Contractors, suppliers and Agencies can identify with a basic concept and proceed to establish their respective programs. The American Association of State Highway and Transportation Officials (AASHTO) has defined QC/QA in AASHTO R 10 in the following manner:

2.2. <u>Quality Control</u>: The system used by a contractor to monitor, assess and adjust their production or placement processes to ensure that the final product will meet the specified level of quality. Quality control includes sampling, testing, inspection and corrective action (where required) to maintain continuous control of a production or placement process.

2.3. <u>Quality Assurance:</u> All those planned and systematic actions necessary to provide confidence that a product or facility will perform satisfactorily in service; or (2) making sure the quality of a product is what it should be.

3. STANDARD DEFINITIONS FOR QC/QA APPLICATIONS

The following terms are defined in the AASHTO R 10 *except Agency*. All other shall be consistent with the **<u>2020 AASHTO Guide Specifications For Highway Construction</u>**.

3.1. Agency: The State Highway or Transportation Department, Commission, or other organization, constituted under State or Commonwealth laws, that administers highway or transportation work.

The term <u>Agency</u> was chosen for the purpose of consistency, as this document is intended for use by <u>any</u> governing organization attempting to prepare specifications for the purpose of highway or transportation work.

3.2. Acceptable Quality Level (**AQL**): The level of established actual quality for a quality characteristic that is fully acceptable.

3.3. Buyer: See *Agency* above.

3.4. Buyer's Risk: Also called *agency's risk*, or *risk of a Type II* or *beta (ß) error*. It is the risk to the agency of accepting rejectable quality level (*RQL*) material or workmanship.

3.5. Certified Technician: A technician certified by some agency as proficient in performing certain duties.

3.6. Disincentive: A pre-established decrease in payment to the contractor applied to a contract bid item for which the level of materials quality and workmanship, determined by statistical means, does not meet the specified acceptable quality level *(AQL)*. The disincentive is usually expressed as a percentage of the original Contract bid-price.

3.7. Incentive/disincentive provision (for quality): A pay adjustment schedule which functions to motivate the contractor to provide a high level of quality.

3.8. Lower Specification Limit (LSL): The lower statistically based limiting value associated with a quality characteristic and used to evaluate the acceptability of a lot.

3.9. Percent Within Limits (PWL): The percentage of the lot falling above a lower specification limit, beneath an upper specification limit, or between upper and lower specification limits.

3.10. Quality Assurance: All those planned and systematic actions necessary to provide confidence that a product or facility will perform satisfactorily in service; or (2) making sure the quality of a product is what it should be.

3.11. Quality Control: Also called *process control*. The system used by a contractor to monitor, assess and adjust their production or placement processes to ensure that the final product will meet the specified level of quality. Quality control includes sampling, testing, inspection and corrective action (where required) to maintain continuous control of a production or placement process.

3.12. Quality Control Plan: A project-specific document prepared by the contractor that identifies all QC personnel and procedures that will be used to maintain all production and placement processes "in control" and meet the agency specification requirements. The document also addresses actions to be taken in the event that a process goes "out of control".

3.13. Quality Level Analysis: A statistical procedure that provides an estimate of the percentage of a given lot that is within specification limits (*PWL*) or outside specifications limits (*PD*).

3.14. Rejectable Quality Level (RQL): The level of established actual quality for a quality characteristic that is rejectable when using a particular quality measure.

3.15. Seller's Risk (α): Also called *contractor's risk,* or *risk of a type 1* or *alpha (α) error.* The risk to the contractor of having acceptable quality level *(AQL)* material or workmanship rejected.

3.16. Target Value: The value that is placed on a quality characteristic that represents the mean of the expected distribution of the specified population.

3.17. Upper Specification Limit (USL): The upper statistically based limiting value associated with a quality characteristic and used with a quality measure to evaluate the quality of a lot.

4. MISCELLANEOUS DEFINITIONS RELATED TO QC/QA

4.1. Lot: An isolated quantity of material which is produced from a single source under similar conditions. A lot is a measured amount of construction assumed to be produced by the same process. For example, the placement of 4,000 tons of hot-mix asphalt (HMA) or one days production for concrete paving. Also referred to as population in statistical analysis.

4.2. Sublot: Sublots are equal divisions (i.e. portions) of a lot. A lot is divided into sublots for sampling purposes. For example, if a lot is considered to be 4,000 tons of HMA and the specification requires that the lot be divided into four sublots, the size of each sublot would be 1,000 tons (4,000 /4). For concrete paving, a lot is considered to be one day's production and the specification requires that the lot be subdivided into five sublots as shown in **Figure 1.**

4.3. Sample: Each individual quantity of material collected for test. A portion of lot.

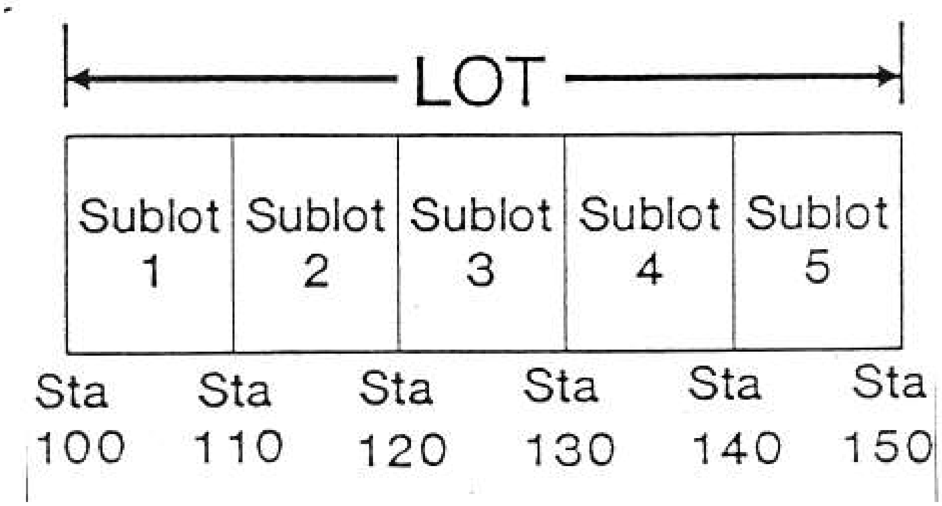


Figure 1. Lot and sublots in a highway construction setting

5. INTRODUCTORY STATISTICAL TERMS

5.1. Average or Mean ($\bar{x}$): Arithmetic mean or average determined for a number of variables (x_i) as below:

$$\bar{x} = \frac{x_1 + x_2 + \cdots + x_n}{n} = \frac{\sum x_i}{n} \qquad (1)$$

5.1.1. *Example: Find the arithmetic mean or average for the asphalt content of six Superpave mix sublots given as: 5.4, 5.8, 6.2, 5.4, 5.4 and 6.0%.*

$$\bar{x} = \frac{5.4 + 5.8 + 6.2 + 5.4 + 5.4 + 6.0}{6} = \frac{34.2}{6} = 5.7$$

5.1.2. *Example: Find the arithmetic mean or average for the percent air in the concrete mix of six sublots given as: 6.6, 6.2, 5.5, 7.8, 6.9 and 6.6%.*

$$\bar{x} = \frac{6.6 + 6.2 + 5.5 + 7.8 + 6.9 + 6.6}{6} = \frac{39.6}{6} = 6.6$$

5.2. Moving Average: Average computed based on a fixed set of continuous data points. For KDOT, the *w* represents the number of tests within a lot:

$$x_{ma} = \frac{x_{i-3} + x_{i-2} + x_{i-1} + x_i}{w} \tag{2}$$

5.2.1. *Example: Find the 4-point moving average for the above asphalt content data:*

Asphalt content (%)	4-point moving average
5.4	-
5.8	-
6.2	-
5.4	5.7
5.4	5.7
6.0	5.8

5.2.2. *Example: Find the 4-point moving average for the above percent air content data:*

Air content (%)	4-point moving average
6.6	-
6.2	-
5.5	-
7.8	6.5
6.9	6.6
6.6	6.7

5.3. Range (R): Range is the difference between the largest and smallest values. A simple measure of variability.

$$R = x_{max} - x_{min} \tag{3}$$

5.3.1. *Example: Find the Range (R) for the asphalt content data in 5.2.1. above:*

$R = 6.2 - 5.4 = 0.8\%$

5.3.2. *Example: Find the Range (R) for the air content data in 5.2.2. above:*

R = 7.8 - 5.5 = 2.3%

5.4. Sample Standard Deviation (s): Standard deviation is the root mean square of the deviation from the mean. This is a better measure of variability than range and is computed as below:

$$s = \sqrt{\frac{\sum(x_i - \bar{x})^2}{n-1}} \tag{4}$$

where, n is the sample size.

5.4.1. *Example: Find the standard deviation for the asphalt content data given below:*

x_i	$\bar{x}$	$x_i-\bar{x}$	$(x_i-\bar{x})^2$
5.4	5.7	-0.3	0.09
5.8	5.7	0.1	0.01
6.2	5.7	0.5	0.25
5.4	5.7	-0.3	0.09
5.4	5.7	-0.3	0.09
6.0	5.7	0.3	0.09
----------			-----------
n =6			Σ = 0.62

$$s = \sqrt{\frac{\sum(x_i - \bar{x})^2}{n-1}} = \sqrt{\frac{0.62}{6-1}} = 0.35$$

5.4.2. *Example: Find the standard deviation for the air content data given below:*

x_i	$\bar{x}$	$x_i-\bar{x}$	$(x_i-\bar{x})^2$
6.6	6.6	0.0	0.00
6.2	6.6	-0.4	0.16
5.5	6.6	-1.1	1.21
7.8	6.6	1.2	1.44
6.9	6.6	0.3	0.09
6.6	6.6	0.0	0.00
----------			-----------
n =6			Σ = 2.90

$$s = \sqrt{\frac{\sum(x_i - \bar{x})^2}{n-1}} = \sqrt{\frac{2.90}{6-1}} = 0.76$$

5.5. Population Standard Deviation (σ): When the sample size n is large (usually greater than 30), the standard deviation obtained is for the population. The equation is same as in (4) except that the denominator is replaced by n.

5.6. Variance (s^2): Sample variance is simply the square of the sample standard deviation.

5.6.1. *Example: Find the variance of the asphalt content data given above:*

$s = 0.35;$ $\qquad\qquad s^2 = (0.35)^2 = 0.123$

5.6.2. *Example: Find the variance of the air content data given above:*

$s = 0.76;$ $\qquad\qquad s^2 = (0.76)^2 = 0.578$

5.7. Coefficient of Variation (COV): The coefficient of variation is defined as the standard deviation as a percentage of the mean. It is an additional measure of variability and is calculated as:

$$C.O.V.(\%) = \frac{s}{\bar{x}} \times 100 \qquad (5)$$

5.7.1. *Example: Find the coefficient of variation of the asphalt content data given above:*

$$C.O.V.(\%) = \frac{0.35}{5.7} \times 100 = 6.1\%$$

5.7.2. *Example: Find the coefficient of variation of the asphalt content data given above:*

$$C.O.V.(\%) = \frac{0.76}{6.6} \times 100 = 11.5\%$$

5.8. Normal Distribution Curve: It is a typical "bell-shaped" symmetrical curve which usually will describe the distribution of engineering measurements, e.g. test results of HMA or concrete mixes. **Figures 2, 3 and 4** show various examples of normal distribution curves and how they vary but are interrelated.

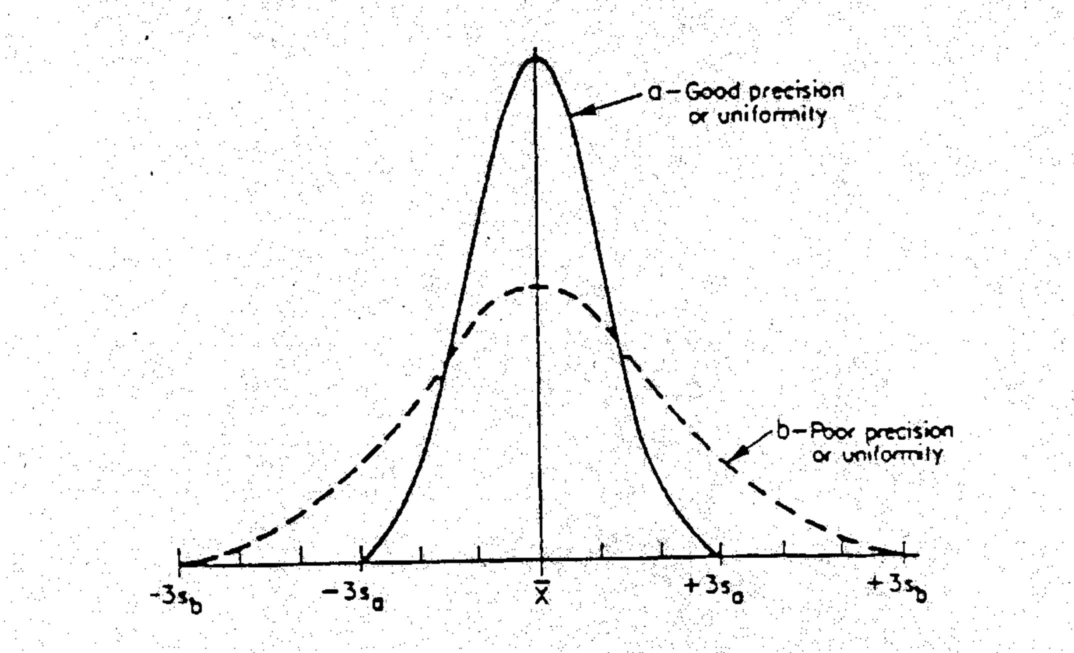


Figure 2. Normal distribution curves

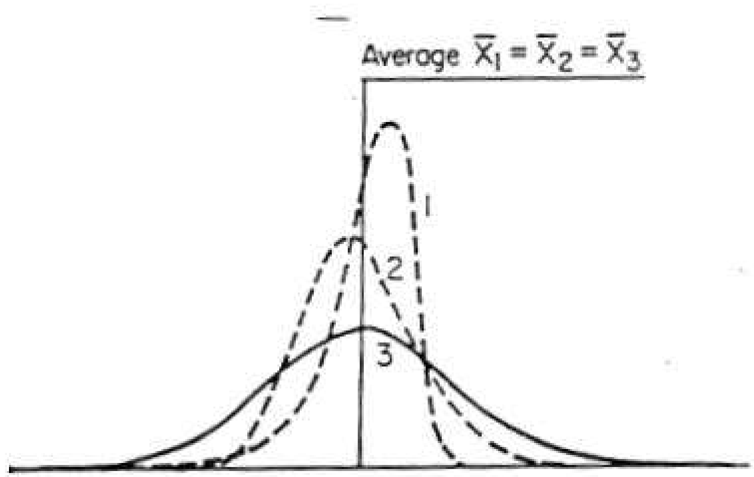


Figure 3. Quite different distributions may have the same average

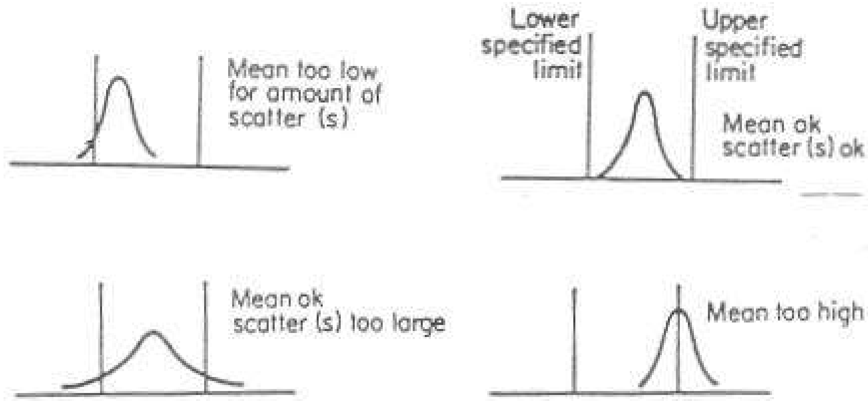


Figure 4. Process control related to specification limits

5.9. Control charts: Control charts are horizontal line charts. The horizontal lines (for single test results or for "average" type charts) generally consist of a central line at the specified average and an upper line at the specified upper acceptance limit and a lower line at the lower acceptance limit (if both are applicable) - for an "acceptance" control chart. **Figure 5** shows a typical control chart for average 9.5 mm aggregate size (percent retained). Control charts are very helpful for identifying possible problems. Examples are provided in **Figures 6, 7, 8, and 9.** It is to be noted that if these charts are plotted using individual test results, then the chance causes cannot be distinguished from assignable causes. However, the moving average tends to smooth out chance variations and a control chart based on moving averages can be used to indicate significant trends due to variation in materials and processes.

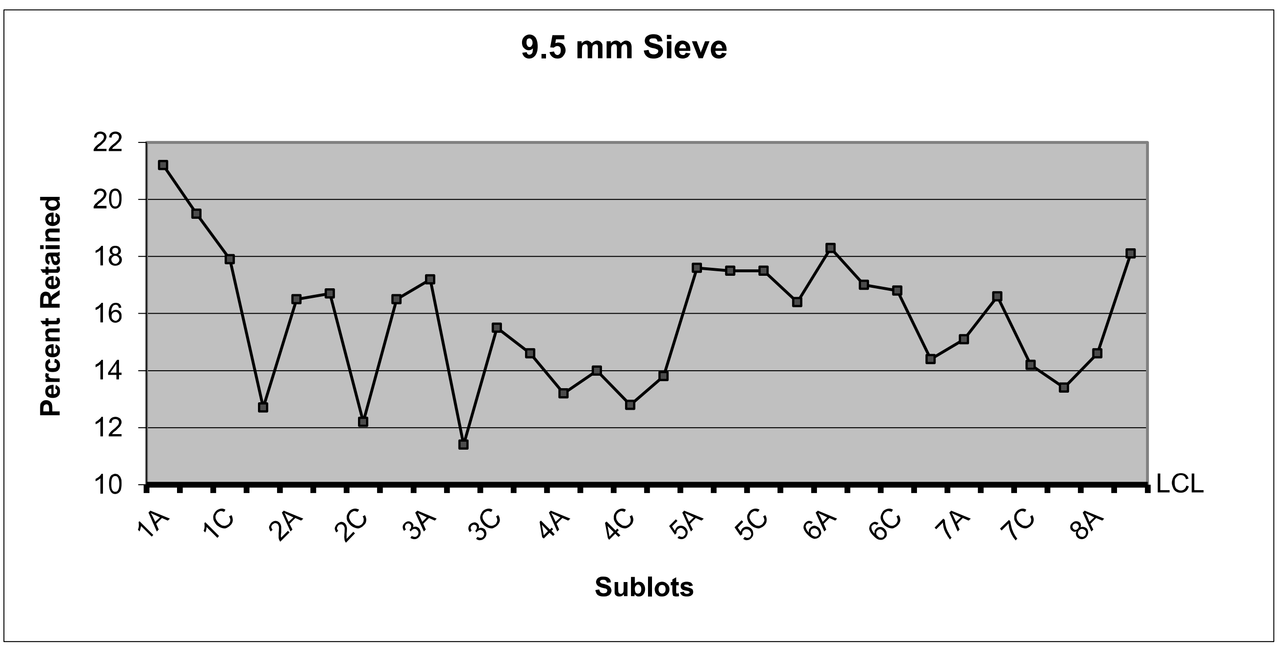


Figure 5. A typical control chart

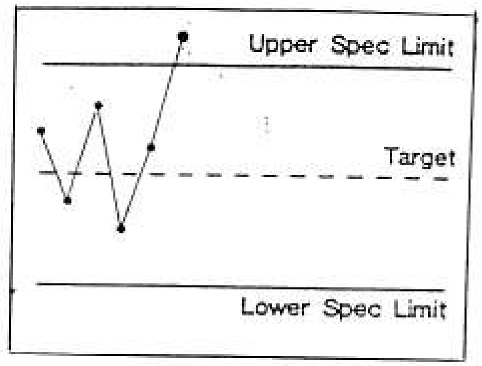


Figure 6. A point outside the upper specification limits

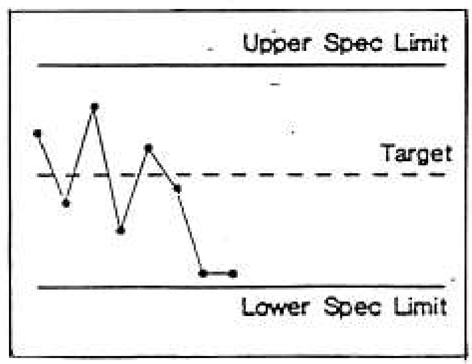


Figure 7. Two consecutive points near the upper or lower specification limits

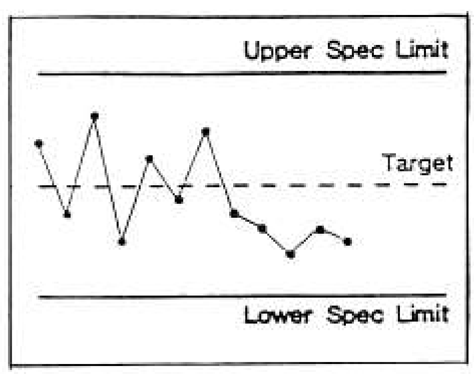


Figure 8. Five consecutive points on one side of the center target value

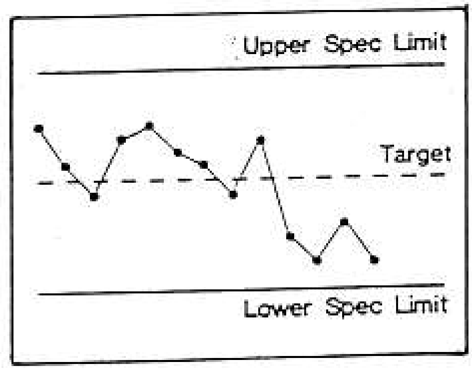


Figure 9. A sudden change in the level of results

5.10. Statistical Control charts: It is to be noted that regardless of the shape of the normal curve and spread (s), 68.26% of the test results will be within ± 1s, 95.44% within ± 2 s and 99.74% within ± 3 s. Thus, it is apparent that a control chart based on the test statistics (x and s) could be easily developed. The center line could be the mean of k sample means, each based on tests. The Upper Specification Limit (USL) and the Lower Specification Limit (LSL) can be fixed based on multiples of s resulting in a typical statistical control chart as shown in **Figure 10.**

5.11. Random Number: A number selected entirely by chance as from a table of random numbers as shown in **Table 1 of the KDOT Construction Manual Section 5.2.2.2**. (A scientific calculator can also generate random number; however, this method needs to be approved by the District Materials Engineer).

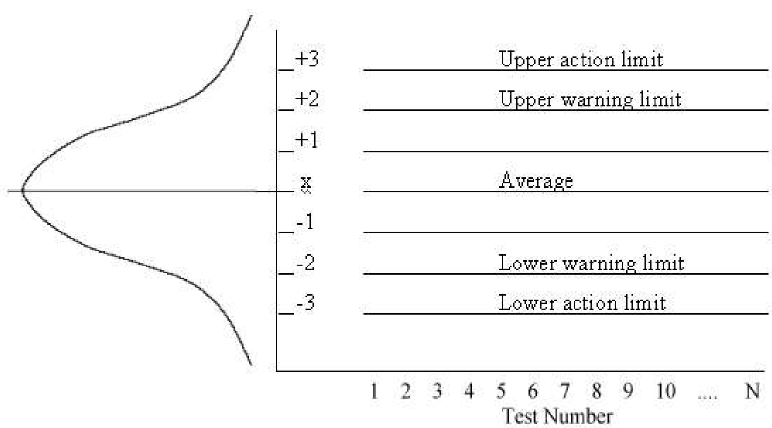


Figure 10. Statistical control chart

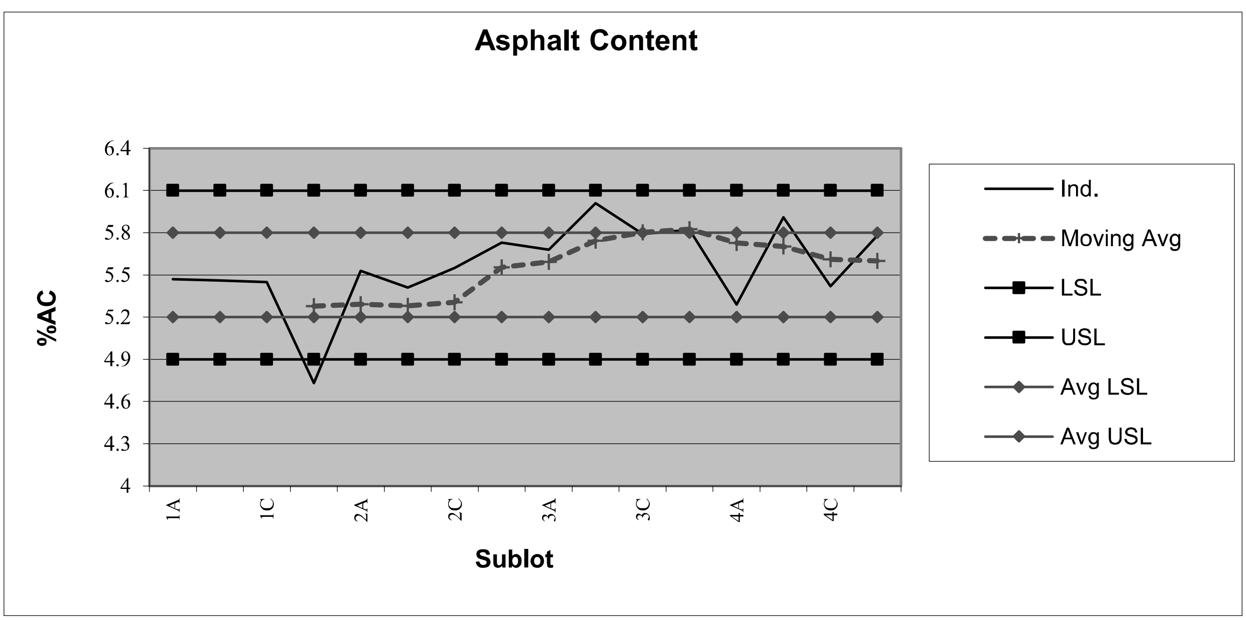
5.12. Moving Average

Within KDOT's QC/QA specifications, moving averages are to be plotted on the same chart as the individual test results. This is a simple process to include on the graphs. The number of tests in each average will be dictated by the specifications for the project. For the following illustration, a 4-point moving average will be considered.

Table 1: Individual Asphalt Content Test Data

Sublot	AC%	
1A	5.47	
1B	5.46	
1C	5.45	
1D	4.73	1st avg = (5.47 + 5.46 + 5.45 + 4.73)/4 = 5.28
2A	5.53	2nd avg = (5.46 + 5.45 + 4.73 + 5.53)/4 = 5.29
2B	5.41	3rd avg = (5.45 + 4.73 + 5.53 + 5.41)/4 = 5.28
2C	5.55	4th avg = (4.73 + 5.53 + 5.41 + 5.55)/4 = 5.31
2D	5.73	5th avg = (5.53 + 5.41 + 5.55 + 5.73)/4 = 5.56
3A	5.68	6th avg = (5.41 + 5.55 + 5.73 + 5.68)/4 = 5.59
3B	6.01	7th avg = (5.55 + 5.73 + 5.68 + 6.01)/4 = 5.74
3C	5.79	8th avg = (5.73 + 5.68 + 6.01 + 5.79)/4 = 5.80
3D	5.82	9th avg = (5.68 + 6.01 + 5.79 + 5.82)/4 = 5.83
4A	5.29	10th avg = (6.01 + 5.79 + 5.82 + 5.29)/4 = 5.73
4B	5.91	11th avg = (5.79 + 5.82 + 5.29 + 5.91)/4 = 5.70
4C	5.42	12th avg = (5.82 + 5.29 + 5.91 + 5.42)/4 = 5.61
4D	5.78	13th avg = (5.29 + 5.91 + 5.42 + 5.78)/4 = 5.60

When starting out, the first four tests (1 thru 4) will be used to determine the average. As the fifth test becomes available for plotting, a second 4-point moving average becomes available by taking the average of the 2nd thru 5th tests. This process continues as additional tests become available. Using the test data from **Table 1**, a clear pattern emerges for calculating the averages.



MOVING AVERAGE

Notice how the individual test result fails in sublot 1D which exceeded the single lower specification limit (LSL). There is also a failure of the moving average in 3D. Read the specifications to determine what, if any, lower and upper specification limits exist for test results and what action is warranted when such an event occurs.

6. QUALITY LEVEL ANALYSIS

6.1. *Quality Level Analysis* is a statistical procedure that provides a method of estimating the percentage of each lot or sublot of material, product item of construction, or completed construction that may be expected to be within specified tolerance limits. This percent within limits is represented by the unshaded areas under the normal curves in **Figure 11**.

6.2. When the specifications require that the percent within limits be established by Quality Level Analysis, the following procedure shall apply:

Terminology:

6.2.1. x_i = the individual values under consideration

6.2.2. n = the number of individual values under consideration

6.2.3. $\bar{X}$ = the arithmetic mean or average of values under consideration. $\bar{X}$ may be expressed as $\Sigma x_i/n$, or the sum of the individual values divided by the number of individual values.

6.2.4. Q_U = Upper Quality Index. Found by subtracting the average $\bar{X}$ from the Upper Specification Limit (USL) and dividing by the sample standard deviation(s).

6.2.5. Q_L = Lower Quality Index. Found by subtracting the Lower Specification Limit (LSL) from the average $\bar{X}$ and dividing by the sample standard deviation (s).

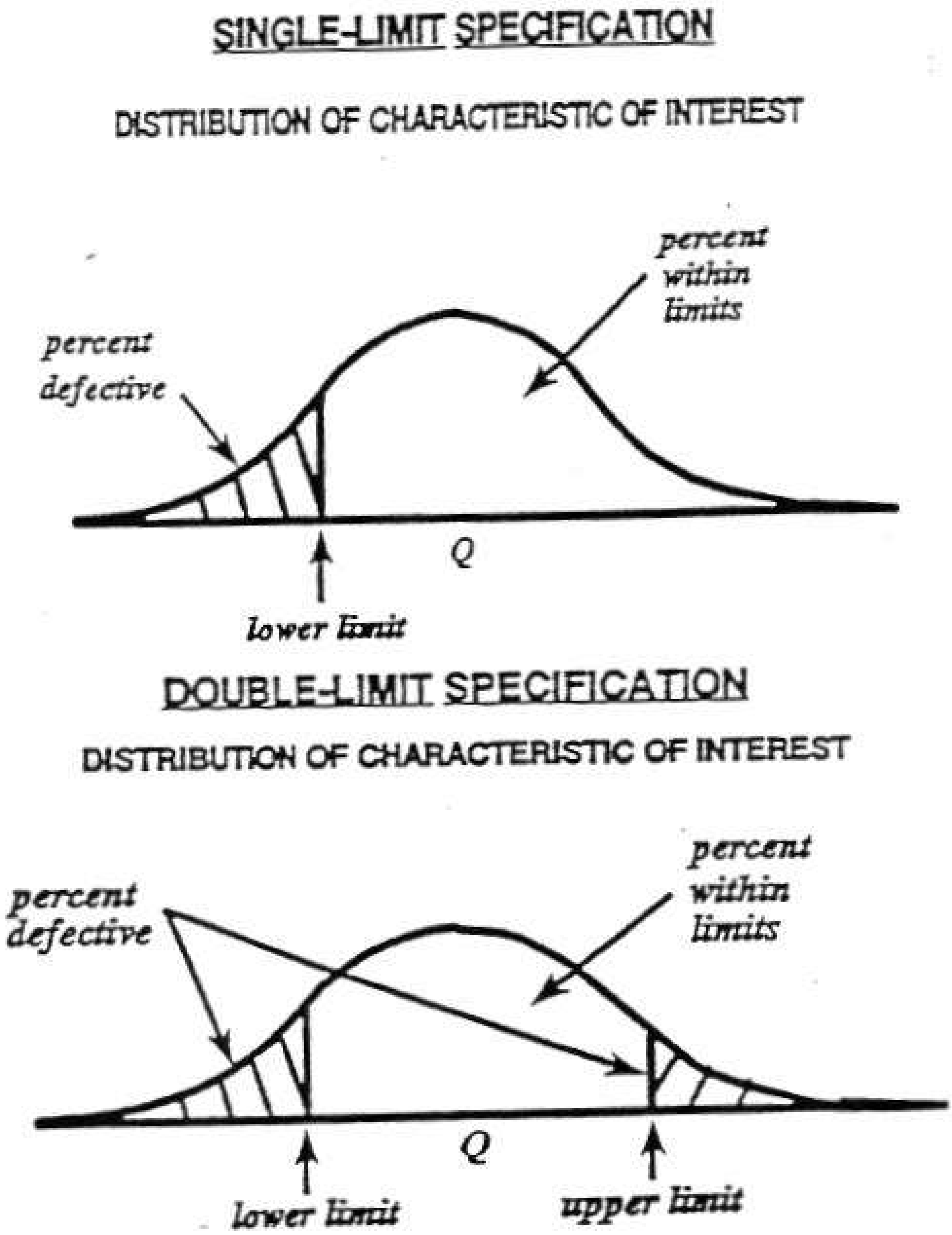


Figure 11. Concept of Percent Defective

6.3. Steps in Analysis for a double-limit specification:

6.3.1. Locate “n” sampling positions on the lot or sublot in a random manner.

6.3.2. Make a measurement at each sample position or take a test portion and make the measurement on the test portion.

6.3.3. Average all measurements to find $\bar{x}$.

6.3.4. Compute the sample standard deviation using:

$$s = \sqrt{\frac{\Sigma(x_i - \bar{x})^2}{n-1}}$$

6.3.5. Find the Upper Quality Index (Q_U) by subtracting the average ($\bar{x}$) from the Upper Specification Limit (USL) and dividing the result by s.

$$Q_u = \frac{(USL - \bar{x})}{s}$$

6.3.6. Find the Lower Quality Index (Q_L) by subtracting the Lower Specification Limit (LSL) from the average ($\bar{x}$) and dividing the result by s.

$$Q_L = \frac{(\bar{x} - LSL)}{s}$$

6.3.7. Estimate the percentage that will fall below the Upper Specification limit (PWL_U). This is done by referring to **Table 2** with the computed value of Q_U and then reading the appropriate PWL_U value.

6.3.8. Estimate the percentage that will fall above the Lower Specification Limit (PWL_L).

6.3.9. Determine the Quality Level stated as percent within limits (PWL).

$$PWL = (PWL_{U} + PWL_{L}) - 100$$

6.4. Steps in Analysis for a single-limit specification with lower-limit specified:

6.4.1. Locate "n" sampling positions on the lot or sublot in a random manner.

6.4.2. Make a measurement at each sample position or take a test portion and make the measurement on the test portion.

6.4.3. Average all measurements to find $\bar{x}$.

6.4.4. Compute the sample standard deviation using:

$$s = \sqrt{\frac{\sum(x_i - \bar{x})^2}{n-1}}$$

6.4.5. Find the Quality Index (Q) by subtracting the Lower Specification Limit (LSL) from the average ($\bar{x}$) and dividing the result by s.

$$Q = \frac{(\bar{x} - LSL)}{s}$$

6.4.6. Estimate the percentage that will fall above the Specification limit (PWL). This is done by referring to **Table 2** with the computed value of Q and then reading the appropriate PWL value.

6.5. Quality Level Analysis: Example Problem for double-limit specification

A contractor has run air voids tests on five lots of SM-19B. The specification limits for air voids are 4 ± 1.25 %. This sets the lower specification limit (LSL) at 2.75 % (4 - 1.25 %) air voids and the upper specification limit (USL) at 5.25 % (4 + 1.25 %) air voids. Conduct a Quality Level Analysis and compute the percent within limits.

Lot	Sublot	Percent Air Voids
1	1A	4.30
	1B	3.77
	1C	4.05
	1D	4.80
2	2A	4.90
	2B	5.07
	2C	3.82
	2D	3.53
3	3A	2.67
	3D	2.09
	3C	2.92
	3D	2.56
4	4A	2.39
	4B	2.87
	4C	5.56
	4D	4.74
5	5A	2.36
	5B	2.00
	5C	5.99
	5D	3.73

Solution:

Lot 1: $\bar{x}$ = 4.23, s_x = 0.437, n = 4

$Q_U = \frac{5.25 - 4.23}{0.437} = 2.33$ from Table **2** PWLU = 100 %

$Q_L = \frac{4.23 - 2.75}{0.437} = 3.39$ from Table **2** PWLL = 100 %

PWL = (100 + 100) - 100 = 100 %

Lot 2: $\bar{x}$ = 4.33, sx = 0.769, n = 4

$Q_U = \frac{5.25 - 4.33}{0.769} = 1.20$ from Table **2** PWLU = 90 %

$Q_L = \frac{4.33 - 2.75}{0.769} = 2.05$ from Table **2** PWLL = 100 %

PWL = (90 + 100) - 100 = 90 %

Lot 3: $\bar{x}$ = 2.56, s_x = 0.348, n = 4

$Q_U = \frac{5.25 - 2.56}{0.348} = 7.73$ from Table **2** PWLU = 100 %

$Q_L = \frac{2.56 - 2.75}{0.348} = -.55$ from Table **2** PWL Table = 68.33 %

If Q_L is a negative number, the PWL is equal to 100 % - (value looked up in **Table 2**)

$PWL_{L} =$ (100 - 68.33) = 31.67 %

PWL = (100 + 31.67) - 100 = 31.67 %

Lot 4: $\bar{x}$ = 3.89, s_x = 1.506, n = 4

$Q_U = \frac{5.25 - 3.89}{1.506} = 0.90$ from **Table 2** PWL_U = 80.0 %

$Q_L = \frac{3.89 - 2.75}{1.506} = 0.76$ from **Table 2** PWL_L = 75.33 %

PWL = (80.0 + 75.33) - 100 = 55.33 %

Lot 5: $\bar{x} = 3.52$, $s_x = 1.807$, $n = 4$

$Q_U = \dfrac{5.25 - 3.52}{1.807} = 0.96$ from Table **2** PWLU = 82.0 %

$Q_L = \dfrac{3.52 - 2.75}{1.807} = 0.43$ from **Table 2** PWL_L = 64.33 %

PWL = (82.0 + 64.33) - 100 = 46.33 %

6.6. Quality Level Analysis: Example Problem for single-limit specification

A contractor has made thickness cores on three lots of concrete pavement. The lower specification limit (LSL) is 275 mm. Conduct a Quality Level Analysis and compute the percent within limits.

Lot	Sublot	Thickness (mm)
1	1A	278
	1B	274
	1C	276
	1D	280
	1E	280
2	2A	261
	2B	284
	2C	275
	2D	269
	2E	281
3	3A	293
	3D	288
	3C	297
	3D	299
	3E	290

Solution:

Lot 1: $\bar{x}$ = 277.6, sx = 2.608, n = 5

$Q = \dfrac{277.6 - 275}{2.608} = 0.997$ from Table **2.** PWL = 83.64 %

Lot 2 : $\bar{x}$ = 274.0, s_x = 9.274, n = 5

$Q = \dfrac{274 - 275}{9.274} = -0.11$ from Table **2.** PWL_{Table} = 53.91 %

If Q is a negative number, the PWL is equal to 100 % - (value looked up in **Table 2.**)
PWL = (100.0 - 53.91) = 46.09 %

Lot 3: $\bar{x}$ = 293.4, s_x = 4.615, n = 5

$Q = \dfrac{293.4 - 275}{4.615} = 3.99$ from Table **2.** PWL = 100.00 %

Table 2 for Estimation of Lot Percent Within Limits
Variability Unknown Procedure
Standard Deviation Method

Quality Index Q_U or Q_L	Percent Within Limits for Selected Sample Sizes												
	N=3	N=4	N=5	N=6	N=7	N=8	N=9	N=10	N=15	N=20	N=30	N=50	N=100
0.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
0.01	50.28	50.33	50.36	50.37	50.37	50.38	50.38	50.38	50.39	50.39	50.40	50.40	50.40
0.02	50.55	50.67	50.71	50.73	50.75	50.76	50.76	50.77	50.78	50.79	50.79	50.79	50.80
0.03	50.83	51.00	51.07	51.10	51.12	51.14	51.15	51.15	51.17	51.18	51.19	51.19	51.19
0.04	51.10	51.33	51.42	51.47	51.50	51.51	51.53	51.54	51.56	51.57	51.58	51.59	51.59
0.05	51.38	51.67	51.78	51.84	51.87	51.89	51.91	51.92	51.95	51.96	51.98	51.98	51.99
0.06	51.65	52.00	52.13	52.20	52.24	52.27	52.29	52.30	52.34	52.36	52.37	52.38	52.39
0.07	51.93	52.33	52.49	52.57	52.62	52.65	52.67	52.69	52.73	52.75	52.76	52.78	52.78
0.08	52.21	52.67	52.85	52.94	52.99	53.03	53.05	53.07	53.12	53.14	53.16	53.17	53.18
0.09	52.48	53.00	53.20	53.30	53.37	53.41	53.43	53.46	53.51	53.53	53.55	53.57	53.58
0.10	52.76	53.33	53.56	53.67	53.74	53.78	53.82	53.84	53.90	53.92	53.95	53.96	53.97
0.11	53.04	53.67	53.91	54.04	54.11	54.16	54.20	54.22	54.29	54.31	54.34	54.36	54.37
0.12	53.31	54.00	54.27	54.40	54.49	54.54	54.58	54.60	54.67	54.70	54.73	54.75	54.76
0.13	53.59	54.33	54.62	54.77	54.86	54.92	54.96	54.99	55.06	55.09	55.12	55.14	55.16
0.14	53.87	54.67	54.98	55.14	55.23	55.29	55.34	55.37	55.45	55.48	55.52	55.54	55.55
0.15	54.15	55.00	55.33	55.50	55.60	55.67	55.71	55.75	55.84	55.87	55.91	55.93	55.95
0.16	54.42	55.33	55.69	55.87	55.97	56.04	56.09	56.13	56.22	56.26	56.30	56.32	56.34
0.17	54.70	55.67	56.04	56.23	56.35	56.42	56.47	56.51	56.61	56.65	56.69	56.71	56.73
0.18	54.98	56.00	56.40	56.60	56.72	56.79	56.85	56.89	56.99	57.04	57.08	57.11	57.12
0.19	55.26	56.33	56.75	56.96	57.09	57.17	57.23	57.27	57.38	57.43	57.47	57.50	57.52
0.20	55.54	56.67	57.10	57.32	57.46	57.54	57.60	57.65	57.76	57.81	57.85	57.89	57.91
0.21	55.82	57.00	57.46	57.69	57.83	57.92	57.98	58.03	58.15	58.20	58.24	58.27	58.30
0.22	56.10	57.33	57.81	58.05	58.20	58.29	58.36	58.40	58.53	58.58	58.63	58.66	58.69
0.23	56.38	57.67	58.16	58.41	58.56	58.66	58.73	58.78	58.91	58.97	59.01	59.05	59.07
0.24	56.66	58.00	58.52	58.78	58.93	59.03	59.11	59.16	59.29	59.35	59.40	59.44	59.46
0.25	56.95	58.33	58.87	59.14	59.30	59.41	59.48	59.53	59.67	59.73	59.78	59.82	59.85
0.26	57.23	58.67	59.22	59.50	59.67	59.78	59.85	59.91	60.05	60.11	60.17	60.21	60.23
0.27	57.51	59.00	59.57	59.86	60.03	60.15	60.23	60.28	60.43	60.49	60.55	60.59	60.62
0.28	57.80	59.33	59.92	60.22	60.40	60.52	60.60	60.66	60.81	60.87	60.93	60.97	61.00
0.29	58.08	59.67	60.28	60.58	60.77	60.89	60.97	61.03	61.19	61.25	61.31	61.35	61.38
0.30	58.37	60.00	60.63	60.94	61.13	61.25	61.34	61.40	61.56	61.63	61.69	61.73	61.76
0.31	58.65	60.33	60.98	61.30	61.50	61.62	61.71	61.77	61.94	62.01	62.07	62.11	62.14
0.32	58.94	60.67	61.33	61.66	61.86	61.99	62.08	62.14	62.31	62.38	62.45	62.49	62.52
0.33	59.23	61.00	61.68	62.02	62.22	62.35	62.45	62.51	62.69	62.76	62.82	62.87	62.90
0.34	59.51	61.33	62.03	62.38	62.58	62.72	62.81	62.88	63.06	63.13	63.20	63.25	63.28
0.35	59.80	61.67	62.38	62.73	62.94	63.08	63.18	63.25	63.43	63.51	63.57	63.62	63.65
0.36	60.09	62.00	62.72	63.09	63.31	63.45	63.54	63.62	63.80	63.88	63.95	63.99	64.03
0.37	60.38	62.33	63.07	63.45	63.67	63.81	63.91	63.98	64.17	64.25	64.32	64.37	64.40
0.38	60.67	62.67	63.42	63.80	64.02	64.17	64.27	64.35	64.54	64.62	64.69	64.74	64.77
0.39	60.97	63.00	63.77	64.16	64.38	64.53	64.63	64.71	64.90	64.98	65.06	65.11	65.14
0.40	61.26	63.33	64.12	64.51	64.74	64.89	65.00	65.07	65.27	65.35	65.42	65.47	65.51
0.41	61.55	63.67	64.46	64.86	65.10	65.25	65.36	65.43	65.63	65.72	65.79	65.84	65.88
0.42	61.85	64.00	64.81	65.21	65.45	65.61	65.71	65.79	66.00	66.08	66.15	66.21	66.24
0.43	62.15	64.33	65.15	65.57	65.81	65.96	66.07	66.15	66.36	66.44	66.52	66.57	66.61
0.44	62.44	64.67	65.50	65.92	66.16	66.32	66.43	66.51	66.72	66.80	66.88	66.93	66.97

Table 2 for Estimation of Lot Percent Within Limits
Variability Unknown Procedure
Standard Deviation Method

Quality Index Q_U or Q_L	Percent Within Limits for Selected Sample Sizes												
	N=3	N=4	N=5	N=6	N=7	N=8	N=9	N=10	N=15	N=20	N=30	N=50	N=100
0.45	62.74	65.00	65.84	66.27	66.51	66.67	66.79	66.87	67.08	67.16	67.24	67.29	67.33
0.46	63.04	65.33	66.19	66.62	66.87	67.03	67.14	67.22	67.43	67.52	67.60	67.65	67.69
0.47	63.34	65.67	66.53	66.96	67.22	67.38	67.49	67.58	67.79	67.88	67.96	68.01	68.05
0.48	63.65	66.00	66.88	67.31	67.57	67.73	67.85	67.93	68.15	68.23	68.31	68.37	68.40
0.49	63.95	66.33	67.22	67.66	67.92	68.08	68.20	68.28	68.50	68.59	68.67	68.72	68.76
0.50	64.25	66.67	67.56	68.00	68.26	68.43	68.55	68.63	68.85	68.94	69.02	69.07	69.11
0.51	64.56	67.00	67.90	68.35	68.61	68.78	68.90	68.98	69.20	69.29	69.37	69.43	69.46
0.52	64.87	67.33	68.24	68.69	68.96	69.13	69.24	69.33	69.55	69.64	69.72	69.77	69.81
0.53	65.18	67.67	68.58	69.04	69.30	69.47	69.59	69.68	69.90	69.99	70.07	70.12	70.16
0.54	65.49	68.00	68.92	69.38	69.64	69.82	69.93	70.02	70.24	70.33	70.41	70.47	70.51
0.55	65.80	68.33	69.26	69.72	69.99	70.16	70.28	70.36	70.59	70.68	70.76	70.81	70.85
0.56	66.12	68.67	69.60	70.06	70.33	70.50	70.62	70.71	70.93	71.02	71.10	71.15	71.19
0.57	66.43	69.00	69.94	70.40	70.67	70.84	70.96	71.05	71.27	71.36	71.44	71.49	71.53
0.58	66.75	69.33	70.27	70.74	71.01	71.18	71.30	71.39	71.61	71.70	71.78	71.83	71.87
0.59	67.07	69.67	70.61	71.07	71.34	71.52	71.64	71.72	71.95	72.04	72.11	72.17	72.21
0.60	67.39	70.00	70.95	71.41	71.68	71.85	71.97	72.06	72.28	72.37	72.45	72.50	72.54
0.61	67.72	70.33	71.28	71.75	72.02	72.19	72.31	72.40	72.61	72.70	72.78	72.84	72.87
0.62	68.04	70.67	71.61	72.08	72.35	72.52	72.64	72.73	72.95	73.04	73.11	73.17	73.20
0.63	68.37	71.00	71.95	72.41	72.68	72.85	72.97	73.06	73.28	73.37	73.44	73.50	73.53
0.64	68.70	71.33	72.28	72.74	73.01	73.18	73.30	73.39	73.61	73.69	73.77	73.82	73.86
0.65	69.03	71.67	72.61	73.08	73.34	73.51	73.63	73.72	73.93	74.02	74.10	74.15	74.18
0.66	69.37	72.00	72.94	73.40	73.67	73.84	73.96	74.04	74.26	74.34	74.42	74.47	74.51
0.67	69.70	72.33	73.27	73.73	74.00	74.17	74.28	74.37	74.58	74.67	74.74	74.79	74.83
0.68	70.04	72.67	73.60	74.06	74.32	74.49	74.61	74.69	74.90	74.99	75.06	75.11	75.14
0.69	70.39	73.00	73.93	74.39	74.65	74.81	74.93	75.01	75.22	75.30	75.38	75.43	75.46
0.70	70.73	73.33	74.26	74.71	74.97	75.14	75.25	75.33	75.54	75.62	75.69	75.74	75.77
0.71	71.08	73.67	74.59	75.04	75.29	75.46	75.57	75.65	75.85	75.94	76.01	76.05	76.09
0.72	71.43	74.00	74.91	75.36	75.61	75.77	75.89	75.97	76.17	76.25	76.32	76.36	76.40
0.73	71.78	74.33	75.24	75.68	75.93	76.09	76.20	76.28	76.48	76.56	76.63	76.67	76.70
0.74	72.14	74.67	75.56	76.00	76.25	76.41	76.51	76.59	76.79	76.87	76.93	76.98	77.01
0.75	72.50	75.00	75.89	76.32	76.56	76.72	76.83	76.90	77.10	77.17	77.24	77.28	77.31
0.76	72.87	75.33	76.21	76.63	76.88	77.03	77.14	77.21	77.40	77.48	77.54	77.58	77.61
0.77	73.24	75.67	76.53	76.95	77.19	77.34	77.44	77.52	77.70	77.78	77.84	77.88	77.91
0.78	73.61	76.00	76.85	77.26	77.50	77.65	77.75	77.82	78.01	78.08	78.14	78.18	78.21
0.79	73.98	76.33	77.17	77.58	77.81	77.96	78.06	78.13	78.30	78.37	78.43	78.47	78.50
0.80	74.36	76.67	77.49	77.89	78.12	78.26	78.36	78.43	78.60	78.67	78.73	78.77	78.79
0.81	74.75	77.00	77.81	78.20	78.42	78.56	78.66	78.73	78.90	78.96	79.02	79.06	79.08
0.82	75.14	77.33	78.13	78.51	78.73	78.86	78.96	79.02	79.19	79.25	79.31	79.35	79.37
0.83	75.53	77.67	78.44	78.82	79.03	79.16	79.25	79.32	79.48	79.54	79.60	79.63	79.65
0.84	75.93	78.00	78.76	79.12	79.33	79.46	79.55	79.61	79.77	79.83	79.88	79.91	79.94
0.85	76.33	78.33	79.07	79.43	79.63	79.76	79.84	79.90	80.06	80.11	80.16	80.20	80.22
0.86	76.74	78.67	79.38	79.73	79.93	80.05	80.13	80.19	80.34	80.40	80.44	80.47	80.49
0.87	77.16	79.00	79.69	80.03	80.22	80.34	80.42	80.48	80.62	80.68	80.72	80.75	80.77
0.88	77.58	79.33	80.00	80.33	80.52	80.63	80.71	80.77	80.90	80.95	81.00	81.02	81.04
0.89	78.01	79.67	80.31	80.63	80.81	80.92	81.00	81.05	81.18	81.23	81.27	81.30	81.31

Table 2 for Estimation of Lot Percent Within Limits
Variability Unknown Procedure
Standard Deviation Method

Quality Index Q_U or Q_L	Percent Within Limits for Selected Sample Sizes N=3	N=4	N=5	N=6	N=7	N=8	N=9	N=10	N=15	N=20	N=30	N=50	N=100
0.90	78.45	80.00	80.62	80.93	81.10	81.21	81.28	81.33	81.46	81.50	81.54	81.57	81.58
0.91	78.89	80.33	80.93	81.22	81.39	81.49	81.56	81.61	81.73	81.77	81.81	81.83	81.85
0.92	79.34	80.67	81.23	81.51	81.67	81.77	81.84	81.89	82.00	82.04	82.08	82.10	82.11
0.93	79.81	81.00	81.54	81.81	81.96	82.05	82.12	82.16	82.27	82.31	82.34	82.36	82.37
0.94	80.27	81.33	81.84	82.10	82.24	82.33	82.39	82.44	82.54	82.57	82.60	82.62	82.63
0.95	80.75	81.67	82.14	82.39	82.52	82.61	82.67	82.71	82.80	82.84	82.86	82.88	82.89
0.96	81.25	82.00	82.45	82.67	82.80	82.88	82.94	82.97	83.06	83.10	83.12	83.13	83.14
0.97	81.75	82.33	82.75	82.96	83.08	83.15	83.21	83.24	83.32	83.35	83.37	83.39	83.39
0.98	82.26	82.67	83.04	83.24	83.35	83.43	83.47	83.51	83.58	83.61	83.63	83.64	83.64
0.99	82.79	83.00	83.34	83.52	83.63	83.69	83.74	83.77	83.84	83.86	83.88	83.88	83.89
1.00	83.33	83.33	83.64	83.80	83.90	83.96	84.00	84.03	84.09	84.11	84.12	84.13	84.13
1.01	83.89	83.67	83.93	84.08	84.17	84.22	84.26	84.28	84.34	84.36	84.37	84.37	84.38
1.02	84.47	84.00	84.22	84.36	84.44	84.49	84.52	84.54	84.59	84.60	84.61	84.62	84.62
1.03	85.07	84.33	84.52	84.63	84.70	84.75	84.77	84.79	84.83	84.85	84.85	84.85	84.85
1.04	85.69	84.67	84.81	84.91	84.97	85.00	85.03	85.04	85.08	85.09	85.09	85.09	85.09
1.05	86.34	85.00	85.09	85.18	85.23	85.26	85.28	85.29	85.32	85.33	85.33	85.32	85.32
1.06	87.02	85.33	85.38	85.45	85.49	85.51	85.53	85.54	85.56	85.56	85.56	85.55	85.55
1.07	87.73	85.67	85.67	85.71	85.74	85.76	85.78	85.78	85.80	85.80	85.79	85.78	85.78
1.08	88.49	86.00	85.95	85.98	86.00	86.01	86.02	86.03	86.03	86.03	86.02	86.01	86.00
1.09	89.29	86.33	86.24	86.24	86.25	86.26	86.27	86.27	86.26	86.26	86.25	86.23	86.23
1.10	90.16	86.67	86.52	86.50	86.51	86.51	86.51	86.50	86.49	86.48	86.47	86.46	86.45
1.11	91.11	87.00	86.80	86.76	86.75	86.75	86.74	86.74	86.72	86.71	86.69	86.68	86.66
1.12	92.18	87.33	87.07	87.02	87.00	86.99	86.98	86.97	86.95	86.93	86.91	86.89	86.88
1.13	93.40	87.67	87.35	87.28	87.25	87.23	87.21	87.20	87.17	87.15	87.13	87.11	87.09
1.14	94.92	88.00	87.63	87.53	87.49	87.46	87.45	87.43	87.39	87.37	87.34	87.32	87.30
1.15	97.13	88.33	87.90	87.78	87.73	87.70	87.68	87.66	87.61	87.58	87.55	87.53	87.51
1.16	100.00	88.67	88.17	88.03	87.97	87.93	87.90	87.88	87.82	87.79	87.76	87.74	87.72
1.17	100.00	89.00	88.44	88.28	88.21	88.16	88.13	88.10	88.04	88.00	87.97	87.94	87.92
1.18	100.00	89.33	88.71	88.53	88.44	88.39	88.35	88.32	88.25	88.21	88.18	88.15	88.12
1.19	100.00	89.67	88.98	88.77	88.67	88.61	88.57	88.54	88.46	88.42	88.38	88.35	88.32
1.20	100.00	90.00	89.24	89.01	88.90	88.83	88.79	88.76	88.66	88.62	88.58	88.54	88.52
1.21	100.00	90.33	89.50	89.25	89.13	89.06	89.00	88.97	88.87	88.82	88.78	88.74	88.71
1.22	100.00	90.67	89.77	89.49	89.35	89.27	89.22	89.18	89.07	89.02	88.97	88.93	88.91
1.23	100.00	91.00	90.03	89.72	89.58	89.49	89.43	89.39	89.27	89.22	89.16	89.12	89.09
1.24	100.00	91.33	90.28	89.96	89.80	89.70	89.64	89.59	89.47	89.41	89.36	89.31	89.28
1.25	100.00	91.67	90.54	90.19	90.02	89.91	89.85	89.79	89.66	89.60	89.54	89.50	89.47
1.26	100.00	92.00	90.79	90.42	90.23	90.12	90.05	90.00	89.85	89.79	89.73	89.68	89.65
1.27	100.00	92.33	91.04	90.64	90.45	90.33	90.25	90.19	90.04	89.98	89.91	89.87	89.83
1.28	100.00	92.67	91.29	90.87	90.66	90.53	90.45	90.39	90.23	90.16	90.10	90.05	90.01
1.29	100.00	93.00	91.54	91.09	90.87	90.74	90.65	90.58	90.42	90.34	90.28	90.22	90.18
1.30	100.00	93.33	91.79	91.31	91.07	90.94	90.84	90.78	90.60	90.52	90.45	90.40	90.36
1.31	100.00	93.67	92.03	91.52	91.28	91.13	91.04	90.97	90.78	90.70	90.63	90.57	90.53
1.32	100.00	94.00	92.27	91.74	91.48	91.33	91.23	91.15	90.96	90.88	90.80	90.74	90.70
1.33	100.00	94.33	92.51	91.95	91.68	91.52	91.41	91.34	91.14	91.05	90.97	90.91	90.87
1.34	100.00	94.67	92.75	92.16	91.88	91.71	91.60	91.52	91.31	91.22	91.14	91.08	91.03

Table 2 for Estimation of Lot Percent Within Limits
Variability Unknown Procedure
Standard Deviation Method

Quality Index Q_U or Q_L	Percent Within Limits for Selected Sample Sizes												
	N=3	N=4	N=5	N=6	N=7	N=8	N=9	N=10	N=15	N=20	N=30	N=50	N=100
1.35	100.00	95.00	92.98	92.37	92.08	91.90	91.78	91.70	91.48	91.39	91.31	91.24	91.19
1.36	100.00	95.33	93.21	92.58	92.27	92.09	91.96	91.88	91.65	91.56	91.47	91.40	91.35
1.37	100.00	95.67	93.44	92.78	92.46	92.27	92.14	92.05	91.82	91.72	91.63	91.56	91.51
1.38	100.00	96.00	93.67	92.98	92.65	92.45	92.32	92.23	91.99	91.88	91.79	91.72	91.67
1.39	100.00	96.33	93.90	93.18	92.83	92.63	92.49	92.40	92.15	92.04	91.95	91.88	91.82
1.40	100.00	96.67	94.12	93.37	93.02	92.81	92.67	92.56	92.31	92.20	92.10	92.03	91.98
1.41	100.00	97.00	94.34	93.57	93.20	92.98	92.83	92.73	92.47	92.36	92.26	92.18	92.13
1.42	100.00	97.33	94.56	93.76	93.38	93.15	93.00	92.90	92.63	92.51	92.41	92.33	92.27
1.43	100.00	97.67	94.77	93.95	93.55	93.32	93.17	93.06	92.78	92.66	92.56	92.48	92.42
1.44	100.00	98.00	94.98	94.13	93.73	93.49	93.33	93.22	92.93	92.81	92.70	92.62	92.56
1.45	100.00	98.33	95.19	94.32	93.90	93.65	93.49	93.37	93.08	92.96	92.85	92.76	92.70
1.46	100.00	98.67	95.40	94.50	94.07	93.81	93.65	93.53	93.23	93.10	92.99	92.90	92.84
1.47	100.00	99.00	95.61	94.67	94.23	93.97	93.80	93.68	93.37	93.25	93.13	93.04	92.98
1.48	100.00	99.33	95.81	94.85	94.40	94.13	93.96	93.83	93.52	93.39	93.27	93.18	93.12
1.49	100.00	99.67	96.01	95.02	94.56	94.29	94.11	93.98	93.66	93.52	93.40	93.31	93.25
1.50	100.00	100.00	96.20	95.19	94.72	94.44	94.26	94.13	93.80	93.66	93.54	93.45	93.38
1.51	100.00	100.00	96.39	95.36	94.87	94.59	94.40	94.27	93.94	93.80	93.67	93.58	93.51
1.52	100.00	100.00	96.58	95.53	95.03	94.74	94.55	94.41	94.07	93.93	93.80	93.71	93.64
1.53	100.00	100.00	96.77	95.69	95.18	94.88	94.69	94.55	94.20	94.06	93.93	93.83	93.76
1.54	100.00	100.00	96.95	95.85	95.33	95.03	94.83	94.69	94.33	94.19	94.05	93.96	93.89
1.55	100.00	100.00	97.13	96.00	95.48	95.17	94.97	94.82	94.46	94.31	94.18	94.08	94.01
1.56	100.00	100.00	97.31	96.16	95.62	95.31	95.10	94.95	94.59	94.44	94.30	94.20	94.13
1.57	100.00	100.00	97.48	96.31	95.76	95.44	95.23	95.08	94.71	94.56	94.42	94.32	94.25
1.58	100.00	100.00	97.65	96.46	95.90	95.58	95.36	95.21	94.84	94.68	94.54	94.44	94.36
1.59	100.00	100.00	97.81	96.60	96.04	95.71	95.49	95.34	94.96	94.80	94.66	94.55	94.48
1.60	100.00	100.00	97.97	96.75	96.17	95.84	95.62	95.46	95.08	94.92	94.77	94.67	94.59
1.61	100.00	100.00	98.13	96.89	96.31	95.97	95.74	95.59	95.19	95.03	94.88	94.78	94.70
1.62	100.00	100.00	98.28	97.03	96.43	96.09	95.86	95.70	95.31	95.14	94.99	94.89	94.81
1.63	100.00	100.00	98.43	97.16	96.56	96.21	95.98	95.82	95.42	95.25	95.10	94.99	94.92
1.64	100.00	100.00	98.58	97.29	96.69	96.33	96.10	95.94	95.53	95.36	95.21	95.10	95.02
1.65	100.00	100.00	98.72	97.42	96.81	96.45	96.22	96.05	95.64	95.47	95.32	95.21	95.13
1.66	100.00	100.00	98.85	97.55	96.93	96.57	96.33	96.16	95.75	95.57	95.42	95.31	95.23
1.67	100.00	100.00	98.98	97.67	97.05	96.68	96.44	96.27	95.85	95.68	95.52	95.41	95.33
1.68	100.00	100.00	99.11	97.79	97.16	96.79	96.55	96.38	95.95	95.78	95.62	95.51	95.43
1.69	100.00	100.00	99.23	97.91	97.27	96.90	96.66	96.48	96.06	95.88	95.72	95.61	95.53
1.70	100.00	100.00	99.34	98.02	97.38	97.01	96.76	96.59	96.16	95.98	95.82	95.70	95.62
1.71	100.00	100.00	99.45	98.13	97.49	97.11	96.86	96.69	96.25	96.07	95.91	95.80	95.71
1.72	100.00	100.00	99.55	98.24	97.59	97.21	96.97	96.79	96.35	96.17	96.01	95.89	95.81
1.73	100.00	100.00	99.64	98.34	97.70	97.31	97.06	96.89	96.44	96.26	96.10	95.98	95.90
1.74	100.00	100.00	99.73	98.45	97.80	97.41	97.16	96.98	96.54	96.35	96.19	96.07	95.99
1.75	100.00	100.00	99.81	98.55	97.89	97.51	97.25	97.07	96.63	96.44	96.28	96.16	96.07
1.76	100.00	100.00	99.88	98.64	97.99	97.60	97.35	97.17	96.72	96.53	96.37	96.24	96.16
1.77	100.00	100.00	99.94	98.73	98.08	97.69	97.44	97.26	96.80	96.62	96.45	96.33	96.24
1.78	100.00	100.00	99.98	98.82	98.17	97.78	97.53	97.34	96.89	96.70	96.53	96.41	96.33
1.79	100.00	100.00	100.00	98.91	98.26	97.87	97.61	97.43	96.97	96.79	96.62	96.49	96.41

Table 2 for Estimation of Lot Percent Within Limits
Variability Unknown Procedure
Standard Deviation Method

Quality Index Q_U or Q_L	Percent Within Limits for Selected Sample Sizes											
	N=3	N=4	N=5	N=6	N=7	N=8	N=9	N=10	N=15	N=20	N=30	N=50	N=100
1.80	100.00	100.00	100.00	98.99	98.35	97.96	97.70	97.51	97.06	96.87	96.70	96.57	96.49
1.81	100.00	100.00	100.00	99.07	98.43	98.04	97.78	97.60	97.14	96.95	96.78	96.65	96.57
1.82	100.00	100.00	100.00	99.15	98.51	98.12	97.86	97.68	97.21	97.02	96.85	96.73	96.64
1.83	100.00	100.00	100.00	99.22	98.59	98.20	97.94	97.75	97.29	97.10	96.93	96.81	96.72
1.84	100.00	100.00	100.00	99.29	98.66	98.28	98.02	97.83	97.37	97.18	97.01	96.88	96.79
1.85	100.00	100.00	100.00	99.36	98.74	98.35	98.09	97.91	97.44	97.25	97.08	96.95	96.87
1.86	100.00	100.00	100.00	99.43	98.81	98.42	98.16	97.98	97.52	97.32	97.15	97.03	96.94
1.87	100.00	100.00	100.00	99.49	98.88	98.49	98.24	98.05	97.59	97.39	97.22	97.10	97.01
1.88	100.00	100.00	100.00	99.54	98.94	98.56	98.30	98.12	97.66	97.46	97.29	97.17	97.08
1.89	100.00	100.00	100.00	99.60	99.01	98.63	98.37	98.19	97.72	97.53	97.36	97.23	97.15
1.90	100.00	100.00	100.00	99.65	99.07	98.69	98.44	98.25	97.79	97.60	97.43	97.30	97.21
1.91	100.00	100.00	100.00	99.70	99.13	98.76	98.50	98.32	97.86	97.66	97.49	97.37	97.28
1.92	100.00	100.00	100.00	99.74	99.19	98.82	98.56	98.38	97.92	97.73	97.55	97.43	97.34
1.93	100.00	100.00	100.00	99.78	99.24	98.88	98.63	98.44	97.98	97.79	97.62	97.49	97.40
1.94	100.00	100.00	100.00	99.82	99.30	98.93	98.68	98.50	98.04	97.85	97.68	97.55	97.46
1.95	100.00	100.00	100.00	99.85	99.35	98.99	98.74	98.56	98.10	97.91	97.74	97.61	97.52
1.96	100.00	100.00	100.00	99.88	99.40	99.04	98.80	98.62	98.16	97.97	97.80	97.67	97.58
1.97	100.00	100.00	100.00	99.91	99.44	99.09	98.85	98.67	98.22	98.03	97.86	97.73	97.64
1.98	100.00	100.00	100.00	99.93	99.49	99.14	98.90	98.73	98.27	98.08	97.91	97.79	97.70
1.99	100.00	100.00	100.00	99.95	99.53	99.19	98.95	98.78	98.33	98.14	97.97	97.84	97.75
2.00	100.00	100.00	100.00	99.97	99.57	99.24	99.00	98.83	98.38	98.19	98.02	97.90	97.81
2.01	100.00	100.00	100.00	99.98	99.61	99.28	99.05	98.88	98.43	98.24	98.07	97.95	97.86
2.02	100.00	100.00	100.00	99.99	99.64	99.33	99.10	98.93	98.48	98.29	98.13	98.00	97.91
2.03	100.00	100.00	100.00	100.00	99.68	99.37	99.14	98.97	98.53	98.34	98.18	98.05	97.96
2.04	100.00	100.00	100.00	100.00	99.71	99.41	99.18	99.02	98.58	98.39	98.23	98.10	98.01
2.05	100.00	100.00	100.00	100.00	99.74	99.45	99.23	99.06	98.63	98.44	98.27	98.15	98.06
2.06	100.00	100.00	100.00	100.00	99.77	99.48	99.27	99.10	98.67	98.49	98.32	98.20	98.11
2.07	100.00	100.00	100.00	100.00	99.79	99.52	99.30	99.14	98.72	98.53	98.37	98.24	98.16
2.08	100.00	100.00	100.00	100.00	99.82	99.55	99.34	99.18	98.76	98.58	98.41	98.29	98.21
2.09	100.00	100.00	100.00	100.00	99.84	99.58	99.38	99.22	98.80	98.62	98.46	98.34	98.25
2.10	100.00	100.00	100.00	100.00	99.86	99.61	99.41	99.26	98.84	98.66	98.50	98.38	98.29
2.11	100.00	100.00	100.00	100.00	99.88	99.64	99.45	99.29	98.88	98.70	98.54	98.42	98.34
2.12	100.00	100.00	100.00	100.00	99.90	99.67	99.48	99.33	98.92	98.74	98.58	98.46	98.38
2.13	100.00	100.00	100.00	100.00	99.92	99.70	99.51	99.36	98.96	98.78	98.62	98.50	98.42
2.14	100.00	100.00	100.00	100.00	99.93	99.72	99.54	99.39	99.00	98.82	98.66	98.54	98.46
2.15	100.00	100.00	100.00	100.00	99.94	99.74	99.57	99.42	99.03	98.86	98.70	98.58	98.50
2.16	100.00	100.00	100.00	100.00	99.95	99.77	99.59	99.45	99.07	98.90	98.74	98.62	98.54
2.17	100.00	100.00	100.00	100.00	99.96	99.79	99.62	99.48	99.10	98.93	98.78	98.66	98.58
2.18	100.00	100.00	100.00	100.00	99.97	99.81	99.64	99.51	99.13	98.97	98.81	98.70	98.61
2.19	100.00	100.00	100.00	100.00	99.98	99.83	99.67	99.54	99.17	99.00	98.85	98.73	98.65
2.20	100.00	100.00	100.00	100.00	99.99	99.84	99.69	99.56	99.20	99.03	98.88	98.77	98.69
2.21	100.00	100.00	100.00	100.00	99.99	99.86	99.71	99.59	99.23	99.06	98.91	98.80	98.72
2.22	100.00	100.00	100.00	100.00	99.99	99.87	99.73	99.61	99.26	99.10	98.95	98.83	98.75
2.23	100.00	100.00	100.00	100.00	100.00	99.89	99.75	99.63	99.29	99.13	98.98	98.87	98.79
2.24	100.00	100.00	100.00	100.00	100.00	99.90	99.77	99.66	99.31	99.15	99.01	98.90	98.82

Table 2 for Estimation of Lot Percent Within Limits
Variability Unknown Procedure
Standard Deviation Method

Quality Index Q_U or Q_L	Percent Within Limits for Selected Sample Sizes												
	N=3	N=4	N=5	N=6	N=7	N=8	N=9	N=10	N=15	N=20	N=30	N=50	N=100
2.25	100.00	100.00	100.00	100.00	100.00	99.91	99.79	99.68	99.34	99.18	99.04	98.93	98.85
2.26	100.00	100.00	100.00	100.00	100.00	99.92	99.80	99.70	99.37	99.21	99.07	98.96	98.88
2.27	100.00	100.00	100.00	100.00	100.00	99.93	99.82	99.71	99.39	99.24	99.10	98.99	98.91
2.28	100.00	100.00	100.00	100.00	100.00	99.94	99.83	99.73	99.42	99.26	99.12	99.02	98.94
2.29	100.00	100.00	100.00	100.00	100.00	99.95	99.85	99.75	99.44	99.29	99.15	99.05	98.97
2.30	100.00	100.00	100.00	100.00	100.00	99.96	99.86	99.77	99.46	99.32	99.18	99.07	99.00
2.31	100.00	100.00	100.00	100.00	100.00	99.96	99.87	99.78	99.48	99.34	99.20	99.10	99.03
2.32	100.00	100.00	100.00	100.00	100.00	99.97	99.89	99.80	99.51	99.36	99.23	99.13	99.05
2.33	100.00	100.00	100.00	100.00	100.00	99.98	99.90	99.81	99.53	99.39	99.25	99.15	99.08
2.34	100.00	100.00	100.00	100.00	100.00	99.98	99.91	99.82	99.55	99.41	99.28	99.18	99.10
2.35	100.00	100.00	100.00	100.00	100.00	99.98	99.92	99.84	99.57	99.43	99.30	99.20	99.13
2.36	100.00	100.00	100.00	100.00	100.00	99.99	99.92	99.85	99.58	99.45	99.32	99.22	99.15
2.37	100.00	100.00	100.00	100.00	100.00	99.99	99.93	99.86	99.60	99.47	99.34	99.25	99.18
2.38	100.00	100.00	100.00	100.00	100.00	99.99	99.94	99.87	99.62	99.49	99.37	99.27	99.20
2.39	100.00	100.00	100.00	100.00	100.00	100.00	99.95	99.88	99.64	99.51	99.39	99.29	99.22
2.40	100.00	100.00	100.00	100.00	100.00	100.00	99.95	99.89	99.65	99.53	99.41	99.31	99.25
2.41	100.00	100.00	100.00	100.00	100.00	100.00	99.96	99.90	99.67	99.55	99.43	99.33	99.27
2.42	100.00	100.00	100.00	100.00	100.00	100.00	99.96	99.91	99.68	99.56	99.44	99.35	99.29
2.43	100.00	100.00	100.00	100.00	100.00	100.00	99.97	99.92	99.70	99.58	99.46	99.37	99.31
2.44	100.00	100.00	100.00	100.00	100.00	100.00	99.97	99.92	99.71	99.60	99.48	99.39	99.33
2.45	100.00	100.00	100.00	100.00	100.00	100.00	99.98	99.93	99.73	99.61	99.50	99.41	99.35
2.46	100.00	100.00	100.00	100.00	100.00	100.00	99.98	99.94	99.74	99.63	99.52	99.43	99.37
2.47	100.00	100.00	100.00	100.00	100.00	100.00	99.98	99.94	99.75	99.64	99.53	99.45	99.38
2.48	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.95	99.76	99.66	99.55	99.46	99.40
2.49	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.95	99.77	99.67	99.56	99.48	99.42
2.50	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.96	99.79	99.68	99.58	99.50	99.44
2.51	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.96	99.80	99.70	99.59	99.51	99.45
2.52	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.97	99.81	99.71	99.61	99.53	99.47
2.53	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.97	99.82	99.72	99.62	99.54	99.49
2.54	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.97	99.83	99.73	99.63	99.56	99.50
2.55	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.98	99.83	99.74	99.65	99.57	99.52
2.56	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.98	99.84	99.75	99.66	99.59	99.53
2.57	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.98	99.85	99.76	99.67	99.60	99.54
2.58	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.86	99.77	99.68	99.61	99.56
2.59	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.87	99.78	99.70	99.62	99.57
2.60	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.87	99.79	99.71	99.64	99.59
2.61	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.88	99.80	99.72	99.65	99.60
2.62	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.89	99.81	99.73	99.66	99.61
2.63	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.89	99.82	99.74	99.67	99.62
2.64	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.90	99.83	99.75	99.68	99.63
2.65	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.91	99.84	99.76	99.69	99.65
2.66	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.91	99.84	99.77	99.70	99.66
2.67	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.92	99.85	99.78	99.71	99.67
2.68	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.92	99.86	99.78	99.72	99.68
2.69	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.93	99.86	99.79	99.73	99.69

Table 2 for Estimation of Lot Percent Within Limits
Variability Unknown Procedure
Standard Deviation Method

Quality Index Q_U or Q_L	Percent Within Limits for Selected Sample Sizes												
	N=3	N=4	N=5	N=6	N=7	N=8	N=9	N=10	N=15	N=20	N=30	N=50	N=100
2.70	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.93	99.87	99.80	99.74	99.70
2.71	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.94	99.88	99.81	99.75	99.71
2.72	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.94	99.88	99.82	99.76	99.72
2.73	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.94	99.89	99.82	99.77	99.73
2.74	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.95	99.89	99.83	99.78	99.73
2.75	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.95	99.90	99.84	99.78	99.74
2.76	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.95	99.90	99.84	99.79	99.75
2.77	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.96	99.91	99.85	99.80	99.76
2.78	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.96	99.91	99.86	99.81	99.77
2.79	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.96	99.92	99.86	99.81	99.77
2.80	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.97	99.92	99.87	99.82	99.78
2.81	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.97	99.93	99.87	99.83	99.79
2.82	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.97	99.93	99.88	99.83	99.80
2.83	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.97	99.93	99.88	99.84	99.80
2.84	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.97	99.94	99.89	99.84	99.81
2.85	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.98	99.94	99.89	99.85	99.82
2.86	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.98	99.94	99.90	99.86	99.82
2.87	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.98	99.95	99.90	99.86	99.83
2.88	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.98	99.95	99.91	99.87	99.83
2.89	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.98	99.95	99.91	99.87	99.84
2.90	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.98	99.95	99.91	99.88	99.84
2.91	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.96	99.92	99.88	99.85
2.92	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.96	99.92	99.88	99.86
2.93	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.96	99.92	99.89	99.86
2.94	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.96	99.93	99.89	99.87
2.95	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.97	99.93	99.90	99.87
2.96	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.97	99.93	99.90	99.87
2.97	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.97	99.94	99.90	99.88
2.98	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.97	99.94	99.91	99.88
2.99	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.97	99.94	99.91	99.89
3.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.97	99.95	99.92	99.89
3.01	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.98	99.95	99.92	99.89
3.02	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.98	99.95	99.92	99.90
3.03	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.98	99.95	99.93	99.90
3.04	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.98	99.95	99.93	99.91
3.05	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.98	99.96	99.93	99.91
3.06	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.98	99.96	99.93	99.91
3.07	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.98	99.96	99.94	99.92
3.08	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.96	99.94	99.92
3.09	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.96	99.94	99.92
3.10	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.97	99.94	99.92
3.11	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.97	99.95	99.93
3.12	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.97	99.95	99.93
3.13	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.97	99.95	99.93
3.14	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.97	99.95	99.93

Table 2 for Estimation of Lot Percent Within Limits
Variability Unknown Procedure
Standard Deviation Method

Quality Index Q_U or Q_L	Percent Within Limits for Selected Sample Sizes												
	N=3	N=4	N=5	N=6	N=7	N=8	N=9	N=10	N=15	N=20	N=30	N=50	N=100
3.15	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.97	99.95	99.94
3.16	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.98	99.96	99.94
3.17	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.98	99.96	99.94
3.18	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.98	99.96	99.94
3.19	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.98	99.96	99.95
3.20	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.98	99.96	99.95
3.21	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.98	99.96	99.95
3.22	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.98	99.97	99.95
3.23	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.98	99.97	99.95
3.24	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.98	99.97	99.96
3.25	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.98	99.97	99.96
3.26	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.97	99.96
3.27	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.97	99.96
3.28	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.97	99.96
3.29	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.98	99.96
3.30	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.98	99.96
3.31	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.98	99.97
3.32	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.98	99.97
3.33	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.98	99.97
3.34	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.98	99.97
3.35	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.98	99.97
3.36	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.98	99.97
3.37	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.98	99.97
3.38	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.98	99.97
3.39	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.98	99.98
3.40	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.99	99.98
3.41	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.99	99.98
3.42	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.99	99.98
3.43	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.99	99.98
3.44	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.99	99.98
3.45	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.98
3.46	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.98
3.47	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.98
3.48	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.98
3.49	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.98
3.50	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.98
3.51	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.99
3.52	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.99
3.53	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.99
3.54	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.99
3.55	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.99
3.56	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.99
3.57	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.99
3.58	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.99
3.59	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.99

Table 2 for Estimation of Lot Percent Within Limits
Variability Unknown Procedure
Standard Deviation Method

Quality Index Q_U or Q_L	Percent Within Limits for Selected Sample Sizes												
	N=3	N=4	N=5	N=6	N=7	N=8	N=9	N=10	N=15	N=20	N=30	N=50	N=100
3.60	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.99
3.61	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.99
3.62	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
3.63	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
3.64	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
3.65	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
3.66	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
3.67	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
3.68	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
3.69	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
3.70	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
3.71	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
3.72	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
3.73	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
3.74	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
3.75	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
3.76	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

The estimates of lot percent within limits (PWL) provided in the tables are obtained by numerically integrating the beta distribution function corresponding to Quality Index (Q) and Sample Size (N).

To find PWL from the tables, compute Q from the sample mean and sample standard deviation with unknown population variability, and the lower or upper specification limits.

To find the PWL for a negative Quality Index, first get the PWL for the positive value of the Quality Index from the tables and subtract the result from 100.

5.8.3. SEGREGATION CHECK USING THE NUCLEAR DENSITY GAUGE

1. OBJECTIVE

The objective of these instructions is to give guidance on establishing a density profile behind the laydown machine. This is accomplished by taking multiple readings within a 50 foot (15 m) section. Use the nuclear density gauge results to plot a density profile. Check the profile for a drop in density caused by segregation. Check the roadway profile location for visible segregation. It is important to record the profile location to permit possible future evaluation of the segregated section. It is intended that English projects use English values and that metric projects use metric values.

2. PROJECT STARTUP

NOTE: Check gauge to verify it is in asphalt mode.

At the start of the project, allow the paving unit 1000 ft (300 m) progress with each mix designation before implementing a profile analysis.

3. SELECTION OF PROFILE LOCATIONS

It is intended that visibility identifiable segregated areas be profiled. Two basic types of segregation are encountered on the roadway. They are truck load segregation and longitudinal segregation.

- Truck load segregation (spot, chevron, or gull wing type segregation) has a visible pattern repeated with each truck load. These segregated areas are about the same longitudinal distance apart. This type of segregation will normally occur 10 to 25 ft (3 to 7.5 m) from the screed stop point when trucks dump directly into the paver. The use of a material transfer vehicle (MTV) has been known to extend this further down the paving section.

- Longitudinal segregation (streaking) is normally caused by the paver. This streaking is parallel to the centerline of the project, and may occur continually, or may periodically start and stop.

If the laydown machine continues to progress without stops, then the engineer will establish profile starting points.

If the laydown machine periodically stops, then use the location where the screed stops as the “zero” point for the profile starting point. The Engineer should use caution on whether to run a profile if the laydown machine has been stopped for more that 10 minutes, due to cooling of the mix.

4. LOCATION OF DENSITY READINGS

Take readings approximately every 5 ft (1.5 m) along the longitudinal direction. The first reading should be located approximately 10 ft (3 m) behind the screed (zero point). If a segregated location is visible between two locations, then take an additional reading at that location.

- When checking for truck load segregation, the longitudinal distance from centerline may vary, but not the transverse distance (see **Figure 1**).

- When checking for longitudinal streaking, the longitudinal distance from centerline will vary.

This is done so the profile will cross over the longitudinal streaks. Determine the transverse distance from centerline to the longitudinal segregation. Start the profile approximately 2 ft (0.6 m) farther transversely than the center of the longitudinal streak. End the profile approximately 2 ft (0.6 m) less transversely than the center of the longitudinal streak. The approximate distance (2 ft or 0.6 m) from the center of the streak to start and end the profile will be determined by the Engineer (see **Figure 1**). Pick a distance from either edge of which you believe will be most likely to detect segregation. That distance shall be more than 2 ft (0.6 m) from either edge of placement. Only one distance is to be used throughout the length of a single profile section for truck load segregation. When testing for longitudinal segregation, each end of the profile will be more than 1 ft (0.3 m) from the edge of paving. If there is no visible segregation, then randomly select the location for the profile section.

5. NUCLEAR GAUGE READINGS

Minus No. 30 (600 µm) aggregate from the mix will be used to fill any voids in the surface. Smooth and level the minus No. 30 (600 µm) material with a metal plate or straight edge. The aggregate is not to be used as a thin film between the hot mix and the gauge. Use only enough aggregate to fill the voids. (For this procedure, the aggregate shall be minus No. 30 (600 µm) material from the mix with no more than 20% passing the No. 100 (150 µm) sieve.

NOTE: For uniformity, position the source rod so it is closest to the laydown machine (point the gauge towards the roller).

In backscatter mode, take 3 one-minute readings and average. If one of the readings varies by more than 1 lb/ft^3 (16 kg/m^3) of the average, then discard and take an additional reading to replace it. It is not necessary for the gauge to be calibrated to the mix.
Take a minimum of ten locations along the profile section. It is not necessary to maintain a rigid longitudinal spacing of 5 ft (1.5 m) as stated above. Remember to take additional readings if a segregated location is encountered along the profile.

NOTE: Check tip of source rod to assure it is free of any foreign substance (i.e. grease, asphalt, concrete, etc.).

6. PROFILE EVALUATION

Initially perform four segregation checks for each mix. When four consecutive profile evaluations meet the acceptable criteria established in the Contract Documents, the District Materials Engineer may reduce the segregation checks to a frequency deemed appropriate.

The contractor field representative will be provided results of the segregation checks as they are completed. When one of the segregation checks fails the acceptable criteria established in the Contract Documents, the contractor will be allowed to make changes to the mix, plant, or roadway operations before the next profile evaluation is made. If any changes are to be made by the contractor, these changes are to be made within the first hour of production following notification of a failing evaluation. Production of the hot mix is to cease whenever two consecutive checks fail. The contractor will make changes to the mix or process before production is restarted. The contractor may produce enough mix to place approximately 2000 ft (600 m) of pavement one paver width wide. Two segregation checks will be taken within this 2000 ft (600 m) of production. If both segregation checks meet acceptable criteria, the contractor may resume normal production. If one or both of the segregation checks fail, the contractor will make changes before production is restarted. The contractor may then produce enough mix for an additional 2000 ft (600 m) of pavement and this production will be evaluated as was the previous 2000 ft (600 m) of production. This procedure of placing and evaluating 2000 ft (600 m) sections will be continued until both segregation checks pass. Normal production and segregation checks will resume when both evaluations pass.

The drop in density caused by segregation will be calculated by subtracting the lowest density obtained from the average profile density. The average profile density shall be calculated using all density determinations in the profile section. The density range will be calculated by subtracting the lowest from the highest profile density.

7. SEGREGATION CHECK FORM

The **SEGREGATION CHECK USING THE NUCLEAR GAUGE** form provides the user a means of recording key information to pinpoint the location of the profile section. It also provides a chart for graphing the average recorded nuclear density readings.

Note: the screed location is referred to as the zero point. When the paver is stopped, rollers are prevented from compacting all of the asphalt material that has been laid down. A portion of material has the chance to cool before being compacted. Recording the densities behind the screed provides the gauge operator a complete profile of possible low density locations.

On the right side of the chart is a location to place a different scale in case the left side does not fall in the density region of the material being profiled. If this side is used, cross out values on the left side to help eliminate any confusion.

8. DENSITY GAUGES AND TEMPERATURE

It is recommended to allow the compacted surface to cool for as long as possible prior to using the density gauge. Remove the gauge from the surface immediately after the readings have been taken.

Although the density gauge is designed for high surface temperatures [350°F (175°C)], the ambient temperature inside the gauge is not to exceed 160°F (70°C). If the gauge remains on the surface for any length of time, the surface temperature becomes the ambient temperature inside the gauge. This occurs when the surface temperature penetrates up into the electronics. The electronics can experience temporary malfunction or permanent damage due to excessive heat.

SEGREGATION CHECK USING THE NUCLEAR DENSITY GAUGE

rev 08/12/96

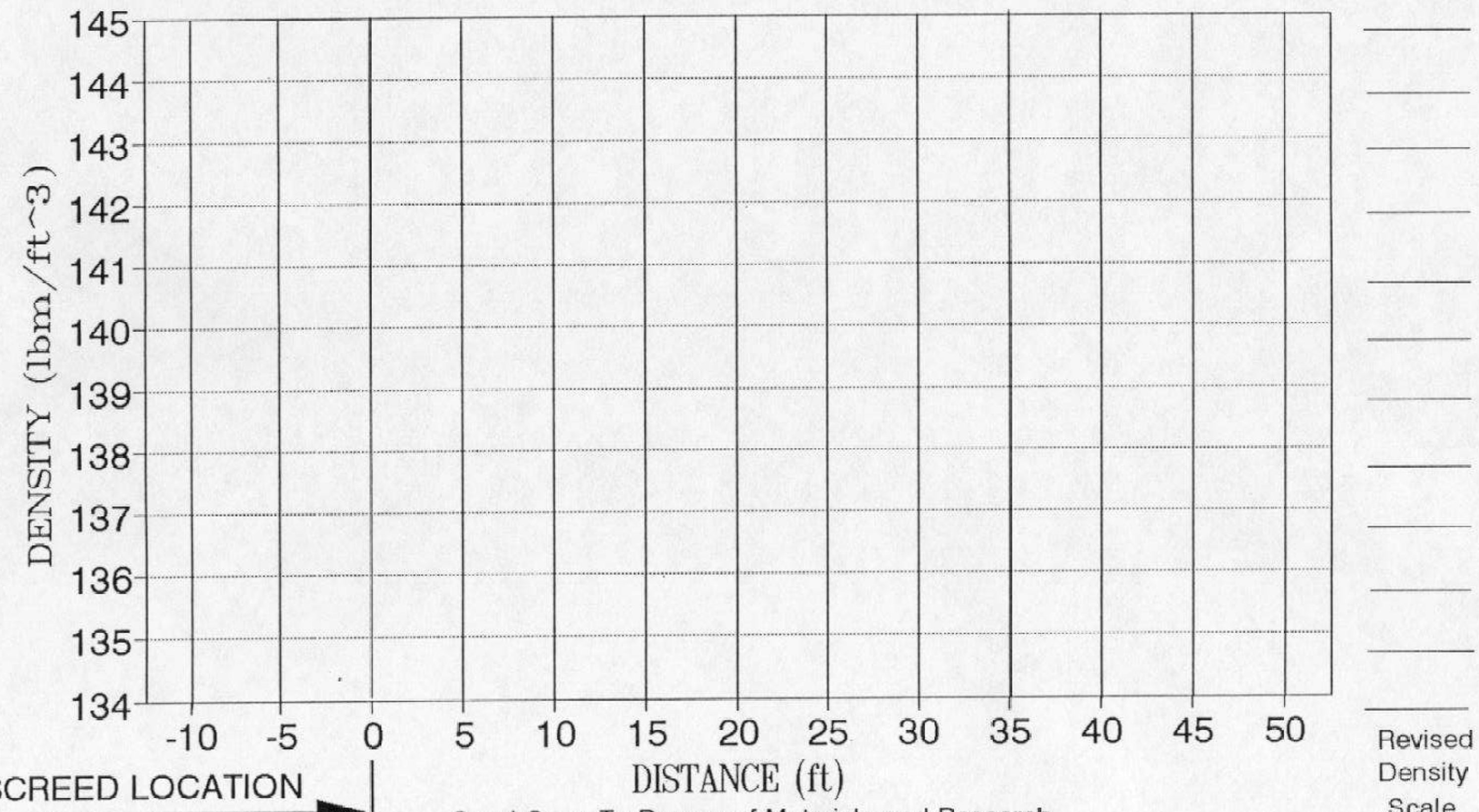
Project No. ____ Mix Type ____ O/L Thickness ____ Profile No. ____ Dist. ____

Profile Station No. ____ Profile Lift No. ____ Visible Segregation (Yes/No) ____

Date ____ Gauge Serial No. ____ Profile Distance From CL ____

Operator ____ Contractor ____ Brand and Model of Paver ____

Remix Equipment (In or Ahead of Paver): None, Auger Paver, Shuttle Buggy, Pick Up Device, Material Transfer Device, Other________



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SEGREGATION CHECK USING THE NUCLEAR DENSITY GAUGE

Rev 08/12/96

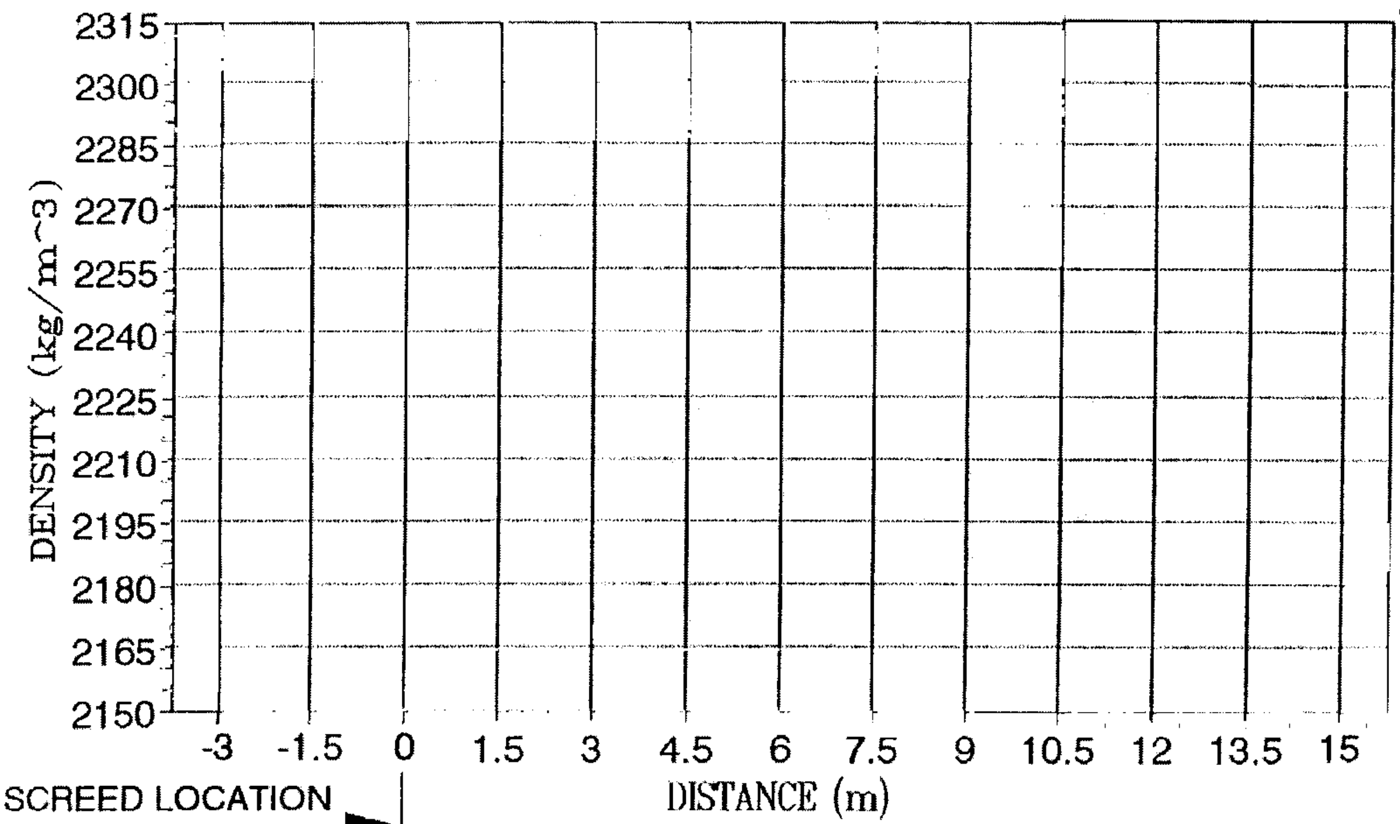
Project No. Mix Type O/L Thickness Profile No. Dist.

Profile Station No. Profile Lift No. Visible Segregation (Yes/No)

Date Gauge Serial No. Profile Distance From CL

Operator Contractor Brand and Model of Paver

Remix Equipment (In or Ahead of Paver): None, Auger Paver, Shuttle Buggy, Pick Up Device, Material Transfer Device, Other



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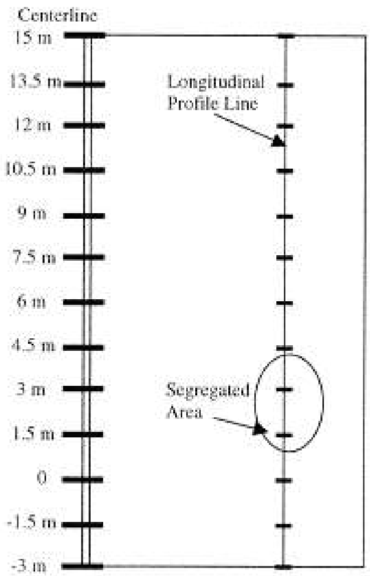
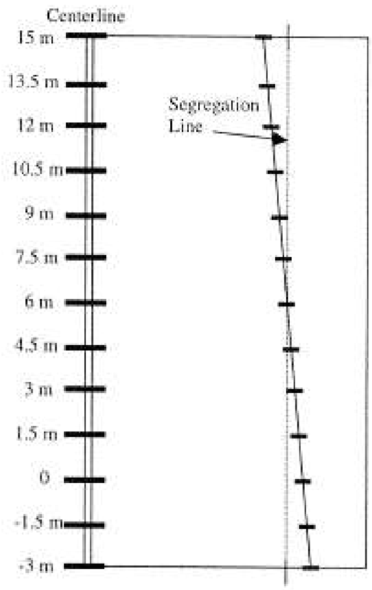
Revised Density Scale

FIGURE 1: SEGREGATION PROFILE LOCATION



Truck Load Segregation
(Spot, Chevron, Gullwing)



Longitudinal Segregation
(Streaking)

SEGREGATION CHECK POINTS

STOCKPILES

- Avoid HIGH DRY CONES of coarse material. They guarantee segregation, it's just a question of how much..
- Low, flat piles or individual truck dumps are better.
- Visual inspection should detect stockpile segregation.

LOADING COLD BINS

- Some stockpile segregation can probably be corrected by the front end loader operation, but don't depend on it.
- The bins should be loaded evenly. Avoid the pile it high - run it dry syndrome. Cones and lop-sided loads will segregate just as they do in the stockpile.
- DO NOT allow material to slop over from one bin to the other.

COLD BIN OPERATION

- Bin openings should be high enough to prevent clogging. A large opening and a slow belt is the best combination.
- If one bin cannot properly handle the necessary material, you may have to split it into two bins.
- "Overworked" bins are prime sources of segregation.
- Gobs of wet material - for example: sand - should be smoothed out with a drag chain or other suitable means.

COLD FEED CONVEYORS

- Material coming off the end of a belt will segregate. The coarse material will be thrown out further than the fine.
- This is particularly obvious when one belt feeds another at an angle. Plates, baffles or other appropriate devices are necessary to prevent belt end segregation.
- Any segregation up to this point will show up on the cold feed belt going into the drum or dryer.
- Careful sampling at this point is very important - it can identify and/or isolate several potential sources of segregation.
- Remember, segregation can occur both along and across the belt. Proper sampling can detect either or both.

- Don't forget to look at the aggregate going off the belt into the drum or dryer. The coarse particles may be flying off by themselves. When you are recycling, there are two such points.

DRUM MIXER OR DRYER

- Don't expect the drum or the dryer to put segregated material back together again. They won't do it. In fact, they can be a source of segregation. Coarse material will pass through faster than the fine.
- Most drums are designed to operate at 1/2" to 3/4" drop per foot. The coarser the material, the flatter the slope should be. Don't overlook this item.
- Uncoated or partially coated material segregates worse than properly coated material. The location of the asphalt discharge in the drum is important. Moving the discharge point closer to the drum inlet may eliminate uncoated particles. Moving it too close can cause burning of the asphalt as evidenced by blue smoke.

HOT CONVEYORS (DRUM MIXER)

- The hot belt should be covered. Chilling the material on one side of the belt is a good way to promote segregation.
- Proper sampling of the material on the hot belt can determine whether segregation is occurring in the drum. (if you have previously determined that the material going into the drum is not segregated). Segregation can occur along or across the belt.

SLAT CONVEYOR (DRUM MIXER)

Slats should have enough capacity so material does not fall back down the conveyor after approximately the first 10 feet.
The output of the drum should deposit the material uniformly across the slats. Segregation has been observed across improperly loaded slats.

GOB HOPPER (DRUM MIXER)

Check this one carefully and often. Check the following points:

- The material should be directed into the hopper so it is spread out uniformly, not coned in the middle or stacked against the side.
- The hopper should be loaded as full as possible before the gates open.
- The gates should close before the hopper runs dry.
- The gates should open and close quickly enough to produce a "GOB", not a gentle trickle.

HOT BINS (BATCH PLANT)

- If the dry aggregate going into the bin, or bins, is not segregated, and the mix out of the pug mill is segregated, then whatever configuration of screens and bins you are using is segregating the material so badly that good pug mill operation can't remix it.
- If operating with only one bin, it should only be large enough to hold one batch at a time and it should be close to the middle of the pug mill.
- There is an optimum size batch for each pug mill - use it.
- Worn, missing or improperly adjusted blades should be replaced and/or adjusted.
- Mixing time should be adequate.

HOT CONVEYOR AND GOB HOPPER (BATCH PLANT)

Batch plants, drag slat conveyors and Gob Hoppers may be incompatible. Here is a scenario observed at a plant:

When a batch was augered across to the drag conveyor, the slats would grab more than they could handle and coarse aggregate would come rattling back down the chute in a steady stream. The last to go up was a slug of coarse material.

Meanwhile, the Gob Hopper was opening and closing on a cycle which had no relation to the batch cycle. Sometimes it would open when almost full, sometimes when in contained a few pebbles and sometimes the material flowed directly through the open gates.

The resulting mix was severely segregated.

Segregation was appreciably -reduced when trucks were loaded directly from the pug mill and the project was completed this way.

Because of the "stop and go"-mode of batch plants, drag conveyors should be capable of conveying without spilling back, and gob hopper cycles should be determined by weight instead of time.

SURGE BIN

- The bin should be plumb. There is evidence that tilted bins do segregate.
- The bin should never be operated "out of the cone". Gates must be locked when material draws down to the cone. Bypass of this lock is for cleanout only.
- One experiment showed that the height of the material in the surge bin has some influence on segregation.
- When the level of the bin was between one-half full and the top of the cone, segregation was less than when the level was between full and one-half full. The apparent reason was the longer drop of the "Gob" caused the material to splatter and distribute evenly across the bin instead of making a cone in the middle.
- The gates on the surge bin should open and close quickly.

LOADING TRUCKS

- This is a place where a little care may pay big dividends.
- AVOID SINGLE CONES - coarse material runs down the cone and collects along the sides and ends of the trucks.
- Every time you add material to a single cone, you add coarse material to the collection.
- Every one of those bits and dribbles added to "sneak up" on full load adds its bit to segregation.
- If you are serious about reducing segregation, instruct your scalesperson to keep those little bits to a minimum and don't let truck drivers load their trucks. They tend to push the button just because it's there.
- Multiple dumps are better than one large one. Use three dumps - front - back, then middle for tandems - about 3 ft. apart. It's not necessary, nor advisable, to overload the back axle. Longer trucks may require four or more dumps.
- Uncovered trucks may add to segregation.

TRUCKS TO LAYDOWN MACHINE

Here is probably the worst possible scenario:

A truck has just finished unloading. The coarse material which was in the front of the truck came out last and was moved back to the augers as the hopper was emptied. While that truck was unloading, the coarse material along the sides of the truck trickled out through the gap between the truck bed and the tailgate and came to rest on the hopper wings. As soon as the hopper was empty, the wings were dumped and the material moved back to the augers. The tailgate of the next truck is then opened and the bed slowly raised allowing the coarse material which is in the back of the truck to join the coarse material which was in the sides and front of the previous trucks.

The result of this phenomenon, which may occur at regularly spaced intervals, is usually visible, sometimes audible, and always detrimental.

Try the following:

- DO NOT empty the hopper after each load.
- Raise the truck bed before opening the tailgate and flood the hopper. Then, slack off and try to maintain an even flow out of the truck and through the laydown machine. Every time this flow is interrupted coarse particles trickle out onto the wings.
- Do not dump the wings into an empty hopper. If the wings are loaded with coarse material, NEVER dump them into the hopper.
- DO NOT empty the hopper after each load.

LAYDOWN MACHINE

- In the interest of reducing segregation and enhancing quality workmanship in general -AVOID THE "HURRY UP AND WAIT" SYNDROME
- The longer a laydown machine sits between loads the colder it and the material get. Cool material segregates worse than hot material.
- Augers running too fast will segregate coarse material.
- Maintain an even flow through the machine, don't over or under feed the augers run them as much as possible - 90 percent is a good goal. This requires the right combination of gate openings and limit switch settings.
- Check the paddles in the center of the screed for wear - they put the split material back together.
- Check the crown - It should be approximately 1/4" higher in front.
- Check for excess wear and looseness in adjusting screws.
- Check to see if the pull point on the screed is at the factory recommended height for the lift thickness.
- Check distance between screed and augers. Materials should feed down and not lay dormant.
- AND - don't segregate the centerline joint with rakes and lutes trying to correct for improper paver operation.

C & M 09-15-95
typographical corrections 09-03-98

5.8.4. JOINT DENSITY EVALUATION USING THE NUCLEAR DENSITY GAUGE

(For English projects use English units)
(For metric projects use SI units)

1. OBJECTIVE

The objective of these instructions is to give procedures for evaluating traveled way joint density. This is accomplished by taking two or three readings in the transverse direction one paver width wide. The traveled way joint density, either one or two locations, is subtracted from the interior density and the difference in density compared to the allowable limits. It is important to record the profile location to permit possible future evaluation of this location.

2. PROJECT STARTUP

NOTE: Check gauge to verify it is in asphalt mode.

At the start of the project, allow the paving unit 1000 ft (300 m) progress with each mix designation before implementing the joint density evaluation. During this initial 1000 ft (300 m) the contractor should be establishing laydown and compaction procedures and training personnel. The contractor should make preliminary nuclear gauge evaluations of their procedures.

3. SELECTION OF JOINT DENSITY EVALUATION LOCATIONS

A lot is defined as the distance paved with each mix designation per day. Determine the number of sublots from **Table 1**. Make each sublot approximately the same length. Randomly select one longitudinal location within each sublot.

Table 1. Determination of Number of Sublots Per Day

Distance Paved		Number of Sublot
English (ft)	Metric (m)	
0 - 500	0 - 150	0
501 - 1000	151 - 300	1
1001 - 2000	301 - 600	2
2001 - 3000	601 - 900	3
3001 - 4000	901 - 1200	4
4001 and greater	1201 - and greater	5

At each sublot longitudinal test location, determine the nuclear density on the traveled way at two or three transverse locations. (See **Figures 1 and 2**) Sublot joint density evaluation will be completed before compaction is completed in the third sublot. (Second sublot evaluated before fourth sublot compaction completed. Third sublot evaluated before fifth sublot completed.)

Figure 1

- Traveled way without hot mix shoulders or shoulders placed at the same time as the traveled way. Test two transverse locations. Test each lane as placed.

↓ Random Longitudinal Location ↓ Interior edge of mat

Θ 8" (0.2 m) from edge of mat

↑ 2' (0.6 m) from edge of mat

TRAVELED WAY

Direction of Travel →

■ Random Transverse Distance

↓ 2' (0.6 m) from edge of mat

(drawing not to scale) ↑ Exterior edge of mat

Test two or three locations as follows: (For three locations, see **Figure 2**)

1. Locate the random longitudinal location as described above in selection of Joint Density Evaluation Locations.

2. Θ Determine "joint density" with the source rod of the gauge 8" (0.2 m) off the mat edge that will become a longitudinal joint. Position the source rod so it is closest to the laydown machine (point the gauge towards the roller).

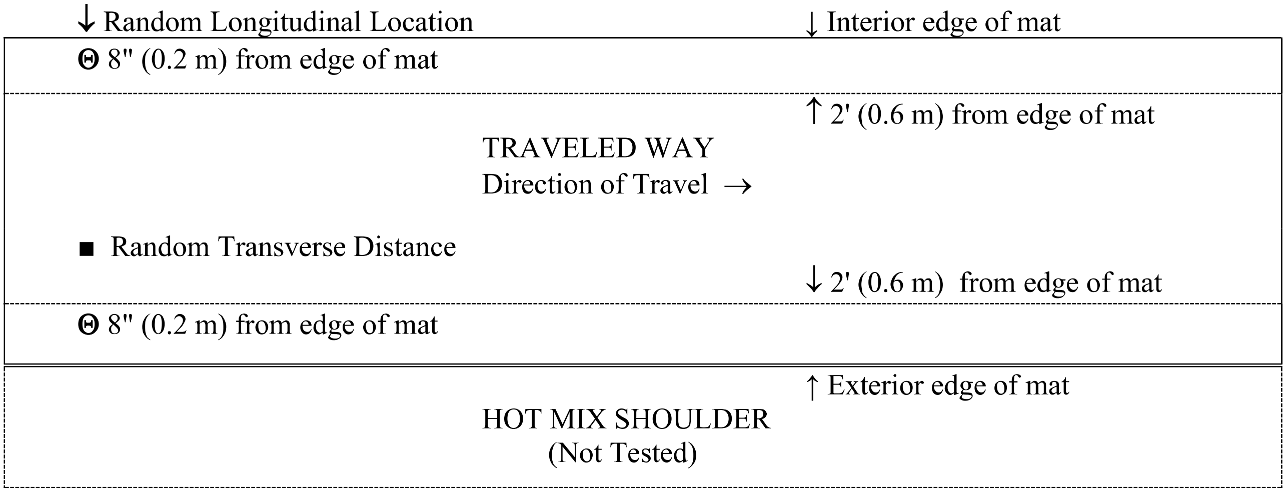
Note: Check tip of source rod to assure it is free of any foreign substance, (i.e. grease, asphalt, concrete, etc.).

3. ■ Randomly select a transverse location between 2' (0.6 m) for each edge of the mat. Determine "interior density." Position the source rod so it is closest to the laydown machine (point the gauge towards the roller).

Note: Check tip of source rod to assure it is free of any foreign substance, (i.e. grease, asphalt, concrete, etc.).

Figure 2

Traveled way with hot mix shoulder or shoulders not placed at the same time as the traveled way. Test three transverse locations as described above. Test each lane as placed.



(drawing not to scale)

4. NUCLEAR GAUGE READINGS

In backscatter mode, take 5 one- minute readings, record wet density values, discard the single highest and lowest values, average the three remaining values, and record the average value. It is necessary for the gauge to be calibrated to the mix.

NOTE: Check tip of source rod to assure it is free of any foreign substance, (i.e. grease, asphalt, concrete, etc.).

5. PROFILE EVALUATION

The contractor field representative will provide the Engineer results of the joint density evaluation as they are completed. Whenever the Engineer makes independent joint density verifications, the contractor will be supplied joint density evaluation results as they are completed. Whenever one of the evaluations fails the acceptable criteria established in **Division 600, Section 602 of the 2015 Standard Specifications for State Road and Bridge Construction**, the contractor will make changes to the mix, plant or roadway operations. Production of the hot mix is to cease whenever two consecutive checks by the contractor or by the Engineer fail. The contractor will make changes to the mix or process before production is restarted. The contractor may produce enough mix to place approximately 2000 ft (600 m) of pavement one paver width wide. Two joint density evaluations will be taken within this 2000 ft (600 m) of production. If both joint density evaluations meet acceptable criteria, the contractor may resume normal production. If one or both of the joint density evaluations fail, the contractor will make changes before production is restarted. The contractor may then produce enough mix for an additional 2000 ft (600 m) of pavement and this production will be evaluated as was the previous 2000 ft (600 m) of production. This procedure of placing and evaluating 2000 ft (600 m) sections will be continued until both joint density evaluations pass. Once the evaluation passes, normal production and joint density evaluations will resume.

Calculate the "drop in density" by subtracting the "joint density" from the "interior density." Compare drop in density to specification limits. (Note: whenever three tests are taken at one transverse location, each joint density evaluation must pass the specified limits to be considered a passing location.)

SAMPLING AND TESTING FREQUENCY CHART
CONTRACTOR QUALITY CONTROL TESTING

CONSTRUCTION OR MATERIAL TYPE 2015 Std. Spec. (SS 2015)	TESTS REQUIRED (RECORDED TO)	TEST METHOD	CODE	QUALITY CONTROL BY CONTRACTOR	CODE	VERIFICATION BY KDOT
DIVISION 300						
CEMENT TREATED BASE (CTB) Sec. 306 & 1105	Sieve Analysis of Aggregate (1%, 0.1% for No. 200 sieve, of mass)	KT-02	c h	1 per day.		1 per week.
	Moisture Tests (0.1 g or 0.01% of mass)	KT-11 or KT-41		4 per day per design.		1 per week.
	Density (0.1 lb/ft^3 or 0.1% of optimum density)	KT-37 or KT-20*		1 per day per design (* KT-20 option is only permitted in conjunction with a fluid mix.)		1 per project per design.
	Compressive Strength (1 psi)	KT-37		1 specimen per sublot		1 specimen per lot.
Completed Base	Field Density Tests (0.1 lb/ft^3 or 0.1% of optimum density)	KT-13 or KT-41		4 per day per design.		1 per week per design.
	Moisture Tests (0.1 g or 0.01% of mass)	KT-11 or KT-41		4 per day per design.		1 per week per design.
DIVISION 500						
PORTLAND CEMENT CONCRETE PAVEMENT Sec. 501 & 503	Sieve Analysis of Aggregate (1%, 0.1% for No. 200 sieve, of mass)	KT-02	c m	1 per 350 CY of concrete.		1 per project.
Individual Aggregates	Clay Lumps and Friable Particles in Aggregate (0.1 g or 0.01% of mass)	KT-07	c h			As required.

SAMPLING AND TESTING FREQUENCY CHART
CONTRACTOR QUALITY CONTROL TESTING

CONSTRUCTION OR MATERIAL TYPE 2015 Std. Spec. (SS 2015)	TESTS REQUIRED (RECORDED TO)	TEST METHOD	CODE	QUALITY CONTROL BY CONTRACTOR	CODE	VERIFICATION BY KDOT
DIVISION 500 (continued)						
PORTLAND CEMENT CONCRETE PAVEMENT Sec. 501 & 503 (continued) **Individual Aggregates (continued)**	Shale or Shale-Like Materials in Aggregate (0.1 g or 0.01% of mass)	KT-08	c h			As required.
	Sticks in Aggregate (0.01% of mass)	KT-35	c h			As required.
	Unit Weight – lightweight aggregates only (0.1 lb or 0.1% of mass)	KT-05	c k			As required.
	Moisture in Aggregate (0.1 g or 0.01% of mass)	KT-24	p	1 per 1/2 day.		1 per week.
	Coal	AASHTO T 113				As required.
	Organic Impurities	AASHTO T 21				As required.
Concrete	Mass per cubic foot (0.1 lb/ft^3)	KT-20	a	1 per 500 yd^3.		1 per day.
	Slump (0.25 in)	KT-21	a	1 per 500 yd^3.		1 per day.
	Temperature (1 °F)	KT-17	a	1 per 500 yd^3.		1 per day.

SAMPLING AND TESTING FREQUENCY CHART
CONTRACTOR QUALITY CONTROL TESTING

CONSTRUCTION OR MATERIAL TYPE 2015 Std. Spec. (SS 2015)	TESTS REQUIRED (RECORDED TO)	TEST METHOD	CODE	QUALITY CONTROL BY CONTRACTOR	CODE	VERIFICATION BY KDOT
DIVISION 500 (continued)						
PORTLAND CEMENT CONCRETE PAVEMENT Sec. 501 & 503 (continued) **Concrete (continued)**	Air Content (0.25%)	KT-18 or KT-19	a	1 per 500 yd^3 or every 2 hours (mainline), every 4 hours (other slipformed pvmt), whichever is more frequent. Determine the air loss due to paving operations once in the AM and once in the PM. Determine the difference between the air content from concrete sampled before the paver, and concrete sampled behind the paver.		1 per day.
	Density of Fresh Concrete ($0.1\ lb/ft^3$)	KT-38		Initially, 1 complete transverse profile, then 1 density per ½ day.		1 density per week.
	Beams (1 psi)	KT-22 & KT-23		1 set of 3 as required for opening to traffic.		1 set of 3 per week as required for opening to traffic.
	Cores (1 lbf, 0.01 in, 1 psi)	KT-49		As required in SS 2015 section 501.5g.		Thickness measurement and compression test – 1 per lot.

SAMPLING AND TESTING FREQUENCY CHART
CONTRACTOR QUALITY CONTROL TESTING

CONSTRUCTION OR MATERIAL TYPE 2015 Std. Spec. (SS 2015)	TESTS REQUIRED (RECORDED TO)	TEST METHOD	CODE	QUALITY CONTROL BY CONTRACTOR	CODE	VERIFICATION BY KDOT
DIVISION 500 (continued)						
PORTLAND CEMENT CONCRETE PAVEMENT Sec. 501 & 503 (continued)	Air Void Analyzer (0.0001 in)	KT-71		Prequalification of mix required as per SS 2015 sec. 403.4.		1 test randomly during every 4 weeks of production.
Concrete (continued)	Permeability (0.01%, KT-73; 10 coulomb, AASHTO T 277; nearest 0.1 kΩ-cm, KT-79	KT-73 or AASHTO T 277 or KT-79	o			1 per mix design per project.
	Profilograph	KT-46		2 tracks per 12 ft of width for the full length of the project.		At the Engineer's discretion.
	Vibrator Frequency Per Standard Specification 154.2e	SS 154.2e		Every 4 hours		Daily
ON-GRADE CONCRETE (OGCA)						See 5.6 Section 5.4.4 of this manual.

CONSTRUCTION OR MATERIAL TYPE 2015 Std. Spec. (SS 2015)	TESTS REQUIRED (RECORDED TO)	TEST METHOD	CODE	QUALITY CONTROL BY CONTRACTOR	CODE	VERIFICATION BY KDOT
DIVISION 600						
HMA (Plant Mix) Sec. 602, 603, 611 & 1103						
Individual Aggregates	Sieve Analysis of Aggregate (1%, 0.1% for No. 200 sieve, of mass)	KT-02	c	1 per 1000 TONS for each individual aggregate.		1 during the first 5000 TONS of HMA produced for each individual aggregate.
	Clay Lumps and Friable Particles in Aggregate (0.1 g or 0.01% of mass)	KT-07	c h			As required.
	Shale or Shale-Like Materials in Aggregate (0.1 g or 0.01% of mass)	KT-08	c h			As required.
	Sticks in Aggregate (0.01% of mass)	KT-35	c h			As required.
	Uncompacted Void Content of Fine Aggregate (0.1%)	KT-50	l	1 on the first lot then 1 per 10,000 TONS of crushed gravel.		1 during the first 5000 TONS of HMA produced.
	Uncompacted Void Content of Coarse Aggregate (0.01%)	KT-80	l	1 on the first lot then 1 per 10,000 TONS of crushed gravel.		1 during the first 5000 TONS of HMA produced.

SAMPLING AND TESTING FREQUENCY CHART
CONTRACTOR QUALITY CONTROL TESTING

CONSTRUCTION OR MATERIAL TYPE 2015 Std. Spec. (SS 2015)	TESTS REQUIRED (RECORDED TO)	TEST METHOD	CODE	QUALITY CONTROL BY CONTRACTOR	CODE	VERIFICATION BY KDOT
DIVISION 600 (continued)						
HMA (Plant Mix) continued Sec. 602, 603, 611 & 1103						
Mineral Filler Supplement	Sieve Analysis of Aggregate (1%, 0.1% for No. 200 sieve, of mass)	KT-02	c h	1 per 250 TONS.		1 during the first 5000 TONS of HMA produced.
	Plasticity Tests (0.01 g or 0.1% of mass)	KT-10	c h	1 per 250 TONS.		
Combined Aggregate	Coarse Aggregate Angularity (Determination of Crushed Particles in Crushed Gravel) (0.1% of mass)	KT-31	c g	1 per lot		1 per week or 1 per 10,000 TONS.
	Uncompacted Void Content of Fine Aggregate (0.1%)	KT-50		1 on the first lot then 1 per 10,000 TONS of combined aggregate.		1 during the first 5000 TONS of HMA produced.
	Sand Equivalent Test (1%)	KT-55	f	1 per lot.		
	Flat or Elongated Particles (1%)	KT-59		1 on the first lot.		
	Moisture Tests (0.1 g or 0.01% of mass)	KT-11		1 per lot.		
Asphalt Material	Sampling	KT-26	b e	Sample per sampling frequency level chart		
HMA Mixtures	Percent Moisture in Mixture (0.1 g or 0.01% of mass)	KT-11		1 per lot.		1 during the first 5000 TONS of HMA produced.
	Air Voids (V_a = 0.01%; G_{mm} & G_{mb} = 0.001)	KT-15, KT-39, KT-58, & SF Manual	q	1 per sublot. (See code n for G_{mm})	j	1 per lot. [Compact split sample on KDOT Gyratory – 1 per week or every 15,000 TONS]

SAMPLING AND TESTING FREQUENCY CHART
CONTRACTOR QUALITY CONTROL TESTING

CONSTRUCTION OR MATERIAL TYPE 2015 Std. Spec. (SS 2015)	TESTS REQUIRED (RECORDED TO)	TEST METHOD	CODE	QUALITY CONTROL BY CONTRACTOR	CODE	VERIFICATION BY KDOT
DIVISION 600 (continued)						
HMA (Plant Mix continued) Sec. 602, 603, 611 & 1103						
HMA Mixtures (continued)	Binder Content (by ignition) (0.1 g or 0.01% of mass)	KT-57		1 per sublot.	j	1 per lot.
	Mix Gradation (after ignition) (0.1 g or 0.01% of mass)	KT-34		1 per sublot.		1 per lot.
	Moisture Damage to Mix (Modified Lottman) (0.1%)	KT-56	d	1 on first lot then 1 per week or every 10,000 TONS.		1 during the first 5000 TONS of HMA produced. Performed by the District Lab.
Reclaimed Asphalt Pavement (RAP)	Binder Content in RAP (by ignition) (0.1 g or 0.01% of mass)	KT-57		1 during the first lot then 1 per 1000 TONS of RAP.	j	1 during the first lot then 1 per 4000 TONS of RAP.
	RAP Gradation (after ignition) (0.1 g or 0.01% of mass)	KT-34		1 per 1000 TONS of RAP.		1 during the first 5000 TONS of HMA produced.
	Percent Moisture in RAP (0.1 g or 0.01% of mass)	KT-11		1 per lot.		
Recycled Asphalt Shingles (RAS)	Binder Content in RAS (by ignition) (0.1 g or 0.01% of mass)	KT-57		1 during the first lot then 1 per 1000 TONS of RAP + RAS.	j	1 during the first lot then 1 per 4000 TONS of RAP + RAS.
	RAS Gradation (after ignition) (0.1 g or 0.01% of mass)	KT-34		1 per 1000 TONS of RAP + RAS.		1 during the first 5000 TONS of HMA produced.
	Percent Moisture in RAS (0.1 g or 0.01% of mass)	KT-11		1 per lot.		

SAMPLING AND TESTING FREQUENCY CHART
CONTRACTOR QUALITY CONTROL TESTING

CONSTRUCTION OR MATERIAL TYPE 2015 Std. Spec. (SS 2015)	TESTS REQUIRED (RECORDED TO)	TEST METHOD	CODE	QUALITY CONTROL BY CONTRACTOR	CODE	VERIFICATION BY KDOT
DIVISION 600 (continued)						
HMA (Plant Mix continued) Sec. 602, 603, 611 & 1103						
Completed Road Work <u>Field Density Tests</u> (Use Cores or Nuclear Density Gauge on all HMA roadway or shoulder construction greater than or equal to 1.5 inches)	Field Density - Cores or Nuclear Density Gauge (G_{mb} = 0.001; 0.1 lb/ft^3 or 0.01% of G_{mm})	KT-15 or KT-32	i	10 tests per lot.	i	5 companion tests per lot.
(Use approved rolling procedure and Nuclear Density Gauge on all HMA roadway or shoulder construction less than 1.5 inches)	Field Density -Nuclear Density Gauge (G_{mb} = 0.001; 0.1 lb/ft^3 or 0.01% of G_{mm})	KT-32	i	10 Nuclear Gauge readings per lot Verify Approved Rolling Procedure every 2 hours		
	Profilograph	KT-46		2 tracks per 12 ft of width for the full length of the project.		At the Engineer's discretion.
Cold In-Place Recycle (CIR) Sec. 604	Sampling Aggregate	KT-01		2 per mile. (Sieve according to specification.)	k	1 per day.
	Percent Retained on the #200 Sieve by Dry Screen	KT-04		2 per day.		
	Field Moisture Tests (0.1 g or 0.01% of mass)	KT-32				Minimum 1 per day. Use nuclear gauge w/o correction. (Test before overlay or seal.)
	Field Density (G_{mb} = 0.001; 0.1 lb/ft^3 or 0.01% of G_{mm})	KT-32				3 locations per width laid per mile per lift. Minimum of 1 per day.

SAMPLING AND TESTING FREQUENCY CHART
CONTRACTOR QUALITY CONTROL TESTING

CONSTRUCTION OR MATERIAL TYPE 2015 Std. Spec. (SS 2015)	TESTS REQUIRED (RECORDED TO)	TEST METHOD	CODE	QUALITY CONTROL BY CONTRACTOR	CODE	VERIFICATION BY KDOT
DIVISION 600 (continued)						
Asphalt Material (Emulsion)	Sampling	KT-26	b	1 sample for every 3 loads.	b	
Lime Slurry	Percent Solids of Lime Slurry	KT-62		1 at beginning of project then 1 at each mix design change.	k	
MICROSURFACING Sec. 606 & 1109	Sieve Analysis of Aggregate (1%, 0.1% for No. 200 sieve, of mass)	KT-02	c	1 per 250 TONS for each individual aggregate.		1 per day.
	Moisture Tests (0.1 g or 0.01% of mass)	KT-11		3 per day.		1 per day.
	Emulsified Asphalt	KT-26		1 per project.	k	
	Sampling Cement	KT-29		1 per project.	k	
	Percent Crushed Particles in Crushed Gravel (0.1%)	KT-31		1 per project.	k	
	Uncompacted Void Content of Fine Aggregate (0.1%)	KT-50		1 per project.	k	
	Sand Equivalent Test (1%)	KT-55		1 per project.	k	
ULTRATHIN BONDED ASPHALT SURFACE (UBAS) Sec. 613 & 1103						
Individual Aggregates	Sieve Analysis of Aggregate (1%, 0.1% for No. 200 sieve, of mass)	KT-02	c h	1 per 1000 TONS for each individual aggregate.		1 per project per individual aggregate.
	Uncompacted Void Content of Fine Aggregate (0.1%)	KT-50	l	1 on the first lot then 1 per 10,000 TONS of crushed gravel.		1 per project.

SAMPLING AND TESTING FREQUENCY CHART
CONTRACTOR QUALITY CONTROL TESTING

CONSTRUCTION OR MATERIAL TYPE 2015 Std. Spec. (SS 2015)	TESTS REQUIRED (RECORDED TO)	TEST METHOD	CODE	QUALITY CONTROL BY CONTRACTOR	CODE	VERIFICATION BY KDOT
DIVISION 600 (continued)						
ULTRATHIN BONDED ASPHALT SURFACE (UBAS) Sec. 613 & 1103 (continued)						
Mineral Filler Supplement	Sieve Analysis of Aggregate (1%, 0.1% for No. 200 sieve, of mass)	KT-02	c h	1 per 250 TONS.		1 per project.
	Plasticity Tests (0.01 g or 0.1% of mass)	KT-10	c h	1 per 250 TONS.		1 per project.
Combined Aggregate	Coarse Aggregate Angularity (0.1% of mass)	KT-31	c g h	1 per lot of combined aggregate		1 per week or 1 per 10,000 TONS.
	Uncompacted Void Content of Fine Aggregate (0.1%)	KT-50	f	1 on the first lot then 1 per 10,000 TONS of combined aggregate.		1 per project.
	Sand Equivalent Test (1%)	KT-55	f	1 per lot.		1 per project.
	Moisture Tests (0.1 g or 0.01% of mass)	KT-11		1 per 2000 TONS of combined mix.		1 per project.
Asphalt Material	Sampling	KT-26	b e	Sample per sampling frequency level chart		
HMA Mixtures	Percent Moisture in Mixture (0.1 g or 0.01% of mass)	KT-11		1 per 2000 TONS of combined mix.		1 per project.
	Theoretical Maximum Specific Gravity (Rice) (G_{mm} = 0.001)	KT-39	n	1 per sublot.		1 per lot.
	Binder Content (by ignition) (0.1 g or 0.01% of mass)	KT-57		1 per sublot.	j	1 per lot.
	Mix Gradation (after ignition) (0.1 g or 0.01% of mass)	KT-34		1 per sublot.		1 per lot.

SAMPLING AND TESTING FREQUENCY CHART
CONTRACTOR QUALITY CONTROL TESTING

CONSTRUCTION OR MATERIAL TYPE 2015 Std. Spec. (SS 2015)	TESTS REQUIRED (RECORDED TO)	TEST METHOD	CODE	QUALITY CONTROL BY CONTRACTOR	CODE	VERIFICATION BY KDOT
DIVISION 600 (continued)						
HMA Base [Reflective Crack Interlayer (RCI)] Sec. 614						
Individual Aggregates	Sieve Analysis of Aggregate (1%, 0.1% for No. 200 sieve, of mass)	KT-02	c	1 per 1000 TONS for each individual aggregate.		1 during the first 5000 TONS of HMA produced for each individual aggregate.
	Clay Lumps and Friable Particles in Aggregate (0.1 g or 0.01% of mass)	KT-07	c h			As required.
	Shale or Shale-Like Materials in Aggregate (0.1 g or 0.01% of mass)	KT-08	c h			As required.
	Sticks in Aggregate (0.01% of mass)	KT-35	c h			As required.
Mineral Filler Supplement	Sieve Analysis of Aggregate (1%, 0.1% for No. 200 sieve, of mass)	KT-02	c h	1 per 250 TONS.		1 during the first 5000 TONS of HMA produced.
	Plasticity Tests (0.01 g or 0.1% of mass)	KT-10	c h	1 per 250 TONS.		
Combined Aggregate	Sand Equivalent Test (1%)	KT-55	f	1 per lot.		
	Flat or Elongated Particles (1%)	KT-59		1 on the first lot.		
	Moisture Tests (0.1 g or 0.01% of mass)	KT-11		1 per lot.		
Asphalt Material	Sampling	KT-26	b e	Sample per sampling frequency level chart		
HMA Mixtures	Percent Moisture in Mixture (0.1 g or 0.01% of mass)	KT-11		1 per lot.		1 during the first 5000 TONS of HMA produced.

SAMPLING AND TESTING FREQUENCY CHART
CONTRACTOR QUALITY CONTROL TESTING

CONSTRUCTION OR MATERIAL TYPE 2015 Std. Spec. (SS 2015)	**TESTS REQUIRED (RECORDED TO)**	**TEST METHOD**	**CODE**	**QUALITY CONTROL BY CONTRACTOR**	**CODE**	**VERIFICATION BY KDOT**
DIVISION 600 (continued)						
HMA Base [Reflective Crack Interlayer RCI)] Sec. 614 (continued)						
HMA Mixtures (continued)	Air Voids (Va = 0.01%; G_{mm} & G_{mb} = 0.001)	KT-15, KT-39, KT-58, & SF Manual	q	1 per sublot. (See code n for G_{mm})	j	1 per lot. [Compact split sample on KDOT Gyratory – 1 per week or every 15,000 TONS]
	Binder Content (by ignition) (0.1 g or 0.01% of mass)	KT-57		1 per sublot.	j	1 per lot.
	Mix Gradation (after ignition) (0.1 g or 0.01% of mass)	KT-34		1 per sublot.		1 per lot.
Completed Road Work	Field Density Approved Rolling Procedure Nuclear Gauge (Gmb = 0.001; 0.1 lb/ft^3 or 0.01% of Gmm)	KT-32		Verify Approved Rolling Procedure every 2 hours 10 Nuclear Gauge readings per day		

SAMPLING AND TESTING FREQUENCY CHART
QUALITY CONTROL/QUALITY ASSURANCE SPECIFICATIONS

CODE	INSTRUCTION
a	The contractor may reduce the sampling and testing frequency to one test per 1,000 yd^3 provided the first two tests each day show compliance with the specification requirements.
b	Sampled by the district field personnel, or contractor and tested at KDOT Central Materials Laboratory (Materials and Research Center).
c	The aggregate producer's tests may be used for quality control purposes if the tests were performed by an appropriately certified technician. In such cases, the contractor shall perform testing as necessary to determine the degrading effects of hauling and stockpiling on the individual aggregates. For CTB, the minimum testing frequency shall be every 4,000 Tons.
d	At least one Modified Lottman test is required weekly. When more than 10,000 Tons of production occurs in a week, then run additional tests to meet the requirement of 1 test per 10,000 Tons.
e	Specification compliance will be determined on a producer basis not on a project basis. Producer and product testing frequency is maintained in AWP. Start with one in three loads, then generally, the sampling frequency will be reduced to one sample per six loads and then per twelve loads if test results determined by the Department show satisfactory compliance of the material with the specifications.
f	Determine the Sand Equivalent (SE) value on the combined virgin aggregates on the first lot of production and then frequency may be reduced to one test per week provided the SE value exceeds the minimum specified value by five (5) percentage points. The frequency may be reduced to one test per two weeks provided the SE value exceeds the minimum specified value by 25 percentage points. When any test (including verification and assurance) shows the SE value to be less than five (5) percentage points above the specified minimum value then the testing frequency will revert to one per lot until two consecutive tests exceed the minimum specified value by five (5) percentage points.
g	All aggregate types except siliceous gravels and steel slag will be considered to have at least two crushed faces on 100% of the aggregate particles. For mixes containing crushed or uncrushed siliceous gravels or steel slag, determine the Coarse Aggregate Angularity (CAA) value of the combined virgin aggregate of the first lot of production. After three consecutive passing tests, the frequency may be reduced to one per three lots or one per week. If any of the quality control or verification tests fail, the frequency will revert to one per lot until the above criteria for reduced frequency is met.
h	If during the determination of individual aggregate gradation, clay lumps and soft or friable particles, shale or shale-like particles, or sticks are found then perform KT-07, KT-08, and KT-35, respectively, at such frequencies as jointly deemed necessary by the Contractor and the District
i	For small lots [lots with less than 1,000 tons], the number of tests may be reduced (see special provision).
j	Provide access to Contractor owned forced air ignition furnace, ovens, and Superpave Gyratory compactor, as required, for the State Inspector to perform verification tests.

SAMPLING AND TESTING FREQUENCY CHART
QUALITY CONTROL/QUALITY ASSURANCE SPECIFICATIONS

CODE	INSTRUCTION
k	Engineer's discretion. Frequency of tests shall be agreed upon by the Field Engineer and the District Materials Engineer. Frequency will be governed by field conditions. Written documentation of the agreed upon testing frequency shall be included in the project records.
l	This testing of crushed gravel is only needed to confirm that 35% or less natural sand is used in the traveled way mixes. If 95% or more of crushed gravel is retained on the #8 sieve, then the material must have a minimum Uncompacted Void Content of Coarse Aggregate (UVA) value of 45 when tested in accordance with KT-80. Test at the same frequency as KT-50. Do not use material with a UVA value less than 45.
m	The contractor may reduce the sampling and testing frequency to one test per 1,500 CY provided the first ten tests show compliance with the specification requirements.
n	If more than one test is performed on the sample, use the average value.
o	Verification method must be the same test method as used for mix design approval.
p	Frequency may be reduced to 1 pre-production verification test per day provided the following are met: 1) Handheld moisture meter is used at least once per every 50 cubic yards of production. 2) The meter has an accuracy of ±0.5% of the pre-production verification test. 3) Moistures obtained from the meter are used to adjust batch-to-batch moisture corrections.
q	KT-58 test requires the average of two (2) gyratory plugs

GENERAL NOTES

- All sampling and testing frequencies listed are minimums. Additional quality control, verification, and assurance tests will be performed, when necessary, to provide effective control the work. When any quality control test result fails to comply with the specification requirements then the next sublot of production after obtaining the failing test results will be sampled and tested, regardless of any lesser frequency specified in this appendix.
- For the AASHTOWare Project (AWP), Acceptance Sampling and Tests have been divided into three sections. Items called "ACC" will be Acceptance Tests and will have a quantity assigned. Items called "INF" and "VER" will be additional tests and they will not be for payment. "ACC" tests make the assignment of tested materials to the contract or mix plant. "Sample Type" must = "ACC" when assignment of a pay quantity is being made. "INF" and "VER" when recording test values for additional acceptance information.
- For QUALITY CONTROL BY CONTRACTOR, AWP uses INF or ACC unless otherwise noted. For VERIFICATION BY KDOT, AWP uses ACC or INF or VER unless otherwise noted. For INDEPENDENT ASSURANCE BY KDOT, AWP uses ASW (Assurance Witness), ASR (Assurance Replicate), and ASP (Assurance Split) unless otherwise noted (see section 5.4.2 of this manual).
- For a better explanation of metric (SI) units, see section 5.9, "Sampling and Test Methods Forward", of this manual.
- All samples will be taken from the place of incorporation into the project unless otherwise noted.

5.9.25 SAMPLING AND SPLITTING PLANT MIXED ASPHALT MIXTURES
(Kansas Test Method KT-25)

1. SCOPE

This method covers the procedure for sampling plant mixed asphalt mixtures from truck beds, continuous mix plants, and roadways. The procedure for sampling from trucks may be followed when sampling asphalt mixtures from other containers or in stockpiles. **KT-25** reflects testing procedures found in **AASHTO R 97**.

2. REFERENCED DOCUMENTS

2.1. AASHTO T 168; Standard Method of Test for Sampling Bituminous Paving Mixtures

2.2. AASHTO R 47; Standard Practice for Reducing Samples of Asphalt Mixtures to Testing Size

3. APPARATUS

3.1. Square pointed shovel or scoop.

3.2. Sampling Devices.

3.2.1. Plants shall be equipped with sampling devices capable of providing a sample of sufficient size from the full width of the mixer discharge flow. Sampling devices shall be designed so those samples may be taken while the plant is operating at normal production rates.

3.2.2. A container that will hold a minimum of 55 lb (25 kg) of loose, hot asphalt mixtures. The container should be equipped with a handle or handles that will permit it to be easily carried.

4. SAMPLING PROCEDURE

4.1. Plant Discharge.

4.1.1. Drum plants shall be capable of sampling at the discharge outlet. When a sample is taken at the discharge, the sampling container shall be of sufficient size to accommodate the entire stream uniformly. If a by-pass chute is utilized, a representative sample shall be obtained.

4.1.2. Take the sample in at least three increments to obtain the total sample. Combine the increments and mix thoroughly.

4.1.3. The combined sample size shall be at least four times the amount required for testing.

4.2. Truck Beds.

4.2.1. Divide the truck bed into at least three areas of approximately equal size.

4.2.2. Dig a hole about 1 ft (0.3 m) deep at a point that will be representative of each area.

4.2.3. Take a sample weighing 4 to 6 lb (2 to 3 kg) near the bottom of each hole, taking care to prevent segregation.

4.2.4. Combine the individual samples into a single sample at least four times the amount required for testing.

4.3. Roadways Prior to Compaction.

4.3.1. Randomly select the truckload in which the sample is to be obtained. Calculate the expected yield of that truckload and obtain at least three approximately equal increments from the roadway within the randomly selected truckload. These increments shall be the full depth of the lift, full width of the laydown machine minus 2 ft (ignore 1 ft on both edges of the laydown machine).

4.3.2. Insert the template through the full depth of the lift and remove all of the loose material above the tack layer from the template. Combine the increments and mix thoroughly.

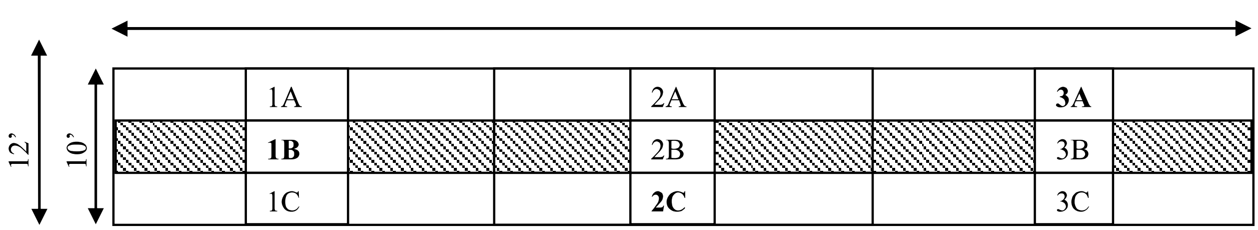
NOTE: An approximate 12 in (300 mm) square template can be used to obtain the sample. Size and shape of the template can be altered to best fit the required sampling quantity without segregating the material. Take the number of squares required to obtain the necessary quantity for testing.

4.3.3. The sample size shall be at least four times the amount required for testing. For Superpave projects, the minimum sample size is shown in the specifications.

4.3.4. EXAMPLE:
Assume the yield for the random truckload of HMA is 100' long for a 12' wide roadway. Excluding the outside 1' edges, the width of the sampled area is 10'. Divide both the width and the length by 3 to obtain potentially 9 equal sublots for obtaining the sample. If only 3 sublots (the minimum) are to be used to create the sample, then select the sublots so that each third of the length is represented and each third of the width is represented by the sublots. In this example, sublots 1B, 2C and 3A were selected. When more than 3 sublots are to be used, then continue to select the additional material from sublots not yet selected varying the length segment and width segment i.e., sublots 3C, 2B and 1A etc.

3 segments at ~33'each = 100'

The expected yield of the truckload in this example is 100' x 12'



5. SAMPLE SPLITTING AND REHEATING

5.1. Reduce sample to the required size by splitting or quartering in the following manner:

5.1.1. Spread a sheet of paper (Kraft or similar) on a hard, clean, smooth and level surface. Place the sample in a pile near the center of the paper and mix by alternately lifting each corner towards the opposite corner thereby rolling the mixture to the opposite corner. This should be performed in a vigorous manner. Placing the sample on clean sheet metal and mixing thoroughly with a trowel is an acceptable alternative.

5.1.2. Divide the pile into four equal quarters with a straightedge (trowel or similar metal blade) and completely remove two pre-selected diagonally opposite quarters.

5.1.3. Continue this quartering procedure until the original sample is reduced to the approximately desired size. On the final quartering step, if the sample is too large before quartering, but will be too small after quartering, the sample pile is divided into equal opposite sectors but unequal adjacent sectors. This can be accomplished by varying the dividing angle at the center of the sample pile from the normal 90°. Opposite sections can then be selected to obtain the desired sample size.

5.2. After mixing and reducing, samples may be reheated briefly, if necessary, to bring to specified compaction temperature. Care must be exercised to avoid overheating any part of the sample. Insulated containers are recommended for transporting and storing samples until used.