

QC/QA ASPHALT SPECIFICATIONS HANDBOOK – 2020



INSTRUCTOR:
KDOT, Bureau of Construction and Materials

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KDOT
Field Engineer

KANSAS STATE
POLYTECHNIC

Kansas
Department of Transportation

**QUALITY CONTROL/QUALITY ASSURANCE (QC/QA)
ASPHALT SPECIFICATION CERTIFICATION TRAINING
AGENDA**

DAY ONE/TUESDAY:

8:30 Welcome, Introduction & House Keeping

8:40 602.1 DESCRIPTION

9:20 Break

9:30 602.2 CONTRACTOR QUALITY CONTROL REQUIREMENTS

10:30 Break

10:40 602.3 MATERIALS

11:45 Lunch

12:45 602.9 BASIS OF ACCEPTANCE

a. General

b. Density Pay Adjustment for "HMA Overlay"

1:50 Break

2:00 602.9 BASIS OF ACCEPTANCE

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

2:50 Break

3:00 602.9 BASIS OF ACCEPTANCE

d. Air Void Pay Adjustment

3:50 Break

4:00 602.4 CONSTRUCTION REQUIREMENTS

5:00 Adjourn

DAY TWO/WEDNESDAY:

8:30 602.5 PROCESS CONTROL

9:20 Break

9:30 602.6 COMPACTION TESTING

602.7 WEATHER LIMITATIONS

602.8 MIXTURE ACCEPTANCE

10:20 Break

10:30 602.10 DETERMINATION OF THICKNESS, THICKNESS PAY ADJUSTMENT
AND AREA PAY ADJUSTMENTS FOR "HMA PAVEMENT"

11:45 602.11 MEASUREMENT AND PAYMENT

12:00 Lunch

1:00 Review

2:00 Quiz & Course Evaluation

3:30 Adjourn

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Part V: 5.2.7.1 Contractor's Quality Control Plan
Part V: Appendix B: Sampling and Testing Frequency Chart

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

<u>CERTIFICATIONS</u>	
NUC	Nuclear Meter Operators Certification
PO	Profilograph Operators Certification
QC/QA Asp	QC/QA Asphalt Specifications Certification
SF	Superpave Field Certification
<u>GENERAL</u>	
AASHTO	American Association of State Highway and Transportation Officials
JMF	Job Mix Formula
KT-Methods	Kansas Test Methods
MRC	Materials and Research Center at 2300 Van Buren in Topeka, KS
QA	Quality Assurance (KDOT)
QC	Quality Control (Contractor)
RAP	Reclaimed Asphalt Pavement
RAS	Recycled Asphalt Shingles
SR	Superpave Recycle Mix
<u>SPECIFIC GRAVITIES</u>	
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}
<u>SUPERPAVE TERMINOLOGY</u>	
CAA	Coarse Aggregate Angularity
D/B	Dust to Effective Binder Ratio
FAA	Fine Aggregate Angularity ("U" Value)
N_{des}	Design Number of Gyration
N_{ini}	Initial Number of Gyration
N_{max}	Maximum Number of Gyration
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
<u>STATISTICS TERMINOLOGY</u>	
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
\bar{X}	Average or Mean

QC/QA Asphalt Specifications 2020

KANSAS STATE
POLYTECHNIC



QC/QA Asphalt Specifications Special Provision 15-06007-R01 Outline

- 602.1 Description (Sheet 1 of 29)
- 602.2 Contractor QC Requirements
(Sheets 1 to 4 of 29)
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- 602.10 HMA Paid by the Area (Sheets 24 to 28 of 29)
- 602.11 Measurement and Payment (Sheets 28 to 29 of 29)

QC/QA Asphalt Specifications

- Class Times
 - Today: 8:30 AM – 5:00 PM
 - Tomorrow: 8:30 AM – 3:30 PM
- Lunch and Breaks
- Cell Phones
- Environment and Comfort
- Ask, Tell, Help
- Test & Evaluation
- Organization of Manual – items to tab

QC/QA Asphalt Specifications Special Provision 15-06007-R01 Outline

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602.1 Description

Introduction to Superpave



602.1 Description

Objectives

- 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

**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

HMA Base (*)(**)(***)
HMA Surface (*)(**)(***)
HMA Overlay (*)(**)(***)
HMA Pavement (#) (##)
HMA Pavement (#) Shoulder
Emulsified Asphalt (****)
Asphalt Core (Set Price)
Material for HMA Patching (Set Price)
Quality Control Testing (HMA)
*Mix Designation
**Grade of Asphalt Binder
***Shoulder
****Type and Grade of Emulsified Asphalt
Thickness
##Type of surface course HMA mixture

UNITS

Ton
Ton
Ton
Square Yard
Square Yard
Ton
Each
Ton
Ton

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.

602.1 Description

BID ITEMS

HMA Base (*)(**)(***)
 HMA Surface (*)(**)(***)
 HMA Overlay (*)(**)(***)
 HMA Pavement (#) (# #)
 HMA Pavement (#) Shoulder
 Emulsified Asphalt (****)
 Asphalt Core (Set Price)
 Material for HMA Patching (Set Price)
 Quality Control Testing (HMA)
 *Mix Designation
 **Grade of Asphalt Binder
 ***Shoulder
 ****Type and Grade of Emulsified Asphalt
 # Thickness
 # # Type of surface course HMA mixture

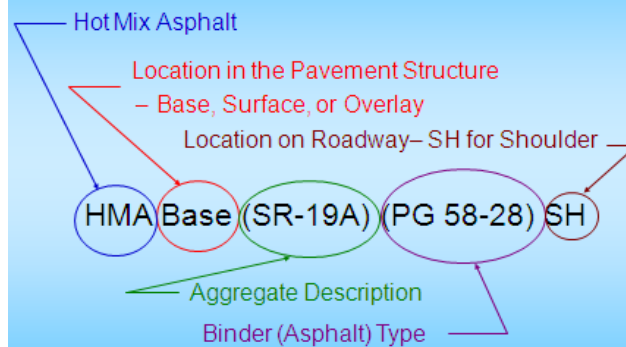
UNITS

Ton
 Ton
 Ton
 Square Yard
 Square Yard
 Ton
 Each
 Ton
 Ton

Superpave Mixes Typical Pavement X-Section

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

Components of Superpave Mixes



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

Components of Superpave Mixes Aggregates

HMA Base (SR-19A) (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)

Components of Superpave Mixes Aggregates

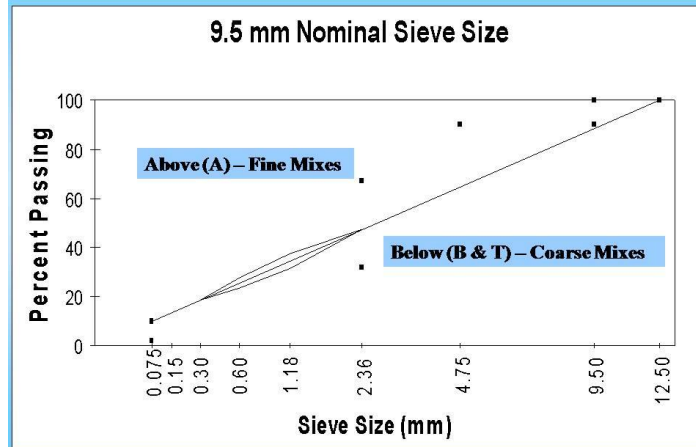
HMA Base (SR-19A) (PG 58-28) SH

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)

Typical Gradation Control



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

Components of Superpave Mixes Performance Graded (PG) Binders

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

Binder (Asphalt) Type

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 82 (incr. 6)
- PG 70 and PG 64 are typical for mainline surface mixes

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 PG64 are used in shoulder mixes
- PG 76 and PG 82 are used sparingly
 - High truck volumes
 - Slow or stopped traffic
- PG 52 used in some high RAP and RAS mixes

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:	82°C = 180°F
Stopped Traffic:	76°C = 169°F
Heavy Traffic:	70°C = 158°F
Normal Traffic:	64°C = 147°F
Shoulder Traffic:	58°C = 136°F

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 -16 to -34 (incr. 6)

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
- -34 used in some high RAP and RAS mixes

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

Superpave Mixes Binders Used in Kansas

- PG 58-28 } Neat Asphalts
- PG 64-22 } Hi Side + Lo Side < 90

- PG 64-28
 - PG 70-22
 - PG 70-28
 - PG 76-22
 - PG 76-28
 - PG 82-22
- } Modified Binders

Superpave Mixes Typical Mainline Mixes

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

Superpave Mixes Typical Shoulder Mixes

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

Superpave Mixes Typical Pavement Section

MAINLINE	SHOULDER
1.5" HMA	1.5" HMA
2.5" HMA	2.5" HMA
8" HMA	4" HMA

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

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Superpave For Inspectors



Superpave For Inspectors

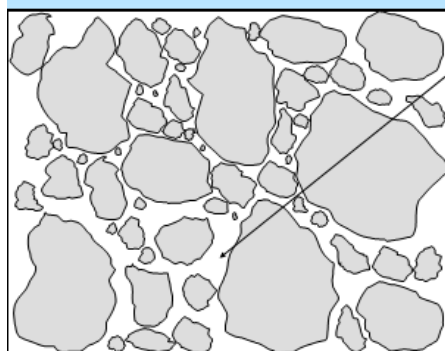
Everything a Field Inspector
should know about Superpave
Design and was afraid to ask

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}

Superpave Volumetric Properties

VMA



VMA is the voids between the Aggregate

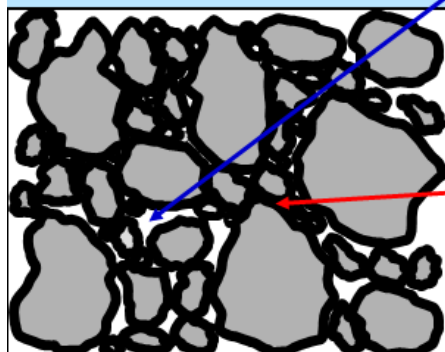
$$VMA\% = \frac{V_v}{V_{mb}} \times 100$$

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

86% is Aggregate

Superpave Volumetric Properties

V_a 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

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

Superpave Volumetric Properties

Specific Gravity

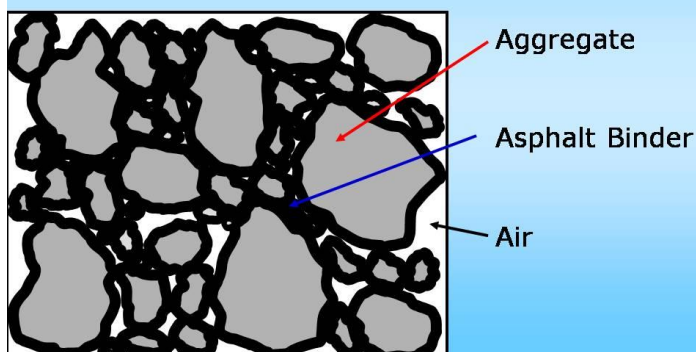
$$\text{Specific Gravity} = \frac{\text{Density of the Material}}{\text{Density of Water}}$$

Typical Specific Gravities

Styrofoam	0.04
Wood	0.45
SAE 30 Oil	0.90
Water	1.00
Coal	1.30
HMA	2.30
Rocks	2.65
Steel	7.85
Lead	11.3
Gold	19.3

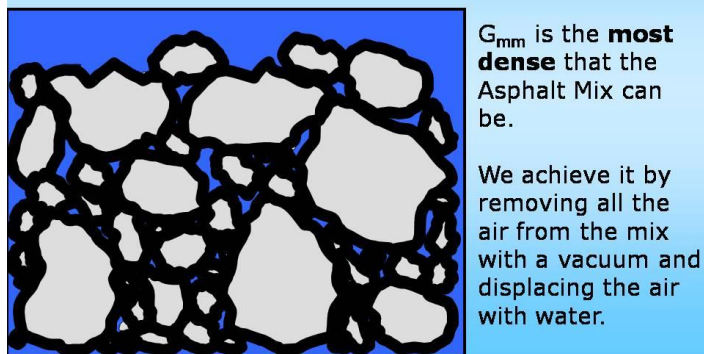
Superpave Volumetric Properties

Theoretical Maximum Specific Gravity (G_{mm})



Superpave Volumetric Properties

Theoretical Maximum Specific Gravity (G_{mm})



Superpave Volumetric Properties

Theoretical Maximum Specific Gravity (G_{mm}) Rice Test



Superpave Volumetric Properties

Theoretical Maximum Specific Gravity (G_{mm}) Rice Test

The G_{mm} value is used to compare

- In-Place Density on the Road
- Air Voids in Gyratory Compacted Plugs

Superpave Volumetric Properties Superpave Gyratory Compactor

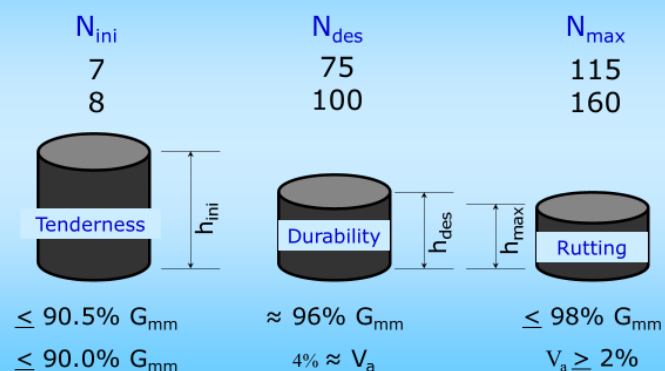
N – Number of Gyration

ini – Initial
des – Design
max – Maximum

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



Superpave Volumetric Properties Superpave Gyratory Compactor



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

Superpave Volumetric Properties Contractor Pay Items

Air Voids (V_a)

G_{mb} @ N_{des}

And

G_{mm}

In-Place Density

Nuclear Gauge

And

G_{mm}

OR

Cut Cores from the Pavement and get G_{mb}

And

G_{mm}

Review

What Bid Item(s) are used for 1R Projects?

What Bid Item(s) are generally used for MM Projects?

What 2 Properties are necessary to determine Air Voids?

What 2 Tests are usually run to determine Field Density?

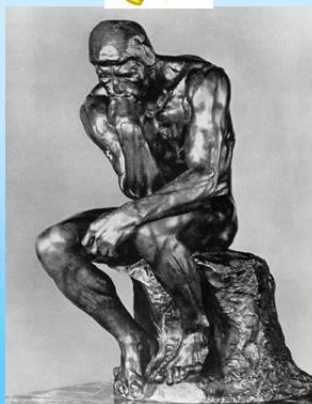
Superpave Volumetric Properties

 N_{max}

VMA

 N_{des} V_a  G_{mb} G_{mm}

VFA

 N_{ini} 

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**KANSAS DEPARTMENT OF TRANSPORTATION
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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

HMA Base (*)(**)(***)
HMA Surface (*)(**)(***)
HMA Overlay (*)(**)(***)
HMA Pavement (#) (##)
HMA Pavement (#) Shoulder
Emulsified Asphalt (****)
Asphalt Core (Set Price)
Material for HMA Patching (Set Price)
Quality Control Testing (HMA)
*Mix Designation
**Grade of Asphalt Binder
***Shoulder
****Type and Grade of Emulsified Asphalt
Thickness
##Type of surface course HMA mixture

UNITS

Ton
Ton
Ton
Square Yard
Square Yard
Ton
Each
Ton
Ton

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.

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

PART V MATERIALS CONTROL

5.1 GENERAL

PART V – MATERIALS CONTROL

5.1. GENERAL

5.1.1. MATERIALS CONTROL FUNCTIONS OF THE SECRETARY OF TRANSPORTATION

By state statute, the Secretary of Transportation has the power, duty, authority and jurisdiction “to inspect and test all materials...used for state highway purposes or highway projects involving federal funds, and to develop methods and procedures for this purpose.” (K.S.A. 68-404(h)). The Secretary’s inspection and testing of materials and the methods and procedures employed to conduct this inspection and testing are for the Department’s benefit. They are not for the benefit of contractors, producers, or suppliers.

Part V of this Manual and KDOT’s Standard Specifications are two means by which the Secretary fulfills the Secretary’s statutory obligations. Nothing in Part V or KDOT’s Standard Specifications shall be construed to limit KDOT’s discretion to adopt and/or revise standards, specifications, test procedures, removal procedures, or other policies and procedures applicable to the materials used for highway construction/maintenance. Nothing in Part V or KDOT’s Standard Specifications, including without limitation, prequalification or preapproval of materials/sources of material, is a guarantee to contractors, producers, or suppliers that a given material/source of material for highway construction/maintenance will be approved by or remain approved by KDOT, be accepted by KDOT, or be purchased by KDOT or others.

Part V and KDOT’s Standard Specifications include provisions for the Department’s Quality Control/Quality Assurance Program (QC/QA Program), which is required by FHWA to assure the quality of materials and construction in all Federal-aid highway projects and as a condition precedent to use of federal funds. The Department administers its state program in the same manner as its federal program. The Secretary has delegated to the Bureau of Construction and Materials the responsibility for the establishment and administration of the materials’ portion of the Department’s QC/QA Program.

5.1.2. MATERIALS CONTROL FUNCTIONS OF THE BUREAU OF CONSTRUCTION AND MATERIALS

The Bureau of Construction and Materials has responsibility for the establishment and administration of the materials portion of the Department's Quality Control/Quality Assurance (QC/QA) Program.

The Bureau develops standards and specifications for materials, establishes sampling procedures and frequencies, and establishes testing procedures that are used in the laboratory and the field in order to assure compliance with specifications. The fact that KDOT develops objective specifications and testing criteria and approves or preapproves materials is not intended to limit the Department’s discretion regarding the inspection, sampling, testing and acceptance of materials for highway construction/maintenance.

The Bureau performs materials testing to assist the districts in administering quality assurance functions of the QC/QA Program. Such testing includes tests on materials purchased by

BUREAU OF CONSTRUCTION & MATERIALS (C&M)

Responsible for:
Materials Portion
Of
KDOT's QC/QA Program

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

5.2.3. REASONS FOR QUALITY CONTROL/QUALITY ASSURANCE (QC/QA) AND THE CERTIFIED INSPECTOR TRAINING AND TESTING PROGRAM (CIT²)

1. Compliance with Specifications.

The primary reason for requiring inspection, sampling and testing of materials, through an adequate and effective QC/QA system for materials used in a project, is for KDOT to verify that all materials furnished by the contractor and incorporated into the work and the completed work itself meet the requirements of the contract documents (plans, specifications, special provisions and other supplemental documents).

Specifications and plans have been prepared to require the use of materials that are expected to perform satisfactorily with minimal maintenance throughout the life of the facility. Any material that deviates from specification or plan limits will not perform as expected, and, in all probability, will shorten the life of the facility or add appreciably to the cost of its maintenance. Inspectors are expected to review the applicable clauses and covenants of the Standard Specifications at regular intervals.

2. Uniform Relations with Contractors and Producers.

The contract documents provide an equitable basis for bidding by contractors since they define the requirements that are to be met. The contractors who bid the work and producers supplying material to the contractors commit to KDOT to furnish materials and completed work that will equal or exceed such requirements.

The Engineer must determine, through quality assurance measures that the contractor is providing and the State is receiving what is specified under the contract. The Engineer should accept nothing less for the use of taxpayer funds.

It is essential that quality assurance be applied uniformly by all engineers and inspectors from project to project so that all contractors and suppliers are treated alike. This manual provides guidance to the Engineer and inspector on interpretation of the specifications and the application of quality assurance, so no contractors or producers are given an unfair advantage over other contractors and producers.

3. Documentation of Expenditure of Public Funds.

When payment is to be made to the contractor for materials furnished and work performed, the duly designated state official must authorize disbursement of public funds for this purpose. The disbursing officer must depend upon others for evidence to support the expenditure. Through the materials quality assurance system, the Field Engineer will acquire substantiating data in the form of test results, inspection records and measurements to justify acceptance of the contractor's work. Thus the Engineer can assure and furnish documentation to the officials responsible for authorizing payment that the contractor has fulfilled its obligation and is entitled to full or adjusted payment as provided for in the contract documents.

In case of failure to meet the minimum requirements, quality assurance data will constitute the basis for rejection of work as unacceptable.

Complete records, including test and inspection reports covering acceptance or rejection, should be maintained in the Engineer's project files while the necessary copies should be furnished to the appropriate headquarters personnel as needed for verification and as supporting evidence for payment documents.

5.2.3
REASONS FOR QC/QA

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

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

4. Compliance with Federal Regulations

Title 23, Chapter 1, Part 637 of the Code of Federal Regulations includes many requirements which must be adhered to for Federal-aid highway construction. Some of these requirements include:

- State Transportation Departments have a Quality Assurance program in place.
- Testing of highway materials is performed by Qualified Laboratories.
- State Transportation Departments have an Independent Assurance program in place.
- Sampling of materials used in highway construction is accomplished in a Random manner.
- Qualified personnel are used for sampling and testing of materials used in highway construction.

Part 637 defines Quality Assurance as “All those planned and systematic actions necessary to provide confidence that a product or service will satisfy given requirements for quality”. A Quality Assurance Program is required under 637.205 which states in part: “Each STD (State Transportation Department) shall develop a quality assurance program which will assure that the materials and workmanship incorporated into each Federal-aid highway construction project on the NHS are in conformity with the requirements of the approved plans and specifications”.

Other requirements and definitions can be found on the Government Printing Office website:

<http://www.gpo.gov/fdsys/browse/collectionCfr.action?collectionCode=CFR>.

5.2.4. PROCEDURES FOR QUALITY ASSURANCE

1. General

KDOT has two procedures for assuring quality on project produced materials. The two **Sampling and Testing Frequency Charts in Appendix A and B** help clarify some of the differences between the two procedures.

1.1. The older of the two is **“Method Specs”**. Under this procedure, KDOT’s test results are used as the basis of acceptance for project produced materials, and the contractor is not required to conduct quality control testing, although the contractor may choose to do so.

1.2. A more current procedure is **“QC/QA” specifications**. Under this method of quality assurance, the **contractor conducts quality control testing**, and these test results can be used as a basis of acceptance, provided **KDOT’s quality assurance verifies the results**.

2. Authorized Personnel.

2.1. Under a “method spec”, all inspection, sampling and testing for acceptance must be performed by an authorized representative of the Kansas Department of Transportation. The representative may be an employee of the Kansas Department of Transportation, an employee of another highway agency or an employee of a commercial testing laboratory or inspection agency. The contractor's/producer's process control test results may be used for partial acceptance when allowed by the contract documents. (See basis of acceptance.)

Arrangements for inspection and sampling of materials by agencies other than the Department are made by the Chief, Bureau of Construction and Materials.

Samples submitted to the laboratory for tests by unauthorized individuals or agencies will not be tested except by authorization of the Chief, Bureau of Construction and Materials.

2.2. **Under “QC/QA” specifications, all technicians must demonstrate qualifications** for each Test Group in which they wish to conduct materials sampling and testing. These qualifications include some type of certificate for the completion of a training program or a combination of demonstration of the test procedures and completion of written exams covering the group of test methods. For a list of Test Groups, see **Appendix C**. Acceptable certifications include KDOT training and testing, training conducted at **KSU-Salina or Manhattan, American Concrete Institute certification, or a certificate of completion from a program similar to those described and issued or approved by another state’s DOT. KDOT has final judgment on a technician’s qualifications.**

Certification in one group may be required before attendance in the certification course of another group. For example, Aggregate Field is required before a technician may attend the Superpave Field training.

All contractors conducting QC/QA sampling and testing for KDOT projects are responsible for the annual calibration and verification of their equipment by an AASHTO Accredited Laboratory using NIST traceable equipment, or by some other NIST traceable source (see **Appendix C** for calibration and verification frequencies). **Calibrations and verifications required more often than every 12 months may be conducted by the contractor if the equipment is checked annually by an AASHTO Accredited Laboratory. Equipment will be made available to the District Materials Engineer for spot checks of the calibrations** when necessary.

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

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

5.2.4: PROCEDURES FOR QUALITY ASSURANCE

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

5.2.4: PROCEDURES FOR QUALITY ASSURANCE

2. Authorized Personnel

2) QC/QA Specs

- Equipment Calibration and Verification
 - Contractor is Responsible
 - AASHTO Accredited Lab
 - Frequencies more often than 12 months can be done by the Contractor
 - DME can Spot Check Equipment Calibrations

5.2.5. QUALITY CONTROL/QUALITY ASSURANCE (QC/QA) TESTS

1. General

This section establishes terminology and procedures for the various tests that are included in the QC/QA system.

2. Definitions

2.1. Acceptance Program - All factors that comprise the State's determination of the degree of compliance with contract requirements and value of a product. These factors include the State's sampling, testing and inspection, and validated results of contractor sampling and testing.

2.2. Assurance Sampling and Testing - Split or replicate samples used as an independent check of the sampling and testing procedures and equipment. These samples are to assure testing is being performed properly by both the contractor's and the State's personnel. The results of assurance tests are not to be used as a basis of material acceptance.

2.3. Dispute Resolution - The procedure used to resolve conflicts resulting from discrepancies between the State's verification results and the Contractor's quality control results of sufficient magnitude to impact payment. Any laboratory used for dispute resolution must be accredited by the AASHTO Accreditation program for the tests to be performed.

2.4. Independent Assurance (IA) - IA is an unbiased and independent verification of the Quality Assurance system used and of the reliability of the test results obtained in the regular sampling and testing activities. KDOT's IA will consist of observations by independent personnel to assure that specified procedures are followed (witnessing), and split or replicate sampling and testing.

2.5. Quality Assurance (QA) - All those planned and systematic actions necessary to provide adequate confidence that a product or service will satisfy given requirements for quality. QA activities include: acceptance, independent assurance, verification, and prequalification sampling and testing; inspection; reporting of results; and any follow up that may be necessary due to test failure. Without these actions, it would be impossible for the Engineer to accurately verify compliance or in many cases the level of compliance with the requirements of the contract documents.

2.6. Quality Control (QC) - The sum total of operational techniques and activities performed or conducted by the contractor and/or producer to make sure that a product meets contract specification requirements. QC activities generally are outlined in a contractor's process control plan which lists such items as types of tests to be performed, sampling locations, sampling frequencies, equipment calibration procedures and frequencies, and documentation procedures.

2.7. Qualified Laboratories - Laboratories used for sampling and testing of materials are those approved through appropriate programs as determined by KDOT.

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

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

5.2.5 QUALITY CONTROL/QUALITY ASSURANCE (QC/QA) TESTS

2.) Definitions

2.5 Quality Assurance (QA)

- Necessary
- Provide Confidence – Quality Product

2.6 Quality Control (QC)

- By Contractor
- QC Activities are Outline in QC Plan

2.8. Qualified Technician - Personnel who are certified through appropriate programs determined by KDOT.

2.9. Replicate Tests - Tests performed by independent assurance personnel using equipment other than that used by project personnel, but performed on a portion of the sample used by project personnel.

2.10. Split Samples - Sampling and splitting of the material conducted under the observation of independent assurance personnel. Tests on separate portions are performed by KDOT designated independent assurance personnel using equipment other than that used by project personnel.

2.11. Verification Sampling and Testing - Sampling and testing performed to validate the quality of the product or to check the adequacy of mix designs. If quality control sampling and testing is used in the acceptance program, verification sampling and testing will also be used to validate the quality control sampling and testing. Verification samples are independent samples obtained by KDOT.

2.11.1. On Grade Concrete Aggregate (OGCA) Production Samples - Sampling and testing procedures utilized to verify that the production of OGCA complies with the specification quality requirements

2.12. Other - sampling and testing by the District Materials laboratories not otherwise designated in this instruction or specified in the Sampling and Testing Frequency Chart, such as determination of asphalt content in maintenance mixes, or a Marshall design.

3. Independent Assurance

KDOT uses a systems wide approach to Independent Assurance Sampling and Testing of project produced materials. Each test is included in one of the following Groups according to the type of material: Aggregates, Concrete, Asphalt Mixes, and Soils. A breakdown of requirements for each Group is provided in **Appendix C**. Independent assurance will be conducted once per calendar year per technician per group of tests performed by that technician during that year. It may not be possible to witness all the tests within a group during the assurance process. There are, however, critical Core Tests within each group that must be witnessed before annual Independent Assurance requirements are completed by a technician for that group of tests. These Core Tests are marked with a double asterisk (**) on the list in **Appendix C**.

KDOT's MRC at 2300 Van Buren is AASHTO Accredited. District Materials personnel are responsible for conducting the independent assurance witnessing and testing. The equipment that the Districts use to conduct independent assurance testing is calibrated or verified annually by the MRC personnel, by another AASHTO Accredited Laboratory, or by outside NIST traceable sources.

Independent Assurance consists of witnessing the technician properly conduct the test, and split or replicate samples. The District conducts the split or replicate testing whenever possible

5.2.5 QUALITY CONTROL/QUALITY ASSURANCE (QC/QA) TESTS

2.) Definitions

2.10 Split Samples

- Observed by IA Personnel
- Tests on Separate equipment

2.11 Verification Sampling and Testing

- By KDOT
- Validates QC Sampling and Testing

QUALITY CONTROL/QUALITY ASSURANCE (QC/QA) TESTS

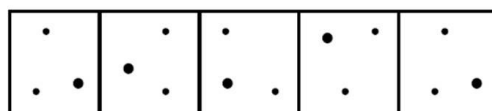
Split Sampling

Follow KT-25



QUALITY CONTROL/QUALITY ASSURANCE (QC/QA) TESTS

Random Sampling



RANDOM Sampling ≠ SPLIT Sampling

Which will give you closer results?

Split Sampling

5.2.7 CONTRACTOR'S QUALITY CONTROL PLAN

1. SCOPE

The following subsections provide guidance for contractors to maintain quality control laboratories and personnel for QC/QA designated projects.

5.2.7.1. HMA: Contractor's Quality Control plan

5.2.7.2. Guide for Quality Control and Acceptance Requirements for HMA

5.2.7.3. Example of a Laboratory Quality Manual for HMA

5.2.7.4. Concrete: Contractor's Quality Control Plan

5.2.7.5. Example of a Laboratory Quality Manual for Concrete

5.2.7.6. Concrete Structures: Contractor's Quality Control Plan

5.2.7.7. Example of Contractor's Concrete Structures Quality Plan for Controlling Evaporation

5.2.7.8 CEMENT TREATED BASE: Contractor's Quality Control Plan (CTB)

5.2.7-1

PART V: 5.2.7.1 HMA: CONTRACTOR'S QUALITY CONTROL PLAN

- Quality Control
- Samples, Tests and Referenced Cited Specifications
- Qualified Testing Laboratory
- Equipment Calibration and Verification
- Technician Certification

5.2.7.1. HMA: CONTRACTOR'S QUALITY CONTROL PLAN

1. QUALITY CONTROL

The Contractor shall provide and maintain a Quality Control (QC) Plan that will assure all materials and products submitted to KDOT for acceptance will conform to the contract requirements whether manufactured or processed by the contractor, or procured from suppliers, subcontractors, or vendors. The contractor shall perform or have performed the inspections and tests required to substantiate product conformance to contract document requirements. The contractor shall also perform or have performed all inspections and tests otherwise required by the contract. The contractor's quality control inspections and tests shall be documented and provided to KDOT. The contractor shall maintain adequate records of all inspections and tests. The records shall include the nature, number, and type of deficiencies found; the quantities rejected by the contractor; and the nature of corrective action taken, as appropriate. The contractor shall maintain standard equipment and qualified personnel as required by the Specifications to assure conformance to contract requirements. Procedures will be subject to approval by KDOT before work is started.

The contractor shall prepare a QC Plan detailing the type and frequency of inspection, sampling, and testing deemed necessary to measure and control the various properties of materials and construction governed by the Specifications. The QC Plan shall be submitted in writing to KDOT at the preconstruction conference. This plan shall include the following:

Construction items covered by the plan

Tests and Test Frequency to be performed

* Part V; Appendix B

Sampling locations and techniques

Documentation procedures, including:

*Identify the QC laboratory to be used and its credentials

*Identify the QC personnel and their qualifications

*Inspection and test records

*Temperature measurements

*Accuracy and readability, calibration, or re-calibration checks performed on production or testing equipment.

*Control charts

The Plan shall identify the personnel responsible for the contractor's quality control. This shall include the name of the company official who will act as liaison with KDOT personnel and the names of the Certified Technicians who will direct and conduct the inspection program. The contractor shall provide a testing facility or laboratory.

NOTE: Guide for Quality Control and Acceptance Requirements for HMA, will help define the minimum contents necessary for an acceptable Quality Control Plan.

2. SAMPLES, TESTS AND REFERENCED CITED SPECIFICATIONS

The contractor shall be responsible for the quality of construction and materials incorporated into the contract. The contractor shall perform all necessary quality control inspection, sampling and testing. All materials will be approved for acceptance through KDOT's acceptance procedures. KDOT has the responsibility for determining the acceptability of the construction and materials incorporated therein. KDOT may use the results of the contractor's inspection, approved quality control program. To eliminate confusion when transferring information, provide all critical information as outlined in Table 1.

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

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

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)

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

Table 1
Request Report Requirements

a. Name and address of the testing laboratory
b. Identification of the report and the date issued
c. Project number and contract number
d. Description and identification of the test sample (including subplot numbers)
e. Date(s) of receipt of the test
f. Date(s) of test performance
g. Identification of the standard test method used and a notation of all known deviations from the test method
h. Test results and other pertinent data required by the standard test method
i. Identification of any test results obtained from test performed by a subcontractor
j. Name and certification number of the person (s) technically responsible for the test report

3. QUALIFIED TESTING LABORATORY

The Materials and Research Center is accredited through the **AASHTO Accreditation Program (AAP)**. If the contractor's QC laboratory is not participating in the AAP, then the contractor shall have an AAP approved laboratory inspect the QC laboratory's equipment annually. The inspection shall include all equipment necessary to perform testing on specified types of material related to the contract; base and grading, aggregate, HMA and concrete.

The contractor's QC laboratory shall be furnished and maintained with adequate ventilation, heat, light, water, sink and drainage, electrical or gas outlets or both, work tables, shelves, and supply cabinets. The laboratory shall be supplied with equipment and materials necessary to perform all tests required by the specifications and shall be maintained in such condition that the equipment will meet the applicable requirements of KDOT.

KDOT will annually inspect and document the acceptability of the sampling and testing equipment. This includes sampling and testing equipment owned by contractors, consultants or vendors. Checks on equipment during the life of a project should be accomplished by project sampling and testing personnel as well as KDOT personnel.

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 AAP Approved Lab Inspect QC Lab's Equipment Annually



5.2.7.1

3. Qualified Testing Laboratory

- Have Equipment/Materials for Tests
- Equipment Properly Maintained



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

4. EQUIPMENT CALIBRATION AND VERIFICATION

The QC laboratory shall have all significant testing equipment calibrated or verified that is associated with tests covered by the scope of this standard which the QC laboratory performs. Copies of all current equipment calibration records shall be maintained in a Quality Manual and stored in the laboratory. As a minimum, the equipment listed in **Table 2** shall be included if it is associated with tests performed by the QC laboratory. Applicable equipment shall be calibrated or verified at the intervals specified in the QC Laboratory's Quality Manual. The intervals specified in the Quality Manual shall be no greater than those indicated in **Table 2**. Newly acquired equipment without manufacturer's certification and equipment that has not been calibrated or verified because it has been removed from service shall be calibrated or verified before being placed in service. The QC laboratory shall have detailed written procedures for all in-house calibration and verification activities not addressed in standards. These procedures shall indicate the equipment required to perform the calibration or verification.

Certain items in **Table 2** can be verified by the contractor's QC certified technician. These items are; mechanical shakers, ovens, sieves and weighted foot.

NOTE: Example of a Laboratories Quality Manual will provide examples of equipment procedures to verify that equipment is in proper condition. Also, examples of records for calibrating/verifying equipment are presented.

5. TECHNICIAN CERTIFICATION

KDOT requires that all individuals be certified who perform one or more of the actual sampling testing and inspection functions for KDOT, Contractor or private laboratories. A certification program helps to ensure qualifications of sampling and testing personnel and increases pride in the work performed.

Certified sampling and testing personnel provide added assurances that the sampling and testing will be performed correctly and that the results will be valid.

The individuals performing any sampling and testing of materials must be knowledgeable in the sampling and testing procedures that have been specified by KDOT.

Certification programs recognized by KDOT should be one or more of the following:

Certified Inspector Training Program

For additional information concerning an acceptable certification program, contact the Bureau of Construction and Materials, CIT Program Administrator.

5.2.7.1

4. Equipment Calibration and Verification

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

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])	Check Physical Condition and Dimensions of Openings	6
Fine Sieves (openings < No. 4 [4.75 mm])	Check Physical Condition	6
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

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])	Check Physical Condition and Dimensions of Openings	6
Fine Sieves (openings < No. 4 [4.75 mm])	Check Physical Condition	6
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

NOTE: Section 5.2.7.2 of this manual, Guide for Quality Control and Acceptance Requirements for HMA, will help to define the minimum contents necessary for an acceptable Quality Control Plan.

Section 5.2.7.3 of this manual, Example of a Laboratories Quality Manual, will provide examples of equipment procedures to verify that equipment is in proper condition. Also, examples of records for calibrating/verifying equipment are presented

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 Increases

Sampling and Testing will be Done Correctly

Results will be valid

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

5.2.7.2. GUIDE FOR QUALITY CONTROL AND ACCEPTANCE REQUIREMENTS FOR HMA

1. Purpose

The purpose of this guide is to establish minimum requirements for the Contractor's quality control system for use in QC/QA Plan. It is intended that these requirements be used as a procedural guide in detailing the inspection, sampling and testing deemed necessary to maintain compliance with the specification requirements.

2. Scope

This procedure is applicable to the production and construction of HMA.

3. Requirements

3.1. General

As stated in the specifications, a Quality Control Plan must be developed by the producer and submitted in writing to the Engineer at the pre-construction conference. Acceptance of the Quality Control Plan by the Engineer will be contingent upon its conformance with these guidelines. For this reason, the plan shall clearly describe the methods by which the quality control program will be conducted. For example, the items to be controlled, tests to be performed, testing frequencies, sampling locations and techniques all shall be included and each item shall be listed separately. Also include a table stating what actions will occur when test results indicate specification limits are approached or exceeded. See **Table 1** at end of this guide for an example. Also, a detailed plan of action regarding disposition of non-specification material shall be included. Such a plan shall provide for immediate notification of all parties involved in the event nonconforming situations are detected. **Example 1. HMA Quality Control Plan** may be used as an example for a Quality Control Plan.

Inspection and testing records shall be maintained, kept current, and made available for review by KDOT personnel throughout the life of the Contract. All other documentation, such as date of inspections, tests performed, temperature measurements, and accuracy, calibration or re-calibration checks performed on production of testing equipment shall be recorded.

The Contractor shall maintain standard equipment and qualified personnel in accordance with Contract and specification requirements for the item(s) being produced.

3.2. Quality Control Plan

Operation Quality Control Plans shall be submitted for each Project to the District Engineer where the Project is located. Distribution of the approved Quality Control Plans will be made by the Engineer.

Section 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

5.2.7.3 EXAMPLE OF A LABORATORY QUALITY MANUAL

This example is designed to provide the contractor with general guidelines in creating and maintaining a contractor's Quality Manual. The QC process requires records for equipment calibrations/verifications. Maintaining records in an orderly manner will assist the District Materials Engineer in quickly determining if the laboratory meets QC/QA requirements. Having the field laboratory fully prepared and the Quality Manual properly maintained represent two items that can keep the start of a project on schedule. It also aids in demonstrating the contractor's commitment to the QC process.

The following records are presented to illustrate what is required in the Quality Manual. Records need not be exactly as illustrated but should supply all necessary information concerning the equipment calibration/verification.

NOTE: After calibrating any force-load testing equipment (stability machine, gyratory, etc.) a copy of the certification for the calibration device (proving ring, load cell, etc.) shall be attached to the calibration record.

NOTE: All equipment shall be verified immediately after repairs (this may include new or replacement parts, or mechanical or electrical adjustments) that may in any way affect the ability of the equipment to provide accurate readings as established during the calibration/verification process.

DISCLAIMER: It is not the intent of these guidelines to endorse manufacturers, suppliers, calibrating services, etc. The examples are used to provide guidance in establishing a thoroughly developed Quality Manual.

Section 5.2.7.3

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

Review

Who Does Quality Control?

Who Does Quality Verification?

Who Does Independent Assurance?

Why do we Sample, Test, and Inspect?

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

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

**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

HMA Base (*)(**)(***)
HMA Surface (*)(**)(***)
HMA Overlay (*)(**)(***)
HMA Pavement (#) (##)
HMA Pavement (#) Shoulder
Emulsified Asphalt (****)
Asphalt Core (Set Price)
Material for HMA Patching (Set Price)
Quality Control Testing (HMA)
*Mix Designation
**Grade of Asphalt Binder
***Shoulder
****Type and Grade of Emulsified Asphalt
Thickness
##Type of surface course HMA mixture

UNITS

Ton
Ton
Ton
Square Yard
Square Yard
Ton
Each
Ton
Ton

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.

602.2: CONTRACTOR QUALITY CONTROL REQUIREMENTS

... and now back to
SECTION 602
(SP 15-06007)

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

**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

HMA Base (*)(**)(***)
HMA Surface (*)(**)(***)
HMA Overlay (*)(**)(***)
HMA Pavement (#) (##)
HMA Pavement (#) Shoulder
Emulsified Asphalt (****)
Asphalt Core (Set Price)
Material for HMA Patching (Set Price)
Quality Control Testing (HMA)
*Mix Designation
**Grade of Asphalt Binder
***Shoulder
****Type and Grade of Emulsified Asphalt
Thickness
##Type of surface course HMA mixture

UNITS

Ton
Ton
Ton
Square Yard
Square Yard
Ton
Each
Ton
Ton

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.

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

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 Org Chart in Contractor's Lab
- 2) Certified Technicians
 - Process Control – SF category
 - Aggregate Field – AGF category
 - Aggregate Lab – AGL category
 - QC/QA Asp Spec – at Least 1 on Project
 - Profilograph – PO category
 - Nuclear Gauge – NUC Category

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 on a daily basis. 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}

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 to assure it is operating properly

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

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 furnished with:
 - Broadband internet connection (4 computers)
 - Air conditioner

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
 - Failing test results

- and N_{max} , voids in mineral aggregate (VMA), voids filled with asphalt (VFA) and dust to effective binder content (D/B) ratio; and
- **Copies of all failing test results** (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.

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 1/3 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 subplot 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 subplot 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 1/3 of the sample;
- supply 1/3 of the sample to the KDOT field laboratory for testing; and
- supply 1/3 of the sample to the KDOT District Materials Laboratory for testing.

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

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

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

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
 - 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

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

(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 subplot 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.

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"

602.2 CONTRACTOR QC REQUIREMENTS

i. Testing Requirements for Lots 2 and Greater

1) Random Samples

- Per approved 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

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

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

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

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



Sampling and Testing Frequency Chart (STFC)

Located in
Part V of the Construction Manual,
Appendix B (2016)

**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	1	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.

**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						
Individual Aggregates (continued)	Uncompacted Void Content of Coarse Aggregate (0.01%)	KT-80	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.
Mineral Filler Supplement	Sieve Analysis of Aggregate (1%, 0.1% for No. 200 [75 µm] sieve, of mass)	KT-02	c h	1 per 250 TONS (250 Mg).		1 during the first 5000 TONS (5000 Mg) of HMA produced.
	Plasticity Tests (0.01 g or 0.1% of mass)	KT-10	c h	1 per 250 TONS (250 Mg).		
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 (10,000 Mg).
	Uncompacted Void Content of Fine Aggregate (0.1%)	KT-50		1 on the first lot then 1 per 10,000 TONS (10,000 Mg) of combined aggregate.		1 during the first 5000 TONS (5000 Mg) 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	1 sample for every 3 loads. (CMS = VER)		
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 (5000 Mg) 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						
HMA Mixtures (continued)	Air Voids ($V_a = 0.01\%$; G_{mm} & $G_{mb} = 0.001$)	KT-15, KT-39, KT-58, & SF Manual		1 per subplot. (See code n for G_{mm})	j	1 per lot. [Compact split sample on KDOT Gyratory – 1 per week or every 15,000 TONS (15,000 Mg)]
	Binder Content (by ignition) (0.1 g or 0.01% of mass)	KT-57		1 per subplot.	j	1 per lot.
	Mix Gradation (after ignition) (0.1 g or 0.01% of mass)	KT-34		1 per subplot.		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 (10,000 Mg).		1 during the first 5000 TONS (5000 Mg) 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 (1000 Mg) of RAP.	j	1 during the first lot then 1 per 4000 TONS (4000 Mg) of RAP.
	RAP Gradation (after ignition) (0.1 g or 0.01% of mass)	KT-34		1 per 1000 TONS (1000 Mg) of RAP.		1 during the first 5000 TONS (5000 Mg) 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 (1000 Mg) of RAP + RAS.	j	1 during the first lot then 1 per 4000 TONS (4000 Mg) of RAP + RAS.
	RAS Gradation (after ignition) (0.1 g or 0.01% of mass)	KT-34		1 per 1000 TONS (1000 Mg) of RAP + RAS.		1 during the first 5000 TONS (5000 Mg) 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) (Use approved rolling procedure and Nuclear Density Gauge on all HMA roadway or shoulder construction less than 1.5 inches)	Field Density - Cores or Nuclear Density Gauge ($G_{mb} = 0.001$; 0.1 lb/ft ³ [1 kg/m ³] or 0.01% of G_{mm})	KT-15 or KT-32	i	10 tests per lot.	i	5 companion tests per lot.
	Field Density - Nuclear Density Gauge ($G_{mb} = 0.001$; 0.1 lb/ft ³ [1 kg/m 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 (3.7 m) 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 (1.5 km). (Sieve according to specification.)	k	1 per day.
	Percent Retained on the #200 (75 μ m) 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.)

SAMPLING AND TESTING FREQUENCY CHART
QUALITY CONTROL/QUALITY ASSURANCE SPECIFICATIONS

<u>CODE</u>	<u>INSTRUCTION</u>
a	The contractor may reduce the sampling and testing frequency to one test per 1,000 yd ³ (1,000 m 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 (4,000 Mg).
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 requirement of 1 test per 10,000 Tons (10,000 Mg).
e	Specification compliance will be determined on a producer basis not on a project basis. Producer and product testing frequency is maintained in CMS. 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-7, KT-8, and KT-35, respectively, at such frequencies as jointly deemed necessary by the Contractor and the District Materials Engineer.
i	For small lots [lots with less than 1,000 tons (1,000 Mg)], the number of tests may be reduced (see special provision).
j	Provide access to Contractor owned forced air ignition furnace, ovens, and Superpave Gyrotory compactor, as required, for the State Inspector to perform verification tests.

SAMPLING AND TESTING FREQUENCY CHART QUALITY CONTROL/QUALITY ASSURANCE SPECIFICATIONS

<u>CODE</u>	<u>INSTRUCTION</u>
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 (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. 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 2,000 Tons (2,000 Mg) 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 $\pm 0.5\%$ of the pre-production verification test. 3) Moistures obtained from the meter are used to adjust batch-to-batch moisture corrections.

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 subplot of production after obtaining the failing test results will be sampled and tested, regardless of any lesser frequency specified in this appendix.
- For the Construction Management System (CMS), Acceptance Sampling and Tests have been divided into two sections. Items called "ACC" will be Acceptance Tests and will have a quantity assigned. Items called "ACT" will be Acceptance Information Tests and they will normally have a quantity assigned, but not for payment. "ACC" tests make the assignment of tested materials to the contract or mix plant. "Type Insp" must = "ACC" when assignment of a pay quantity is being made. "ACT" when recording test values for additional acceptance information.
- For QUALITY CONTROL BY CONTRACTOR, CMS uses ACI or ACC unless otherwise noted. For VERIFICATION BY KDOT, CMS uses VER unless otherwise noted. For INDEPENDENT ASSURANCE BY KDOT, CMS 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.

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 subplot.

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
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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)

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	

INDIVIDUAL AGGREGATE

Columns 2&3 Tests Required (Record to) {Test Method}	Column 4 <u>Quality Control</u> by <u>Contractor</u>	Column 5 <u>Verification</u> by <u>KDOT</u>
Sieve Analysis of Aggregate (1%, 0.1% for the No. 200 [75 μ m] 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.		

INDIVIDUAL AGGREGATE

Columns 2&3 Tests Required (Record to) {Test Method}	Column 4 <u>Quality Control</u> by <u>Contractor</u>	Column 5 <u>Verification</u> by <u>KDOT</u>
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.		



INDIVIDUAL AGGREGATE

Columns 2&3

**Tests Required
(Record to)**

{Test Method}

**Uncompacted Void
Content of Fine
Aggregate (0.1%)
{KT-50}**

**Uncompacted Void
Content of Coarse
Aggregate (0.01%)
{AASHTO KT-80}**

Column 4

**Quality Control
by Contractor**

**I One on the first lot, then
one per 10,000 Tons
(10,000 Mg)
of crushed gravel**

**I One on the first lot, then
one per 10,000 Tons
(10,000 Mg)
of crushed gravel**

Column 5

**Verification
by KDOT**

**1 during the
first 5000 T of
HMA production**

I 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.

KT-50



KT-80



MINERAL FILLER SUPPLEMENT

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

COMBINED AGGREGATE

Columns 2&3 Tests Required (Record to) {Test Method}	Column 4 <u>Quality Control</u> by <u>Contractor</u>	Column 5 <u>Verification</u> by <u>KDOT</u>
Coarse Aggregate Angularity (0.1% of mass) {KT-31}	c One per Lot g	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

COMBINED AGGREGATE

Columns 2&3

Tests Required (Record to)

{Test Method}

Uncompacted Void
Content of Fine
Aggregate
(0.1%)
{KT-50}

Sand Equivalent Test
(1%)
{KT-55}

Column 4

Quality Control by Contractor

One on first lot
then one per
10,000 Tons
(10,000 Mg) of
comb. aggregate.

f One per Lot

Column 5

Verification by KDOT

1 during the first
5000 T of HMA
produced

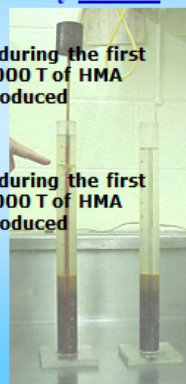
1 during the first
5000 T of HMA
produced

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



COMBINED AGGREGATE

Columns 2&3

Tests Required (Record to)

{Test Method}

Flat or Elongated
Particles (1%)
{KT-59}

Moisture Tests (0.1 g
or 0.01% of mass)
{KT-11}

Column 4

Quality Control by Contractor

One on first lot

One per Lot

Column 5

Verification by KDOT

1 during the first
5000 T of HMA

1 during the first
5000 T of HMA



ASPHALT MATERIAL

Columns 2&3

Tests Required (Record to)

{Test Method}

Sampling
{KT-26}

Column 4

Quality Control by Contractor

e One Sample Every 3
b Loads

Column 5

Verification by KDOT



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

HMA MIXTURES

Columns 2&3 Tests Required (Record to) {Test Method}	Column 4 <u>Quality Control</u> by <u>Contractor</u>	Column 5 <u>Verification</u> by <u>KDOT</u>
% 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 ($V_a = 0.01\%$, $G_{mm} = 0.001$ & $G_{mb} = 0.001$) {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.

HMA MIXTURES

Columns 2&3 Tests Required (Record to) {Test Method}	Column 4 <u>Quality Control</u> by <u>Contractor</u>	Column 5 <u>Verification</u> by <u>KDOT</u>
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.



HMA MIXTURES

Columns 2&3 Tests Required (Record to) {Test Method}	Column 4 <u>Quality Control</u> by <u>Contractor</u>	Column 5 <u>Verification</u> by <u>KDOT</u>
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).

RECLAIMED ASPHALT PAVEMENT (RAP)

Columns 2&3 Tests Required (Record to) {Test Method}	Column 4 <u>Quality Control</u> by <u>Contractor</u>	Column 5 <u>Verification</u> by <u>KDOT</u>
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.

RECYCLED ASPHALT SHINGLES (RAS)

Columns 2&3 Tests Required (Record to) {Test Method}	Column 4 <u>Quality Control</u> by <u>Contractor</u>	Column 5 <u>Verification</u> by <u>KDOT</u>
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.

COMPLETED ROAD WORK

Columns 2&3
Tests Required
(Record to)
{Test Method}

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

Column 4
Quality Control
by Contractor

i 10 Tests per Lot

Column 5
Verification
by KDOT

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)



Review

Who Tests the Pre-Production Sample?

What Type of Sample is the Pre-Production Sample?

Where is the Sampling and Testing Frequency Chart?

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

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

QC/QA Asphalt Specifications Special Provision 15-06007-R01 Outline

- 602.1 Description (Sheet 1 of 29)
- 602.2 Contractor QC Requirements
(Sheets 1 to 4 of 29)
- 602.3 Materials (Sheets 4 to 8 of 29)**
- 602.4 Construction Requirements (Sheets 4 to 14 of 29)
- 602.5 Process Control (Sheets 14 to 16 of 29)
- 602.6 Compaction Testing (Sheets 16 to 18 of 29)
- 602.7 Weather Limitations (Sheet 18 of 29)
- 602.8 Mixture Acceptance (Sheets 18 to 21 of 29)
- 602.9 Basis of Acceptance (Sheets 21 to 24 of 29)
- 602.10 HMA Paid by the Area (Sheets 24 to 28 of 29)
- 602.11 Measurement and Payment (Sheets 28 to 29 of 29)

(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 subplot 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.

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**

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



602.3 MATERIALS

a. Asphalt Binder

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



**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

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
 - i. ~~Asphalt Cement (AC)~~ (removed by 15-12001-R01)
- 1201.3 - Test Methods
- 1201.4 - Prequalification
- 1201.5 - Basis of Acceptance

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 $\Delta T_c \geq -5.0^\circ\text{C}$ 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.

1202.4 PREQUALIFICATION

Prequalify material according to **SECTION 1201**.

1202.5 BASIS OF ACCEPTANCE

See applicable requirements under **SECTION 1201**.

602.3 MATERIALS

a. Asphalt Binder

- **Section 1202 and SP 15-12002**

- 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 82-28
 - Separation (Max) is 2
 - Elastic Recovery is specified.
 - $\Delta T_c \geq -5.0$ (new requirement)
- Perform all tests after adding 0.5% high molecular weight amine antistripping agent to the PGAB. (Why?)

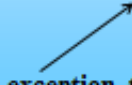
602.3 MATERIALS

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

602.3 MATERIALS

Shoulder Binder Changes

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

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)

15-06007-5

b. Reclaimed Asphalt Pavement (RAP) and Recycled Asphalt Shingles (RAS). Provide RAP and RAS that comply with **SECTION 1103**.

15-11002-R01-2

15-11002-R01-3

1103.2a.

(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 1/4 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 1103-1: 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

602.3 MATERIALS

**b. Reclaimed Asphalt Pavement (RAP).
Fractionated RAP (FRAP).
Recycled Asphalt Shingles (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 2 1/4" Grizzly

602.3 MATERIALS

**b. Reclaimed Asphalt Pavement (RAP).
Fractionated RAP (FRAP).
Recycled Asphalt Shingles (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

SECTION 1101

GENERAL REQUIREMENTS FOR AGGREGATES

c. Certification of Aggregates. Provide the Engineer a certification for each classification of aggregate utilized in a project.

(1) Aggregates Delivered to the Site: **Certify each classification of aggregate delivered to a project or product preparation site.** Prepare these certifications under the signature of the aggregate producer or their designated representative.

(a) Certify aggregates that are tested at their destination to determine final disposition as to the locations of the deposits from which they were produced.

(b) Certify aggregates that are tested at their production site to determine final disposition. These certifications state that the aggregates were removed from a KDOT tested and approved stockpile at the production site, or that they were removed from a plant while it was producing aggregate that was in compliance with the applicable specifications.

(2) Aggregates Incorporated into the Project: At locations where aggregates and products that incorporate aggregates are produced for KDOT and non-KDOT use, provide certifications stating that only KDOT tested and approved aggregate were provided for KDOT projects.

(3) Frequency of Certification:

(a) **Before the initial delivery of aggregates to a project or product preparation site, provide the Engineer a certification.** This certification is to be under the signature of the aggregate producer or their designated representative and states that all aggregates to be provided for the project are in compliance with all the applicable KDOT specifications.

(b) **Upon completion of the project, provide certifications as specified in 1101.2c.(1),(2) to the Engineer.** These certifications apply to all aggregates that were delivered to the project or product preparation site and ultimately used in the project.

These certifications are to indicate the approximate quantities in tons or cubic yards of each aggregate delivered to the project and the approximate quantities in tons or cubic yards of each aggregate delivered to the product preparation site and incorporated into a product that was utilized in the project.

(4) Certification Requirement for Chat: Sellers of chat must complete and submit the Chat User's Certificate within 30 days of the date of acquisition. The certification will contain the following information: location of origin of the chat, amount of chat acquired, and a certification that the chat will be used in accordance with the criteria of Chat Rule, 40 Code of Federal Regulations (CFR) Part 278. The certification should be submitted to both the Kansas Department of Health and Environment (KDHE) and to the Bureau of Construction and Materials. If the chat is sold or otherwise transferred to another party, the seller shall provide a copy of the certification to the new owner of the chat. The initial or any subsequent acquirer of chat will maintain copies of the following for a minimum of 3 years: a) a copy of the certification following transmittal to KDHE, and, as appropriate, b) any Synthetic Precipitation Leaching Procedure testing results, or c) any site specific risk assessments.

1101.3 TEST METHODS

Test all aggregates in accordance with the applicable methods cited in **SECTION 1115.**

1101.4 PREQUALIFICATION

With the exception of Lightweight (expanded shale) Aggregate, aggregates from each source require "Official Quality" testing on samples obtained by an authorized representative of KDOT before use on KDOT projects. These samples are taken from actual production, which may be "pit-run", "crusher-run" or may involve some processing. Approved sources remain approved only if there are no major changes in the production methods or deposit characteristics.

Lightweight (expanded shale) Aggregate must be prequalified. In-state producers wishing to get their product prequalified must submit a written request to the District Materials Engineer for the District in which the production facility is located. Out-of-state producers must submit their written request to the Engineer of Tests. In the request, the producer must specify whether they want the material to be used for Modified Lightweight Aggregate [**subsection 1102.2.e.(2)**] or for Cover Material (**subsection 1109**). Samples will be collected by KDOT and tested for compliance with applicable specifications. Lightweight aggregates that comply with all applicable requirements

1100-1

1100-2

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

**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**.

(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 42 and 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.

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

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 (1,2,4,7) – (Cement, Crushed Stone, Hydrated Lime, and Processed Chat Sludge)

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		Schoepel		SW 1/4 S16 T15S R25W		00833501		Trego																																																																																																										
PG64-22				Sinclair, P-Burg (WYO)				00002603																																																																																																												
Total		100.00																																																																																																																		
<table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <thead> <tr> <th>Aggr. Desig.</th> <th>% in Mix</th> <th>1</th> <th>3/4</th> <th>1/2</th> <th>3/8</th> <th>#4</th> <th>#8</th> <th>#16</th> <th>#30</th> <th>#50</th> <th>#100</th> <th>#200</th> </tr> </thead> <tbody> <tr> <td>CG-1</td> <td>5.000</td> <td></td> <td></td> <td>0</td> <td>30</td> <td>96</td> <td>97</td> <td>98</td> <td>98</td> <td>99</td> <td>99</td> <td>99.5</td> </tr> <tr> <td>CG-2</td> <td>5.000</td> <td></td> <td></td> <td></td> <td>0</td> <td>9</td> <td>39</td> <td>59</td> <td>71</td> <td>79</td> <td>88</td> <td>92.8</td> </tr> <tr> <td>CG-4</td> <td>23.000</td> <td></td> <td></td> <td>0</td> <td>6</td> <td>38</td> <td>61</td> <td>74</td> <td>82</td> <td>86</td> <td>89</td> <td>92.5</td> </tr> <tr> <td>CG-5</td> <td>30.000</td> <td></td> <td></td> <td>0</td> <td>1</td> <td>11</td> <td>35</td> <td>67</td> <td>82</td> <td>90</td> <td>95</td> <td>96.4</td> </tr> <tr> <td>SSG-1</td> <td>35.000</td> <td></td> <td></td> <td></td> <td>0</td> <td>7</td> <td>29</td> <td>56</td> <td>78</td> <td>95</td> <td>99</td> <td>99.3</td> </tr> <tr> <td>MFS-1</td> <td>2.000</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>0</td> <td>2</td> <td>3</td> <td>5</td> <td>10</td> <td>16.0</td> </tr> <tr> <td>Total</td> <td>100.00</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> </tbody> </table>													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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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%																																																																													
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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																																																																																
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Total	100.00																																																																																									

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												

(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%

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

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-6. 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-6 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.

602.3 MATERIALS

d. Combined Aggregates.

- Table 602-1 (Mixes)
- Tables 1103-1 and 1103-2 (Individual Aggs)
- < 0.5% Moisture in HMA
- CSSL \leq 50% (Repeat from Section 1103)
- and ...

602.3 MATERIALS

d. Combined Aggregates.

No More than 35% Natural Sand is Permitted in Traveled Way Mixes.



Review

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

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

What defines a natural sand?

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

What is the maximum % moisture permitted in HMA?

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-6. 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-6 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 602-2: 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 3.5% to 4.5%.
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-6	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.

602.3 MATERIALS

e. Contractor Trial Mix Design.



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

602.3 MATERIALS

TABLE 602-2: MIX PROPERTIES

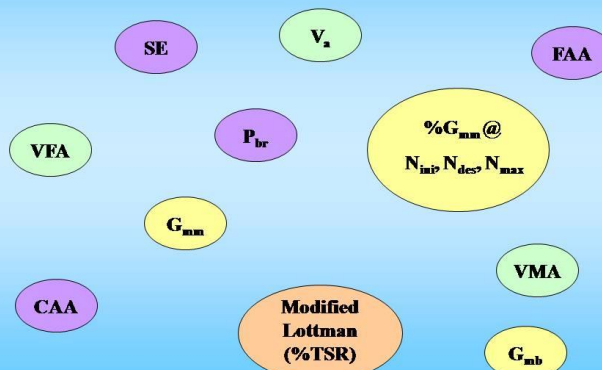


TABLE 602-3: MATERIAL SUBMITTALS			
Submittal	Quantity	Description	Additional Information
Aggregate for KT-15	3 Samples	Sized for 6 inch Plugs	Comply with Job Mix Gradation.
Aggregate for KT-39	2 Samples	Sized for G_{mm} Testing	Comply with Job Mix Gradation.
Binder for KT-15	As Needed	Sized for 3 Plugs at P_{br}	
Binder for KT-39	As Needed	Sized for 2 G_{mm} Tests	
Each Aggregate for KT-6	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 602-6: 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.

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.

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**

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.

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.

602.3e. (last Paragraph)

For each aggregate used in the mix design, determine the specific gravity using KT-6. 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-6 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.

602.3f.

f. Additives. Provide Warm Mix Asphalt (WMA) additives or processes that comply with SECTION 1203. 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.

15-06007-R01-7

15-06007-R01-5

15-06007-R01-8

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

December 2016 LETTING							
PROCEDURE I SPECIFIC GRAVITIES							
Producer	CMS ID Producer	Location	Bulk Dry (Gib)	Saturated Surf Dry	Apparent	Percent Absorb	Date Modified or Verified
Allied Inc	811604	Ellis Co	2.579	2.609	2.658	1.2	November 1, 2015
Alsop	811105	Cloud Co.	2.538	2.565	2.603	1.0	July 1, 2015
Alsop	811107	Dickinson Co.	2.556	2.611	2.705	2.2	December 1, 2013
Alsop	811114	Republic Co.	2.518	2.559	2.627	1.7	November 1, 2015
Anchor Stone (WESW)	836402	Jasper Co. MO	2.532	2.584	2.672	2.1	February 1, 2016
APAC (FRLY)	804008	Miami Co	2.603	2.615	2.692	1.4	September 1, 2016
APAC (FRLYARG)	804008	Miami Co	2.402	2.515	2.709	4.7	January 1, 2015
APAC (FRLYARG)	804008	Miami Co	2.533	2.595	2.703	2.5	August 1, 2016
APAC Kansas	810903	Ford Co.	2.578	2.602	2.641	0.9	September 1, 2013
APAC Kansas	826003	Lincoln Co.	2.604	2.630	2.674	1.0	March 1, 2016
APAC Kansas (CPCK)	803705	Johnson Co.	2.532	2.599	2.716	2.7	July 1, 2015
APAC Kansas (FRLY Ledge)	803705	Johnson Co.	2.610	2.653	2.727	1.6	May 19, 2016
APAC Kansas (STNK)	803903	Johnson Co.	2.570	2.621	2.704	2.0	October 1, 2015
APAC-Shears	801934	Reno Co.	2.560	2.583	2.653	0.9	August 1, 2015
APAC-Shears (HMFJ)	801935	Coffey Co.	2.566	2.621	2.715	2.1	May 1, 2015
Associated	819904	Sumner County	2.557	2.581	2.621	0.9	September 1, 2013
Associated	819905	Sedgwick County	2.554	2.578	2.618	1.0	January 1, 2016
Bayer Const Co.	801830	Geary Co.	2.546	2.611	2.715	2.4	November 1, 2015
Bayer Const Co. (TRKO)	802449	Riley Co.	2.515	2.584	2.703	2.8	November 1, 2015
Bayer Crushed Rock Co (BFLS)	806901	Cass Co. MO	2.545	2.595	2.677	1.9	May 1, 2016
Bingham (Sooner Pile)	821812	Ottawa Co. OK	2.525	2.572	2.648	1.8	November 1, 2014
Bladen Sand	823802	Franklin Co. NE	2.581	2.597	2.619	0.6	February 1, 2015
Blue River Sand	805404	Marshall Co.	2.559	2.584	2.624	1.0	November 1, 2014

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

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				0	0-5	0-10		40-70	88.0-94.0	16.0	0.9 – 2.0
SR-4.75A			0	0-2	0-5	0-10		40-70	88.0-94.0	16.0	0.9 – 2.0
SM-9.5A				0	0-10	10 min.	33-53		90.0-98.0	15.0	0.6 – 1.2
SR-9.5A			0	0-2	0-10	10 min.	33-53		90.0-98.0	15.0	0.6 – 1.2
SM-9.5B				0	0-10	10 min.	53-68		90.0-98.0	15.0	0.8 – 1.6
SR-9.5B			0	0-2	0-10	10 min.	53-68		90.0-98.0	15.0	0.8 – 1.6
SM-9.5T				0	0-10	10 min.	53-68		90.0-98.0	15.0	0.8 – 1.6
SR-9.5T			0	0-2	0-10	10 min.	53-68		90.0-98.0	15.0	0.8 – 1.6
SM-12.5A			0	0-10	10 min.		42-61		90.0-98.0	14.0	0.6 – 1.2
SR-12.5A		0	0-2	0-10	10 min.		42-61		90.0-98.0	14.0	0.6 – 1.2
SM-12.5B			0	0-10	10 min.		61-72		90.0-98.0	14.0	0.8 – 1.6
SR-12.5B		0	0-2	0-10	10 min.		61-72		90.0-98.0	14.0	0.8 – 1.6
SM-19A		0	0-10	10 min.			51-65		92.0-98.0	13.0	0.6 – 1.2
SR-19A	0	0-2	0-10	10 min.			51-65		92.0-98.0	13.0	0.6 – 1.2
SM-19B		0	0-10	10 min.			65-77		92.0-98.0	13.0	0.8 – 1.6
SR-19B	0	0-2	0-10	10 min.			65-77		92.0-98.0	13.0	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 4.0% 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 98.0% of the G_{mm} .

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 3.5% to 4.5%.
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-6	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 602-1

COMBINED AGG 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

TABLE 602-1

COMBINED AGG 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

**TABLE 602-1
COMBINED AGG 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)

**TABLE 602-1
COMBINED AGG REQUIREMENTS**

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

**TABLE 602-1
COMBINED AGG 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

Superpave Volumetric Properties

VMA

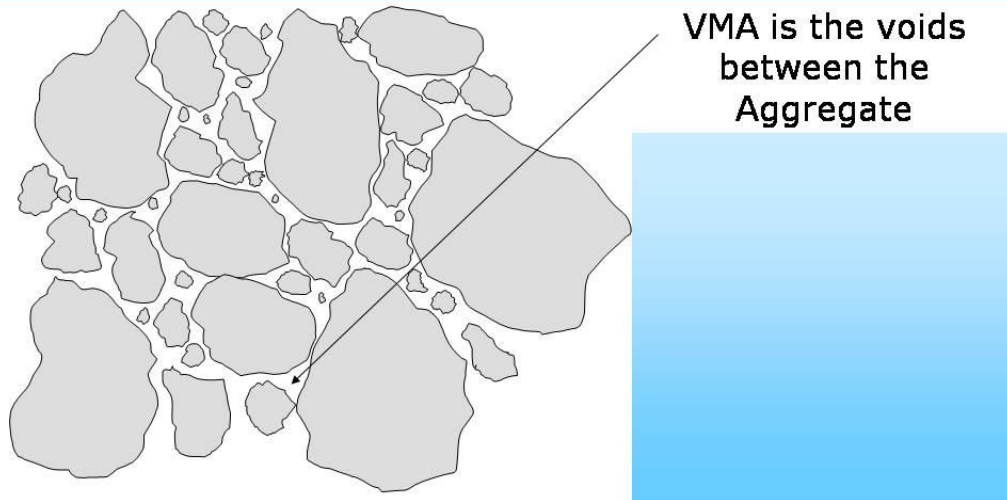


TABLE 602-1 COMBINED AGG REQUIREMENTS

6 Notes follow Table 602-1

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

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

SECTION 602

MODIFIED REQUIREMENTS – ASPHALT MIXTURES

Project Number: 160-88 KA-4202-01

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 (PG64-22)⁽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	2.598
COMPACTION REVOLUTIONS:	
N _{ini} (level of compaction)	7 (≤ 90.5)
N _{des}	75
N _{max}	115
MIX:	
VFA	65 - 78

- ⁽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 (PG64-22).

Percent RAP	Name
0	SM-12.5A (PG64-22)
1 - 15	SR-12.5A (PG64-22)
16 - 25	SR-12.5A (PG58-28)

For information only, the 20 year design lane traffic is 1.7 million ESALs.

8/4/15 C&M (BTH)

TABLE 602-1: Note 1

Special Provision 15-MR0008

TABLE 1: Project Mix Requirements

MIX CRITERIA	SR-12.5A (PG 64-22)
AGGREGATE:	
Coarse Angularity (min. %)	75
Uncompacted Voids- Fine (min.%)	42
Sand Equivalent (min.%)	40
RAP (max.%)	25
RAP Bulk Specific Gravity	2.598
COMPACTION REVOLUTIONS:	
N _{ini} (level of compaction)	7 (≤ 90.5)
N _{des}	75
N _{max}	115
MIX:	
VFA	65 - 78

TABLE 602-1: Note 1

Special Provision 15-MR0008

TABLE 1: Project Mix Requirements

MIX CRITERIA	SR-12.5A (PG 64-22)
AGGREGATE:	
Coarse Angularity (min. %)	CAA \geq 75
Uncompacted Voids- Fine (min.%)	FAA \geq 42
Sand Equivalent (min.%)	SE \geq 40
RAP (max.%)	25
RAP Bulk Specific Gravity	2.598
COMPACTION REVOLUTIONS:	
N _{ini} (level of compaction)	7 (≤ 90.5)
N _{des}	75
N _{max}	115
MIX:	
VFA	65 - 78

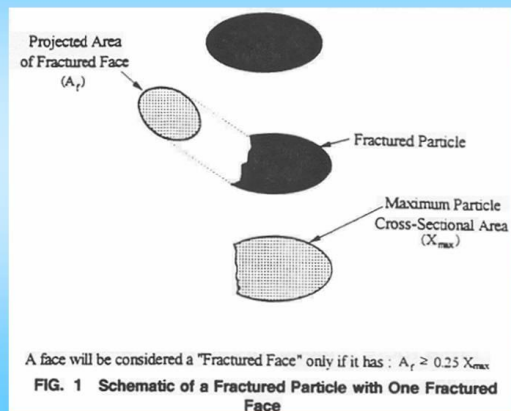
Coarse Aggregate Angularity (CAA)



Coarse Aggregate Angularity (CAA)



Coarse Aggregate Angularity (CAA) (KT-31)

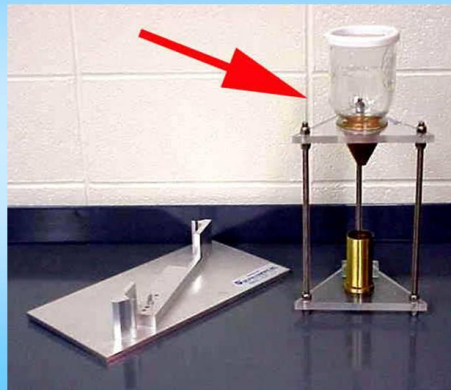


Fine Aggregate Angularity (FAA)



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

Fine Aggregate Angularity (FAA) (KT-50)



Sand Equivalent (SE) (KT-55)

Clay Reading after 20 min.
Then Sand Reading
Ratio of Sand over Clay *100
Higher the Better



TABLE 602-1: Note 1

Special Provision 15-MR0008

TABLE 1: Project Mix Requirements

MIX CRITERIA	SR-12.5A (PG 64-22)
AGGREGATE:	
Coarse Angularity (min. %)	CAA \geq 75 (KT-31)
Uncompacted Voids- Fine (min.%)	FAA \geq 42 (KT-50)
Sand Equivalent (min.%)	SE \geq 40 (KT-55)
RAP (max.%)	25
RAP Bulk Specific Gravity	2.598
COMPACTION REVOLUTIONS:	
N _{ini} (level of compaction)	7 (\leq 90.5)
N _{des}	75
N _{max}	115
MIX:	
VFA	65 - 78

TABLE 602-1: Note 1

Special Provision 15-MR0008

TABLE 1: Project Mix Requirements

MIX CRITERIA	SR-12.5A (PG 64-22)
AGGREGATE:	
Coarse Angularity (min. %)	75
Uncompacted Voids- Fine (min.%)	42
Sand Equivalent (min.%)	40
RAP (max.%)	25
RAP Bulk Specific Gravity	2.598
COMPACTION REVOLUTIONS:	
N _{ini} (level of compaction)	7 (\leq 90.5)
N _{des}	75
N _{max}	115
MIX:	
VFA	65 - 78

TABLE 602-1: Note 1

Special Provision 15-MR0008

TABLE 1: Project Mix Requirements

MIX CRITERIA	SR-12.5A (PG 64-22)
AGGREGATE:	
Coarse Angularity (min. %)	75
Uncompacted Voids- Fine (min.%)	42
Sand Equivalent (min.%)	40
RAP (max.%)	25
RAP Bulk Specific Gravity	2.598
COMPACTION REVOLUTIONS:	
N_{ini} (level of compaction)	7 (≤ 90.5)
N_{des}	75
N_{max}	115
MIX:	
VFA	65 - 78

TABLE 602-1: Note 1

Compaction Revolutions

Traffic (10^6 ESALs)	N_{ini}	N_{des}	N_{max}
< 0.3	6	50	75
0.3 to < 3.0	7	75	115
3.0 to < 30.0	8	100	160
≥ 30.0	9	125	205

May see them written as:

6, 50, 75 7, 75, 115 8, 100, 160 9, 125, 205

TABLE 602-1: Note 1

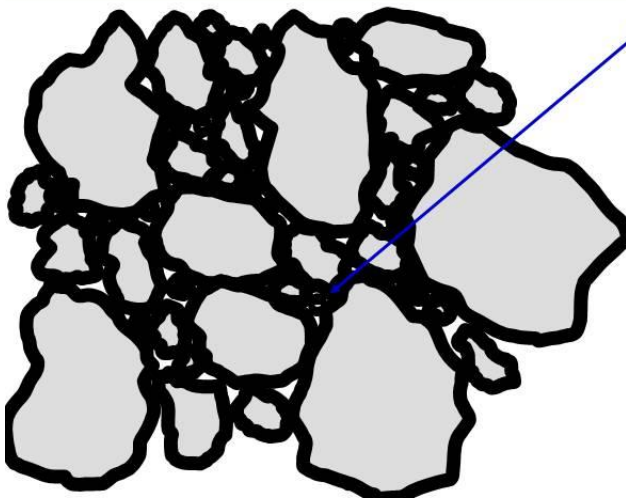
Special Provision 15-MR0008

TABLE 1: Project Mix Requirements

MIX CRITERIA	SR-12.5A (PG 64-22)
AGGREGATE:	
Coarse Angularity (min. %)	75
Uncompacted Voids- Fine (min.%)	42
Sand Equivalent (min.%)	40
RAP (max.%)	25
RAP Bulk Specific Gravity	2.598
COMPACTION REVOLUTIONS:	
N _{ini} (level of compaction)	7 (≤ 90.5)
N _{des}	75
N _{max}	115
MIX:	
VFA	65 - 78

Superpave Volumetric Properties

VFA



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

We want 65%-78% for this project

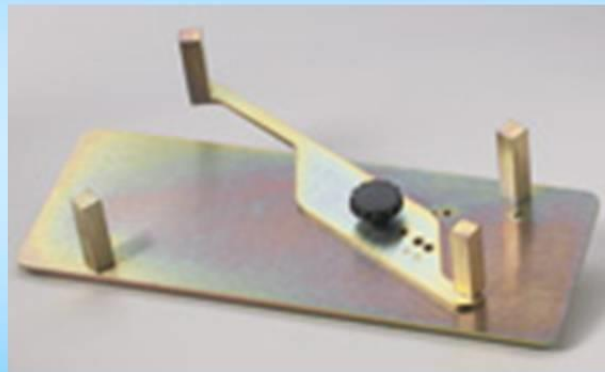
TABLE 602-1 COMBINED AGG REQUIREMENTS

6 Notes follow Table 602-1

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

TABLE 602-1: Note 2

Flat and Elongated (KT-59) $\leq 10\%$



Proportional Caliper Device

TABLE 602-1 COMBINED AGG REQUIREMENTS

6 Notes follow Table 602-1

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

TABLE 602-1 COMBINED AGG REQUIREMENTS

6 Notes follow Table 602-1

1. Look at Contract Special Provision for more Mix Requirements.
2. Flat and Elongated (KT-59) $\leq 10\%$
3. Maximum Moisture in Mix (KT-11) $\leq 0.5\%$
4. **Target Air Voids at $N_{des} = 4.0\%$**
5. TSR (KT-56) $\geq 80\%$
6. **Level of Compaction at $N_{max} < 98.0\% G_{mm}$**

TABLE 602-1: Notes 4 & 6

Target Air Voids at $N_{des} = 4.0\%$
Level of Compaction at $N_{max} < 98.0\% G_{mm}$



Compact the HMA plugs
per KT-58



Weigh the plugs
per KT-15

TABLE 602-1 COMBINED AGG REQUIREMENTS

6 Notes follow Table 602-1

1. Look at Contract Special Provision for more Mix Requirements.
2. Flat and Elongated (KT-59) $\leq 10\%$
3. Maximum Moisture in Mix (KT-11) $\leq 0.5\%$
4. Target Air Voids at $N_{des} = 4.0\%$
- 5. TSR (KT-56) $\geq 80\%$**
6. Level of Compaction at $N_{max} < 98.0\% G_{mm}$

TABLE 602-1: Note 5

Tensile Strength Ratio (TSR) (KT-56) $\geq 80\%$
Lottman Test

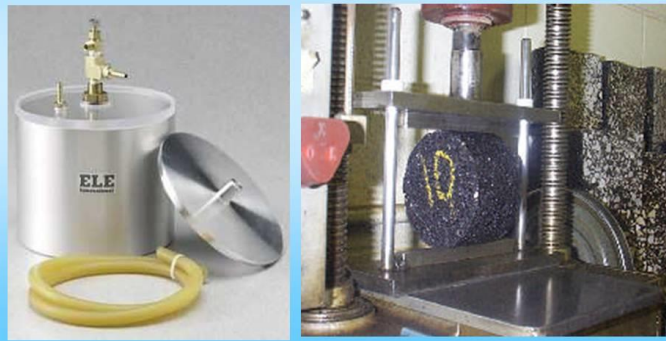


TABLE 602-1 COMBINED AGG REQUIREMENTS

6 Notes follow Table 602-1

1. Look at Contract Special Provision for more Mix Requirements.
2. Flat and Elongated (KT-59) $\leq 10\%$
3. Maximum Moisture in Mix (KT-11) $\leq 0.5\%$
4. Target Air Voids at $N_{des} = 4.0\%$
5. TSR (KT-56) $\geq 80\%$
6. Level of Compaction at $N_{max} < 98.0\% G_{mm}$

Review

When is the Mix Design due to the DME?

What table has gradations and the VMA requirements?

Where is the max. permitted % of RAP stated?

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

What is the minimum TSR% requirement?

Where are the required number of SGC gyrations stated?

QC/QA Asphalt Specifications Special Provision 15-06007-R01 Outline

- 602.1 Description (Sheet 1 of 29)
- 602.2 Contractor QC Requirements (Sheets 1 to 4 of 29)
- 602.3 Materials (Sheets 4 to 8 of 29)
- 602.4 Construction Requirements
(Sheets 4 to 14 of 29)**
- 602.5 Process Control (Sheets 14 to 16 of 29)
- 602.6 Compaction Testing (Sheets 16 to 18 of 29)
- 602.7 Weather Limitations (Sheet 18 of 29)
- 602.8 Mixture Acceptance (Sheets 18 to 21 of 29)
- 602.9 Basis of Acceptance (Sheets 21 to 24 of 29)
- 602.10 HMA Paid by the Area (Sheets 24 to 28 of 29)
- 602.11 Measurement and Payment (Sheets 28 to 29 of 29)

602.4 CONSTRUCTION REQUIREMENTS

- a. Plant Operations**
- 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**

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 1203**. 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.

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 antistrip in line with AC going from 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

(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 340°F 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) Batch Operation. Coordinate HMA batchers (Gob Hoppers) with the plant production rate at all times so the hopper is more than $\frac{3}{4}$ 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, 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.

602.4 CONSTRUCTION REQUIREMENTS

a. Plant Operation.

2) Preparation of Mineral Aggregate

a) Temperature Requirements

- Dry the Aggregates
- No Mixing or Compacting above 340°F
- Deliver HMA to Paver at a sufficient temperature for:
- Compaction to the specified density
- Meet Surface Tolerance Requirement



602.4 CONSTRUCTION REQUIREMENTS

a. Plant Operation.

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

- Air temperature (morning startup) < 70°F.
 - May run plant 10°F warmer than mixing temperature printed on the asphalt bill of lading
 - Temperature shall not exceed 350°F.
- 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 340°F.

(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 340°F 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 $\frac{3}{4}$ 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, 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.

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 $\frac{3}{4}$ full before opening gates
 - Close Gates before HMA flows directly to surge bin
- e) Wasted Material - Measured not for Pay

4.0 CONSTRUCTION REQUIREMENTS

Segregation Issues

The Gob Hopper (Correct Discharge)



Open when $\geq \frac{3}{4}$ full

4.0 CONSTRUCTION REQUIREMENTS

Segregation Issues

The Gob Hopper (Flowing Partially)



Close before material can pass directly through the Gob Hopper

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

(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.

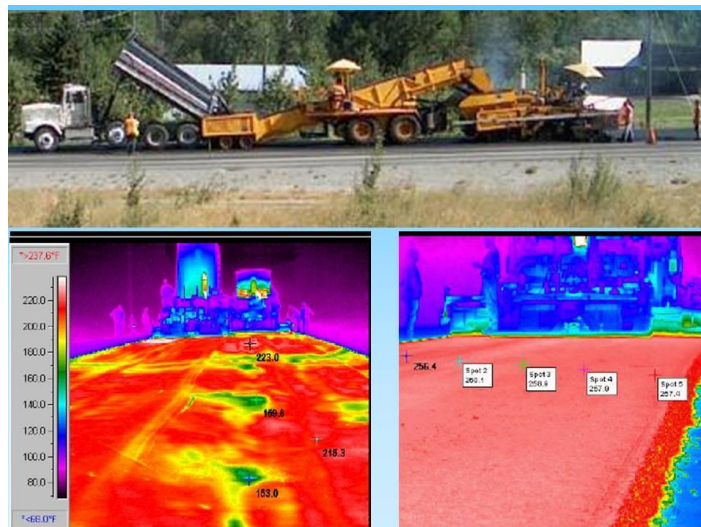
The Engineer will check segregation and uniformity of density using methods outlined in Section 5.8.3 - Segregation Check Using the Nuclear Density Gauge, Part V. For shoulders with a plan width of less than or equal to 3 feet, and placed at the same time as the traveled way, do not take nuclear density 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.

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, SM-9.5A & SR-9.5A excluded (unless segregation is observed)



602.4 CONSTRUCTION REQUIREMENTS

e. Paving Operations.

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



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 than 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

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

602.4 CONSTRUCTION REQUIREMENTS

Longitudinal Segregation

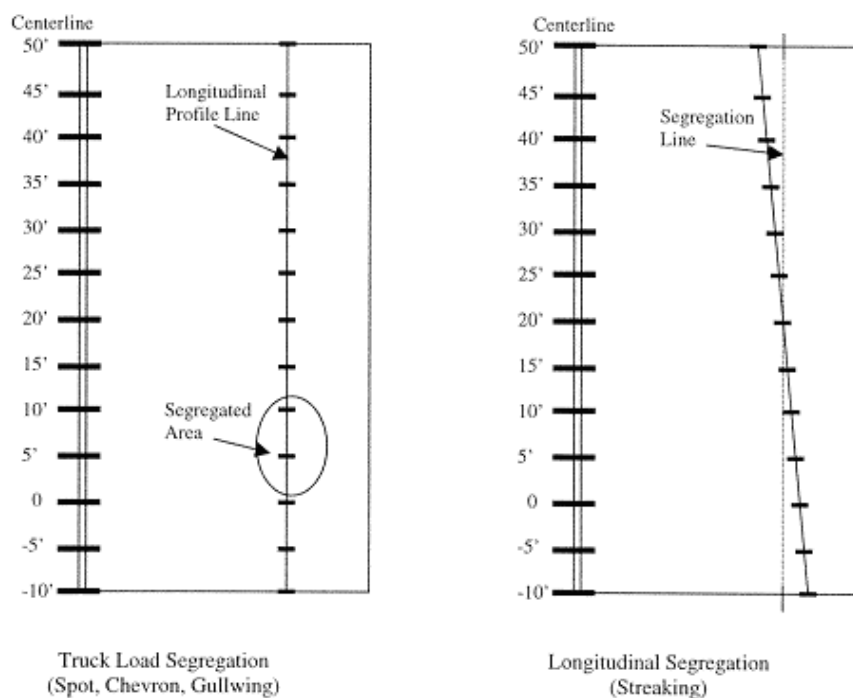


602.4 CONSTRUCTION REQUIREMENTS

Segregation Issues

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

FIGURE 1: SEGREGATION PROFILE LOCATION



Locate profile as follows:

- 1) Mark location where paver stops.
- 2) Determine worst visible segregated area.
- 3) Take profile through area staying at least 0.6 m (2 ft.) from centerline or edge of pavement.

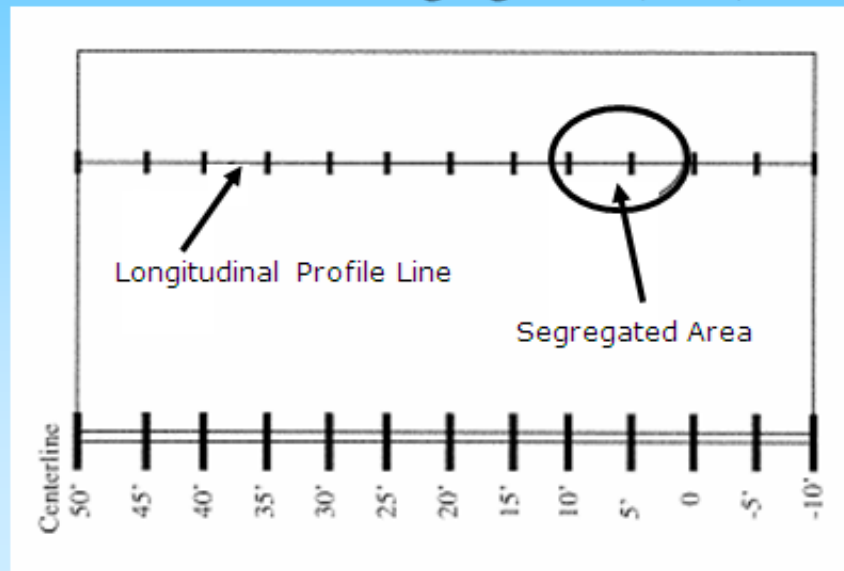
Locate profile as follows:

- 4) Determine worst longitudinal segregated area.
- 5) Take profile at an angle (offset from each end by 0.6 m or 2 ft.)
- 6) Keep ends of profile more than 0.3 m (1 ft.) From edge of paved section.

602.4 CONSTRUCTION REQUIREMENTS

Segregation Issues

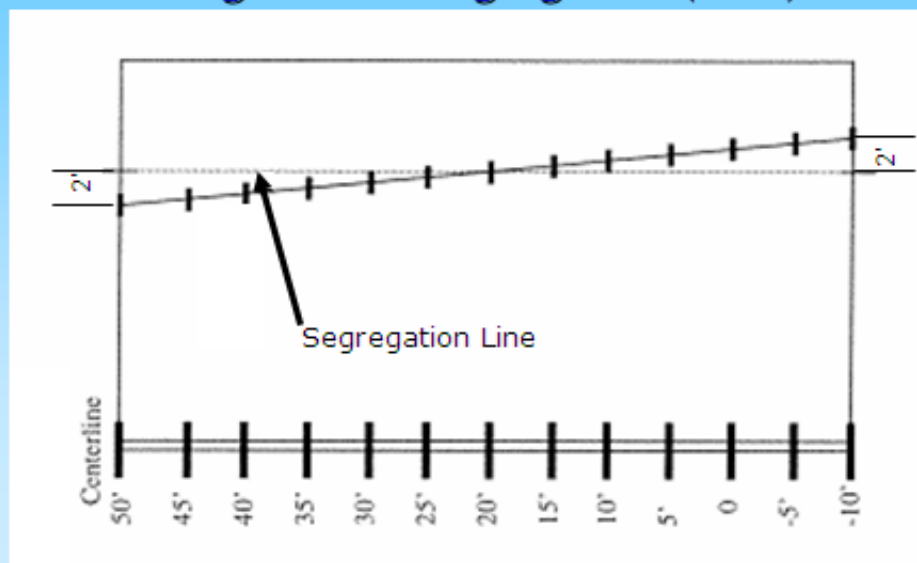
Truck Load Segregation (5.8.3)



602.4 CONSTRUCTION REQUIREMENTS

Segregation Issues

Longitudinal Segregation (5.8.3)



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/ft³ (16 kg/m³) 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.

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

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.

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

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	$\geq 90.00\%$ 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.

- 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.
- Reference Shoe. Attach a short reference shoe or joint matching device to the paver for control in matching surface grades along longitudinal joints.
- 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.
- 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.

602.4 CONSTRUCTION REQUIREMENTS

Segregation Issues Acceptable Criteria

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.

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

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 subplot approximately the same length. Randomly select one longitudinal location within each subplot.

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 subplot 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 subplot. (Second subplot evaluated before fourth subplot compaction completed. Third subplot evaluated before fifth subplot completed.)

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
≥ 4,001'	5

602.4 CONSTRUCTION REQUIREMENTS

Joint Density

1st sublot tested before
3rd sublot compacted

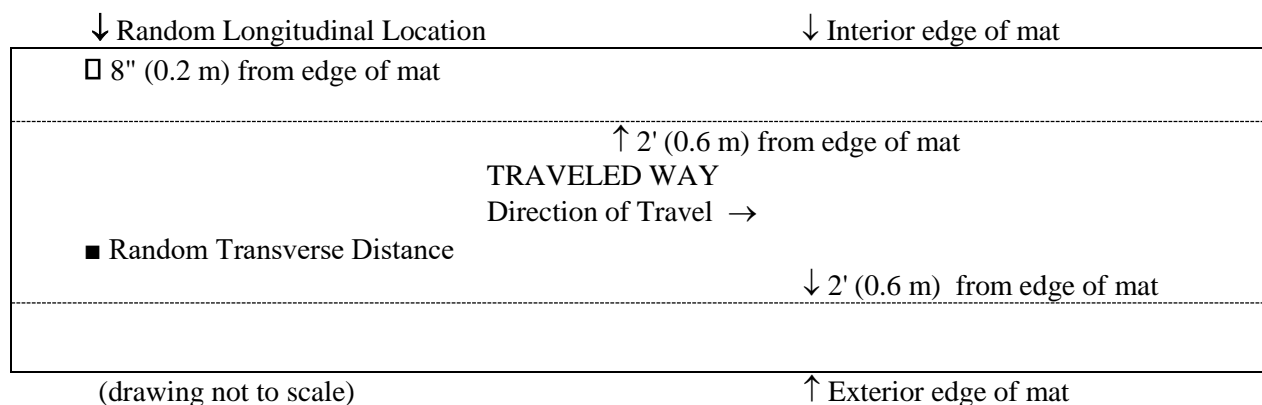
2nd sublot tested before
4th sublot compacted

3rd sublot tested before
5th sublot compacted



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.



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

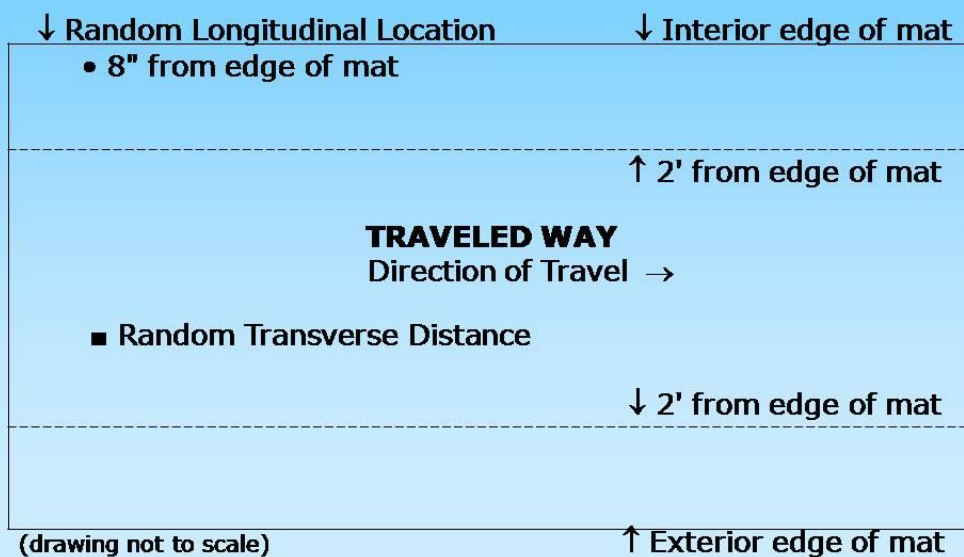
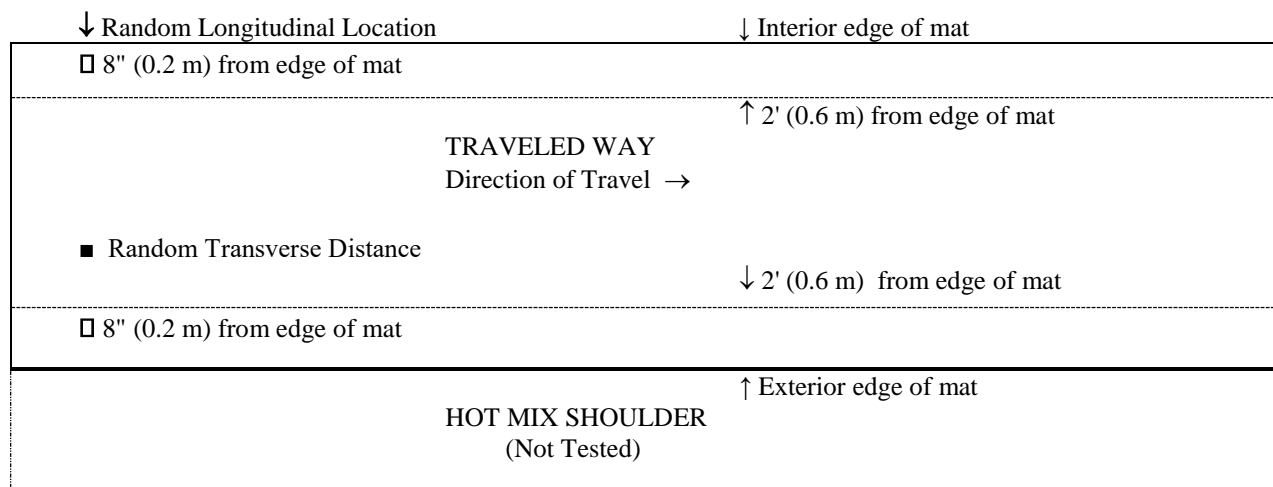


Figure 1A- Traveled Way Without Hot Mix Shoulders or Shoulders Placed at The Same Time



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.)

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

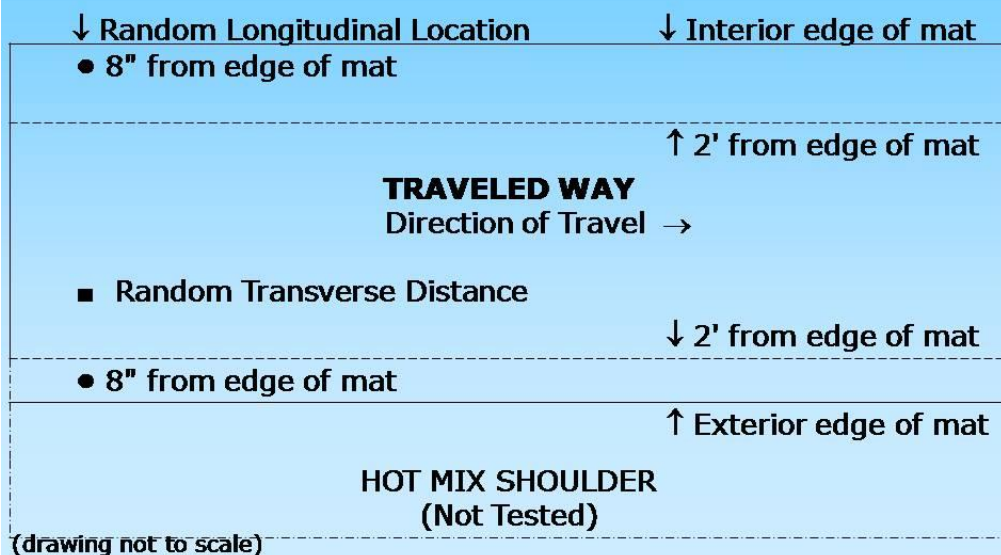
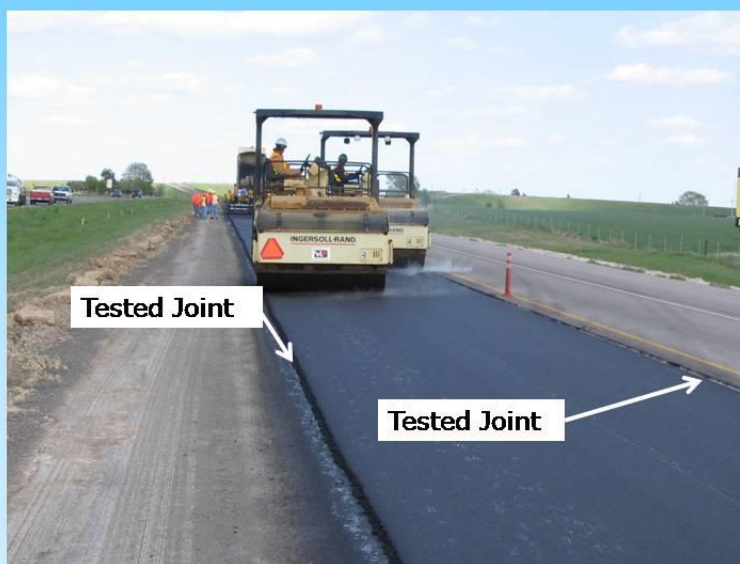


Figure 1B- Traveled Way With Hot Mix Shoulders or Shoulders Not Placed at the Same Time



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	$\geq 90.00\%$ 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

602.4 CONSTRUCTION REQUIREMENTS**Joint Density**Acceptable Criteria

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

OR

Joint Density \geq 90.00% of G_{mm}

Each Joint must pass.

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.

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	
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Interior Density minus Joint Density	≤ 3.0 lbs./cu. ft.
OR	
Joint Density	$\geq 90.00\%$ 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

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.

**TABLE 602-1
COMBINED AGG 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)	3/8"
SM/SR-9.5T	3/8" (9.5 mm)	3/8"
SM/SR-12.5A	1/2" (12.5 mm)	1/2"
SM/SR-19A	3/4" (19.0 mm)	3/4"

602.4 CONSTRUCTION REQUIREMENTS**e.(3) Lift Thickness**

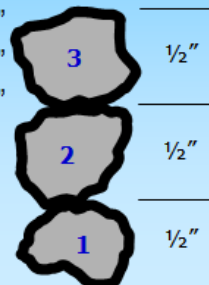
Min. lift thickness $\geq 3 \times \{\text{NMAS}\}$

SM-4.75A: $3/16" \times 3 = 9/16"$

SM-9.5T or SM-9.5A: $3/8" \times 3 = 1 1/8"$

SM-12.5A: $1/2" \times 3 = 1 1/2"$

SM-19A: $3/4" \times 3 = 2 1/4"$



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 finishing, vibratory rollers in the static 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 and periodically, 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

602.4 CONSTRUCTION REQUIREMENTS

e.(6) Density Requirements

a) Specified Mix Thickness $\geq 1\frac{1}{2}$ "

– 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

602.4 CONSTRUCTION REQUIREMENTS

e.(6) Density Requirements

a) Specified Mix Thickness $\geq 1\frac{1}{2}$ "

– 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

602.4 CONSTRUCTION REQUIREMENTS

e.(6) Density Requirements

b) Specified Mix Thickness $< 1\frac{1}{2}$ "

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

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 165°F. 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. Maintenance of Traffic. Maintain traffic according to **DIVISION 800** and the following:

Maintain one-way traffic, and restrict traffic speeds to 20 miles per hour in the vicinity of workers, unless otherwise designated. Use pilot cars to lead traffic through the area of paving and rolling operations, and if directed, through a curing area. The use of flaggers is allowed through patching operations, unless the patching area or distance between flaggers exceeds ½ mile, in which case the use of a pilot car shall be required. On overlay projects with 2 lanes or more in each direction for traffic use, the Engineer may waive the pilot car requirements.

Station one flagger ahead of the application of the tack coat and one flagger ahead of the area being protected from traffic. Take adequate protection for traffic on side roads approaching the tack area.

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

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 $\geq 1\frac{1}{2}$ " thick: Contractor may choose to obtain 10 tests. If so, KDOT will obtain 5 verification tests.

**For mixes $< 1\frac{1}{2}$ " 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

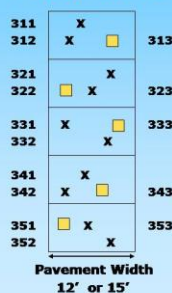


Chart Key:

Sample Number (Your Choice)

Example : **352**

3 = Lot Number

5 = Sublot Number

2 = Sample Number

X - Quality Control Tests by Contractor

Yellow Square - 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

Yellow Square - Verification Tests by KDOT

Review

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

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

Who performs segregation checks?

What's causes longitudinal segregation?

Review

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

When is a joint density reading taken?

Who performs joint density checks?

What's the criteria for a passing joint density?

Review

What's the minimum lift thickness for a mix?

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

QC/QA Asphalt Specifications Special Provision 15-06007-R01 Outline

- 602.1 Description (Sheet 1 of 29)
- 602.2 Contractor QC Requirements (Sheets 1 to 4 of 29)
- 602.3 Materials (Sheets 4 to 8 of 29)
- 602.4 Construction Requirements (Sheets 4 to 14 of 29)
- 602.5 Process Control (Sheets 14 to 16 of 29)**
- 602.6 Compaction Testing (Sheets 16 to 18 of 29)
- 602.7 Weather Limitations (Sheet 18 of 29)
- 602.8 Mixture Acceptance (Sheets 18 to 21 of 29)
- 602.9 Basis of Acceptance (Sheets 21 to 24 of 29)
- 602.10 HMA Paid by the Area (Sheets 24 to 28 of 29)
- 602.11 Measurement and Payment (Sheets 28 to 29 of 29)

g. 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.

h. 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 subplot 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**.

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

602.5 PROCESS CONTROL and 602.8 MIXTURE ACCEPTANCE

Sheet 15-06007-R01-21

Section j. Suspension of Mix Production

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

TABLE 602-12

Mix Characteristic	Tolerance from JMF			
	Single Test Value	Plot	4 Point Moving Average Value	Plot
Binder Content	$\pm 0.6\%$	*	$\pm 0.3\%$	*
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_{600} gyrations	$\pm 2.0\%$	*	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_{mi} 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.

602.5 PROCESS CONTROL

Binder Content

Single Test Value Range = $\pm 0.6\%$

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 = $\pm 0.3\%$

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 = $5.0\% + 0.3\% = 5.3\%$

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_{600} gyrations	±2.0%	*	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_{mi} 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.

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.

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_{600} gyrations	±2.0%	*	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_{mi} 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.

602.5 PROCESS CONTROL

Air Voids

Single Test Value Range = **±2.0%**

The Target Air Voids is Generally = **4.0%**

The Lower Single Test Value = $4.0\% - 2.0\% = \mathbf{2.0\%}$

The Upper Single Test Value = $4.0\% + 2.0\% = \mathbf{6.0\%}$

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

N/A means not applicable

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

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_{600} gyrations	±2.0%	*	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_{mi} 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.

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 = $14.0\% - 1.0\% = \mathbf{13.0\%}$

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

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_{600} gyrations	±2.0%	*	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_{mi} 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.

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% - 78%**.

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

The Upper 4-Pt Moving Avg Value = **78%**

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_{600} gyrations	±2.0%	*	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_{mi} 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.

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%	} These Values must be met or exceeded (refer to Project Specific Mix Requirements and Table 602-1)
SE minimum	= 40%	
FAA minimum	= 42%	
%TSR minimum	= 80%	

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

N/A means not applicable

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

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 @ $N_{d_{25}}$ gyrations	±2.0%	*	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.

602.5 PROCESS CONTROL

Density at N_{ini} and N_{max}

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 @ $N_{ini} \leq 90.5\%$. (project specific mix req)

Density @ $N_{max} < 98.0\%$. (Table 602-1)

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

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_{600} gyrations	±2.0%	*	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_{mi} 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.

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 = **0.8 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 = **0.8 to 1.2**

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

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 \$40 per ton. The Engineer will create a change order (**SECTION 104**) adding the item of work with a unit price of \$40/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 \$40 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).

**602.5 PROCESS CONTROL
and
602.8 MIXTURE ACCEPTANCE**

Sheet 15-06007-R01-21

Section j. Suspension of Mix Production

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

602.5 PROCESS CONTROL

Plotting Example Binder Content

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 @ $N_{d_{25}}$ gyrations	±2.0%	*	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.

Process Control

Plotting Example VMA

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 @ $N_{d_{25}}$ gyrations	±2.0%	*	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.

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	±2.0%	*	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 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. Take the readings a minimum of 2 hours apart and a maximum of 6 hours apart. Do not take the readings 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:

$$\text{Equation A: } \% \text{RAP} = \frac{\text{RAP} * 100}{\text{RAP} + \text{AGG}_v}$$

%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 3%.
- 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 3% of the maximum allowed %RAP 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.

602.5 PROCESS CONTROL

d. Mixes with RAP

- **Objective :**
 - Prevent the maximum % of RAP specified in the Project Special Provision from being exceeded.
- **Accomplish this by**
 - Using the Totalizer Readings to Calculate RAP
 - Monitoring the Scale Factors
 - Take Readings
 - at least twice a day
 - at least 2 hours apart
 - and not more than 6 hours apart

- If the 4-point moving average exceeds the maximum allowed %RAP by more than 1% then the Contractor will be assessed the following penalty.

Equation B:
$$\text{Contract Deduct} = \frac{\text{BP} * \text{Q} * (\% \text{RAP}_4 - \% \text{RAP}_{\text{max}})}{100}$$

Contract 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.

%RAP₄ is the 4-point moving average of %RAP.

%RAP_{max} is the Maximum %RAP from the Project Special Provision.

Contract Deducts 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 Contract 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 %RAP₄ 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.

QC/QA Asphalt Specifications Special Provision 15-06007-R01 Outline

- 602.1 Description (Sheet 1 of 29)
- 602.2 Contractor QC Requirements (Sheets 1 to 4 of 29)
- 602.3 Materials (Sheets 4 to 8 of 29)
- 602.4 Construction Requirements (Sheets 4 to 14 of 29)
- 602.5 Process Control (Sheets 14 to 16 of 29)
- 602.6 Compaction Testing (Sheets 16 to 18 of 29)**
- 602.7 Weather Limitations (Sheet 18 of 29)
- 602.8 Mixture Acceptance (Sheets 18 to 21 of 29)
- 602.9 Basis of Acceptance (Sheets 21 to 24 of 29)
- 602.10 HMA Paid by the Area (Sheets 24 to 28 of 29)
- 602.11 Measurement and Payment (Sheets 28 to 29 of 29)

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

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 gauge 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 lot's 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 subplot unless the Engineer's results (1 test per subplot) 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 subplot size based on anticipated production. If actual production does not meet anticipated production, the subplot 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.

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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



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)

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 gauge 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 lot's 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 subplot unless the Engineer's results (1 test per subplot) 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 subplot size based on anticipated production. If actual production does not meet anticipated production, the subplot 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.

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602.6 COMPACTION TESTING

a. General

- 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)

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

602.6 COMPACTION TESTING

a. General

Shoulder Information

Plan Width $\leq 3'$ 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

(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 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 subplot unless the Engineer's results (1 test per subplot) 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 subplot size based on anticipated production. If actual production does not meet anticipated production, the subplot 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 subplot. The Engineer will take 1 random nuclear density verification test per subplot. 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 subplot, 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 subplot. 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, subplot 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

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

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

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 sand vs. no sand test not performed

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

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
- 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)

602.6 COMPACTION TESTING**b. Nuclear Density Tests ($T \geq 1.5''$)****Calibration**

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

c. Cores (For mixes with a specified thickness of 1½ inches or greater.) Take 2 cores at random locations within each subplot. 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, subplot 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 subplot (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 (°F)			Surface Temperature (°F)		
		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

602.6 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

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**

602.6 COMPACTION TESTING

c. Cores ($T \geq 1.5''$)



KT-15, Procedure III

QC/QA Asphalt Specifications Special Provision 15-06007-R01 Outline

- 602.1 Description (Sheet 1 of 29)
- 602.2 Contractor QC Requirements (Sheets 1 to 4 of 29)
- 602.3 Materials (Sheets 4 to 8 of 29)
- 602.4 Construction Requirements (Sheets 4 to 14 of 29)
- 602.5 Process Control (Sheets 14 to 16 of 29)
- 602.6 Compaction Testing (Sheets 16 to 18 of 29)
- 602.7 Weather Limitations (Sheet 18 of 29)**
- 602.8 Mixture Acceptance (Sheets 18 to 21 of 29)
- 602.9 Basis of Acceptance (Sheets 21 to 24 of 29)
- 602.10 HMA Paid by the Area (Sheets 24 to 28 of 29)
- 602.11 Measurement and Payment (Sheets 28 to 29 of 29)

602.7 WEATHER LIMITATIONS



602.7 WEATHER LIMITATIONS

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

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 (°F)			Surface Temperature (°F)		
		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



QC/QA Asphalt Specifications Special Provision 15-06007-R01 Outline

- 602.1 Description (Sheet 1 of 29)
- 602.2 Contractor QC Requirements (Sheets 1 to 4 of 29)
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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

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, subplot 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.

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)



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

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 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.

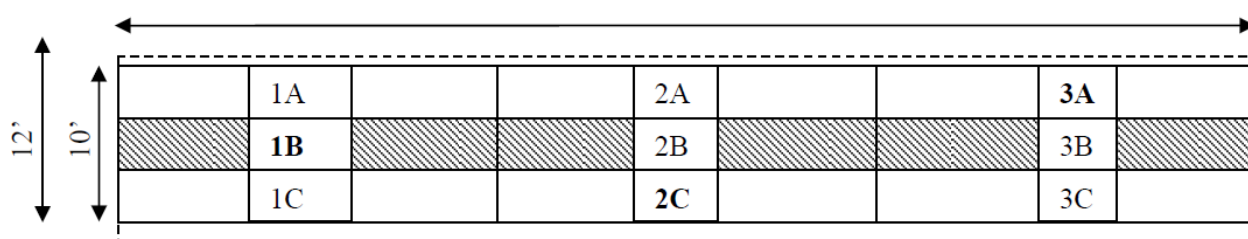
4.3.3. The sample size shall be at least four times the amount required for testing. For Superpave projects, the minimum sample size is shown in the specifications.

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.



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, subplot 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.

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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

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

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

- 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 subplot 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 tolerance shown for all mix characteristics listed in TABLE 602-12 and without a V_a penalty, the subplot 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 subplot size, the subplot size may again be increased to 1,250 tons per subplot (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

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

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

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

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.

602.8 MIXTURE ACCEPTANCE

- (f) Lot Size = 3,000 tons
 - 4 Equal Sublots
 - 750 tons per subplot
 - 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 \geq 250 tons/Hr
 - Notification of Engineer

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 tolerance 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

602.8 MIXTURE ACCEPTANCE

g. Increased Lot Size

- 5,000 Tons (4-1,250 Ton Sublots)
 - 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:

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

602.8 MIXTURE ACCEPTANCE

g. Increased Lot Size

- 5,000 Tons (4-1,250 Ton Sublots)
 - 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.

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 tolerance 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

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

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

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

602.8 MIXTURE ACCEPTANCE

i. Pre-Production Mix (Test Strip)

When HMA is Paid by the Ton

- 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

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 \$40 per ton. The Engineer will create a change order (**SECTION 104**) adding the item of work with a unit price of \$40/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.

602.8 MIXTURE ACCEPTANCE**i. Pre-Production Mix (Test Strip)****When HMA is Paid by the Square Yard**

- 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"

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

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

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

QC/QA Asphalt Specifications Special Provision 15-06007-R01 Outline

- 602.1 Description (Sheet 1 of 29)
- 602.2 Contractor QC Requirements (Sheets 1 to 4 of 29)
- 602.3 Materials (Sheets 4 to 8 of 29)
- 602.4 Construction Requirements (Sheets 4 to 14 of 29)
- 602.5 Process Control (Sheets 14 to 16 of 29)
- 602.6 Compaction Testing (Sheets 16 to 18 of 29)
- 602.7 Weather Limitations (Sheet 18 of 29)
- 602.8 Mixture Acceptance (Sheets 18 to 21 of 29)
- 602.9 Basis of Acceptance (Sheets 21 to 24 of 29)**
- 602.10 HMA Paid by the Area (Sheets 24 to 28 of 29)
- 602.11 Measurement and Payment (Sheets 28 to 29 of 29)

Objective

Calculate pay adjustments for roadway compaction on 1R (HMA Overlay) projects



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 \$40 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 THICKNESS⁴			
Specified Thickness →	≥ 2"	≥ 1½"	
	All	Continuous Action⁵	No Continuous Action⁶
% of G_{mm} Average of 10 Density Tests¹	Pay Factor²		Pay Factor²
93.00% or greater	1.040		1.040
92.00 to 92.99%	A1		A1
91.00 to 91.99%	1.000		1.000
90.00 to 90.99%	A2		1.000
89.00 to 89.99%	0.840 or Remove ³		A3
less than 89.00%	0.840 or Remove ³		0.840 or Remove ³

¹For 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**.

²Shoulders: 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 90.00% (if specified thickness is ≥ 2") or 89.00% (if the specified thickness is from 1½" to 1¾") 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.

³Low 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.

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

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

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

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%
- Calculate Density Pay Factor to 0.001
- Density Pay Adjustment
 - = $P_D \times \text{Tons in lot} \times \40 per Ton
 - Where: P_D = Density Pay Adjustment Factor

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

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 $\geq 1\frac{1}{2}''$ thick: Contractor may choose to obtain 10 tests. If so, KDOT will obtain 5 verification tests.

**For mixes $< 1\frac{1}{2}''$ 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.

5.2.6 COMPARISON OF QUALITY CONTROL AND VERIFICATION TESTS

This procedure is carried out to compare two different sets of multiple test results for finding the same parameter. Typical example would be comparing contractor QC test results and KDOT verification test results to determine if the material under test came from the same population. The statistical test which would be used to compare two means would be popularly known as Student's t-test or simply t-tests for testing a null hypothesis (H_0) with certain confidence (e.g. 99%) or level of significance (risk of rejecting a null hypothesis when it is true, e.g., 1%) is as follows:

H_0 : There is no difference in the sample means, ie. the means are statistically equal

If the test results do not support this hypothesis than an alternate hypothesis (H_a) is accepted as:

H_a : The means are different, ie. the means are not statistically equal

This test is generally applicable when the number of tests (or observations as is known in Statistics) is less than or equal to 30. However, since the approach used in the t-test is dependent upon whether or not the variances (square of the sample standard deviation) are equal for the two sets of data, it is necessary to test the variances of the test results before comparing the means of the test results.

F-test for the Sample Variances

The F-test determines whether the difference in the variability of the contractor's QC tests and that of KDOT's verification tests is larger than might be expected from chance if they came from the same population. In this case, a hypothesis testing is done at a certain level of significance. The null hypothesis in the test is:

H_0 : There is no difference in the sample variances, ie. the variances are statistically equal

If the test results do not support this hypothesis than an alternate hypothesis is accepted as:

H_a : The variances are different, i.e. the variances are not statistically equal

The following steps need to be followed in doing an F-test:

- i) Compute the variance (the standard deviation squared) for the QC tests, s_c^2 , and the KDOT verification tests, s_v^2
- ii) Compute F statistic as:

$$F = s_c^2 / s_v^2 \text{ or } s_v^2 / s_c^2$$

Always use the larger of the two variances in the numerator.

- iii) Choose the level of significance, α , for the test. The recommended α is 1%

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 (\bar{X})
- Compare Contractor's QC and KDOT's QA Test Results
 - Air Voids
 - G_{mm}
 - Density

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

iv) Find the critical F value F_{crit} , from the **Table 1** using the degrees of freedom associated with each set of test results. The degrees of freedom for each set of results is the number of test results in the set, less one. If the number of QC tests is n_c and the number of verification tests is n_v , then the degrees of freedom associated with s_c^2 is (n_c-1) and the degrees of freedom associated with s_v^2 is (n_v-1) . The values in Table 5.17.08-1 are tabulated to test if there is a difference (either larger or smaller) between two variance estimates. This is known as a two-sided or two-tailed test. Care must be taken when using other tables of the F distribution, since they are usually based on a one-tailed test, i.e., testing specifically whether one variance is larger than another. When finding F_{crit} be sure that the appropriate degrees of freedom for the numerator and denominator are used.

v) Find the value for F_{crit} from **Table 1**.

vi) If $F \geq F_{crit}$, then the null hypothesis is rejected i.e. the two sets of tests have significantly different variabilities. If $F < F_{crit}$ then there is no reason to believe that the variabilities are significantly different.

t-test for Sample Means

Once the variances have been tested and been assumed to be either equal or not equal, the means of the test results can be tested to determine whether they differ from one another or can be assumed equal. The desire is to determine whether it is reasonable to assume that the QC tests came from the same population as the verification tests. As mentioned before, a t-test is used to compare the sample means. Two approaches for the t-test are necessary.

If the sample variances are assumed equal, then the t-test is conducted based on the two samples using a *pooled estimate for the variance* (s_p^2) and the pooled degrees of freedom. If the sample variances are found to be different in the F-test, the t-test is conducted using the individual sample variances, the individual sample sizes, and the effective degrees of freedom (estimated from the sample variances and sample sizes).

In either of the two cases discussed earlier, the null hypothesis used is:

$$H_o : \quad \text{There is no difference in the sample means, i.e. the means are statistically equal}$$

If the test results do not support this hypothesis than an alternate hypothesis is accepted as:

$$H_a : \quad \text{The means are different, i.e. the means are not statistically equal}$$

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

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**

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**

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 \$40 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 THICKNESS⁴			
Specified Thickness →	≥ 2"	≥ 1½"	
	All	Continuous Action⁵	No Continuous Action⁶
% of G_{mm} Average of 10 Density Tests¹	Pay Factor²		Pay Factor²
93.00% or greater	1.040		1.040
92.00 to 92.99%	A1		A1
91.00 to 91.99%	1.000		1.000
90.00 to 90.99%	A2		1.000
89.00 to 89.99%	0.840 or Remove ³		A3
less than 89.00%	0.840 or Remove ³		0.840 or Remove ³

¹For 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**.

²Shoulders: 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 90.00% (if specified thickness is ≥ 2") or 89.00% (if the specified thickness is from 1½" to 1¾") 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.

³Low 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.

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

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

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

602.9 BASIS OF ACCEPTANCE

b. Density Pay Adjustment for "HMA Overlay"

- Mixes with Specified Thickness $< 1\frac{1}{2}$ inches
 - No Density Pay Adjustments
- Plan thickness of $\geq 1\frac{1}{2}$ inches
- By **lot**
 - Based on % G_{mm}
 - Average the % G_{mm} values to 0.01%

602.9 BASIS OF ACCEPTANCE

b. Density Pay Adjustment for "HMA Overlay"

- Calculate Pay Adjustment Factor to 0.001
- Density Pay Adjustment
 - = $P_D \times \text{Tons in lot} \times \40 per Ton
 - Where: P_D = Density Pay Adjustment Factor
 - P_D = Density Pay Factor – 1.000
 - Pay Factor from Table 602-15

602.9 BASIS OF ACCEPTANCE

b. Density Pay Adjustment for "HMA Overlay"

TABLE 602-15: DENSITY PAY FACTORS FOR SPECIFIED THICKNESS⁴

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

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': % $G_{mm} \geq 90.00\%$ (if $T \geq 2"$) or % $G_{mm} \geq 89.00\%$ (if T is between $1\frac{1}{2}"$ and $1\frac{7}{8}"$).
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 $T \geq 1\frac{1}{2}"$ when another continuous action is completed ahead of this overlay.
- 6) Use Right Table for $T \geq 1\frac{1}{2}"$ when another continuous action is not completed before the overlay

602.9 BASIS OF ACCEPTANCE

b. Density Pay Adjustment for "HMA Overlay" Continuous Actions



Overlay



Cold Recycle



Surface Recycle



Milling

602.9 BASIS OF ACCEPTANCE

b. Density Pay Adjustment for "HMA Overlay"

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

$$A1 = [100 + 4 (\%G_{mm} - 92.00)] \div 100$$

$$A2 = [84 + 16 (\%G_{mm} - 90.00)] \div 100$$

$$A3 = [84 + 16 (\%G_{mm} - 89.00)] \div 100$$

$$P_D = \text{Density Pay Factor} - 1.000$$

COMPUTATION OF DENSITY PAY FACTORS



DENSITY PAY FACTOR EXAMPLE (HMA Overlay (SM-12.5A)(PG64-22))(1.5" LIFT) (Lot 4)

No Continuous Action

602.9b. (Sheets 15-06007-R01-21 and 15-06007-R01-22)

Date	Test	Lift	Station	Lane	Dist from CL (ft)	Nuclear Gauge (pcf)	Maximum (Rice) Specific Gravity	% G _{mm}	Tons
8/21/2008	411	First	154+30	NB	3.4	131.3	2.385	88.45	364
8/21/2008	412	First	181+76	NB	10.8	132.8	2.385	89.46	
8/21/2008	421	First	198+65	NB	1.1	135.8	2.385	91.48	364
8/21/2008	422	First	201+62	NB	8.9	134.0	2.385	90.27	
8/21/2008	431	First	221+77	NB	2.8	131.7	2.385	88.72	364
8/21/2008	432	First	241+13	NB	4.4	132.7	2.385	89.39	
8/21/2008	441	First	258+33	NB	5.9	134.7	2.385	90.74	364
8/21/2008	442	First	272+61	NB	6.9	131.7	2.385	88.72	
8/21/2008	451	First	293+79	NB	9.9	135.7	2.385	91.41	364
8/21/2008	452	First	304+39	NB	3.1	133.1	2.385	89.66	

DENSITY PAY FACTOR EXAMPLE (HMA Overlay (SM-12.5A)(PG64-22)) (1.5" LIFT) (Lot 5)**Continuous Action****602.9b. (Sheets 15-06007-R01-21 and 15-06007-R01-22)**

Date	Test	Lift	Station	Lane	Dist from CL (ft)	Nuclear Gauge (pcf)	Maximum (Rice) Specific Gravity	% G _{mm}	Tons
8/21/2008	511	First	154+94	NB	8.8	139.0	2.388	93.52	364
8/21/2008	512	First	173+98	NB	3.0	137.3	2.388	92.37	
8/21/2008	521	First	193+78	NB	2.9	136.4	2.388	91.77	364
8/21/2008	522	First	205+65	NB	10.0	138.7	2.388	93.32	
8/21/2008	531	First	227+75	NB	3.5	138.9	2.388	93.45	364
8/21/2008	532	First	235+97	NB	10.3	136.4	2.388	91.77	
8/21/2008	541	First	260+15	NB	9.4	138.6	2.388	93.25	364
8/21/2008	542	First	272+59	NB	4.1	137.2	2.388	92.31	
8/21/2008	551	First	297+55	NB	5.8	136.4	2.388	91.77	364
8/21/2008	552	First	312+23	NB	5.8	135.5	2.388	91.16	

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

- 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 Travelway
 - Have no Incentive for Density (only Disincentive)
- Know if you have a Continuous Action



QC/QA Asphalt Specifications Special Provision 15-06007-R01 Outline

- 602.1 Description (Sheet 1 of 29)
- 602.2 Contractor QC Requirements (Sheets 1 to 4 of 29)
- 602.3 Materials (Sheets 4 to 8 of 29)
- 602.4 Construction Requirements (Sheets 4 to 14 of 29)
- 602.5 Process Control (Sheets 14 to 16 of 29)
- 602.6 Compaction Testing (Sheets 16 to 18 of 29)
- 602.7 Weather Limitations (Sheet 18 of 29)
- 602.8 Mixture Acceptance (Sheets 18 to 21 of 29)
- 602.9 Basis of Acceptance (Sheets 21 to 24 of 29)**
- 602.10 HMA Paid by the Area (Sheets 24 to 28 of 29)
- 602.11 Measurement and Payment (Sheets 28 to 29 of 29)

Objective

Calculate pay adjustments for roadway compaction on Major Modification projects



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 \$40 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:

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

\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 5.17.09, 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 \$40 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).

602.9 BASIS OF ACCEPTANCE

c. Density Pay Adjustment for Bid Items "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 Factor to 0.001
- Density Pay Adjustment
 - = P_D * Tons in lot * \$40 per Ton
 - Where: P_D = Density Pay Adjustment Factor

602.9 BASIS OF ACCEPTANCE

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

- Shoulders $\leq 3'$ 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

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 \$40 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:
$$Q_{LD} = \frac{\bar{X} - LSL}{S}$$

\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 5.17.09, 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 \$40 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).

602.9 BASIS OF ACCEPTANCE

c. Density Pay Adjustment for Bid Items "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

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 $\geq 1\frac{1}{2}$ " thick: Contractor may choose to obtain 10 tests. If so, KDOT will obtain 5 verification tests.

**For mixes $< 1\frac{1}{2}$ " 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.

MOVING AVERAGE

Notice how the individual test result fails in subplot 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 subplot 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).

602.9 BASIS OF ACCEPTANCE

QUALITY LEVEL ANALYSIS

KDOT Construction Manual
Section 5.2.1
Pages 12 -26

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*.

602.9 BASIS OF ACCEPTANCE

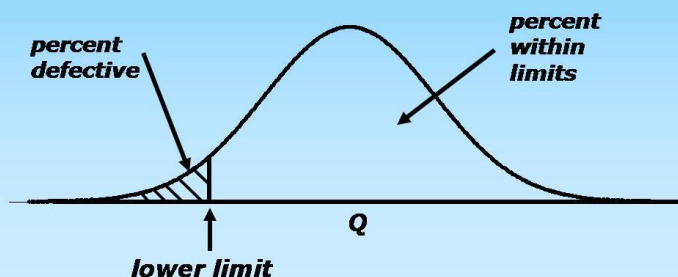
Percent Within Limits (PWL)

Definition:

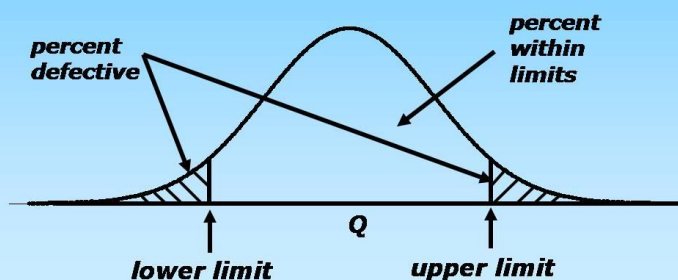
Amount of material or workmanship that has been determined by statistical method, to be within the pre-established characteristic boundary(ies)

602.9 BASIS OF ACCEPTANCE

Percent Within Limits (PWL)

SINGLE-LIMIT SPECIFICATION**602.9 BASIS OF ACCEPTANCE**

Percent Within Limits (PWL)

DOUBLE-LIMIT SPECIFICATION**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

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

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

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

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)

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 \$40 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:

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

\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 5.17.09, 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 \$40 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).

602.9 BASIS OF ACCEPTANCE**c. Density Pay Adjustment for Bid Items "HMA Surface", "HMA Base" and "HMA Pavement"****Shoulders > 3' (not placed with ML)**

- $LSL = 90.00\% G_{mm}$
- $PWL \geq 50.00\%$, 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)

602.9 BASIS OF ACCEPTANCE**c. Density Pay Adjustment for Bid Items "HMA Surface", "HMA Base" and "HMA Pavement"****Determination of P_D and 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 $PWL_{LD} = 100.00$

602.9 BASIS OF ACCEPTANCE**c. Density Pay Adjustment for Bid Items "HMA Surface", "HMA Base" and "HMA Pavement"****Determination of P_D and 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)
- $PWL_{LD} \geq 50.00\%$, then Equation 2

P_D - Rounded to nearest thousandths (0.000)

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

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 \$40 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:

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

\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 5.17.09, 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 \$40 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).

602.9 BASIS OF ACCEPTANCE

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

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

\bar{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)

602.9 BASIS OF ACCEPTANCE

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

Equation 2:

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

COMPUTATION OF DENSITY PAY FACTORS



DENSITY PAY FACTOREXAMPLE (HMA Base (SM-19A)(PG64-22))(4" LIFT) (Lot 5)									
602.9c. (Sheets 15-06007-R01-22 and 15-06007-R01-23)									
Date	Test	Lift	Station	Lane	Dist from CL	Nuclear Gauge	Maximum (Rice)	% Gmm	Tons
					(ft)	(pcf)	Specific Gravity		
5/21/2008	511	First	751+29	WB	2.6	137.6	2.385	92.69	500
5/21/2008	512	First	759+96	WB	4.4	137.8	2.385	92.83	
5/21/2008	521	First	775+33	WB	4.7	135.3	2.385	91.14	500
5/21/2008	522	First	777+53	WB	1.2	139.1	2.385	93.70	
5/21/2008	531	First	791+88	WB	3.2	138.3	2.385	93.16	500
5/21/2008	532	First	800+76	WB	1.4	137.6	2.385	92.69	
5/21/2008	541	First	808+41	WB	9.7	139.3	2.385	93.84	500
5/21/2008	542	First	816+32	WB	2.4	137.5	2.385	92.62	
5/21/2008	551	First	819+10	WB	3.2	136.9	2.385	92.22	500
5/21/2008	552	First	831+72	WB	6.5	137.5	2.385	92.62	

DENSITY PAY FACTOREXAMPLE (HMA Surface (SM-9.5A)(PG64-28))(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	Nuclear Gauge	Maximum (Rice)	% Gmm	Tons
					(ft)	(pcf)	Specific Gravity		
6/18/2008	611	First	648+15	WB	3.2	136.4	2.379	92.11	225
6/18/2008	612	First	660+57	WB	9.9	138.7	2.379	93.67	
6/18/2008	621	First	669+16	WB	6.6	135.8	2.379	91.71	225
6/18/2008	622	First	675+94	WB	8.9	137.8	2.379	93.06	
6/18/2008	631	First	686+09	WB	3.3	138.2	2.379	93.33	225
6/18/2008	632	First	694+85	WB	5.0	138.5	2.379	93.53	
6/18/2008	641	First	697+34	WB	5.7	137.1	2.379	92.59	225
6/18/2008	642	First	705+75	WB	3.5	136.5	2.379	92.18	
6/18/2008	651	First	716+55	WB	9.4	137.5	2.379	92.86	225
6/18/2008	652	First	729+59	WB	8.9	137.9	2.379	93.13	

602.9 BASIS OF ACCEPTANCE

c. Compaction Pay Adjustment

• Keys

- 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
- No Incentive on Shoulders, but there is disincentive

QC/QA Asphalt Specifications Special Provision 15-06007-R01 Outline

- 602.1 Description (Sheet 1 of 29)
- 602.2 Contractor QC Requirements (Sheets 1 to 4 of 29)
- 602.3 Materials (Sheets 4 to 8 of 29)
- 602.4 Construction Requirements (Sheets 4 to 14 of 29)
- 602.5 Process Control (Sheets 14 to 16 of 29)
- 602.6 Compaction Testing (Sheets 16 to 18 of 29)
- 602.7 Weather Limitations (Sheet 18 of 29)
- 602.8 Mixture Acceptance (Sheets 18 to 21 of 29)
- 602.9 Basis of Acceptance (Sheets 21 to 24 of 29)**
- 602.10 HMA Paid by the Area (Sheets 24 to 28 of 29)
- 602.11 Measurement and Payment (Sheets 28 to 29 of 29)

Objective

Calculate pay adjustments for air voids for both Major Modification and 1R projects



602.9 BASIS OF ACCEPTANCE

d. Air Void Pay Adjustment

- By **lot**
 - 4 Contiguous V_a Tests (same mix design)
 - Measured V_a of plant produced material
- Calculate Air Voids Pay Factor to 0.001
- Air Void Pay Adjustment
 - = P_v * Tons in lot * **\$40** per Ton
 - Where: P_v = Air Voids Pay Adj. Factor
- Two Scenarios
 - Passing "t" test - Use Paragraph **602.9d(1)**
 - Failing "t" test - Use Paragraph **602.9d(2)**

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 \$40 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:
$$Q_{UV} = \frac{USL - \bar{X}}{S}$$

Equation 4:
$$Q_{LV} = \frac{\bar{X} - LSL}{S}$$

\bar{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 5.00%.

LSL is the lower specification limit for V_a and is defined as 3.00%.

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 .

(2) Air Voids Pay Adjustment (Failing t-Test). If the t-test fails, KDOT's test result will be used to calculate the P_V for the lot. Follow the procedures given in **subsection 602.9d.(1)** to determine the P_V or disposition of the lot. Use the values from **TABLE 602-16** to calculate Q_{UV} , Q_{LV} , PWL_{UV} and 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
\bar{X}	Average or Mean	KDOT's test result for the lot
S	Standard Deviation	0.50
USL	Upper Specification Limit	5.50%
LSL	Lower Specification Limit	2.50%
N	Sample Size	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.

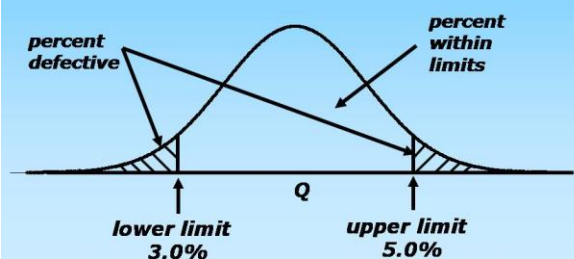
602.8 MIXTURE ACCEPTANCE

(f) Lot Size = 3,000 tons

- 4 Equal Sublots
- 750 tons per subplot
- 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 \geq 250 tons/Hr
 - Notification of Engineer

602.9 BASIS OF ACCEPTANCE**Percent Within Limits (PWL)****DOUBLE-LIMIT SPECIFICATION****602.9 BASIS OF ACCEPTANCE****d.(1) Air Void Pay Adjustment (Passing t-Test)**

Equation 3

$$Q_{UV} = \frac{USL - \bar{X}}{S}$$

$$USL = 5.00\%$$

Equation 4

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

$$LSL = 3.00\%$$

\bar{X} - Mean of Air Voids in Lot

S - Standard Deviation of Air Voids in Lot

Equation 5

$$P_V = ((PWL_{UV} + PWL_{LV} - 100) * 0.0030) - 0.270$$

- If Q is $>$ than largest value in Table 5.2.1-2, then $PWL = 100.00$

602.9 BASIS OF ACCEPTANCE

d.(1) Air Void Pay Adjustment (Passing t-Test)

Low Quality Material

- If either Q_{UV} or Q_{LV} is a negative value or
- If $PWL_{UV} + PWL_{LV}$ 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.)

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
\bar{X}	Average or Mean	KDOT's test result for the lot
S	Standard Deviation	0.50
USL	Upper Specification Limit	5.50%
LSL	Lower Specification Limit	2.50%
N	Sample Size	3

Use Equations 3, 4 and 5 to calculate Q_{UV} , Q_{LV} , and P_V

6.0 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

COMPUTATION OF AIR VOID PAY FACTORS



Air Voids Pay Factor Example

**HMA Overlay (SM-12.5A)(PG64-22)
(1.5" LIFT) (Lot 1)
602.9d (Sheets 15-06007-R01-23 and
15-06007-R01-24)**

Date	Test	Lift	Station	Lane	Air Void (%)	\bar{X} (%)	S (%)	Quantity (Tons)
8/18/2008	1A	First	34+83	NB	4.30	4.23	0.44	750
8/18/2008	1B	First	87+69	NB	3.77			750
8/18/2008	1C	First	216+47	NB	4.05			750
8/19/2008	1D	First	223+70	NB	4.80			750

Air Voids Pay Factor Example

**HMA Overlay (SM-12.5A)(PG64-22)
(1.5" LIFT) (Lot 2)
602.9d. (Sheets 15-06007-R01-23 and
15-06007-R01-24)**

Date	Test	Lift	Station	Lane	Air Void (%)	\bar{X} (%)	S (%)	Quantity (Tons)
8/19/2008	2A	First	337+71	NB	2.65	2.57	0.35	750
8/19/2008	2B	First	398+86	NB	2.94			750
8/20/2008	2C	First	482+99	NB	2.57			750
8/20/2008	2D	First	511+21	NB	2.10			750

Air Voids Pay Factor Example
HMA Surface (SM-12.5A)(PG64-22)
(1.5" LIFT) (Lot 3)
602.9d. (Sheets 15-06007-R01-23 and
15-06007-R01-24)

Date	Test	Lift	Station	Lane	Air Void (%)	\bar{X} (%)	S (%)	Quantity (Tons)
8/21/2008	3A	First	597+48	NB	2.64	3.89	1.22	750
8/21/2008	3B	First	667+45	NB	3.14			750
8/22/2008	3C	First	719+75	NB	5.29			750
8/22/2008	3D	First	801+09	NB	4.49			750

6.0 BASIS OF ACCEPTANCE

d. Air Void Pay Adjustment

- Keys
 - Air Voids Pay Adjustment for all Lots (shoulders, too)
 - Different procedure for Failing t-Test
 - Must calculate a lower and upper quality index
 - LSL and USL are normally 3.00% and 5.00%, respectively

QC/QA Asphalt Specifications Special Provision 15-06007-R01 Outline

- 602.1 Description (Sheet 1 of 29)
- 602.2 Contractor QC Requirements (Sheets 1 to 4 of 29)
- 602.3 Materials (Sheets 4 to 8 of 29)
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- 602.5 Process Control (Sheets 14 to 16 of 29)
- 602.6 Compaction Testing (Sheets 16 to 18 of 29)
- 602.7 Weather Limitations (Sheet 18 of 29)
- 602.8 Mixture Acceptance (Sheets 18 to 21 of 29)
- 602.9 Basis of Acceptance (Sheets 21 to 24 of 29)
- 602.10 HMA Paid by the Area (Sheets 24 to 28 of 29)**
- 602.11 Measurement and Payment (Sheets 28 to 29 of 29)

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"**

602.10 HMA PAID BY THE AREA

Objectives

- Demonstrate basic knowledge in:
 - Calculating pay adjustments for uniform thickness on Major Modification projects
 - Calculating pay for areas placed and not placed.

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

602.10 HMA PAID BY THE AREA

Bid Items

MAINLINE	SHOULDER
HMA Pavement (12") (A64)	HMA Pavement (8") Shoulder

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

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 subplot 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 subplot. 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 subplot 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 subplot.

For Percent Within Limits (PWL) thickness analysis, if any subplot thickness exceeds the design thickness by more than 1.0 inch, the Excel spreadsheet will automatically consider that subplot 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 subplot.

15-06007-R01-24

15-06007-R01-25

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

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

602.10 HMA PAID BY THE AREA

b. Measurements

Engineer generates 1 random core location per subplot

- 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. SM-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



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 subplot 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 subplot. 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 subplot 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 subplot.**

For Percent Within Limits (PWL) thickness analysis, **if any subplot thickness exceeds the design thickness by more than 1.0 inch, the Excel spreadsheet will automatically consider that subplot 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 subplot.

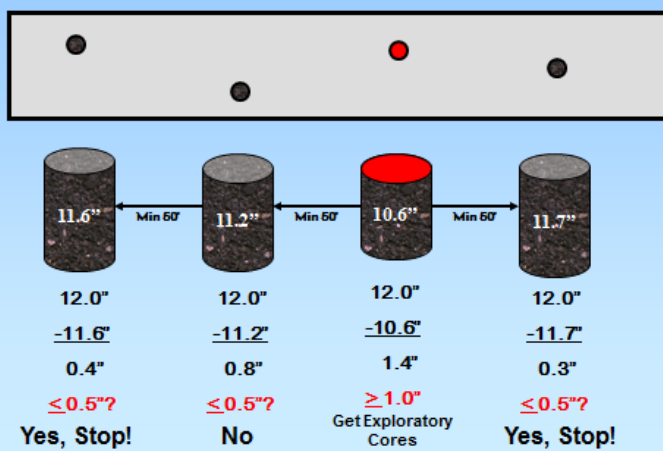
602.10 HMA PAID BY THE AREA b. Measurements

- Areas trimmed without automatic equipment may be designated as a lot.
 - Divide into 5 sublots
 - Obtain 1 core/sublot
- Thick Cores > 1" thicker than plan thickness
 - Will calculate as 1" 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

602.10 HMA PAID BY THE AREA c. Deficient Measurements for Driving Lanes

- Deficient by 1" or more
- Exploratory Cores not less than 50' intervals
 - Continue until deficiency is $\leq 0.5"$
 - Defines minimum length of overlay required
- Overlay width is full roadway width
- Overlay thickness $\geq 3 \times \{\text{Nom Max Agg Size}\}$
- Engineer must approve the overlay
- Mill Butt joints at ends
- Randomly select another core outside overlaid area to represent the subplot for pay

Plan Thickness = 12.0" (Mainline)



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 subplot.

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 subplot 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

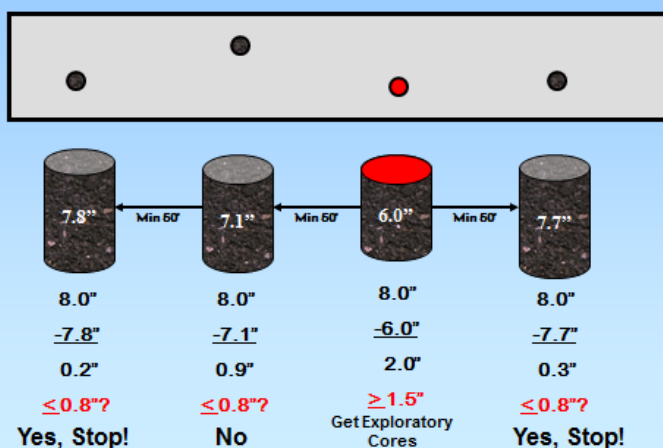
BP = Bid Price for either the driving lanes or the shoulder, as applicable

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

602.10 HMA PAID BY THE AREA d. Deficient Measurements for Shoulders

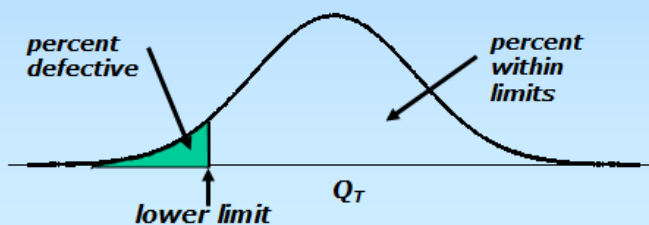
- Deficient by 1.5" or more
- Exploratory Cores not less than 50' intervals
 - Continue until deficiency is $\leq 0.8"$
 - Defines minimum length of:
 - Removal and replacement, left in place at a reduced price, overlay
- Full Depth Repair is full shoulder width
- Rework, restabilize (if required), & regrade Subgrade & Base
- Mill Butt joints at ends of overlay
- Randomly select another core outside overlaid area to represent the subplot for pay

Plan Thickness = 8.0" (Shoulder)



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: $TPA_{DL} = P_T(\Sigma PDLA)(\$1.90)(\text{Plan Thickness})$
 - Eq 7: $TPA_{SH} = P_T(\Sigma PSA)(\$1.70)(\text{Plan Thickness})$



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: $TPA_{DL} = P_T (\sum PDLA) (\$1.90) (\text{Plan Thickness})$

Equation 7: $TPA_{SH} = P_T (\sum PSA) (\$1.70) (\text{Plan Thickness})$

TPA_{DL} = Thickness Pay Adjustment per Lot for Driving Lane

TPA_{SH} = Thickness Pay Adjustment per Lot for Shoulder

$\sum PDLA$ = Pay Driving Lane Area per Lot, Square Yard

$\sum PSA$ = 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 (Q_T) Computation. In each lot, calculate Q_T for the total pavement thickness using Equation 8 and round to hundredths.

Equation 8:
$$Q_T = \frac{\bar{X} - LSL}{S}$$

\bar{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 Q_T to determine the thickness Percent Within Limits value (PWL_T) by locating the Q_T in the left column of the Percent Within Limits (PWL) Table in Section 5.2.1 - Statistics, Part V. Select the appropriate PWL_T by moving across the selected Q_T row to the column representing the number of samples in the lot.

If the computed 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 subplot, and calculate a new pay factor. For lots that have been entirely overlaid, the maximum pay factor is zero.

If the computed Q_T is greater than the largest Q_T shown in the PWL Table, a value of 100.00 is assigned as the PWL_T for thickness.

For each lot and all lanes and shoulders, compute the thickness pay factor (P_T) for the total pavement thickness using Equation 9 and round to nearest thousandth. No bonus will be paid for shoulders, thus use $P_T = 0.000$ whenever P_T calculates greater than 0.000 for shoulders.

Equation 9:
$$P_T = \left(\frac{(PWL_T) * 0.30}{100} \right) - 0.270$$

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

$$\text{(Equation 8)} \quad Q_T = \frac{\bar{X} - LSL}{S}$$

(Q_T will be rounded to the nearest 0.01)

\bar{X} = Avg of all cores in lot rounded to 0.1"

LSL = Plan Thickness of Driving Lane – 0.5"
Plan Thickness of Shoulder – 0.8"

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 subplot, and calculate a new pay factor.
- For lots that have been entirely overlaid, the maximum pay factor is zero.

602.10 HMA PAID BY THE AREA f. Thickness Pay Adjustments

Determination of P_T

$$\text{(Equation 9)} \quad P_T = \left(\frac{(PWL_T) * 0.3}{100} \right) - 0.270$$

(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

602.10 HMA PAID BY THE AREA f. Thickness Pay Adjustments

We can now calculate P_T In Equations 6 and 7

$$\text{Eq 6: } \text{TPA}_{\text{DL}} = P_T(\Sigma\text{PDLA})(\$1.90)(\text{Plan Thickness})$$

$$\text{Eq 7: } \text{TPA}_{\text{SH}} = P_T(\Sigma\text{PSA})(\$1.70)(\text{Plan Thickness})$$

We still need to determine ΣPDLA and ΣPSA

ΣPDLA = Pay Driving Lane Area per Lot

ΣPSA = Pay Shoulder Area per Lot

But 1st We'll compute P_T for a lot or 2

COMPUTATION OF THICKNESS PAY FACTORS



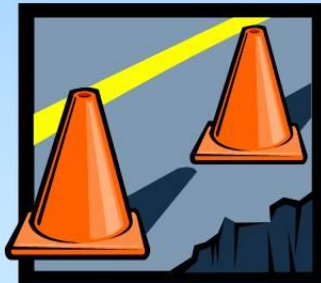
Mainline Example

THICKNESS PAY FACTOR EXAMPLE								
Mainline 602.10 (Sheets 15-06007-R01-24 to 28)								
Date	Test	Station	Lane	Dist from CL (ft)	Core Length (in)	Adjusted Core Length (in)	Plan Thickness (in)	Pay Driving Lane Area in Lot (yd ²)
10/12/2006	1A	8+58	NB	2.6	11.6	11.6	12.0	6,667
10/12/2006	1B	15+24	NB	6.0	11.2	11.2		
10/12/2006	1C	26+37	NB	8.5	13.2	13.0		
10/12/2006	1D	39+21	NB	10.7	12.4	12.4		
10/12/2006	1E	47+53	NB	7.9	11.4	11.4		

Shoulder Example

THICKNESS PAY FACTOR EXAMPLE								
Shoulder		602.10 (Sheets 15-06007-R01-24 to 28)						
Date	Test	Station	Lane	Dist from CL (ft)	Core Length (in)	Adjusted Core Length (in)	Plan Thickness (in)	Pay Shoulder Area in Lot (yd ²)
10/12/2006	1A	6+44	NB	4.7	8.0	8.0	8.0	5,556
10/12/2006	1B	12+93	NB	2.8	8.3	8.3		
10/12/2006	1C	28+14	NB	8.2	8.5	8.5		
10/12/2006	1D	33+27	NB	6.1	7.9	7.9		
10/12/2006	1E	43+85	NB	5.5	8.1	8.1		

PAY PER LOT FOR AREAS PLACED AND NOT PLACED



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 Shoulder⁵				
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

¹Deductions will be made for unplaced areas.

²Calculate 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.

³MSW shall be between PSW and PSW + 0.25 feet. Any excess width over 0.25 feet will not be included in PSW.

⁴MSW+ EDLW shall be between PSW and PSW + 0.25 feet. Any excess width over 0.25 feet will not be included in PSW.

⁵Shoulder is normally 0.00 feet to 3.00 feet wide and placed at the same time as the driving lane. PTLW = PDLW + PSW

⁶MSTLW shall be between PTLW and PTLW + 0.25 feet. Any excess width over 0.25 feet will not be included for pay.

602.10 HMA PAID BY THE AREA
e. Area Pay Adjustments

Pay per Lot for Driving Lanes

Pay Equations per Lot for Driving Lane Areas
Placed

Equation 10:

$$\text{Pay for Driving Lane} = (\Sigma \text{PDLA})(\text{BP})$$

Not Placed (Deducted)

Equation 11:

$$\text{Pay Deduct for Driving Lanes} = 2(\Sigma \text{PDLDA})(\text{BP})$$

ΣPDLA = Pay Driving Lane Area per Lot

ΣPDLDA = Pay Driving Lane Deduct Area per Lot

BP = Bid Price

602.10 HMA PAID BY THE AREA
e. Area Pay Adjustments

Pay per Lot for Shoulders

Pay Equations per Lot for Shoulder Areas
Placed

Equation 12:

$$\text{Pay for Shoulder} = (\Sigma \text{PSA})(\text{BP})$$

Not Placed (Deducted)

Equation 13:

$$\text{Pay Deduct for Shoulder} = 2(\Sigma \text{PSDA})(\text{BP})$$

ΣPSA = Pay Shoulder Area per Lot

ΣPSDA = Pay Shoulder Deduct Area per Lot

BP = Bid Price

602.10 HMA PAID BY THE AREA
e. Area Pay Adjustments

TABLE 602-18
HMA UNIFORM THICKNESS SUBLOT
CALCULATIONS

EQUATIONS FOR AREA CALCULATIONS

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 \geq Plan Width

B - Wide Driving Lane

- 1) - Measured Shoulder Width + Excess Driving Lane Width < Plan Width
- 2) - Measured Shoulder Width + Excess Driving Lane Width \geq Plan Width

II. – No Separate Bid Item for Shoulders

A - Narrow Driving Lane and Shoulder

B - Wide Driving Lane and Shoulder

I. – Separate Bid Item for Shoulders

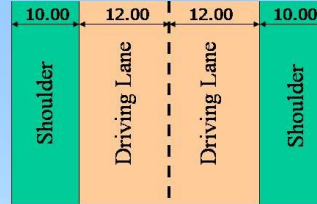
MDLW = **M**asured **D**riving
Lane **W**idth

PDLW = **P**lan **D**riving **L**ane **W**idth

MSW = **M**asured **S**houlder **W**idth

PSW = **P**lan **S**houlder **W**idth

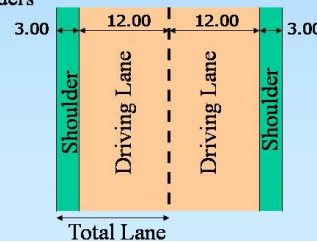
EDLW = **E**xcess **D**riving **L**ane
Width



II. – No Separate Bid Item for Shoulders

MTLW = **M**asured **T**otal **L**ane
Width

PTLW = **P**lan **T**otal **L**ane **W**idth



Ask Yourself 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 -- --

1A.1) 1A.2) 1B.1) 1B.2) 11A. 11B.

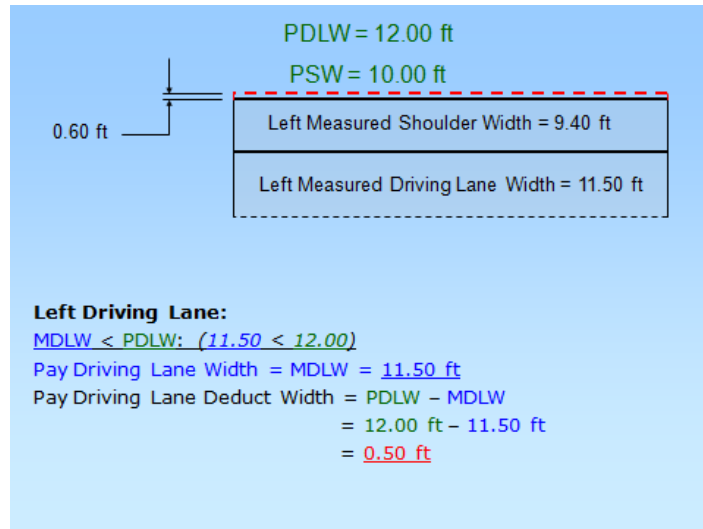
This Row tells which Section to Use for Pay Width(s) determination(s).

TABLE 602-18: HMA UNIFORM THICKNESS SUBLOT CALCULATIONS

Row	Condition	PDL Width Pay Driving Lane Width	PDLW 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					
1A.1)	MSW < PSW	MDLW	PDLW - MDLW	MSW	PSW - MSW
1A.2)	MSW > PSW	MDLW	PDLW - MDLW	Min (MSW, PSW + 0.25)	0
B. Wide Driving Lane					
1B.1)	MSW + EDLW < PSW	PDLW	0	MSW + EDLW	PSW - MSW - EDLW
1B.2)	MSW + EDLW > PSW	PDLW	0	Min (MSW + EDLW, PSW + 0.25)	0
II. Projects without a Separate Bid Item for Shoulder					
11A)	Narrow Driving Lane and Shoulder	MTLW	PTLW - MTLW	N/A	N/A
11B)	Wide Driving Lane and Shoulder	Min (MTLW, PTLW + 0.25)	0	N/A	N/A

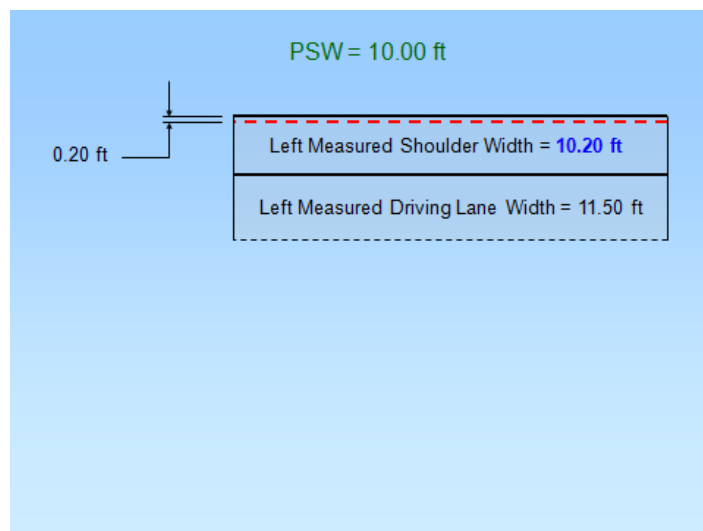
Ask Yourself These Questions				YES	NO
1) Is the Shoulder a Separate Bid Item?			Top Table (I)	Bottom Table (II)	
2) Is the Measured Driving Lane Width less than the Plan Driving Lane Width?			Narrow Rows (A)	Wide Rows (B)	
3) If a Separate Shoulder then is it narrow?			Upper Row (1)	Lower Row (2)	
Find 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) I A 2) I B 1) I B 2) II A II B This Row tells which Section to Use for Pav Width(s) determination(s)					

DRIVING LANE			SHOULDER	
TABLE 602-48 HMA UNIFORM THICKNESS SUBLOT CALCULATIONS				
Condition	PDL Width Pay Driving Lane Width	FDL Width Pay Driving Lane Deduct Width	PS Width Pay Shoulder Width	FSD Width Pay Shoulder Deduct Width
Row	I. Projects with a Separate Bid Item for Shoulder			
	A. Narrow Driving Lane			
I A 1)	MSW<PSW	MTLW	PTLW<MTLW	MSW
I A 2)	MSW<PSW	MTLW	PTLW<MTLW	Min (MSW, PSW+0.25)
	B. Wide Driving Lane			
I B 1)	MSW<EDLW<PSW	PDLW	0	MSW<EDLW
I B 2)	MSW<EDLW>PSW	PDLW	0	Min (MSW<EDLW, PSW+0.25)
	II. Projects without a Separate Bid Item for Shoulder			
II A	Narrow Driving Lane and Shoulder	MTLW	PTLW<MTLW	N/A
II B	Wide Driving Lane and Shoulder	Min (MTLW, PTLW+0.25)	0	N/A

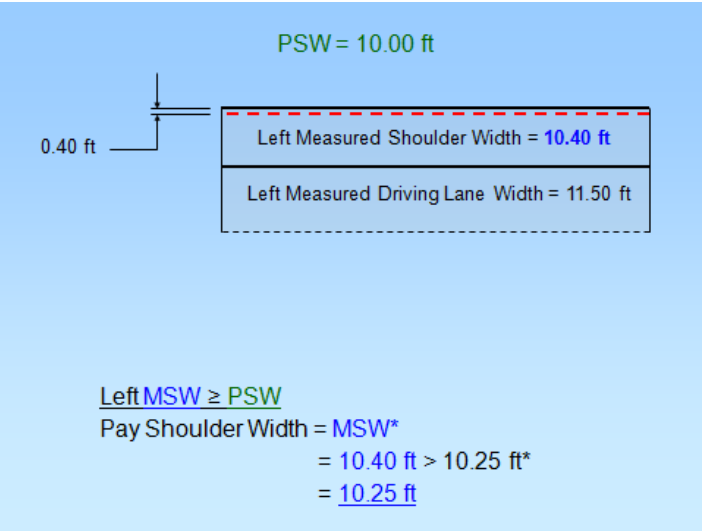
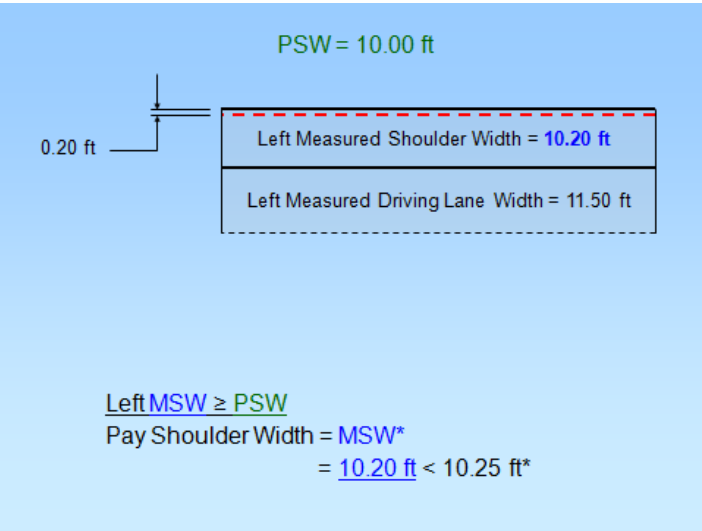


Ask Yourself These Questions:		YES		NO	
1) Is the Shoulder a Separate Bid Item?		Top Table (I.)		Bottom Table (II.)	
2) Is the Measured Driving Lane Width less than the Plan Driving Lane Width?		Narrow Rows (A.)		Wide Rows (B.)	
3) If a Separate Shoulder then is it narrow?		Upper Row (1)		Lower Row (2)	
Find the Column Corresponding to your Answers					
1) YES		YES	YES	YES	NO
2) YES		YES	NO	NO	YES
3) YES		NO	YES	NO	---
1A.1) 1A.2) 1B.1) 1B.2) II.A) II.B) This Row tells which Section to Use for Pav Width(s) determination(s)					

DRIVING-LANE				SHOULDER	
TABLE 602-18. HMA UNIFORM THICKNESS SUBLOT CALCULATIONS					
	Condition	PDL Width Pay Driving Lane Width	PDL 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				
1A.1)	MSW<PSW	MDLW	PDLW-MDLW	MSW	PSW-MSW
1A.2)	MSW>PSW	MDLW	PDLW-MDLW	Min(MSW, PSW+0.25)	0
	B. Wide Driving Lane				
1B.1)	MSW+EDLW<PSW	PDLW	0	MSW+EDLW	PSW-MSW-EDLW
1B.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	MDLW	PTLW-MDLW	N/A	N/A
II.B)	Wide Driving Lane and Shoulder	Min(MDLW, PTLW+0.25)	0	N/A	N/A



Ask Yourself 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 Pav Width's determination(s).			
DRIVING LANE			SHOULDER		
TABLE 602-18 HMA UNIFORM THICKNESS SUBLOT CALCULATIONS					
Condition	PDL Width	PDL Width	FS Width	PSD Width	
	Pay Driving Lane Width	Pay Driving Lane Deduct Width	Pay Shoulder Width	Pay Shoulder Deduct Width	
Row	I. Projects with a Separate Bid Item for Shoulder				
	A. Narrow Driving Lane				
I.A.1)	MSW<=PSW	MTLW	PDLW-MTLW	MSW	PSW-MSW
I.A.2)	MSW>PSW	MTLW	PDLW-MTLW	Min(0,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

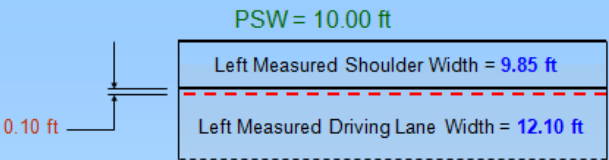


PDLW = 12.00 ft
PSW = 10.00 ft

Left Measured Shoulder Width = 9.85 ft
Left Measured Driving Lane Width = 12.10 ft

Ask Yourself 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	NO
2) YES	YES	NO	YES
3) YES	NO	YES	NO
1.A.1) 1.A.2) 1.B.1) 1.B.2) II.A. II.B.		This Row tells which Section to Use for Pav Width's determination's)	

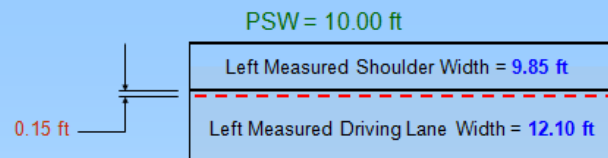
		DRIVING LANE		SHOULDER	
TABLE 602-18: HMA UNIFORM THICKNESS SUBLOT CALCULATIONS					
Condition	PDL Width	PDL D Width	PS Width	PSD Width	
	Pay Driving Lane Width	Pay Driving Lane Deduct Width	Pay Shoulder Width	Pay Shoulder Deduct Width	
Row	I. Projects with a Separate Bid Item for Shoulder				
	A. Narrow Driving Lane				
1.A.1)	MSW>PSW	MDLW	MSW	PSW-MSW	
1.A.2)	MSW>PSW	MDLW	Min(Q.SW, PSW+0.25)	0	
	B. Wide Driving Lane				
1.B.1)	MSW+EDLW<PSW	PDLW	MSW+EDLW	PSW-MSW-EDLW	
1.B.2)	MSW+EDLW>PSW	PDLW	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(Q.MTLW, PTLW+0.25)	0	N/A	N/A



Left MDLW ≥ PDLW
Pay Driving Lane Width = PDLW
= 12.00 ft

Ask Yourself 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	---	---
1.A.1) 1.A.2) 1.B.1) 1.B.2) II.A II.B				This Row tells which Section to Use for Pav Width(s) determination(s)	

DRIVING LANE				SHOULDER	
TABLE 602-18: HMA UNIFORM THICKNESS SUBLOT CALCULATIONS					
	Condition	PDL Width Pay Driving Lane Width	PDL/D 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				
1.A.1)	MSW<PSW	MDLW	PDLW-MDLW	MSW	PSW-MSW
1.A.2)	MSW>PSW	MDLW	PDLW-MDLW	Min(0,MSW-PSW+0.25)	0
	B. Wide Driving Lane				
1.B.1)	MSW+EDLW<PSW	PDLW	0	MSW+EDLW	PSW-MSW-EDLW
1.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	MDLW	PTLW-MDLW	N/A	N/A
II.B	Wide Driving Lane and Shoulder	Min(MDLW,PTLW+0.25)	0	N/A	N/A



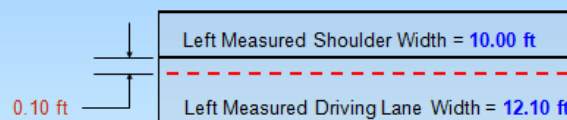
$$MSW + EDLW < PSW$$

$$\begin{aligned} \text{Pay Shoulder Width} &= MSW + EDLW \\ &= 9.85 \text{ ft} + (12.10 \text{ ft} - 12.00 \text{ ft}) \\ &= 9.85 \text{ ft} + (0.10 \text{ ft}) \\ &= 9.95 \text{ ft} \end{aligned}$$

$$\begin{aligned} \text{Pay Shoulder Deduct Width} &= PSW - MSW - EDLW \\ &= 10.00 \text{ ft} - 9.85 \text{ ft} - 0.10 \text{ ft} \\ &= 0.05 \text{ ft} \end{aligned}$$

$$PSW = 10.00 \text{ ft}$$

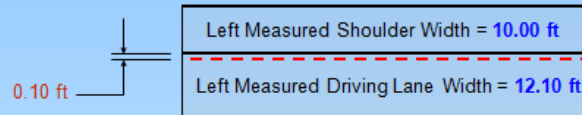
$$PDLW = 12.00 \text{ ft}$$



Ask Yourself 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 Pav Width's determination's).	

DRIVING LANE				SHOULDER	
TABLE 602-18 HMA UNIFORM THICKNESS SUBLOT CALCULATIONS					
	Condition	PDL Width	PDL Width	PS Width	PSD Width
		Pay Driving Lane Width	Pay Driving Lane Deduct Width	Pay Shoulder 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	MDLW	PTLW-MDLW	N/A	N/A
II.B)	Wide Driving Lane and Shoulder	Min(MDLW, PTLW-0.25)	0	N/A	N/A

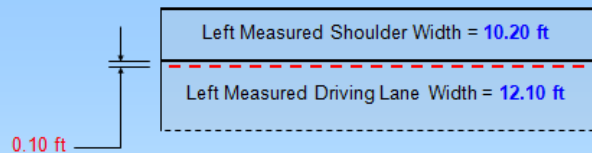
$$PSW = 10.00 \text{ ft}$$



$$MSW + EDLW \geq PSW$$

$$\begin{aligned} \text{Pay Shoulder Width} &= MSW + EDLW^{**} \\ &= 10.00 \text{ ft} + (12.10 \text{ ft} - 12.00 \text{ ft}) \\ &= 10.00 \text{ ft} + (0.10 \text{ ft}) \\ &= 10.10 \text{ ft} < 10.25 \text{ ft}^{**} \end{aligned}$$

$$PSW = 10.00 \text{ ft}$$



Ask Yourself 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 Pav Width's determination's).	

DRIVING LANE			SHOULDER	
TABLE 602-18. HMA UNIFORM THICKNESS SUBLOT CALCULATIONS				
Condition	PDL Width Pay Driving Lane Width	PDL 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	PSW-MDLW	MSW
I.A.2)	MSW+PSW	MDLW	PSW-MDLW	Min(MSW-PSW+0.25)
	B. Wide Driving Lane			
I.B.1)	MSW+EDLW<PSW	PDLW	0	MSW+EDLW
I.B.2)	MSW+EDLW>PSW	PDLW	0	Min(MSW+EDLW, PSW+0.25)
	II. Projects without a Separate Bid Item for Shoulder			
II.A	Narrow Driving Lane and Shoulder	MTLW	PTLW-MTLW	N/A
II.B	Wide Driving Lane and Shoulder	Min(MTLW, PTLW+0.25)	0	N/A

PSW = 10.00 ft

Left Measured Shoulder Width = 10.20 ft

Left Measured Driving Lane Width = 12.10 ft

0.10 ft

$MSW + EDLW \geq PSW$

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

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

Ask Yourself 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
2) YES	YES	NO	NO	YES
3) YES	NO	YES	NO	---
1.A.1) 1.A.2) 1.B.1) 1.B.2) II.A II.B			This Row tells which Section to Use for Pav Width(s) determination(s)	

DRIVING LANE			SHOULDER	
TABLE 602-18 HMA UNIFORM THICKNESS SUBLOT CALCULATIONS				
Condition	PDL Width Pay Driving Lane Width	PDL 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			
1.A.1)	MSW>PSW	MDLW	PDLW-MDLW	MSW
1.A.2)	MSW>PSW	MDLW	PDLW-MDLW	Min(0,MSW,PSW+0.25)
	B. Wide Driving Lane			
1.B.1)	MSW+EDLW<PSW	PDLW	0	MSW+EDLW
1.B.2)	MSW+EDLW>PSW	PDLW	0	Min(MSW+EDLW, PSW+0.25)
	II. Projects without a Separate Bid Item for Shoulder			
II.A	Narrow Driving Lane and Shoulder	MTLW	PTLW-MTLW	N/A
II.B	Wide Driving Lane and Shoulder	Min(MTLW,PTLW+0.25)	0	N/A

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

$PDLW = \text{Min} (MILW, PDLW + .25 \text{ ft})$

$MILW = 15.5, > 15 + .25 = 15.25$

$PDLW = 15.25 \text{ ft}$

Ask Yourself 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
2) YES	YES	NO	NO	YES
3) YES	NO	YES	NO	---
1.A.1) 1.A.2) 1.B.1) 1.B.2) II.A) II.B)			This Row tells which Section to Use for Pav Width(s) determination(s)	

DRIVING LANE			SHOULDER		
TABLE 602-18 HMA UNIFORM THICKNESS SUBLOT CALCULATIONS					
	Condition	PDL Width Pay Driving Lane Width	PDL 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				
1.A.1)	MSW>PSW	MDLW	PDLW-MDLW	MSW	PSW-MSW
1.A.2)	MSW>PSW	MDLW	PDLW-MDLW	Min(0,MSW,PSW+0.25)	0
	B. Wide Driving Lane				
1.B.1)	MSW+EDLW<PSW	PDLW	0	MSW+EDLW	PSW-MSW-EDLW
1.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

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
 $PDLW = MTLW$
 $MTLW = 14.8 \text{ ft}$
 $PDLW = PTLW - MTLW$
 $15.0 \text{ ft} - 14.8 \text{ ft} = 0.2 \text{ ft}$

602.10 HMA PAID BY THE AREA

Pay per Lot for Driving Lanes

Pay Equations per Lot for Driving Lane Areas
Placed

Equation 10:
 $\text{Pay for Driving Lane} = (\Sigma PDLA)(BP)$

Not Placed (Deducted)

Equation 11:
 $\text{Pay Deduct for Driving Lanes} = 2(\Sigma PDLDA)(BP)$

$\Sigma PDLA = \text{Pay Driving Lane Area per Lot}$
 $\Sigma PDLDA = \text{Pay Driving Lane Deduct Area per Lot}$
 $BP = \text{Bid Price}$

602.10 HMA PAID BY THE AREA

Pay per Lot for Shoulders

Pay Equations per Lot for Shoulder Areas
Placed

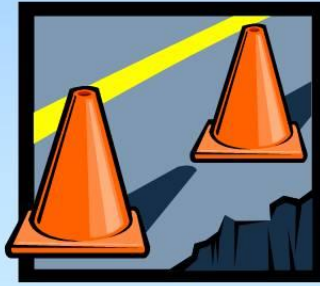
Equation 12:
 $\text{Pay for Shoulder} = (\Sigma PSA)(BP)$

Not Placed (Deducted)

Equation 13:
 $\text{Pay Deduct for Shoulder} = 2(\Sigma PSDA)(BP)$

$\Sigma PSA = \text{Pay Shoulder Area per Lot}$
 $\Sigma PSDA = \text{Pay Shoulder Deduct Area per Lot}$
 $BP = \text{Bid Price}$

COMPUTATIONS FOR
PAY PER LOT FOR AREAS PLACED
AND NOT PLACED



Pay per Lot for Lanes & Shoulders
Shoulders are Placed Separately

Sublot Length (SL) = 1000 ft
 Bid Price (BP) = \$23.00 per yd²

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) Difference (ft)	(D) Effective 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		

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 (Q_T) Computation. In each lot, calculate Q_T for the total pavement thickness using Equation 8 and round to hundredths.

Equation 8:
$$Q_T = \frac{\bar{X} - LSL}{S}$$

\bar{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 Q_T to determine the thickness Percent Within Limits value (PWL_T) by locating the Q_T in the left column of the Percent Within Limits (PWL) Table in Section 5.2.1 - Statistics, Part V. Select the appropriate PWL_T by moving across the selected Q_T row to the column representing the number of samples in the lot.

If the computed 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 subplot, and calculate a new pay factor. For lots that have been entirely overlaid, the maximum pay factor is zero.

If the computed Q_T is greater than the largest Q_T shown in the PWL Table, a value of 100.00 is assigned as the PWL_T for thickness.

For each lot and all lanes and shoulders, compute the thickness pay factor (P_T) for the total pavement thickness using Equation 9 and round to nearest thousandth. No bonus will be paid for shoulders, thus use $P_T = 0.000$ whenever P_T calculates greater than 0.000 for shoulders.

Equation 9:
$$P_T = \left(\frac{(PWL_T) * 0.30}{100} \right) - 0.270$$

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 \$40 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.

602.10 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 \$40 per Ton

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

QC/QA Asphalt Specifications Special Provision 15-06007 Outline

- 602.1 Description (Sheet 1 of 29)
- 602.2 Contractor QC Requirements (Sheets 1 to 4 of 29)
- 602.3 Materials (Sheets 4 to 8 of 29)
- 602.4 Construction Requirements (Sheets 4 to 14 of 29)
- 602.5 Process Control (Sheets 14 to 16 of 29)
- 602.6 Compaction Testing (Sheets 16 to 18 of 29)
- 602.7 Weather Limitations (Sheet 18 of 29)
- 602.8 Mixture Acceptance (Sheets 18 to 21 of 29)
- 602.9 Basis of Acceptance (Sheets 21 to 24 of 29)
- 602.10 HMA Paid by the Area (Sheets 24 to 28 of 29)
- 602.11 Measurement and Payment (Sheets 28 to 29 of 29)**

602.11 MEASUREMENT AND PAYMENT

Objective

- Identify the bid items for payment and how they are measured

If this minimum quantity of surface course or base course is not placed, a deduction of \$40 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 (*) (**) (***)" or "HMA Base (*) (**) (***)".

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 subplot length separately. Measure the lengths (to the nearest 0.01 feet) a minimum of once per subplot. 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 subplot 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.

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

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" or "HMA Base".
 - Sideroads
 - Entrances
 - Mailbox Turnouts

602.11 MEASUREMENT AND PAYMENT

b. HMA Pavement & 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 subplot length separately
- Measure the lengths (to the nearest 0.01 ft) a minimum of once per subplot
- The location of the width measurements will be the same location as the mainline cores

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. For mixes containing Reclaimed HMA Pavement (RAP) or Recycled Asphalt Shingles (RAS), compute the HMA material contained in the RAP and RAS using the binder content determined from ignition oven testing. Maintain this information for materials tracking purposes. No separate payment for HMA material in RAP and RAS will be made. Combined gradation results will be used 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.

07-27-18 C&M (BTH)
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602.11 MEASUREMENT AND PAYMENT

b. HMA Pavement & 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

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.



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

SECTION 602

MODIFIED REQUIREMENTS – ASPHALT MIXTURES

Project Number: 160-88 KA-4202-01

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 (PG64-22)⁽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	2.598
COMPACTION REVOLUTIONS:	
N _{ini} (level of compaction)	7 (≤ 90.5)
N _{des}	75
N _{max}	115
MIX:	
VFA	65 - 78

- ⁽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 (PG64-22).

Percent RAP	Name
0	SM-12.5A (PG64-22)
1 - 15	SR-12.5A (PG64-22)
16 - 25	SR-12.5A (PG58-28)

For information only, the 20 year design lane traffic is 1.7 million ESALs.

8/4/15 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

HMA Base (*)(**)(***)
HMA Surface (*)(**)(***)
HMA Overlay (*)(**)(***)
HMA Pavement (#) (##)
HMA Pavement (#) Shoulder
Emulsified Asphalt (****)
Asphalt Core (Set Price)
Material for HMA Patching (Set Price)
Quality Control Testing (HMA)
*Mix Designation
**Grade of Asphalt Binder
***Shoulder
****Type and Grade of Emulsified Asphalt
Thickness
##Type of surface course HMA mixture

UNITS

Ton
Ton
Ton
Square Yard
Square Yard
Ton
Each
Ton
Ton

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 on a daily basis. 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; and

- Copies of all failing test results (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.

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 $\frac{1}{3}$ 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 subplot 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 subplot 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 $\frac{1}{3}$ of the sample;
- supply $\frac{1}{3}$ of the sample to the KDOT field laboratory for testing; and
- supply $\frac{1}{3}$ 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 subplot 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-6. 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-6 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
	1½"	1"	¾"	½"	⅜"	No. 4	No. 8	No. 16	No. 200		
SM-4.75A SR-4.75A			0	0	0-5	0-10		40-70	88.0-94.0	16.0	0.9 – 2.0
			0	0-2	0-5	0-10		40-70	88.0-94.0	16.0	0.9 – 2.0
SM-9.5A SR-9.5A			0	0	0-10	10 min.	33-53		90.0-98.0	15.0	0.6 – 1.2
			0	0-2	0-10	10 min.	33-53		90.0-98.0	15.0	0.6 – 1.2
SM-9.5B SR-9.5B			0	0	0-10	10 min.	53-68		90.0-98.0	15.0	0.8 – 1.6
			0	0-2	0-10	10 min.	53-68		90.0-98.0	15.0	0.8 – 1.6
SM-9.5T SR-9.5T			0	0	0-10	10 min.	53-68		90.0-98.0	15.0	0.8 – 1.6
			0	0-2	0-10	10 min.	53-68		90.0-98.0	15.0	0.8 – 1.6
SM-12.5A SR-12.5A		0	0	0-10	10 min.		42-61		90.0-98.0	14.0	0.6 – 1.2
		0	0-2	0-10	10 min.		42-61		90.0-98.0	14.0	0.6 – 1.2
SM-12.5B SR-12.5B		0	0	0-10	10 min.		61-72		90.0-98.0	14.0	0.8 – 1.6
		0	0-2	0-10	10 min.		61-72		90.0-98.0	14.0	0.8 – 1.6
SM-19A SR-19A	0	0	0-10	10 min.			51-65		92.0-98.0	13.0	0.6 – 1.2
	0	0-2	0-10	10 min.			51-65		92.0-98.0	13.0	0.6 – 1.2
SM-19B SR-19B	0	0	0-10	10 min.			65-77		92.0-98.0	13.0	0.8 – 1.6
	0	0-2	0-10	10 min.			65-77		92.0-98.0	13.0	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 4.0% 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 98.0% of the G_{mm} .

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 3.5% to 4.5%.
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-6	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-6	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 1203**. 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 340°F 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) Batch Operation. Coordinate HMA batchers (Gob Hoppers) with the plant production rate at all times so the hopper is more than $\frac{3}{4}$ 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, 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	$\geq 90.00\%$ 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 finishing, vibratory rollers in the static 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 and periodically, 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 165°F. 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. Maintenance of Traffic. Maintain traffic according to **DIVISION 800** and the following:

Maintain one-way traffic, and restrict traffic speeds to 20 miles per hour in the vicinity of workers, unless otherwise designated. Use pilot cars to lead traffic through the area of paving and rolling operations, and if directed, through a curing area. The use of flaggers is allowed through patching operations, unless the patching area or distance between flaggers exceeds ½ mile, in which case the use of a pilot car shall be required. On overlay projects with 2 lanes or more in each direction for traffic use, the Engineer may waive the pilot car requirements.

Station one flagger ahead of the application of the tack coat and one flagger ahead of the area being protected from traffic. Take adequate protection for traffic on side roads approaching the tack area.

g. 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.

h. 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 subplot 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	±2.0%	*	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 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. Take the readings a minimum of 2 hours apart and a maximum of 6 hours apart. Do not take the readings 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:

$$\text{Equation A: } \% \text{RAP} = \frac{\text{RAP} * 100}{\text{RAP} + \text{AGG}_v}$$

%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 3%.
- 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 3% of the maximum allowed %RAP 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% then the Contractor will be assessed the following penalty.

Equation B:
$$\text{Contract Deduct} = \frac{\text{BP} * \text{Q} * (\% \text{RAP}_4 - \% \text{RAP}_{\text{max}})}{100}$$

Contract 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.

%RAP₄ is the 4-point moving average of %RAP.

%RAP_{max} is the Maximum %RAP from the Project Special Provision.

Contract Deducts 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 Contract 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 %RAP₄ 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 subplot unless the Engineer's results (1 test per subplot) 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 subplot size based on anticipated production. If actual production does not meet anticipated production, the subplot 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 subplot. The Engineer will take 1 random nuclear density verification test per subplot. 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 subplot, 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 subplot. 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, subplot 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 subplot (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 (°F)			Surface Temperature (°F)		
		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, subplot 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 subplot 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 tolerance shown for all mix characteristics listed in **TABLE 602-12** and without a V_a penalty, the subplot 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 subplot size, the subplot size may again be increased to 1,250 tons per subplot (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 subplot 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 subplot 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 subplot 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 subplot 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 \$40 per ton. The Engineer will create a change order (**SECTION 104**) adding the item of work with a unit price of \$40/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 \$40 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	
93.00% or greater	1.040	1.040	
92.00 to 92.99%	A1	A1	
91.00 to 91.99%	1.000	1.000	
90.00 to 90.99%	A2	1.000	
89.00 to 89.99%	0.840 or Remove ³	A3	
less than 89.00%	0.840 or Remove ³	0.840 or Remove ³	

¹For 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**.

²Shoulders: 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 90.00% (if specified thickness is ≥ 2") or 89.00% (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.

³Low 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.

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

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

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

Calculations for Density Pay Factors A1, A2 and A3:

$$A1 = [100 + 4 (\% \text{ of lot } G_{mm} - 92.00)] \div 100$$

$$A2 = [84 + 16 (\% \text{ of lot } G_{mm} - 90.00)] \div 100$$

$$A3 = [84 + 16 (\% \text{ of lot } G_{mm} - 89.00)] \div 100$$

Density Pay Adjustment Factor Calculation:

$$\text{Density Pay Adjustment Factor (P}_D\text{)}^* = \text{Density Pay Factor} - 1.000$$

*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 \$40 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:
$$Q_{LD} = \frac{\bar{X} - LSL}{S}$$

\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 5.17.09, 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 \$40 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:
$$Q_{UV} = \frac{USL - \bar{X}}{S}$$

Equation 4:
$$Q_{LV} = \frac{\bar{X} - LSL}{S}$$

\bar{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 5.00%.

LSL is the lower specification limit for V_a and is defined as 3.00%.

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 .

(2) Air Voids Pay Adjustment (Failing t-Test). If the t-test fails, KDOT's test result will be used to calculate the P_V for the lot. Follow the procedures given in **subsection 602.9d.(1)** to determine the P_V or disposition of the lot. Use the values from **TABLE 602-16** to calculate Q_{UV} , Q_{LV} , PWL_{UV} and 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
\bar{X}	Average or Mean	KDOT's test result for the lot
S	Standard Deviation	0.50
USL	Upper Specification Limit	5.50%
LSL	Lower Specification Limit	2.50%
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 subplot.

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 subplot 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 Shoulder⁵				
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

¹Deductions will be made for unplaced areas.

²Calculate 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.

³MSW shall be between PSW and PSW + 0.25 feet. Any excess width over 0.25 feet will not be included in PSW.

⁴MSW+ EDLW shall be between PSW and PSW + 0.25 feet. Any excess width over 0.25 feet will not be included in PSW.

⁵Shoulder is normally 0.00 feet to 3.00 feet wide and placed at the same time as the driving lane. PTLW = PDLW + PSW

⁶MSTLW 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: $TPA_{DL} = P_T (\sum PDLA) (\$1.90) (\text{Plan Thickness})$

Equation 7: $TPA_{SH} = P_T (\sum PSA) (\$1.70) (\text{Plan Thickness})$

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

Σ 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 (Q_T) Computation. In each lot, calculate Q_T for the total pavement thickness using Equation 8 and round to hundredths.

Equation 8:
$$Q_T = \frac{\bar{X} - LSL}{S}$$

\bar{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 Q_T to determine the thickness Percent Within Limits value (PWL_T) by locating the Q_T in the left column of the Percent Within Limits (PWL) Table in Section 5.2.1 - Statistics, Part V. Select the appropriate PWL_T by moving across the selected Q_T row to the column representing the number of samples in the lot.

If the computed 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 subplot, and calculate a new pay factor. For lots that have been entirely overlaid, the maximum pay factor is zero.

If the computed Q_T is greater than the largest Q_T shown in the PWL Table, a value of 100.00 is assigned as the PWL_T for thickness.

For each lot and all lanes and shoulders, compute the thickness pay factor (P_T) for the total pavement thickness using Equation 9 and round to nearest thousandth. No bonus will be paid for shoulders, thus use $P_T = 0.000$ whenever P_T calculates greater than 0.000 for shoulders.

Equation 9:

$$P_T = \left(\frac{(PWL_T) * 0.3}{100} \right) - 0.270$$

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 \$40 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 (*)(**)(***)" or "HMA Base(*)(**)(***)".

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 subplot length separately. Measure the lengths (to the nearest 0.01 feet) a minimum of once per subplot. 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 subplot 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. For mixes containing Reclaimed HMA Pavement (RAP) or Recycled Asphalt Shingles (RAS), compute the HMA material contained in the RAP and RAS using the binder content determined from ignition oven testing. Maintain this information for materials tracking purposes. No separate payment for HMA material in RAP and RAS will be made. Combined gradation results will be used 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.

**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 42 and 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[illegible]

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 dolomitic 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.		
<ul style="list-style-type: none"> 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)
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**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):

ΔT_c -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 40°F. 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 addition 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.

**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 $\Delta T_c \geq -5.0^\circ\text{C}$ 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 Spread¹, °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.

1202.4 PREQUALIFICATION

Prequalify material according to **SECTION 1201**.

1202.5 BASIS OF ACCEPTANCE

See applicable requirements under **SECTION 1201**.

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-10-06 (2011) in the following manner:

2.2. Quality 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.

2.3. 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. STANDARD DEFINITIONS FOR QC/QA APPLICATIONS

The following terms are defined in the AASHTO R-10-06 (2011) *except Agency*. All other shall be consistent with the **2008 AASHTO Guide Specifications For Highway Construction**.

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 Agency was chosen for the purpose of consistency, as this document is intended for use by any 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 (β) 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 days 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.

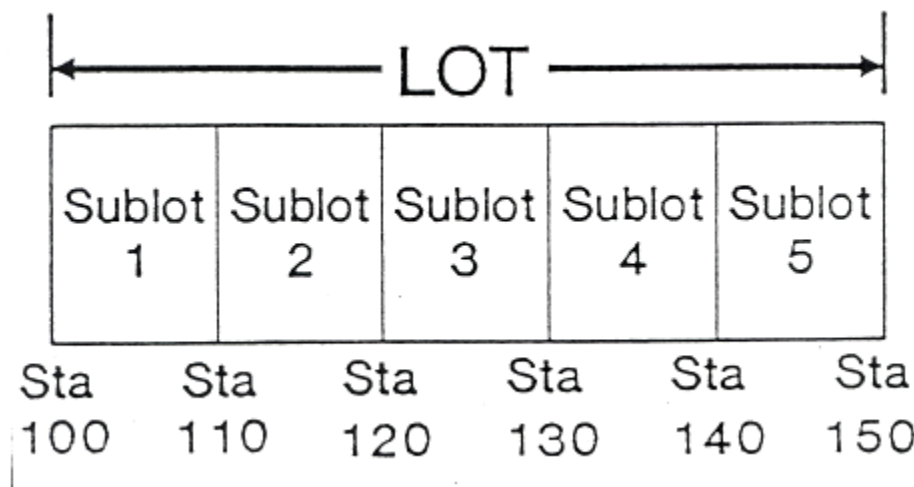


Figure 1. Lot and sublots in a highway construction setting

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:

$$\bar{x} = \frac{x_1 + x_2 + \dots + x_n}{n} = \frac{\sum x_i}{n} \quad (1)$$

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:

$$x_{ma} = \frac{x_{i-3} + x_{i-2} + x_{i-1} + x_i}{w} \quad (2)$$

5.2.1. Example: Find the 4-point moving average for the above asphalt content data:

<u>Asphalt content (%)</u>	<u>4-point moving average</u>
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:

<u>Air content (%)</u>	<u>4-point moving average</u>
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.

$$R = x_{\max} - x_{\min} \quad (3)$$

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:

$$s = \sqrt{\frac{\sum(x_i - \bar{x})^2}{n-1}} \quad (4)$$

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			$\Sigma = 0.62$

$$s = \sqrt{\frac{\sum(x_i - \bar{x})^2}{n-1}} = \sqrt{\frac{0.62}{6-1}} = 0.35$$

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			$\Sigma = 2.90$

$$s = \sqrt{\frac{\sum(x_i - \bar{x})^2}{n-1}} = \sqrt{\frac{2.90}{6-1}} = 0.76$$

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:

$$s = 0.35; \quad s^2 = (0.35)^2 = 0.123$$

5.6.2. Example: Find the variance of the air content data given above:

$$s = 0.76; \quad s^2 = (0.76)^2 = 0.578$$

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:

$$C.O.V.(\%) = \frac{s}{\bar{x}} \times 100 \quad (5)$$

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.

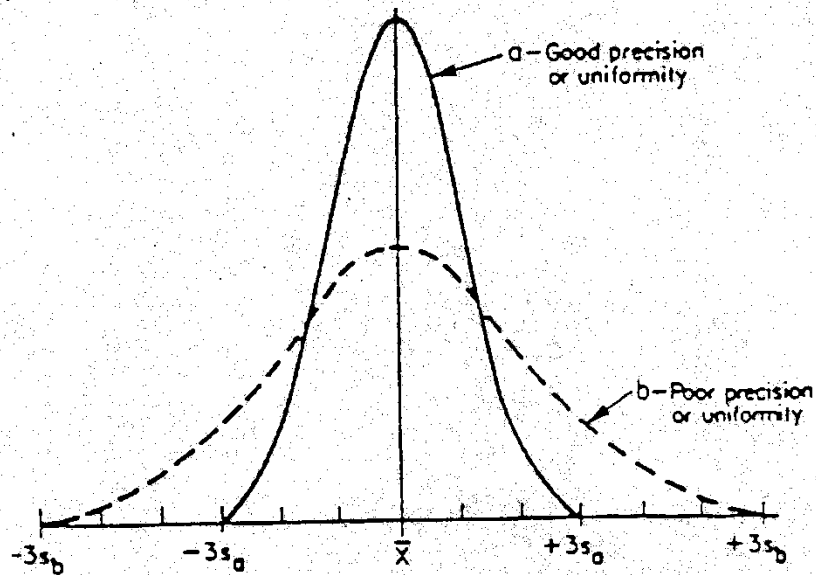


Figure 2. Normal distribution curves

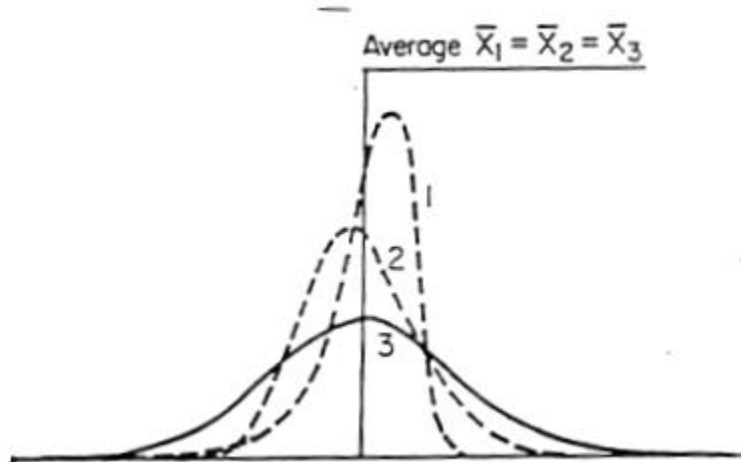


Figure 3. Quite different distributions may have the same average

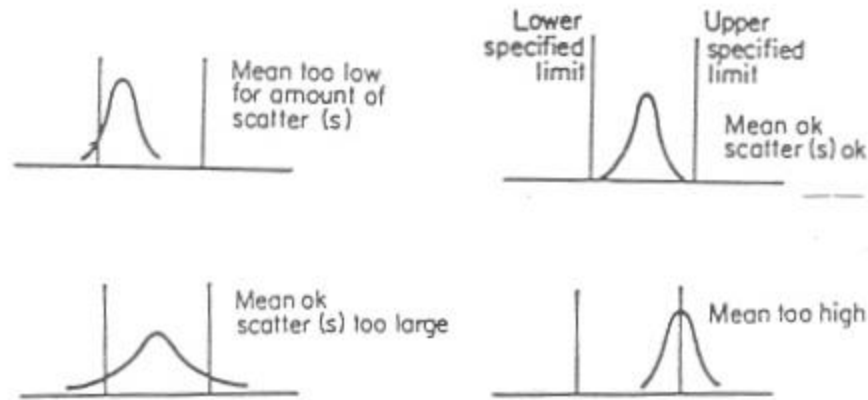


Figure 4. Process control related to specification limits

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.

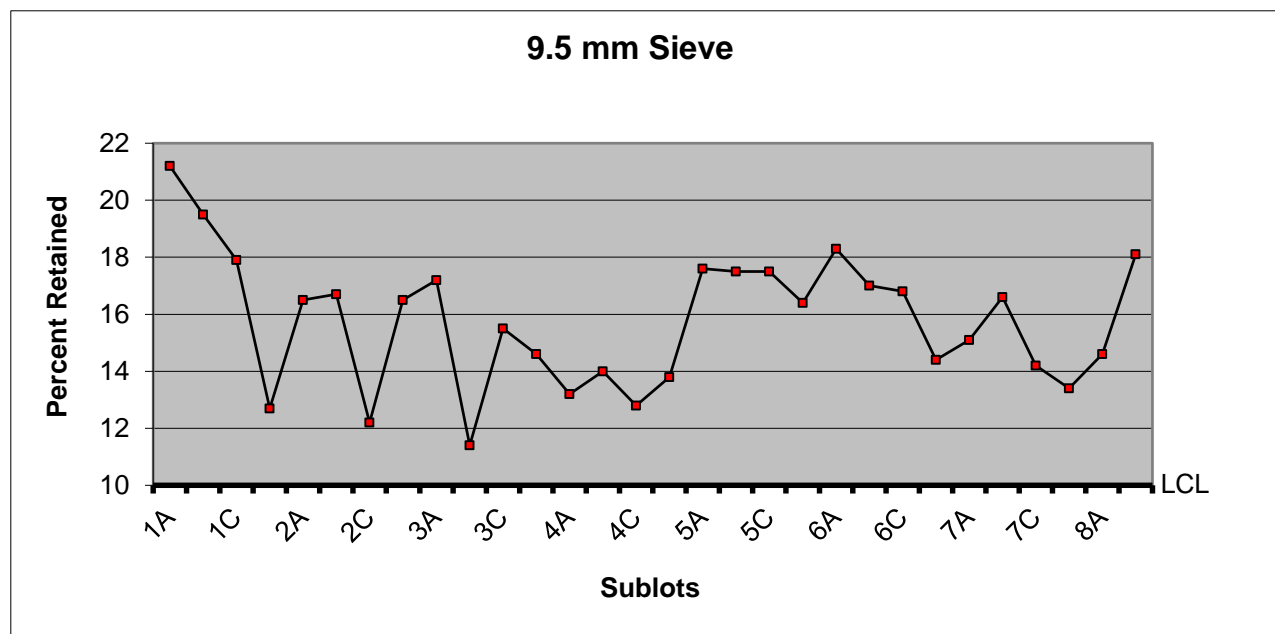


Figure 5. A typical control chart

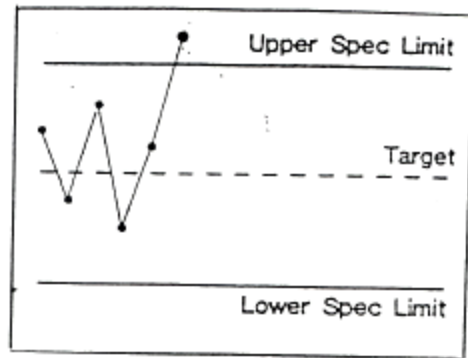


Figure 6. A point outside the upper specification limits

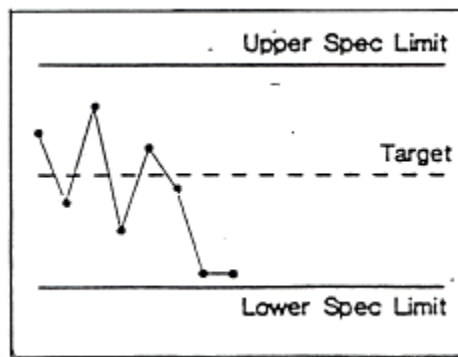


Figure 7. Two consecutive points near the upper or lower specification limits

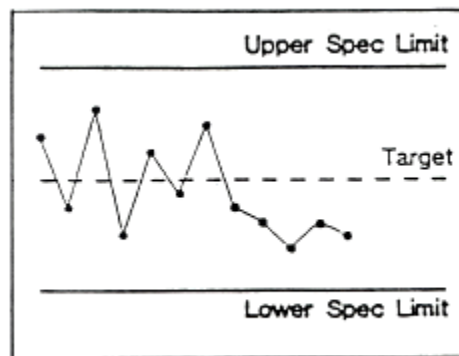


Figure 8. Five consecutive points on one side of the center target value

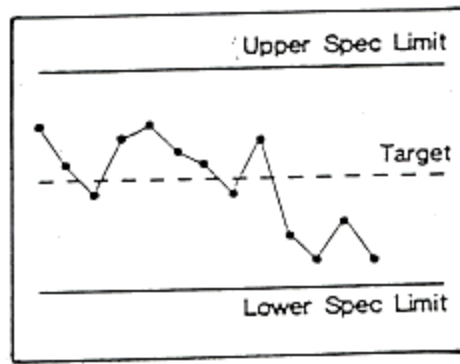


Figure 9. A sudden change in the level of results

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 $\pm 1s$, 95.44% within $\pm 2s$ and 99.74% within $\pm 3s$. Thus, it is apparent that a control chart based on the test statistics (\bar{x} and s) could be easily developed. The center line could be the mean of k sample means, each based on n 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).

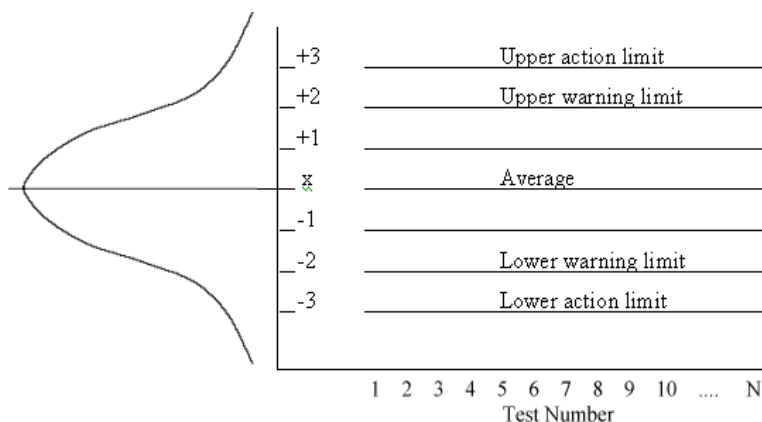


Figure 10. Statistical control chart

5.12. Moving Average

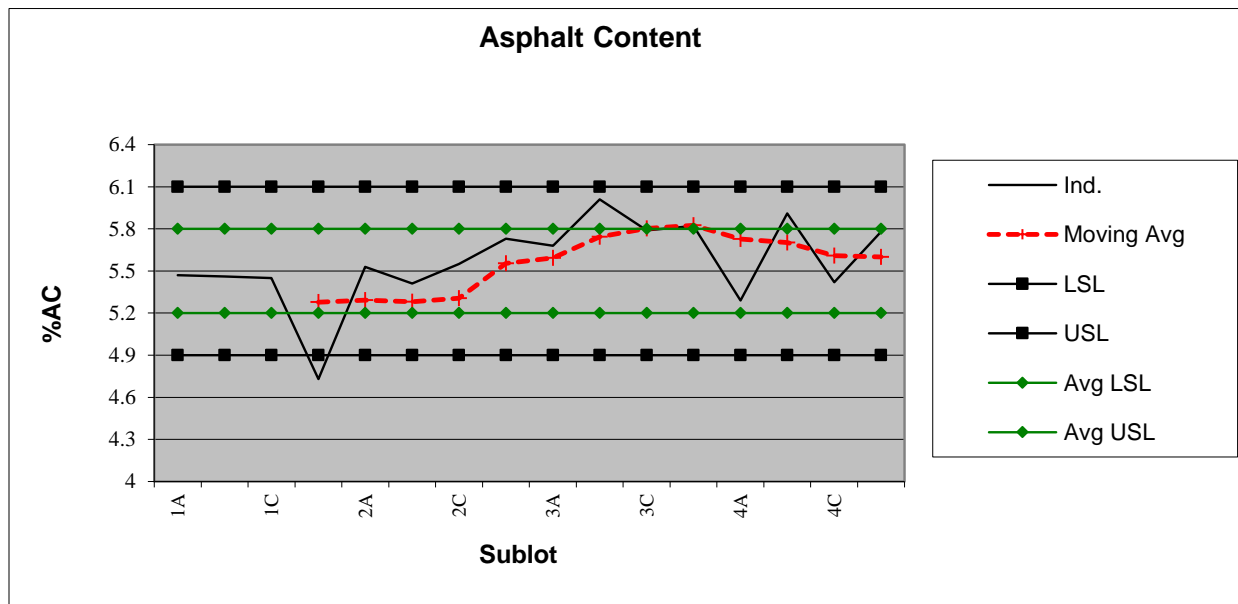
Within KDOT's QC/QA specifications, moving averages are to be plotted on the same chart as the individual test results. This is a simple process to include on the graphs. The number of tests in each average will be dictated by the specifications for the project. For the following illustration, a 4-point 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
2A	5.53
2B	5.41
2C	5.55
2D	5.73
3A	5.68
3B	6.01
3C	5.79
3D	5.82
4A	5.29
4B	5.91
4C	5.42
4D	5.78

1st avg = (5.47 + 5.46 + 5.45 + 4.73)/4 = 5.28
2nd avg = (5.46 + 5.45 + 4.73 + 5.53)/4 = 5.29
3rd avg = (5.45 + 4.73 + 5.53 + 5.41)/4 = 5.28
4th avg = (4.73 + 5.53 + 5.41 + 5.55)/4 = 5.31
5th avg = (5.53 + 5.41 + 5.55 + 5.73)/4 = 5.56
6th avg = (5.41 + 5.55 + 5.73 + 5.68)/4 = 5.59
7th avg = (5.55 + 5.73 + 5.68 + 6.01)/4 = 5.74
8th avg = (5.73 + 5.68 + 6.01 + 5.79)/4 = 5.80
9th avg = (5.68 + 6.01 + 5.79 + 5.82)/4 = 5.83
10th avg = (6.01 + 5.79 + 5.82 + 5.29)/4 = 5.73
11th avg = (5.79 + 5.82 + 5.29 + 5.91)/4 = 5.70
12th avg = (5.82 + 5.29 + 5.91 + 5.42)/4 = 5.61
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 subplot 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 subplot 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

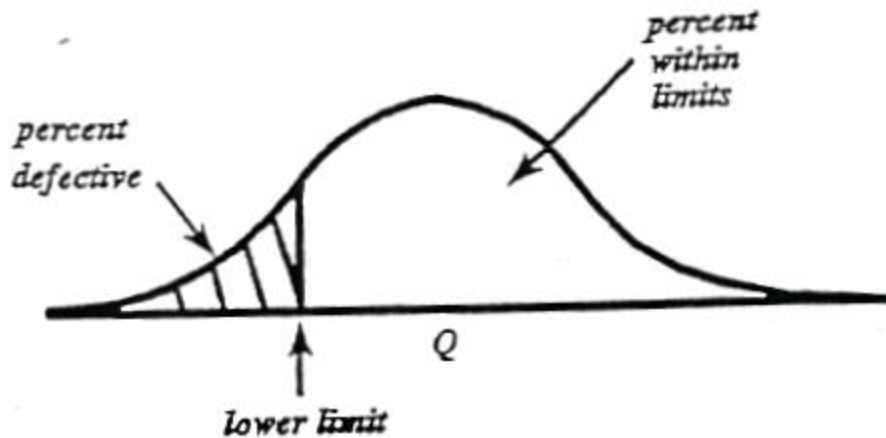
6.2.3. \bar{X} = the arithmetic mean or average of values under consideration. \bar{X} may be expressed as $\Sigma x_i/n$, or the sum of the individual values divided by the number of individual values.

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).

SINGLE-LIMIT SPECIFICATION

DISTRIBUTION OF CHARACTERISTIC OF INTEREST



DOUBLE-LIMIT SPECIFICATION

DISTRIBUTION OF CHARACTERISTIC OF INTEREST

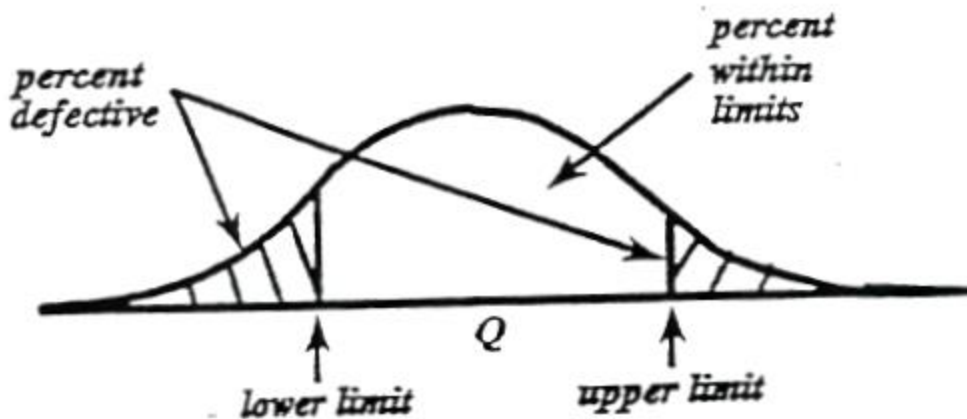


Figure 11. Concept of Percent Defective

6.3. Steps in Analysis for a double-limit specification:

6.3.1. Locate “n” sampling positions on the lot or subplot 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:

$$s = \sqrt{\frac{\sum (x_i - \bar{x})^2}{n - 1}}$$

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 subplot 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:

$$\text{Lot 1: } \bar{X} = 4.23, s_x = 0.437, n = 4$$

$$Q_U = \frac{5.25 - 4.23}{0.437} = 2.33 \quad \text{from Table 2 } PWL_U = 100 \%$$

$$Q_L = \frac{4.23 - 2.75}{0.437} = 3.39 \quad \text{from Table 2 } PWL_L = 100 \%$$

$$PWL = (100 + 100) - 100 = 100 \%$$

$$\text{Lot 2: } \bar{X} = 4.33, s_x = 0.769, n = 4$$

$$Q_U = \frac{5.25 - 4.33}{0.769} = 1.20 \quad \text{from Table 2 } PWL_U = 90 \%$$

$$Q_L = \frac{4.33 - 2.75}{0.769} = 2.05 \quad \text{from Table 2 } PWL_L = 100 \%$$

$$PWL = (90 + 100) - 100 = 90 \%$$

$$\text{Lot 3: } \bar{X} = 2.56, s_x = 0.348, n = 4$$

$$Q_U = \frac{5.25 - 2.56}{0.348} = 7.73 \quad \text{from Table 2 } PWL_U = 100 \%$$

$$Q_L = \frac{2.56 - 2.75}{0.348} = -0.55 \quad \text{from Table 2 } PWL_{Table} = 68.33 \%$$

If Q_L is a negative number, the PWL is equal to 100 % - (value looked up in **Table 2**)

$$PWL_L = (100 - 68.33) = 31.67 \%$$

$$PWL = (100 + 31.67) - 100 = 31.67 \%$$

$$\text{Lot 4: } \bar{X} = 3.89, s_x = 1.506, n = 4$$

$$Q_U = \frac{5.25 - 3.89}{1.506} = 0.90 \quad \text{from Table 2 } PWL_U = 80.0 \%$$

$$Q_L = \frac{3.89 - 2.75}{1.506} = 0.76 \quad \text{from Table 2 } PWL_L = 75.33 \%$$

$$PWL = (80.0 + 75.33) - 100 = 55.33 \%$$

Lot 5: $\bar{X} = 3.52$, $s_x = 1.807$, $n = 4$

$$Q_U = \frac{5.25 - 3.52}{1.807} = 0.96 \quad \text{from Table 2 } PWL_U = 82.0 \%$$

$$Q_L = \frac{3.52 - 2.75}{1.807} = 0.43 \quad \text{from Table 2 } PWL_L = 64.33 \%$$

$$PWL = (82.0 + 64.33) - 100 = 46.33 \%$$

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: $\bar{X} = 277.6$, $s_x = 2.608$, $n = 5$

$$Q = \frac{277.6 - 275}{2.608} = 0.997 \quad \text{from Table 2. } PWL = 83.64 \%$$

Lot 2: $\bar{X} = 274.0$, $s_x = 9.274$, $n = 5$

$$Q = \frac{274 - 275}{9.274} = -0.11 \quad \text{from Table 2. } PWL_{Table} = 53.91 \%$$

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: $\bar{X} = 293.4$, $s_x = 4.615$, $n = 5$

$$Q = \frac{293.4 - 275}{4.615} = 3.99 \quad \text{from Table 2. } PWL = 100.00 \%$$

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

Quality Index Qu or QL	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	Percent Within Limits for Selected Sample Sizes												
QU or QL	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	Percent Within Limits for Selected Sample Sizes												
Q _U or Q _L	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	Percent Within Limits for Selected Sample Sizes												
Qu or Ql	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 Qu or QL	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 Qu or QL	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												
	<u>N=3</u>	<u>N=4</u>	<u>N=5</u>	<u>N=6</u>	<u>N=7</u>	<u>N=8</u>	<u>N=9</u>	<u>N=10</u>	<u>N=15</u>	<u>N=20</u>	<u>N=30</u>	<u>N=50</u>	<u>N=100</u>
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 than 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.

rev 08/12/96

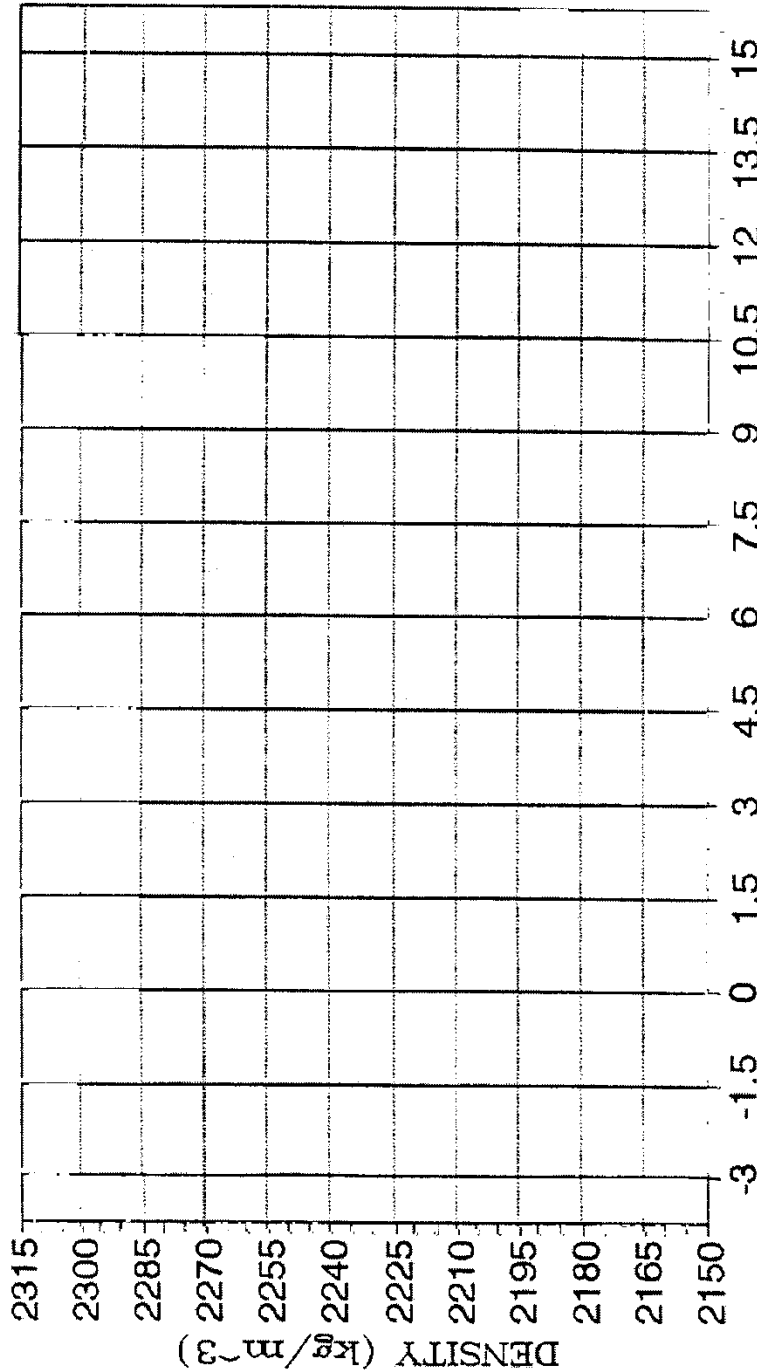
Remix Equipment (In or Ahead of Paver): None, Auger Paver, Shuttle Buggy, Pick Up Device, Material Transfer Device, Other _____

SEGREGATION CHECK USING THE NUCLEAR DENSITY GAUGE

Rev 09/12/98

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

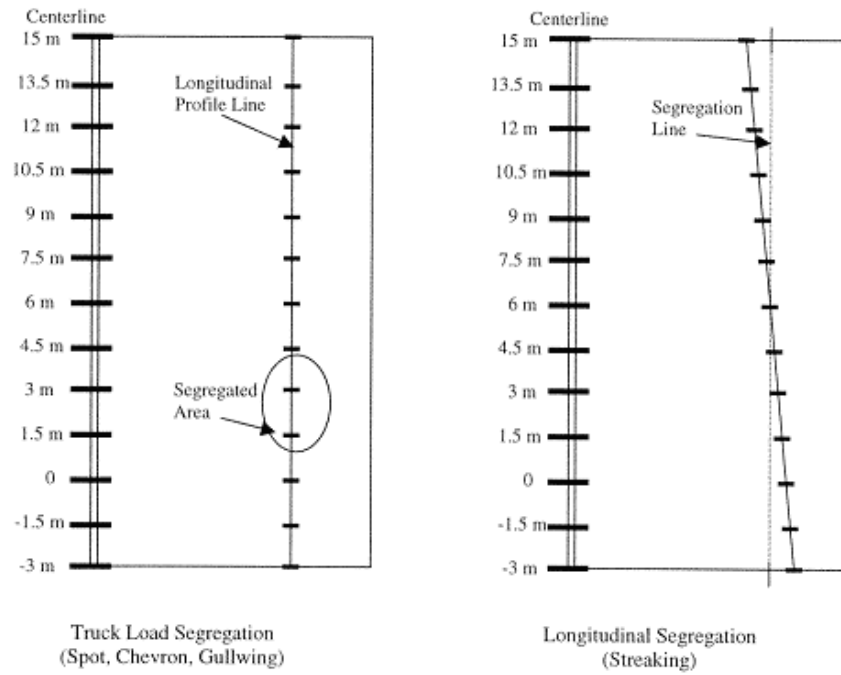


Revised
Density
Scale

SCREED LOCATION

Send Copy To Bureau of Materials and Research

FIGURE 1: SEGREGATION PROFILE LOCATION



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 subplot approximately the same length. Randomly select one longitudinal location within each subplot.

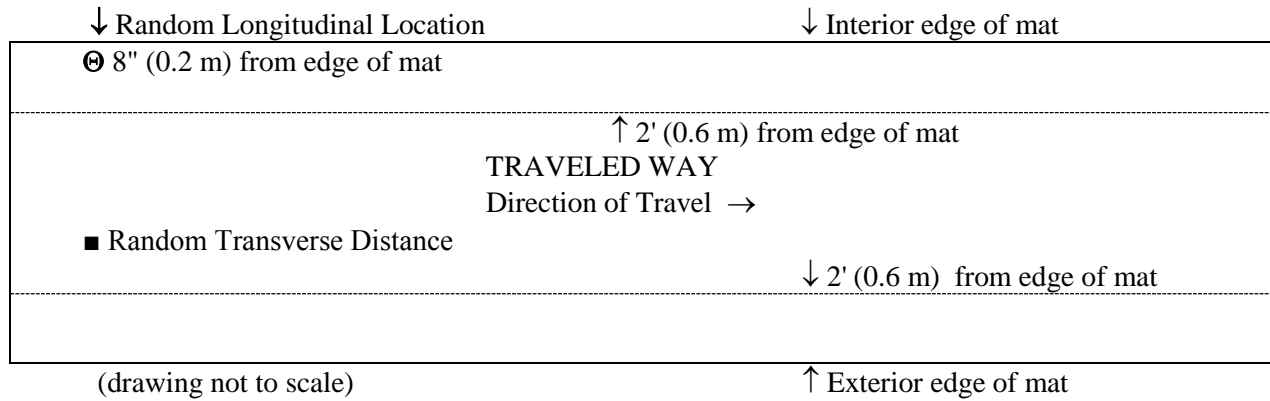
Table 1. Determination of Number of Sublots Per Day

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 subplot 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 subplot. (Second subplot evaluated before fourth subplot compaction completed. Third subplot evaluated before fifth subplot 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.



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. ⊕ 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).

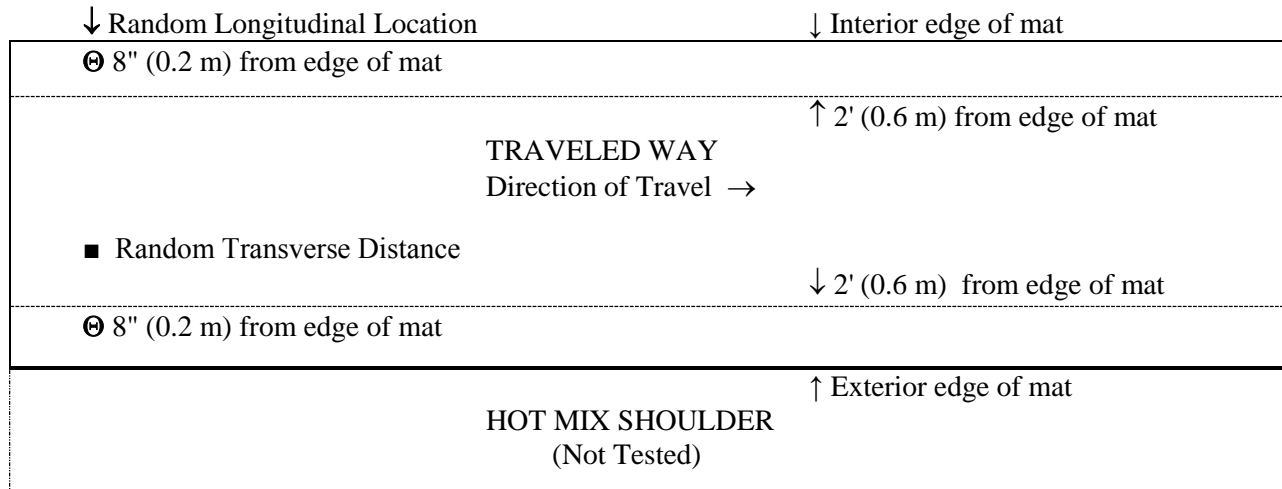
Note: Check tip of source rod to assure it is free of any foreign substance, (i.e. grease, asphalt, concrete, etc.).

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 [75 µm] 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 [1 kg/m 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 [0.01 MPa])	KT-37		1 specimen per subplot		1 specimen per lot.
Completed Base	Field Density Tests (0.1 lb/ft ³ [1 kg/m 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 Individual Aggregates	Sieve Analysis of Aggregate (1%, 0.1% for No. 200 [75 µm] sieve, of mass)	KT-02	c m	1 per 500 TONS (500 Mg) of combined aggregate.		1 per project.
	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 [50 g] 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 [1 kg/m ³])	KT-20	a	1 per 500 yd ³ (500 m ³).		1 per day.
	Slump (0.25 in [5 mm])	KT-21	a	1 per 500 yd ³ (500 m ³).		1 per day.
	Temperature (1 °F [0.5 °C])	KT-17	a	1 per 500 yd ³ (500 m 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 (500 m 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 [1 kg/m ³])	KT-38		Initially, 1 complete transverse profile, then 1 density per ½ day.		1 density per week.
	Beams (1 psi [1 kPa])	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 [1 N], 0.01 in [1 mm], 1 psi [0.01 MPa])	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) Concrete (continued)	Air Void Analyzer (0.0001 in [0.001 mm])	KT-71		Prequalification of mix required as per SS 2015 sec. 403.4.		1 test randomly during every 4 weeks of production.
	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 (3.7 m) 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.

**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.

**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						
Individual Aggregates (continued)	Uncompacted Void Content of Coarse Aggregate (0.01%)	KT-80	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.
Mineral Filler Supplement	Sieve Analysis of Aggregate (1%, 0.1% for No. 200 [75 µm] sieve, of mass)	KT-02	c h	1 per 250 TONS (250 Mg).		1 during the first 5000 TONS (5000 Mg) of HMA produced.
	Plasticity Tests (0.01 g or 0.1% of mass)	KT-10	c h	1 per 250 TONS (250 Mg).		
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 (10,000 Mg).
	Uncompacted Void Content of Fine Aggregate (0.1%)	KT-50		1 on the first lot then 1 per 10,000 TONS (10,000 Mg) of combined aggregate.		1 during the first 5000 TONS (5000 Mg) 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	1 sample for every 3 loads. (CMS = VER)		
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 (5000 Mg) 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						
HMA Mixtures (continued)	Air Voids ($V_a = 0.01\%$; G_{mm} & $G_{mb} = 0.001$)	KT-15, KT-39, KT-58, & SF Manual		1 per subplot. (See code n for G_{mm})	j	1 per lot. [Compact split sample on KDOT Gyratory – 1 per week or every 15,000 TONS (15,000 Mg)]
	Binder Content (by ignition) (0.1 g or 0.01% of mass)	KT-57		1 per subplot.	j	1 per lot.
	Mix Gradation (after ignition) (0.1 g or 0.01% of mass)	KT-34		1 per subplot.		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 (10,000 Mg).		1 during the first 5000 TONS (5000 Mg) 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 (1000 Mg) of RAP.	j	1 during the first lot then 1 per 4000 TONS (4000 Mg) of RAP.
	RAP Gradation (after ignition) (0.1 g or 0.01% of mass)	KT-34		1 per 1000 TONS (1000 Mg) of RAP.		1 during the first 5000 TONS (5000 Mg) 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 (1000 Mg) of RAP + RAS.	j	1 during the first lot then 1 per 4000 TONS (4000 Mg) of RAP + RAS.
	RAS Gradation (after ignition) (0.1 g or 0.01% of mass)	KT-34		1 per 1000 TONS (1000 Mg) of RAP + RAS.		1 during the first 5000 TONS (5000 Mg) 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) (Use approved rolling procedure and Nuclear Density Gauge on all HMA roadway or shoulder construction less than 1.5 inches)	Field Density - Cores or Nuclear Density Gauge ($G_{mb} = 0.001$; 0.1 lb/ft ³ [1 kg/m ³] or 0.01% of G_{mm})	KT-15 or KT-32	i	10 tests per lot.	i	5 companion tests per lot.
	Field Density -Nuclear Density Gauge ($G_{mb} = 0.001$; 0.1 lb/ft ³ [1 kg/m 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 (3.7 m) 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 (1.5 km). (Sieve according to specification.)	k	1 per day.
	Percent Retained on the #200 (75 μ m) 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.)

**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)						
Cold In-Place Recycle (CIR) Sec. 604 (continued)	Field Density ($G_{mb} = 0.001$; 0.1 lb/ft ³ [1 kg/m ³] or 0.01% of G_{mm})	KT-32				3 locations per width laid per mile (1.5 km) per lift. Minimum of 1 per day.
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 [75 µm] sieve, of mass)	KT-02	c	1 per 250 TONS (250 Mg) 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 [75 µm] sieve, of mass)	KT-02	ch	1 per 1000 TONS (1000 Mg) for each individual aggregate.		1 per project per individual aggregate.

**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)						
Individual Aggregates (continued)	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 per project.
Mineral Filler Supplement	Sieve Analysis of Aggregate (1%, 0.1% for No. 200 [75 µm] sieve, of mass)	KT-02	c h	1 per 250 TONS (250 Mg).		1 per project.
	Plasticity Tests (0.01 g or 0.1% of mass)	KT-10	c h	1 per 250 TONS (250 Mg).		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 (10,000 Mg).
	Uncompacted Void Content of Fine Aggregate (0.1%)	KT-50	f	1 on the first lot then 1 per 10,000 TONS (10,000 Mg) 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 (200 Mg) of combined mix.		1 per project.
Asphalt Material	Sampling	KT-26	b e	1 sample for every 3 loads. (CMS = VER)		
HMA Mixtures	Percent Moisture in Mixture (0.1 g or 0.01% of mass)	KT-11		1 per 2000 TONS (200 Mg) of combined mix.		1 per project.
	Theoretical Maximum Specific Gravity (Rice) ($G_{mm} = 0.001$)	KT-39	n	1 per subplot.		1 per lot.
	Binder Content (by ignition) (0.1 g or 0.01% of mass)	KT-57		1 per subplot.	j	1 per lot.
	Mix Gradation (after ignition) (0.1 g or 0.01% of mass)	KT-34		1 per subplot.		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 [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.
Mineral Filler Supplement	Sieve Analysis of Aggregate (1%, 0.1% for No. 200 [75 µm] sieve, of mass)	KT-02	c h	1 per 250 TONS (250 Mg).		1 during the first 5000 TONS (5000 Mg) of HMA produced.
	Plasticity Tests (0.01 g or 0.1% of mass)	KT-10	c h	1 per 250 TONS (250 Mg).		
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	1 sample for every 3 loads. (CMS = VER)		
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 (5000 Mg) 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 ($V_a = 0.01\%$; G_{mm} & $G_{mb} = 0.001$)	KT-15, KT-39, KT-58, & SF Manual		1 per subplot. (See code n for G_{mm})	j	1 per lot. [Compact split sample on KDOT Gyratory – 1 per week or every 15,000 TONS (15,000 Mg)]
	Binder Content (by ignition) (0.1 g or 0.01% of mass)	KT-57		1 per subplot.	j	1 per lot.
	Mix Gradation (after ignition) (0.1 g or 0.01% of mass)	KT-34		1 per subplot.		1 per lot.
Completed Road Work	Field Density Approved Rolling Procedure Nuclear Gauge ($G_{mb} = 0.001$; 0.1 lb/ft ³ [1 kg/m ³] or 0.01% of G_{mm})	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

<u>CODE</u>	<u>INSTRUCTION</u>
a	The contractor may reduce the sampling and testing frequency to one test per 1,000 yd ³ (1,000 m 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 (4,000 Mg).
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 requirement of 1 test per 10,000 Tons (10,000 Mg).
e	Specification compliance will be determined on a producer basis not on a project basis. Producer and product testing frequency is maintained in CMS. 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-7, KT-8, and KT-35, respectively, at such frequencies as jointly deemed necessary by the Contractor and the District Materials Engineer.
i	For small lots [lots with less than 1,000 tons (1,000 Mg)], 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 (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. 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 2,000 Tons (2,000 Mg) 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 $\pm 0.5\%$ of the pre-production verification test. 3) Moistures obtained from the meter are used to adjust batch-to-batch moisture corrections.

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 subplot of production after obtaining the failing test results will be sampled and tested, regardless of any lesser frequency specified in this appendix.
- For the Construction Management System (CMS), Acceptance Sampling and Tests have been divided into two sections. Items called "ACC" will be Acceptance Tests and will have a quantity assigned. Items called "ACI" will be Acceptance Information Tests and they will normally have a quantity assigned, but not for payment. "ACC" tests make the assignment of tested materials to the contract or mix plant. "Type Insp" must = "ACC" when assignment of a pay quantity is being made. "ACI" when recording test values for additional acceptance information.
- For QUALITY CONTROL BY CONTRACTOR, CMS uses ACI or ACC unless otherwise noted. For VERIFICATION BY KDOT, CMS uses VER unless otherwise noted. For INDEPENDENT ASSURANCE BY KDOT, CMS 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 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.

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 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.

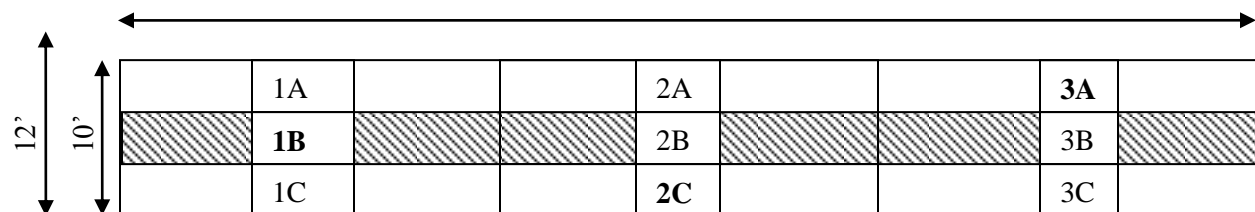
4.3.3. The sample size shall be at least four times the amount required for testing. For Superpave projects, the minimum sample size is shown in the specifications.

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.

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 it 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