PREFACE:

<u>The objective of this course</u> is to give the student a working knowledge of HMA plant operations, mix proportioning, mixture related problem solving techniques, and basic lay-down operations needed for producing and placing of asphalt mixtures in the State of Illinois.

To supplement the lecture portion of this class, students will be put in groups to discuss unusual and recurring problems that can and/or has been experienced in the field. The object of the discussion groups is to determine solutions based off of the presented information and any personal experience. After completing the lecture portion of the course there will be a written exam.

The current Illinois Department of Transportation Standard Specifications for Road and Bridge Construction manual is effective as of April 1, 2016 and this class manual will present the information herein based on these specifications along with other supporting documents. It must be understood that the official date of an IDOT-let contract and included contract specification references will determine what specific documents and requirements will control the work to be performed by the contractor.

References in this manual and supporting specifications will use the term "IDOT QC/QA" as a description of the program but it should be understood that the term has recently been changed to "IDOT QMTP" (**<u>Q</u>**uality **<u>M</u>**anagement **<u>T</u>**raining **<u>P</u>**rogram). This new term better exemplifies the purpose of the program.

IDOT has implemented **<u>P</u>**ayment **<u>F</u>**or **<u>P</u>**erformance (PFP) specifications for HMA projects. This particular specification normally applies to mixture quantities in excess of 8,000 tons, although there are some exceptions. **<u>Q</u>**uality **<u>C</u>**ontrol for **<u>P</u>**erformance (QCP) specifications is typically for pay items or projects that don't meet PFP requirements. See the official specifications for specifics. Both types of contracts will utilize different aspects of the original QC/QA specifications.

Both types of specifications, PFP and QCP, will utilize pay factors applied to contract pay items which can and will affect the Contractor's ability to be successful when completing a HMA project in Illinois.

Although PFP and QCP specifications will not be the main focus of this class, references will be made throughout class in order to help the technician understand the importance of proper mixture control and complying with HMA contracts in Illinois. The emphasis will be on suggested ways to control the HMA production process.

<u>Bottom line</u>, a complete understanding of all specifications is beneficial in comprehending the importance of the contractor responsibilities of mixture control when placing HMA products in the State of Illinois.

Knowledge of all applicable specifications pertaining to HMA is vital to be successful as a HMA Quality Control manager and/or a Level II HMA technician.

Successful completion of this course will allow an individual to act in the capacity of a Quality Control manager and/or a Level II HMA technician. However, this course alone will not prepare you for what lies ahead…

…………… **ONLY EXPERIENCE CAN DO THAT!**

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Hot Mix Asphalt Level II Technician Schedule Overview

Note: Schedule is tentative and can be altered to improve the class

Class starts promptly at 8:00 am and should conclude no later than 5:00 pm

DAY 1

I. Registration, Orientation, and Introductions

II. Chapter 1

A. HMA Mixtures QC/QA Specifications

1) High ESAL
2) Low ESAL

B. Bituminous Materials

C. Aggregate Specifications

1) Fine Aggregate Specifications
2) Coarse Aggregate Specifications
3) Coarse Aggregate Friction Policy

III. Chapter 2

A. General Plant Information
B. Batch Plants
C. Weigh Checks
D. Special Problems
E. Dryer-Drum Plants

IV. Chapter 3

Surge and Storage Bins

DAY 2

V. Chapter 4

Basic Proportioning and Adjustments

A. Aggregate Blending Information
B. Dryer-Drum Plant Set-up
C. RAP and/or RAS Plant Set-up
D. Batch Plant Set-up
E. Mixture Adjustment

DAY 3

VI. Chapter 5

Segregation

VII. Chapter 7

Laydown and Compaction

1) Paving Operations
2) Pavers & Rollers
3) Yield Calculations
4) Quantity Corrections

VIII. Chapter 8

Test Strip Specifications & Procedures

IX. Appendix A

PFP & QCP Specifications

X. Chapter 10

Documentation & Report Forms

XI. Appendix

Responsibilities & Duties Checklist
Model QC/QA Plan
Model QC/QA Addendum

DAY 4

XI!. Chapter 6

Mixture Evaluation & Examples

XIII. Chapter 9

Nuclear Gauges & Core Correlation Guideline Procedures

DAY 5

XIV. Written Examination (4.5 hour time limit starting at 8:00 am)

Phone Policy:

Phones are a major distraction to the class and students during class. Please be responsible and turn your phone to silent or turn it off all together during class. Continued class disturbance, due to a phone, will result in the appropriate action being taken to control the situation. This could result in longer class sessions or the student being asked to leave class (see attendance policy). **PLEASE BE RESPONSIBLE FOR THE BENEFIT OF EVERYONE IN CLASS**!

Attendance Policy:

Students are required to attend all class sessions in their entirety or risk disqualification from receiving a HMA Level II Technician certification.

Students are required to be on time to all class sessions, including the first day of class, or risk disqualification from receiving a HMA Level II Technician certification.

If the student misses any class session(s), the student will be required to make up the missed session(s) in a future class. Class certification will not be approved by the instructor until all class requirements are completed, which includes the attendance policy. **There will be no exceptions to this policy!**

Prerequisite Courses:

Students are required to successfully complete: A Mixture Aggregate Technician Course (3-Day Aggregates)
or an Aggregate Technician Course (5-Day Aggregates)

and the HMA Level I Technician Course

NOTE: If you do not meet the prerequisite requirement for the HMA Level II Technician Course, the HMA Level II Technician certification will not be issued **AND** the course will have to be repeated in its entirety by the student, paying all appropriate class fees.

Written Test Policy:

Students are required to successfully complete a written test to complete the class and receive the HMA Level II Technician certification. The time limit for the written test will be 4.5 hours.

A minimum grade of 70% must be achieved in order to pass the test to receive the HMA Level II Technician certification.

Cell phones are not allowed during testing and cannot be used as a calculator. **Class failure will result if it is found that a student used a cell phone during the test**. A retest will not be allowed and the student will be required to repeat the entire class paying all appropriate class fees.

Retest Policy:

If the student fails the written test, a retest may be completed. A minimum grade of 70% will be required to pass the retest. There is no fee for the retest. The student will be required to complete the retest before the end of Lake Land College's academic year, which runs from September 1st through August 31st (officially the last business day in August).

Arrangements for the retest must be made through the Lake Land College IDOT QMTP department. Call Kathy Willenborg at 217-234-5285.

Failure of the retest or failure to comply with the academic year retest time limit shall require the student to retake the class, in its' entirety, paying all appropriate class fees.

Lake Land College Course and Instructor Evaluation

Course: **HMA Level II Technician** Section Number ________________ Date ____________________

Instructors: **Rick Watson** **Steve Niebrugge**

Purpose: The main emphasis at Lake Land College is teaching. In this regard, each instructor must be continuously informed of the quality of his/her teaching skills and the respects in which these skills can be improved. As a student, you are in a position to judge the quality of instruction and materials used from direct experience, and in order to help maintain the quality of instruction at Lake Land, you are asked to complete this evaluation in an objective, **fair** and **honest** manner.

Please do not sign your name: Your anonymity will be protected so that you can be **forthright** with your evaluation of this course and the instructors. Your participation in this evaluation is greatly valued and appreciated.

Directions: Please enter the appropriate scale which seems most appropriate to you for the course and instructors. On the back of this form you are encouraged to record any comments that will clarify a particular rating. Please refer to the item on which you are commenting by noting its assigned letter.

Rate the following using this scale: **1 – Ineffective 2 – Weak 3 – Average 4 – Good 5 – Strong**

Course Evaluation: (Circle your choice)

			Rating
A)	**Objectives**	The objectives of this course were clearly and adequately covered.	1 2 3 4 5
B)	**Content**	The content covered was relevant and met the requirements of the course.	1 2 3 4 5
C)	**Organization**	Classroom activities were organized and clearly related to the subject.	1 2 3 4 5
D)	**Materials**	Instructional material and resources were current and clearly related to the course.	1 2 3 4 5
E)	**Presentation**	Content of lessons was presented so that it was understandable to the students.	1 2 3 4 5
F)	**Points of View**	When appropriate, different points of view and/or methods were used.	1 2 3 4 5
G)	**Exam**	The exam correlated well with the information covered during the class.	1 2 3 4 5

Instructor Evaluation: (Circle your choice)

			Rick	Steve
H)	**Preparation**	Was organized and prepared for each session.	1 2 3 4 5	1 2 3 4 5
I)	**Knowledge**	Was knowledgeable of the information presented.	1 2 3 4 5	1 2 3 4 5
J)	**Vocabulary**	Used appropriate and understandable terminology and vocabulary.	1 2 3 4 5	1 2 3 4 5
K)	**Participation**	Encouraged students to participate and solicited student responses.	1 2 3 4 5	1 2 3 4 5
L)	**Interest**	Indicated an interest/enthusiasm for teaching of the subject matter.	1 2 3 4 5	1 2 3 4 5
M)	**Familiarity**	Was familiar and up to date with current industry practices.	1 2 3 4 5	1 2 3 4 5
N)	**Mannerisms**	Conducted themselves in a professional manner.	1 2 3 4 5	1 2 3 4 5
O)	**Helpfulness**	Indicated a willingness to help the students as time permitted.	1 2 3 4 5	1 2 3 4 5
P)	**Impartiality**	Was fair and impartial in dealings with students in accordance to classroom policies.	1 2 3 4 5	1 2 3 4 5

↓↓↓ ↓↓↓ ↓↓↓ **Please continue filling out the other side of this form** ↓↓↓ ↓↓↓ ↓↓↓

Lake Land College Course and Instructor Evaluation

Rate the following using this scale: **1 – Ineffective 2 – Weak 3 – Average 4 – Good 5 – Strong**

SUMMARY:

Considering everything, how would you rate the instructors? (Circle your choice)

Rick					**Steve**				
1	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**

Please record any general impressions and/or comments about the instructors you might have:

Rick - Comments ____

____

____

Steve - Comments ____

____

____

Q) Considering everything, how would you rate this course? (Circle your choice)

1 2 3 4 5

Please record any general impressions and/or comments about the class and/or materials used:

General Comments ____

____

____

____

____

Please place the completed evaluation in the provided receptacle before you leave.

Do not sign your name or hand the evaluation to an instructor in order to protect your anonymity.

We thank you for your interest and participation in this course and hope you walked out more knowledgeable of the subject matter.

Cost Responsibility Example

Plant Production @ 325 Tons per Hour

325 TPH X 10 Hr/Day = 3250 Tons/Day

3250 Tons/Day X $100/Ton = $325,000 per Day

The Quality Control Manager and Level II HMA Technician are responsible:

1. To be knowledgeable of any and all specifications that applies to applicable HMA contracts in their control.
2. For the proper production and placement of all HMA materials included in the contract(s) as described by the applicable specifications for the contract.
3. To address all concerns or problems that might/will arise while implementing the work of the contract.
4. To be familiar with all testing requirements for HMA established in the Manual of Test Procedures of Materials and applicable specifications.

As a Quality Control Manager and/or Level 2 HMA Technician, this translates to a **great responsibility** being placed on his/her shoulders. PFP and QCP contracts increase this responsibility even more.

This page is reserved

Beneficial references to specifications pertaining to HMA found the Standard Specifications for Road and Bridge Construction adopted 04/01/2016

Item	Article
Subgrades, Subbases, Base Course	**300**
Base Course	355
Base Course Widening	356
Surface Courses, Pavements, Rehabilitation and Shoulders	**400**
HMA Binder & Surface Course	406
HMA Pavement (Full-Depth)	407
HMA Incidental Surfacing ……..	408
HMA Shoulders	482
Materials	**1000**
Fine Aggregates	1003
Coarse Aggregates	1004
Coarse Aggregate 'HMA Friction Policy' 1004.03..	1004
Fly Ash	1010
Mineral Filler	1011
Hydrated Lime	1012
HMA Materials	1030
Reclaimed Asphalt Pavement (RAP)	1031
Bituminous Materials	1032
Road Equipment	**1100**
Rollers	1101.01
Pavement Surface Test Equipment	1101.10
HMA Equipment	**1102**
HMA Plants – Requirements for All Plants	1102.01 (a)
Batch Plant Requirements	1102.01 (b)
Dryer Drum Plant Requirements ……..	1102.01 (c)
Spreading & Finishing Machines	1102.03
Heating Equipment	1102.07

NOTE: In addition to the above specification references, the Manual of Test Procedures contains important information needed to help the HMA Level II Technician to determine testing and equipment specification compliance.

ASPHALT AND BITUMINOUS ITEMS

SECTION 1030. HOT-MIX ASPHALT

1030.01 Description. This section describes the materials, mix design, quality control/quality assurance (QC/QA), proportioning, mixing, and transportation requirements to produce hot-mix asphalt (HMA) using Illinois Modified Strategic Highway Research Program (SHRP) Superpave criteria.

For simplicity of text, the following HMA nomenclature applies to this Section.

High ESAL	IL-19.0 binder; IL-9.5 surface
Low ESAL	IL-19.0L binder; IL-9.5L surface; Stabilized Subbase (HMA) 1/ HMA Shoulders 2/

1/ Uses 19.0L binder mix.

2/ Uses 19.0L for lower lifts and 9.5L for surface lift.

1030.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Coarse Aggregate	1004.03
(b) Fine Aggregate	1003.03
(c) RAP Material	1031
(d) Mineral Filler	1011
(e) Hydrated Lime	1012.01

(f) Slaked Quicklime (Note 1)
(g) Performance Graded Asphalt Binder (Note 2) 1032
(h) Fibers (Note 3)
(i) Warm Mix Asphalt (WMA) Technologies (Note 4)

Note 1. Slaked quicklime shall be according to ASTM C 5.

Note 2. The asphalt binder shall be an SBS PG 76-28 when the SMA is used on a full-depth asphalt pavement and SBS PG76-22 when used as an overlay.

Note 3. A stabilizing additive such as cellulose or mineral fiber shall be added to SMA mixtures according to Illinois Modified AASHTO M 325. The stabilizing additive shall meet the Fiber Quality Requirements listed in Illinois Modified AASHTO M 325. Prior to approval and use of fibers, the Contractor shall submit a notarized certification by the producer of these materials stating they meet these requirements.

Note 4. Warm mix additives or foaming processes shall be selected from the Department's qualified producer list.

1030.03 Equipment. Equipment shall be according to the following.

	Item	Article/Section
(a)	Hot-Mix Asphalt Plant	1102.01
(b)	Heating Equipment (Note 1)	1102.07
(c)	Hot-Mix Surge Bins	1102.01(a)(6)

Note 1. The asphalt binder shall be transferred to the asphalt tanks and brought to a temperature of 250 to 350 °F (120 to 180 °C). If, at anytime, the asphalt binder temperature exceeds 350 °F (180 °C), the asphalt binder shall not be used. Polymer modified asphalt binder, when specified, shall be shipped, maintained, and stored at the mix plant according to the manufacturer's requirements. Polymer modified asphalt binder shall be placed in an empty tank and shall not be blended with other asphalt binders.

1030.04 Mixture Design. The Contractor shall submit designs for each required mixture. The mixture design shall be performed at a HMA mix design laboratory according to the current Bureau of Materials and Physical Research Policy Memorandum, "Minimum Private Laboratory Requirements for Construction Materials Testing or Mix Design". Each design shall be verified and approved by the Department as detailed in the current Quality Control/Quality Assurance document "Hot-Mix Asphalt Design Verification Procedure". In no case will a mix design be verified until determination of the apparent low bidder.

When specified on the plans, RAP material meeting the requirements of Section 1031 may be used. The Engineer reserves the right to adjust the quantities of RAP material contained in the mixture for the purpose of mix design or field production, on the basis of test results.

The HMA mixtures shall be designed according to the respective Illinois Modified AASHTO references listed below.

AASHTO M 323	Standard Specification for Superpave Volumetric Mix Design
AASHTO R 30	Standard Practice for Mixture Conditioning of Hot-Mix Asphalt (HMA)
AASHTO R 35	Standard Practice for Superpave Volumetric Design for Hot-Mix Asphalt (HMA)
AASHTO T 209	Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures
AASHTO T 305	Standard Method of Test for Determination of Draindown Characteristics in Uncompacted Asphalt Mixtures
AASHTO T 312	Preparing and Determining the Density of Hot Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor
AASHTO T 308	Determining the Asphalt Binder Content of Hot Mix Asphalt (HMA) by the Ignition Method
AASHTO T 324	Hamburg Wheel-Track Testing of Compacted Hot Mix Asphalt (HMA)
AASHTO T 283	Resistance of Compacted Hot Mix Asphalt (HMA) to Moisture-Induced Damage

The SMA mixture shall be designed according to the following additional Illinois Modified AASHTO references listed below, except as modified herein.

AASHTO M 325	Standard Specification for Designing Stone Matrix Asphalt (SMA)
AASHTO R 46	Standard Practice for Designing Stone Matrix Asphalt (SMA)
AASHTO T 305	Determination of Draindown Characteristics in Uncompacted Mixtures

(a) Mixture Composition. The Job Mix Formula (mix design) represents the aggregate grading and asphalt binder content that produce the desired mix criteria in the laboratory. The ingredients of the HMA shall be combined in such proportions as to produce a mixture conforming to the composition limits by weight.

For all HMA mixtures, it is recommended that the selected combined aggregate gradation not pass through the restricted zones specified in Illinois Modified AASHTO M 323.

(1) High ESAL Mixtures. The Job Mix Formula (JMF) shall fall within the following limits.

HIGH ESAL, MIXTURE COMPOSITION (% PASSING) 1/								
Sieve Size	IL-19.0 mm		SMA 12.5 4/		IL-9.5 mm		IL-4.75 mm	
	min	max	min	max	min	max	min	max
1 1/2 in. (37.5 mm)								
1 in. (25 mm)		100						
3/4 in. (19 mm)	90	100		100				
1/2 in. (12.5 mm)	75	89	90	99		100		100
3/8 in. (9.5 mm)			50	85	90	100		100
#4 (4.75 mm)	40	60	20	40	32	69	90	100
#8 (2.36 mm)	26	42	16	24 5/	32	52 2/	70	90
#16 (1.18 mm)	15	30			10	32	50	65
#50 (300 µm)	6	15			4	15	15	30
#100 (150 µm)	4	9			3	10	10	18
#200 (75 µm)	3	6	8.0	11.0 3/	4	6	7	9 3/
Ratio Dust/Asphalt Binder		1.0				1.0		1.0

1/ Based on percent of total aggregate weight.

2/ The mixture composition shall not exceed 44 percent passing the #8 (2.36 mm) sieve for surface courses with Ndesign = 90.

3/ Additional minus No. 200 (0.075 mm) material required by the mix design shall be mineral filler, unless otherwise approved by the Engineer.

4/ The maximum percent passing the #635 (20 µm) sieve shall be ≤ 3 percent.

5/ When establishing the Adjusted Job Mix Formula (AJMF) the percent passing the #8 (2.36 mm) sieve shall not be adjusted above 24 percent.

(2) Low ESAL Mixtures. The Job Mix Formula (JMF) shall fall within the following limits.

Low ESAL, MIXTURE COMPOSITION (% PASSING)				
Sieve Size	IL-9.5L		IL-19.0L	
	min.	max.	min.	max.
1 in. (25.0 mm)				100
3/4 in. (19.0 mm)			95	100
1/2 in. (12.5 mm)		100		
3/8 in. (9.5 mm)	95	100		
#4 (4.75 mm)	52	80	38	65
#8 (2.36 mm)	38	65		
#30 (600 µm)		< 50% of the percentage passing the #4		< 50% of the percentage passing the #4
#200 (75 µm)	4.0	8.0	3.0	7.0
Asphalt Binder %	4.0	8.0	4.0	8.0
Ratio Dust/Asphalt Binder		1.0 @ design		1.0 @ design

(b) Volumetric Requirements.

(1) High ESAL Mixtures. The target value for the air voids of the HMA shall be 4.0 percent at the design number of gyrations. The VMA and VFA of the HMA design shall be based on the nominal maximum size of the aggregate in the mix, and shall conform to the following requirements.

VOLUMETRIC REQUIREMENTS High ESAL				
Ndesign	Voids in the Mineral Aggregate (VMA), % minimum			Voids Filled with Asphalt Binder (VFA),%
	IL-19.0	IL-9.5	IL-4.75 1/	
50	13.5	15.0	18.5	65 - 78 2/
70				65 - 75
90				

1/ Maximum Draindown for IL-4.75 shall be 0.3 percent.

2/ VFA for IL-4.75 shall be 76-83 percent.

(2) Low ESAL Mixtures.

VOLUMETRIC REQUIREMENTS Low ESAL				
Mixture Composition	Design Compactive Effort	Design Air Voids Target, %	VMA (Voids in the Mineral Aggregate), % min.	VFA (Voids Filled with Asphalt Binder), %
IL-9.5L	N_{DES}=30	4.0	15.0	65 - 78
IL-19.0L	N_{DES}=30	4.0	13.5	N/A

(3) SMA Mixtures.

ESALs (million)	Ndesign	Design Air Voids Target, %	Voids in the Mineral Aggregate (VMA), % min.	Voids Filled with Asphalt (VFA), %
≤ 10	50	4.0	16.0	75 – 80
> 10	80	4.0	17.0	75 – 80

(c) Determination of Need for Anti-Stripping Additive. The mixture designer shall determine if an additive is needed in the mix to prevent stripping. The determination will be made on the basis of tests performed according to Illinois Modified AASHTO T 283. To be considered acceptable by the Department as a mixture not susceptible to stripping, the conditioned to unconditioned split tensile strength ratio (TSR) shall be equal to or greater than 0.85 for 6 in. (150 mm) specimens. Mixtures, either with or without an additive, with TSRs less than 0.85 for 6 in. (150 mm) specimens will be considered unacceptable. Also, the conditioned tensile strength for mixtures containing an anti-strip additive shall not be lower than the original conditioned tensile strength determined for the same mixture without the anti-strip additive.

If it is determined that an additive is required, the additive may be hydrated lime, slaked quicklime, or a liquid additive, at the Contractor's option.

Dry hydrated lime shall be added at a rate of 1.0 to 1.5 percent by weight of total dry aggregate. Slurry shall be added in such quantity as to provide the required amount of hydrated lime solids by weight of total dry aggregate. The exact rate of application for all anti-stripping additives will be determined by the Engineer. The method of application shall be according to Article 1102.01(a)(10).

(d) Verification Testing. High ESAL, IL-4.75, and SMA mix designs submitted for verification will be tested to ensure that the resulting mix designs will pass the required criteria for the Hamburg Wheel Test (Illinois Modified AASHTO T 324) and the Tensile Strength Test (Illinois Modified AASHTO T 283). The Department will perform a verification test on gyratory specimens compacted by the Contractor. If the mix fails the Department's verification test, the Contractor shall make necessary changes to the mix and provide passing Hamburg Wheel and tensile strength test results from a private lab. The Department will verify the passing results.

All new and renewal mix designs shall meet the following requirements for verification testing.

(1) Hamburg Wheel Test Criteria. The maximum allowable rut depth shall be 0.5 in. (12.5 mm). The minimum number of wheel passes at the 0.5 in. (12.5 mm) rut depth criteria shall be based on the high temperature binder grade of the mix as specified in the mix requirements table of the plans.

Illinois Modified AASHTO T 324 Requirements 1/	
PG Grade	Number of Passes
PG 58-xx (or lower)	5,000
PG 64-xx	7,500
PG 70-xx	15,000
PG 76-xx (or higher)	20,000

1/ When produced at temperatures of 275 ± 5 °F (135 ± 3 °C) or less, loose Warm Mix Asphalt shall be oven aged at 270 ± 5 °F (132 ± 3 °C) for two hours prior to gyratory compaction of Hamburg Wheel specimens.

(2) Tensile Strength Criteria. The minimum allowable conditioned tensile strength shall be 60 psi (415 kPa) for non-polymer modified performance graded (PG) asphalt binder and 550 kPa (80 psi) for polymer modified PG asphalt binder. The maximum allowable unconditioned tensile strength shall be 200 psi (1380 kPa).

1030.05 Quality Control/Quality Assurance (QC/QA).

(a) QC/QA Documents. QC/QA documents shall be as follows.

(1) Model Annual Quality Control (QC) Plan for Hot-Mix Asphalt (HMA) Production
(2) Model Quality Control (QC) Addenda for Hot-Mix Asphalt (HMA) Production
(3) Hot-Mix Asphalt QC/QA Laboratory Equipment
(4) Illinois Modified ASTM D 2950, Standard Test Method for Determination of Density of Bituminous Concrete In-Place by Nuclear Method
(5) Standard Test Method for Correlating Nuclear Gauge Densities with Core Densities
(6) Hot-Mix Asphalt QC/QA Start-Up Procedures
(7) Hot-Mix Asphalt QC/QA QC Personnel Responsibilities and Duties Checklist
(8) Hot-Mix Asphalt QC/QA Initial Daily Plant and Random Samples
(9) Determination of Random Density Test Site Locations
(10) Hot-Mix Asphalt QC/QA Control Charts/Rounding Test Values

(11) Hot-Mix Asphalt Design Verification Procedure
(12) Hot-Mix Asphalt Mix Design Procedure for Dust Correction Factor Determination
(13) Development of Gradation Bands on Incoming Aggregate at Mix Plants
(14) Bureau of Materials and Physical Research Policy Memorandum, “Minimum Private Laboratory Requirements for Construction Materials Testing or Mix Design”
(15) Segregation Control of Hot-Mix Asphalt
(16) Calibration of Equipment for Asphalt Content Determination

(b) Laboratory. The Contractor shall provide a laboratory, at the plant, according to the current Bureau of Materials and Physical Research Policy Memorandum, “Minimum Private Laboratory Requirements for Construction Materials Testing or Mix Design”. The laboratory shall be of sufficient size and be furnished with the necessary equipment and supplies for adequately and safely performing the Contractor's QC testing. The Contractor is referred to the QC/QA document "Model Annual Quality Control Plan for Hot-Mix Asphalt (HMA) Production" for detailed information on the required laboratories. The required laboratory equipment for production and mix design is listed in the QC/QA document "Hot-Mix Asphalt QC/QA Laboratory Equipment".

The laboratory and equipment furnished by the Contractor shall be properly maintained. The Contractor shall maintain a record of calibration results at the laboratory. The Engineer may inspect measuring and testing devices at any time to confirm both calibration and condition. If the Engineer determines the equipment is not within the limits of dimensions or calibration described in the appropriate test method, the Engineer may stop production until corrective action is taken. If laboratory equipment becomes inoperable, the Contractor shall cease mix production.

(c) Annual Quality Control (QC) Plan and Addenda. The approved Annual QC Plan and QC Addenda shall become part of the contract between the Department and the Contractor but shall not be construed, in itself, as acceptance of any HMA produced. Failure to execute the contract according to the approved Annual QC Plan and QC Addenda will result in suspension of HMA production or other appropriate actions as directed by the Engineer.

The Contractor shall submit, in writing to the Engineer, a proposed Annual QC Plan for each HMA plant for approval before each construction season. Job-specific QC Addenda to the Annual QC Plan must be submitted in writing to the Engineer for approval before the pre-construction conference. The Annual QC Plan and the QC Addenda shall address all elements involved in the production and quality control of the HMA incorporated in the project. The proposed QC Plan shall be the QC/QA document "Model Annual Quality Control Plan for Hot-Mix Asphalt (HMA) Production", and the QC Addenda shall be the QC/QA document "Model Quality Control Addendum for Hot-Mix Asphalt (HMA) Production".

Construction of HMA mixtures shall not begin without written approval of the Annual QC Plan and QC Addenda by the Engineer.

The Contractor may propose revisions to portions of the Annual QC Plan and QC Addenda. Likewise, the Annual QC Plan and QC Addenda may be amended during the progress of the work, by either party, subject to mutual agreement. Revisions require proper justification be provided to the Department by the Contractor to ensure product quality. Any revision in the Annual QC Plan or QC Addenda must be approved in writing by the Engineer.

(d) Quality Control by Contractor. The Contractor shall perform or have performed the inspection and tests required to assure conformance to contract requirements. Control includes the recognition of obvious defects and their immediate correction. This may require increased testing, communication of test results to the plant or the job site, modification of operations, suspension of HMA production, rejection of material, or other actions as appropriate. Inability to control HMA production is cause for the Engineer to stop the operation until the Contractor completes an investigation identifying the problems causing failing test results.

The Engineer shall be immediately notified of any failing tests and subsequent remedial action. Passing tests shall be reported to the Engineer no later than the start of the next work day.

If the Contractor receives approval to use an alternative mixture to that required by the contract, the QC program will be specified by the Department.

(1) Personnel. The Contractor shall provide a Quality Control (QC) Manager who shall have overall responsibility and authority for quality control. This individual shall have successfully completed the Department's “Hot-Mix Asphalt Level II” Technician Course.

In addition to the QC Manager, the Contractor shall provide sufficient personnel to perform the required visual inspections, sampling, testing, and documentation in a timely manner. Mix designs shall be developed by personnel who have successfully completed the Department's “Hot-Mix Asphalt Level III Course”. All technicians performing mix design testing and plant sampling/testing shall have successfully completed the Department's “Hot-Mix Asphalt Level I Technician Course”. The Contractor may also provide a Gradation Technician who has successfully completed the Department's "Gradation Technician Course" to run gradation tests only under the supervision of a Hot-Mix Asphalt Level II Technician. The Contractor shall provide a Hot-Mix Asphalt Density Tester who has successfully completed the Department's "Nuclear Density Testing Course” to run all required density tests on the job site.

All quality control personnel shall perform the required quality control duties. The Contractor is referred to the QC/QA document "Hot-Mix Asphalt QC/QA QC Personnel Responsibilities and Duties Checklist" for a description of personnel qualifications and duties. Testing shall be conducted to control the production of the mixture.

(2) Plant Tests. Contractor testing of all plant samples shall be completed within 3 1/2 hours of sampling.

a. Frequency. The Contractor shall use the test methods identified to perform the following mixture tests at a frequency not less than that indicated.

Parameter	Frequency of Tests High ESAL Mixture Low ESAL Mixture	Test Method See Manual of Test Procedures for Materials
Aggregate Gradation % passing sieves: 1/2 in. (12.5 mm), No. 4 (4.75 mm), No. 8 (2.36 mm), No. 30 (600 µm), No. 200 (75 µm)	1 washed ignition oven test on the mix per half day of production Note 3.	Illinois Procedure
Asphalt Binder Content by Ignition Oven Note 1.	1 per half day of production	Illinois Modified AASHTO T 308
VMA Note 2.	Day's production ≥ 1200 tons (1090 metric tons) 1 per half day of production	Illinois Modified AASHTO R 35
	Day's production < 1200 tons (1090 metric tons) 1 per half day of production for first 2 days and 1 per day thereafter (first sample of the day)	

Parameter	Frequency of Tests High ESAL Mixture Low ESAL Mixture	Test Method See Manual of Test Procedures for Materials
Air Voids Bulk Specific Gravity of Gyratory Sample Note 4.	Day's production ≥ 1200 tons (1090 metric tons) 1 per half day of production	Illinois Modified AASHTO T 312
	Day's production < 1200 tons (1090 metric tons) 1 per half day of production for first 2 days and 1 per day thereafter (first sample of the day)	
Maximum Specific Gravity of Mixture	Day's production ≥ 1200 tons (1090 metric tons) 1 per half day of production	Illinois Modified AASHTO T 209
	Day's production < 1200 tons (1090 metric tons) 1 per half day of production for first 2 days and 1 per day thereafter (first sample of the day)	

Note 1. The Engineer may waive the ignition oven requirement for asphalt binder content if the aggregates to be used are known to have ignition asphalt binder content calibration factors which exceed 1.5 percent. If the ignition oven requirement is waived, other Department approved methods shall be used to determine the asphalt binder content.

Note 2. The G_{sb} used in the voids in the mineral aggregate (VMA) calculation shall be the same average G_{sb} value listed in the mix design.

Note 3. The Engineer reserves the right to require additional hot bin gradations for batch plants if control problems are evident.

Note 4. The WMA compaction temperature for mixture volumetric testing shall be 270 ± 5 °F (132 ± 3 °C) for quality control testing. The WMA compaction temperature for quality assurance testing will be 270 ± 5 °F (132 ± 3 °C) if the mixture is not allowed to cool to room temperature. If the mixture is allowed to cool to room temperature, it shall be reheated to standard HMA compaction temperatures.

b. Dust-to-Asphalt and Moisture Content. During production, the dust-to-asphalt binder ratio and the moisture content of the mixture at discharge from the mixer shall meet the following.

Parameter	High ESAL Mixture Low ESAL Mixture
Ratio Dust/Asphalt Binder 1/	0.6 to 1.2
Moisture	0.3 %

1/ Does not apply to SMA.

If at any time the dust-to-asphalt binder ratio or moisture content of the mixture falls outside the stated limits, production of the HMA shall cease. The cause shall be determined and corrective action satisfactory to the Engineer shall be initiated prior to resuming production.

c. Anti-Strip Additive. During production, mixtures containing an anti-strip additive will be tested by the Department for stripping according to Illinois Modified AASHTO T 283. If the mixture fails to meet the TSR criteria for acceptance, no further mixture will be accepted until the Contractor takes such action as is necessary to furnish a mixture meeting the criteria.

d. Small Tonnage. The Contractor may apply the following for small tonnage of mixture.

Gradation analysis, voids, and asphalt binder content tests may not be required on a specific mixture if the day's production is less than 250 tons (225 metric tons) per mix. A minimum of one set of plant tests for each mix shall be performed for each five consecutive production-day period when the accumulated tonnage produced in that period exceeds 500 tons (450 metric tons). A Hot-Mix Asphalt Level II Technician shall oversee all quality control operations. If the required tonnage of any mixture for a single pay item is less than 250 tons (225 metric tons) in total, the Contractor shall state his/her intentions of waiving the "Required Plant Tests" in the QC Addenda. The mixture shall be produced using a mix design that has been verified as specified and validated by the Department's recent acceptable field test data. A Hot-Mix Asphalt Level II Technician shall oversee all quality control operations for the mixture.

e. Asphalt Binder Sampling. Asphalt binder samples shall be taken by the Contactor and witnessed by the Engineer at a frequency of one injection line-sample per week, per HMA plant. Sample containers will be furnished by the Department. The Engineer will submit the properly identified samples to the Bureau of Materials and Physical Research for testing.

f. HMA Sampling. For HMA mixture sampling, the Contractor shall obtain required plant samples according to the QC/QA document, "Hot-Mix Asphalt QC/QA Initial Daily Plant and Random Samples". The Contractor shall split all required samples and identify the split samples per the Engineer's instructions. These split samples shall be retained by the Contractor for assurance testing by the Engineer and be disposed of only with the permission of the Engineer. The split samples shall be stored in a dry, protected location.

The Contractor shall, when necessary, take and test additional samples (designated "check" samples) at the plant during HMA production. These samples in no way replace the required plant samples described above. Check samples shall be tested only for the parameters deemed necessary by the Contractor. Check sample test results shall be noted in the Plant Diary and shall not be plotted on the control charts. The Contractor shall detail the situations in which check samples will be taken in his/her Annual QC Plan.

(3) Required Field Tests. The Contractor shall control the compaction process by testing the mix density at random locations as determined according to the QC/QA document, "Determination of Random Density Test Site Locations", and recording the results on forms approved by the Engineer. The Contractor shall follow the density testing procedures detailed in the QC/QA document, "Illinois Modified ASTM D 2950, Standard Test Method for Determination of Density of Bituminous Concrete In-Place by Nuclear Method".

The Contractor shall be responsible for establishing the correlation to convert nuclear density results to core densities according to the QC/QA document, "Standard Test Method for Correlating Nuclear Gauge Densities with Core Densities". The Engineer may require a new nuclear/core correlation if the Contractor's gauge is recalibrated during the project.

If the Contractor and Engineer agree the nuclear density test method is not appropriate for the mixture, cores shall be taken at random locations determined according to the QC/QA document "Determination of Random Density Test Site Locations". Three cores shall be taken at equal distances across the test site. These cores shall be averaged to provide a single test site result. Core densities shall be determined using the Illinois Modified AASHTO T 166 or T 275 procedure.

Quality control density tests shall be performed at randomly selected locations within 1/2 mile (800 m) intervals and for each lift of 3 in. (75 mm) or less in thickness. For lifts in excess of 3 in. (75 mm) in thickness, a test shall be performed within 1/4 mile (400 m) intervals.

Testing of lifts equal to or greater than 4 in. (100 mm) compacted thickness shall be performed in the direct transmission mode according to the QC/QA document "Illinois Modified ASTM D 2950, Standard Test Method for Determination of Density of Bituminous Concrete In-Place by Nuclear Method". Density testing shall be accomplished intermittently throughout the day. In no case shall more than one-half day's production be completed without performing density testing.

Density tests shall be performed each day on patches located nearest the randomly selected location. The daily testing frequency shall be a minimum of two density tests per mix. Density testing shall be accomplished intermittently throughout the day. In no case shall more than one half day's production be completed without performing density testing.

(4) Control Limits. Target values shall be determined by applying adjustment factors to the AJMF where applicable. The target values shall be plotted on the control charts within the following control limits.

CONTROL LIMITS						
Parameter	High ESAL Low ESAL		SMA		IL-4.75	
	Individual Test	Moving Avg. of 4	Individual Test	Moving Avg. of 4	Individual Test	Moving Avg. of 4
% Passing: 1/						
1/2 in. (12.5 mm)	± 6 %	± 4 %	± 6 %	± 4 %		
3/8 in. (9.5mm)			± 4 %	± 3 %		
No. 4 (4.75 mm)	± 5 %	± 4 %	± 5 %	± 4 %		
No. 8 (2.36 mm)	± 5 %	± 3 %	± 4 %	± 2 %		
No. 16 (1.18 mm)			± 4 %	± 2 %	± 4 %	± 3 %
No. 30 (600 µm)	± 4 %	± 2.5 %	± 4 %	± 2.5 %		
Total Dust Content No. 200 (75 µm)	± 1.5 %	± 1.0 %			± 1.5 %	± 1.0 %
Asphalt Binder Content	± 0.3 %	± 0.2 %	± 0.2 %	± 0.1 %	± 0.3 %	± 0.2 %
Voids	± 1.2 %	± 1.0 %	± 1.2 %	± 1.0 %	± 1.2 %	± 1.0 %
VMA	-0.7 % 2/	-0.5 % 2/	-0.7 % 2/	-0.5 % 2/	-0.7 % 2/	-0.5 % 2/

1/ Based on washed ignition oven

2/ Allowable limit below minimum design VMA requirement

DENSITY CONTROL LIMITS		
Mixture Composition	Parameter	Individual Test
IL-4.75	Ndesign = 50	93.0 – 97.4 % [1/]
IL-9.5	Ndesign = 90	92.0 – 96.0 %
IL-9.5, IL-9.5L,	Ndesign < 90	92.5 – 97.4 %
IL-19.0	Ndesign = 90	93.0 – 96.0 %
IL-19.0, IL-19.0L	Ndesign < 90	93.0 [2/] – 97.4 %
SMA	Ndesign = 50 & 80	93.5 – 97.4 %

1/ Density shall be determined by cores or by correlated, approved thin lift nuclear gauge.

2/ 92.0 percent when placed as first lift on an unimproved subgrade.

(5) Control Charts. Standardized control charts shall be maintained by the Contractor at the field laboratory. The control charts shall be displayed and be accessible at the field laboratory at all times for review by the Engineer.

Individual required test results obtained by the Contractor shall be recorded on the control chart immediately upon completion of a test, but no later than 24 hours after sampling. Only the required tests and resamples shall be recorded on the control chart. Any additional testing of check samples may be used for controlling the Contractor's processes, but shall be documented in the plant diary.

The results of assurance tests performed by the Engineer will be posted as soon as available.

The following parameters shall be recorded on standardized control charts as described in the QC/QA document "Hot-Mix Asphalt QC/QA Control Charts/Rounding Test Values".

Control limits for each required parameter, both individual tests and the average of four tests, shall be exhibited on control charts. Test results shall be posted within the time limits previously outlined.

CONTROL CHART REQUIREMENTS	HIGH ESAL, LOW ESAL, SMA, & IL-4.75
Gradation 1/ 3/	% Passing Sieves: 1/2 in. (12.5 mm) 2/ No. 4 (4.75 mm) No. 8 (2.36 mm) No. 30 (600 µm)
Total Dust Content 1/	No. 200 (75 µm)
	Asphalt Binder Content
	Bulk Specific Gravity
	Maximum Specific Gravity of Mixture
	Voids
	Density
	VMA

1/ Based on washed ignition oven.

2/ Does not apply to IL-4.75.

3/ SMA also requires the 3/8 in. (9.5mm) sieve.

(6) Corrective Action for Required Plant Tests.

a. Individual Test Results. When an individual test result exceeds its control limit, the Contractor shall immediately resample and retest. If at the end of the day no material remains from which to resample, the first sample taken the following day shall serve as the resample as well as the first sample of the day. This result shall be recorded as a retest. If the retest passes, the Contractor may continue the required plant test frequency. Additional check samples should be taken to verify mix compliance.

1. Voids, VMA, and Asphalt Binder Content for High ESAL and Low ESAL Mixtures. If the retest for voids, VMA, or asphalt binder content exceeds control limits, HMA production shall cease and immediate corrective action shall be instituted by the Contractor. After corrective action, HMA production shall be restarted, the HMA production shall be stabilized, and the Contractor shall immediately resample and retest. HMA production may continue when approved by the Engineer. The corrective action shall be documented.

2. Gradation. For gradation retest failures, immediate corrective action shall be instituted by the Contractor. After corrective action, the Contractor shall immediately resample and retest. The corrective action shall be documented.

b. Moving Average. When the moving average values trend toward the moving average control limits, the Contractor shall take corrective action and increase the sampling and testing frequency. The corrective action shall be documented.

The Contractor shall notify the Engineer whenever the moving average values exceed the moving average control limits. If two consecutive moving average values fall outside the moving average control limits, the Contractor shall cease operations. Corrective action shall be immediately instituted by the Contractor. Operations shall not be reinstated without the approval of the Engineer. Failure to cease operations shall subject all subsequently produced material to be considered unacceptable.

c. Dust Control. If the washed ignition oven gradation test results indicate a problem with controlling dust, corrective action to control the dust shall be taken and approved by the Engineer. If the Engineer determines that Positive Dust Control Equipment is necessary, the equipment as specified in Article 1102.01(d)(7), shall be installed prior to the next construction season.

d. HMA Production Control. If the Contractor is not controlling the production process and is making no effort to take corrective action, the operation shall stop.

(7) Corrective Action for Required Field Tests (Density). When an individual density test exceeds the control limits, the Contractor shall immediately retest in a location that is halfway between the failed test site and the finish roller. If the retest passes, the Contractor shall continue the normal density test frequency. An additional density check test should be performed to verify the mix compaction.

If the retest fails, the Contractor shall immediately conduct one of the following procedures.

a. Low Density. If the failing density retest indicates low densities, the Contractor shall immediately increase the compaction effort, review all mixture test results representing the HMA being produced, and make corrective action as needed. The Contractor shall immediately perform a second density retest within the area representing the increased compaction effort and mixture adjustments.

b. High Density. If the failing density retest indicates high densities, the Contractor shall cease production and placement until all mixture test results are reviewed and corrective action is taken. If the high density failure is a result of a change in the mixture, any existing material in the surge bin may be subject to rejection by the Engineer. After restart of HMA production, a second density retest shall then be performed in the area representing the mixture adjustments.

If the second retest from either procedure passes, production and placement of the HMA may continue. The increased compaction effort for low density failures shall not be reduced to that originally being used unless it is determined by investigation that the cause of the low density was unrelated to compaction effort, the cause was corrected, and tests show the corrective action has increased the density within the required limits.

If the second retest fails, production and placement of the HMA shall cease until the Contractor has completed an investigation and the problem(s) causing the failing densities has/have been determined. If the Contractor's corrective action is approved by the Engineer, production and placement of the HMA may then be resumed. The Contractor shall increase the frequency of density testing to show, to the satisfaction of the Engineer, that the corrective action taken has corrected the density problem.

If the Contractor is not controlling the compaction process and is making no effort to take corrective action, the operation, as directed by the Engineer, shall stop.

(e) Quality Assurance by the Engineer. The Engineer will conduct independent assurance tests on split samples taken by the Contractor for quality control testing. In addition, the Engineer will witness the sampling and splitting of these samples a minimum of twice a month and will immediately retain the samples for quality assurance testing.

The overall testing frequency will be performed over the entire range of Contractor samples and will be equal to or greater than ten percent for gradations and equal to or greater than 20 percent for asphalt binder content, bulk specific gravity, maximum specific gravity and field density. The Engineer may select any or all split samples for assurance testing. The Engineer will initiate independent assurance testing during mixture field verification. These tests may be performed immediately or anytime up to ten working days after sampling. The test results will be made available to the Contractor as soon as they become available.

The Contractor's nuclear/core correlation will be verified utilizing Department nuclear gauges.

The Engineer may witness the sampling and testing being performed by the Contractor. The Engineer will document all witnessed samples and tests.

The Engineer will promptly notify the Contractor, both verbally and in writing, of observed deficiencies. If the Engineer observes that the sampling and quality control tests are not being performed according to the applicable test procedures, the Engineer may stop production until corrective action is taken.

The Engineer may elect to obtain samples for testing, separate from the Contractor's quality control process, to verify specification compliance. No more than 20 cores per day will be required by the Engineer for the purpose of acceptance and/or comparison with nuclear gauge measurements. The cost of this work will not be paid for separately, but shall be considered as included in the unit price bid for the HMA item involved. Differences between the Contractor's and the Engineer's split sample test results will be considered acceptable if within the following limits.

Test Parameter	Acceptable Limits of Precision
% Passing: [1/]	
1/2 in. (12.5 mm)	5.0 %
No. 4 (4.75 mm)	5.0 %
No. 8 (2.36 mm)	3.0 %
No. 30 (600 µm)	2.0 %
Total Dust Content No. 200 (75 µm)	2.2 %
Asphalt Binder Content	0.3 %
Maximum Specific Gravity of Mixture	0.026
Bulk Specific Gravity	0.030
VMA	1.4 %
Density (% Compaction)	1.0 % (Correlated)

1/ Based on washed ignition.

The Department may run extractions for assurance, when deemed necessary by the Engineer.

In the event comparison of the required plant test results is outside the above acceptable limits of precision, Department split or independent samples fail the control limits, a Department extraction indicates non-compliance, or a continual trend of difference between Contractor and Department test results is identified, the Engineer will immediately investigate. The Engineer may suspend production as stated in Article 108.07 of the Standard Specifications, while the investigation is in progress. The investigation may include testing by the Engineer of any remaining split samples or a comparison of split sample test results on the HMA currently being produced. The investigation may also include review and observation of the Contractor's technician performance, testing procedure, and equipment.

If a problem is identified with the mix, the Contractor shall take immediate corrective action. After corrective action, both the Contractor and the Engineer shall immediately resample and retest according to Article 1030.05(d)(6).

In the event comparison of the required field test results (densities) are outside the above acceptable limits of precision, Department split or independent samples fail the density limits, or a continual trend of difference between Contractor and Department test results is identified, the Engineer will immediately investigate. The investigation will include testing by the Engineer of any remaining random density locations. The Engineer may establish additional locations for testing by both the Contractor and the

Department to provide further comparison results. The investigation shall also include review and observation of the Density Tester performance, testing procedure, and equipment. The original correlation and/or comparison data, for both gauges, shall be reviewed as part of the investigation process. If the problem continues, the Engineer may require a new correlation be performed.

(f) Acceptance by the Engineer. Final acceptance will be based on the following.

(1) Validation of the Contractor's quality control by the assurance process.

(2) The Contractor's process control charts and actions.

(3) Department assurance tests for voids, field VMA, and density.

If any of the above is not met, the work will be considered in non-conformance with the contract.

(g) Documentation. The Contractor shall be responsible for documenting all observations, records of inspection, adjustments to the mixture, test results, retest results, and corrective actions in a bound hardback field book or bound hardback diary which will become the property of the Department.

The Contractor shall be responsible for the maintenance of all permanent records whether obtained by the Contractor, the Contractor's consultants, or the producer of the HMA.

The Contractor shall provide the Engineer full access to all documentation throughout the progress of the work.

Adjustments to mixture production and test results shall be recorded in duplicate and sent to the Engineer on forms approved by the Engineer.

Each construction season, prior to production of HMA, the Contractor shall submit to the Engineer, on appropriate forms, documentation that the HMA plant(s) have been calibrated and approved.

1030.06 Start of HMA Production and Job Mix Formula (JMF) Adjustments. The start of HMA production and JMF adjustments shall be as follows.

(a) High ESAL, IL-4.75, WMA, and SMA Mixtures. For each contract, a 300 ton (275 metric tons) test strip will be required at the beginning of HMA production for each mixture with a quantity of 3000 tons (2750 metric tons) or more according to the Manual of Test Procedures for Materials "Hot-Mix Asphalt Test Strip Procedures".

Before start-up, target values shall be determined by applying gradation correction factors to the JMF when applicable. These correction factors shall be determined from previous experience. The target values, when approved by the Engineer, shall be used to control HMA production. Plant settings and control charts shall be set according to target values.

Before constructing the test strip, target values shall be determined by applying gradation correction factors to the JMF when applicable. After any JMF adjustment, the JMF shall become the Adjusted Job Mix Formula (AJMF). Upon completion of the first acceptable test strip, the JMF shall become the AJMF regardless of whether or not the JMF has been adjusted. If an adjustment/plant change is made, the Engineer may require a new test strip to be constructed. If the HMA placed during the initial test strip is determined to be unacceptable to remain in place by the Engineer, it shall be removed and replaced.

The limitations between the JMF and AJMF are as follows.

Parameter	Adjustment
1/2 in. (12.5 mm)	± 5.0 %
No. 4 (4.75 mm)	± 4.0 %
No. 8 (2.36 mm)	± 3.0 %
No. 30 (600 µm)	*
No. 200 (75 µm)	*
Asphalt Binder Content	± 0.3 %

* In no case shall the target for the amount passing be greater than the JMF.

Any adjustments outside the above limitations will require a new mix design.

Mixture sampled to represent the test strip shall include additional material sufficient for the Department to conduct Hamburg Wheel testing according to Illinois Modified AASHTO T 324 (approximately 60 lb (27 kg) total).

The Contractor shall immediately cease production upon notification by the Engineer of failing Hamburg Wheel tests. All prior produced material may be paved out provided all other mixture criteria is being met. No additional mixture shall be produced until the Engineer receives passing Hamburg Wheel tests.

The Department may conduct additional Hamburg Wheel tests on production material as determined by the Engineer.

(b) Low ESAL Mixtures. In the field, slight adjustments to the gradation and/or asphalt binder content may be necessary to obtain the desired air voids, density, uniformity, and constructability. These adjustments define the Adjusted Job Mix Formula (AJMF) and become the target values for quality control operations. Limitations between the JMF and AJMF are as follows. Any adjustments outside the limitations will require a new mix design.

Parameter	Adjustment
1/2 in. (2.5 mm)	± 6 %
No. 4 (4.75 mm)	± 5 %
No. 200 (75 µm)	± 2.5 %
Asphalt Binder Content	± 0.5 %

Production is not required to stop after a growth curve has been constructed. The test results shall be available to both the Contractor and Engineer before production may resume the following day.

During production, the Contractor and Engineer shall continue to evaluate test results and mixture laydown and compaction performance. Adjustments within the above requirements may be necessary to obtain the desired mixture properties. If an adjustment/plant change is made, the Engineer may request additional growth curves and supporting plant tests.

SECTION 1031. RECLAIMED ASPHALT PAVEMENT

1031.01 Description. RAP is reclaimed asphalt pavement resulting from cold milling or crushing of an existing dense graded hot-mix asphalt (HMA) pavement. The Contractor shall supply written documentation that the RAP originated from routes or airfields under federal, state or local agency jurisdiction.

1031.02 Stockpiles. The Contractor shall construct individual, sealed RAP stockpiles meeting one of the following definitions. No additional RAP shall be added to the pile after the pile has been sealed.

(a) Homogeneous. Homogeneous RAP stockpiles shall consist of RAP from Class I, Superpave (High ESAL), HMA (High ESAL), or equivalent, mixtures only and represent; 1) the same aggregate quality, but shall be at least C quality or better; 2) the same type of crushed aggregate (either crushed natural aggregate, ACBF slag, or steel slag); 3) similar gradation; and 4) similar asphalt binder content. If approved by the Engineer, combined single pass surface/binder millings may be considered "homogenous", with a quality rating dictated by the lowest coarse aggregate quality present in the mixture. Stockpiles shall meet the testing requirements of Article 1031.07. Stockpiles not meeting these requirements may be processed (crushing and screening) and retested.

(b) Conglomerate. Conglomerate RAP stockpiles shall consist of RAP from Class I, Superpave (High ESAL), HMA (High ESAL), or equivalent, mixtures only. The coarse aggregate in this RAP shall be crushed aggregate only and may represent more than one aggregate type and/or quality but shall be at least C quality or better. This RAP may have an inconsistent gradation and/or asphalt binder content prior to processing. All conglomerate RAP shall be processed prior to testing by crushing to where all RAP shall pass the 5/8 in. (16 mm) or smaller screen. Stockpiles shall not contain steel slag or other expansive material as determined by the Department. Stockpiles shall meet the testing requirements of Article 1031.07.

(c) Conglomerate "D" Quality (DQ). Conglomerate DQ RAP stockpiles shall consist of RAP containing coarse aggregate (crushed or round) that is at least D quality or better. Conglomerate DQ RAP stockpiles shall not contain steel slag or other expansive material as determined by the Department. Conglomerate DQ RAP shall meet the testing requirements of Article 1031.07.

Reclaimed Superpave (Low ESAL)/HMA (Low ESAL) IL-19.0L binder and IL-9.5L surface mixtures shall be placed in conglomerate DQ RAP stockpiles due to potential of rounded aggregate.

(d) Other. RAP stockpiles that do not meet the requirements of the stockpile categories listed above shall be classified as "Other". "Other" RAP stockpiles shall not be used in HMA.

1031.03 Contaminants. RAP containing contaminants, such as earth, brick, sand, concrete, sheet asphalt, bituminous surface treatment (i.e. chip seal), pavement fabric, joint sealants, etc., will be unacceptable unless the contaminants are removed to the satisfaction of the Engineer. Sheet asphalt shall be stockpiled separately.

1031.04 Quality Designation of Aggregate in RAP. The use of RAP in HMA shall be set by the lowest quality of coarse aggregate in the RAP stockpile and are designated as follows.

(a) RAP from Class I, Superpave (High ESAL) or HMA (High ESAL) surface mixtures are designated as containing Class B quality coarse aggregate only.

(b) RAP from Superpave (Low ESAL)/HMA (Low ESAL) IL-19.0L binder and IL-9.5L surface mixtures are designated as Class C quality coarse aggregate only.

(c) RAP from Class I, Superpave (High ESAL), or HMA (High ESAL) binder mixtures, bituminous base course mixtures, and bituminous base course widening mixtures are designated as containing Class C quality coarse aggregate only.

(d) RAP from bituminous stabilized subbase and BAM shoulders are designated as containing Class D quality coarse aggregate only.

The Contractor shall supply written documentation that the RAP meets the above quality designations.

Any mixture not listed above shall have the designated quality determined by the Department.

1031.05 RAP in HMA. The use of RAP in HMA shall be as follows.

(a) Coarse Aggregate Size. The coarse aggregate in all RAP shall be equal to or less than the nominal maximum size requirement for the HMA mixture to be produced using RAP.

(b) Steel Slag Stockpiles. RAP stockpiles containing steel slag or other expansive material, as determined by the Department, shall be homogeneous and will be approved for use in HMA (High ESAL and Low ESAL) surface mixtures only.

(c) Use in High and Low ESAL Mixtures. RAP stockpiles for use in HMA mixtures (High ESAL and Low ESAL) shall be either homogeneous or conglomerate, except conglomerate stockpiles shall not be used in HMA surface mixture Ndesign 50 or greater.

(d) Use in Shoulders and Subbase. RAP stockpiles for use in HMA shoulders and stabilized subbase (HMA) shall be homogeneous, conglomerate, or conglomerate DQ.

1031.06 RAP in Aggregate Surface Course and Aggregate Shoulders. The use of RAP in Aggregate Surface Course and Aggregate Shoulders shall be as follows.

(a) Stockpiles. RAP stockpiles may be any of those listed in Article 1031.02.

(b) Gradation. One hundred percent of the RAP material shall pass the 1 1/2 in. (37.5 mm) sieve. The RAP material shall be reasonably well graded from coarse to fine. RAP material that is gap-graded or single sized will not be accepted.

(c) Exclusion. The requirements of Article 1031.07 do not apply.

1031.07 Testing. All RAP shall be sampled and tested either during or after stockpiling.

For testing during stockpiling, washed extraction samples shall be run at the minimum frequency of one sample per 500 tons (450 metric tons) for the first 2000 tons (1800 metric tons) and one sample per 2000 tons (1800 metric tons) thereafter. A minimum of five tests shall be required for stockpiles less than 4000 tons (3600 metric tons).

For testing existing stockpiles, the Contractor shall submit a plan for approval to the District proposing a satisfactory method of sampling and testing the RAP pile either in-situ or by restockpiling. The sampling plan shall meet the minimum frequency required above and detail the procedure used to obtain representative samples throughout the pile for testing.

Each field sample shall be split to obtain two samples for testing. One of the test samples from the final split shall be labeled and stored for Department use. The Contractor shall extract the other test sample according to Illinois Modified AASHTO T 164. The Engineer reserves the right to test any sample (split or Department-taken) to verify Contractor test results.

All of the extraction results shall be compiled and averaged for asphalt binder content and gradation. Individual extraction test results, when compared to the averages, will be accepted if within the tolerances listed below.

Parameter	Homogeneous / Conglomerate	Conglomerate "D" Quality
1 in. (25 mm)		± 5 %
1/2 in. (12.5 mm)	± 8 %	± 15 %
No. 4 (4.75 mm)	± 6 %	± 13 %
No. 8 (2.36 mm)	± 5 %	
No. 16 (1.18 mm)		± 15 %
No. 30 (600 µm)	± 5 %	
No. 200 (75 µm)	± 2.0 %	± 4.0 %
Asphalt Binder	± 0.4 %	± 0.5 %

If more than 20 percent of the individual sieves are out of the gradation tolerances, or if more than 20 percent of the asphalt binder content test results fall outside the appropriate tolerances, the RAP shall not be used in HMA unless the RAP representing the failing tests is removed from the stockpile. All test data and acceptance ranges shall be sent to the District for evaluation.

If additional RAP stockpiles are tested and found that no more than 20 percent of the results are outside of the control tolerances set for the original RAP stockpile and HMA mix design, the additional RAP stockpiles may be used in the original mix design at the percent previously verified.

With the approval of the Engineer, the ignition oven may be substituted for extractions according to the ITP, "Calibration of the Ignition Oven for the Purpose of Characterizing Reclaimed Asphalt Pavement (RAP)".

SECTION 1032. BITUMINOUS MATERIALS

1032.01 Description. Bituminous materials shall include asphalt binders, emulsified asphalts, rapid curing liquid asphalt, medium curing liquid asphalts, slow curing liquid asphalts, asphalt fillers, and road oils. All bituminous materials used in a given construction shall be uniform in character, appearance, and consistency.

1032.02 Measurement. Asphalt binders, emulsified asphalts, rapid curing liquid asphalts, medium curing liquid asphalts, slow curing liquid asphalts, asphalt fillers, and road oils will be measured by weight.

A weight ticket for each truck load shall be furnished to the Engineer. The truck shall be weighed at a location approved by the Engineer. The ticket shall show the weight of the empty truck (the truck being weighed each time before it is loaded), the weight of the loaded truck, and the net weight of the bituminous material.

When an emulsion or cutback is used for prime or tack coat, the percentage of asphalt residue of the actual certified product shall be shown on the producer's bill of lading or attached certificate of analysis. If the producer adds extra water to an emulsion at the request of the purchaser, the amount of water shall also be shown on the bill of lading.

Payment will not be made for bituminous materials in excess of 105 percent of the amount specified by the Engineer.

1032.03 Delivery. When bituminous materials are not approved at their source by the Department, they shall be delivered far enough in advance of their use to permit the necessary tests to be made. When not delivered in tank cars or tank trucks, the bituminous materials shall be delivered in suitable containers or packages, plainly labeled to show the kind of material, the name of manufacturer, and the lot or batch number. Each shipment and each carload shall be kept separate until the material has been accepted.

Asphalt binder, when delivered in tank cars or tank trucks, shall be delivered at a temperature not to exceed 350 °F (175 °C).

Petroleum asphalts PAF-1 and PAF-2 shall be shipped in new, double end, metal drums. The thickness of the metal used shall not be less than 0.0149 in. (0.4 mm). The side seams of the drums shall be double lapped, spot welded single lapped, or stitch welded single lapped. The seams shall meet the approval of the Engineer. The drums shall be manufactured so that there will be no leakage during hot weather. The capacity of each drum shall be approximately 460 lb (210 kg), the drums being 35 in. (890 mm) maximum in height and approximately 22 in. (560 mm) in diameter.

Petroleum asphalts PAF-3 and PAF-4 shall be shipped in new, open end, metal drums. The thickness of the metal used shall be not less than the 0.0149 in. (0.4 mm). The seams shall be constructed so that the filled drums will withstand shipping and handling. The inside of the drums shall be coated with talc or other approved material to facilitate peeling. The capacity of each drum shall be approximately 460 lb (210 kg), the drums being 35 in. (890 mm) maximum in height

SECTION 1003. FINE AGGREGATES

1003.01 Materials. Fine aggregate materials shall be according to the following.

(a) Description. The natural and manufactured materials used as fine aggregate are defined as follows.

(1) Sand. Sand shall be the fine granular material resulting from the natural disintegration of rock. Sand produced from deposits simultaneously with, and by the same operations as, gravel coarse aggregate may contain crushed particles in the quantity resulting normally from the crushing and screening of oversize particles.

(2) Silica Sand. Silica sand shall be composed of not less than 99.5 percent silica ($Si0_2$).

(3) Stone Sand. Stone sand shall be produced by washing, or processing by air separation, the fine material resulting from crushing rock quarried from undisturbed, consolidated deposits, or crushing gravel. The acceptance and use of crushed gravel stone sand shall be according to the current Bureau of Materials and Physical Research Policy Memorandum, “Crushed Gravel Producer Self-Testing Program”.

(4) Chats. Chats shall be the tailings resulting from the separation of metals from rocks in which they occur.

(5) Wet Bottom Boiler Slag. Wet bottom boiler slag shall be the hard, angular by-product of the combustion of coal in wet bottom boilers.

(6) Slag Sand. Slag sand shall be the graded product resulting from the screening of air-cooled blast furnace slag. Air-cooled blast furnace slag shall be the nonmetallic product, consisting essentially of silicates and alumino-silicates of lime and other bases, which is developed in a molten condition simultaneously with iron in a blast furnace.

The acceptance and use of air-cooled blast furnace slag sand shall be according to the current Bureau of Materials and Physical Research

Policy Memoranda, "Crushed Slag Producer Certification and Self-Testing Program" and "Slag Producer Self-Testing Program".

(7) Granulated Slag Sand. Granulated slag sand shall be the graded product resulting from the screening of granulated slag. Granulated slag shall be the nonmetallic product, consisting essentially of silicates and alumino-silicates of lime and other bases, which is developed in a molten condition simultaneously with iron in a blast furnace. Granulated slag sand is formed by introducing a large volume of water under high pressure into the molten slag.

(8) Steel Slag Sand. Steel slag sand shall be the graded product resulting from the screening of crushed steel slag. Crushed steel slag shall be the nonmetallic product which is developed in a molten condition simultaneously with steel in an open hearth, basic oxygen, or electric furnace. The acceptance and use of steel slag sand shall be according to the current Bureau of Materials and Physical Research Policy Memorandum, "Slag Producer Self-Testing Program".

(9) Crushed Concrete Sand. Crushed concrete sand shall be the angular fragments resulting from crushing portland cement concrete by mechanical means. The acceptance and use of crushed concrete sand shall be according to the current Bureau of Materials and Physical Research Policy Memorandum, "Recycling Portland Cement Concrete Into Aggregate".

(10) Construction and Demolition Debris Sand. Construction and demolition debris sand shall be the angular fragments resulting from mechanical crushing/screening of unpainted exterior brick, mortar, and/or concrete with small amounts of other materials. Construction and demolition debris sand shall be according to the current Bureau of Materials and Physical Research Policy Memorandum, "Construction and Demolition Debris Sand as a Fine Aggregate for Trench Backfill".

(b) Quality. The fine aggregate shall meet the quality standards listed in the following table. Except for the minus No. 200 (75 µm) sieve material, all fine aggregate shall meet specified quality requirements before being proportioned for mix or combined to adjust gradation. The blended materials shall meet the minus No. 200 (75 µm) sieve requirements.

FINE AGGREGATE QUALITY			
QUALITY TEST	CLASS		
	A	B	C
Na_2SO_4 Soundness 5 Cycle, ITP 104, % Loss max.	10	15	20
Minus No. 200 (75 µm) Sieve Material, ITP 11, % max. 4/	3	6 1/	10 1/
Organic Impurities Check, ITP 21	Yes 2/	---	---
Deleterious Materials: 3/ 5/			
Shale, % max.	3.0	3.0	---
Clay Lumps, % max.	1.0	3.0	---
Coal, Lignite, & Shells, % max.	1.0	3.0	---
Conglomerate, % max.	3.0	3.0	---
Other Deleterious, % max.	3.0	3.0	---
Total Deleterious, % max.	3.0	5.0	---

1/ Does not apply to Gradations FA 20 or FA 21.

2/ Applies only to sand. Sand exceeding the colorimetric test standard of 11 (ITP 21) will be checked for mortar making properties according to ITP 71, and shall develop a compressive strength at the age of 14 days when using Type I or II Cement of not less than 95 percent of the comparable standard.

3/ Applies only to sand.

4/ Fine aggregate used for hot-mix asphalt (HMA) shall not contain more than three percent clay (2 micron or smaller) particles as determined by Illinois Modified AASHTO T 88.

5/ Tests shall be run according to ITP 204.

(c) Gradation. All aggregates shall be produced according to the current Bureau of Materials and Physical Research Policy Memorandum, “Aggregate Gradation Control System”.

The gradations prescribed may be manufactured by any suitable commercial process and by the use of any sizes or shapes of plant screen openings necessary to produce the sizes within the limits of the sieve analysis specified.

The gradation of the material from any one source shall be reasonably uniform and shall not be subject to the extreme percentages of gradation represented by the tolerance limits of the various sieve sizes.

The gradation numbers and corresponding gradation limits are listed in the following tables.

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FINE AGGREGATE GRADATIONS											
Grad No.	Sieve Size and Percent Passing										
	3/8	No. 4	No. 8 4/	No. 10	No. 16	No. 30 5/	No. 40	No. 50	No. 80	No. 100	No. 200 1/
FA 1	100	97±3			65±20			16±13		5±5	
FA 2	100	97±3			65±20			20±10		5±5	
FA 3	100	97±3		80±15			50±20		25±15		3±3
FA 4 7/	100				5±5						
FA 5	100	92±8								20±20	15±15
FA 6		92±8 2/								20±20	6±6
FA 7		100		97±3			75±15		35±10		3±3
FA 8			100				60±20			3±3	2±2
FA 9			100					30±15		5±5	
FA 10				100			90±10		60±30		7±7
FA 20	100	97±3	80±20		50±15			19±11		10±7	4±4
FA 21 3/	100	97±3	80±20		57±18			30±10		20±10	9±9
FA 22	100	6/	6/		8±8						2±2

FINE AGGREGATE GRADATIONS (Metric)											
Grad No.	Sieve Size and Percent Passing										
	9.5 mm	4.75 mm	2.36 mm 4/	2.00 mm	1.18 mm	600 µm 5/	425 µm	300 µm	180 µm	150 µm	75 µm 1/
FA 1	100	97±3			65±20			16±13		5±5	
FA 2	100	97±3			65±20			20±10		5±5	
FA 3	100	97±3		80±15			50±20		25±15		3±3
FA 4 7/	100				5±5						
FA 5	100	92±8								20±20	15±15
FA 6		92±8 2/								20±20	6±6
FA 7		100		97±3			75±15		35±10		3±3
FA 8			100				60±20			3±3	2±2
FA 9			100					30±15		5±5	
FA 10				100			90±10		60±30		7±7
FA 20	100	97±3	80±20		50±15			19±11		10±7	4±4
FA 21 3/	100	97±3	80±20		57±18			30±10		20±10	9±9
FA 22	100	6/	6/		8±8						2±2

1/ Subject to maximum percent allowed in Fine Aggregate Quality Table.

2/ 100 percent shall pass the 1 in. (25 mm) sieve, except that for bedding material 100 percent shall pass the 3/8 in. (9.5 mm) sieve. If 100 percent passes the 1/2 in. (12.5 mm) sieve, the No. 4 (4.75 mm) sieve may be 75 ± 25.

3/ For all HMA mixtures. When used, either singly or in combination with other sands, the amount of material passing the No. 200 (75 µm) sieve (washed basis) in the total sand fraction for mix design shall not exceed ten percent.

4/ For each gradation used in HMA, the aggregate producer shall set the midpoint percent passing, and the Department will apply a range of

±15 percent. The midpoint shall not be changed without Department approval.

5/ For each gradation used in HMA, the aggregate producer shall set the midpoint percent passing, and the Department will apply a range of ±13 percent. The midpoint shall not be changed without Department approval.

6/ For the fine aggregate gradation FA 22, the aggregate producer shall set the midpoint percent passing, and the Department will apply a range of ± ten percent. The midpoint shall not be changed without Department approval.

7/ When used as backfill for pipe underdrains, Type 3, the fine aggregate shall meet one of the modified FA 4 gradations shown in the following table.

FA 4 Modified		
Sieve Size	Percent Passing	
	Option 1	Option 2
3/8 in. (9.5 mm)	100	100
No. 4 (4.75 mm)		97 ± 3
No. 8 (2.36 mm)		5 ± 5
No. 10 (2 mm)	10 ± 10	
No. 16 (1.18 mm)	5 ± 5	2 ± 2
No. 200 (75 µm)	1 ± 1	1 ± 1

(d) Incompatibility. Incompatibility of any of the gradations or combinations of gradations permitted resulting in unworkable mixtures, nonadherence to the final mix gradation limits, or any other indication of incompatibility shall be just cause for rejection of one or both of the sizes.

(e) Storage of Fine Aggregate. Sites for storage of all fine aggregates shall be grubbed and cleaned prior to storing the material.

Stockpiles shall be built according to the current Bureau of Materials and Physical Research Policy Memorandum, “Aggregate Gradation Control System” and the following.

(1) Fine aggregate of various gradations and from different sources shall be stockpiled separately.

(2) Stockpiles shall be separated to prevent intermingling at the base. If partitions are used, they shall be of sufficient heights to prevent intermingling.

(3) Fine aggregates for portland cement concrete and HMA shall be handled in and out of the stockpiles in such a manner that will prevent contamination, segregation, and degradation.

Art. 1003.01 Fine Aggregates

At the time of use, the fine aggregate shall be free from frozen material, material used to caulk rail cars, and all foreign materials which may have become mixed during transportation and handling.

(f) Shipping Tickets. Shipping tickets for the material shall be according to the current Bureau of Materials and Physical Research Policy Memorandum, "Designation of Aggregate Information on Shipping Tickets".

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Art. 1003.03 Fine Aggregates

For mixture IL-4.75 and surface mixtures with an Ndesign = 90, at least 50 percent of the required fine aggregate fraction shall consist of either stone sand, slag sand, or steel slag meeting the FA 20 gradation.

For mixture IL-19.0, Ndesign = 90 the fine aggregate fraction shall consist of at least 67 percent manufactured sand meeting FA 20 or FA 22 gradation. For mixture IL-19.0, Ndesign = 50 or 70 the fine aggregate fraction shall consist of at least 50 percent manufactured sand meeting FA 20 or FA 22 gradation. The manufactured sand shall be stone sand, slag sand, steel slag sand, or combinations thereof.

Gradation FA 1, FA 2, or FA 3 shall be used when required for prime coat aggregate application for HMA.

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SECTION 1004. COARSE AGGREGATES

1004.01 Materials. Coarse aggregate materials shall be according to the following.

(a) Description. The natural and manufactured materials used as coarse aggregate are defined as follows.

(1) Gravel. Gravel shall be the coarse granular material resulting from the reduction of rock by the action of the elements and having subangular to rounded surfaces. It may be partially crushed.

(2) Chert Gravel. Chert gravel shall be the coarse granular material occurring in alluvial deposits resulting from reworking by weathering and erosion of chert bearing geological formations and containing a minimum of 80 percent chert or similar siliceous material.

(3) Crushed Gravel. Crushed gravel shall be the product resulting from crushing, by mechanical means, and shall consist entirely of particles obtained by crushing gravel. The acceptance and use of crushed gravel shall be according to the current Bureau of Materials and

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Physical Research Policy Memorandum, “Crushed Gravel Producer Self-Testing Program”.

(4) Crushed Stone. Crushed stone shall be the angular fragments resulting from crushing undisturbed, consolidated deposits of rock by mechanical means. Crushed stone shall be divided into the following, when specified.

a. Carbonate Crushed Stone. Carbonate crushed stone shall be either dolomite or limestone. Dolomite shall contain 11.0 percent or more magnesium oxide (MgO). Limestone shall contain less than 11.0 percent magnesium oxide (MgO).

b. Crystalline Crushed Stone. Crystalline crushed stone shall be either metamorphic or igneous stone, including but is not limited to, quartzite, granite, rhyolite and diabase.

(5) Wet Bottom Boiler Slag. Wet bottom boiler slag shall be the hard, angular by-product of the combustion of coal in wet bottom boilers.

(6) Crushed Slag. Crushed slag shall be the graded product resulting from the processing of air-cooled blast furnace slag. Air-cooled blast furnace slag shall be the nonmetallic product, consisting essentially of silicates and alumino-silicates of lime and other bases, which is developed in a molten condition simultaneously with iron in a blast furnace. It shall be air-cooled and shall have a compact weight (ITP 19) of not less than 70 lb/cu ft (1100 kg/cu m). The acceptance and use of air-cooled blast furnace slag shall be according to the current Bureau of Materials and Physical Research Policy Memoranda, “Crushed Slag Producer Certification and Self-Testing Program” and “Slag Producer Self-Testing Program”.

(7) Crushed Sandstone. Crushed sandstone shall be the angular fragments resulting from crushing, by mechanical means, a cemented sand composed predominantly of quartz grains. Sandstone shall have an Insoluble Residue of 50.0 percent or higher.

(8) Crushed Concrete. Crushed concrete shall be the angular fragments resulting from crushing portland cement concrete by mechanical means. The acceptance and use of crushed concrete shall be according to the current Bureau of Materials and Physical Research Policy Memorandum, “Recycling Portland Cement Concrete Into Aggregate”.

(9) Chats. Chats shall be the tailings resulting from the separation of metals from the rocks in which they occur.

(10) Crushed Steel Slag. Crushed steel slag shall be the graded product resulting from the processing of steel slag. Steel slag shall be the nonmetallic product which is developed in a molten condition simultaneously with steel in an open hearth, basic oxygen, or electric furnace. The acceptance and use of crushed steel slag shall be

according to the current Bureau of Materials and Physical Research Policy Memorandum, “Slag Producer Self-Testing Program”.

(b) Quality. The coarse aggregate shall be according to the quality standards listed in the following table.

COARSE AGGREGATE QUALITY				
QUALITY TEST	CLASS			
	A	B	C	D
Na_2SO_4 Soundness 5 Cycle, ITP 104 1/, % Loss max.	15	15	20	25 2/
Los Angeles Abrasion, ITP 96, % Loss max.	40 3/	40 4/	40 5/	45
Minus No. 200 (75 µm) Sieve Material, ITP 11	1.0 6/	---	2.5 7/	---
Deleterious Materials 10/				
Shale, % max.	1.0	2.0	4.0 8/	---
Clay Lumps, % max.	0.25	0.5	0.5 8/	---
Coal & Lignite, % max.	0.25	---	---	---
Soft & Unsound Fragments, % max.	4.0	6.0	8.0 8/	---
Other Deleterious, % max.	4.0 9/	2.0	2.0 8/	---
Total Deleterious, % max.	5.0	6.0	10.0 8/	---

1/ Does not apply to crushed concrete.

2/ For aggregate surface course and aggregate shoulders, the maximum percent loss shall be 30.

3/ For portland cement concrete, the maximum percent loss shall be 45.

4/ Does not apply to crushed slag or crushed steel slag.

5/ For hot-mix asphalt (HMA) binder mixtures, the maximum percent loss shall be 45.

6/ For crushed aggregate, if the material finer than the No. 200 (75 µm) sieve consists of the dust from fracture, essentially free from clay or silt, this percentage may be increased to 2.5.

7/ Does not apply to aggregates for HMA binder mixtures.

8/ Does not apply to Class A seal and cover coats.

9/ Includes deleterious chert. In gravel and crushed gravel aggregate, deleterious chert shall be the lightweight fraction separated in a 2.35 heavy media separation. In crushed stone aggregate, deleterious chert shall be the lightweight fraction separated in a

2.55 heavy media separation. Tests shall be run according to ITP 113.

10/ Test shall be run according to ITP 203.

All varieties of chert contained in gravel coarse aggregate for portland cement concrete, whether crushed or uncrushed, pure or impure, and irrespective of color, will be classed as chert and shall not be present in the total aggregate in excess of 25 percent by weight (mass).

Aggregates used in Class BS concrete (except when poured on subgrade), Class PS concrete, and Class PC concrete (bridge superstructure products only, excluding the approach slab) shall contain no more than two percent by weight (mass) of deleterious materials. Deleterious materials shall include substances whose disintegration is accompanied by an increase in volume which may cause spalling of the concrete.

(c) Gradation. All aggregates shall be produced according to the current Bureau of Materials and Physical Research Policy Memorandum, "Aggregate Gradation Control System".

The sizes prescribed may be manufactured by any suitable commercial process and by the use of any sizes or shapes of plant screen openings necessary to produce the sizes within the limits of the sieve analysis specified.

The gradation of the material from any one source shall be reasonably close to the gradation specified and shall not be subject to the extreme percentages of gradation represented by the tolerance limits for the various sieve sizes. The gradation numbers and corresponding gradation limits are listed in the following table.

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Grad No.	COARSE AGGREGATE GRADATIONS												
	Sieve Size and Percent Passing												
	3 in.	2 1/2 in.	2 in.	1 1/2 in.	1 in.	3/4 in.	1/2 in.	3/8 in.	No. 4	No. 8	No. 16	No. 50	No. 200 [1/]
CA 1	100	95±5	60±15	15±15	3±3								
CA 2		100	95±5		75±15		50±15		30±10		20±15		8±4
CA 3		100	93±7	55±20	8±8		3±3						
CA 4			100	95±5	85±10		60±15		40±10		20±15		8±4
CA 5				97±3 [2/]	40±25		5±5		3±3				
CA 6				100	95±5		75±15		43±13		25±15		8±4
CA 7				100	95±5		45±15 [7/]		5±5				
CA 8				100	97±3	85±10	55±10		10±5		3±3 [3/]		
CA 9				100	97±3		60±15		30±15		10±10		6±6
CA 10					100	95±5	80±15		50±10		30±15		9±4
CA 11					100	92±8	45±15 [4/7/]		6±6		3±3 [3/5/]		
CA 12						100	95±5	85±10	60±10		35±10		9±4
CA 13						100	97±3	80±10	30±15		3±3 [3/]		
CA 14							90±10 [6/]	45±20	3±3				
CA 15							100	75±15	7±7		2±2		
CA 16							100	97±3	30±15		2±2 [3/]		
CA 17	100								65±20		45±20	20±10	10±5
CA 18	100				95±5				75±25		55±25	10±10	2±2
CA 19	100				95±5				60±15		40±15	20±10	10±5
CA 20							100	92±8	20±10	5±5	3±3		

Grad No.	COARSE AGGREGATE GRADATIONS (metric)												
	Sieve Size and Percent Passing												
	75 mm	63 mm	50 mm	37.5 mm	25 mm	19 mm	12.5 mm	9.5 mm	4.75 mm	2.36 mm	1.18 mm	300 µm	75 µm [1/]
CA 1	100	95±5	60±15	15±15	3±3								
CA 2		100	95±5		75±15		50±15		30±10		20±15		8±4
CA 3		100	93±7	55±20	8±8		3±3						
CA 4			100	95±5	85±10		60±15		40±10		20±15		8±4
CA 5				97±3 [2/]	40±25		5±5		3±3				
CA 6				100	95±5		75±15		43±13		25±15		8±4
CA 7				100	95±5		45±15 [7/]		5±5				
CA 8				100	97±3	85±10	55±10		10±5		3±3 [3/]		
CA 9				100	97±3		60±15		30±15		10±10		6±6
CA 10					100	95±5	80±15		50±10		30±15		9±4
CA 11					100	92±8	45±15 [4/7/]		6±6		3±3 [3/5/]		
CA 12						100	95±5	85±10	60±10		35±10		9±4
CA 13						100	97±3	80±10	30±15		3±3 [3/]		
CA 14							90±10 [6/]	45±20	3±3				
CA 15							100	75±15	7±7		2±2		
CA 16							100	97±3	30±15		2±2 [3/]		
CA 17	100								65±20		45±20	20±10	10±5
CA 18	100				95±5				75±25		55±25	10±10	2±2
CA 19	100				95±5				60±15		40±15	20±10	10±5
CA 20							100	92±8	20±10	5±5	3±3		

1/ Subject to maximum percent allowed in Coarse Aggregate Quality table.

2/ Shall be 100 percent passing the 1 3/4 in. (45 mm) sieve.

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3/ When used in HMA (High and Low ESAL) mixtures, the percent passing the No. 16 (1.18 mm) sieve for gradations CA 8, CA 11, CA 13, or CA 16 shall be 4±4 percent.

4/ When using gradation CA 11 for IL-19.0 and IL-19.0L binder, the percent passing the 1/2 in. (12.5 mm) sieve may also be 15±10.

5/ The No. 16 (1.18 mm) requirement will be waived when CA 11 is used in the manufacture of portland cement concrete.

6/ Shall be 100 percent passing the 5/8 in. (16 mm) sieve.

7/ When Class BS concrete is to be pumped, the coarse aggregate gradation shall have a minimum of 45 percent passing the 1/2 in. (12.5 mm) sieve. The Contractor may combine two or more coarse aggregate sizes, consisting of CA 7, CA 11, CA 13, CA 14, and CA 16, provided a CA 7 or CA 11 is included in the blend.

Note: When CA 7, CA 8, CA 11, CA 13, CA 14, CA 15, or CA 16 are used under paved median, Notes 3, 4, 5, and 6 shall apply.

(d) Incompatibility. Incompatibility of any of the gradations or combinations of gradations permitted resulting in unworkable mixtures, nonadherence to the final mix gradation limits, or any other indication of incompatibility shall be just cause for rejection of one or both of the sizes.

(e) Storage. Sites for stockpiles shall be grubbed and cleaned prior to storing the aggregates.

The stockpiles shall be built according to the current Bureau of Materials and Physical Research Policy Memorandum, “Aggregate Gradation Control System” and the following.

(1) Segregation or degradation due to improper stockpiling or loading out of stockpiles shall be just cause for rejecting the material.

(2) Separate stockpiles shall be provided for the various kinds of aggregates.

(3) Stockpiles shall be separated to prevent intermingling at the base. If partitions are used, they shall be of sufficient heights to prevent intermingling.

(4) Coarse aggregates shall be handled in and out of the stockpiles in such a manner that will prevent contamination and degradation.

(5) Crushed concrete, crushed slag, or lightweight aggregate for portland cement concrete shall be stockpiled in a moist condition (saturated surface dry or greater) and the moisture content shall be maintained uniformly throughout the stockpile by periodic sprinkling.

Art. 1004.02 Coarse Aggregates

At the time of use, the coarse aggregate shall be free from frozen material, material used to caulk rail cars, and all foreign material which may have become mixed during transportation and handling.

(f) Shipping Tickets. Shipping tickets for the material shall be according to the current Bureau of Materials and Physical Research Policy Memorandum, "Designation of Aggregate Information on Shipping Tickets".

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1004.03 Coarse Aggregate for Hot-Mix Asphalt (HMA). The aggregate be according to Article 1004.01 and the following.

(a) Description. The coarse aggregate for HMA shall be according t following table.

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<table>
<tr><th>Use</th><th>Mixture</th><th colspan="2">Aggregates Allowed</th></tr>
<tr><td>Class A</td><td>Seal or Cover</td><td colspan="2"><u>Allowed Alone or in Combination</u> [5/]:

Gravel
Crushed Gravel
Carbonate Crushed Stone
Crystalline Crushed Stone
Crushed Sandstone
Crushed Slag (ACBF)
Crushed Steel Slag
Crushed Concrete</td></tr>
<tr><td>HMA
Low ESAL</td><td>Stabilized Subbase or Shoulders</td><td colspan="2"><u>Allowed Alone or in Combination</u> [5/]:

Gravel
Crushed Gravel
Carbonate Crushed Stone
Crystalline Crushed Stone
Crushed Sandstone
Crushed Slag (ACBF)
Crushed Steel Slag [1/]
Crushed Concrete</td></tr>
<tr><td>HMA
High ESAL
Low ESAL</td><td>Binder
IL-19.0
or IL-19.0L

SMA Binder</td><td colspan="2"><u>Allowed Alone or in Combination</u> [5/]:

Crushed Gravel
Carbonate Crushed Stone [2/]
Crystalline Crushed Stone
Crushed Sandstone
Crushed Slag (ACBF)
Crushed Concrete [3/]</td></tr>
<tr><td>HMA
High ESAL
Low ESAL</td><td>C Surface and Leveling Binder
IL-9.5 or IL-9.5L

SMA
Ndesign 50 Surface</td><td colspan="2"><u>Allowed Alone or in Combination</u> [5/]:

Crushed Gravel
Carbonate Crushed Stone [2/]
Crystalline Crushed Stone
Crushed Sandstone
Crushed Slag (ACBF)
Crushed Steel Slag [4/]
Crushed Concrete [3/]</td></tr>
<tr><td rowspan="5">HMA
High ESAL</td><td rowspan="5">D Surface and Leveling Binder
IL-9.5

SMA
Ndesign 50
Surface</td><td colspan="2"><u>Allowed Alone or in Combination</u> [5/]:

Crushed Gravel
Carbonate Crushed Stone (other than Limestone) [2/]
Crystalline Crushed Stone
Crushed Sandstone
Crushed Slag (ACBF)
Crushed Steel Slag [4/]
Crushed Concrete [3/]</td></tr>
<tr><td colspan="2"><u>Other Combinations Allowed:</u></td></tr>
<tr><td>Up to...</td><td>With...</td></tr>
<tr><td>25% Limestone</td><td>Dolomite</td></tr>
<tr><td>50% Limestone</td><td>Any Mixture D aggregate other than Dolomite</td></tr>
<tr><td></td><td></td><td>75% Limestone</td><td>Crushed Slag (ACBF) or Crushed Sandstone</td></tr>
</table>

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Art. 1004.03 Coarse Aggregates

Use	Mixture	Aggregates Allowed	
HMA High ESAL	E Surface IL-9.5 SMA Ndesign 80 Surface	<u>Allowed Alone or in Combination</u> 5/: Crushed Gravel Crystalline Crushed Stone Crushed Sandstone Crushed Slag (ACBF) Crushed Steel Slag Crushed Concrete3/ No Limestone.	
		<u>Other Combinations Allowed:</u>	
		Up to...	*With...*
		50% Dolomite2/	Any Mixture E aggregate
		75% Dolomite2/	Crushed Sandstone, Crushed Slag (ACBF), Crushed Steel Slag, or Crystalline Crushed Stone
		75% Crushed Gravel or Crushed Concrete3/	Crushed Sandstone, Crystalline Crushed Stone, Crushed Slag (ACBF), or Crushed Steel Slag
HMA High ESAL	F Surface IL-9.5 SMA Ndesign 80 Surface	<u>Allowed Alone or in Combination</u> 5/: Crystalline Crushed Stone Crushed Sandstone Crushed Slag (ACBF) Crushed Steel Slag No Limestone.	
		<u>Other Combinations Allowed</u>:	
		Up to...	*With...*
		50% Crushed Gravel, Crushed Concrete3/, or Dolomite2/	Crushed Sandstone, Crushed Slag (ACBF), Crushed Steel Slag, or Crystalline Crushed Stone

1/ Crushed steel slag allowed in shoulder surface only.

2/ Carbonate crushed stone shall not be used in SMA Ndesign 80. In SMA Ndesign 50, carbonate crushed stone shall not be blended with any of the other aggregates allowed alone in Ndesign 50 SMA binder or Ndesign 50 SMA surface.

3/ Crushed concrete will not be permitted in SMA mixes.

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4/ Crushed steel slag shall not be used as leveling binder.

5/ When combinations of aggregates are used, the blend percent measurements shall be by volume.

(b) Quality. For surface courses, the coarse aggregate shall be Class B quality or better. For SMA surface and binder courses the coarse aggregate shall be Class B Quality or better. For Class A (seal or cover coat), other binder courses, and surface course IL-9.5L (Low ESAL), the coarse aggregate shall be Class C quality or better.

(c) Gradation. The coarse aggregate gradations shall be as listed in the following table.

Use	Size/Application	Gradation No.
Class A-1, 2, & 3	3/8 in. (10 mm) Seal	CA 16
Class A-1	1/2 in. (13 mm) Seal	CA 15
Class A-2 & 3	Cover	CA 14
HMA High ESAL	IL-19.0 IL-9.5	CA 11 1/ CA 16 and/or CA 13 CA 16
HMA Low ESAL	IL-19.0L IL-9.5L Stabilized Subbase or Shoulders	CA 11 1/ CA 16

1/ CA 16 or CA 13 may be blended with the gradations listed.

(d) Flat and Elongated Particles. For SMA the coarse aggregate shall meet the criteria for Flat and Elongated Particles listed in Illinois Modified AASHTO M 325.

(e) Absorption. For SMA the coarse aggregate shall also have water absorption $\leq$ 2.5 percent.

State of Illinois
Department of Transportation
Bureau of Materials and Physical Research

POLICY MEMORANDUM

Revised: January 1, 2017	11-08.5
This Policy Memorandum supersedes number 11-08.4 dated March 1, 2014	

TO: REGIONAL ENGINEERS AND HIGHWAY BUREAU CHIEFS

SUBJECT: AGGREGATE GRADATION CONTROL SYSTEM (AGCS)

1.0 SCOPE

1.1 This program shall apply to all Sources that supply certified aggregate for uses identified in this program to projects let under the jurisdiction of the Illinois Department of Transportation (includes local agency projects with state/federal funding). All aggregate shipped for program-designated uses on these projects shall be from a Certified Source.

2.0 PURPOSE

2.1 To establish a procedure of certification whereby Sources shall supply aggregate for designated use meeting test properties cited by the Bureau.

2.2 To set forth the conditions for Source certification and revocation of certification.

3.0 DEFINITIONS

3.1 **AGCS Technician** - A technician at the Source who has successfully completed the Department's AGCS Technician Course. This individual may perform all duties of the Aggregate Technician under the Gradation Control Program except gradation testing. Gradation testing (including splitting) must be performed by an Aggregate Technician or a Mixture Aggregate Technician. This training course is no longer available.

3.2 **Aggregate Inspector** - District materials inspector who has successfully completed the Department’s Aggregate Technician Course and is responsible for inspection at an aggregate Source. A Consultant, hired by the Department to perform the duties of an Aggregate Inspector, shall not be allowed to take any quality or Freeze-Thaw samples at an aggregate source.

3.3 **Aggregate Technician** - Sampling and testing technician at the Source who has successfully completed the Department’s Aggregate Technician Course and is responsible for the Gradation Control Program at the Source.

3.4 **Approved/Qualified Aggregate Source List** - A list maintained by the Department identifying aggregate sources certified to supply aggregate to Department/Local Agency projects.

3.5 **Bureau** - The Central Bureau of Materials, of the Illinois Department of Transportation, located in Springfield, Illinois.

3.6 **Department** - Illinois Department of Transportation.

3.7 **District** - Materials Office located at each Illinois Department of Transportation highway district office.

3.8 **Failing Gradation Sample** - A gradation sample which, when tested, exceeds the established Master Band on the critical sieve and/or exceeds the specification ranges on the other sieves for that gradation.

3.9 **Gradation Technician** - A technician who has successfully completed the Department's Gradation Technician Course and is responsible only for testing gradation samples. The Gradation Technician shall be monitored on a daily basis by the Aggregate Technician. To be certified as a Gradation Technician, contact the local IDOT Aggregate Inspector.

3.10 **Mechanical Blending** - Blending for gradation or of different types of materials shall be through interlocked feeders or a blending plant such that the prescribed blending percentage is maintained throughout the blending process.

3.11 **Mixture Aggregate Technician** - A technician who has successfully completed the Department's 3-day Aggregate for Mixtures course and is responsible only for sampling and testing gradation.

3.12 **Monitor Sample** - Gradation sample taken from the Source, Terminal, Supplier Yard, or mix plant and tested by the Department to monitor the gradation being produced by the Source under its Gradation Control Program. This sample shall also be used to evaluate the adequacy of procedures and equipment used by the Source in its Gradation Control Program.

3.13 **Outlying (OS) Source** – A certified aggregate source located out-of-state which is specifically designated by the inspecting District and the Bureau and required to run the requirements listed in Section 8.0 herein.

3.14 **Quality Control (QC) Manager** - The Aggregate Technician or the AGCS Technician designated by the Source who shall be responsible for compliance with the requirements of the Aggregate Gradation Control System. The QC Manager shall have successfully completed the Department's Aggregate Technician Course or the AGCS Technician Course.

3.15 **Source** - Individual aggregate source, i.e., a specific quarry or pit location supplying a specific product or products.

3.16 **Source Classification** - Under this program, a Source will be classified as Certified, De-Certified, or Non-Certified.

3.16.1 **Certified Source** - A Source that has met the requirements for certification and is allowed to supply aggregate for Department/Local Agency projects.

3.16.2 **De-Certified Source** - A Source that has had its Certified Source status revoked because requirements warranting certification have not been maintained. A De-Certified Source shall not be allowed to supply aggregate to Department/Local Agency projects.

3.16.3 **Non-Certified Source** - A Source that does not initially meet certification requirements or has not applied for certification.

3.17 **Source QC Plan** - A QC Plan detailing how a source designated as Outlying will comply with the AGCS.

3.18 **Standard Specifications** - Current edition of the Illinois Department of Transportation *Standard Specifications for Road and Bridge Construction.*

3.19 **Supplier Yard** – A Yard which buys aggregate from an AGCS or IDOT-inspected source and resells the aggregate from the yard for use on IDOT contracts (including local agency).

3.20 **Terminal** – A location owned by, leased to, or provided to an AGCS or IDOT-inspected source from which the source ships aggregate for use on IDOT contracts (including local agency).

4.0 GENERAL RESPONSIBILITIES

4.1 The Bureau shall maintain an Approved/Qualified Aggregate Source List identifying certified sources. Only Certified Sources shall supply material to Department/Local Agency projects. Each Certified Source shall maintain its own Gradation Control Program unless producing Category IV aggregate only. Aggregate shipped from a Certified Source shall be certified to meeting the quality and gradation requirements in the Standard Specifications. However, if approved by the District, the Source may choose to certify and supply other than standard Department gradations as established by the criteria in Article 6.2 herein.

4.2 A Supplier Yard shall meet the requirements of the AGCS on all aggregates which will be used on IDOT contracts (including local agency with state/federal funding). Start-of-Production (6.3.1) and Normal-Production (6.3.2) sampling/testing shall be waived. Incoming aggregate sampling/testing shall be run. The sampling/testing shall be according to the current Department QC/QA document, Model Annual Quality Control (QC) Plan for Hot-Mix Asphalt (HMA) Production, Section B. Materials, 1. Aggregates, b. Incoming Aggregate Gradation Samples.

4.3 A Terminal shall meet all the requirements of the AGCS on all aggregates which will be used on IDOT contracts (including Local Agency with state/federal funding). Start-of-Production (6.3.1) and Normal-Production (6.3.2) sampling/testing shall be waived.

5.0 REQUIREMENTS FOR SOURCE CERTIFICATION

5.1 A Certified Source shall have been checked using the procedures set forth in Section 9.0 herein and found to meet the requirements for Source certification. Any Source subsequently found not meeting these or any other requirements of this program shall be removed from the Approved Aggregate Source List based on the procedure detailed in Section 11.0. The requirements for Source certification are as follows:

5.1.1 Gradation Control Program - Gradation samples shall be taken and tested as per Section 6.0 herein.

Gradations and their ranges established per Article 6.2 herein which do not meet the Standard Specifications shall be submitted to the District for approval prior to production.

5.1.2 Stockpiling and Handling - Degradation is of primary concern in handling aggregates. Steel-tracked equipment shall not be permitted on stockpiles. Free-fall from conveyor equipment onto load-out stockpiles shall be held to a maximum of 15 feet. The fall height requirement may be waived if the aggregate source uses special remixing procedures or a device approved by the Central Bureau of Materials. A comparison of a series of samples taken during the reclaiming or loading-out operation to those taken from the production belt should be made to estimate the effect of the aggregate-handling method on degradation.

Stockpiling and handling methods of aggregate should be designed to hold segregation to a minimum. Coned stockpiles built with stationary or movable conveyor equipment shall not be permitted unless the reclaiming method is such that the loaded-out material visually shows little segregation. Radial and longitudinal conveyors or stackers shall be kept in motion to reduce coning. Where possible, a spreader chute on the stacker shall be used to broaden or flatten the wedge shape of the pile. Cascading down the sides of the pile should be held to a minimum. Material shall be reclaimed from wedge-shaped piles with an end-loader or equipment having similar type loading action working from the end of the pile, with care taken to work the entire width of the pile to remix the material as much as possible. Aggregate-handling methods using tunnel conveyor systems to reclaim aggregate from coned surge piles should be checked for consistency of gradation. The method of aggregate-handling and stockpiling currently in use at a particular source shall be considered satisfactory provided that the product, when checked at a loading-out point, meets the gradation requirements.

Materials certified under this program shall be stockpiled separately and identified by signs. Signs shall have a minimum of 3” lettering. Each individual sign shall be free-standing and moveable. Any changes made to signing must be pre-approved by the district.

5.1.3 Approved Laboratory - Laboratory facilities and equipment must conform to Section 7.0 herein. Laboratories shall be checked by District personnel and reapproved on an biennial basis. One (1) laboratory may be used as an approved laboratory for more than one (1) Source as long as no problems occur in maintaining each Source’s Gradation Control Program.

5.1.4 Aggregate Technicians - Sampling and testing personnel (including consultants and contractors) at the Source shall be Aggregate Technicians.
The Source may use an AGCS Technician to perform all duties of an Aggregate Technician except splitting and gradation testing. When an AGCS Technician is used, splitting and gradation testing must be performed by an Aggregate Technician or a Mixture Aggregate Technician.

The Source may use Gradation Technicians for splitting and gradation testing only. The Gradation Technician shall be under the direct supervision of the Aggregate Technician when testing gradation samples. The source may also use Mixture Aggregate

Technicians for sampling and gradation testing only. The Mixture Aggregate Technician shall be under the supervision of the Aggregate Technician or the AGCS Technician. The Aggregate Technician, Gradation Technician or Mixture Aggregate Technician, shall demonstrate gradation testing proficiency to the Aggregate Inspector on a quarterly basis.

A mixture QC/QA Technician shall not be allowed to concurrently perform the duties of an Aggregate Technician, an AGCS Technician, or a Mixture Aggregate Technician in the *AGCS.*

6.0 GRADATION CONTROL PROGRAM

6.1 The Gradation Control Program shall be run by an Aggregate Technician or an AGCS Technician as defined in Section 3.0 herein. The QC Manager shall assume responsibility for compliance with the Aggregate Gradation Control System and specifically shall ensure that the Aggregate Technician, AGCS Technician, or Mixture Aggregate Technician is performing all the required duties under the Aggregate Gradation Control System.

All communication concerning the Aggregate Gradation Control System shall be directed to the QC Manager.

Primary duties of the Aggregate Technician shall include frequent visual inspection, gradation sampling and testing, documentation, etc., as detailed herein and in QC/QA Procedure, “Quality Control (QC) Manager / Aggregate Technician / AGCS Technician / IDOT Inspector / Gradation Technician Responsibilities”, located in the current ”Manual of Test Procedures for Materials.” The AGCS Technician may perform the same duties as the Aggregate Technician except gradation testing. Gradation testing shall be performed by an Aggregate Technician or a Mixture Aggregate Technician.

6.2 **Gradation Specifications** - Sieve limits for each sieve/each product under the Aggregate Gradation Control System shall be as specified in the Department’s Standard Specifications and/or as amended herein. The special critical sieve criteria for certain designated products as described in QC/QA Procedure, “Aggregate Producer Control Chart Procedure” located in the current ”Manual of Test Procedures for Materials” are also required.

The midpoint/tolerance range of a designated critical sieve shall be developed from an average as shown in QC/QA Procedure, “Aggregate Producer Control Chart Procedure,”. The average shall be a historical average or a production average derived from start-of-production samples that is agreed to by the Department. All 5 Start of production samples must pass the established critical sieve limit. Critical sieve limits shall take precedence over Standard Specification limits. Requests for critical sieve limits shall be submitted in writing to the District Materials Engineer for approval.
For sieves other than the top and bottom specification sieves, sieve limits may be developed based on historical or average production values. These sieve limits may be different from those in the Standard Specifications. These modifications are also allowed for fine aggregate. Changes in the top sieve or any No. 200 sieve ranges will not be permitted. In cases where the bottom sieve is other than the No. 200 sieve, a variance in limits may be granted if the Bureau determines the minus No. 200 material to be within acceptable limits.

The Source shall request in writing to the District Materials Engineer approval of limits other than those in the Standard Specifications, but the range of the limits shall remain the same as the Standard Specifications.

Although the Department reserves the right to reject unacceptable material at any point prior to incorporation into the final product, the agreed upon gradation limits shall apply at the final point of shipping within the Source's control.

6.3 **Sampling and Testing** - Gradation samples shall be reduced to testing size by Illinois Test Procedure 248. Minimum Field Sample Size and Minimum Test Sample Size shall be as noted in the Sample Size table, Illinois Specification 201. All sampling and gradation testing shall conform to Illinois Test Procedure 2, Illinois Test Procedure 11, and Illinois Test Procedure 27. The Illinois Test Procedures noted above are located in the current "Manual of Test Procedures for Materials."

Sampling and testing frequencies (including washed tests) by category/use shall be as noted in Table 1. Definitions of each frequency are as follows:

6.3.1 **Start-of-Production Frequency** - After a seasonal shutdown of production or when first producing a new product, the sampling and testing of start-up production or of the new product shall be at start-of-production frequencies/requirements noted in Table 1.

6.3.2 **Normal-Production Frequency** - During normal production, the minimum production sampling and testing frequency/requirements as noted in Table 1 shall be maintained.

6.3.3 **Stockpile Frequency** - During loadout of stockpiles, the minimum stockpile sampling and testing frequency/requirements as noted in Table 1 shall be maintained for each stockpile.

6.3.4 **Production Changes (Short-Term Shutdown, Screen Change, Crusher Modification, Different Feed Rate, New Products, etc.)** - If a production change is made, a washed gradation sample shall immediately be run on all affected products. The start-of-production sampling frequency shall be implemented if the result on any critical sieve in that sample exceeds the warning bands on the critical sieve or if any results fail any specified sieve limits.

6.4 **Documentation** - Gradation results shall be charted on control charts, if required in Table 1, according to QC/QA Procedure, "Aggregate Producer Control Chart Procedure", located in the current "Manual of Test Procedures for Materials". Within one (1) working day of sampling, all gradation results shall be charted, posted, or entered into a source computer, each of which shall be located at the source and/or approved laboratory, at the District's option. Computer-maintained charting must be approved by the Department and accessible in a timely manner during any Department inspection. Computer-maintained charts shall be printed and displayed once per week or at the request of the Department. Control charts are the property of the Department and shall not be removed or altered in any manner. The Aggregate Inspector shall check the control charts on a regular basis. Source gradation computation sheets shall be maintained by the Department for a minimum of three (3) years after the date run.

A Source diary shall be maintained by the Aggregate Technician or the AGCS Technician. The Aggregate Technician or the AGCS Technician will log all actions taken

during the production day, such as new product production, sampling, resampling, screen changes, separate stockpiling, visual inspections, etc., as noted in QC/QA Procedure, "Quality Control (QC) Manager / Aggregate Technician / AGCS Technician / IDOT Inspector / Gradation Technician Responsibilities." in the current "Manual of Test Procedures for Materials."
The Source shall immediately notify the District whenever new products are being produced at the Source under its Gradation Control Program.

6.5 **<u>Failing Gradation Samples</u>** - Any Failing Gradation Sample (start-of-production, normal-production, or stockpile) shall be evaluated according to the following procedure and, if necessary, immediate action taken to correct the failing gradation.

If a gradation sample fails, one (1) resample from the same sampling location shall immediately be taken and tested. If the resample passes, the testing frequency being run prior to the failure shall be resumed. If the resample fails, a second resample shall immediately be taken.

If the second resample passes, the start-of-production sampling frequency shall be initiated. All samples in the series must pass before the normal production or stockpile sampling frequency for that location can be restarted.

If the second production resample fails, production of that specified aggregate shall not be incorporated in the approved stock, or, in the case of the second stockpile resample failing, shipment from that stockpile shall cease. Corrective action shall be initiated by the Source. No material shall be placed on or, in the case of stockpile problems, shipped from the certified stock until a passing gradation sample is taken and tested. The start-of-production frequency shall then be run at that location. All samples in the series must pass before the normal-production or stockpile sampling frequency for that location can be restarted.

All resamples shall be washed gradation tests except as stated under Note 2 in Table 1.

Any action taken, such as resampling, screen changes, separate stockpiling, etc., shall be noted on the bottom of the failing test computation sheet and in the Source diary.

The Aggregate Technician or the AGCS Technician shall monitor the corrective action. Failure to comply with Article 6.5 herein shall cause the Source to be removed from the Approved Aggregate Source list as per Section 11.0 herein.

6.6 **<u>Failing Monitor Gradation Samples</u>** - Any Source's failing Monitor gradation sample taken and tested by the Department and determined to be a source problem per Section 9.6 shall be considered a Failing Gradation Sample under the Source's Gradation Control Program and shall cause the Source to enact Article 6.5 herein.

7.0 APPROVED LABORATORY

7.1 An approved Source laboratory shall have the following equipment or alternatives approved by the Bureau (see "Aggregate Laboratory Equipment" in the current *Manual of Test Procedures for Materials*:

7.2 If a mixture QC laboratory is used for AGCS testing, the following additional equipment is required for use only on AGCS aggregate samples:

- One set of nested sieves for coarse and/or fine aggregate.
- One set of wash sieves.
- One coarse and/or fine aggregate splitter.

8.0 OUTLYING (OS) SOURCE REQUIREMENTS

8.1 Each district may designate in writing to the Bureau a certified aggregate source located out-of-state which shall follow specific requirements in running the AGCS, listed herein. The District shall detail the criteria used to select the source for the Outlying designation. The Source QC plan tentatively approved by the District shall accompany the District request.

The Bureau shall notify the District Materials Engineer in writing as to whether the aggregate source has met the Outlying criteria, the Source QC Plan is acceptable, and the Source will be designated as an Outlying (OS) Source.

8.2 The OS Source shall follow all requirements of the AGCS program unless otherwise noted within this section. A Source QC plan shall be submitted for department approval to the inspecting District. Other states' QC/QA programs or parts thereof may be substituted for the Illinois AGCS program, if approved by the Bureau. All substitutions/changes shall be noted in the Source QC Plan. The minimum sampling frequencies noted in the Illinois AGCS program shall be met regardless of frequencies listed in the other state programs.

8.3 The District will, at least annually, visit each Source to obtain quality/gradation samples, observe program procedures, and inspect the AGCS laboratory. Laboratory inspections conducted under other states' programs may be used if the OS Source has been approved to use the other states' QC/QA program.

These inspections may be unannounced.

8.4 The District will inspect, sample, and test incoming aggregate at the specified AGCS monitor frequency at Illinois sites (job sites, mix plants, terminals, or supplier yards). Split sample, load-out, and comparison requirements noted in Section 9 herein shall be waived.

The District shall communicate the test results to the QC Manager at the aggregate Source for appropriate action, including any corrective action. In addition, the District shall communicate the test results to any QC Manager or Resident Engineer at the jobsite, mix plant, terminal, or supplier yard, for appropriate action, including corrective action.

8.5 Outlying Sources shall notify their inspecting District of all scheduled AGCS shipments/production (including shipments to mix plants, terminals, and supplier yards) prior to the shipment/production.

8.6 Once designated as an Outlying Source, all aggregate, including Category I, III, and IV, shipped to Illinois Department of Transportation projects (including all Local Agency projects) shall be produced under the AGCS program. Category IV shall be run at the Category III frequency.

9.0 DEPARTMENT RESPONSIBILITIES

9.1 Sampling and testing for quality shall remain the responsibility of the Department. A Consultant, hired by the Department to perform the duties of an Aggregate Inspector, shall not be allowed to take any quality or Freeze-Thaw samples at an aggregate source.

9.2 Monitor gradation samples at the Source shall be taken, by or in the presence of an Aggregate Inspector, from each aggregate being produced for designated use at each Certified Source. All Monitor samples shall be split samples of a Source's gradation sample taken as per the Source's Gradation Control Program.

Additionally, the Department does reserve the right to sample Monitor samples at any time. At least two (2) out of every five (5) Monitor samples shall be taken from the stockpile's loadout face once loadout procedures have started. The Monitor samples shall be tested by District personnel on Department testing equipment according to the first paragraph of Section 6.3 herein. All Monitor samples shall be washed gradation tests unless Note 2 in Table 1 is applicable. Each Monitor sample shall be identified as to sampling location and gradation test procedure used.

9.3 Sampling and testing frequency for the Monitor gradation samples shall be a minimum of one (1) sample per every twenty (20) production days for each gradation being produced for designated use.

9.4 All Monitor gradations run shall be reported in the MISTIC system. Computation sheets shall be retained for a minimum of three (3) years in the Department's Source file.

9.5 The Inspector shall compare both the Monitor sample and the Source's split sample for validity as defined by the Department's "Guideline for Sample Comparison" (see Appendix A of the current "Manual of Test Procedures for Materials"). The reason for any <u>significant</u> difference between the two (2) samples shall be determined and corrected.

9.6 All Monitor gradations shall be communicated to the QC Manager. All failing monitor gradations shall be investigated by the Department. Any failing gradations, which are determined to be a Source problem not already corrected by the Producer, shall cause Article 6.6 herein to be enacted by the Source. The Aggregate Inspector shall compare the failing gradation to the Source's control charts and/or split sample computation sheet. If the control chart indicates that the Source is aware of the problem and is taking corrective action, normal Monitor sampling shall resume.

The Aggregate Inspector shall continue to visually monitor the problem and the Source's corrective action. If the control chart indicates the Source is not aware of the problem, a split sample of the Source's next sample as specified in Article 6.5 shall be tested. Failure of the Source to follow Article 6.6 shall result in the Source being removed from the Approved Aggregate Source list per Section 11.0 herein.

10.0 SOURCE CERTIFICATION PROCEDURE

10.1 An aggregate Source wishing to become certified shall verbally contact the District. A preliminary meeting may be held to discuss requirements of the program. After the initial contact or the preliminary meeting, a written request for certification shall be submitted to the District Materials Engineer.

10.2 An evaluation team composed of two (2) District personnel shall conduct an inspection of the Source for compliance to the certification checklist for all sources producing Category I, II, and III aggregate. A formal meeting with the Source's management, QC Manager, and quality control personnel shall be held to discuss the Source's Gradation Control Program requirements. The Source shall submit a certification letter and a quality on tickets form as designated by the Department. Each Source shall provide and maintain on their quality on tickets forma listing of current certified gradations being produced under the Aggregate Gradation Control System. The certification letter and Quality on Tickets form, shall be forwarded to the Bureau.

10.3 The Bureau shall notify the District Materials Engineer in writing whether or not the aggregate Source has met the certification criteria and has been added to the Approved Aggregate Source list.

10.4 Each Certified Source shall be reevaluated on an biennial basis by District personnel. The reevaluation shall be a complete evaluation of the Source's laboratory and technician(s). A copy of the reevaluation checklist and comments shall be forwarded to the Bureau. Failure to comply with the certification criteria shall result in the Source's certification being revoked as per the procedure detailed in Section 11.0 and the Source will be classified as De-Certified and removed from the Approved/Qualified Aggregate Source list.

10.5 If at any time a Certified Source does not maintain the proper QC personnel, the source will be given one (1) month to comply by either hiring a new QC person or by contracting with a qualified consultant. If after one (1) month the source does not have the proper QC personnel; the source's Certification will be revoked by the BMPR. Section 11.0 will not apply to this type of Revocation. The source will be reinstated as an Approved Aggregate Source once the proper QC personnel are acquired.

As an option to this type of Revocation, a source may utilize a Gradation Technician for gradation testing as long as the following criteria are met:

- The Source must inform the district, in writing, of the QC personnel change.
- The source must have an Aggregate Technician visit the source a minimum of three (3) times a day to oversee the Gradation Technician.
- The source must have the proper personnel trained and in place as soon as possible.

11.0 REVOCATION OF A SOURCE'S CERTIFICATION

11.1 The Department may revoke a Source's Certification for any of the following reasons:

- Failing to follow the procedures and requirements of the Aggregate Gradation Control System (AGCS) Policy Memorandum.
- Misrepresentation of materials or products.
- Failing to follow the approved Quality Control Plan, if applicable.

11.2 Before removal, the District Materials Engineer shall detail, in a non-conformance letter to the Source's QC Manager, why the Department is seeking to revoke the Source's Certification. The Source has within two weeks to reply. The Source shall not place materials in question on certified stockpiles during the two-week period. If the Department's reasons warrant, the Source may be required to stop shipment of any and all products to Department and/or Local Agency projects.

11.3 Within this two-week period, the Source's QC Manager shall reply, in writing, outlining the steps the Source is taking to address the issues outlined within the Department's non-conformance letter.

11.4 After receipt of the Source's letter, the District will schedule a meeting with the Source to discuss the proposed revocation and the Source's response. After such meeting, the District Materials Engineer will either (1) conclude the steps taken by the Source's QC Manager are adequate and terminate the revocation process, or (2) conclude the Source's response does not address the issues outlined in the Department's non-conformance letter and recommend in writing to the Central Bureau of Materials the Source be taken off the Approved Aggregate Source List. The recommendations shall include details and District/Source comments concerning the proposed revocation. Copies of all correspondence, including meeting minutes, shall be sent to the Bureau and the Source.

11.5 If requested by the Source within seven days of the District's recommendation to revoke the Certification, the Bureau will schedule a meeting with the Source's QC Manager and the District. After such meeting, the Bureau will either terminate the revocation process or proceed with removing the Source from the Approved Aggregate Source List.

The Bureau's decision to revoke the Source's Certification is a final agency decision of the Illinois Department of Transportation.

11.6 The Bureau shall notify the District Materials Engineer and Source in writing when a Source's Certification has been revoked and the Source has been removed from the Approved Aggregate Source List as a De-Certified Source.

The Source may not provide aggregate materials or products for Department and/or Local Agency projects until such time as the Source's Certification has been reinstated.

11.7 The QC Manager, at any time, may inform the District in writing that the Source is no longer producing or shipping a specific certified gradation. This action shall terminate any revocation process against the source concerning that certified gradation. Production of that gradation for the AGCS shall not be restarted unless the District concurs that corrective action has been completed by the Source. If the revocation process is based on misrepresentation of materials or products, and/or failure to follow the overall general requirements of this policy, 11.7 does not pertain

12.0 REINSTATEMENT OF A SOURCE'S CERTIFICATION

12.1 The Source may re-apply for reinstatement of its certification at the end of the revocation period. Re-application shall be in writing to the Central Bureau of Materials and include the specific steps to be taken to correct the cause for loss of certification.

TABLE 1

Category	Use	Start of Production	Normal Production	Stockpile/ Loadout	Control Charts	Masterband
I (Notes 1 & 5)	Coarse Aggregate and Manufactured Sand Used in HMA and PCC Coarse Aggregate for Pavement Drainage	5@1,000 T (all wash)	1@2,000 T 2 per day max (wash 1/3 coarse agg.) (wash all manufactured sand)	2/week (all wash) (Note 3)	Yes	Yes (Note 8)
III (Notes 1 & 5)	Natural Sand for All PCC and HMA Projects Aggregate Surface Course Granular Shoulders Granular Sub-base Granular Base Granular Embankment Special Cover/Seal Coat Sand Bedding Porous Granular Embankment and Bedding, Sand Backfill for Underdrains French Drains Membrane Waterproofing Mortar Sand Blotter Granular Embankment Aggregate Subgrade (Note 9)	2@2,000 T (all wash) (Note 2)	1@10,000 T 2 per day max 1 per week min (all wash) (Notes 2 & 6)	1/week (all wash) (Notes 2 & 7)	No	No

Table 1 (cont.)						
Category	**Use**	**Start of Production**	**Normal Production**	**Stockpile/ Loadout**	**Control Charts**	**Masterband**
IV (Note 4)	Rock Fill Erosion and Sediment Control Rip-Rap Bedding Ice Control Abrasives Trench Backfill	Department Testing				

Note 1: A producer may adjust gradation bands for any product in accordance with Article 6.2 of the AGCS.

Note 2: Wash only products used for HMA, PCC, Seal/cover coat and products with #200 sieve requirements.

Note 3: No loadout tests for quantities under 500 tons or less shipped weekly. When loadout occurs but no weekly loadout test is run, the tonnage shipped shall be accumulated from the start of that week. When the accumulated tonnage exceeds 500 tons, a loadout sample shall be run.

Note 4: Testing to be performed by IDOT personnel.

Note 5: Testing frequency may be reduced based on conformance to QC requirements, consistency in meeting sieves' midpoints, statistical consistency, etc.

Note 6: Minimum of 1 per week after the first 10,000 tons of production per week for aggregate surface course, granular shoulders, granular subbase, granular base, and granular embankment special; minimum of 1 every 2 weeks if producing less than 10,000 tons per 2-week period.

Note 7: No loadout tests for quantities under 1,000 tons or less shipped weekly. When loadout occurs but no weekly loadout test is run, the tonnage shipped shall be accumulated from the start of that week. When the accumulated tonnage exceeds 1,000 tons, a loadout sample shall be run.

Note 8: Refer to current QC/QA Procedure, “Aggregate Producer Control Chart Procedure” for required gradations.

Note 9: Only Normal Production test shall apply.

Illinois Specification 201
Illinois Department of Transportation (IDOT)
AGGREGATE GRADATION SAMPLE SIZE TABLE & QUALITY CONTROL SIEVES

Effective: December 1, 2017

COARSE AGGREGATE GRADATION TABLE																					
CA(CM)[1,2]	**Minimum Field Sample Size [3]**	**Minimum Test Sample Size[3]**	**3”**	**2 1/2”**	**2”**	**1 3/4”**	**1 1/2”**	**1”**	**3/4”**	**5/8”**	**1/2”**	**3/8”**	**1/4”**	**#4**	**#8**	**#16**	**#40**	**#50**	**#200**
CA01	110 lbs (50 kg)	10,000 g	X	X^{MN}	X		X	X											X
CA02	110 lbs (50 kg)	10,000 g		X	X^{MN}		XC	X	XC		X			X		X	X		X
CA03	110 lbs (50 kg)	10,000 g		X	X^{MN}		X	X			X								X
CA04	110 lbs (50 kg)	10,000 g			X		X^{MN}	X	XC		X	XC		X		X	X		X
CA05[5]	110 lbs (50 kg)	10,000 g				X	X^{MN}	X^{MB,6}	XC		X			X^{6}					X
CA06	55 lbs (25 kg)	5,000 g					X	X^{MN}	XC		X	XC		X		X	X		X
CA07[5]	55 lbs (25 kg)	5,000 g					X	X^{MN}	XC	XC	X^{MB,6}	XC	XC	X^{6}					X
CA08	55 lbs (25 kg)	5,000 g					X	X^{MN}	X	XC	X	XC	XC	X		X			X
CA09	55 lbs (25 kg)	5,000 g					X	X^{MN}	XC	XC	X	XC	XC	X		X			X
CA10	55 lbs (25 kg)	5,000 g						X	X^{MN}	XC	X	XC	XC	X		X	X		X
CA11[5]	55 lbs (25 kg)	5,000 g						X	X^{MN}	XC	X^{MB,6}	XC	XC	X		X^{6}			X
CA12	35 lbs (16 kg)	2,000 g							X		X^{MN}	X	XC	X	XC	X	X		X
CA13[5]	35 lbs (16 kg)	2,000 g							X		X^{MN}	X	XC	X^{MB,6}	XC	X^{6}			X
CA14[5]	35 lbs (16 kg)	2,000 g								X	X^{MN}	X^{MB,6}	XC	X^{6}					X
CA15	35 lbs (16 kg)	2,000 g									X	X^{MN}	XC	X	XC	X			X
CA16[5]	25 lbs (11 kg)	1,500 g									X	X^{MN}	XC	X^{MB,6}	XC	X^{6}			X
CA17	35 lbs (16 kg)[4]	4,000 g[4]	X		XC			XC			XC	XC		X^{MN,4}		X		X	X
CA18	35 lbs (16 kg)[4]	4,000 g[4]	X					X^{MN,4}			XC	XC		X		X		X	X
CA19	35 lbs (16 kg)[4]	4,000 g[4]	X					X^{MN,4}			XC	XC		X		X	X	X	X
CA20	25 lbs (11 kg)	2,000 g									X	X^{MN}	XC	X	X	X			X

Note: See footnotes below Fine Aggregate Gradation Table for explanation of symbols.

Illinois Specification 201
Illinois Department of Transportation (IDOT)
AGGREGATE GRADATION SAMPLE SIZE TABLE & QUALITY CONTROL SIEVES

Effective: <u>December 1, 2017</u>

FINE AGGREGATE GRADATION TABLE

FA(FM)[1,2]	Minimum Field Sample Size [3]	Minimum Test Sample Size[3]	1"	1/2"	3/8"	#4	#8	#10	#16	#30	#40	#50	#80	#100	#200
FA01	25 lbs (11 kg)	500 g			X	X^{MN}	X^{MB}		X	X^{MB}		X		X	X
FA02	25 lbs (11 kg)	500 g			X	X^{MN}	X^{MB}		X	X^{MB}		X		X	X
FA03	25 lbs (11 kg)	500 g			X	X^{MN}		X			X		X		X
FA04	25 lbs (11 kg)	500 g			X				X^{MN}						
FA05	25 lbs (11 kg)	500 g			X	X^{MN}								X	X
FA06	25 lbs (11 kg)	500 g	X	X	X	X^{MN}								X	X
FA07	25 lbs (11 kg)	100 g				X		X^{MN}			X		X		X
FA08	25 lbs (11 kg)	100 g					X				X^{MN}			X	X
FA09	25 lbs (11 kg)	100 g					X					X^{MN}		X	X
FA10	25 lbs (11 kg)	100 g						X			X^{MN}		X		X
FA20[5]	25 lbs (11 kg)	500 g			X	X^{MN}	X^{MB}		X	$X^{MB, 6}$		X		X	X^{6}
FA21[5]	25 lbs (11 kg)	500 g			X	X^{MN}	X^{MB}		X	$X^{MB, 6}$		X		X	X^{6}
FA22[5]	25 lbs (11 kg)	500 g			X	X^{MB}	$X^{MB, 6}$		X						X^{6}

<u>Notes below apply to Fine and Coarse Aggregate Gradation Tables Only</u>

X = Required Gradation Specification Sieves
XC = Required Cutter Sieves
MB = Master Band Sieves for Category I & II Coarse Aggregate for PCC and HMA Mixes; Bituminous use only for fine aggregate.
MN = Maximum Nominal Sieve for Crushed Gravels – Maximum Nominal Size is defined as the first specification sieve in the product gradation on which material may be retained.
1 = CA = Coarse Aggregate; CM = Coarse Aggregate, Modified; FA = Fine Aggregate; FM = Fine Aggregate, Modified
2 = CM and FM gradations shall be sampled and tested the same as the corresponding CA and FA gradations.
3 = Slag should be adjusted accordingly due to its lighter or heavier mass.
4 = Will vary with the gradation of the material being used
5 = Control Charts Required
6 = Required Sieve for Control Charts

Illinois Specification 201
Illinois Department of Transportation (IDOT)
AGGREGATE GRADATION SAMPLE SIZE TABLE & QUALITY CONTROL SIEVES

Effective: December 1, 2017

LARGE SIZED AGGREGATE GRADATION TABLE										
CS/RR[1,2]	**Minimum Test Sample Size[3]**	**8”**	**6”**	**4”**	**3”**	**2”**	**1 ½”**	**1”**	**½”**	**#4**
CS01	50,000 g	X	X	X	XC	X		XC	XC	X
CS02	50,000 g		X	X	XC	X		XC	XC	X
RR01	20,000 g				X	XC	X	XC	XC	X
RR02	20,000 g			X	XC	X	XC	XC	XC	X

Notes below apply to Large Sized Aggregate Gradation Table Only

X = Required Gradation Specification Sieves
XC = Required Cutter Sieves
1 = CS = Coarse Aggregate Subgrade; RR/RRM = Rip Rap
2 = Dry Gradations Only
3 = Slag should be adjusted accordingly due to its lighter or heavier mass.
4 = A round nosed shovel may be used for sampling.
5 = Metal plates with precisely sized square holes by be used for the gradation
6 = Test sample size shall be taken in the field. No splitting is required.

Illinois Modified Test Procedure
Effective Date: June 1, 2012
Revised Date: December 1, 2017

Standard Method of Test
for
Hamburg Wheel-Track Testing of Compacted Hot Mix Asphalt (HMA)

Reference AASHTO T 324-17

AASHTO Section	***Illinois Modification***
1.2	Revise the last sentence as follows: Alternatively, field cores with a diameter of 150 mm (5.91 in.), 255 mm (10 in.), 300 mm (12 in.), or saw-cut slab specimens may be tested.
2.1	Revise the individual AASHTO Standards with the appropriate Illinois modified AASHTO Standards: ▪ R 30, Mixture Conditioning of Hot Mix Asphalt (HMA) ▪ T 166, Bulk Specific Gravity of Compacted Hot Mix Asphalt (HMA) Using Saturated Surface-Dry Specimens ▪ T 209, Theoretical Maximum Specific Gravity and Density of Hot Mix Asphalt (HMA) ▪ T 312, Preparing and Determining the Density of Hot Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor
4.1	Revise the second sentence as follows: The specimen is submerged in a temperature-controlled water bath at 50 ± 1.0°C (122 ± 1.8°F).
6.1	Replace Section 6.1 with the following: *Number of Test Specimens* – A single slab specimen, two 150 mm (5.91 in.) diameter gyratory compacted specimens, or field cores according to Section 6.4 will be tested under each wheel in the Hamburg Wheel Tester. A test is currently defined as HMA specimens being tested using two wheels. However, if the District has sufficient experience with how their mixtures perform in the Hamburg Wheel Tester, a test may be conducted using a single wheel, at the discretion of the District.
6.2.2	Replace with the following: The mixing temperature shall be according to IL Modified AASHTO T 312.
6.2.4	Replace with the following: Laboratory mixed test samples shall be conditioned at the appropriate compaction temperature according to the short-term conditioning procedure in IL Modified AASHTO R 30.
6.2.5	Replace with the following: The compaction temperature shall be according to IL Modified AASHTO T 312.

Illinois Modified Test Procedure
Effective Date: June 1, 2012
Revised Date: December 1, 2017

Standard Method of Test
for
Hamburg Wheel-Track Testing of Compacted Hot Mix Asphalt (HMA)
(continued)
Reference AASHTO T 324-17

AASHTO Section	***Illinois Modification***
6.2.6.2	Replace with the following: *Compacting SGC Cylindrical Specimens*--Material shall be compacted into specimens using an SGC according to IL Modified AASHTO T 312. A specimen thickness of 62±2 mm (2.4±0.1 in.) shall be used. The specimen thickness shall be at least twice the nominal maximum aggregate size. Two 150 mm (5.91 in.) diameter specimens are needed for each wheel. Compacted specimens shall be cooled at room temperature on a clean, flat surface until the specimen is cool to the touch. If compaction of a 62±2 mm specimen requires more than the design number of gyrations for that particular mix design, then a single specimen with a height larger than 62 mm, which can be compacted within the approximate design number of gyrations, may be fabricated. The top 62±2 mm shall be cut away using a wet-saw, kept, and tested, keeping the cut face down. The air voids of the top 62 mm shall meet the tolerance specified in Section 7.3. Discard the bottom material cut from the specimen.
6.3.2.2	Replace with the following: *Compacting SGC Cylindrical Specimens*—Material shall be compacted into specimens using an SGC according to IL Modified AASHTO T 312. A specimen thickness of 62±2 mm (2.4±0.1 in.) shall be used. The specimen thickness shall be at least twice the nominal maximum aggregate size. Compacted specimens shall be cooled at room temperature on a clean, flat surface until the specimen is cool to the touch. Two 150 mm (5.91 in.) diameter specimens are needed for each wheel. If compaction of a 62±2 mm specimen requires more than the design number of gyrations for that particular mix design, then a single specimen with a height larger than 62 mm, which can be compacted within the approximate design number of gyrations, may be fabricated. The top 62±2 mm shall be cut away using a wet-saw, kept, and tested, keeping the cut face down. The air voids of the top 62 mm shall meet the tolerance specified in Section 7.3. Discard the bottom material cut from the specimen.
6.4.1	Replace sentence one with the following: *Cutting Field Cores or Field Slab Specimens*--Field cores or field slab specimens may be taken from compacted HMA pavements. Replace sentence five with the following: The height of a field core specimen may need to be adjusted to fit the specimen mounting system.

Illinois Modified Test Procedure
Effective Date: June 1, 2012
Revised Date: December 1, 2017

Standard Method of Test
for
Hamburg Wheel-Track Testing of Compacted Hot Mix Asphalt (HMA)
(continued)
Reference AASHTO T 324-17

AASHTO Section	*Illinois Modification*
Note 2	Replace the second sentence with the following: In order for the total sample height to be 62±2 mm (2.4±0.1 in.), the sample must be trimmed with a wet saw if it is too tall. If the sample is too short then it must be shimmed up with Plaster of Paris (or equivalent).
7.3	Replace the second sentence with the following: For laboratory-compacted specimens, the target air void content shall be 6.0±1.0 percent for SMA mixes and 7.0±1.0 percent for all other mixes.
8.2	Replace with the following: SGC Cylindrical and Field Core Specimen Mounting – Place the HDPE molds in the mounting tray. Insert the cut specimens in the molds. Shim the molds in the mounting tray as necessary. Secure the molds into the mounting tray by hand-tightening the bolts of the edge plate.
8.6.1	Replace with the following: *Test Temperature*-The test temperature shall be 50±1°C (122±1.8°F).
8.6.2	Replace with the following: *Maximum Rut Depth*-The maximum allowable rut depth shall be less than or equal to 12.5 mm (0.5 in.). When setting the machine up for testing, the maximum rut depth should be set at a value greater than 12.5 mm (14.0 mm suggested) to avoid a premature end of the test caused by temporary rut depth spikes.
8.6.3	Add the following: *Selecting the Number of Wheel Passes*-The minimum number of wheel passes at the 0.5 in. (12.5 mm) rut depth criteria shall be selected based upon the PG Grade high temperature of the asphalt binder as specified in the mix requirements table of the plans. • PG 58-xx or lower 5,000 wheel passes • PG 64-xx 7,500 wheel passes • PG 70-xx 15,000 wheel passes • PG 76-xx or higher 20,000 wheel passes It may be useful to run every test for 20,000 wheel passes to collect additional data on moisture sensitivity.
8.6.4	Replace the first sentence with the following: Enter a start delay of 30 min to precondition the test specimens.

Illinois Modified Test Procedure
Effective Date: June 1, 2012
Revised Date: December 1, 2017

Standard Method of Test
for
Hamburg Wheel-Track Testing of Compacted Hot Mix Asphalt (HMA)
(continued)
Reference AASHTO T 324-17

AASHTO Section	***Illinois Modification***
8.8.4	Replace with the following: Each wheel on the wheel-tracking device shall shut off independent of the other wheel. The end of a test for each wheel can occur when the specified number of wheel passes listed in Section 8.6.1.1 or the number of passes otherwise specified has occurred on that wheel. Further, each wheel on the device shall be set to lift independently when the LVDT displacement is 14.0 mm (0.55 in.) for that wheel. The HWTD measures the rut depth at multiple points per pass across the specimen. The maximum rut depth is defined as the average rut depth of the point with the deepest rut depth and the rut depth of the two points physically closest to it. The testing device software automatically saves the test data file for each wheel.
8.8.4.1 New Section	Add the following: If the test was conducted using two wheels, a passing test requires both wheels to have a rut depth less than or equal to 12.5 mm at the prescribed number of passes in section 8.6.1.1. The test result is reported as the average of the two rut depths. A test is considered as failing if one or both rut depths exceed 12.5 mm at, or less than, the prescribed number of passes in section 8.6.3. If the test was conducted using a single wheel, a passing test from that wheel shall have a rut depth less than or equal to 12.5 mm at the prescribed number of passes in section 8.6.3.
8.9.2	Replace the first sentence with the following: Precondition the test specimens in the water bath for 30 min after the water has reached the selected test temperature.
8.9.3	Replace the first sentence with the following: Lower the wheels onto the specimens after the test specimens have preconditioned at the selected test temperature for 30 min.
9.1	Delete
X1.1	Replace with the following: Follow the manufacturer's recommendations for lubrication and cleaning.

Standard Method of Test for

Hamburg Wheel-Track Testing of Compacted Hot Mix Asphalt (HMA)

AASHTO Designation: T 324-11

1. SCOPE

1.1. This test method describes a procedure for testing the rutting and moisture-susceptibility of hot mix asphalt (HMA) pavement samples in the Hamburg Wheel-Tracking Device.

1.2. The method describes the testing of submerged, compacted HMA in a reciprocating rolling-wheel device. This test provides information about the rate of permanent deformation from a moving, concentrated load. A laboratory compactor has been designed to prepare slab specimens. Also, the Superpave® Gyratory Compactor (SGC) has been designed to compact specimens in the laboratory. Alternatively, field cores of diameter, [150 mm (6 in.), 250 mm (10 in.), or 300 mm (12 in.)], or saw-cut slab specimens may be tested.

1.3. The test method is used to determine the premature failure susceptibility of HMA due to weakness in the aggregate structure, inadequate binder stiffness, or moisture damage. This test method measures the rut depth and number of passes to failure.

1.4. The potential for moisture damage effects are evaluated since the specimens are submerged in temperature-controlled water during loading.

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

2. REFERENCED DOCUMENTS

2.1. *AASHTO Standards*:
- R 30, Mixture Conditioning of Hot Mix Asphalt (HMA)
- T 166, Bulk Specific Gravity of Compacted Hot Mix Asphalt(HMA) Using Saturated Surface-Dry Specimens
- T 168, Sampling Bituminous Paving Mixtures
- T 209, Theoretical Maximum Specific Gravity and Density of Hot Mix Asphalt (HMA)
- T 269, Percent Air Voids in Compacted Dense and Open Asphalt Mixtures
- T 312, Preparing and Determining the Density of Hot Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor

3. SIGNIFICANCE AND USE

3.1. This test measures the rutting and moisture susceptibility of an HMA specimen.

4. SUMMARY OF METHOD

4.1. A laboratory-compacted specimen of HMA, a saw-cut slab specimen, or a core taken from a compacted pavement is repetitively loaded using a reciprocating steel wheel. The specimen is submerged in a temperature-controlled water bath of 40 to 50°C (104 to 122°F) or a temperature specified for the binder being used. The deformation of the specimen, caused by the wheel loading, is measured.

4.2. The impression is plotted as a function of the number of wheel passes. An abrupt increase in the rate of deformation coincides with stripping of the asphalt binder from the aggregate in the HMA specimen.

5. APPARATUS

5.1. *Hamburg Wheel-Tracking Machine*—An electrically powered machine capable of moving a 203.2-mm (8-in.) diameter, 47-mm (1.85-in.) wide steel wheel over a test specimen. The load on the wheel is 705 ±4.5 N (158 ±1.0 lb). The wheel shall reciprocate over the specimen, with the position varying sinusoidally over time. The wheel shall make 52 ±2 passes across the specimen per minute. The maximum speed of the wheel shall be approximately 0.305 m/s (1 ft/s) and will be reached at the midpoint of the specimen.

5.2. *Temperature Control System*—A water bath capable of controlling the temperature within ± 1.0°C (1.8°F) over a range of 25 to 70°C (77 to 158°F). This bath shall have a mechanical circulating system to stabilize the temperature within the specimen tank.

5.3. *Impression Measurement System*—An linear variable differential transducer (LVDT) device capable of measuring the depth of the impression of the wheel within 0.15 mm (0.006 in.), over a minimum range of 0 to 20 mm (0.8 in.). The system shall be mounted and capable of measuring the depth of the impression at different intervals across the width of the wheel's path on the test specimen. The impression shall be measured at least every 400 passes of the wheel. This system must be capable of measuring rut depth without stopping the wheel. This measurement must be referenced to the number of wheel passes.

5.4. *Wheel Pass Counter*—A non-contacting solenoid that counts each wheel pass over the specimen. The signal from this counter shall be coupled to the wheel impression measurement, allowing for the rut depth to be expressed as a function of the wheel passes.

5.5. *Slab Specimen Mounting System*—A stainless steel tray that can be mounted rigidly to the machine. This mounting system must restrict shifting of the specimen to within 0.5 mm (0.02 in.) during testing. The mounting system shall suspend the specimen, allowing for free circulation of the water bath on all sides. The mounting system shall be designed to provide a minimum of 20 mm (0.8 in.) of free circulating water on all sides of the specimen.

5.6. *Cylindrical Specimen Mounting System*—A stainless steel tray that can be mounted rigidly to the machine. This mounting system must restrict shifting of the specimen to within 0.5 mm (0.02 in.) during testing. The mounting system shall include two high-density polyethylene molds (as shown in Figures 1 and 2) placed in a stainless steel tray to secure the specimen. The stainless steel tray is suspended in the machine, allowing for free circulation of the water bath on all sides. The mounting system shall be designed to provide a minimum of 20 mm (0.8 in.) of free circulating water on all sides of the specimen.

5.7. *Linear Kneading Compactor*—A hydraulic powered unit used to compact asphalt mixtures into rectangular slabs. The mixture is placed in a mold and compacted through a series of vertically aligned steel plates that compress the asphalt mixture into a flat slab of predetermined thickness and density.

5.8. *Balance*—Balance of 12 000 g capacity, accurate to 0.1 g.

5.9. *Ovens*—Ovens for heating aggregate and asphalt binders.

5.10. *Superpave Gyratory Compactor*—Superpave gyratory compactor (SGC) and molds conforming to T 312.

5.11. Bowls, spoon, spatula, etc.

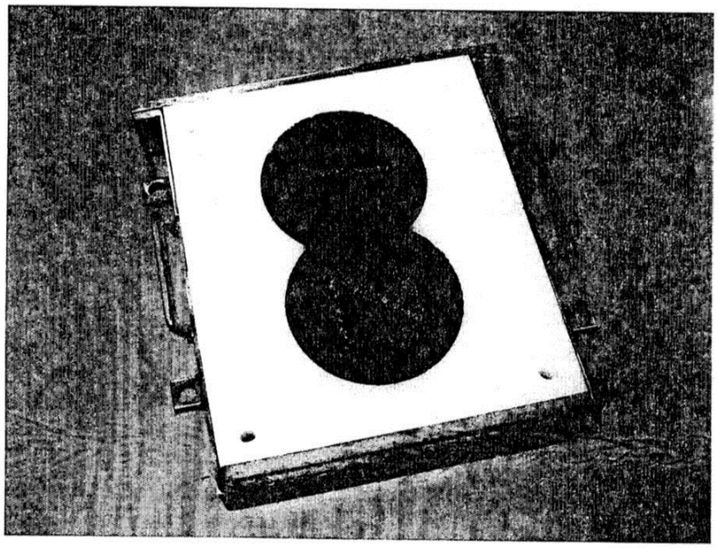
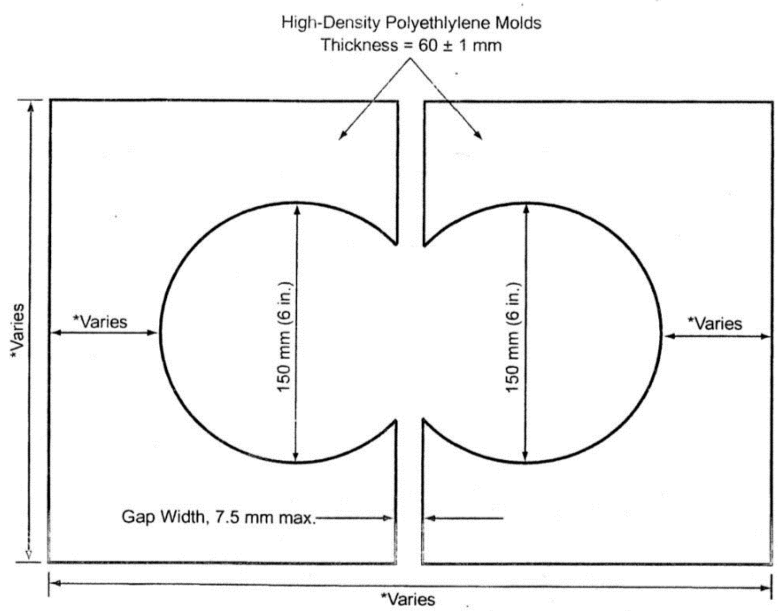


Figure 1—Cylindrical Specimen Mounting System



* Dimension may vary depending on manufacturer.

Figure 2—Schematic of Cylindrical Specimen Mounting System

6. SPECIMEN PREPARATION

6.1. *Number of Test Specimens*—Two test specimens shall be prepared for each test. Specimens may either be slab specimens or cylinders.

6.2. *Laboratory-Produced HMA*:

6.2.1. Mixture proportions are batched in accordance with the desired job mix formula.

6.2.2. The temperature to which the asphalt binder must be heated to achieve a viscosity of 170 ±20 cSt shall be the mixing temperature. For modified asphalt binders, use the mixing temperature recommended by the binder manufacturer.

6.2.3. Dry-mix the aggregates and mineral admixture (if used) first; then add the correct percentage of asphalt binder. Mix the materials until all aggregates are thoroughly coated. (Wet-mix the aggregates if a lime slurry or other wet materials are used.)

6.2.4. Test samples shall be conditioned at the appropriate compaction temperature in accordance with the short-term conditioning procedure for mechanical properties in R 30.

6.2.5. The temperature to which the asphalt binder must be heated to achieve a viscosity of 280 ±30 cSt shall be the compaction temperature. For modified asphalt binders, use the compaction temperature recommended by the binder manufacturer.

6.2.6. *Laboratory Compaction of Specimens*—Specimens compacted in the laboratory shall be either compacted slab specimens or SGC cylindrical specimens.

6.2.6.1. *Compacting Slab Specimens*—Material shall be compacted into slab specimens using a Linear Kneading Compactor (or equivalent) and shall be 320 mm (12.5 in.) long and 260 mm (10.25 in.) wide. A slab specimen thickness of 38 mm (1.5 in.) to 100 mm (4 in.) can be used. The slab specimen thickness shall be at least twice the nominal maximum aggregate size. Compacted slab specimen shall be cooled at room temperature on a clean, flat surface until the specimen is cool to the touch.

6.2.6.2. *Compacting SGC Cylindrical Specimens*—Material shall be compacted into specimens using an SGC according to T 312. A specimen thickness of 38 mm (1.5 in.) to 100 mm (4 in.) can be used. The specimen thickness shall be at least twice the nominal maximum aggregate size. Two 150-mm (6-in.) diameter specimens are needed. Compacted specimens shall be cooled at room temperature on a clean, flat surface until the specimen is cool to the touch.

6.3. *Field-Produced HMA—Loose Mix*:

6.3.1. Obtain a sample of HMA according to T 168.

6.3.2. *Laboratory Compaction of Specimens*—Specimens compacted in the laboratory shall be either compacted slab specimens or SGC cylindrical specimens.

6.3.2.1. *Compacting Slab Specimens*—Material shall be compacted into slat specimens using a Linear Kneading Compactor (or equivalent) and shall be 320 mm (12.5 in.) long and 260 mm (10.25 in.) wide. A slab specimen thickness of 38 mm (1.5 in.) to 100 mm (4 in.) can be used. The slab specimen thickness shall be at least twice the nominal maximum aggregate size. Compacted slab specimens shall be cooled at normal room temperature on a clean, flat surface until the specimen is cool to the touch.

6.3.2.2. *Compacting SGC Cylindrical Specimens*—Material shall be compacted into specimens using an SGC according to T 312. A specimen thickness of 38 mm (1.5 in.) to 100 mm (4 in.) can be used. The specimen thickness shall be at least twice the nominal maximum aggregate size. Compacted specimens shall be cooled at room temperature on a clean, flat surface until the specimen is cool to the touch. Two 150-mm (6-in.) diameter specimens are needed.

6.4. *Field-Produced HMA*—Field Compacted (Core/Slab Specimen):

6.4.1. *Cutting Field Cores or Field Slab Specimens*—Field cores or field slab specimens shall consist of wet saw-cut compacted specimens taken from HMA pavements. Field cores shall be 300 mm (12 in.), 250 mm (10 in.), or 150 mm (6 in.) in diameter. Field slab specimens shall be wet saw-cut to approximately 260 mm (10.25 in.) wide by 320 mm (12.5 in.) long. A slab specimen thickness of 38 mm (1.5 in.) to 100 mm (4 in.) may be used. The height of a field core or field slab specimen is typically 38 mm (1.5 in.), but may be adjusted to fit the specimen mounting system by wet saw-cutting. Field cores shall also be cut according to Section 6.4.2.

Note 1—Care should be taken to load the sample so it is level to the surface of the mold. The sample must be trimmed if it is too tall or shimmed up if it is too short (support with plaster if needed). The down pressure from the wheel is calibrated to be 705 N (158 lb) at the center, level to the top of the mold position. Even a small change in elevation will change the down pressure significantly.

6.4.2. *Cutting SGC Cylindrical Specimens and Field Cores*—Cut specimens using a wet saw after a minimum of 24 h from the time of compaction. Saw the specimens along a secant line (or chord) such that when joined together in the molds there is no space between the cut edges. The amount of material sawed from the SGC cylindrical specimens may vary to achieve a gap width no greater than 7.5 mm (0.3 in.) between the molds.

7. DETERMINING AIR VOID CONTENT

7.1. Determine the bulk specific gravity of the specimens in accordance with T 166.

7.2. Determine the maximum specific gravity of the mixture in accordance with T 209.

7.3. Determine the air void content of the specimens in accordance with T 269. It is recommended, for laboratory-compacted specimens, that the target air void content be 7.0 ± 1.0 percent. Field specimens may be tested at the air void content at which they are obtained.

8. PROCEDURE

8.1. *Slab and Large Field Core Specimen Mounting*—Use Plaster-of-Paris to rigidly mount the 300 mm (12 in.), 250 mm (10 in.), or slab specimens in the mounting trays. Mix the plaster at approximately a 1:1 ratio of plaster to water. Pour the plaster to a height equal to that of the specimen so that the air space between the specimen and the sides of the mounting tray is filled. The slab specimen shall be in direct contact with the mounting tray; however, plaster may flow underneath the specimen. The plaster underneath the specimen shall not exceed 2 mm (0.08 in.). Allow the plaster at least 1 h to set. If other mounting material is used, it should be able to withstand 890 N (200 lb) of load without cracking.

8.2. *SGC Cylindrical and Field Core Specimen Mounting*—Place the high-density polyethylene molds in the mounting tray. Insert the cut specimens in the high-density polyethylene molds. Shim the molds in the mounting tray as necessary. Secure the molds into the mounting tray by tightening the bolts of the edge plate "hand-tight."

8.3. Place the mounting tray(s) with the test specimens into the device and secure by tightening the bolts "hand-tight."

8.4. Turn the testing device and computer on.

8.5. Start the software used to communicate with the testing device.

8.6. Enter the pertinent project information and testing configuration requirements.

8.6.1. Select the test temperature based upon the applicable specifications.

8.6.2. Select the maximum allowable rut depth based upon the applicable specifications.

8.6.3. Enter a start delay of 30 min to precondition the test specimens. The temperature of the specimens in the mounting tray shall be the test temperature selected in Section 8.8.1 upon completion of this preconditioning period.

8.7. Proceed to Section 8.8 to operate the testing device in "Auto" mode. Proceed to Section 8.15 to operate the testing device in "Manual" mode.

Note 2—Perform the test in "Auto" mode for testing devices manufactured in the United States later than 1998, where software will automatically open and close the valves to fill and drain the water bath. Devices made available to the United States prior to 1998 do not have this option and must be operated manually.

8.8. *Performing the Test in Auto Mode*:

8.8.1. Adjust the height of the LVDT to a location as per manufacturer's recommendations.

Note 3—The LVDT for each steel wheel is automatically zeroed at the start of the test. The software will display a zero at the start of the test.

8.8.2. Lower the wheels onto the edge of the test specimens, such that a majority of the wheel is in contact with the high-density polyethylene molds in the mounting tray.

8.8.3. Start the test by selecting the "Start" button of the testing device software.

Note 4—The start delay time or preconditioning time will start after the water heats to the test temperature selected in Section 8.6.1.

8.8.4. The wheel-tracking device shall shut off when 20,000 passes have occurred or when the test has achieved the maximum impression depth established in Section 8.6.2. The testing device software automatically saves the test data file.

8.8.5. Raise the wheel(s) and remove the specimen mounting tray(s) and rutted specimens.

8.8.6. Proceed to Section 8.10.

8.9. *Performing the Test in Manual Mode*:

8.9.1. Close the drain valve(s) and fill the water bath of the wheel-tracking device with water until the float device(s) raises to a horizontal position.

Note 5—Adjust the amount of hot and cold water if necessary, as the water temperature may vary.

8.9.2. Precondition the test specimens in the water bath for 30 min after the water has reached the selected test temperature.

8.9.3. Lower the wheels onto the specimens after the test specimens have preconditioned at the selected test temperature for 30 min. For machines that start automatically after the selected preconditioning time, it is allowable to lower the wheels before the preconditioning cycle. The wheel shall not be in contact with the specimen for more than 5 min prior to starting the wheel.

8.9.4. Ensure the micro-control unit's LVDT reads between 10 mm (0.4 in.) and 18 mm (0.7 in.). Adjust the LVDT height to obtain this reading. Loosen the two screws on the LVDT mount and slide the LVDT up or down to the desired height. Tighten the screws.

8.9.5. Start the test.

8.9.6. The wheel-tracking device will disengage when 20,000 passes have occurred. The device will also disengage if the average LVDT displacement (read from the micro-control unit, not the screen) is 40.90 mm (1.6 in.) or greater for an individual specimen. Note that the screen readout subtracts the initial LVDT reading from the total displacement.

8.9.7. Open the valve(s) beneath the tanks and drain the water bath. Raise the wheel(s) and remove the specimen mounting tray(s) and rutted specimens.

8.10. Clean the water bath, heating coils, wheels, and temperature probe with water and scouring pads or as per the manufacturer's recommendations. Use a wet-dry vacuum to remove particles that have settled to the bottom of the baths. Clean the filter element and spacers after every test or as per the manufacturer's recommendations. Do not use solvents to clean the water bath.

8.11. Turn the wheels after each test so the same section of the wheel surface is not in contact with the test specimen from test to test. This rotation will provide for even wear over the entire wheel. The test should operate with a smooth movement across the test specimen.

9. CALCULATIONS

9.1. Plot the rut depth versus number of passes for each test. A typical plot of the output produced by the Hamburg Wheel-Tracking Device is shown in Figure 3. From this plot, obtain the following values:

Slope and intercept of the first steady-state portion of the curve.

Slope and intercept of the second steady-state portion of the curve.

9.2. Calculate the following test parameters:

All of the test parameters below are expressed in "Passes."

$$\text{Stripping Inflection Point (SIP)} = \frac{\text{Intercept (second portion)} - \text{Intercept (first portion)}}{\text{Slope (first portion)} - \text{Slope (second portion)}} \quad (1)$$

where:

Failure Rut Depth is the specified maximum allowable rut depth for the test.

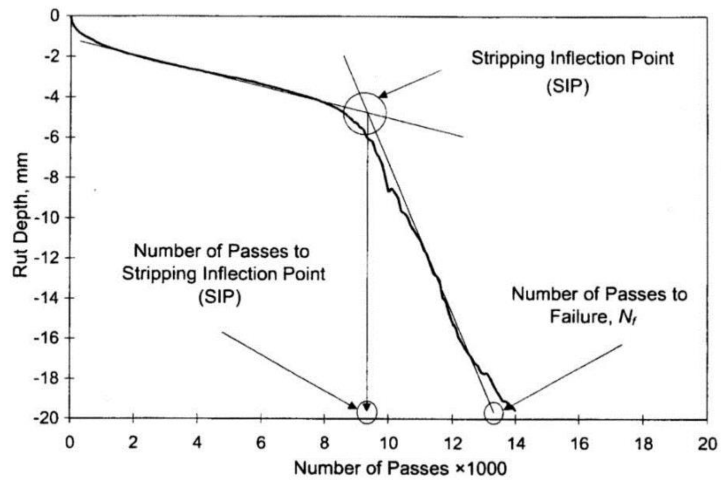


Figure 3—Hamburg Curve with Test Parameters

10. REPORT

10.1. *The report shall include the following parameters*:

10.1.1. HMA Production (Field or Lab);

10.1.2. Compaction method (slab or SGC cylindrical specimen);

10.1.3. Number of passes at maximum impression;

10.1.4. Maximum impression;

10.1.5. Test temperature;

10.1.6. Specimen(s) air voids;

10.1.7. Type and amount of anti-stripping additive used;

10.1.8. Creep slope;

10.1.9. Strip slope; and

10.1.10. Stripping inflection point.

11. PRECISION AND BIAS

11.1. Work is underway to develop precision and bias statements for this standard.

12. KEYWORDS

12.1. Compacted hot mix asphalt; moisture-susceptibility; rutting; wheel-track testing.

APPENDIXES

(Nonmandatory Information)

X1. MAINTENANCE

X1.1. All eight of the grease fittings shall be greased with fresh grease every 20 tests (not to exceed two months) per the manufacturer's recommendations.

X2. CALIBRATION/EQUIPMENT VERIFICATION

X2.1. Verify the water bath temperature is within ±1.0°C (1.8°F) of the temperature readout from the testing device or software every six months. Measure the water bath temperature at four locations as per manufacturer's recommendations. Average the four measurements and report this as the water bath verification temperature.

X2.2. Verify the LVDT calibration in accordance with ASTM D 6027-96 or as per manufacturer's recommendations.

X2.3. Verify the load from the wheel loading assembly at the level position as per manufacturer's recommendations to be 705 ±4.5 N (158 ±1.0 lb). A calibrated load cell, accurate to 0.4 N (0.1 lb) is sufficient for this check.

X2.4. Verify that the wheel is reciprocating back and forth on the test sample at 52 ±2 passes per minute.

HOT-MIX ASPHALT – MIXTURE DESIGN VERIFICATION AND PRODUCTION (MODIFIED FOR I-FIT PROJECTS ONLY) (CBM)

Effective: November 1, 2013
Revised: December 6, 2016

Description. This special provision provides the requirements for Illinois Flexibility Index Test (I-FIT) testing for Low ESAL, High ESAL, IL-4.75, and Stone Matrix Asphalt (SMA) HMA mixes (excluding Class D patches, pavement patching and incidental HMA) during mix design verification and production.

Mix Design Testing. Add the following to the referenced standards in Article 1030.04 of the Standard Specifications:

"Illinois Test Procedure (ITP) 405 Illinois Flexibility Index Test (I-FIT)"

Revise Article 1030.04(d) of the Standard Specifications to read:

"(d) Verification Testing. High ESAL, IL-4.75, and SMA mix designs shall be submitted for verification testing to ensure that the resulting mix designs will pass the required criteria for the Hamburg Wheel Test (Illinois Modified AASHTO T 324), Tensile Strength Test (Illinois Modified AASHTO T 283) and the I-FIT (ITP 405). Low ESAL mix designs shall be submitted for verification testing to ensure that the resulting mix designs will pass the required criteria for the I-FIT. The Department will perform a verification test on gyratory specimens compacted by the Contractor. If the mix fails the Department's verification test, the Contractor shall make necessary changes to the mix and provide passing Hamburg Wheel, Tensile Strength, and I-FIT test results from a private lab. The Department will verify the passing results.

All new and renewal mix designs shall meet the following requirements for verification testing.

(1) Hamburg Wheel Test Criteria. The maximum allowable rut depth shall be 0.5 in. (12.5 mm). The minimum number of wheel passes at the 0.5 in. (12.5 mm) rut depth criteria shall be based on the high temperature binder grade of the mix as specified in the mix requirements table of the plans.

Illinois Modified AASHTO T 324 Requirements 1/

PG Grade	Number of Passes
PG 58-xx (or lower)	5,000
PG 64-xx	7,500
PG 70-xx	15,000
PG 76-xx (or higher)	20,000

1/ When produced at temperatures of 275 ± 5 °F (135 ± 3 °C) or less, loose Warm Mix Asphalt shall be oven aged at 270 ± 5 °F (132 ± 3 °C) for two hours prior to gyratory compaction of Hamburg Wheel specimens.

(2) Tensile Strength Criteria. The minimum allowable conditioned tensile strength shall be 60 psi (415 kPa) for non-polymer modified performance graded (PG) asphalt binder and 80 psi (550 kPa) for polymer modified PG asphalt binder. The maximum allowable unconditioned tensile strength shall be 200 psi (1380 kPa).

(3) I-FIT Flexibility Index (FI) Criteria 1/. The minimum allowable FI shall be as follows:

Minimum Flexibility Index (FI)	
HMA	8.0
SMA	8.0

1/ Existing mix designs shall also meet the FI Criteria for verification testing."

Production Testing. Revise Article 1030.06(a) of the Standard Specifications to read:

"(a) High ESAL, IL-4.75, WMA, and SMA Mixtures. A 300 ton (275 metric tons) test strip will be required at the beginning of HMA production for each mixture. The test strip shall be according to the Manual of Test Procedures for Materials "Hot Mix Asphalt Test Strip Procedures", except the minimum 3000 ton (2750 metric ton) quantity requirement does not apply and the mixture sampled to represent the test strip shall include material sufficient for the Department to conduct Hamburg Wheel testing according to Illinois modified AASHTO T 324 and I-FIT testing according to ITP 405. The test strip will not be required for shoulder applications; however, the shoulder mixture shall be sampled on the first day of production for the I-FIT and Hamburg Wheel testing.

Before start-up, target values shall be determined by applying gradation correction factors to the JMF when applicable. These correction factors shall be determined from previous experience. The target values, when approved by the Engineer, shall be used to control HMA production. Plant settings and control charts shall be set according to target values.

Before constructing the test strip, target values shall be determined by applying gradation correction factors to the JMF when applicable. After any JMF adjustment, the JMF shall become the Adjusted Job Mix Formula (AJMF). Upon completion of the first acceptable test strip, the JMF shall become the AJMF regardless of whether or not the JMF has been adjusted. If an adjustment/plant change is made, the Engineer may require a new test strip to be constructed. If the HMA placed during the initial test strip is determined to be unacceptable to remain in place by the Engineer, it shall be removed and replaced.

The limitations between the JMF and AJMF are as follows.

Parameter	Adjustment
1/2 in. (12.5 mm)	± 5.0 %
No. 4 (4.75 mm)	± 4.0 %
No. 8 (2.36 mm)	± 3.0 %
No. 30 (600 µm)	*
No. 200 (75 µm)	*
Asphalt Binder Content	± 0.3 %

* In no case shall the target for the amount passing be greater than the JMF.

Any adjustments outside the above limitations will require a new mix design.

Mixture sampled to represent the test strip shall include additional material sufficient for the Department to conduct the following tests:

- Hamburg Wheel testing according to Illinois Modified AASHTO T 324 (approximately 60 lb (27 kg) total).

- I-FIT testing according to the ITP 405 (approximately 60 lb (27 kg) total).

The Contractor shall immediately cease production upon notification by the Engineer of a failing Hamburg Wheel test and/or I-FIT per the criteria specified in Article 1030.04(d)(1) and (3) herein. All prior produced material may be paved out provided all other mixture criteria is being met. No additional mixture shall be produced until the Engineer receives passing Hamburg Wheel test and I-FIT results.

The Department may conduct additional Hamburg Wheel or I-FIT testing on production material as determined by the Engineer."

Add the following to Article 1030.06(b) of the Standard Specifications:

"The Department will perform I-FIT testing according to the ITP 405 for Low ESAL mixtures (excluding Class D patches, pavement patching and incidental HMA) during mixture production.

The Contractor shall immediately cease production upon notification by the Engineer of a failing I-FIT per the criteria specified in Article 1030.04(d)(3) herein. All prior produced material may be paved out provided all other mixture criteria is being met. No additional mixture shall be produced until the Engineer receives passing I-FIT results.

The Department may conduct additional I-FIT testing on production material as determined by the Engineer."

RECLAIMED ASPHALT PAVEMENT AND RECLAIMED ASPHALT SHINGLES (MODIFIED FOR I-FIT PROJECTS ONLY)

Effective: November 1, 2012
Revise: January 1, 2018

Revise Section 1031 of the Standard Specifications to read:

"SECTION 1031. RECLAIMED ASPHALT PAVEMENT AND RECLAIMED ASPHALT SHINGLES

1031.01 Description. Reclaimed asphalt pavement and reclaimed asphalt shingles shall be according to the following.

(a) Reclaimed Asphalt Pavement (RAP). RAP is the material produced by cold milling or crushing an existing hot-mix asphalt (HMA) pavement. The Contractor shall supply written documentation that the RAP originated from routes or airfields under federal, state, or local agency jurisdiction.

(b) Reclaimed Asphalt Shingles (RAS). Reclaimed asphalt shingles (RAS). RAS is from the processing and grinding of preconsumer or post-consumer shingles. RAS shall be a clean and uniform material with a maximum of 0.5 percent unacceptable material, as defined in Central Bureau of Materials Policy Memorandum, "Reclaimed Asphalt Shingle (RAS) Sources", by weight of RAS. All RAS used shall come from a Central Bureau of Materials approved processing facility where it shall be ground and processed to 100 percent passing the 3/8 in. (9.5 mm) sieve and 93 percent passing the #4 (4.75 mm) sieve based on a dry shake gradation. RAS shall be uniform in gradation and asphalt binder content and shall meet the testing requirements specified herein. In addition, RAS shall meet the following Type 1 or Type 2 requirements.

(1) Type 1. Type 1 RAS shall be processed, preconsumer asphalt shingles salvaged from the manufacture of residential asphalt roofing shingles.

(2) Type 2. Type 2 RAS shall be processed post-consumer shingles only, salvaged from residential, or four unit or less dwellings not subject to the National Emission Standards for Hazardous Air Pollutants (NESHAP).

1031.02 Stockpiles. RAP and RAS stockpiles shall be according to the following.

(a) RAP Stockpiles. The Contractor shall construct individual, sealed RAP stockpiles meeting one of the following definitions. No additional RAP shall be added to the pile after the pile has been sealed. Stockpiles shall be sufficiently separated to prevent intermingling at the base. Stockpiles shall be identified by signs indicating the type as listed below (i.e. "Homogeneous Surface").

Prior to milling, the Contractor shall request the District provide documentation on the quality of the RAP to clarify the appropriate stockpile.

(1) Fractionated RAP (FRAP). FRAP shall consist of RAP from Class I, HMA (High and Low ESAL) mixtures. The coarse aggregate in FRAP shall be crushed aggregate and may represent more than one aggregate type and/or quality, but shall be at least C quality. All FRAP shall be fractionated prior to testing by screening into a minimum of two size fractions with the separation occurring on or between the #4 (4.75 mm) and 1/2 in. (12.5 mm) sieves. Agglomerations shall be minimized such that 100 percent of the RAP shall pass the sieve size specified below for the mix into which the FRAP will be incorporated.

Mixture FRAP will be used in:	Sieve Size that 100 % of FRAP Shall Pass
IL-19.0	1 1/2 in. (40 mm)
IL-9.5	3/4 in. (20 mm)
IL-4.75	1/2 in. (13 mm)

(2) Homogeneous. Homogeneous RAP stockpiles shall consist of RAP from Class I, HMA (High and Low ESAL) mixtures and represent: 1) the same aggregate quality, but shall be at least C quality; 2) the same type of crushed aggregate (either crushed natural aggregate, ACBF slag, or steel slag); 3) similar gradation; and 4) similar asphalt binder content. If approved by the Engineer, combined single pass surface/binder millings may be considered "homogeneous" with a quality rating dictated by the lowest coarse aggregate quality present in the mixture.

(3) Conglomerate. Conglomerate RAP stockpiles shall consist of RAP from Class I, HMA (High and Low ESAL) mixtures. The coarse aggregate in this RAP shall be crushed aggregate and may represent more than one aggregate type and/or quality, but shall be at least C quality. This RAP may have an inconsistent gradation and/or asphalt binder content prior to processing. All conglomerate RAP shall be processed prior to testing by crushing to where all RAP shall pass the 5/8 in. (16 mm) or smaller screen. Conglomerate RAP stockpiles shall not contain steel slag.

(4) Non-Quality. RAP stockpiles that do not meet the requirements of the stockpile categories listed above shall be classified as "Non-Quality".

RAP/FRAP containing contaminants, such as earth, brick, sand, concrete, sheet asphalt, bituminous surface treatment (i.e. chip seal), pavement fabric, joint sealants, etc., will be unacceptable unless the contaminants are removed to the satisfaction of the Engineer. Sheet asphalt shall be stockpiled separately.

(b) RAS Stockpiles. Type 1 and Type 2 RAS shall be stockpiled separately and shall not be intermingled. Each stockpile shall be signed indicating what type of RAS is present.

Unless otherwise specified by the Engineer, mechanically blending manufactured sand (FM 20 or FM 22) up to an equal weight of RAS with the processed RAS will be permitted to improve workability. The sand shall be "B Quality" or better from an approved Aggregate Gradation Control System source. The sand shall be accounted for in the mix design and during HMA production.

Records identifying the shingle processing facility supplying the RAS, RAS type, and lot number shall be maintained by project contract number and kept for a minimum of three years.

1031.03 Testing. RAP/FRAP and RAS testing shall be according to the following.

(a) RAP/FRAP Testing. When used in HMA, the RAP/FRAP shall be sampled and tested either during or after stockpiling.

(1) During Stockpiling. For testing during stockpiling, washed extraction samples shall be run at the minimum frequency of one sample per 500 tons (450 metric tons) for the first 2000 tons (1800 metric tons) and one sample per 2000 tons (1800 metric tons) thereafter. A minimum of five tests shall be required for stockpiles less than 4000 tons (3600 metric tons).

(2) After Stockpiling. For testing after stockpiling, the Contractor shall submit a plan for approval to the District proposing a satisfactory method of sampling and testing the RAP/FRAP pile either in-situ or by restockpiling. The sampling plan shall meet the minimum frequency required above and detail the procedure used to obtain representative samples throughout the pile for testing.

Each sample shall be split to obtain two equal samples of test sample size. One of the two test samples from the final split shall be labeled and stored for Department use. The Contractor shall extract the other test sample according to Department procedure. The Engineer reserves the right to test any sample (split or Department-taken) to verify Contractor test results.

(b) RAS Testing. RAS or RAS blended with manufactured sand shall be sampled and tested during stockpiling according to Central Bureau of Materials Policy Memorandum, “Reclaimed Asphalt Shingle (RAS) Source”.

Samples shall be collected during stockpiling at the minimum frequency of one sample per 200 tons (180 metric tons) for the first 1000 tons (900 metric tons) and one sample per 250 tons (225 metric tons) thereafter. A minimum of five samples are required for stockpiles less than 1000 tons (900 metric tons). Once a ≤ 1000 ton (900 metric ton), five-sample/test stockpile has been established it shall be sealed. Additional incoming RAS or RAS blended with manufactured sand shall be stockpiled in a separate working pile as designated in the Quality Control plan and only added to the sealed stockpile when the test results of the working pile are complete and are found to meet the tolerances specified herein for the original sealed RAS stockpile.

Before testing, each sample shall be split to obtain two test samples. One of the two test samples from the final split shall be labeled and stored for Department use. The Contractor shall perform a washed extraction and test for unacceptable materials on the other test sample according to Department procedures. The Engineer reserves the right to test any sample (split or Department-taken) to verify Contractor test results.

If the sampling and testing was performed at the shingle processing facility in accordance with the QC Plan, the Contractor shall obtain and make available all of the test results from start of the initial stockpile.

1031.04 Evaluation of Tests. Evaluation of test results shall be according to the following.

(a) Evaluation of RAP/FRAP Test Results. All of the extraction results shall be compiled and averaged for asphalt binder content and gradation, and when applicable G_{mm}. Individual extraction test results, when compared to the averages, will be accepted if within the tolerances listed below.

Parameter	FRAP/Homogeneous/ Conglomerate
1 in. (25 mm)	
1/2 in. (12.5 mm)	± 8 %
No. 4 (4.75 mm)	± 6 %
No. 8 (2.36 mm)	± 5 %
No. 16 (1.18 mm)	
No. 30 (600 µm)	± 5 %
No. 200 (75 µm)	± 2.0 %
Asphalt Binder	± 0.4 % 1/
G_{mm}	± 0.03

1/ The tolerance for FRAP shall be ± 0.3 %.

If more than 20 percent of the individual sieves and/or asphalt binder content tests are out of the above tolerances, the RAP/FRAP shall not be used in HMA unless the RAP/FRAP representing the failing tests is removed from the stockpile. All test data and acceptance ranges shall be sent to the District for evaluation.

With the approval of the Engineer, the ignition oven may be substituted for extractions according to the ITP, "Calibration of the Ignition Oven for the Purpose of Characterizing Reclaimed Asphalt Pavement (RAP)".

(b) Evaluation of RAS and RAS Blended with Manufactured Sand Test Results. All of the test results, with the exception of percent unacceptable materials, shall be compiled and averaged for asphalt binder content and gradation. Individual test results, when compared to the averages, will be accepted if within the tolerances listed below.

Parameter	RAS
No. 8 (2.36 mm)	± 5 %
No. 16 (1.18 mm)	± 5 %
No. 30 (600 µm)	± 4 %
No. 200 (75 µm)	± 2.0 %
Asphalt Binder Content	± 1.5 %

If more than 20 percent of the individual sieves and/or asphalt binder content tests are out of the above tolerances, or if the percent unacceptable material exceeds 0.5 percent by weight of material retained on the # 4 (4.75 mm) sieve, the RAS or RAS blend shall not be used in Department projects. All test data and acceptance ranges shall be sent to the District for evaluation.

1031.05 Quality Designation of Aggregate in RAP/FRAP.

(a) RAP. The aggregate quality of the RAP for homogeneous and conglomerate stockpiles shall be set by the lowest quality of coarse aggregate in the RAP stockpile and are designated as follows.

(1) RAP from Class I, Superpave/HMA (High ESAL), or (Low ESAL) IL-9.5L surface mixtures are designated as containing Class B quality coarse aggregate.

(2) RAP from Class I binder, Superpave/HMA (High ESAL) binder, or (Low ESAL) IL-19.0L binder mixtures are designated as containing Class C quality coarse aggregate.

(b) FRAP. If the Engineer has documentation of the quality of the FRAP aggregate, the Contractor shall use the assigned quality provided by the Engineer.

If the quality is not known, the quality shall be determined as follows. Coarse and fine FRAP stockpiles containing plus #4 (4.75 mm) sieve coarse aggregate shall have a maximum tonnage of 5000 tons (4500 metric tons). The Contractor shall obtain a representative sample witnessed by the Engineer. The sample shall be a minimum of 50 lb (25 kg). The sample shall be extracted according to Illinois Modified AASHTO T 164 by a consultant laboratory prequalified by the Department for the specified testing. The consultant laboratory shall submit the test results along with the recovered aggregate to the District Office. The cost for this testing shall be paid by the Contractor. The District will forward the sample to the Central Bureau of Materials Aggregate Lab for MicroDeval Testing, according to ITP 327. A maximum loss of 15.0 percent will be applied for all HMA applications.

1031.06 Use of RAP/FRAP and/or RAS in HMA. The use of RAP/FRAP and/or RAS shall be the Contractor's option when constructing HMA in all contracts.

(a) RAP/FRAP. The use of RAP/FRAP in HMA shall be as follows.

(1) Coarse Aggregate Size. The coarse aggregate in all RAP shall be equal to or less than the nominal maximum size requirement for the HMA mixture to be produced.

(2) Steel Slag Stockpiles. Homogeneous RAP stockpiles containing steel slag will be approved for use in all HMA (High ESAL and Low ESAL) Surface and Binder Mixture applications.

(3) Use in HMA Surface Mixtures (High and Low ESAL). RAP/FRAP stockpiles for use in HMA surface mixtures (High and Low ESAL) shall be FRAP or homogeneous in which the coarse aggregate is Class B quality or better. FRAP from Conglomerate stockpiles shall be considered equivalent to limestone for frictional considerations. Known frictional contributions from plus #4 (4.75 mm) homogeneous FRAP stockpiles will be accounted for in meeting frictional requirements in the specified mixture.

(4) Use in HMA Binder Mixtures (High and Low ESAL), HMA Base Course, and HMA Base Course Widening. RAP/FRAP stockpiles for use in HMA binder mixtures (High and Low ESAL), HMA base course, and HMA base course widening shall be FRAP, homogeneous, or conglomerate, in which the coarse aggregate is Class C quality or better.

(5) Use in Shoulders and Subbase. RAP/FRAP stockpiles for use in HMA shoulders and stabilized subbase (HMA) shall be FRAP, homogeneous, or conglomerate.

(6) When the Contractor chooses the RAP option, the percentage of RAP shall not exceed the amounts indicated in Article 1031.06(c)(1) below for a given Ndesign.

(b) RAS. RAS meeting Type 1 or Type 2 requirements will be permitted in all HMA applications as specified herein.

(c) RAP/FRAP and/or RAS Usage Limits. Type 1 or Type 2 RAS may be used alone or in conjunction with RAP or FRAP in HMA mixtures up to a maximum of 5.0 percent by weight of the total mix.

(1) RAP/RAS. When RAP is used alone or RAP is used in conjunction with RAS, the percentage of virgin asphalt binder replacement shall not exceed the amounts listed in the Max RAP/RAS ABR table listed below for the given Ndesign.

RAP/RAS Maximum Asphalt Binder Replacement (ABR) Percentage

HMA Mixtures 1/, 2/	RAP/RAS Maximum ABR %		
Ndesign	Binder/Leveling Binder	Surface	Polymer Modified
30	30	30	10
50	25	15	10
70	15	10	10
90	10	10	10

1/ For Low ESAL HMA shoulder and stabilized subbase, the RAP/RAS ABR shall not exceed 50 percent of the mixture.

2/ When RAP/RAS ABR exceeds 20 percent, the high and low virgin asphalt binder grades shall each be reduced by one grade (i.e. 25 percent ABR would require a virgin asphalt binder grade of PG 64-22 to be reduced to a PG 58-28). If warm mix asphalt (WMA) technology is utilized and production temperatures do not exceed 275 °F (135 °C), the high and low virgin asphalt binder grades shall each be reduced by one grade when RAP/RAS ABR exceeds 25 percent (i.e. 26 percent RAP/RAS ABR would require a virgin asphalt binder grade of PG 64-22 to be reduced to a PG 58-28).

(2) FRAP/RAS. When FRAP is used alone or FRAP is used in conjunction with RAS, the percentage of virgin asphalt binder replacement shall not exceed the amounts listed in the FRAP/RAS table listed below for the given Ndesign.

FRAP/RAS Maximum Asphalt Binder Replacement (ABR) Percentage

HMA Mixtures 1/, 2/	FRAP/RAS Maximum ABR %		
Ndesign	Binder/Leveling Binder	Surface	Polymer Modified 3/, 4/
30	55	45	15
50	45	40	15
70	45	35	15
90	45	35	15

1/ For Low ESAL HMA shoulder and stabilized subbase, the FRAP/RAS ABR shall not exceed 50 percent of the mixture.

2/ When FRAP/RAS ABR exceeds 20 percent for all mixes, the high and low virgin asphalt binder grades shall each be reduced by one grade (i.e. 25 percent ABR would require a virgin asphalt binder grade of PG 64-22 to be reduced to a PG 58-28). If warm mix asphalt (WMA) technology is utilized and production temperatures do not exceed 275 °F (135 °C), the high and low virgin asphalt binder grades shall each be reduced by one grade when FRAP/RAS ABR exceeds 25 percent (i.e. 26 percent ABR would require a virgin asphalt binder grade of PG 64-22 to be reduced to a PG 58-28).

3/ For SMA the FRAP/RAS ABR shall not exceed 25 percent.

4/ For IL-4.75 mix the FRAP/RAS ABR shall not exceed 35 percent.

1031.07 HMA Mix Designs. At the Contractor’s option, HMA mixtures may be constructed utilizing RAP/FRAP and/or RAS material meeting the detailed requirements specified herein.

(a) RAP/FRAP and/or RAS. RAP/FRAP and/or RAS mix designs shall be submitted for verification. If additional RAP/FRAP and/or RAS stockpiles are tested and found that no more than 20 percent of the results, as defined under “Testing” herein, are outside of the control tolerances set for the original RAP/FRAP and/or RAS stockpile and HMA mix design, and meets all of the requirements herein, the additional RAP/FRAP and/or RAS stockpiles may be used in the original mix design at the percent previously verified.

(b) RAS. Type 1 and Type 2 RAS are not interchangeable in a mix design.

The RAP, FRAP, and RAS stone bulk specific gravities (G_{sb}) shall be according to the "Determination of Aggregate Bulk (Dry) Specific Gravity (G_{sb}) of Reclaimed Asphalt Pavement (RAP) and Reclaimed Asphalt Shingles (RAS)" procedure in the Department's Manual of Test Procedures for Materials.

1031.08 HMA Production. HMA production utilizing RAP/FRAP and/or RAS shall be as follows.

(a) RAP/FRAP. The coarse aggregate in all RAP/FRAP used shall be equal to or less than the nominal maximum size requirement for the HMA mixture being produced.

To remove or reduce agglomerated material, a scalping screen, gator, crushing unit, or comparable sizing device approved by the Engineer shall be used in the RAP feed system to remove or reduce oversized material.

If the RAP/FRAP control tolerances or QC/QA test results require corrective action, the Contractor shall cease production of the mixture containing RAP/FRAP and either switch to the virgin aggregate design or submit a new RAP/FRAP design.

(b) RAS. RAS shall be incorporated into the HMA mixture either by a separate weight depletion system or by using the RAP weigh belt. Either feed system shall be interlocked with the aggregate feed or weigh system to maintain correct proportions for all rates of production and batch sizes. The portion of RAS shall be controlled accurately to within ± 0.5 percent of the amount of RAS utilized. When using the weight depletion system, flow indicators or sensing devices shall be provided and interlocked with the plant controls such that the mixture production is halted when RAS flow is interrupted.

(c) RAP/FRAP and/or RAS. HMA plants utilizing RAP/FRAP and/or RAS shall be capable of automatically recording and printing the following information.

(1) Dryer Drum Plants.

a. Date, month, year, and time to the nearest minute for each print.

b. HMA mix number assigned by the Department.

c. Accumulated weight of dry aggregate (combined or individual) in tons (metric tons) to the nearest 0.1 ton (0.1 metric ton).

d. Accumulated dry weight of RAP/FRAP/RAS in tons (metric tons) to the nearest 0.1 ton (0.1 metric ton).

e. Accumulated mineral filler in revolutions, tons (metric tons), etc. to the nearest 0.1 unit.

f. Accumulated asphalt binder in gallons (liters), tons (metric tons), etc. to the nearest 0.1 unit.

g. Residual asphalt binder in the RAP/FRAP material as a percent of the total mix to the nearest 0.1 percent.

h. Aggregate and RAP/FRAP moisture compensators in percent as set on the control panel. (Required when accumulated or individual aggregate and RAP/FRAP are printed in wet condition.)

(2) Batch Plants.

a. Date, month, year, and time to the nearest minute for each print.

b. HMA mix number assigned by the Department.

c. Individual virgin aggregate hot bin batch weights to the nearest pound (kilogram).

d. Mineral filler weight to the nearest pound (kilogram).

e. RAP/FRAP/RAS weight to the nearest pound (kilogram).

f. Virgin asphalt binder weight to the nearest pound (kilogram).

g. Residual asphalt binder in the RAP/FRAP/RAS material as a percent of the total mix to the nearest 0.1 percent.

The printouts shall be maintained in a file at the plant for a minimum of one year or as directed by the Engineer and shall be made available upon request. The printing system will be inspected by the Engineer prior to production and verified at the beginning of each construction season thereafter.

1031.09 RAP in Aggregate Surface Course and Aggregate Wedge Shoulders, Type B. The use of RAP in aggregate surface course (temporary access entrances only) and aggregate wedge shoulders, Type B shall be as follows.

(a) Stockpiles and Testing. RAP stockpiles may be any of those listed in Article 1031.02, except "Non-Quality" and "FRAP". The testing requirements of Article 1031.03 shall not apply. RAP used shall be according to the current Central Bureau of Materials Policy Memorandum, "Reclaimed Asphalt Pavement (RAP) for Aggregate Applications".

(b) Gradation. One hundred percent of the RAP material shall pass the 1 1/2 in. (37.5 mm) sieve. The RAP material shall be reasonably well graded from coarse to fine. RAP material that is gap-graded or single sized will not be accepted."

80306 MODIFIED

Illinois Test Procedure 405

Effective Date: January 1, 2016

Modified Date: December 1, 2017

Determining the Fracture Potential of Asphalt Mixtures Using the Illinois Flexibility Index Test (I-FIT)

1. SCOPE

1.1. This test method covers the determination of fracture energy (G_F) and post peak slope of asphalt mixtures using semicircular specimens in the Illinois Flexibility Index Test (I-FIT) conducted at an intermediate test temperature. These parameters are used to calculate the Flexibility Index (FI) to predict the resistance to fracture of an asphalt mixture. The index is used as part of the asphalt mixture evaluation and approval process. The method also includes procedures for calculating other relevant parameters derived from the load-displacement curve.

1.2. These procedures apply to test specimens having a nominal maximum aggregate size (NMAS) of 19 mm or less. Lab compacted and field core specimens can be used. Lab compacted specimens shall be 150 ± 1 mm in diameter and 50 ± 1 mm thick. When field cores are used, specimens shall be 150 ± 8 mm in diameter and 25 to 50 mm thick. A thickness correction factor will need to be developed and applied for field cores tested at a thickness less than 45 mm.

1.3. The I-FIT specimen is a half disc with a notch cut parallel to the loading and the vertical axis of the semicircular disc.

1.4. *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish and follow appropriate health and safety practices and determine the applicability of regulatory limitations prior to use.*

2. REFERENCED DOCUMENTS

2.1. *AASHTO Standards*:

- T 166, Bulk Specific Gravity (G_{mb}) of Compacted Hot Mix Asphalt (HMA) Using Saturated Surface-Dry Specimens
- T 209, Theoretical Maximum Specific Gravity (G_{mm}) and Density of Hot Mix Asphalt (HMA)
- T 269, Percent Air Voids in Compacted Dense and Open Asphalt Mixtures
- T 283, Resistance of Compacted Asphalt Mixtures to Moisture-Induced Damage
- T 312, Preparing and Determining the Density of Asphalt Mixture Specimens by Means of the Superpave Gyratory Compactor

2.2. *ASTM Standards*:

- D 8, Standard Terminology Relating to Materials for Roads and Pavements
- D 3549/D 3549M, Standard Test Method for Thickness or Height of Compacted Bituminous Paving Mixture Specimens
- D 5361/D 5361M, Standard Practice for Sampling Compacted Bituminous Mixtures for Laboratory Testing

3. TERMINOLOGY

3.1. *Definitions:*

3.1.1. *critical displacement, u_1,* —the intersection of the post-peak slope with the displacement-axis.

3.1.2. *displacement at peak load, u_0,* —recorded displacement at peak load.

3.1.3. *fracture energy, G_f*—the energy required to create a unit surface area of a crack.

3.1.4. *flexibility index, FI* — an index intended to characterize the damage resistance of asphalt mixtures.

3.1.5. *linear variable displacement transducer, LVDT*—sensor device for measuring linear displacement.

3.1.6. *ligament area, $Area_{lig}$*—cross-sectional area of the specimen through which the crack propagates, calculated by multiplying the test specimen thickness and ligament length.

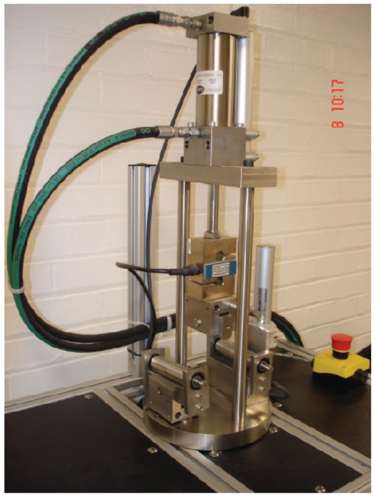
3.1.7. *load line displacement, LLD*—the displacement measured in the direction of the load application.

3.1.8. *post-peak slope, m,* —slope at the first inflection point of the load-displacement curve after the peak.

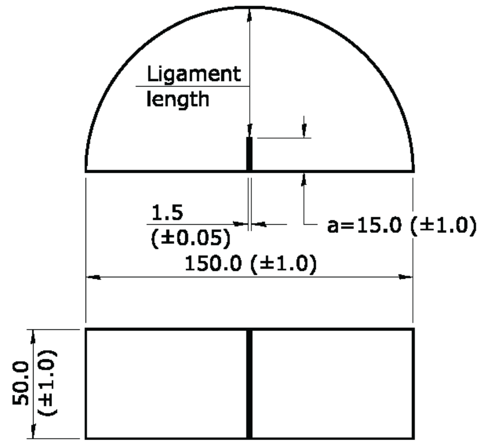
4. SUMMARY OF METHOD

4.1. An asphalt pavement core or Superpave Gyratory Compactor (SGC) compacted asphalt mixture specimen is trimmed and cut in half to create a semicircular shaped test specimen. A notch is sawn in the flat side of the semicircular specimen opposite the curved edge. The specimen is conditioned and maintained through testing at 25°C (77°F). The specimen is positioned in the fixture with the notched side down centered on two rollers. A load is applied along the vertical radius of the specimen and the loads and Load Line Displacement (LLD) are measured during the entire duration of the test. The load is applied such that a constant LLD rate of 50 mm/min is obtained and maintained for the duration of the test. The I-FIT test fixture and I-FIT specimen geometry are shown in figure 1.

4.2. Fracture Energy (G_f), post-peak slope (m), displacement at peak load (u_0), strength, critical displacement (u_1), and a FI are calculated from the load and LLD results.



I-FIT Fixture



I-FIT Lab Compacted Specimen

Figure 1— I-FIT Fixture and test specimen and configuration (dimensions in millimeters)

5. SIGNIFICANCE AND USE

5.1. The I-FIT test is used to determine fracture resistance parameters of an asphalt mixture at an intermediate temperature. From the fracture parameters obtained at intermediate temperature, the FI of an asphalt mixture is calculated. The FI is calculated from the G_f and post-peak slope of load-displacement curve. The FI provides a means to identify brittle mixes that are prone to premature cracking. The range for an acceptable FI will vary according to local environmental conditions, application of the mixture, nominal maximum aggregate size (NMAS), asphalt performance grade (PG), air voids, and expectation of service life, etc.

5.2. The calculated G_f indicates an asphalt mixture's overall capacity to resist cracking related damage. Generally, a mixture with higher G_f can withstand greater stresses with higher damage resistance. The FI should not be directly used in structural design and analysis. FI values obtained using this procedure are used in ranking cracking resistance of alternative mixes for a given layer in a structural design. G_f is a specimen size, loading time, and temperature dependent property. Fracture mechanisms for viscoelastic materials are influenced by crack front viscoelasticity and bulk material (far from crack front) viscoelasticity. Total calculated G_f from this test includes the amount of energy dissipated by crack propagation, viscoelastic mechanisms away from the crack front, and other inelastic irreversible processes (frictional and damage processes at the loading and support points).

5.3. G_f is used as part of the fi to identify mixtures with increased fracture resistance.

5.4. This test method can be used to measure and evaluate the cracking resistance of asphalt mixtures containing various asphalt binders, modifiers of asphalt binders, aggregate blends, fibers, and recycled materials.

5.5. The specimens can be readily obtained from SGC compacted cylinders or from field cores with a diameter of 150 mm.

6. APPARATUS

6.1. *Testing Machine*—An I-FIT test system consists of a closed-loop axial loading device, a load measuring device, a bend test fixture, specimen deformation measurement devices, and a control and data acquisition system. A constant displacement-rate device such as a closed loop, feedback-controlled servo-hydraulic load frame shall be used.

Note 1—An electromechanical, screw driven machine may be used if results are comparable to a closed loop, feedback-controlled servo-hydraulic load frame.

6.1.1. *Axial Loading Device*—The loading device shall be capable of delivering a minimum load of 10N in compression with a minimum resolution of 5N.

6.1.2. *Bend Test Fixture*—The fixture is composed of a loading head, a steel base plate, and two steel rollers with a diameter (D) of 25 mm. The tip of the loading head has a contact curvature with a radius of 12.5 mm. The horizontal loading head shall pivot relative to the vertical loading axis to conform to slight specimen variations. Illustrations of the loading and supports are shown in Figures 2 and 3.

6.1.2.1. *Method* A—Typically the two 25 mm steel rollers are mounted on bearings through their axis of rotation and attached to the steel base plate with brackets. One of the steel rollers pivots on an axis perpendicular to the axis of loading to conform to slight specimen variations. A distance of 120 mm between the two steel rollers is maintained throughout the test.

6.1.2.2. *Method B*—An alternate fixture design uses two 25 mm steel rollers that each rotate in a U-shaped roller support steel block. the initial roller position is fixed by springs and backstops that establish the initial test span dimension of 120 mm. The support rollers are allowed to rotate away from the backstops during the test; but remain in contact with the sample.

6.1.3. *Internal Displacement Measuring Device*— The displacement measurement can be performed using the machine's stroke (position) transducer if the resolution of the stroke is sufficient (0.01 mm or lower). The fracture test displacement data may be corrected for system compliance, loading-pin penetration and specimen compression by performing a calibration of the testing system.

6.1.4. *External Displacement Measuring Device*— If an internal displacement measuring device does not exist or has insufficient precision, an externally applied displacement measurement device such as a linear variable differential transducer (LVDT) can be used (Figure 2 and Figure 3).

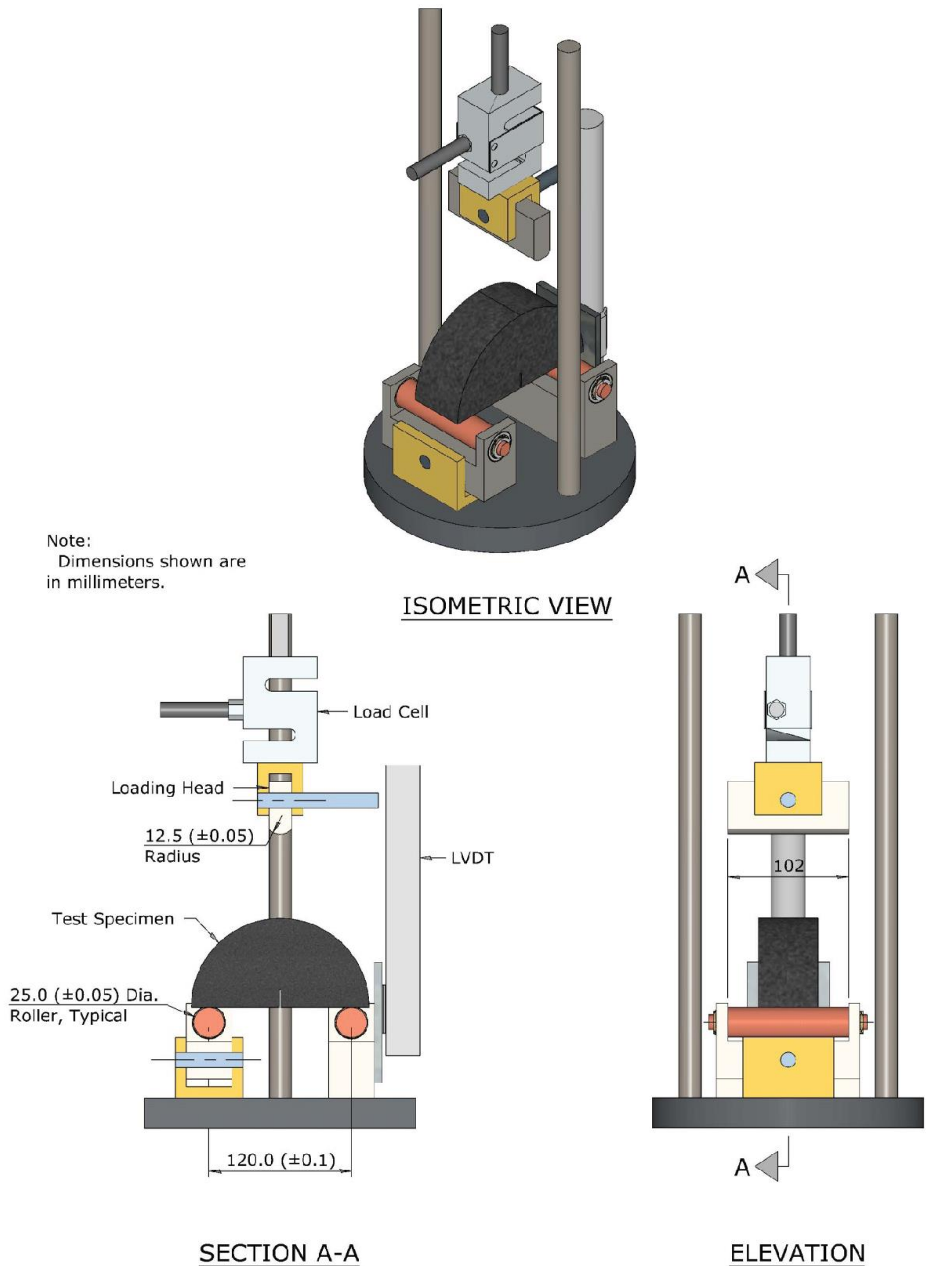


Figure 2— Method A

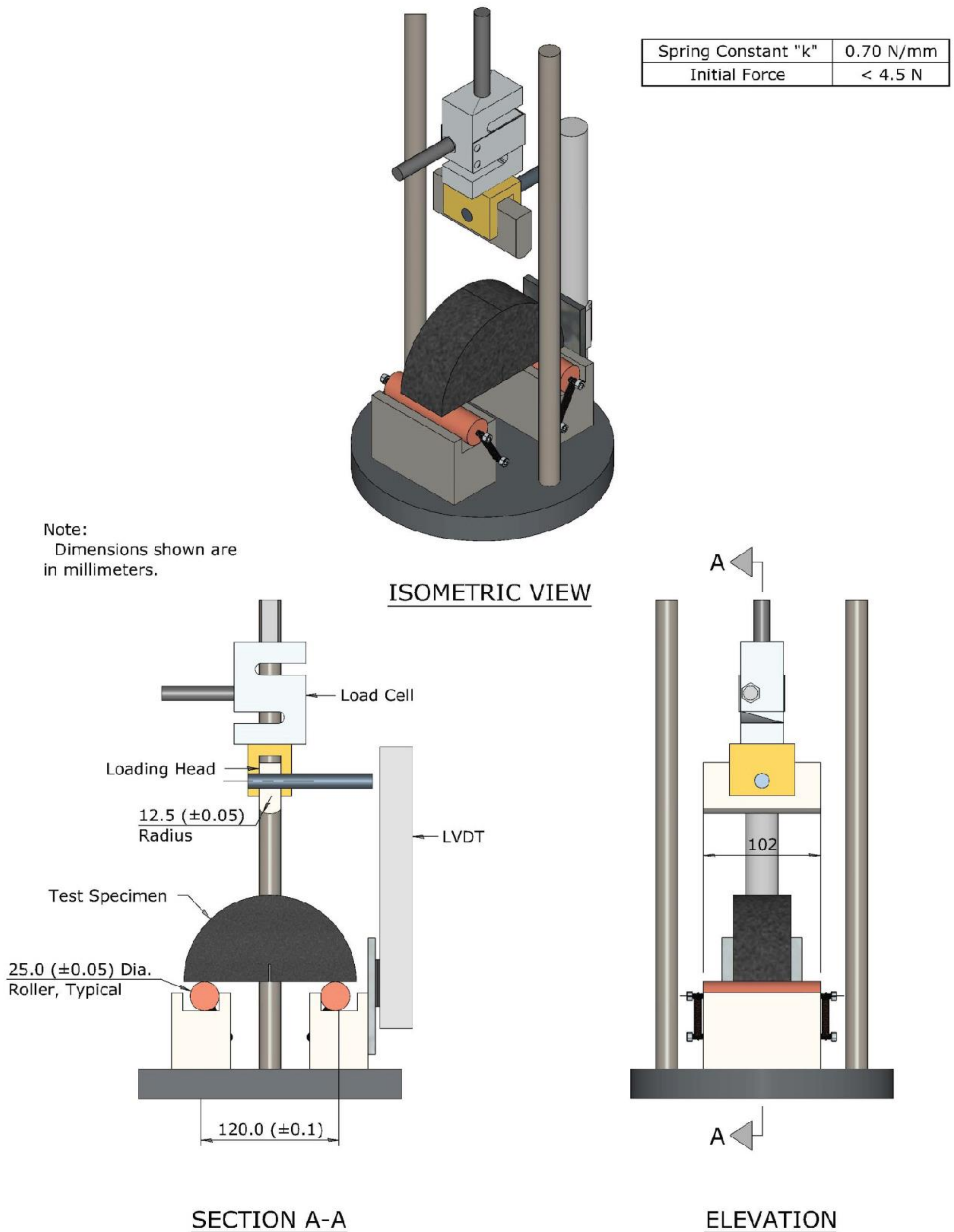


Figure 3—Method B

6.1.5. *Control and Data Acquisition System*—Time and load, and LLD (using external and / or internal displacement measurement device) are recorded. The control data acquisition system is required to apply a constant LLD rate at a precision of 50 ± 1 mm/min and collect data at a minimum sampling frequency of 20 Hz in order to obtain a smooth load-load line displacement curve.

7. HAZARDS

7.1. Standard laboratory caution should be used in handling, compacting and fabricating asphalt mixtures test specimens in accordance with AASHTO T 312 and when using a saw for cutting specimens.

8. CALIBRATION AND STANDARDIZATION

8.1. A water bath as used in AASHTO T 283 will be used to maintain the specimen at a constant and uniform temperature. An environmental chamber may be used in lieu of a water bath.

Note 2— Caution should be used if an oven is selected for conditioning samples as this may result in variable sample conditioning and affect the test results.

8.2. Verify the calibration of all measurement components (such as load cells and LVDTS) of the testing system.

8.3. If any of the verifications yield data that does not comply with the accuracy specified, correct the problem prior to proceeding with testing. Appropriate action may include maintenance of system components, calibration of system components (using an independent calibration agency, service by the manufacturer, or in-house resources), or replacement of the system components.

9. PREPARATION OF TEST SPECIMENS AND PRELIMINARY DETERMINATIONS

9.1. *Specimen Size*—For mixtures with nominal maximum aggregate size of 19 mm or less, prepare the test specimens from a lab compacted SGC cylinder or from pavement cores. The final I-FIT test cylinders shall have smooth parallel faces with a thickness of 50 ± 1 mm and a diameter of 150 ± 1 mm (see Figure 4). If field specimens are used, the final test specimen dimensions shall be 150 ± 8 mm in diameter with smooth parallel faces 25 to 50 mm thick depending on available layer thickness.

Note 3—A typical laboratory saw for mixture specimen preparation can be used to obtain cylindrical discs with smooth parallel surfaces. A tile saw is recommended for cutting the 15 mm notch in the individual I-FIT test specimens. Diamond-impregnated cutting faces and water cooling are recommended to minimize damage to the specimen. When cutting the I-FIT specimens, it is recommended not to push the two halves against each other because it may create an uneven base surface of the test specimen that can affect the results.

SGC Specimens—Prepare a minimum of one laboratory SGC specimen according to T 312 in the SGC with a compaction height a minimum of 160 mm ± 1 mm. From the middle of each 160 mm ± 1 mm-tall specimen, obtain two cylindrical 50 ± 1 mm thick discs (see Figure 4). Cut each disc into two identical "halves" resulting in four individual I-FIT test specimens. **Note 4—**It is recommended that a greater number of SGC specimens (and therefore a greater number of individual test specimens) be fabricated and tested to reduce the risk of a FI that is not representative of the mixture. This is especially important for marginal mixtures that have test results near the established pass/fail criteria.

Note 5—For laboratory compacted specimens, the air voids shall be determined for each of the two circular discs. The air voids for each disc shall be 7.0 +/- 1.0%. It is suggested that the minimum height of the gyratory compacted specimens shall be a minimum 160 ± 1 mm height to achieve the target 7.0 +/- 1.0% air voids in each of the top and bottom discs (see Figure 4). If target air voids cannot be achieved for each disc with 160 ± 1 mm height of the compacted specimens, then the specimen height can be increased. If specimen height cannot be increased or if a SGC has difficulty in compacting 160 mm tall specimens, then two SGC specimens, each at least 115 mm tall, may be compacted and used instead. A 50 mm thick disc will be cut from the middle of each gyratory specimen which will result in four individual I-FIT test specimens.

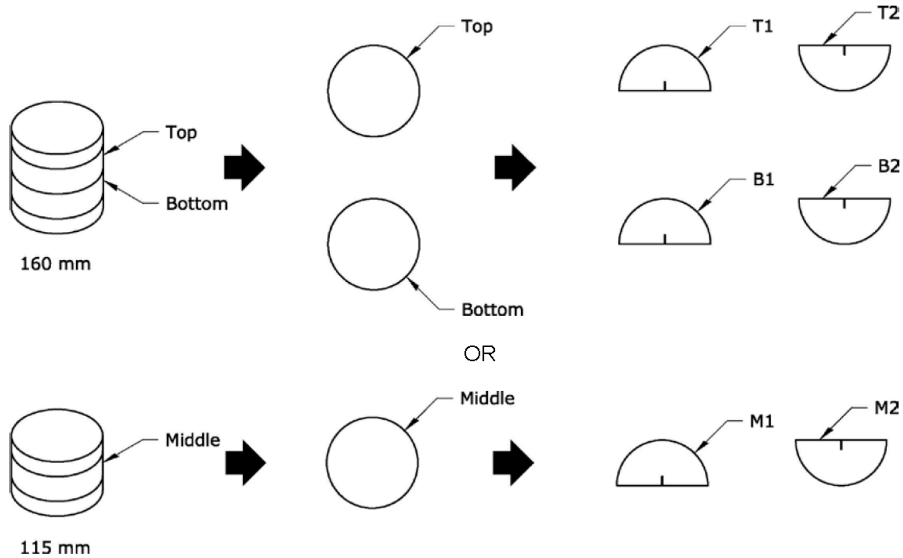


Figure 4— Specimen preparation from 160 mm or 115 mm SGC specimens

9.1.1. *Field Cores*—Obtain field cores from the pavement in accordance with ASTM D 5361. Obtain one 150 mm diameter pavement cores if the lift thickness is greater than 75 mm or two 150 mm diameter cores if the lift thickness is less than 75 mm.

9.1.1.1. *Field Specimens*—From the pavement cores, prepare four replicate I-FIT test specimens with smooth, parallel surfaces that conform to the height and diameter requirements specified herein. The thickness of test specimens in most cases for field cores may vary from 25 to 50 mm. If the lift thickness is less than 50 mm, test specimens should be prepared as thick as possible but in no case be less than two times the nominal maximum aggregate size of the mixture or 25 mm whichever is greater. If lift thickness is greater than 50 mm, a 50 mm slice shall be prepared. Cores from pavements with lifts greater than 75 mm may be sliced to provide two cylindrical specimens of equal thickness. Cut each cylindrical specimen exactly in half to produce two identical, semicircular I-FIT specimens. Each slice of the field core shall have parallel, smooth faces.

9.2. *Notch Cutting*— Cut a notch along the axis of symmetry of each individual I-FIT specimen to a depth of 15 ± 1 mm and 1.5 ± 0.1 mm (0.06 in.) in width (see Figure 1).

Note 6—If the notch terminates in an aggregate particle 9.5 mm or larger on both faces of the specimen, the specimen shall be discarded.

9.3. *Determining Specimen Dimensions*— Measure the notch depth on both faces of the specimen and record the average value to the nearest 0.5 mm. Measure and record the ligament length (see Figure 1) and thickness of each specimen. The ligament length may be measured *directly* on both faces of the specimen with the average value recorded or the ligament length may be measured *indirectly* by subtracting the notch depth from the entire width (radius) of the specimen on both faces of the specimen and averaging the two measurements. Measure the specimen thickness approximately 19.0 mm (0.75 in.) on either side of the notch and on the curved edge directly across from the notch. Average the three measurements and record as the average thickness to the nearest 0.1 mm.

9.4. *Determining the BULK Specific Gravity*—Determine the bulk specific gravity on the discs obtained from SGC cylinders or field cores according to AASHTO T 166.

10. TEST PROCEDURE

10.1. *Conditioning*—Test specimens shall be conditioned in a water bath or an environmental chamber at 25 ± 0.5 °c for 2 ± 0.5 h.

10.1.1. *Temperature Control* —The temperature of the specimen shall be maintained within 0.5 °C of the desired 25 ± 0.5 °C test temperature throughout the conditioning and testing periods. Testing shall be completed within 5 ± 1 minutes after removal from the water bath or environmental chamber.

10.2. *Position Specimen*— Position the test specimen in the test fixture on the rollers so that it is centered in both the “x” and the “y” directions and so that the vertical axis of loading is aligned to pass from the center of the top radius of the specimen through the middle of the notch.

10.3. *Contact Load*— First, impose a small contact load of 0.1 ± 0.01 kN in stroke control with a loading rate of 0.05 kN/s.

10.3.1. *Record Contact Load*— Record the contact load to ensure it is achieved.

10.3.2. *Loading*—After the contact load of 0.1 kN is reached, the test is conducted using LLD control at a rate of 50 mm/min. The test stops when the load drops below 0.1 kN.

11. PARAMETERS

11.1. *Determining Work of Fracture* (W_f)—The work of fracture is calculated as the area under the load vs. load line displacement curve (see Figure 5).

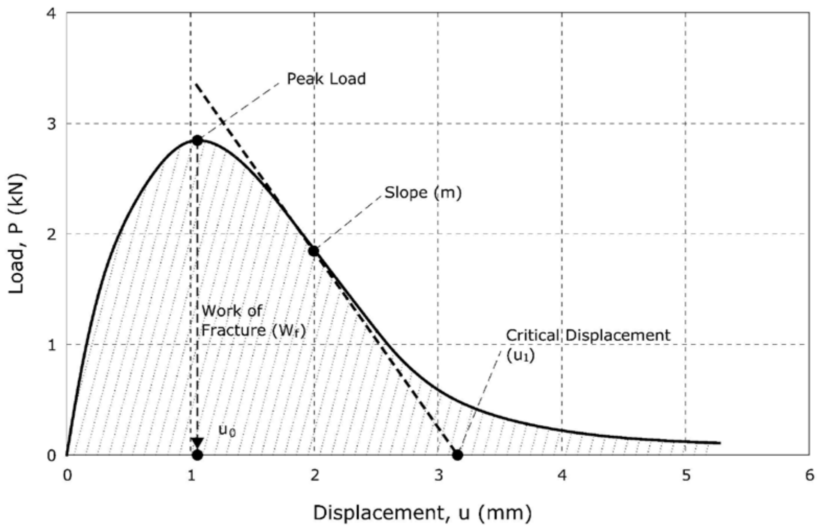


Figure 5—Recorded load (P) versus load line displacement (u) curve

11.2. *Fracture Energy (G_F)*— G_F is calculated by dividing the work of fracture (W_f) by the ligament area (the product of the ligament length and the thickness of the specimen) of the specimen measured prior to testing:

$$G_f = \frac{W_f}{Area_{lig}} \qquad \text{Equation 1}$$

where:

G_f = fracture energy (Joules/m^2);

W_f = work of fracture (Joules)

P = load (kN);

u = displacement (mm);

$Area_{lig}$ = ligament area = (r – a) *x* t, (mm^2)

r = specimen radius (mm);

a = notch length (mm);

t = specimen thickness (mm)

m = post-peak slope (kN/mm)

Note 7—G_f is a size dependent property. This specification does not aim at calculating size independent G_f. Therefore, cracking resistance of asphalt mixes quantified with G_f may vary when the notch length to radius ratio changes.

11.3. *Determining post-peak slope (m)* — The inflection point is determined on the load-displacement curve (Figure 5) after the peak load. The slope of the tangential curve drawn at the inflection point represents post-peak slope.

11.4. *Determining displacement at peak load (u_o)* — Find the displacement when peak load is reached.

11.5. *Determining critical displacement (u_1)* — Intersection of the tangential slope with the displacement axis yields the critical displacement value. A straight line is drawn connecting the inflection point and displacement axis with a slope m.

11.6. *Flexibility Index (FI)* — Flexibility Index can be calculated (by the software) from the parameters obtained using the load displacement curve. The factor A is used for unit conversion and scaling. "A" is equal to 0.01.

$$\mathrm{FI} = \frac{G_f}{|m|} \times A \qquad \text{Equation 2}$$

where:

$|m|$= absolute value of m.

Note 8—When four individual I-FIT specimens are tested, the FI value that is farthest from the average of the four shall be discarded as an outlier to lower the variability of the average FI value that is reported.

12. CORRECTION FACTORS

12.1. *Shift factor from lab to field specimens* — Apply a shift factor between SGC and pavement core specimens based on the age of field specimens, different criteria based on design, plant mix, and aged for different times. This shift factor still needs to be determined.

13. REPORT

13.1. *Report the following information*:

13.1.1. Bulk specific gravity of each specimen tested, to the nearest 0.001;

13.1.2. Average air void content of each disc, to the nearest 0.1;

13.1.3. Thickness t and ligament length of each specimen tested, to the nearest 0.1 mm;

13.1.4. Initial notch length a, to the nearest 0.5 mm;

13.1.5. Peak load and coefficient of variation (COV) of peak load, to the nearest 0.1 kN;

13.1.6. Post-peak slope and COV of post-peak slope (m), to the nearest 0.1 kN/mm

13.1.7. G_f and COV of G_f to the nearest 1 J/m^2.

13.1.8. FI and COV of FI to the nearest 0.1.

14. PRECISION AND BIAS

14.1. *Precision*— The research required to develop precision estimates has not been conducted.

14.2. *Bias*— The research required to establish the bias of this method has not been conducted.

15. KEYWORDS

15.1. Fracture energy; asphalt mixture; Illinois flexibility index test (I-FIT); stiffness; work of fracture; flexibility index.

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HMA Level II Technician

Asphalt Plant Operations & Equipment

Information pertaining to:

Standard Specifications pertaining to:

Asphalt Plant Operations

1. <u>General Plant Information</u>

The Illinois asphalt industry utilizes two types of plants to produce HMA material; drier-drum and batch, with the drier-drum plant being the most common plant in use today. Batch plants are still in use but are rapidly being replaced by the more efficient drier-drum plant. A third type of plant, the continuous plant, dominated the asphalt industry in the earlier years of asphalt production but has since been phased out and with none currently in use in Illinois. In most cases, the components of both the drier-drum and batch plants are similar but there are also some distinct differences.

The asphalt production process begins when individual stockpiled aggregates products are placed into aggregate bins referred to as “cold feeds” (this manual will continue to refer to these aggregate bins as cold feeds). Illinois requires all asphalt plants to have a minimum of four cold feeds equipped with adjustable feeder units to deliver the proper amounts or “proportions” of each aggregate ingredient onto an endless collector belt, or in some plants, to the boot of a bucket elevator. The aggregate blending process starts at the cold feeds where the individual cold feeds deposit the aggregate materials onto a main collector belt or a “cold elevator” which then transports the aggregate materials to the drier. This feeder system is termed the "cold feed" because the aggregates have not been heated and dried yet.

In a drier-drum plant, the cold feed aggregates are carried by an endless conveyor belt into a scalping screen to blend the aggregate materials and remove any oversize material. With a drier-drum plant this is the only screening unit utilized which helps to speed up the production process. The screened material is then deposited onto and carried by another endless belt across a weigh belt system and then into the upper end of a revolving cylindrical drier where a fuel oil, coal or gas burner heats and dries the aggregates. There are a small number of asphalt plants in use that use coal as a fuel source to heat and dry the aggregate materials.

A batch plant will utilize a grizzly screen, to scalp oversize material but can also use a scalping screen, such as found on a drier-drum plant. The cold elevator carries the collected aggregates into the revolving cylinder drier where the aggregate materials are heated and dried. The batch plant will use similar fuels to heat and dry the aggregates as a drier-drum plant. Once the materials exit the batch plant drier, a bucket elevator system, termed the "hot elevator", then transports the hot aggregates from the drier to a screening system at the top of the batch plant tower where the hot aggregate materials are screened into the specific sizes based on the configuration of the screen deck. The hot screened material is then directed into separate compartments or storage bins, termed as "hot bins", located directly beneath the screens.

Mineral filler, often termed "dust", is usually stored in a silo near the plant and is transported through a low-pressure air pipe directly into the drier (drier-drum plant) or into the weigh hopper (batch plant). On some of the older plants, the dust is transported by a conveyor or dust elevator to a bin at the top of the plant and then is augured into the weigh hopper. This material is difficult to handle because, when it builds up pressure, it surges forward through screw conveyors, under gates, and over baffles placed to retard its flow. Indications are that the best results are obtained with the bin kept half-filled and dust added to it at the same rate as it is used in the mixture.

When a low air pressure system is used with a positive cut off system, handling the dust is greatly improved. This is referred to as “positive dust control” and is a required operation on newer plants.

With a drier-drum plant, the weight of the aggregate is determined when the aggregate material passes across a weigh sensing unit referred to as a “weigh belt” or “weighbridge”. This weighing system uses load cells to sense the weight of material going into the drier on the endless belt. This information is sent to the plant computer, which in turn, determines how much liquid asphalt binder is required to coat the heated aggregate and the amount of mineral filler required for the mixture.

The hot liquid asphalt binder is pumped from a storage tank and injected directly into the drier-drum, coating the heated aggregates. Mineral filler, when used, will be injected into the drier-drum directly after the hot asphalt to insure proper mixing, coating and consolidation. The plant computer controls the amount of asphalt binder based on mix percentages, weigh belt information and aggregate moisture information. Once the materials have been sufficiently mixed, the finished HMA material exits the drier-drum onto a conveyor system, commonly referred to as a “slat conveyor” to transport the materials to a storage system, usually a surge bin or storage silo. This storage system allows the drier-drum plant to run in a continuous operation.

In a batch plant, the weighing of aggregate materials is accomplished when the individual hot bin aggregates are deposited into a weigh hopper located directly below the hot bins. The weigh hopper collects the individually weighed “hot-bin” materials based upon the material proportions necessary to produce a batch of the desired mixture. The plant operator weighs each size of hot-bin material by means of bin gate controls operated manually or automatically. If needed, mineral filler is augured into the weigh hopper after the hot-bin aggregates have been weighed. As soon as all the aggregate material is weighed, the contents of the weigh hopper is discharged into a heated pugmill mixer located directly below the weigh hopper. After a short “dry” mixing time, which is needed to re-blend the dry aggregates, hot liquid asphalt binder is injected into the pugmill where it coats the aggregate material as the mixing process continues. Once mixed, the finished asphalt mixture is then dropped into a waiting truck or diverted into a surge of storage bin.

The hot liquid asphalt binder is pumped from a storage tank into a steam, electrical or hot oil heated weighing container, termed an "asphalt weigh bucket". The required amount of binder is weighed out at the same time as the weighing of the hot-bin aggregates. Instead of weighing the asphalt, it is sometimes measured by volume with automatic measuring devices installed in the lines or pumps that that can be calibrated to deliver the specified amount.

2. Cold Feed System

In order for an asphalt contractor to produce an acceptable and workable mixture that will hold up to the traffic demands of the roadway the materials will be placed upon, aggregate materials have to be blended to meet the correct proportions determined from the design process. In most cases, the aggregate volume will make up approximately 95% of the total volume of the asphalt mixture.

First, aggregate materials have to be controlled during the production process to insure the consistency of the gradations. Aggregate materials used in asphalt mixtures are required to be produced under the "Aggregate Control Gradation System" (AGCS). Once produced, the aggregate materials have to be transported and stockpiled correctly to further insure consistency of the material gradations using the proper stockpiling and handling methods required in the AGCS program. As the stockpiled aggregate materials are placed into the cold feeds, care has to be taken to avoid segregation, degradation and contamination of these materials.

Proper control the percentages of aggregate materials begin at the cold feed system of an asphalt plant.

Beginning of the Standard Specification Article 1102.01(a)(3)

"(3) Aggregate/RAP/RAS Bins and Feeders. The plant shall be provided with accurate mechanical means for uniformly feeding each aggregate, Reclaimed Asphalt Pavement (RAP) and Reclaimed Asphalt Shingles (RAS) used, in the proper proportions so that uniform production and uniform temperature will be obtained. A minimum of four bins and feeders for aggregate will be required. If RAP is used, one additional bin and feeder will be required for each RAP fraction used. If RAS is used, one additional bin and feeder will be required. The bins shall be designed to prevent overflow of material from one bin to another. If any of the materials used in preparing the mixture become intermixed in a bin compartment, the compartment shall be emptied and the intermixed material shall not be used. Each bin shall be provided with a variable speed belt or apron feeder with adjustable gates which can be locked. Each bin shall have a cutoff system that shall automatically stop the HMA production when any bin becomes empty. All feeders shall be calibrated to the desired volumes and/or weights for each material/mixture, to the satisfaction of the Engineer. This calibration may require plant modification. The controls of the total quantity of combined materials fed to the dryer shall be by a variable speed system. Other methods may be approved by the Engineer. When the proportioning gates of the feeders are once set for proper blending, they shall be locked or bolted securely and their positions shall not be changed unless directed by the Engineer."

End of the Standard Specification Article 1102.01(a)(3)

Cold Feed System Types

There are three types of cold feed systems commonly used (see examples on page 2-5):

a) **Open Top Bins**: Open top bins usually have up to six compartments and are usually charged by endloaders, crane with a clamshell, or belt conveyor. The top of each bin shall have a divider, approximately 2.0 feet in height, between each compartment to keep the aggregate from spilling over into the next compartment.

   When charged with an endloader, the top of the compartment shall be at least 2 feet wider than the width of the endloader bucket.

   When charged with a crane, the bucket shall not be more than one half the minimum width of the top of the bin compartment. The maximum length of the bucket when fully open shall be at least one foot less than the length of the top of the bin compartment.

b) **Bunkers**: Bunkers are usually fed by trucks, car unloaders or bottom dump freight cars emptying directly into the bunker.

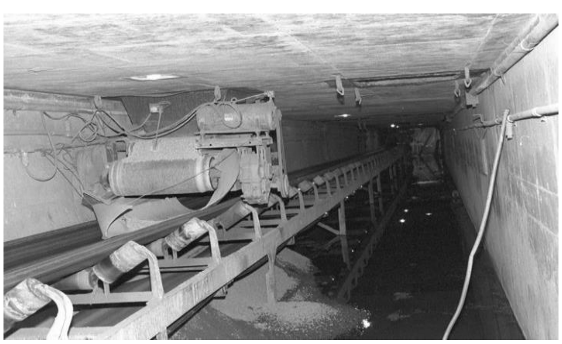
c) **Tunnel Systems**: Bulkheads separate Stockpiles over tunnel systems. Aggregates are usually stockpiled over the tunnel by endloaders, trucks or belt conveyors. Extra care should be taken not to cause segregation of the aggregate materials when belt conveyors are used to build stockpiles that will supply the cold feed system

When charging cold feed bins and tunnel systems with a front endloader, the loader should stay off the stockpile as much as possible. The weight of the loader will cause potential degradation of the materials and vibration from the loader can cause fines to filter down to the bottom of the stockpile. The endloader operator should work the stockpile so the material fed to the plant will be uniform. The endloader operator should keep the bins above one-half full to insure a uniform feed.

Each bin should have a variable speed feeder under it that can be adjusted from the control panel and a master control switch that will speed up or slow down all of the feeders at the same time.


Open Top Bin Systems

Bunker system




Tunnel Systems

Feeder Types

There are several types of feeders: reciprocating plate, vibratory, apron feeder and continuous belt types. Continuous belt feeders are the most common units used by the HMA industry and are what will be referred to in this manual. The feeders should be located beneath the bins in such a manner as to insure a uniform flow of aggregate to a belt that carries the aggregate to the cold feed elevator.

Improperly adjusted cold feeders may cause the following:

a) A sudden increase/decrease of cold or wet material may cause a considerable change of temperature in the aggregate leaving the drier.

b) A sudden increase in the cold feed can overload the screens (batch plant), creating a carryover of the fine aggregate into coarse aggregate hot bins and ruin the screening efficiency of the screen deck.

c) Erratic feeding may cause some hot bins (batch plant) to overfill while starving others. In addition:

    1) Layers of variable grading in the hot bins can lead to alternating coarse and fine batches.

    2) The dust collection system may become overloaded.

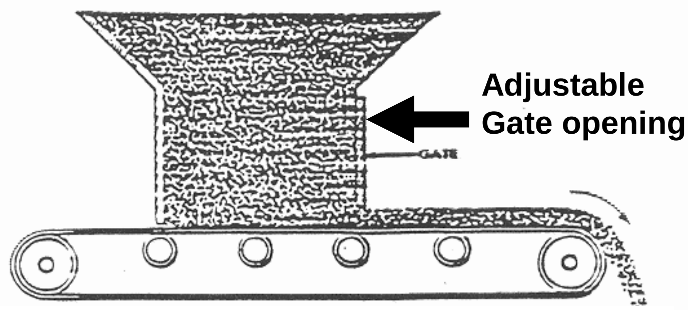
    3) It may reduce draft air.

Cold Feed Calibrations

Control of HMA begins with the gradation and controlling the proper amounts of coarse and fine aggregates going into the mixture. The Quality Control Manager and/or Level 2 HMA technician is required to control the material on the #4 and #8 sieves to meet the mix design requirements (this is the breaking point of the fine and coarse aggregate materials in the combined gradation). This involves proper proportioning of the aggregate materials entering the plant at the cold feeds. With a dryer-drum plant, this is the only place to control the combined gradation. While a batch plant can be proportioned at the hot bins or cold feeds, wasting of expensive aggregate materials will probably result of unbalanced cold feeds if relying solely on the hot bins. To establish proportioning control, specifications require the Contractor /Producer to calibrate the cold feed system before producing HMA from either type of plant to ensure the proper proportions of ingredients.

The Contractor/Producer is required to provide documentation of the rate of materials coming from the cold feeds established when calibrating the cold feeds. During the calibration process the Contractor/Producer will document the weighing, testing and plotting of the appropriate gate and motor speed settings of all the feeders and furnish a copy of the documentation to the Engineer upon request. Once calibrated, it shall be the responsibility of the Contractor/Producer to see that the required gate openings and feeder settings are maintained when production begins.

The Quality Control Manager and/or Level 2 HMA technician shall observe that the setting of the gates and feeders will produce the required percentage of each material in accordance with the preliminary proportions determined by the method described in Chapter 4, "Blending Aggregates" of this manual. This is not difficult in the case of the belt feeders, since the amounts delivered are roughly proportional to the gate openings. The reciprocating and vibrating type feeders are more difficult to set because the amount fed through a given gate varies with the gradation and moisture content of the aggregate (wet sand feeds slower than dry sand and the fine material feeds slower than coarse).



Continuous Belt Feeder
Most common feeder used in the industry

Note that the first setting of the cold feeds is only approximate and adjustments might have to be made to meet mixture specification compliance. The adjustments, to obtain accurate plant settings, must be made after the start of production and is based on the results of sieve analysis’s of a combined belt sample (drier-drum) or hot-bin samples (batch plant). Adjustments are usually necessary to meet required mixture proportions and, in the case of batch plants, obtain and maintain proper levels of the hot-bins. These adjustments are also used to control the approximate total quantity of material fed through the drier.

When material from the cold feed gates is discharged onto a belt conveyor, the individual cold feed output may be checked by shutting down all feeders except one. The feeder to be checked is then set to a predetermined calibration point. The cold feeder being calibrated is filled to normal operating level with the material to be run with during production. The plant is started and brought to normal operating speed.

There are two methods normally used to calibrate cold feeds:

a) The first method involves measuring the amount of material discharged from a cold feeder during a predetermined time at a predetermined feeder speed with a predetermined feeder gate opening.

   This process involves diverting all the material coming from the feeder at the set time, speed and gate opening into a tared truck. At the end of the predetermined time, the feeder is shut down and all remaining material on the conveyor belt continues to be diverted into the tared truck. Once the conveyor belt(s) is clear of material, the truck is weighed in order to determine a net weight of material obtained during the calibration process. Calculations are then performed to determine the amount of material delivered by the feeder, expressed in “Dry Tons per Hour”. These calculations will be covered later in this chapter.

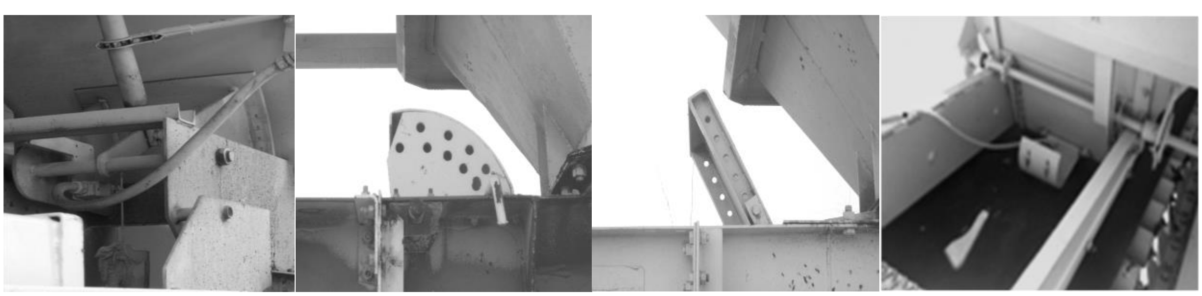
b) The second method involves removing material from a measured distance on a conveyor belt. Once the plant is stopped the material, including the fines, is removed and weighed. The weight of material, divided by the length in feet of the belt section, multiplied by the belt speed in feet per minute, will give the amount of material delivered per minute from that gate opening.

With either method, each material and feeder used, with the appropriate gate opening and settings, will be determined in the same manner and the results are plotted. Each individual aggregate material, in each feeder used, at each gate opening is required to be calibrated with either method. This data is plotted to provide information needed to establish preliminary plant settings and will be used to check material proportions during production.

Gates that feed coarse aggregate should not be set at less than 1-1/2 to 2 times the largest aggregate size to prevent clogging of the opening. For example, if a gate is feeding aggregate with 1-inch maximum size, the gate should not be set at less than 1-1/2 or 2 inches. In most cases, gate openings are set wide open to allow maximum production but sometimes it may be necessary to restrict the opening width to limit or provide better control of materials. This is especially true when mixture ingredients amount to a small percentage of the total volume of mix being produced.

Once the calibrations are established and production settings implemented into the plant, it is important that the cold feed settings are not changed. If the cold feed gate openings or feeder settings are changed or modified, changes in the ingredient percentages will result which will affect mix properties, such as air voids, density and binder content. This could also cause specification limits to be exceeded resulting in unacceptable material being produced. It will be the responsibility of the Quality Control Manager and/or Level 2 HMA technician to verify the proper setting of each aggregate feeder. The plant operator shall be limited to using only the master control to increase or decrease the amount of material being fed into the drier. The plant operator should contact the Quality Control Manager and/or Level 2 HMA technician to determine what adjustments need to be made if problems arise.

A calibration of each feeder and each material being fed through a particular feeder is required for production of HMA to insure the proper proportions of ingredients are incorporated into the mixture. This would include any coarse aggregates, fine aggregates, and RAP or RAS materials. All plant units shall be operated so that they will function properly and produce HMA mixtures having uniform temperatures and mix characteristics and properly calibrated cold feeds will help to insure this is met. The cold feeder and the drier control shall have a workman specifically assigned to these operations if uniform results are not obtained.



Different gate opening controls

Cold Feed Calibration Example

Feeder	Material	Gate Setting	Truck Tare	% Moisture	Date	Insp.
#1	FM-02	6-Hole	17680	6.6%	3-6-15	RW

Time (min)	FPM/RPM	Ave FPM/RPM	Gross Wt. (lbs.)	Net Wt. (lbs.)	Ave Net Wt. (lbs.)	Ave Wet TPH	Ave Dry TPH
6	10.4	10.5	22280	4600	4700	23.5	22.0
6	10.6		22480	4800			
6	10.5		22380	4700			
3	24.3	24.3	22820	5140	5100		
3	24.1		22740	5050			
3	24.5		22790	5110			
3	37.0	37.0	25760	8080	8060		
3	37.0		25740	8060			
3	37.1		25720	8040			

Ave Wet TPH Formula:

$$\frac{\text{Ave Net Wt (lbs)}}{\text{Time (min)}} \times 0.03 = \textbf{Ave Wet TPH}$$

(0.03 is a constant factor that converts lbs/min to ton/hour)

Example:

$$\frac{4700}{6} \times 0.03 = \textbf{23.5 Wet TPH}$$

Ave Dry TPH Formula:

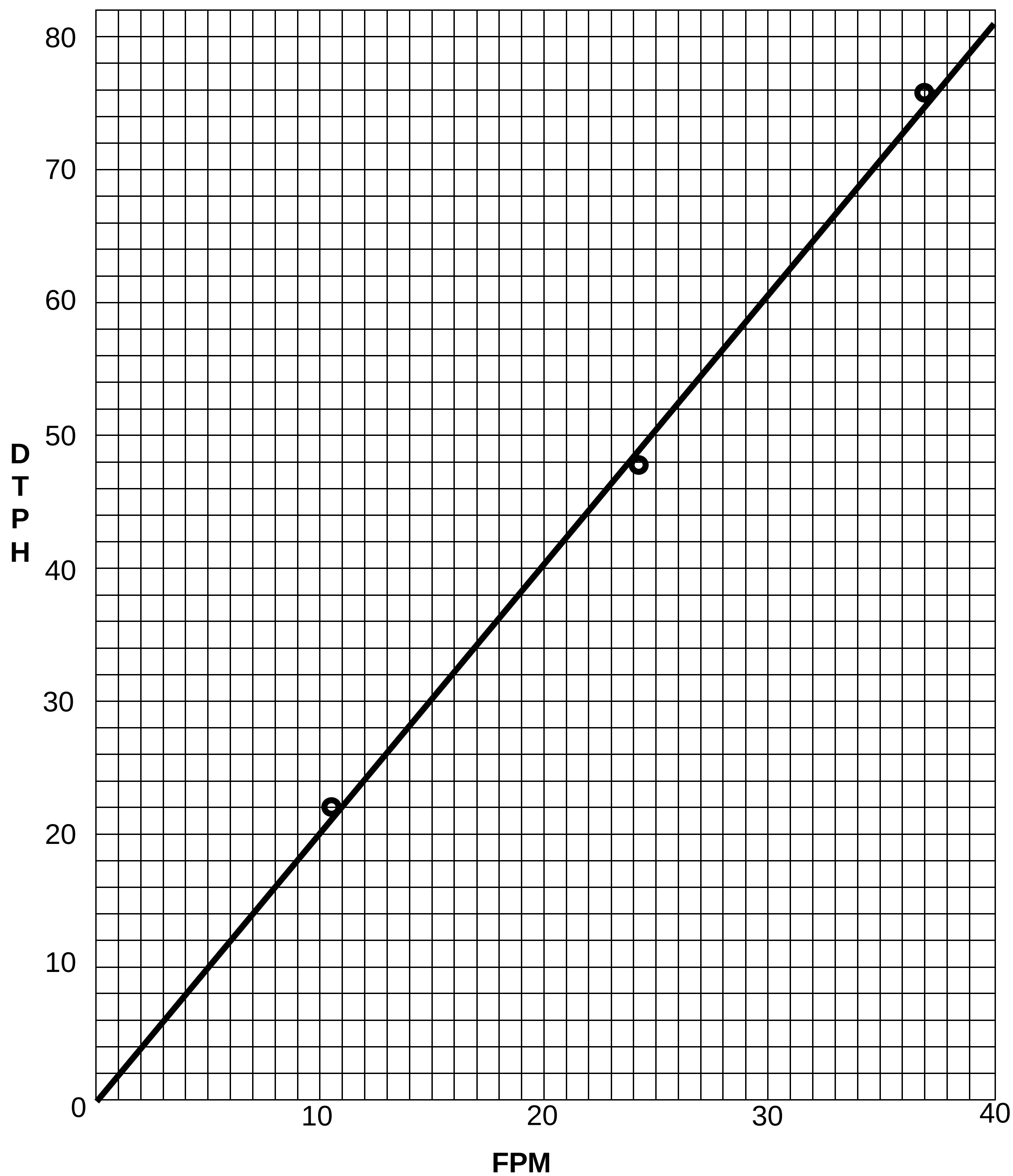
$$\frac{\text{Ave Wet TPH}}{1 + \left(\frac{\text{\% Moisture}}{100}\right)} = \textbf{Ave Dry TPH}$$

Example:

$$\frac{23.5}{1 + \left(\frac{6.6}{100}\right)} = \frac{23.5}{1 + 0.066} = \frac{23.5}{1.066} = \textbf{22.0 Dry TPH}$$

Mattoon Plant 912-01 Feeder #1 @ 6-hole FM-02 @ 6.6% Moisture

Dry Tons per Hour (DTPH) / Feet per Minute (FPM)



3. <u>Cold Elevator</u>

Cold elevators systems deliver aggregates from the cold feeds into the drier by way of continuous belt conveyor systems. The cold elevator will usually employ a scalping screen to remove foreign or oversize material. This is important for the drier-drum plant since this typically is the only screening of the aggregate materials.

Dryer-drum Plant Cold Elevator Conveyor

Batch Plant Cold Elevator

The drier-drum plant employs a weigh bridge on the cold elevator conveyor which senses the weight of material passing into the drier which in turn signals the correct amount of liquid asphalt binder for the mixture. This weighing process employs a load-bearing system, usually load cells, to determine the weight of aggregate. The weigh bridge, like any weighing device used to produce materials paid by weight, has to be calibrated to ensure proper operation (this subject will be discussed later in this chapter). Once calibrated, the weigh bridge can be used to calibrate the cold feeds. This will greatly speed up the calibration process since the aggregate material does not have to be loaded into a truck to be weighed as described in the previous section on calibrating cold feeds.

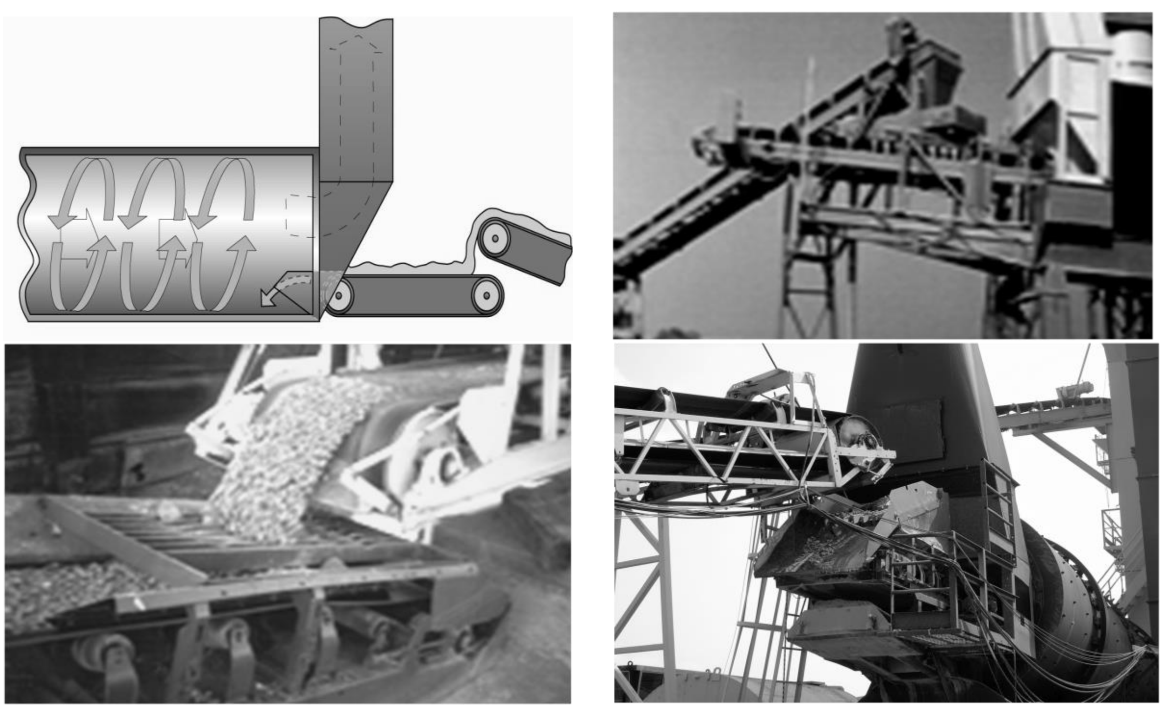
Dryer-Drum Cold Elevator Scalping Screen

Weigh Bridge

Another important part of the cold elevator for a dryer-drum plant is a diversion chute usually located just before the aggregates enter the drier. This diversion chute serves three main purposes: a means to sample the combined aggregates to determine compliance with the established gradation targets for the mixture, to divert and catch material run through a cold feed during the cold feed calibration process and to empty the feed belts when changing mixtures.

Dryer-drum Diversion Chutes

On a batch plant, the cold elevator is normally used just to transport the aggregates from the cold feed system into the drier. Since a batch plant will screen the hot aggregates into hot bins, where the gradation sampling takes place, a diversion chute is not needed. Some manufacturers will place a diversion chute to catching material during the cold feed calibration process or cleaning off the conveyor belt when switching mixtures. Other manufacturers will use slinger belts to divert the aggregates before they enter the drier. Some manufacturers design their plant with a scalping screen at the aggregate's point of entry into the drier, which is blocked to divert the materials from entering the drier.



Batch Plant Slinger Belt, Scalping Screen and Scalping Material Diverter

4. Drier

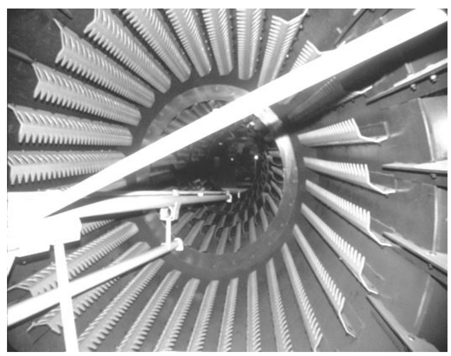
The drier is a revolving cylinder, usually from 3 to 12 feet in diameter and from 20 to 60 feet in length, in which aggregate is dried and heated by an oil, coal or gas burner. The cylinder is equipped with longitudinal cups, or channels, called "lifting flights", which lift the aggregate and drop it in veils through the burner flame and hot gases. The slope of the cylinder, its speed, diameter and the arrangement and number of lifting flights control the length of time required for the aggregate to pass through the drier. The drier drum is sloped to allow gravity and the flighting arrangement to pull the aggregates through while heating and drying the aggregates. The slope and flighting arrangement will then influence the speed of the aggregates through the drier affecting the heating and drying potential, segregation and coating of the aggregates with the liquid asphalt binder (dryer-drum).

Beginning of the Standard Specification Article 1102.01(a)(1) 2nd paragraph

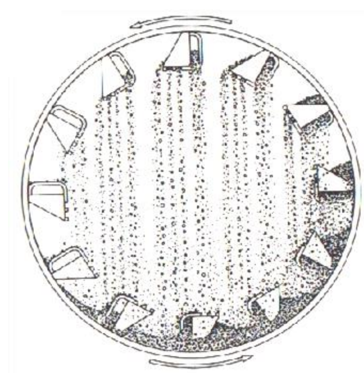
"(1)… For all types of plants, the ingredients shall be heated and combined in such a manner as to produce HMA which when discharged from the plant will in general vary not more than 20 °F (10 °C) from the temperature set by the Engineer. In all cases, the mix temperature shall not be more than 350 °F (180 °C) or less than 250 °F (120 °C). Wide variations in the mixture temperature of successive loads may be cause for rejection of the HMA."

End of the Standard Specification Article 1102.01(a)(1) 2nd paragraph

Drier



Lifting Flights



Aggregate Veil

Burner Units

The drier performs two main functions:

a) Heats the aggregates to insure proper coating of the liquid asphalt binder

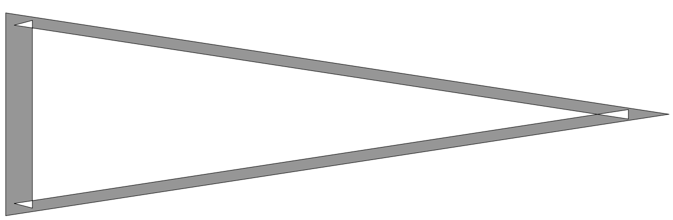
b) Removes moisture from the aggregate, which:

1) The heat of the drier vaporizes the surface and internal moisture.

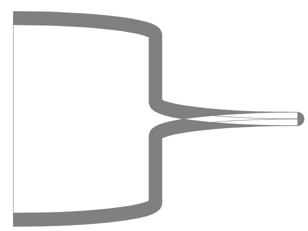
2) The vapor is drawn off by the draft air.

The temperature of the dryer is controlled by the amount of fresh air and amount of fuel. These two factors, along with the type of burner used, must be in balance with the potential drying capacity of the drier to provide the necessary amount of heat and still maintain efficient combustion performance.

Burners of the same combustion efficiency have different burning characteristics. Some burners produce a "long controlled flame" which reaches far into the drier. Other burners tend to produce a fine dispersal of fuel at the nozzle end and, therefore, quick combustion. If the flame is of the "blossom" type, with the heat concentrated close to the burner



Long Controlled Flame



Blossom Flame

Crowding more material through the drier than it can properly handle causes most problems that arise in drier operation. However, there are other factors that will affect efficient drier operation. Several of these factors involve the proper operation of the burner. If the blower air, draft air, and amount of fuel oil are not in balanced adjustment, it may cause incomplete combustion of the fuel, possibly leaving an oily coating on the aggregate particles that are harmful to the finished mixture. Lack of balance between the blower air and the draft air also can create backpressure within the drier, causing "puff back" at the burner end of the drier. "Puff back" indicates that the draft is not sufficient to accommodate the air pressure being introduced by the burner blower.

Most driers are designed for average aggregate moisture content, usually 5%. Very wet aggregate will reduce the drier capacity and require corrective measures:

a) Increase the amount of heat by burning more fuel while the flow of aggregate remains constant.

b) Reducing the aggregate flow.

There is a limit to the amount of potential heat available and beyond that limit the rate of aggregate flow must be reduced to insure proper drying and heating of the aggregate materials.

The following table demonstrates the effect of moisture has on production levels.

Aggregate TPH vs. % Moisture
(Drum Diameter & Length vs. % Surface Moisture Removed = TPH)

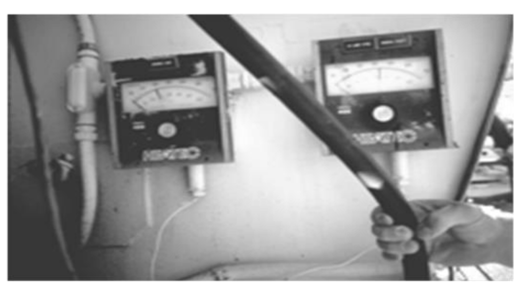
Drum size	2%	3%	4%	5%	6%	7%	8%	9%	10%
5' x 22'	178	140	116	100	84	79	74	63	58
6' x 24'	278	220	178	158	137	121	116	100	89
7' x 30'	420	336	273	236	205	184	163	147	137
8' x 32'	541	430	352	305	263	236	210	194	173
9' x 36'	719	578	478	410	357	315	284	257	236
10' x 40'	956	761	630	541	473	430	378	341	315

Aggregates with highly absorptive characteristics may require longer drying periods. This can be accomplished by reducing the incline (slope) of the drier, by rearranging the drier lifting flights or slowing of production. By increasing the drier time, this will remove more moisture than increasing the heat. Double drying is another option on some aggregate materials, such as air cooled blast-furnace slag. The drier will not remove all of the absorbed moisture out of the aggregate but will only heat the aggregate and surface dry it. The still retained absorbed moisture, referred to as “residual moisture”, will come out of the aggregate in the lag time it takes the material to travel from the drier to the pug mill if heated properly.

Too much residual moisture could come out after the aggregates have been coated with the liquid asphalt binder, which can cause a washing effect by removing (washing) the liquid asphalt binder from the aggregate while in transportation. This can be referred to as “drained down” which is evidenced by pooling of the liquid asphalt binder on the truck bed. Another issue with too much aggregate moisture is that some mixes can inherit tenderness characteristics which can be evidenced but unwanted moving or shoving of the mix during the compaction process.

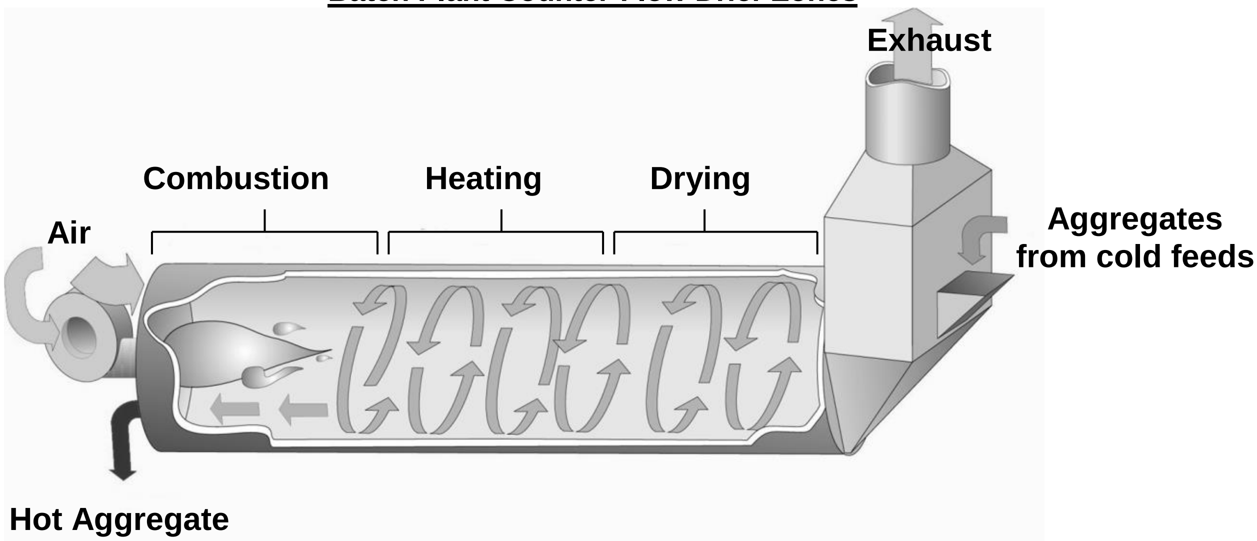
Because of this, specifications state the amount of residual moisture will not exceed 0.3% in the dried aggregate. This is determined by running moisture samples at the plant. The specifications will also specify the temperature range of the aggregate for mixing. These specifications can vary with the type of mix and asphalt being used. Generally, moisture requirements will be met whenever a steady temperature is maintained.

Either a recording thermometer or a recording pyrometer having at least two terminals that measures aggregate temperature is required for asphalt plants. The latter has a much faster reaction speed to changes in temperature and hence is more desirable.

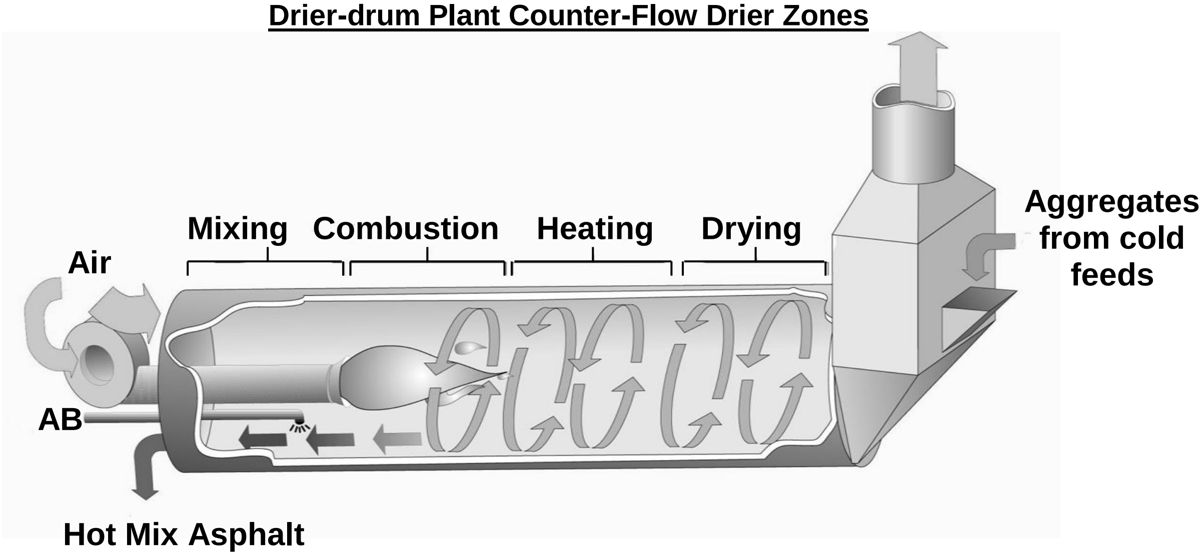



Plant Temperature Controls

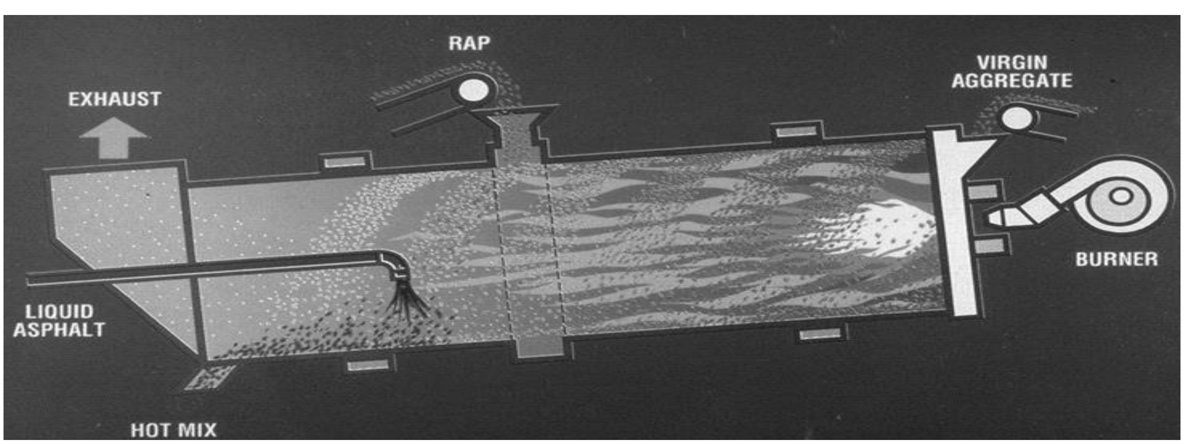
Batch Plant Counter-Flow Drier Zones



Drier-drum Plant Counter-Flow Drier Zones



Drier-drum Plant Parallel-Flow Drier Zones



5. Dust Collection

Aggregate products used in HMA mixtures will naturally include a certain percentage of dust or dust will be generated through shipping and handling of the material through a process called degradation. This ‘dust’ will range in size from around #16 size particles to less than #200 size particles, commonly referred to as “minus 200 material”. Dust is a critical component of an asphalt mixture. It is needed to create friction in the mastic (glue) to help hold the mixture together and as a filler of void spaces in the mixture. Too much dust can have a detrimental effect on the finished roadway causing the mixture to move or deform under traffic. This causes a dangerous situation called “rutting” where the HMA material, especially in the wheel lane areas of the pavement, can distort and shove outward resulting in channeling of the pavement that can hold water. Another result of too much dust is the undesirable movement of the mixture during placement (referred to as “shoving”) because the excess dust will take on a characteristic similar to a liquid providing excessive lubrication which causes slippage of the aggregate particles. It is imperative that the amount of dust in the mixture be controlled to achieve the proper results. In order for asphalt plants to control the dust in the mix, plants have to be outfitted with proper equipment to manage dust.

The dust collection equipment then is an integral part of the asphalt plant because of the part it plays in providing an even flow of adequate air volume through the plant, the retrieval of the dust and removal of moisture laden air. It is important that a proper balance be achieved between the airflow necessary for optimum drying performance and that which will permit proper dust control. Plants demonstrating problems with dust control will be required to upgrade with a system referred to as PDCE or positive dust control equipment which requires all dust to be accurately weighed to an accuracy of 0.5% of the actual weight of dust material being put into the mixture.

There are two types or sizes of dust created during the production of HMA. A coarse dust called “primary dust” with particle sizes generally ranging between the #16 and #200 sieves with a small amount of minus #200 material. A finer dust, referred to as “secondary dust” or “mineral filler”, has particle sizes ranging between the #50 to minus #200. Because of the apparent differences in the gradations of the dust materials it is important that they are stored and handled separately and kept from any intermingling. The two systems used in HMA production for dust control are the primary and secondary dust collectors.

Beginning of the Standard Specification Article 1102.01(a)(4) in part

"(4) Dust Collection. The plant shall be equipped with a primary dust collector, approved by the Engineer, connected to a secondary dust collector (baghouse or wet-wash)…”

End of the Standard Specification Article 1102.01(a)(4) in part

Primary Dust Collector

The purpose of the primary collector is to ‘collect’ the dust particles being carried by the airflow from the drier. As the aggregates pass through the drier, the exhaust gases (airflow) will carry the suspended dust thru ductwork into the primary dust collector. Working properly, the dust collection equipment will collect and return a portion of the fine aggregate back into the mix.

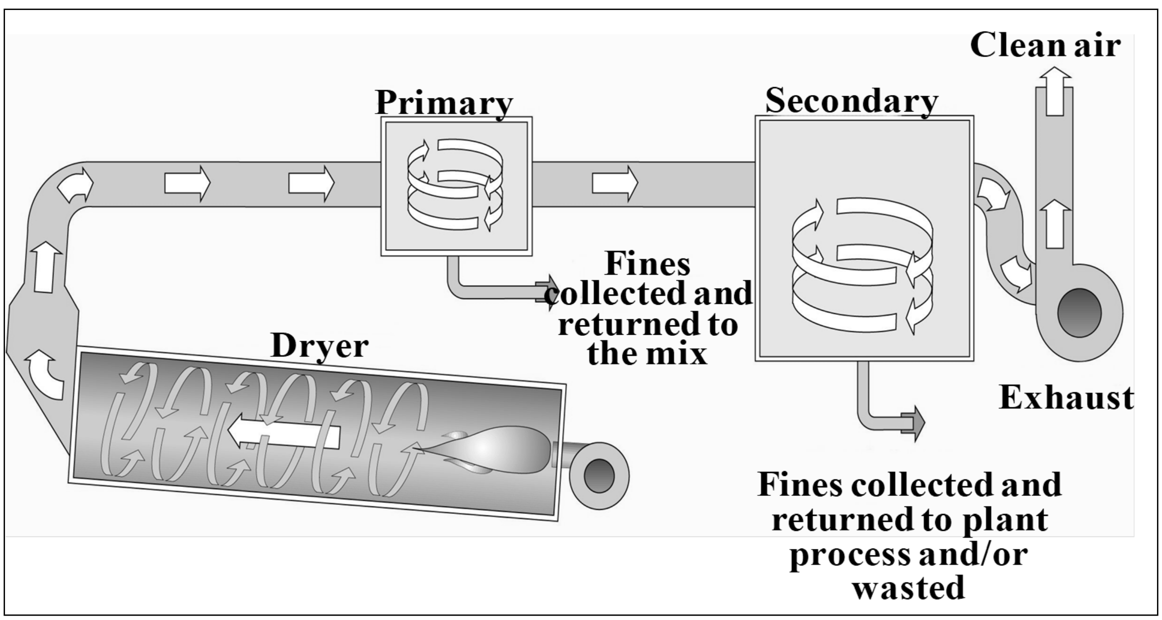
Many factors affect the efficiency of a dust collector, e.g. particle size and shape, gradation of fines, size and proportion of the collectors. Proper operational procedures are needed to prevent condensation in the dust collector so the system needs to keep the air temperatures above the dew point to avoid condensation. Any condensation or moisture can affect the proper removal of dust or cause slowing of the airflow which will influence the efficiency of the dust removal and/or plant production rates.

On start-up, it usually helps to preheat the air system slightly before beginning production. After starting, normal good drier operating procedures will usually insure trouble-free operation; however, when operating in unusually low temperatures, it is sometimes helpful to insulate the dust collector housing.

The primary dust collector is not designed to pull a 100% of the dust out of the air flow. Most primary collectors will work in a 70% to 93% efficiency range. The remaining finer dust will stay in suspension and be carried to the secondary collector system, either a baghouse, or wet washer.

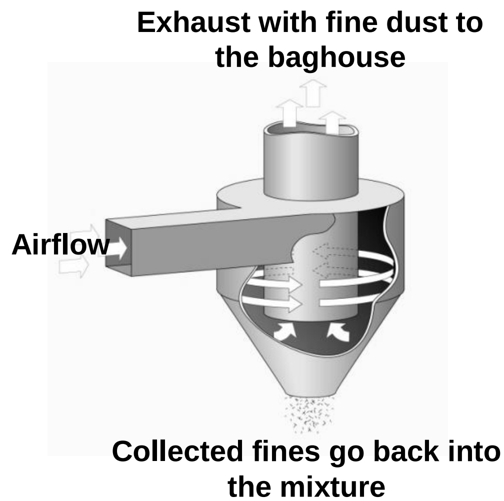
Cyclone Dust Collector

The cyclone collector uses a centrifugal force or cyclonic wind action to remove the larger dust particles from the air flow from the drier. In the cyclone collector, the dust-laden air is forced into a whirling motion. The heavier dust particles in the exhaust gas stream are separated by centrifugal force against the collector shell and are carried to the lower outlet.



Cyclone Dust Collection System

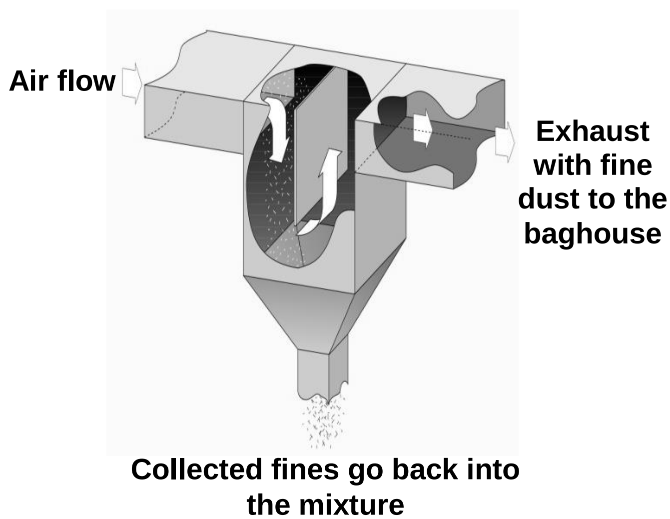
Cyclone Primary Dust Collector



Knockout Dust Collector

Knock out boxes, or sometimes called skimmers, are a part of the drier ductwork and operate by slowing the air flow down thus allowing the heavier dust particles to drop out of suspension from the air flow commonly referred to as ‘knocking’ the dust out of the air.

Dryer-drum Knockout Box



Secondary Dust Collector

The purpose of the secondary dust collector is to remove any fines or dust that wasn’t removed in the primary collector. The secondary dust collector serves two main purposes;

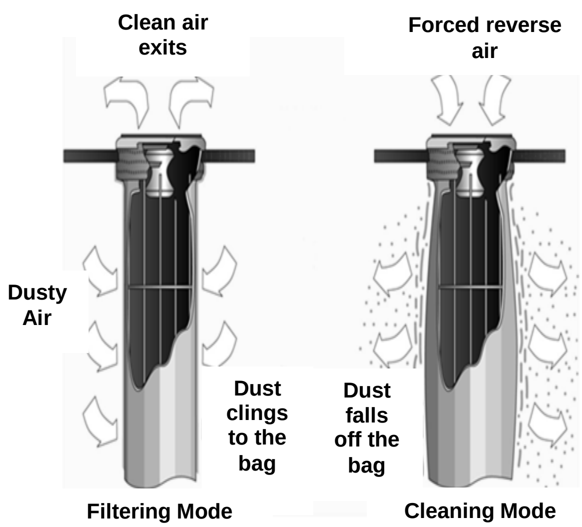
a) To filter out the minute dust particulate matter from the exhaust air so that it won’t be expelled into the environment.

b) To reclaim and allow for storage of the minus #200 dust materials for incorporation back into the HMA mixture, if needed.

There are two types of secondary dust collectors that are typically used on an asphalt plant, the wet-wash and the baghouse. Because of stringent pollution requirements and the importance of accurate dust control for HMA mixes, baghouse collectors are being used instead of the wet-wash systems today.

The operation of a baghouse is relatively simple; air flow is generated by a large blower fan which brings dust-laden air from the primary dust collector into the baghouse. This dust-laden air then passes through filter bags where the dust collects on the outer surface. The dust is removed from the filter bags by shaking, pulsing, or air reversal periodically and collected in a hopper or silo where it can then be fed back into the mix as filler. The dust collected from the baghouse is required to be discharged directly into a separate hopper or silo for temporary storage and/or distribution back into the mixture. But in no case will intermingling of primary and secondary dust in the same hopper or silo be permitted.

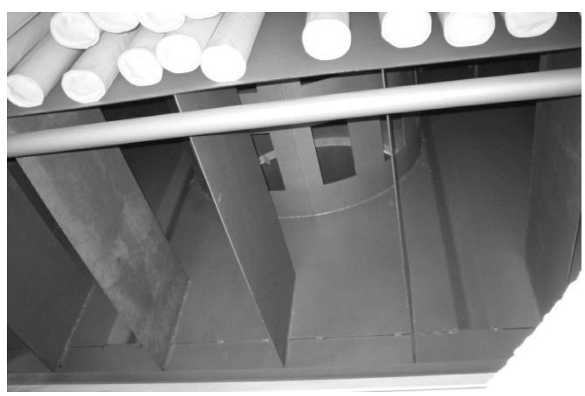
The requirement for a primary dust collector may be waived, provided that the baghouse is equipped internally with a "knock-out box" capable of performing the same function as a primary collector.



Cleaning of the filter bags

Inside a Baghouse

Baghouse



Baghouse Knock-out Box

A wet-wash secondary dust collector works on the principle of 'wetting' the dust particles once the air has traveled through a primary dust collector and then flushing the fines and water into a holding pond. This process has a wide range of variability which makes it hard to control the dust with this type of system.

Wet-wash Dust Collectors

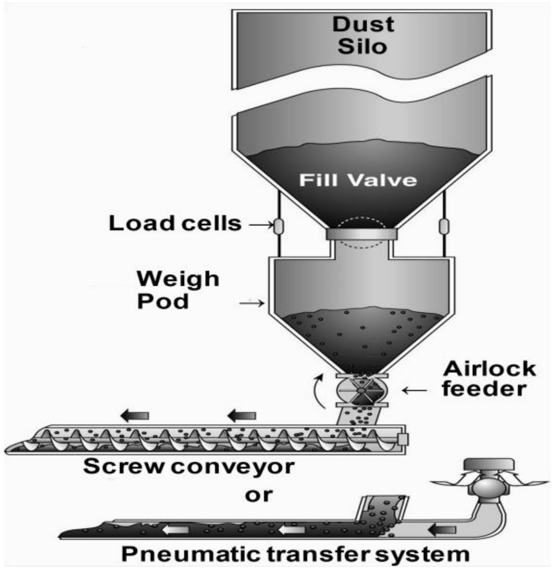
Proper operation of the dust removal system is important with an asphalt plant. Any change in the volume of air going through the baghouse will affect the amount of -#200 material collected by the primary dust collection system. The banks of dust bags in a baghouse will have a set cleaning sequence to prevent segregation in the baghouse.

Also as moisture in the stockpiled aggregate increases and in the baghouse increases, the volume of air getting through the bags in the baghouse will decrease. This is because the bags will become plugged and the damp dust can't be removed as efficiently. Once the bags become plugged the air flow through the plant is slowed making the primary dust collector more efficient. This extra efficiency will allow more of the #50 thru the #200 material and minus #200 material to be collected in the primary collector and be returned to the mixture. When this happens, the minus #200 material will increase in the mixture and greatly affect the air voids and density of the mixture. The ratio of dust to air voids in an asphalt mix is usually 1:1, so for a one percent increase in dust it is expected that the mix will lose one percent in air voids. As discussed earlier, an increase of dust in an asphalt mix can lead to tenderness, unwanted movement and rutting of the mixture on the roadway. If the stockpiled aggregates become saturated due to heavy rains then the plant will probably need to slow production down in order to effectively remove the excess moisture that will be encountered during production.

Mineral Filler and Dust Collection Feed Systems

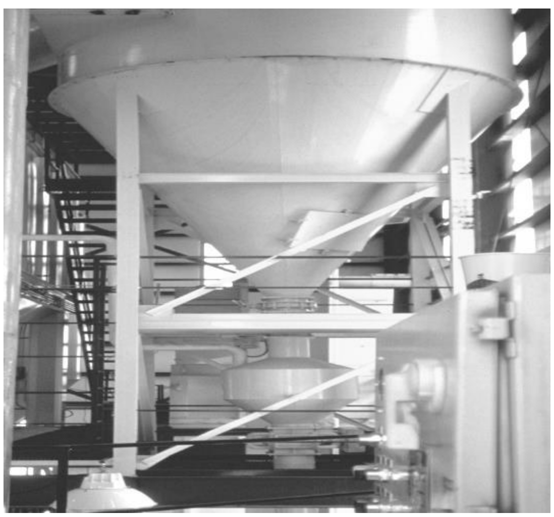
The collected primary and secondary dust material are two completely different gradations of materials and are required to be stored separately and kept from intermingling. The primary dust is identified as a coarser grained material with the grain size ranging from approximately the #16 down to minus 200 material with the majority size being between the #30 and above the #200 sieve. Secondary dust is a lighter and finer sized dust which will register around 80 to 90 percent passing the #200 sieve. Newer plants will use weigh-pods which help to accurately measure and control the amount of dust material being put back into the mixture.

Not all dust generated in an HMA plant will be used and, in certain cases, excessive amounts need to be wasted or transferred to another plant for use.



Weigh Pod System

Dust storage tanks w/weigh pod



Single Weigh-pod System

Dual Weigh-pod System

6. Surge/Storage Bins

In order to for asphalt plants to run continuously (dryer-drum) or to increase production (batch) most producers will employ the use of a HMA storage system. Two common systems used are surge bins and storage silos. A surge bin is a temporary storage usually holding 30 to 50 tons of mixture. This temporary storage creates a cushion for the plant to continue running while waiting for trucks since a dryer-drum plant is not designed to start and stop. Storage bins are designed to hold materials for up to 20 hours, with approval, and will hold 100 plus tons. These components are discussed in greater detail in Chapter 3 of this manual.

Beginning of the Standard Specification Article 1102.01(a)(5) in part

"(5) Hot-Mix Surge Bins. The Contractor may use a hot-mix surge system in the manufacture of HMA provided the bin(s) meet the following requirements and are operated to the satisfaction of the Engineer. The complete surge system shall be designed and operated to prevent segregation and loss of temperature of the mix…"

"…No surge system will be approved by itself but shall be considered as part of a complete operating HMA plant…"

End of the Standard Specification Article 1102.01(a)(5) in part

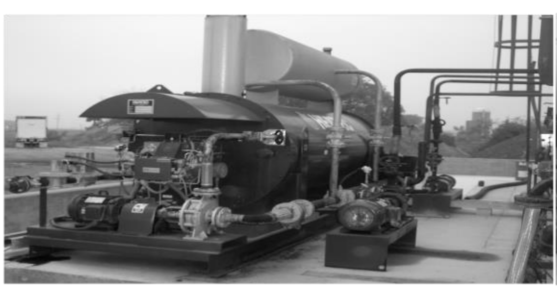
Storage Silos

Surge Bin

7. Storage for Liquid Asphalt Binder

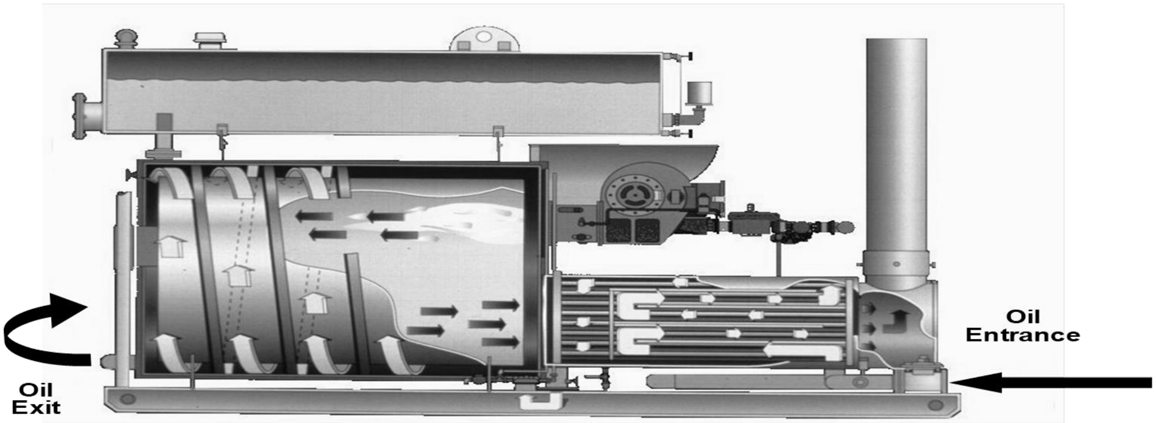
Due to the quantities of liquid asphalt binders needed to produce HMA mixes, the liquid asphalt binders need to be stored on site at an asphalt plant. Storage is in large cylindrical tanks positioned vertically or horizontally. While asphalt plants will still use horizontal storage tanks, the vertical tanks tend to be more efficient. The vertical storage tanks are reported to heat and mix the liquid asphalt binder more efficiently by taking advantage to the natural rise and fall caused by hot and cold liquid materials, respectively (heated materials will naturally rise while the cooler materials will fall).

Heaters are used to heat circulated liquid asphalt binder to keep it at the proper temperature for incorporation into a mix.



Hot Oil Heater

Unloading of an AB tanker



Liquid Asphalt Binder Heating System

To insure the correct liquid asphalt binder is being used, the storage tanks are required to be identified properly. Also, each different type or grade of liquid asphalt binder material will be stored in separate tanks to prevent intermingling of different grades materials.

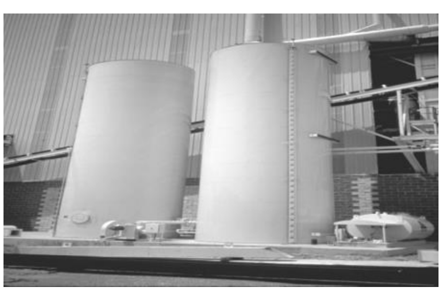
Beginning of the Standard Specification Article 1102.01(a)(6) in part

"(6) Storage Tanks for Asphalt Binders. Tanks for the storage of asphalt binder shall be equipped to heat and hold the material at the required temperatures....An armored thermometer or pyrometer that will accurately show temperatures between 200 and 400 ºF (95 and 205 ºC) shall be suitably located in the asphalt line or within the tank. The instrument shall be located so as to indicate to the plant personnel the temperature of the asphalt binder."

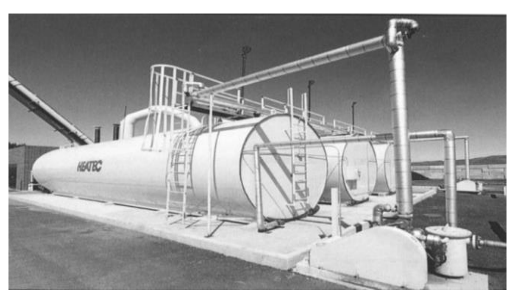
End of the Standard Specification Article 1102.01(a)(6) in part

Liquid asphalt binder is normally transported to the plant by tank truck or on rail (if rail service is available). The temperature range of the liquid asphalt binder should be from 250° F to 350° F for HMA mixtures and shall not be unloaded if above 350° F.

With temperatures above 350° F, important volatiles will be damaged or cooked off resulting in poor performance of the 'glue' used to hold the HMA mixture together. This is true for most all liquid asphalt binders except the newer polymer binder materials now being used. For the new polymer binders, refer to manufacture recommendations for heating temperatures and methods.



Vertical Storage Tanks



Horizontal Storage Tanks

8. Anti-Strip Additives

An anti-strip additive is a product added to HMA mixture to help increase to cohesiveness or bonding of the liquid asphalt binder to the aggregate material of the mixture. Once the bond is lost between the aggregate and liquid asphalt binder, the mixture will start to unravel which will lead to potholes and shortened pavement life. Determination of whether the anti-strip additive is needed is established by running the Tensile Strength test (TSR) during the mix design process. Currently there are two forms of anti-strip additives that may be used; a liquid additive and hydrated lime. Contract specifications for the job and mix design results will control the rate and type of anti-strip additive that is required to be used.

Beginning of the Standard Specification Article 1102.01(a)(8) in part

"(8) Equipment for Anti-Strip Additives. When an anti-stripping additive is required and a liquid additive is used, it shall be added to the asphalt binder by means of an approved in-line blending system located between the plant supply tank and distribution on the heated aggregate.".....“When lime is used as the anti-stripping additive, a separate bin or tank and feeder system shall be provided to store and accurately proportion the lime onto the aggregate..."

End of the Standard Specification Article 1102.01(a)(8) in part

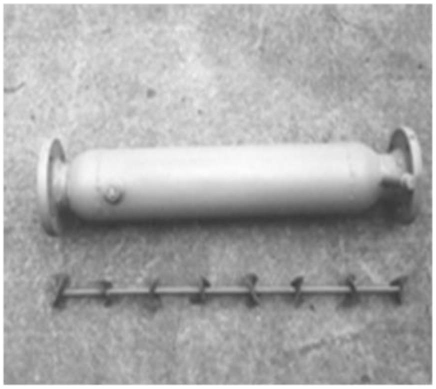
Effects of Liquid Asphalt Binder Stripping

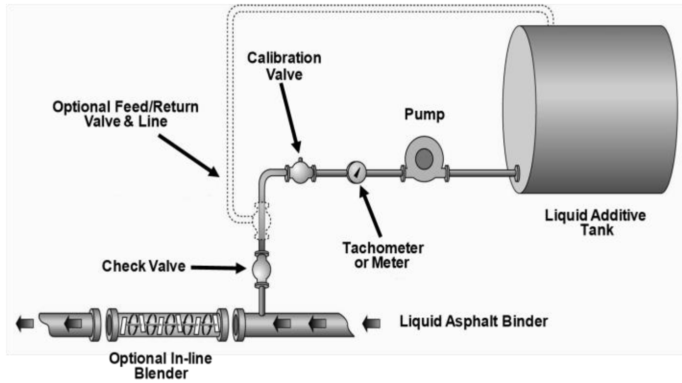
The two forms of anti-strip additives are currently being used in Illinois at this time, liquid and dry hydrated lime.

a) Liquid anti-strip additive. There are a couple of ways liquid additives can be added.

1) The additive may be added by means of a dispensing unit and inline blender. The dispensing unit and inline blender shall be capable of controlling the introduction of the additive into the liquid asphalt binder within $\pm$ 10% of the amount specified or required. The inline blender should be located as close to the weigh bucket or spray bar as possible.

2) The correct amount of liquid anti-strip additive may be added to the liquid asphalt binder as it is unloaded into a storage tank at the plant if the proper equipment is used (such as an inline blender and variable speed anti-strip pump in combination with a known amount of liquid asphalt binder being pumped from the transport).





Inline Blender Unit Anti-strip Delivery Unit

b) Hydrated lime or slaked quicklime may be used in place of a liquid additive. There are three methods used when hydrated lime is employed as an anti-strip additive:

1) Hydrated lime is mixed with water to create a slurry. A pugmill is then used to coat the aggregates with this slurry. The aggregates are then sent to the drier where the coating is baked onto the aggregates as they move through the drier.

2) Dry hydrated lime can be applied to damp aggregates in a pugmill prior to introducing the aggregates into the drier (no slurry).

2) With a Dryer-drum plant, the hydrated lime can be injected onto the hot aggregates prior to adding the liquid asphalt binder. Equipment used in this method is similar to the secondary dust equipment using weigh pods or a metering system.

With a batch plant, the hydrated lime will be added into the weigh hopper during the batching process or using a method approved by the Engineer.

This dried-on coating will create a better bond between the liquid asphalt binder and the aggregates.

9. <u>RAP and/or RAS Equipment</u>

RAP is an acronym for ‘Reclaimed Asphalt Pavement’ and is created during the cold milling process when HMA has reached the limits of its life on the road. Roadways are milled to remove or profile the driving surface to create a level stable base on which the new material will be placed. When RAP is used, it is limited to the cold millings removed from roadways or airfields maintained under federal, state or local agency jurisdiction to insure the quality of materials.

RAS is an acronym for ‘Recycled Asphalt Shingles’. RAS is available from two sources:

a) The waste generated at an asphalt shingle manufacturing facility

b) The waste generated from the tear-off during roof replacement.

Both of these products contain recyclable materials that can replace some of the ‘virgin’ materials used in HMA. In turn, this will reduce production costs, reduce the demand for the production of new materials and is beneficial to the environment by keeping these materials out of the landfills.

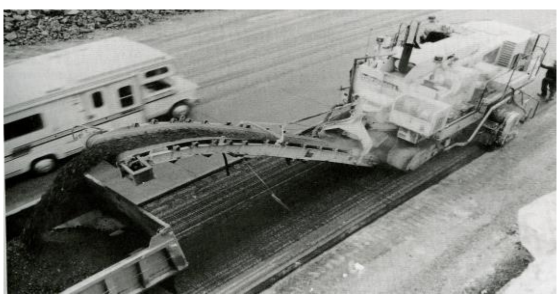
Each of these recycled products will contribute a certain percentage of aggregates and liquid asphalt binder to the mixture making them attractive ingredients for HMA producers. With the current specifications, these materials can be used in most HMA mixtures placed on Illinois roads. Specifications pertaining to and covering RAP and RAS are found in chapter 4 of this manual.

When a producer opts to include RAP or RAS in a mixture, the material has to be crushed, screened or fractionated to the proper size for the mixture in which it is to be used. Producers are required to document the weights of all mixture ingredients, including RAP and RAS materials, used in HMA mixes produced in Illinois. This can be achieved by a weigh-bridge (dryer-drum plant) or weigh hopper (batch plant). RAP and RAS cold feeds are to be calibrated.

<u>Beginning of the Standard Specification Article 1102.01(a)(9)</u>

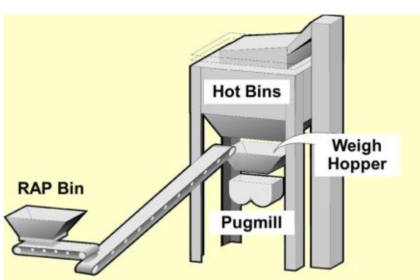
“(9) Equipment for RAP/RAS. When the RAP/RAS option is used, the plant shall be modified to ensure a homogenous, uniformly coated mix is obtained. A scalping screen, crushing unit or comparable sizing device shall be used in the RAP/RAS feed system to remove or reduce oversized material. Modifications shall be approved by the Engineer.”

<u>End of the Standard Specification Article 1102.01(a)(9)</u>

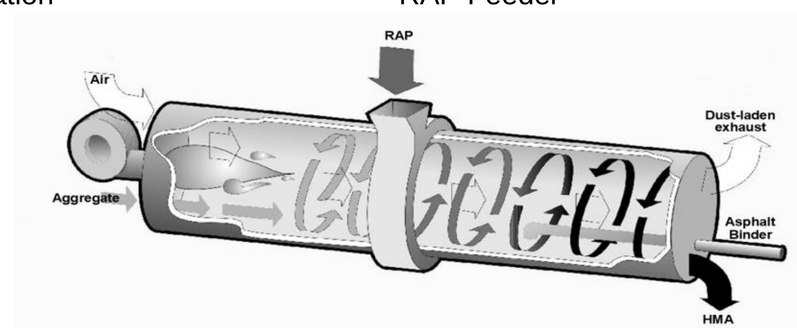


Cold Milling Operation

RAP Feeder

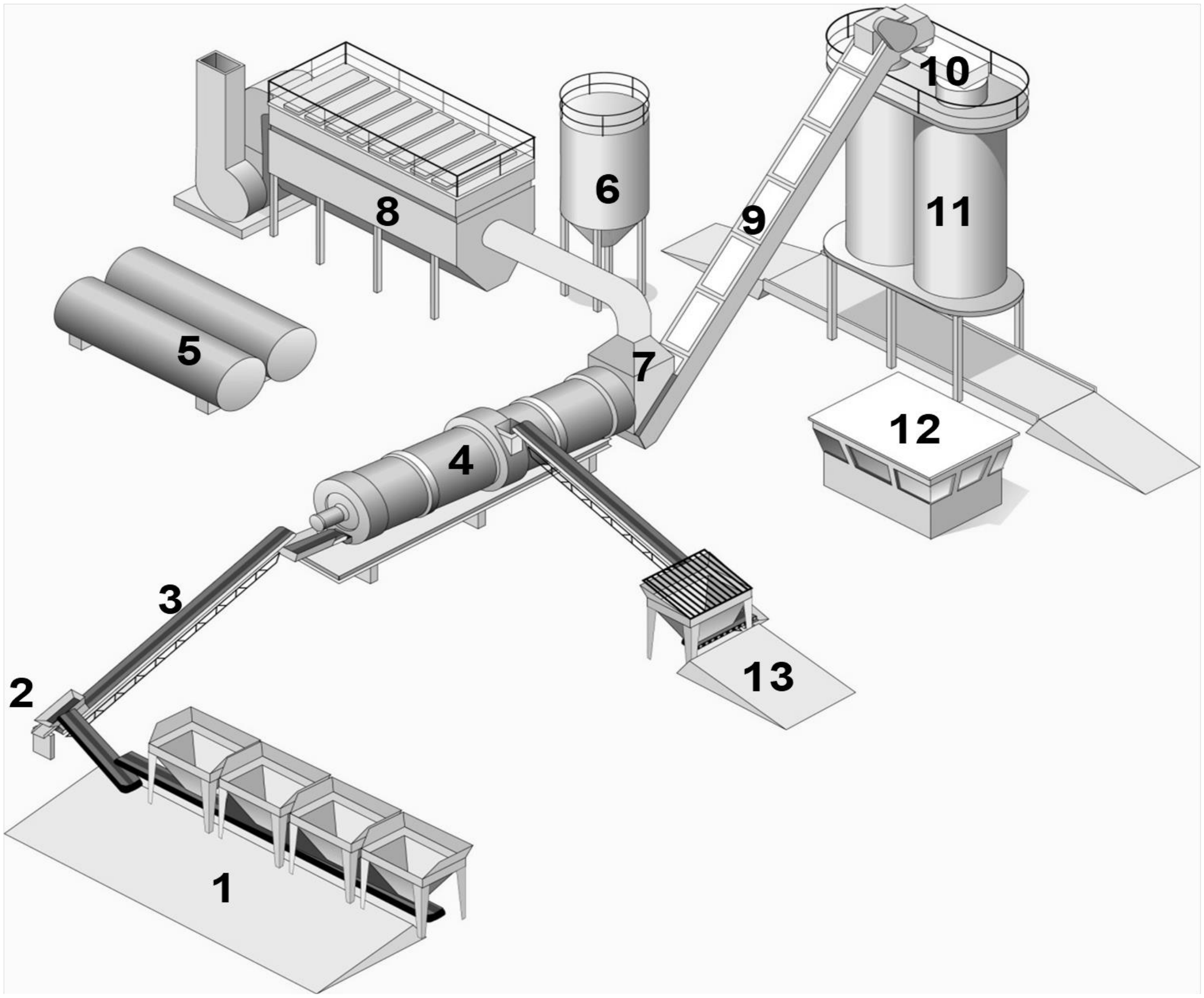


Batch Plant



Dryer-drum Plant

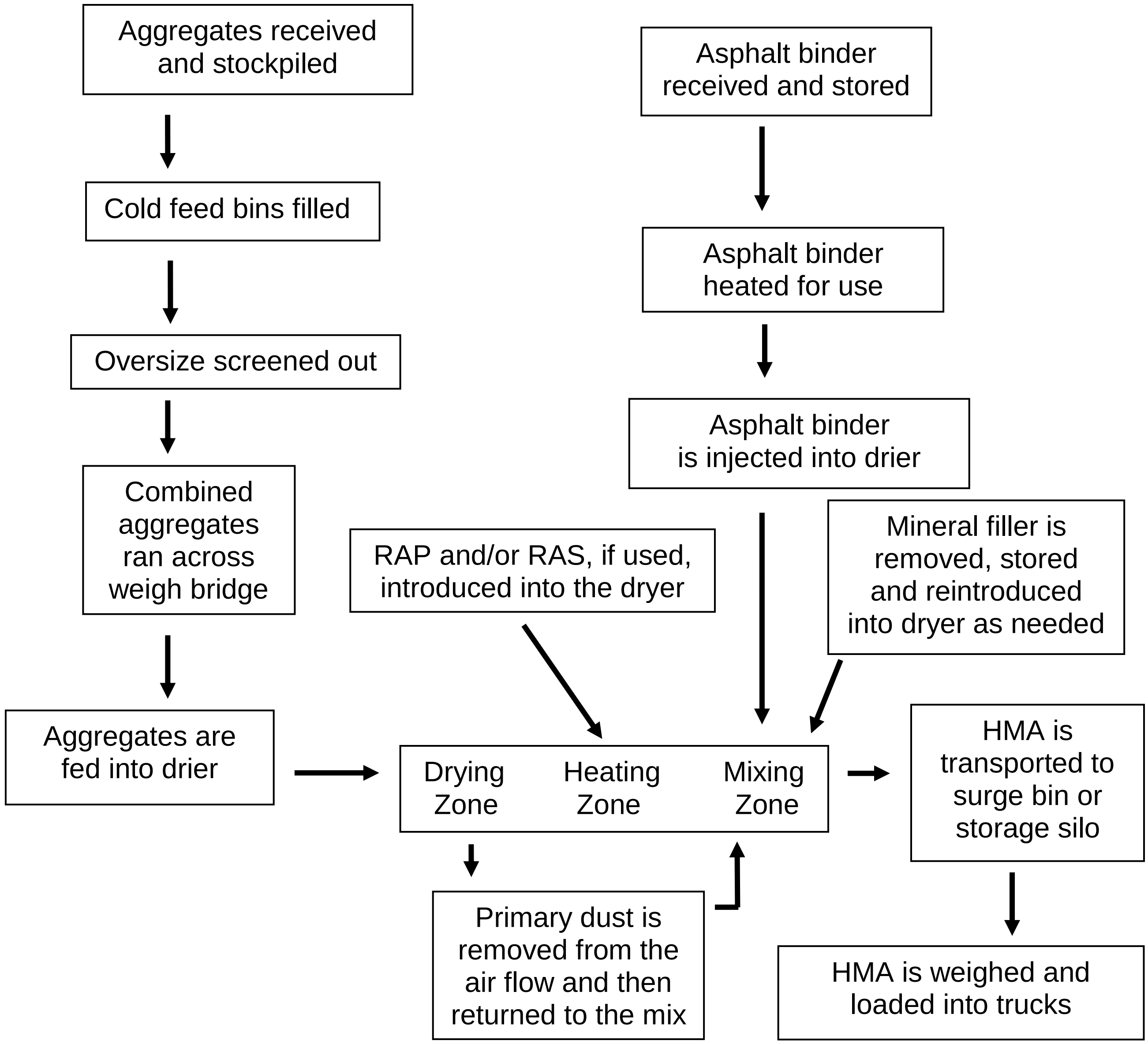
Dryer-Drum Plant Layout



Major Parts of a Dryer-Drum Plant

1. **Cold Feed Bins**
2. **Scalping Screen**
3. **Weigh Belt**
4. **Drum Mixer**
5. **Hot Asphalt Binder Storage**
6. **Mineral Filler System**
7. **Primary Dust Collector**
8. **Secondary Dust Collector**
9. **Slat Conveyor / Elevator**
10. **Gob Hopper**
11. **Surge or Storage Bins**
12. **Control Trailer**
13. **RAP and/or RAS Feeder**

Dryer-Drum Plant Material Flow Chart



DRYER-DRUM COMPONENTS AND OPERATION

Although the dryer-drum plant and batch plant is very similar in how the final product is created there are major differences in the equipment and the processes used to produce the HMA material. When dealing with dryer-drum plant requirements refer to Articles 1102.01 (a) and 1102.01 (c) of the Standard Specifications.

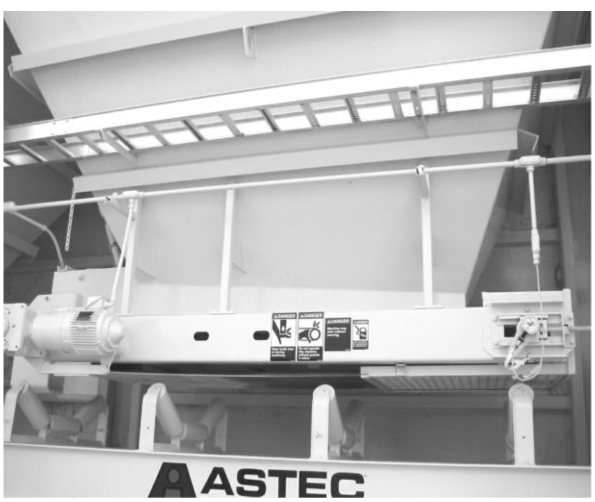
1. <u>Cold Feed System</u>

See Article 1102.01(c)(8)(a)

In most cases, the cold feed system is basically the same for dryer-drum and batch plants; a minimum of four bins with dividers, adjustable locking gates, variable speed belts and automatic master controls. But because of some differences in plant operations, the cold feeds for dryer-drum plants have extra requirements for the cold feed system including; individual cut-off controls, speed of the feeder measured in TPH or RPM off of the tail shaft. The greatest difference is that all the aggregate proportioning is done at the cold feeds which require accurate calibrations of the feeders.

Since there are no bins used to measure the aggregate materials, the cold feed system will be equipped with a cut-off system to detect the absence of materials from an empty or plugged feeder. The cut-off system is usually triggered by limit switches on arms located at the gate opening of the feeder. The limit switch is held open by the flow of material and activates an alarm in the control room when materials stop.

Since the aggregate ingredients of the HMA mixture make up approximately 90% to 95% of the total mixture volume, it is of great importance that the cold feed system is working properly and feeding the correct amount of aggregate materials to fulfill the aggregate proportions of the mix established during the design process. Because of this, specifications require the aggregate/RAP feeders to be accurate within ±1.0% and the RAS feeders ±0.5% of the actual material being delivered by the feeders as compared to the calibration results.



Non-bridging Cold Feed

Open Top Cold Feed Bins

2. <u>Scalping Screen</u> See Article 1102.01(c)(2)

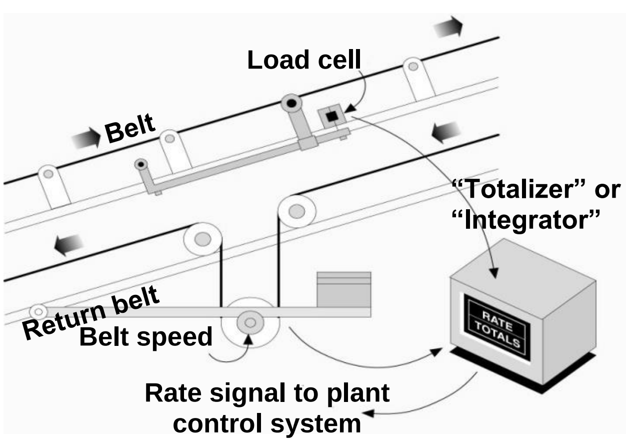
The cold feeds will be equipped with a vibrating scalping screen system to remove any foreign or oversize materials before the combined materials enter the drier. The scalping screens can be individual scalping screens on each feeder or one single scalping unit. This vibrating scalping system will be equipped with screens meeting the maximum nominal top size for the mixture to insure no oversize aggregates get into the mixture. With a dryer-drum plant, this is the only time the aggregate materials are screened. In addition to removing oversize or foreign materials, the screening unit will mix the aggregate materials into a combined state helping to create gradation consistency. It should be noted that the vibrating scalping unit will be independent of the weigh bridge.

Single Scalping Screen

Individual Bin Scalping Screens

3. <u>Weigh-Bridge (Weigh-belt) Conveyor System</u> See Article 1102.01(c)(3)

A dryer-drum plant runs in a continuous non-stop motion and is not designed to store the heated aggregates of the mixture in bins like the batch plant. Because of this continuous non-stop production, a dryer-drum requires a piece of equipment, not found on a batch plant, to weigh the aggregate materials. Instead of using scale heads or weigh buckets, the dryer-drum plant employs a continuous belt weighing system that determines the weight of aggregate material as it passes across a weigh-bridge. This continuous weighing system normally utilizes load cells that senses the weight of material on the belt as it passes across. During windy conditions, the weigh-bridge has to have rigid wind guards in place to prevent gusting winds from affecting the weighing capability during production.



Weigh-bridge

Information from the load cells and speed sensor is sent to the control console. These aggregate weight readings are then corrected for moisture and converted to dry tons per hour. Based on preset percentages of asphalt binder, mineral filler, and any other additive, the computer will then determine the correct amounts of these ingredients needed to produce the mixture at the desired rate of production.

In order to insure the weigh-bridge is working properly, specifications require that the weigh-bridge be calibrated at the beginning of the production season and checked on a daily basis when producing asphalt mix. The daily check is referred to as the “six minute” check. An example of a six-minute check can be found on page 2-34 of this manual.

Calibration of the Weigh-Belt Conveyor

The calibration process for the weigh-bridge conveyor is somewhat similar to calibrating cold feeds where material will be run over the weigh-bridge and collected. A tared truck and an approved truck scale must be available to collect the material for weighing. Before the calibration process begins, the plant controls for moisture have to be set to zero percent so there will be no moisture correction during this operation. While the belt is running without load (empty), the digital aggregates readout should read ‘0’ tons per hour. Once this has been accomplished, the procedure will be as follows:

a) Feed material from one or more of the aggregates feeders over the weigh-belt conveyor and divert that material into a tared truck.

b) When the truck is nearly full, shut off the aggregates feeder(s) and allow the belts to clear and all of the material to go into the truck.

c) Weigh the truck and also read the accumulated tons of material on the control console.

   NOTE: For proportioning control, the weight of material in the truck and the console reading shall not vary more than 0.5 percent.

This process will be performed at least three times per production rate for a minimum of three production rates. In other words, this process is done a minimum of nine times to insure a complete check on the range of production rates. On the weigh belt, these rates shall be 50%, 75%, and 100% of the approved plant production rate. On a RAP or RAS weigh belt; the calibration rates are normally 10% of the lowest production rate and 50% of the highest approved plant production rate. See the next page for an example of a calibration.

Weigh Bridge Load Cell

Hanging Weight on Weigh-bridge

Weight-Belt Conveyor Calibration Example (@ 500 TPH)

Rate	Gross Wt. (lbs.)	Tare Wt. (lbs.)	Net Wt. (lbs.)	Net Wt. (tons)	Console Wt.	Difference
250	44520	18520	26000	13.000	13.015	0.1%
	44120	18520	25600	12.800	12.812	0.1%
	44260	18520	25740	12.870	12.920	0.4%
375	44360	18520	25840	12.920	12.935	0.1%
	44580	18520	26060	13.030	12.982	- 0.4%
	43980	18520	25460	12.730	12.780	0.4%
500	43980	18520	25460	12.730	12.750	0.2%
	43880	18520	25360	12.680	12.710	0.2%
	44580	18520	26060	13.030	12.980	- 0.4%

RAP or RAS Weigh Belt Conveyor Calibration Example (@ 500 TPH)

Rate	Gross Wt. (lbs.)	Tare Wt. (lbs.)	Net Wt. (lbs.)	Net Wt. (tons)	Console Wt.	Difference
50	43250	19260	24260	12.130	12.180	0.4%
	43480	19260	24220	12.110	12.175	0.5%
	43520	19260	24260	12.130	12.150	0.2%
250	44520	19260	25260	12.630	12.680	0.4%
	44360	19260	25100	12.550	12.580	0.2%
	43200	19260	23940	11.970	11.982	0.1%

6-Minute Check Target Value

Once the main weighbridge is calibrated, a target value for the daily verification checks (6-minute checks) shall be established. To establish this target value, weights furnished by the manufacturer shall be hung on the weighbridge. With the weigh-bridge belt running empty and the weight(s) hung on the weigh-bridge, the plant operator will determine and record a reading for six (6) minutes from the accumulated tons counter. The process shall be performed at least three times to establish an average target value.

Once this target value has been established, a daily verification check, referred to as a six-minute check, shall be run twice per day when producing HMA materials. These daily checks are usually accomplished when preparing the plant for production in the morning and after the plant has been cleaned out at the end of the production day. These daily readings shall be within 2.0% of the established target value.

If the accumulated tons vary from the six-minute target value, one of the following reasons may have caused the difference.

a. Computer malfunctions.
b. Not maintaining proper voltage to belt conveyor.
c. Conveyor not at same angle.
d. Load cell malfunctioning.
e. Weights improperly hung on weigh bridge.
f. Moisture still set at console.
g. Weigh idlers binding with weighbridge framework.

The above listing should by no means be construed to be the only reasons for variations greater than 2.0%. If an investigation does not reveal the cause of the difference, a recalibration of the main weigh belt conveyor shall be performed.

Example of a 6-Minute Check for a Drier-Drum Plant

Target (from weight belt calibration) **20.2 accumulated tons**

Allowable Tolerance = ± 2.0% **20.2 X 0.02 = ± 0.4**

Allowable range: **20.2 – 0.4 = 19.8** & **20.2 + 0.4 = 20.6**

The acceptable range is 19.8 to 20.6 accumulated tons

Example:

Print Number	Time	Accumulated tons	6 Minute check
1st	5:00	20.6	---------
2nd	5:06	41.0	20.4
3rd	5:12	61.3	20.3
4th	5:18	81.5	20.2

Class problem

Determine if this is a valid 6-minute check Target: 35.7 accumulated tons

Print Number	Time	Accumulated tons	6 Minute check
1st	6:30	28.9	--------
2nd	6:36	65.1	
3rd	6:42	100.2	
4th	6:48	136.4	

4. <u>Drier Drum Mixer</u> See Article 1102.01(c)(6)

The minimum capacity rate for a drier for a dryer-drum plant shall be 60 tons per hour and is similar to the drier used on a batch plant but with a few differences:

a) Aggregates are heated, dried, mixed and coated with liquid asphalt binder in the drier

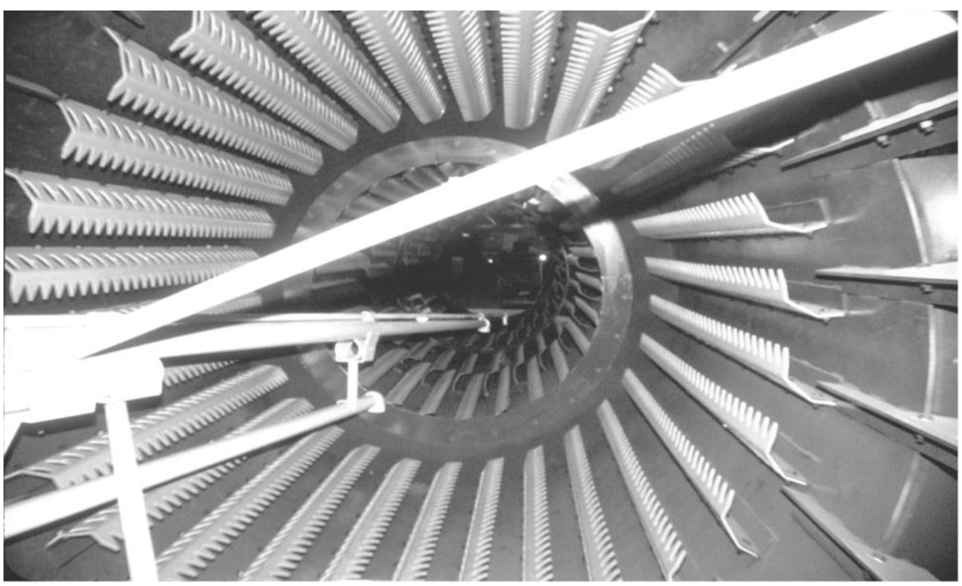
b) RAP and/or RAS is introduced into the drier drying zone

c) Primary dust and mineral filler are introduced into the drier mixing zone

There are two types of drums used on a dryer-drum plant, single and dual drum. The single drum unit incorporates the heating, drying and mixing of the aggregates in the first 2/3s of the drum. The liquid asphalt, primary dust, mineral filler is introduced in the final 1/3 of the drum, the mixing zone. RAP and/or RAS, when used, is introduced into the drum approximately 1/2 way into the drying zone. This takes direct advantage of the heated aggregates to soften these materials for proper incorporation into the mixture.

The dual drum heats, dries and mixes the aggregates in one drum then mixes and coats the aggregates with asphalt binder in another drum. This can be completed with separate drums or an inner-outer drum system.

In either type of dryer-drum plant, the aggregate materials are required to be in the drying portion of the system long enough to be properly dried and heated. Use of retarding dams, adjusting the drum slope or arrangement of the lifting flights will help to insure proper heating and drying of the aggregate materials.

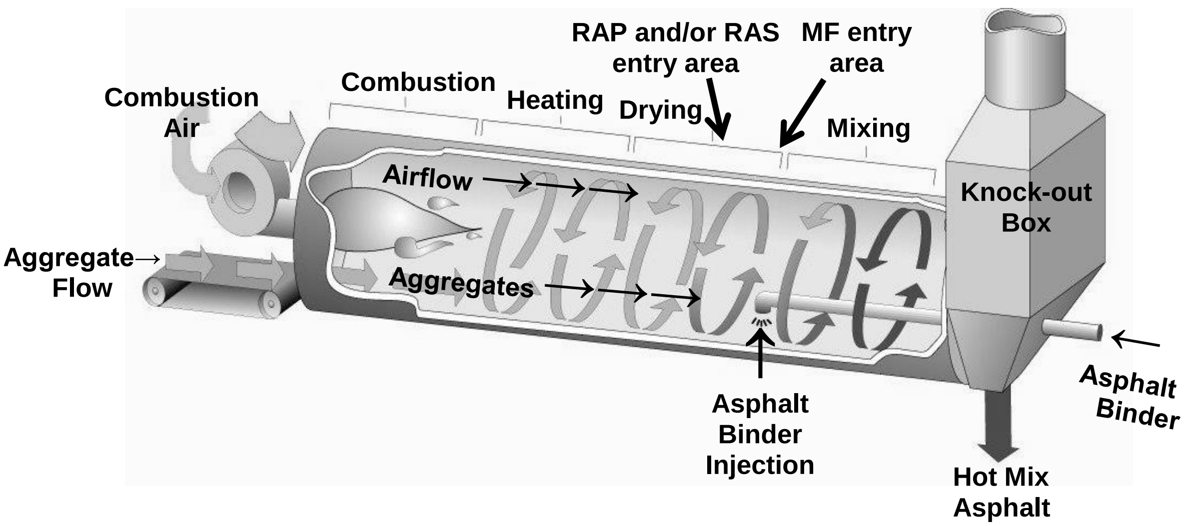


Interior of a Dryer-Drum drier with MF & asphalt binder piping and flighting

Drier drums utilize two main systems of airflow thru the plant: parallel and counter flow:

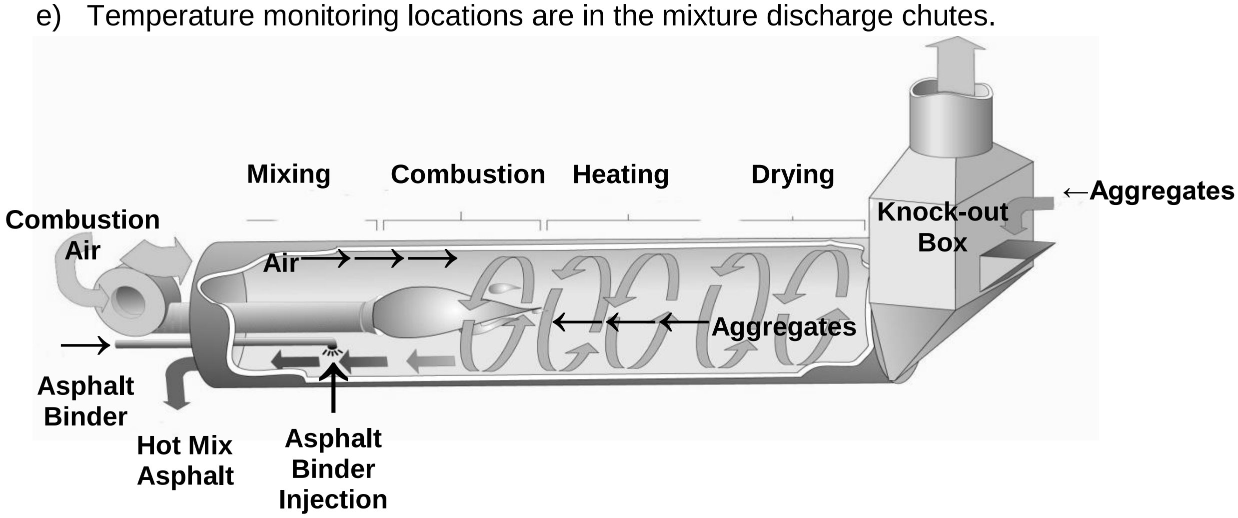
Parallel Flow Dryer-Drum Operation

a) Aggregate material enters at the burner end.
b) Aggregate material flows in the same direction (parallel) as the air flows.
c) Aggregate materials are heated and dried in first 2/3rds of the drum.
d) RAP or RAS is added approximately half way down the drum.
e) Asphalt binder and MF are added simultaneously and all ingredients are mixed in the remaining 1/3 of the drum.
f) Pyrometer is mounted in the drum discharge chute to monitor the mixture discharge temperature.

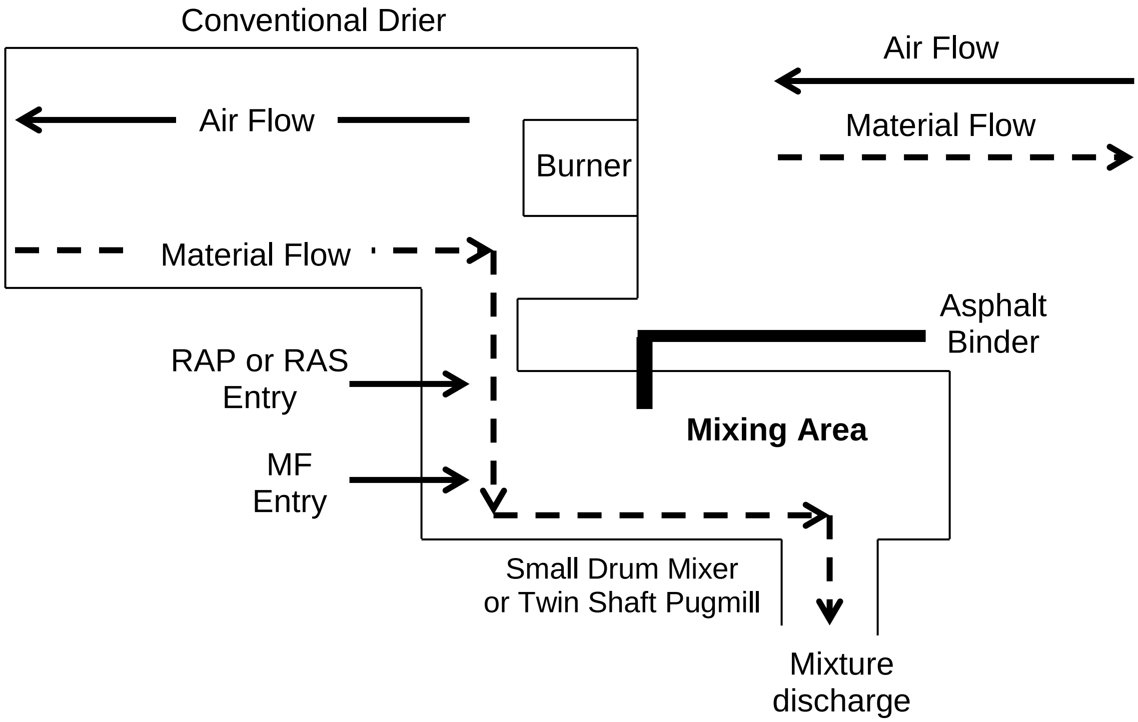


Counter Flow Dryer-Drum Operation

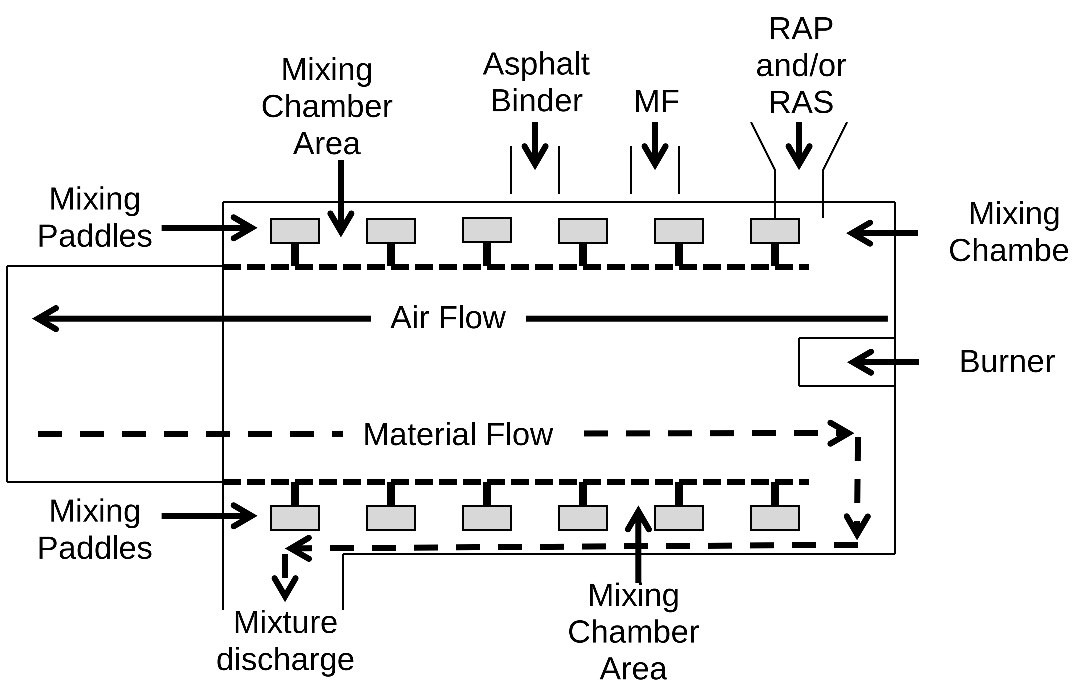
a) Material enters the drum at the opposite end from the burner.
b) Material flows in the opposite direction (counter) as the air flows.
c) Aggregate heating and drying areas differ among manufacturers.
d) RAP, RAS, Asphalt binder and MF entry points will differ.
e) Temperature monitoring locations are in the mixture discharge chutes.



Counter Flow Dryer-Drum with a Conventional Drier



"Double Barrel" Counter Flow Dryer-Drum



5. **Liquid Asphalt Binder Systems**

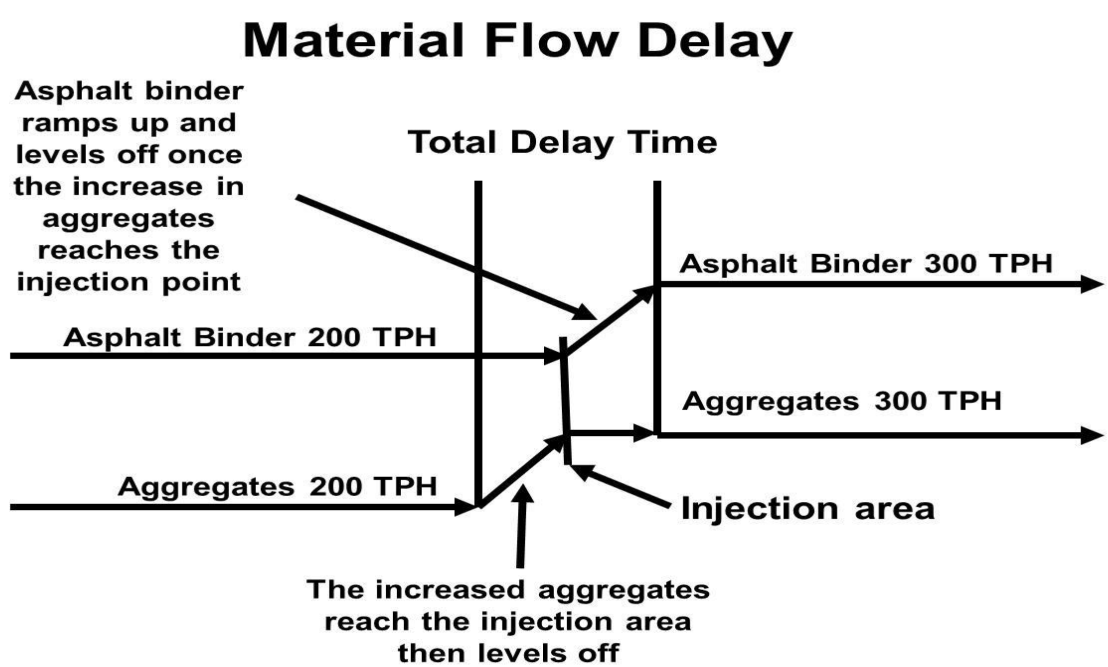
See Article 1102.01(c)(8)(d)

The liquid asphalt binder system for a dryer-drum plant is similar to the batch plant. The same type of storage facilities are used, vertical and horizontal tanks. The main difference between the dryer-drum and batch plant is the delivery system used to incorporate the liquid asphalt binder into the mixture. Most dryer-drum plant manufacturers will employ a pump and metering system differing from the batch plant which normally uses a pump and weigh bucket system. There are three basic types of asphalt metering systems used on a dryer-drum plant: volumetric/mechanical, volumetric/electronic and mass flow.

The delivery system for the liquid asphalt binder will utilize an automatic shut-off system in the event that the liquid asphalt binder stops flowing during production. The computer control system coordinates the amount of liquid asphalt binder needed with the information obtained from the weigh-bridge in order to meet mixture requirements. The control system sends instructions to the asphalt control valve to increase or decrease the amount being delivered in order to maintain the correct rate of flow of the liquid asphalt binder.

A unique situation with a dryer-drum plant is the delays needed when changing the production rate while still maintaining the correct percentage of liquid asphalt binder for the mixture during the transition change.

When the plant production rate is increased or decreased, the change in the rate of feed for the aggregate materials has to take place before the change in the rate for the liquid asphalt binder. As the aggregates materials are increased/decreased, there is a period of time for the aggregate materials to travel from the cold feeds to the point of injection for the liquid asphalt binder. The increase or decrease of liquid asphalt binder has to be delayed until the increased/decreased aggregates reach the injection location. This delay is referred to as a “material flow delay”.



Calibration of the Liquid Asphalt Binder System

The liquid asphalt binder system is required to be calibrated in order to insure proper delivery of the required percentages to meet mixture specifications and is performed comparably to the aggregate calibration process. The liquid asphalt binder is measured and collected under controlled circumstances (time vs. amount delivered). Although different manufacturer systems will require different procedures to calibrate the liquid asphalt system, the procedure is to have a collection receptacle (usually a tank truck) and an approved scale to weigh the collected material. A basic description of the calibration process is:

a) Connect the collection receptacle to the asphalt binder system and pre charge (fill) the line.
b) Set the meter to zero (0) or take an initial reading.
c) Set the asphalt binder readout on the gallon counter or ton counter on the control console to zero.
d) Pump 1,000 gallons (approximately 8,000 lbs.) into the collection receptacle.
e) Weigh the collection receptacle and determine the net weight of the asphalt binder.
f) The asphalt binder metering system (console) be in a tolerance of 0.4% of that actually delivered (net weight).

It is important during the calibration process to:

a) Maintain a constant temperature on the asphalt binder.
b) Avoid "hot" loads being added to storage.
c) Avoid pumping from a low storage level.
d) Avoid air being sucked into the line.

The meter weight and the actual weight in the collection receptacle must be within 0.4%. This procedure shall be performed at least three times at each of three flow rates and the flow rates should be at or near the expected minimum, middle and maximum amounts of asphalt binder required.

Example Calibration of Asphalt Binder Delivery System

<u>Plant Production Rate</u> 500 TPH <u>Type of System</u> Pump pushing Pump

Rate	Gross Wt. (lbs.)	Tare Wt. (lbs.)	Net Wt. (lbs.)	Net Wt. (tons)	Console Wt.	Difference
6	4500	250	4250	2.125	2.130	0.2%
	3800	262	3538	1.769	1.772	0.2%
	4000	242	3758	1.879	1.881	0.1%
18	4412	231	4181	2.091	2.089	- 0.1%
	4316	265	4051	2.026	2.021	- 0.2%
	4385	244	4141	2.071	2.079	0.4%
30	4325	300	4025	2.013	2.020	0.4%
	4368	324	4044	2.022	2.026	0.2%
	4259	285	3974	1.987	1.994	0.4%

6. <u>Mineral Filler Systems</u>

See Article 1102.01(c)(8)(d)

A dryer-drum plant will employ similar mineral filler components as found in a batch plant. There could be two storage systems, one for plant generated mineral filler and one for purchased mineral filler. Either system will use a metering system to put mineral filler back into the mixture during production. Three types of metering systems used are the vane feeder, a holding pod with a vane feeder and a weigh depletion pod. Operation of these systems are similar to the asphalt binder and is interfaced with the weigh-bridge to make certain proper amounts of mineral filler are put into the mixture based on input control percentages and the amount of aggregates going across the weigh-bridge. Material delays are set into the system to allow for material rate changes as discussed earlier.

Mineral filler can be added by weight or volume so the system used has to be calibrated within allowable tolerances to ensure proper delivery into the mixture. The mineral filler is also required to be added at the same point in the drier as the liquid asphalt binder as this will help to incorporate the mineral filler into the mixture without out loss of “fugitive” dust to the dust collection system. Mineral filler systems are required to be fitted with a cut-off system in the event the feeder becomes plugged or running short of mineral filler.

Mineral Filler Storage Systems

7. <u>Dust Collection Systems</u>

See Article 1102.01(c)(4) & (7)

Dryer-drum plants employ similar dust collection systems as the batch plant, primary and secondary, as discussed in the general plant information in the beginning of this chapter.

<u>Primary Dust Collectors</u>

The primary dust collection equipment will use either a knockout box or a cyclone collector depending on the type of drier and airflow. With a parallel airflow drier with knockout box, the fines are drawn through the material that is being mixed, which allows some of the particles to become trapped and thus are returned to the mixture. The particles that do not become trapped continue back to the knockout box, which through a drop in the airflow velocity allows the coarser material to drop out and be remixed in the final mixing area of the drum. The finer material still remaining in the airflow will continue on to the secondary collector. A counter airflow drier with cyclone collector will remove the dust material in a manner similar to a batch plant system, except that the re-entry points will vary among manufacturers.

Secondary Dust Collectors

The secondary collection equipment used on most plants today will be a baghouse although the wet-wash system is still allowed in Illinois but because of strict EPA restrictions the wet-wash systems have just about been eliminated in their use with HMA plants throughout the United States.

The operation of the baghouse is the same as at batch plants, however the fines are normally returned to the mix immediately through the mineral filler system. Some baghouse systems are equipped with a means to monitor the amount of fines being collected and allows for the addition or waste of all or part of that being collected.

The wet-wash system works in a similar manner as a standard wet-wash system found on a batch plant. As with any wet-wash system, care needs to be taken to insure the system is operating correctly because the material being wasted has already been weighed and the liquid asphalt binder being added is based on the original weight of material passing over the weigh-bridge.

Baghouses

8. Slat Conveyor or Skip-Bucket System

Since a Dryer-drum plant needs storage to maintain constant production, slat conveyors or skip-bucket systems are used to transport the HMA to the top of the silo or surge bin. The continuous conveying system is required to be enclosed, heated and/or insulated.

Slat Conveyor

Conveyor Slats

9. Surge or Storage Bins

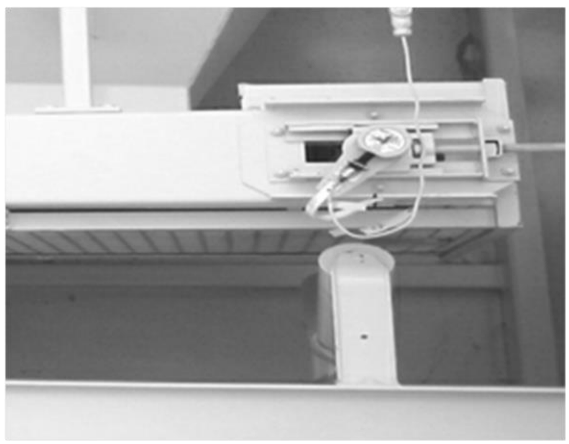
A surge or storage bin, although not required by specification, is essential on a dryer-drum plant to maintain continuous plant operations. Surge and storage bins are discussed at the beginning of this chapter and in detail in chapter 3 of this manual.

10. Plant Controls

See Article 1102.01(c)(9)

Besides normal control for plant operation dryer-drum plants require built in checks and safety guards in case of equipment malfunction or operator error. The plant controls are interlocked to set off an alarm or shut down plant operations if a failure occurs in any part of the process from the cold feeds to the storage bins. The following is brief descriptions of a few of the required controls per specification:

a) Cold feeds – variable speeds, total and proportionate, for individual bins and combined aggregate conveyors. These units will display rates in TPH or RPM. Individual bins will be outfitted with control systems to detect the absence of material flow.



Tachometer Sensor

Flow Detection Paddles

b) Weigh-bridge will be equipped with an alarm for when the actual production rate differs with the preset rate.

c) The liquid asphalt binder system will be interfaced with the aggregate flow on the weigh-bridge, the RAP and/or RAS feeder and the mineral filler system to ensure proper delivery.

d) An automatic printer is required to document in hard copy the different ingredients and their percentages being put into the mixture every six minutes or on demand.

e) Moisture compensators are used to adjust the aggregate weights for added moisture weight that will be lost during the drying process. Moisture percentages for individual aggregates or combined aggregates are input into the plant computer. Some newer plants employ automatic detectors located in the feeder system. Plant technicians need to run moisture percentages on individual stockpiled aggregates or on a combined aggregate sample obtained from a diverter chute. The following is an example of how to determine the composite moisture percentage to input into the plant controls:

Example:

Composite Aggregate Moisture Example					
Feeder #	Material	Stockpile moisture %	Mix percentages	Calculation	Proportionate moisture %
1	CM11	5.0	50.0	5.0 x 0.50	2.5
2	CM16	5.0	10.0	5.0 x 0.10	0.5
3	FM20	6.0	20.0	6.0 x 0.20	1.2
4	FM02	7.0	20.0	7.0 x 0.20	1.4
Total Composite Moisture					5.6

Given information:

Feeder #	Material		Stockpile Moisture	Mix Percentage
Feeder #1	CM11	Coarse aggregate	5.0%	50.0%
Feeder #2	CM16	Coarse aggregate	5.0%	10.0%
Feeder #3	FM20	Fine aggregate	6.0%	20.0%
Feeder #4	FM02	Fine aggregate	7.0%	20.0%

To determine the percentage to be set on the composite moisture compensator, the following calculations would be made:

Coarse Aggregate #1	5.0 x 0.50	=	2.5%	
Coarse Aggregate #2	5.0 x 0.10	=	0.5%	
Fine aggregate #1	6.0 x 0.20	=	1.2%	
Fine aggregate #2	7.0 x 0.20	=	1.4%	
			Total	5.6%

A total of 5.6% would be set in the moisture compensator as the total composite moisture.

NOTE: Some control consoles use individual aggregate moisture percentages.

Class Problem

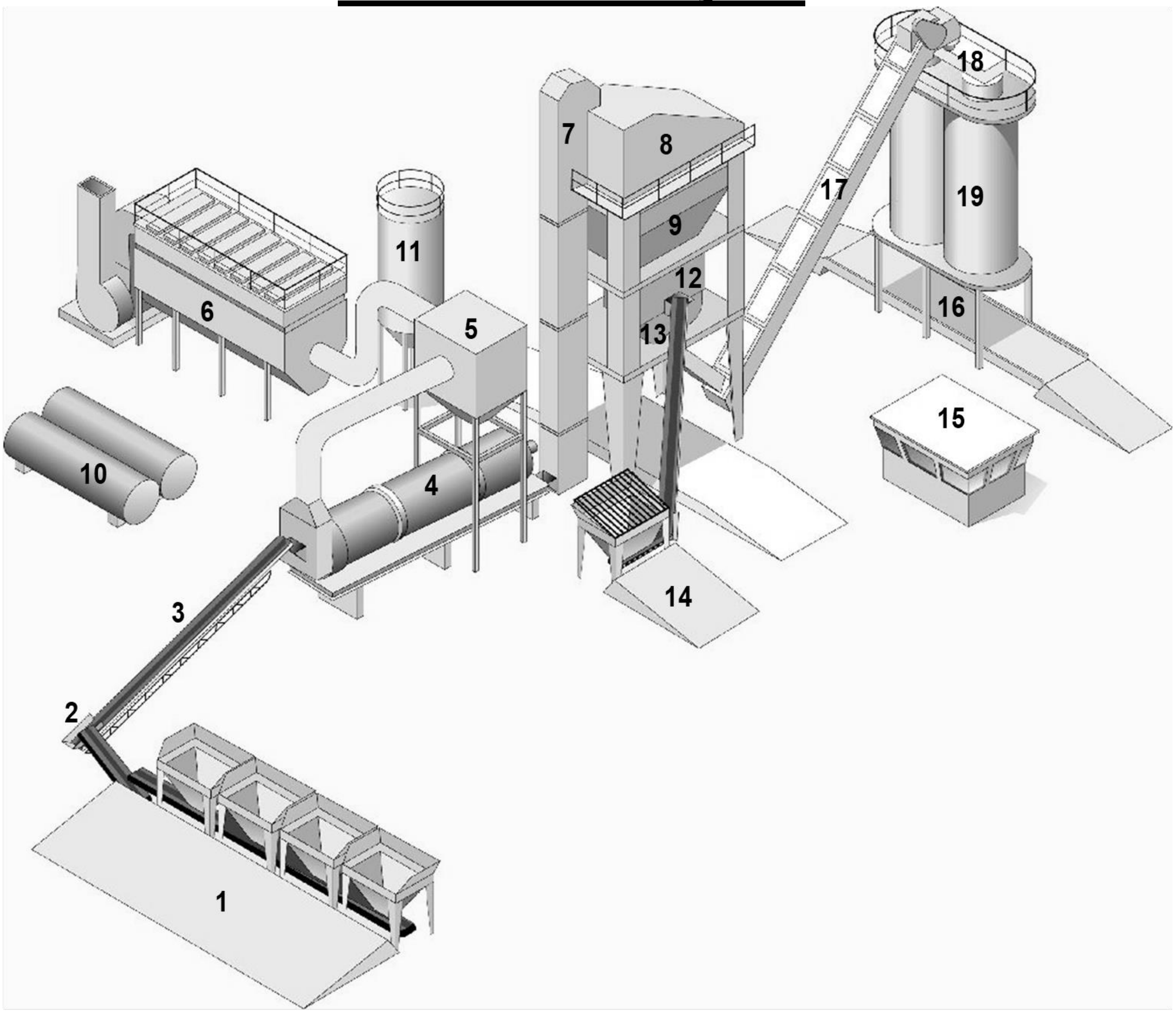
With the given information, determine the amount of composite moisture that needs to be put into the plant computer moisture compensator:

Ingredients	Mix Percent	Moisture Percent	Proportionate Moisture
Coarse Agg. #1	47.6%	4.7%	
Coarse Agg. #2	17.5%	6.3%	
Fine Agg. #1	21.0%	5.5%	
Fine Agg. #2	13.9%	6.1%	
Total Composite Moisture Percentage			

NOTE: This chapter only deals with general industry plant information based on specification requirements. Due to the extensive variations in types of the equipment supplied by the numerous manufacturers, specific operations, different configurations and calibration procedures, plant processes and equipment descriptions may need to be modified to accommodate the differences due to equipment and manufacturers available to the producer.

Descriptions in this class manual are general in nature and may or may not apply to your particular situation and/or equipment. Always refer to the manufacture's recommendations when operating or calibrating equipment.

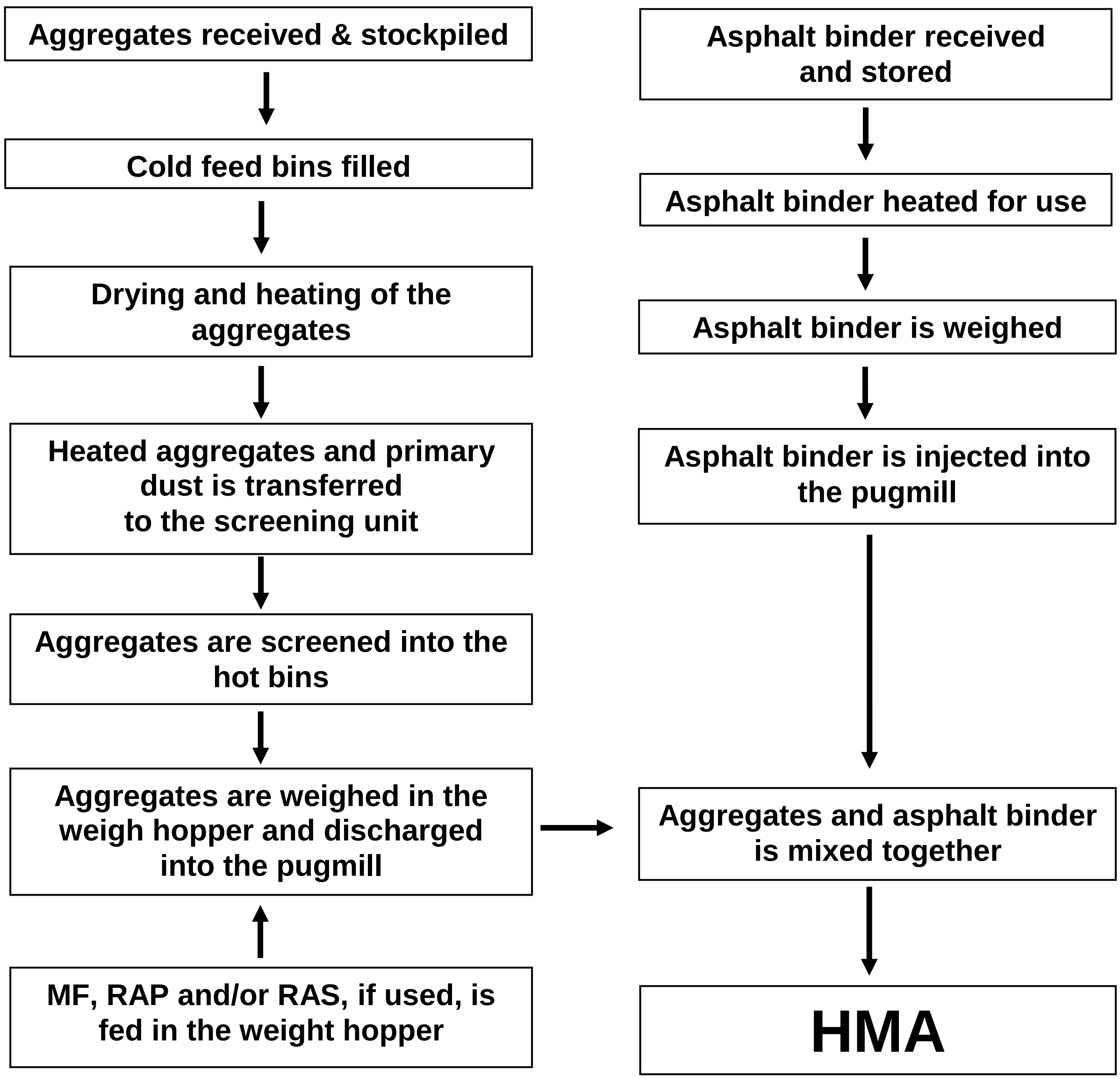
Batch Plant Layout



Major Parts of a Batch Plant

1. Cold Feed Bins
2. Scalping Screen
3. Cold Elevator
4. Drier
5. Primary Dust Collector
6. Secondary Dust Collector
7. Hot Elevator
8. Screen Unit
9. Hot Bins
10. Asphalt Binder Storage Tanks
11. Dust Collection Tank
12. Weigh Hoppers
13. Pug Mill
14. RAP and/or RAS Feeder (optional)
15. Control Trailer
16. Scales (optional)
17. Slat Conveyor (optional)
18. Gob Hopper (optional)
19. Mix Silos or Storage Bins (optional)

Batch Plant Material Flow Chart



As described earlier in this chapter, the batch plant and dryer-drum plant are very similar in how the finished product is created; aggregate is heated and dried then coated with the liquid asphalt binder to make the HMA material that is placed onto our roadways. That is where the similarities end. The dryer-drum plant utilizes equipment that measures the ingredients at a flow rate, in TPH or RPM, while the batch plant measures the ingredients based on weight per batch. The following is descriptions of the batch plant operations and equipment. When dealing with batch plant requirements refer to Articles 1102.01(a) & (b) of the Standard Specifications.

1. <u>Cold Feed System</u> See Article 1102.01(a)(3)

The cold feed system used with a batch plant is very similar to the cold feed system used with a dryer-drum plant. See the descriptions in the general section and dryer-drum section of this chapter.

2. <u>Cold Elevator</u>

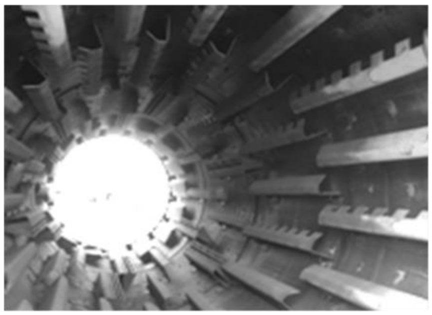
The cold elevator system used with a batch plant is similar to the cold feed system used with a dryer-drum plant with the exceptions of the scalping screen used and no weigh-bridge. See the descriptions in the general section of this chapter.

Scalping (grizzly) screen

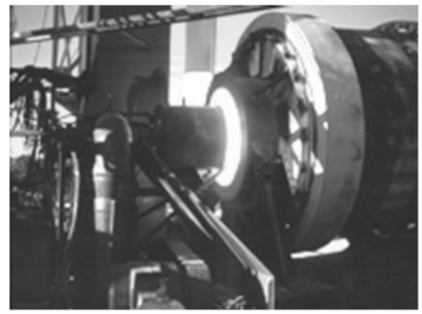
Cold elevator leading into the drier

3. Drier See Article 1102.01(b)(1)

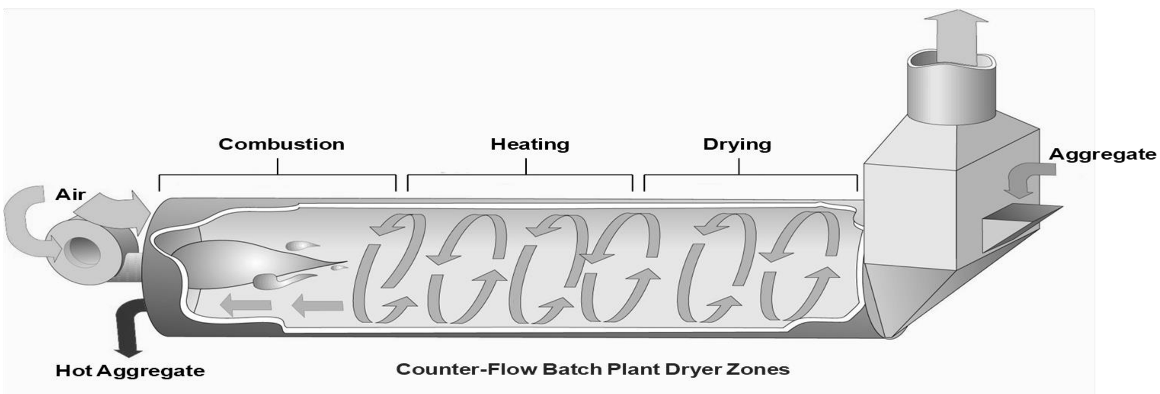
The drier used with a batch plant is similar to that used with a dryer-drum plant with the exception that the drier is only used to heat and dry the combined aggregate material. The piping found in the dryer-drum drier will be absent in the batch plant drier as mineral filler and the liquid asphalt binder is brought into the mixture during the weighing process and pugmill, respectively. See the descriptions of the drier in the general section and dryer-drum section of this chapter.



Inside of a batch plant drier



Batch Plant



4. Primary Dust Collector See Article 1102.01(b)(3)

The batch plant is required to be equipped with an approved dust collecting system. The system will collect both primary and secondary dust that is created during the production process.

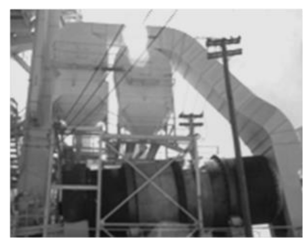
Normally, a batch plant will employ a cyclone-type collector, which utilizes centrifugal force to remove the heavier dust particles from the exhaust gas stream. This centrifugal force creates a whirling motion (a whirlwind cyclonic action) forcing the dust-laden air to the outside of the unit. The pressure on the outside of the unit is lower and this allows the heavier dust to fall out of suspension. The heavy dust will then fall to the bottom of the unit where it is then diverted to an storage hopper. The finer dust in the exhaust gas stream will remain in suspension and is carried out to the secondary collector (either a baghouse, or wet washer). Dry cyclone collectors will normally operate in the 70% - 93% efficiency range.

Once removed, the collected primary dust is to be stored in an approved hopper with a low-bin indicator. This hopper will be equipped to either waste unneeded dust or feed it into the boot of the hot elevator at a uniform rate. The feed rate of the dust will be determined by a variable speed vane feeder or auger feeder during the production. Primary dust will only be fed into the boot of the hot elevator when a full stream of aggregate is flowing from the drier.

When feeding the collected primary dust into the boot of the hot elevator, the system is to be equipped with a flow detector and automatic shut-off. This is done to prevent the primary dust from continuing to be fed into the hot elevator in the event there is a stoppage of the heated mixture aggregates flowing from the drier for any reason, thus contaminating the hotbins.

Newer batch plants will utilize a knock out box or skimmer, which is incorporated into the drier ductwork. These units work by slowing the exhaust gas stream flow allowing the heavier dust particles to drop or fall out of suspension, be collected and reintroduced or wasted as necessary. These units need to meet all requirements of a cyclone collector and when used in this capacity, they are considered to be primary dust collectors and can replace the cyclone units.


Horizontal Cyclone Collector


Dual Vertical Cyclone Collectors

5. <u>Secondary Dust Collector</u> See Article 1102.01(b)(3)

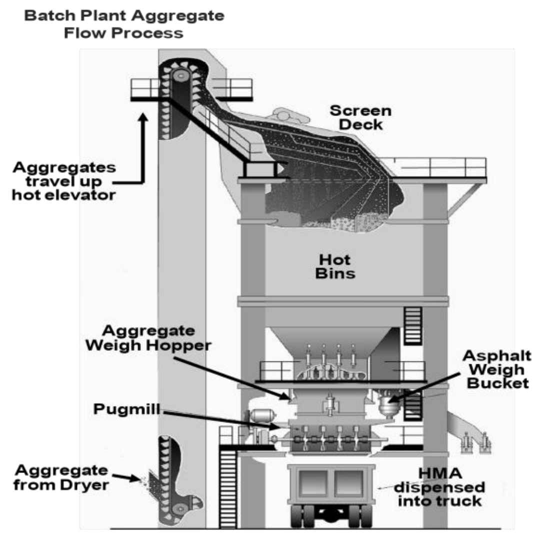
The batch plant secondary dust collector can be a wet collector but most of the industry will utilize a baghouse dust collector because of stringent pollution requirements.

The operation of a baghouse is relatively simple where filter bags collects the fine dust on the outer surface of the bags as air passes through the bags. The dust is released by shaking, pulsing, or air reversal into a hopper, and fed back into the mix as filler when needed.

Secondary Baghouse Dust Collectors

6. Batch Tower

The main difference between a batch plant and a dryer-drum plant is the way the aggregates are handled throughout the plant. While the dryer-drum plant sends a steady stream of combined aggregates through the plant in a continuous motion, the batch plant will dry and grade the combined aggregates into “hot bins” and then recombine the sized aggregates which help to better control the required gradations for the mixture. In order to carry out this extra operation, a batch plant will include a batch tower to hold the necessary equipment. The batch tower will include: a hot elevator, vibrating screening unit, hot bins, weigh hopper, scales, and a pug mill.

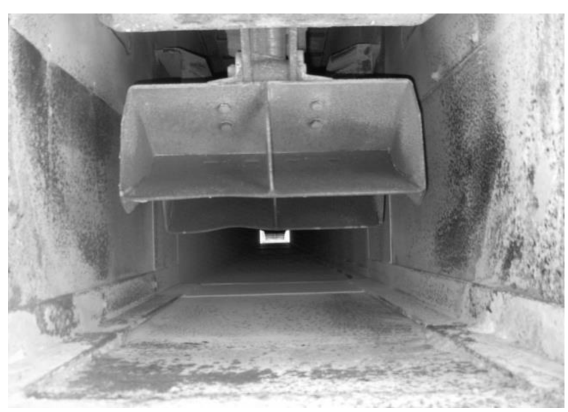


Batch Tower

7. Hot Elevator

The hot dry aggregates are carried to the screening unit on top of the batch tower by a “hot elevator” which normally will employ “buckets” to carry the hot aggregate materials.

Base of the Hot Elevator



Hot Elevator Buckets

8. **Screening Unit**

See Article 1102.01(b)(10)

The screening unit on batch plants can be either a flat vibrating screening unit or inclined vibrating screen unit. Aggregate from the drier is delivered to the screening unit, which is mounted over the hot bins. The function of the screening unit is to accurately separate the aggregate into the specified sizes. To properly perform this function, the effective screening area must be large enough to handle the maximum feed. Although screen size will vary between different manufacturers and the size of the plant, the common size is a 12 foot by 5 foot screen, which is also used in half sizes, 6 foot by 5 foot.

Issues with the screen deck include excessively worn screens, torn screens, blinding and overcrowding. Any of these issues will affect the gradation of materials going into the hot-bins which in turn will affect the properties of the HMA mixture, including density and air voids.

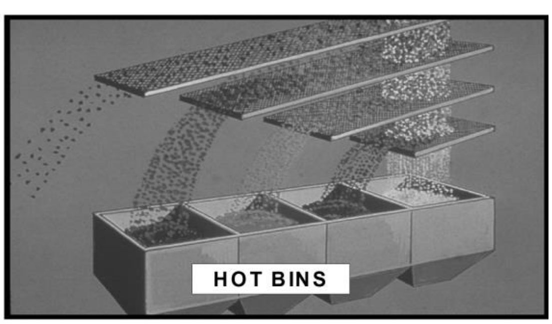
Beginning of the Standard Specification Article 1102.01(b)(10) in part

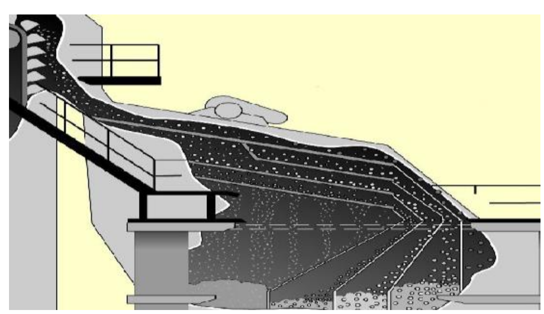
"(10) Screens…Efficiency of separation based on laboratory sieves, shall be such that no more than 20 percent of the material in the bin is smaller than neither the nominal size nor more than 10 percent over size for that bin."

End of the Standard Specification Article 1102.01(b)(10) in part

The condition and cleanliness of the screens will, to a large extent, control their efficiency. If the effective screening area is reduced by plugged screen openings, or if more material is fed to the screens than they can handle, the usual result is "carryover". Carryover is the depositing of finer material in a bin that should contain the next larger size aggregate. When this occurs, uniformity of aggregate grading is often impaired. When carryover fluctuates, lack of uniformity in the aggregate gradation will cause a corresponding lack of uniformity in the mixture, resulting in alternate fat and lean areas in the finished mix. Carryover increases the amount of fine aggregate in the total mix, and since fine aggregate has much more surface area per unit of weight requiring asphalt coating, this condition should be kept at a minimum.

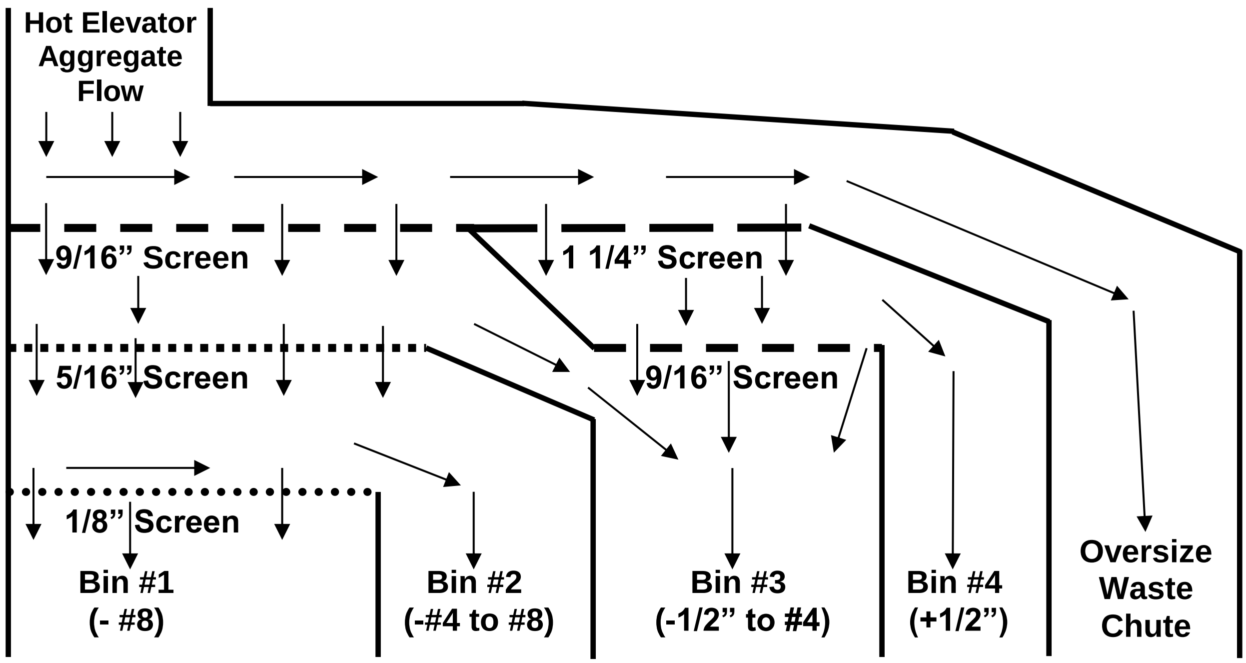
Excessive carryover, or its fluctuations, will be apparent to the technician from the sieve analysis made from the contents of the individual hot bins. Cleaning the screens, regulating the quantity of material coming from the cold feed, or combination of both may be required if conditions warrant to protect the screening efficiency.





Screen Decks

Aggregate Stream-flow for a Typical Batch Plant Screen Deck



10. Hot Aggregate Bins See Article 1102.01(b)(11)

The purpose of the hot bins is to separate the combined hot aggregates, taken from the drier, into 3 or 4 fractionalized sizes (depending on the type of mixture) which is then proportionately put back together in the weigh hopper. The advantage of the batch plant over the dryer-drum plant is the fractionalization of aggregates gives better control of the gradation of the aggregates to meet the mixture gradation requirements. Dryer-drum plants have a distinct advantage over batch plants because of the extra time needed to separate the aggregates and recombine them. Another advantage of the dryer-drum plant is the extra equipment and maintenance required to perform this fractionalization of materials. These are two of a number of reasons why the dryer-drum plant is replacing the batch plant as the asphalt plant of choice by the industry. Currently, dryer-drum plants make up about 85% of the industry while batch plants come in with the remaining 15%.

Typical hot aggregate bin setups:

a) Surface mixtures use a three hot bin setup separating the combined aggregates into various sizes. Generally, the #3 bin will contain 1/2" to #4 size material, the #2 bin will contain #4 to #8 size material and the #1bin will contain #8 to #200 size material unless directed otherwise by the Engineer.

b) Binder mixtures use a four hot bin setup separating the combined aggregates into various sizes. Generally, the #4 bin will contain +1/2" size material, the #3 bin will contain 1/2" to #4 size material, the #2 bin will contain #4 to #8 size material and the #1 bin will contain #8 to #200 size material unless directed otherwise by the Engineer.

c) Although not common, when a five hot bin setup is used, the combined aggregate materials will separate into the following various sizes. Generally, the #5 bin will contain +1/2” size material, the #4 bin will contain -1/2” to 5/16” size material, the #3 bin will contain -5/16” to #4 size material, the #2 bin will contain - #4 to #8 size material and the #1 bin will contain -#8 to #200 size material unless directed otherwise by the Engineer.

Some issues with the hot bin system is size intermingling (contamination) caused by worn or damaged screens, plugged waste chutes, worn bin gates, holes worn in the bin walls or fines collecting in the bin corners (usually the #1 bin) and shortages or overruns of the bin levels. When intermingling of aggregate in the hot bin occurs, the mixture gradation changes, which can affect mixture attributes such as density and air voids. Routine sieve analysis of the aggregate in the hot bins will detect and confirm these issues. The attending plant technician, with experience, will learn to recognize contaminated hot bin samples

Aggregate size contamination can occur from worn or damaged screens allowing oversize materials into the wrong bins. Another form of bin contamination can be caused by plugged waste overflow chutes which allow material to cross over bin partition walls as a bin overfills with material. Because of this potential contamination of materials, each hot bin shall be equipped with an overflow pipe to prevent aggregate from backing up and overflowing into other bins. The overflow pipes shall not be connected to the boot of the hot elevator.

As the hot aggregates are discharged from each hot bin the plant computer and hydraulics control the doors of the hot bins. If these doors don’t close completely or wear out from normal use, the hot aggregates will continue to be released from the bin replacing other size of materials during the weighing process, which then will affect the gradation of the mixture, and in turn, affecting the density and air voids of the mixture. Another issue, which is discouraged, is the plant operator using manual controls to weigh up the individual hot bins, which can affect the mixture, if care is not taken to be as exact as possible with the required weights for each batch.

Because of the constant wearing and friction on the metal walls of the bins, holes can be created. A past practice, which is not allowed, is to cut holes in the bin partition walls to help keep the bins balanced. Both issues will allow material to pass from one bin into another, changing the gradation and mixture properties.

Sometimes material tends to hang up in the bin corners, usually with the finer fractions of the aggregates in the #1 hot bin. As the material falls into the #1 bin, the fines will build up into the vertical corners of the bin and eventually release into the weigh hopper into a batch of mixture. This will result in an excessive amount of fines, which tends to dry up the mix. This surge of fine material normally occurs when the bin material has been reduced to a low level. Welding fillet plates in the bin corners to eliminate the 90-degree angles can alleviate the condition.

If the aggregate materials coming into the plant are segregated, fine or coarse, this will create bin shortages or excesses and must be corrected proportionally by adjusting the cold feeds. This problem can be determined by excess material coming out the overflow chute or constantly waiting on material during the weighing process. To remedy this problem, the stockpiled aggregates need to be in the proper gradations matching the design and following the correct handling procedures of the aggregates established with the AGCS program while feeding material into the plant.

Another issue with a batch plant hot bins is when you change the type of HMA mixture, the plant hot bins should be emptied of all the material. Because of the different gradations of individual aggregate products and the unique combined gradation of the mixture, the hot bin gradations will be different for each type of mixture, especially when switching between surface and binder mixtures.

Hot Bin Sampling

Because the batch plant recombines the aggregates into a unique gradation and the fluctuations in the individual shelf gradations used in the mixtures, the Level 2 HMA technician needs to take and run gradations on the individual hot bins in order to control the mixture and determine gradation compliance with the mixture specifications.

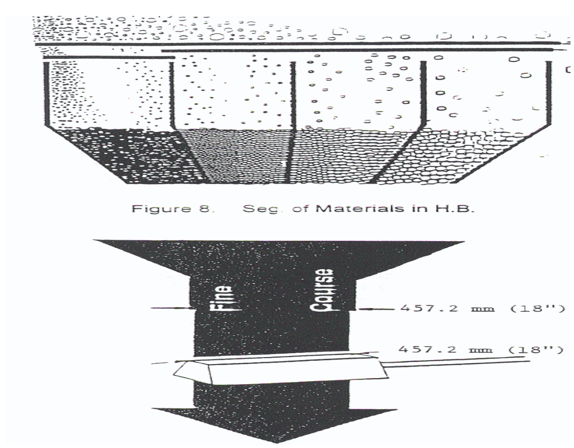
Beginning of the Standard Specification Article 1102.01(b)(11) in part

“(11)…Bin will be constructed so that samples can be readily obtained…“

End of the Standard Specification Article 1102.01(b)(11) in part

Most modern HMA plants are equipped with devices for sampling hot bin aggregates. This will vary from sampling "gates" or "windows" in the sides of the bins, to devices for diverting the flow of aggregate from the bins into sample containers. In the case of batch plants, however, the best place to obtain a representative sample is from the bin gates as the material falls into the weigh hopper. It is essential that sampling facilities be constructed and located so that the samples obtained will be representative of the material in the bins.

Even though the hot bins are the best location to get representative samples, there can be problems. As the aggregates flow over the plant screens, finer particles fall through the screens first, followed by the coarser material. The finer gradation of material will fall to the near side of the bin while the coarser particles will fall to the far side of the bin, thus segregating the material. This is most apparent in the #1 bin but can happen in the other bins on certain types of mixes.



Correct use of sampling device

As the material is drawn from the bin into the weigh hopper the stream will consist of predominantly fine material at one edge and coarse material at the other. Therefore, the sample will be composed of the fine portion or the coarse portion of aggregates and will not represent the actual material being used in the mixture.

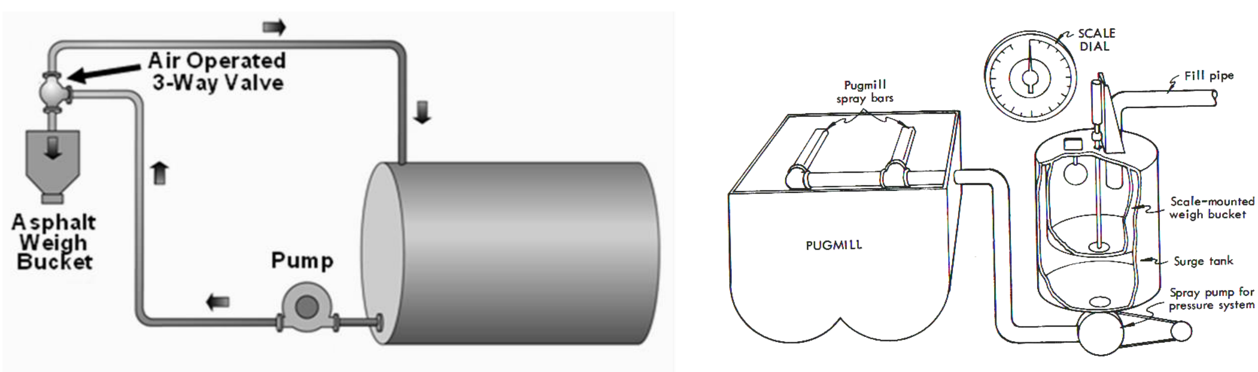
The hot bin sampling pan should be a minimum of 3" in depth. The width and length of the sampling pan shall be equal to the stream of the discharge of material.

Hot bin samples are taken to determine, by sieve analysis, the amount of aggregate needed from each bin to produce the combined gradation to meet the control target values. These samples shall be taken in accordance with the Department's procedures outlined in the “Initial Daily Plant and Random Sampling” document found in the Manual of Test Procedures for Materials. After the plant has been in operation a few days and the cold feeder setting and the hot bin weights have become well established, the hot bin samples shall be tested in accordance with Sampling Frequency requirements of the specifications. Additional hot bin check samples can be taken as a visual check for blanked or broken screens, which will require immediate corrective action.

11. <u>Liquid Asphalt Binders</u> See Article 1102.01(b)(5)

The liquid asphalt binders and storage requirements are the same for the batch plant as for the dryer-drum plant. The requirements can be found in the general information section in beginning of this chapter.

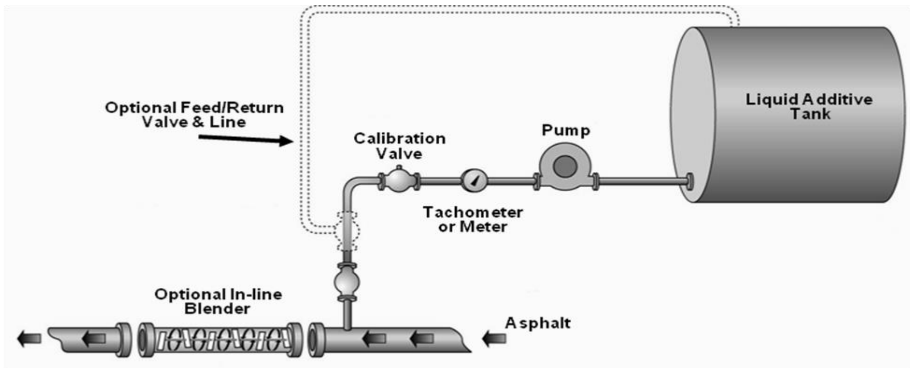
The one main difference for a batch plant is that a weigh bucket is used to determine the amount binder being incorporated into the mixture since the mixture ingredients are controlled by weights. Once weighed, the liquid asphalt binder is then metered or pumped into the pugmill. The binder is weighed as the same time as the weighing of the hot bin aggregates.



Typical Liquid Asphalt Pumping & Weighing System

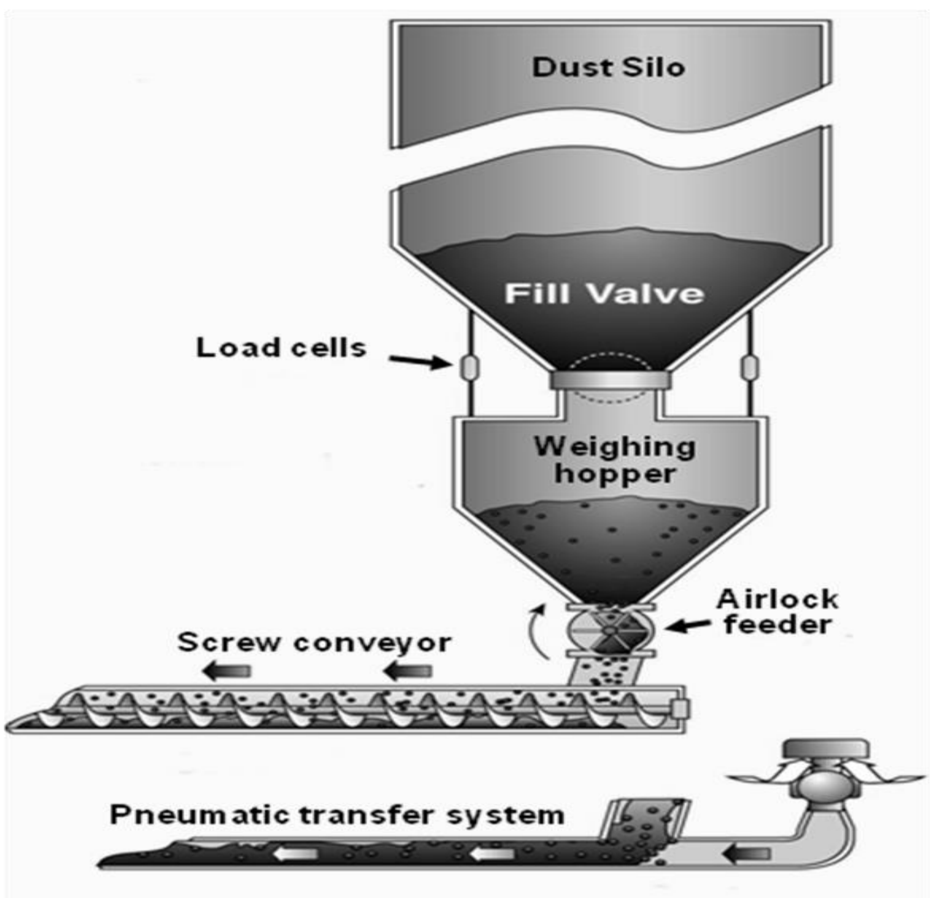
12. Anti-strip Additives

Anti-strip additives are the similar for a batch plant as for a dryer-drum plant.



13. Dust Collection System See Article 1102.01(b)(3)

The dust collection system is similar for a batch plant as for a dryer-drum plant.



14. <u>Weigh Hoppers</u>

See Article 1102.01(b)(2)

Since a batch plant controls the materials by weight then an emphasis is put on the weighing equipment to ensure proper proportioning of the ingredients. The two main weigh hoppers used in a batch plant is for aggregates and liquid asphalt binder.

<u>Beginning of the Standard Specification Articles 1102.01(b)(2) in part</u>

“(2) Equipment for Weighing or Measuring Aggregate/RAP/RAS. The equipment shall include a means for accurately weighing each size of aggregate/RAP/RAS in a weigh hopper suspended on scales and of ample size to hold a full batch without hand raking or running over. The gates shall close tightly so that no material is allowed to leak into the mixer while a batch is being weighed…”

<u>End of the Standard Specification Article 1102.01 (b)(2) in part</u>

<u>Beginning of the Standard Specification Article 1102.01 (b)(5) in part</u>

“(5) Equipment for Weighing or Measuring Asphalt Binder. The equipment used for weighing or measuring the asphalt binder shall consist either of an approved weigh bucket or metering device…”

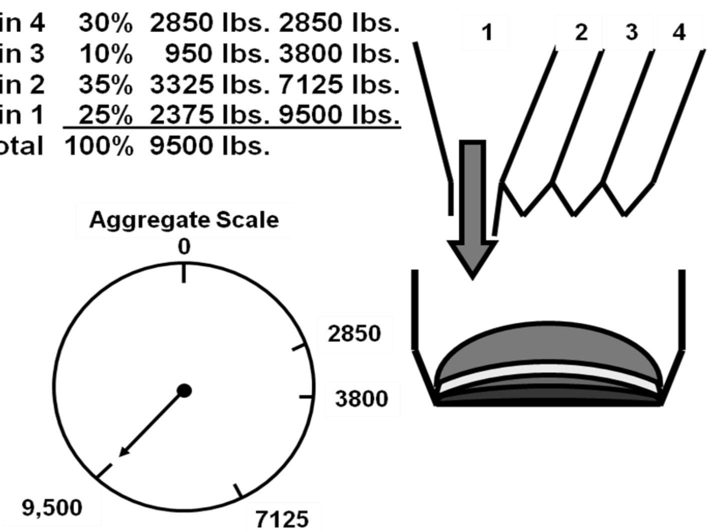
<u>End of the Standard Specification Article 1102.01 (b)(5) in part</u>

<u>Aggregate Weigh Hopper</u>

The aggregate weigh hopper is located directly below the hot bins, which consists of an approved weigh box or hopper that is to be suspended on scales of ample size to hold a full batch. The gates of the hot bins shall close tightly so that no material is allowed to leak into the mixer while the batch is being weighed.

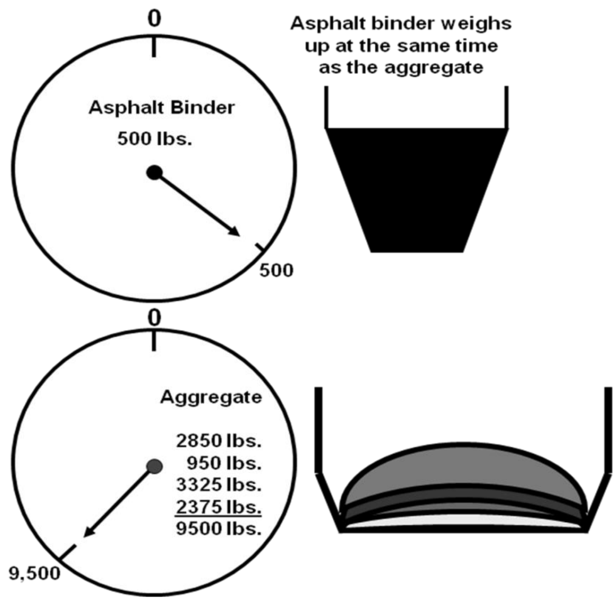
Aggregate percents for a 10,000 lb. batch @ 5% Asp. Binder

Bin 4	30%	2850 lbs.	2850 lbs.
Bin 3	10%	950 lbs.	3800 lbs.
Bin 2	35%	3325 lbs.	7125 lbs.
Bin 1	25%	2375 lbs.	9500 lbs.
Total	100%	9500 lbs.	



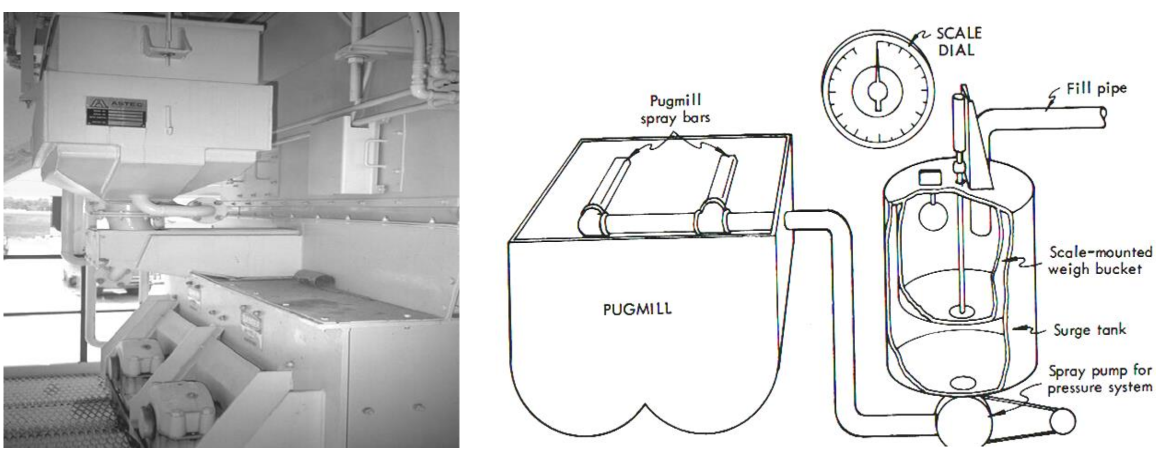
Batching Process

After the ‘graded’ material falls into the respective hot bins, it is then discharged into the aggregate weigh hopper located directly below the hot bins. The hot bins are individually discharged into the weigh hopper starting with the largest aggregate and concluding with the smallest (finest) sized material. The materials are discharged to a pre-determined accumulated weight. If mineral filler, RAP or RAS is to be added to the batch, they are typically added into the aggregate weigh hopper at the end of the weighing process. Also, as the aggregates are being batched, the liquid asphalt binder is being weighed into an “asphalt weigh bucket” to a predetermined weight.



Liquid Asphalt Binder Weigh Hopper

The asphalt binder weigh hopper shall consist either of an approved weigh bucket or metering device. If a weigh bucket is used, it shall be a non-tilting type and completely suspended from a springless dial scale or load cell.



Binder Weigh Bucket System

Scale Calibration

Specifications stipulate any material paid for by weight, with federal, state or local agency funds, require the weighing devices to be properly calibrated by an approved testing agency. The Quality Control Manager and/or Level 2 HMA technician must acquaint themselves with the applicable provisions of Section 1102 of the Standard Specifications. Scales will be a springless dial type complying with the requirements of Article 1103.02(c) of the Standard Specifications. Load cells with digital readouts may be used if approved by the Engineer.

Weigh hoppers and scales shall be provided with suitable protection from the wind and the accuracy and sensitivity of each weighing device shall then be checked to the full weight of any batch that will be used. The specifications require that the contractor furnish ten standard 50-pound weights for this purpose. It is also acceptable for the test weights to be furnished by a recognized commercial scale repairman. The calibration of the scales shall be done in the presence of the Engineer or his authorized representative.

Beginning of the Standard Specification Article 1102.01(b)(6) in part

"(6) Accuracy of Scales. The scales shall meet the requirements of the Weights and Measures Act of the State of Illinois. The scales shall be calibrated at the beginning of each construction season and as often as the Engineer may deem necessary to assure their continued accuracy....The scales shall be inspected frequently for sensitivity, sluggishness or damage. They shall be checked for accuracy at intervals of not more than one week by obtaining the net weight (mass), on truck scales, of a truckload of HMA."

End of the Standard Specification Article 1102.01(b)(6) in part

Once the scales have been calibrated and determined to be accurate, a scale check is performed on the weigh hopper(s) to insure continued accuracy. Before the start of any scale check, the scales should be carefully cleaned and inspected for any issue that could cause inaccuracy and/or loss of sensitivity. The scale shall first be balanced with the hopper empty and no load. Then the standard weights, mentioned previously, are placed on the scale one at a time and documenting the reading matches the applied weights.

When using a metering system the metering devices shall be calibrated in accordance with instructions given a dryer-drum plant operation.

Scale head

15. Pugmill Mixer See Article 1102.01(b)(7)

Beginning of the Standard Specification Article 1102.01(b)(7) in part

"(7) Pugmill Mixer. The batch mixer shall have a rating plate attached showing the manufacturer's rated capacity, and shall be an approved type capable of producing a uniform mixture within the job tolerances....The mixer shall be heated by an approved method and shall have a capacity of not less than 2,000 lb. (905 kg)… The amount of material which the Contractor will be permitted to mix per batch shall be determined by the Engineer…"

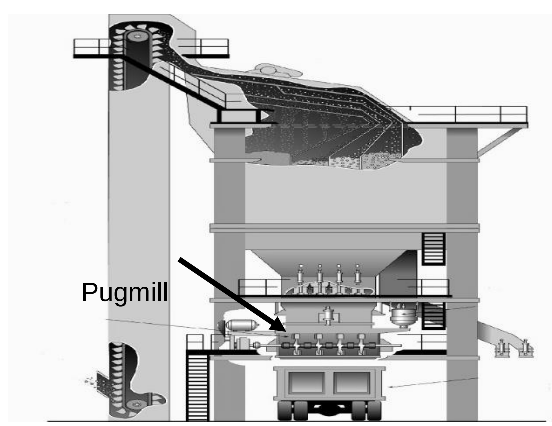
Beginning of the Standard Specification Article 1102.01(b)(7) in part

The pugmill is the unit that mixes the hot dry aggregates and liquid asphalt binder. The mixer is required to be a heated, twin-shaft unit mixing a minimum of 1 ton of material up to the rated maximum capacity. The pugmill will be interlocked with the hot bin gates, the weigh hoppers and the exit door to ensure no material enters or leaves during the mixing operation.

After the weighing of the aggregates, including mineral filler, RAP and/or RAS (if used), the aggregates will drop into the pugmill to start the mixing process. Since the hot bin materials were fractionalized into different sizes, the pugmill will "dry mix" the aggregates for a minimum of 10 seconds to ensure a uniform gradation. Once the aggregates are dry mixed, the "wet mixing" period starts and the liquid asphalt binder is injected into the pugmill. The wet mixing period will last a minimum of 35 seconds to ensure proper coating of the aggregates. If needed, the mixing times can be increased in the case of coating or mixing issues.

One problem when using RAP or RAS materials is that these materials are at a colder temperature than the hot bin aggregates so adjustments to mixing time and mix temperature is needed to make sure these ingredients break down and mix properly with the heated aggregates. The minimum dry and wet mixing time is a total of 45 seconds but can be increased to ensure a consistent mixture. In order to use RAP and/or RAS materials, the hot bins aggregates need to be "super-heated" to off-set the loss of temperature caused by the cold, damp recycled materials. This subject is covered in more detail in chapter 4 of this manual.

Pugmill Mixer



Pugmill Mixer Location

<u>Weigh Check Information</u>

Per IDOT specification, any material paid for by weight is required to be weighed for verification on approved certified scales. The following is information on documenting pay quantities based on weigh tickets and is found in the IDOT "Documentation of Contract Quantities, FY 2016:

<u>Beginning of the IDOT "Documentation of Contract Quantities, FY 2016 (page A-21)</u>

Pay quantities established based on truck weight tickets are not directly measured by Department representatives. For this reason, the following steps are taken to ensure that the quantities shown on the weight ticket are accurate:

1. *The total weight of a truck cannot be obtained by adding separate axle weighings (see Obtaining Tare and Gross Weights of Trucks below).*

2. *The scale must be checked by the Department of Agriculture (DOA). In accordance with the DOA's Bureau of Weights and Measures Inspection Program, permanent scales are to be checked during each period of 12 months, which means that the scale is inspected at sometime within each calendar year. Temporary scales are to checked at each setup. A check by a DOA-approved commercial scale company will be acceptable if the DOA is unable to provide a current inspection. The date on the decal, identification number on the decal and location of the scale shall be recorded in the Quantity Book.* ***No payment is to be made for items measured on an unapproved scale.***

3. *A State representative is to be at the scale to witness the weightings and initial the tickets. This requirement may be waived under certain conditions (see Daily Tare Weights, Automatic Ticket Printers, Weekly Independent Weight Checks, and Small Quantities).*

4. *Every effort should be made to personally collect and initial the delivery tickets for tonnage pay items, however, the inspector is only to initial those tickets that he/she personally collects. A memorandum should be written to the contract file explaining why the inspector was not present in witnessing the delivery material. A daily yield check should be conducted to justify the total amount placed.*

For certain materials, a correction factor is to be applied to the pay quantity shown on the tickets (see Aggregate Moisture Correction and Agricultural Ground Limestone Correction).

Obtaining Tare and Gross Weights of Trucks

All materials, which are paid for on the basis of truck weights, shall be weighed in accordance with the following procedure. Reference for this procedure is the Illinois Weights and Measures Act, which refers to the National Bureau of Standards Handbook 44.

"A vehicle or a coupled vehicle combination shall be commercially weighed on a vehicle scale only as a single draft. That is, the total weight of such a vehicle or combination shall not be determined by adding together the results obtained by separately and not simultaneously weighing each end of such vehicle or individual elements of such coupled combination. However:

(a) The weight of a coupled combination may be determined by uncoupling the various elements (tractor, semi-trailer, trailer), weighing each unit separately as a single draft, and adding together the results, or

(b) The weight of a vehicle or coupled-vehicle combination may be determined by adding together the weights obtained while all individual elements are resting simultaneously on more than one scale platform."

Daily Tare Weights

(Example, page F-37) To determine the pay weight of material delivered by truck, both gross and tare weights must be measured. Ordinarily, both measurements are to be witnessed by a representative of the Department. Frequently, however, the contractor's or supplier's loading operations make two separate weighings for each truck burdensome. For this reason, the Department permits the tare weights of each truck to be measured a minimum of once each day, and the measured tare weight of each is then to be used for the remainder of the day.

When daily tare weights are used, the inspector is to witness and record the tare weights for each truck used in that day's supply operation. The inspector's record must identify each truck, the tare weight of the truck, and whether the driver was in the truck during the measurement. Form BC 1465, Report of Truck Tare Weights, is available for this use. (See Small Quantities)

Weight Checks

A weight check is a comparison of the net weight of material shown on the delivery ticket to the net weight measured on another scale. The purpose of a weight check is to give some assurance that the amount of material paid for, as shown on the delivery tickets, is the amount of material delivered to the job site.

For HMA tonnage items, contractors determine the shipping weight either by direct weighing or by using the nominal batch weights. The Standard Specifications require that scales used to measure HMA mixtures be equipped with automatic printers (Art. 1102.01(a)(9)). For batch plants the specifications also allow the use of the batch weights, instead of direct scale measurement, when surge or storage bins are not used (Art. 406.23(b)). There are three types of weight checks described in the following sections, one for weekly Independent Weight Checks, and two types (which should be alternated) for ticket weights determined from batch weights. All three types require reweighing the net weight of the material on the selected truck. The difference between them is the source of the weight for comparison with the independent scales.

QC Checks by Contractor

On HMA QC/QA contracts, the contractor is also required to perform scale checks and independent weight checks as part of the QC process. Scale checks performed by the contractor are for the purpose of ensuring the accuracy of the scale equipment. The procedures used by the contractor are the same as used by state representatives for performing the three types of weight checks described in the section above, except the contractor may use the approved platform scales at the plant site or a commercial scale approved by the Engineer. The plant scale must not be the scale used for the original *measurement, but may be owned or controlled by the contractor or material supplier. QC checks performed by the contractor do not satisfy the requirement for independent weight checks to be performed by Department personnel.*

Automatic Ticket Printers

Article 1102.01 (a)(9) defines an automatic ticket printer as follows:

"The automatic printer shall be an integral part of the scale equipment or the scale and printer shall be directly connected in a manner that will prohibit the manual entry of weights except as provided in a, below.

a. *If the platform scale equipment measures gross weight (mass), the printer will record the gross weight (mass) as a minimum. Tare and net weights (mass) shall be shown on weight tickets and may be printed automatically or entered manually.*

b. *If scale equipment on a platform scale zeros out the truck tare automatically, the printer shall record the net weight (mass) as a minimum.*

c. *If the scale equipment on a surge bin weigh hopper zeros automatically after discharging each batch, the printer shall record the net weight (mass) as a minimum.*

d. *If the scale equipment on surge bins automatically shuts down the feed system and weighs the amount in the silo before and after discharge, the printer shall record the net weight (mass) as a minimum."*

For any weights recorded by an automatic ticket printer, no inspector will be required to witness the weighing and initial the ticket at the scale location. If tare weights or net weights are not automatically measured, then an inspector must still witness and record the tare weights (see Daily Tare Weights).

Weekly Independent Truck Weight Check/Action Report (Example pages, F-38-40)

A weekly random check must be performed by a State (or Local Agency and QC) representative to verify the actual weight of material delivered. Independent weight checks are to be performed as follows:

1) *The check weights will be measured on an independent, approved platform scale other than the scale on which the original measurement is performed and not owned or controlled by the contractor or material supplier. The independent scale must be approved, and the DOA decal information is to be recorded on the OQCR 2367.*

2) *Trucks are to be selected after leaving the plant, preferably at the paving location. Inspections should be unannounced and randomly scheduled. Under no circumstances should the inspector report to the plant and request a truck be loaded for an independent weight check.*

3) *Gross and tar weights must be measured and recorded, so that the actual net weight of material can be determined. Ensure the independent scale has been zeroed prior to determining both the gross and tare weights.*

4) The independently measured net weight must agree with the weight shown on the tickets within a tolerance of 0.5 percent (HMA) 0.7 percent (aggregate):

Tolerance (%) = (delivery ticket net wt – weight check net wt) X 100 / (weight check net wt)

5) The RE and contractor shall be provided a copy of the OQCR 2367. The information shall also be reported to the District office which in turn inform any other RE being supplied from the same producer. The independent weight check results are to be recorded and placed in the job file available for inspection, with corrective action taken for deviations from tolerance noted.

6) If the independent weight check results are not within tolerance, at the contractor's request, the empty vehicle may be reweighed on a second independent approved scale. The three empty weights will be analyzed to determine the validity of the independent weight check.

7) Independent weight checks must be performed at least once per week per scale (this includes any scale and batch weights) when any item is placed for which payment is based on weight tickets. If the same scale is used for several contracts during the week, a weight check performed for any one of the contracts will be sufficient for all of the contracts, as long as a copy of the check is included in the records for each of the projects. (See Small Quantities)

8) The contractor must respond to the Engineer, in writing, within 7 calendar days as to the cause and correction of the deficient scale.

Note:

a.) The DOA performs maintenance checks of scales that have current decals. If a scale is out of tolerance a red tag is used and the scale is not usable. The scale cannot be used during the time it has a red tag.

b.) The Office of Quality Compliance and Review (OQCR) is conducting random independent weight checks utilizing statewide independent scales. When an independent weight check is performed by OQCR, the Resident can utilize the weight check to satisfy the weekly independent weight check requirement outlined above.

(See Article 109.01 for additional instructions)

Documentation for Payment of Bituminous Mixtures Based on Batch Weights

The Specifications provide for measurement of the mixtures by either weighing the mixtures on approved platform scales or on the basis of plant batch weights. When measured on the basis of plant batch weights, occasional checks shall be made by weighing full truckloads of the mixture on the approved platform scale at the plant site, or on a commercial scale approved by the Engineer.

This check serves two purposes:

(a) To check the accuracy of the scales, either batch, surge bin or the platform scales; or
(b) The accuracy of batching the mixture.

The frequency of check weighing should be a minimum of one per week; however, when the plant is in continuous daily operation, the frequency preferably should be one per day.

The accuracy of the scales should be checked by observing the actual scale weight of the batches produced and comparing the total with the net weight of a truck load from the platform scale. Variation between these weights of more than 0.5 percent would indicate the batch scales or the platform scales should be checked by the Illinois Department of Agriculture.

Scale Accuracy Check *(0.5%Tolerance)*

1. *Tare a truck on an approved platform scale* — *15000 lbs*

2. *As you observe the scale dial stopping on or near the preset scale face marker, record the actual accumulative aggregate weight. Add in the mineral filler and paving asphalt weights.*

	3979.0
	3951.0
	4149.0
	3960.0
	4101.0
	4149.0
	24,289 lbs

3. *Gross the truck on the platform scale.* — *39,401 lbs*

$$\text{Tolerance, 0.5\%} = \frac{\text{net wt. (3-1) - Summation of weighed batches}}{\text{net wt. (3-1)}} \times 100$$

$$= \frac{24{,}401 - 24{,}289}{24{,}401} \times 100$$

$$= 0.46\% \text{ O.K}$$

Scale Accuracy Check Class Problem

Truck tare weight	**(item 1 above)**	**22,100 lbs.**
Observed weights	**(item 2 above)**	**10,020**
		10,000
		10,040
		30,060 lbs
Gross truck weight (item 3 above)		**52,320 lbs.**
Net weight		**________ lbs.**
Scale Accuracy Percent		**________ %**

The accuracy of batching the mixture should be randomly checked with the batch weights compared to the platform scales. The results, with an allowance for accuracy in weighing, should be checked within 0.5 percent of the gross load on the platform scale. If batch weights vary more than 0.5 percent, the batch scales should be recalibrated.

Batching Accuracy Check (0.5%Tolerance)

1.	*On an approved platform scale, weigh a random truck after it has been loaded.*	*37,840.0 lbs*
2.	*Empty it on the job.*	
3.	*Tare the returning truck on the platform scale*	*14,191.0 lbs*
	Actual net weight =	*23,649.0 lbs*
4.	*Record load ticket =*	*24,000.0 lbs*

$$\text{Tolerance, 0.5\%} = \frac{\text{load ticket (4) - act. net wt. (1-3)}}{\text{act. net wt. (1-3)}} \times 100$$

$$= \frac{24{,}000 - 23{,}649}{23{,}649} \times 100 = 1.48\%$$

Recheck and/or recalibrate scales

Batching Accuracy Check Class Problem

Given information:

Gross truck weight	**(item 1 above)**	**52,140 lbs.**
Truck tare weight	**(item 3 above)**	**21,640 lbs.**
Load ticket weight	**(item 4 above)**	**30,400 lbs.**

Net weight __________ **Batching Accuracy Percent** __________

The Specifications also require the batch scales to be calibrated at the beginning of each construction season and at other times as deemed necessary by the Engineer. The accuracy certification will be by the Department of Agriculture.

The calibration and check weighing results are to be recorded and placed in the job file available for inspection with corrective action taken for deviations from tolerance noted.

Each of the above checks can be run on alternate occasions. Report these accuracy checks on Form MI 305, Bituminous Daily Plant Output (Contractor), or form OQCR 2367, Independent Weight Check, (Agency), or other methods using the above format. Results shall be placed in the job file.

End of the IDOT "Documentation of Contract Quantities, FY 2016 (page A-25)

Illinois Department of Transportation
Division of Highways / Bureau of Construction
2300 South Dirksen Parkway, Springfield, Illinois 62764

Subject:
Independent Weight Checks and Scale Checks

CONSTRUCTION MEMORANDUM 00-08

Effective: ***October 1, 2000***
Expires: ***Indefinite***

This Construction Memorandum supersedes Construction Memorandum No. 00-08 effective April 1, 2000. This outlines the Department's Policy for the performance of independent weight checks for pay items where the method of measurement for payment is based on weight.

WEIGHT CHECKS

The Documentation Section of the Construction Manual outlines three types of weight checks which must be performed by state (or Local Agency) representatives. They include one for weekly Independent Weight Checks, and two types (which should be alternated) for ticket weights determined from batch weights.

The weekly Independent Weight Check will be documented on form BC 2367. A copy of the form BC 2367 (performed by Department personnel) will be forwarded to the Central Bureau of Construction and the Office of Quality Compliance and Review.

The two weight checks for batch plants may be reported on 1) the Bituminous Daily Plant Output Report form MI-305 or 2) the Independent Weight Check form BC 2367 or 3) other methods using the format described in the Documentation Section of the Construction Manual. Results shall be placed in the job file. Do not forward copies to the Central Bureau of Construction nor the Office of Quality Compliance and Review.

QC CHECKS BY CONTRACTOR

The Documentation Section of the Construction Manual outlines the Scale checks which must be performed by Contractors as part of the QC process on QC/QA contracts. The Scale Checks will be documented on form BC 2367 and/or the Bituminous Daily Plant Output Report. ***Copies of QC Checks by the Contractor should not be forwarded to the Central Bureau of Construction nor the Office of Quality Compliance and Review.***

Gary Gould
Engineer of Construction

Eric E. Harm
Engineer of Materials & Physical Research

Special HMA Problems

a) Extreme Mixture Temperatures

Regardless of precautions, the plant operator may at times lose control of the heating of the aggregates with the result that the mixture discharged is either extremely hot or cold. It is important that the Quality Control Manager and/or Level 2 HMA technician knows how to proceed under such circumstances.

Extremely high temperatures usually occur at the start of the operations and the Quality Control Manager and/or Level 2 HMA technician shall endeavor to be on hand to observe the first few batches discharged and to take the temperature of the mixture. The experienced Quality Control Manager and/or Level 2 HMA technician is able to spot the extremely hot batches from blue smoke rising from the mix. Often the first batch will be too hot and the second cooler, in which case the temperature probably will drop back to normal. However, if the second and third batches are also hotter than the maximum permitted, it is probable that the bins contain considerable amounts of overheated aggregates. In such event, the mixing shall be stopped and the overheated aggregates shall be drawn from the bins, discharged through the mixer into trucks. This is termed "pulling the bins". The overheated batches of mix shall be discarded.

Cold batches also usually occur at the start of the operations and, like the extremely hot batches, are the result of erroneous judgment by the plant operator in setting the valves controlling the amount of heat applied in the drier. Cold batches can be detected by a rather grayish color of the mixture, caused by the larger pieces of the aggregate not having become completely coated with asphalt binder. If the coarse aggregate particles in the first batch are seriously uncoated and the mixture is very cold, the mixing shall be stopped and the bins pulled. If the uncoated condition is only slightly apparent in the first batch, and if the temperature of the mixture is near the minimum permitted, the wet mixing time shall be lengthened to one minute, or more if necessary, to obtain proper coating. After the temperature set by the Engineer is reached, the normal mixing time may be used.

The use of batches having temperatures outside the limits set by the specifications is not allowed. If the Quality Control Manager and/or Level 2 HMA technician, by being alert and by having knowledge of just what to do, is able to aid the plant operator in the production of a satisfactory mixture, confidence in his judgment will result, and his decisions are not likely to be seriously questioned.

b) Flushing of Mixture in Trucks

Foaming of the asphalt binder as it comes into contact with aggregates not sufficiently dry causes flushing of the mixture when it is discharged into trucks. It is characterized by a sloppy foaming appearance of the mixture with the asphalt binder coming to the top. This difficulty is ordinarily experienced only in an IL-19.0 mixture, because the coarse aggregate particles are larger than in the case of an IL-9.5 mixture and are, therefore, more difficult to dry. The situation is aggravated by any condition tending to make the drying more difficult, such as rain or cold weather.

Sometimes the use of higher temperatures will dry the aggregate and stop the flushing, but may in other instances have the effect of increasing its severity. The most satisfactory remedy is to remove more moisture from the aggregates by having the contractor slow down the feed of material through the drier. The revolutions of the drier may be reduced to seven or eight per minute, or its slope or pitch may be reduced. Most dryer-drums have a slope of 1" to 1 1/4" per foot, and any slope steeper than that is likely to cause problems, especially when combined with a fast rate of turning (improperly coated aggregates, etc.).

Another flushing condition is when the hot HMA mixture is discharged into a truck bed and comes in contact with standing or puddled water. Upon contact with the hot HMA material, the water will quickly vaporize, turning into steam which then will wash or strip the asphalt binder from the aggregate materials. This is evident by puddling of the asphalt binder in the truck bed.

c) Flushing of Compacted Mixture on Road

Flushing of the compacted mixture is entirely different from flushing in the trucks, though the same term denotes both. A mixture, creating this condition, is often referred to as being "rich" or "fat". This situation usually occurs with surface mixtures (IL-9.5) and is characterized by a shiny oily appearance on the compacted mixture which is due to a thin film of asphalt binder rising to the surface. This can be caused by an excess of asphalt binder in relation to the voids in the mixture, and is corrected either by reducing the asphalt binder content of the mixture or by increasing the percentage of material passing the # 8 sieve.

d) Texture of Compacted Surface Course Mixture

Experience has shown that the desired surface texture is obtained when the mixture contains between 28 and 40 percent of the aggregate passing the # 8 sieve. A mixture containing less than 28 percent is termed "open", and a mixture containing more than 40 percent is termed "closed" or "tight". Sometimes there seems to be a point where the compacted mixture takes on a spotty appearance, part of it being open and part of it being closed. This may be avoided by decreasing the percentage of aggregate passing the # 8 sieve.

e) Intermixing of Aggregates in Bins (Batch Plant)

If hot bin samples indicate that any bin contains an undue quantity of a material belonging in some other bin, check [Section 1102.01 (b)(10) of the Standard Specifications] to determine if intermingling is excessive.

The Plant Superintendent should be notified of this condition and it should be corrected as soon as possible. If the intermingling is not excessive and can be controlled by proportioning, the work can continue and repairs made after the plant has stopped production for the day.

The following could be causes for this intermingling of aggregate sizes:

Fine Aggregates in Larger Aggregate Bins

a) Overloading or feeding material too fast and carrying finer material into the larger aggregate bins.

b) By having a clogged or blinded screen, which does not allow the fine material to pass through.

c) By having a hole in the partition between the bins.

d) By the overfilling of the fines bin which allows the material to spill over the top of the divider plate.

Large Aggregate in the Sand Bin

a) An oversize sand screen.

b) A hole in the screen.

c) A hole in the partition between the bins.

f) Errors in Batching

It happens occasionally that even an experienced mixer operator makes a mistake and discharges a batch without asphalt binder, commonly known as a "white batch", or a batch containing asphalt binder and no aggregate or only a part of the aggregate. Most plant operators, if able to look into the truck from where they work, usually will notice any mistake of this kind and take steps to correct it.

Otherwise, the Quality Control Manager and/or Level 2 HMA technician shall inform the operator, and the mixing shall be discontinued until the truck containing the defective HMA batch is removed and another takes its place. At the contractor's option, the defective HMA batch either shall be shoveled from the load or the entire load discarded. In the event that asphalt binder alone is discharged into the truck, it is necessary not only to discharge the asphalt binder from the truck but also to clean the truck bed completely. Otherwise a part of the next load transported in this truck will contain too much asphalt binder and soft flushed spots will occur on the finished HMA pavement surface.

g) Other Problems

If the mixer gate leaks asphalt binder or aggregate during the mixing operations, the contractor shall repair it immediately. This condition usually is easily corrected and shall not be tolerated. Excessive dripping of water from the plant into the mixture in the trucks shall not be permitted.

Any unusual problems arising shall be brought to the attention of the Resident Engineer, District Bituminous Supervisor, or District Materials office.

TABLE A-4 – POSSIBLE CAUSES OF DEFICIENCIES IN HMA PLANT-MIX PAVING MIXTURES

Types of deficiencies that may be encountered in producing hot plant-mix paving mixtures.	Aggregates Too Wet	Inadequate Bunker Separation	Aggregate Feed Gates Not Properly Set	Over-rated Dryer Capacity	Dryer Set Too Steep	Improper Dryer Operation	Temp. Indicator Out of Adjustment	Aggregate Temperatures Too High	Worn Out Screens	Faulty Screen Operation	Bin Overflows Not Functioning	Leaky Bins	Segregation of Aggregates in Bins	Carryover in Bins Due to Overloading Screens	Aggregate Scales Out of Adjustment	Improper Weighing	Feed of Mineral Filler Not Uniform	Insufficient Aggregates in Hot Bins	Improper Weighing Sequence	Insufficient Asphalt Binder	Too Much Asphalt Binder	Faulty Distribution of Asp. Binder to Aggregates	Asphalt Binder Scales Out of Adjustment	Asphalt Binder Meter Out of Adjustments	Undersize or Oversize Batch	Mixing Time Not Proper	Improperly Set or Worn Paddles	Faulty Dump Gate	Asp. Binder and Agg. Feed Not Synchronized	Occasional Dust Shakedown in Bins	Irregular Plant Operation	Faulty Sampling
Asp. Binder Content Does Not Check JMF			A												B	B				A	A	A	B	C	B	B	B		C			A
Aggregate Gradation Does not Check JMF		A	A						B	B	B	B	A	A	B	B	B	A							B		B	B	C	B		A
Excessive Fines in Mix		A	A							B	B	B	A	A	B	B	B	A							B	B			C	B		A
Uniform Temperatures Difficult to Maintain	A			A	A	A	A	A																							A	
Truck Weights Do Not Check Batch Weights												B		B	B										B							
Free Asphalt Binder on Mix in Truck															B	B					A	A	B	C	B		B		C			
Free Dust on Mix in Truck																			B									B				
Large Aggregates Uncoated	A			A	A	A	A													A		A	B	C	B	B	B		C		A	
HMA Mixture in Truck not Uniform										B	B	A	A	A	B	B	B	A	B			A	B	C		B	B	B	C	B	A	
HMA Mixture in Truck Fat on One Side																			B			A			B	B					A	
HMA Mixture Flattens in Truck						A																A	A	B	C	B			C		A	
HMA Mixture Burned			A			A	A	A																							A	
HMA Mixture Too Brown or Gray	A			A	A	A	A			B				A						A			B	C	B				C		A	
HMA Mixture Too Fat															B	B	B	A			A	A	B	C	B				C		A	
HMA Mixture Smokes in Truck						A	A	A																							A	
HMA Mixture Steams in Truck	A			A	A	A	A																								A	
HMA Mixture Appears Dull in Truck						A	A	A											A											A	A	

A – Applies to Batch and Drum Mix Plants. B – Applies to Batch Plants only. C – Applies to Drum Mix Plants only.

<u>Beginning of the Standard Specification Section 1102 (Hot-Mix Asphalt Equipment)</u>

"SECTION 1102. HOT-MIX ASPHALT EQUIPMENT

1102.01 Hot-Mix Asphalt Plant. *The hot-mix asphalt (HMA) plant shall be the batch-type or dryer drum plant. The plants shall be evaluated for prequalification rating and approval to produce HMA according to the current Bureau of Materials and Physical Research Policy Memorandum, "Approval of Hot-Mix Asphalt Plants and Equipment." The plants shall not be used to produce mixtures concurrently for more than one project or for private work unless permission is granted in writing by the Engineer. The plant units shall be so designed, coordinated and operated that they will function properly and produce HMA having uniform temperatures and compositions within the tolerances specified. The plant units shall meet the following requirements.*

(a) <u>Requirements for All Plants. All HMA plants shall be according to the following</u>.

(1) General. The plant shall be approved before production begins. All HMA plants shall be capable of producing HMA within the specification tolerances for gradation and asphalt binder content. The plant owner shall be responsible for demonstrating this capability through a production and testing program defined by the current Bureau of Materials and Physical Research Policy Memorandum, "Approval of Hot-Mix Asphalt Plants and Equipment". If the plant fails to maintain this capability, the Department may require the demonstration to be repeated at any time. Failure to maintain the capability may result in loss of plant approval status. Accessibility to the top of truck beds shall be provided by dual platforms or other suitable device to enable the Engineer to obtain samples and mixture temperature data.

For all types of plants, the ingredients shall be heated and combined in such a manner as to produce HMA which when discharged from the plant will in general vary not more than 20 °F (10 °C) from the temperature set by the Engineer. In all cases, the mix temperature shall not be more than 350 °F (180 °C) or less than 250 °F (120 °C). Wide variations in the mixture temperature of successive loads may be cause for rejection of the HMA.

During the drying process, the moisture content of the aggregate shall be reduced such that the moisture content of the HMA at time of discharge from the mixer will not exceed 0.3 percent. For certain aggregates such as air-cooled blast furnace slag, and other highly absorptive aggregates, special handling and treatment such as double drying may be required.

Whenever a HMA plant is being used to produce High ESAL or Low ESAL mixtures as defined in Article 1030.01, all hot bins shall be emptied and all aggregate in the dryer and on all collector conveyors shall be removed prior to starting production or resuming once production has been interrupted for the purpose of producing a different mixture.

(2) Storage Facilities. The plant used in the preparation of the HMA shall be located where it will have adequate storage and transportation facilities. Sufficient space shall be provided for separate stockpiles of each gradation, source, and quality of aggregate required. If necessary to prevent the intermixing of the different materials, or if stockpiles join together, suitable partitions shall be used between adjacent stockpiles. All aggregates shall be kept separated until they are fed in their proper proportions onto a belt conveyor or into the boot of the cold aggregate elevator. The aggregates shall be handled in such a manner as to prevent contamination, degradation and segregation.

(3) Aggregate/RAP/RAS Bins and Feeders. The plant shall be provided with accurate mechanical means for uniformly feeding each aggregate, Reclaimed Asphalt Pavement (RAP) and Reclaimed Asphalt Shingles (RAS) used, in the proper proportions so that uniform production and uniform temperature will be obtained. A minimum of four bins and feeders for aggregate will be required. If RAP is used, one additional bin and feeder will be required for each RAP fraction used. If RAS is used, one additional bin and feeder will be required. The bins shall be designed to prevent overflow of material from one bin to another. If any of the materials used in preparing the mixture become intermixed in a bin compartment, the compartments hall be emptied and the intermixed material shall not be used. Each bin shall be provided with a variable speed belt or apron feeder with adjustable gates which can be locked. Each bin shall have a cutoff system that shall automatically stop the HMA production when any bin becomes empty. All feeders shall be calibrated to the desired volumes and/or weights for each material/mixture, to the satisfaction of the Engineer. This calibration may require plant modification. The controls of the total quantity of combined materials fed to the dryer shall be by a variable speed system. Other methods may be approved by the Engineer. When the proportioning gates of the feeders are once set for proper blending, they shall be locked or bolted securely and their positions shall not be changed unless directed by the Engineer.

(4) Dust Collection. The plant shall be equipped with a primary dust collector, approved by the Engineer, connected to a secondary dust collector (baghouse or wet-wash).

a. IL-4.75. For mixture IL-4.75 mineral filler and collected dust (baghouse) shall be proportioned according to the following.

1. Mineral filler shall not be stored in the same silo as collected dust (baghouse).

2. Additional minus 200 material needed to meet the Job Mix Formula (JMF) shall be manufactured mineral filler, unless otherwise approved by the Engineer.

3. Collected dust (baghouse) may be used in lieu of manufactured mineral filler according to the following.

(a.) Sufficient collected dust (baghouse) is available for production of the IL-4.75 mixture for the entire project.

(b.) A mix design was prepared based on collected dust (baghouse).

4. A combination of collected dust (baghouse) and manufactured mineral filler may be used according to the following.

(a.) The amount (proportion) of each shall be established and not varied.

(b.) A mix design was prepared based on the established proportions.

b. SMA. SMA shall be according to the following.

1. Mineral Filler. When producing SMA, the mineral filler system shall accurately proportion the large amounts of mineral filler required for the mixture. Alteration or adjustment of the current system may be required. Mineral filler shall not be stored in the same silo as collected dust.

2. Only dust collected during the production of SMA may be returned to the SMA mixture. Any additional minus No. 200 (0.075 mm) material needed to produce the SMA shall be mineral filler meeting the requirements stated herein. Mineral filler shall not be collected dust.

(5) Hot-Mix Surge Bins. The Contractor may use a hot-mix surge system in the manufacture of HMA provided the bin(s) meet the following requirements and are operated to the satisfaction of the Engineer. The complete surge system shall be designed and operated to prevent segregation and loss of temperature of the mix. Maximum retention time shall be eight hours unless longer retention time is authorized in writing by the Engineer. When requested, longer retention time will be evaluated according to the current Bureau of Materials and Physical Research Policy Memorandum, "Storage of Hot-Mix Asphalt". The bin(s) shall be insulated and/or heated, and of an enclosed weatherproof type. A combination low level indicator and cutoff system shall be provided that will automatically stop the discharge of mix from the surge bin(s) when the mix falls below the top of the discharge cone. The conveying system used to transport the mix from the mixer to the bin(s) shall be enclosed, heated and/or insulated for effective control of mix temperature.

No surge system will be approved by itself but shall be considered as part of a complete operating HMA plant. The mix as discharged from the bin(s) shall meet all specification requirements for the mix being produced. Approval for the use of a surge system may be withdrawn at any time, by the Engineer, for unsatisfactory operation.

IL-4.75 mixtures and Stone Matrix Asphalt (SMA) mixtures which contain aggregate having absorptions greater than or equal to 2.5 percent, or which contain steel slag sand, shall have a minimum silo storage plus haul time of 1.5 hours.

(6) Storage Tanks for Asphalt Binders. Tanks for the storage of asphalt binder shall be equipped to heat and hold the material at the required temperatures. The heating shall be accomplished by steam coils, hot oil coils, electricity or other approved means so that no flame shall be in contact with the tank. All asphalt binder lines and fittings shall be steam, electric or hot oil jacketed. Provisions shall be made for sampling the asphalt binder from the line leading to the weigh bucket or metering device. If more than one grade of asphalt binder is required for concurrent operations, adequate storage and separate piping to the weigh bucket or metering device for each grade, or other methods approved by the Engineer that prevent intermingling of the asphalt binders, shall be provided. An armored thermometer or pyrometer which will accurately show temperatures between 200 and 400 °F (95 and 205 °C) shall be suitably located in the asphalt binder line or within the tank. The instrument shall be located so as to indicate to the plant personnel, the temperature of the asphalt binder.

(7) Equipment for Weighing HMA. The HMA shall be weighed on an approved scale furnished by the Contractor meeting the requirements of The Weights and Measures Act of the State of Illinois. Each time the scale is moved, the accuracy shall be retested and certified. For dryer drum plants the load-out scale used to weigh HMA shall be equipped with an automatic printer. Batch plants shall have an automatic printer to record the weight of all ingredient materials. The automatic printer shall be an integral part of the scale equipment or the scale and printer shall be directly connected in a manner that will prohibit the manual entry of weights, except as provided in paragraph a., below.

a. If the platform scale equipment measures gross weight (mass), the printer will record the gross weight (mass) as a minimum. Tare and net weights (masses) shall be shown on weigh tickets and may be printed automatically or entered manually.

b. If scale equipment on a platform scale zeros out the truck tare automatically, the printer shall record the net weight (mass) as a minimum.

c. If the scale equipment on a surge bin weigh hopper zeros automatically after discharging each batch, the printer shall record the net weight (mass) as a minimum.

d. If the scale equipment on surge bins automatically shuts down the feed system weighing and weighs the amount in the silo before and after discharge, the printer shall record the net weight (mass) as a minimum.

The automatic printer shall produce a weight ticket in triplicate. Weights (Masses) shall be shown in tons (metric tons) to the nearest 0.01 ton (0.01 metric ton).

(8) Equipment for Anti-Strip Additives. When an anti-stripping additive is required and a liquid additive is used, it shall be added to the asphalt binder by means

of an approved in-line blending system located between the asphalt binder supply tank and distribution on the heated aggregate. The in-line blending system shall be installed in such a location that the liquid additive cannot recirculate and contaminate the asphalt binder supply tank. The in-line blending system shall be capable of delivering a consistent and controllable stream of material to the asphalt binder under all operating weather conditions and shall be capable of controlling the introduction of additive into the asphalt binder within ±10 percent of the amount specified or required. The Contractor shall use methods and procedures for handling and storage of the additive which meet the manufacturer's safety recommendations.

When hydrated lime is used as the anti-strip additive, a separate bin or tank and feeder system shall be provided to store and accurately proportion the lime onto the aggregate either as a slurry, as dry lime applied to damp aggregates, or as dry lime injected onto the hot aggregates prior to adding the liquid asphalt cement. If the hydrated lime is added either as a slurry or as dry lime on damp aggregates, the lime and aggregates shall be mixed by a power driven pugmill to provide a uniform coating of the lime prior to entering the dryer. If dry hydrated lime is added to the hot dry aggregates in a dryer-drum plant, the lime shall be added in such a manner that the lime will not become entrained into the air stream of the dryer-drum and that thorough dry mixing shall occur prior to the injection point of the liquid asphalt. When a batch plant is used, the hydrated lime shall be added to the mixture in the weigh hopper or as approved by the Engineer. The feeder system shall be controlled by a proportioning device which shall provide accuracy to within ±10 percent of the specified amount of hydrated lime solids. The proportioning device shall have a convenient and accurate means of calibration and shall be interlocked with the aggregate feed or weight system so as to maintain the required proportion. A flow indicator or sensor shall be provided and interlocked with the plant controls such that the production of the mixture will be interrupted if there is a stoppage of the hydrated lime feed. The stockpiling of hydrated lime treated aggregate will not be permitted. The methods of introducing and mixing the anti-stripping additive and aggregate shall be subject to approval by the Engineer prior to beginning production.

(9) Equipment for RAP/RAS. When the RAP/RAS option is used, the plant shall be modified to ensure a homogenous, uniformly coated mix is obtained. A scalping screen, crushing unit or comparable sizing device shall be used in the RAP feed system to remove or reduce oversized material. Modifications shall be approved by the Engineer.

(10) Stabilizing Additive. When a stabilizing additive such as a cellulose or mineral fiber is required to prevent asphalt binder draindown, adequate dry storage shall be provided for the stabilizing fiber additive. A separate feed system shall be provided to proportion the fiber into the mixture uniformly and in desired quantities. The feed system shall be interlocked with the aggregate feed or weigh system to maintain the correct proportions for all rates of production and batch sizes. The proportion of fibers shall be controlled at all times within ± ten percent of the amount of fibers required.

The fiber system shall provide in-process monitoring consisting of either a digital display of output or a printout of the feed-rate, in pounds per minute. Flow indicators or sensing devices for the fiber system shall be provided and interlocked with plant controls so mix production shall be interrupted if fiber introduction fails, or if the output rate is not within the specified tolerances

a. Batch Plant. Stabilizing additive shall be pneumatically added through a separate inlet directly into the weigh hopper above the pugmill. The addition of fibers shall be timed to occur during the hot aggregate charging of the hopper. Adequate mixing time will be required to ensure proper blending of the aggregate and fiber additive. Both the wet and dry mixing times shall each be increased a minimum of five seconds beyond the standard mixing time. The actual mixing time increase shall be determined by the Engineer based on individual plant characteristics. If concentrations of mastic (fiber, asphalt binder, and fines) are visible behind the paver, the batch size shall be reduced in ten percent increments until the problem is alleviated.

b. Drum Mix Plant. Stabilizing additive shall be introduced using specialized equipment to mix the asphalt binder with loose fibers at the time of introduction into the drum mixer. This equipment shall be approved by the Engineer. Care shall be taken to ensure the loose fibers do not become entrained in the exhaust system of the plant.

(b) Batching Plants. Batch plants shall be according to the following.

(1) Dryers. The plant shall be equipped with a revolving cylindrical dryer or dryers capable of heating and drying all of the fine and coarse aggregates to a temperature of 250 to 350 ºF (120 to 180 ºC).

(2) Equipment for Weighing or Measuring Aggregate/RAP/RAS. The equipment shall include a means for accurately weighing each size of aggregate/RAP/RAS in a weigh hopper suspended on scales and of ample size to hold a full batch without hand raking or running over. The gate shall close tightly so that no material is allowed to leak into the pugmill mixer while a batch is being weighed.

The scale shall be a springless dial scale complying with the requirements of Article 1103.02(c). Load cells with digital readouts may be used if approved by the Engineer. The scale shall have a capacity of not more than twice the weight (mass) of the approved capacity of the mixer.

(3) Dust Collection. Material collected from the primary collector shall be discharged into a hopper which is equipped with the means of either wasting stored dust or metering and conveying its contents into the boot of the hot elevator. Metering of dust from the hopper shall be accomplished by either an adjustable variable speed vane or auger feeder. Feed shall be actuated by a control located in the discharge chute between the dryer and the hot elevator, and shall only occur when aggregate is being discharged from the dryer. In all cases, the hopper used for storing the primary material shall be equipped with a low-bin indicator.

Material collected in the secondary collector (baghouse) shall not be stored internally, but shall be discharged directly into a silo. Feed of the material from the silo to the mix shall be accomplished only by weight (mass). In no case shall the collected secondary material be returned to the hot elevator. To meet job mix formula criteria, it may be necessary to waste some or all of the collected secondary material.

(4) Mineral Filler System. The mineral filler shall be weighed in the aggregate weigh hopper. It shall be conveyed to the weigh hopper by approved means. The feeding method shall operate in such manner as will enable small fractions of the material to be weighed. The chute used to introduce the mineral filler into the weigh hopper shall be so constructed that none of the material is retained in it after the required amount has been deposited in the weigh hopper.

(5) Equipment for Weighing or Measuring Asphalt Binder. The equipment used for weighing or measuring the asphalt binder shall consist either of an approved weigh bucket or metering device. If a weigh bucket is used, it shall be a non-tilting type and shall be completely suspended from a springless dial scale. Load cells with digital readouts may be used if approved by the Engineer. The weigh bucket, its discharge valve or valves and spray bar shall be adequately heated and shall have a capacity of at least 15 percent in excess of the weight (mass) of asphalt binder required in any batch. Adequately heated, quick-acting, non-drip valves shall be used in charging the bucket.

If a metering device is used, it shall be of an approved design and have a capacity of at least 15 percent in excess of the quantity of asphalt binder used in a batch. The controls shall be constructed so that they may be locked at any dial setting and will automatically reset to that reading after the addition of asphalt binder to the mix. The dial shall be in full view of the mixer operator. The flow of asphalt binder shall be automatically controlled so that it will begin when the dry mixing period is over. The section of the asphalt line between the charging valve and the spray bar shall be provided with a valve and outlet for calibrating-verifying the meter.

Either the weigh bucket or the meter device shall discharge all the asphalt binder required for one batch in not more than 15 seconds after the flow has started. The size and spacing of the spray bar openings shall provide a uniform application of asphalt binder the full length of the mixer.

(6) Accuracy of Scales. The scales shall meet the requirements of The Weights and Measures Act of the State of Illinois. The scales shall be calibrated at the beginning of each construction season and as often as the Engineer may deem necessary to assure their continued accuracy. Ten standard 50 lb (25 kg) weights meeting the requirements of NIST shall be available at the HMA plant for use in calibrating and testing the weighing equipment. The scales shall be inspected frequently for sensitivity, sluggishness or damage. They shall be checked for accuracy at intervals of not more than one week by obtaining the net weight (mass), on truck scales, of a truck load of HMA.

(7) Pugmill Mixer. The batch mixer shall have a rating plate attached showing the manufacturer's rated capacity, and shall be an approved type capable of producing a uniform mixture within the job tolerances. If not enclosed, the mixer box shall be equipped with a dust hood to prevent loss of dust. The clearance of the blades from all fixed and moving parts shall not exceed 3/4 in. (20 mm).

The capacity of the pugmill mixer will be determined by the Engineer based on 115 percent of the calculated net volume of the mixer below the center of the mixer shafts and 100 lb/cu ft (1600 kg/cu m) material. If the mixer will not operate efficiently at the approved capacity, or if its production does not coordinate with other plant units, the right is reserved to reduce the size of the batch until the desired efficiency is obtained. The Engineer's decision as to the permissible capacity of the pugmill mixer will be final.

The mixer shall be heated by an approved method and shall have a capacity of not less than 2000 lb (905 kg) for any composition required under these specifications. The amount of material which the Contractor will be permitted to mix per batch shall be determined by the Engineer. The mixer shall be of the twin-shaft type.

(8) Time Lock. The mixer shall be equipped with an accurate time lock to control the operations of a complete mixing cycle. It shall lock the weigh hopper gate after the charging of the mixer until the closing of the mixer gate at the completion of the cycle. It shall lock the asphalt binder bucket or meter throughout the dry mixing period and shall lock the mixer gate throughout the dry and wet mixing periods. The dry mixing period is defined as the interval of time between the opening of the weigh hopper gate and the start of introduction of asphalt binder. The wet mixing period is the interval of time between the start of introduction of asphalt binder and the opening of the mixer gate.

The heated aggregates, RAP/RAS when used, and mineral filler shall be mixed in the pugmill mixer for a period of not less than 10 seconds. The asphalt binder shall then be added and the mixing continued. The time required to add the asphalt binder shall be not more than 15 seconds. The total time required for adding the asphalt binder and completing the wet mixing period shall be not less than 35 seconds, or longer if necessary, to produce a homogeneous mixture in which all particles of aggregate are coated uniformly. If a question as to the degree of coating should arise, AASHTO T 195 shall be used. When the RAP/RAS option is used, the mix time may vary in relation to the nature of the aggregate. The total mixing time shall be a minimum of 45 seconds consisting of dry and wet mixing. The times of dry and wet mixing shall be set by the Engineer. The same size batch weights shall be used in the production of HMA, unless permission to change is granted in writing by the Engineer.

The control of the timing shall be flexible and capable of being set at intervals of five seconds or less throughout a total cycle. The setting of time intervals shall be at the direction of the Engineer.

(9) *Batch Counter. An approved mechanical batch and/or tonnage counter shall be installed as part of the time lock device. It shall register only upon the actuation of the asphalt weigh bucket or valve release. It shall not register any dry batches or any material released during the operation of pulling the bins.*

(10) *Screens. The screens used in separating the aggregates shall be of the vibrating types, and when operated at normal speeds shall separate the aggregates satisfactorily. The screening system shall be equipped with a scalping screen having openings not more than 1/2 in. (13 mm) larger than the largest size aggregate used in preparing the HMA. The screening system shall have a tailing pipe for the removal of oversized aggregate. The discharge point of the tailing pipe shall be located so that it will not create a hazard or nuisance. The screens shall produce aggregate in the proper bins, as required.*

Efficiency of separation based on laboratory sieves, shall be such that no more than 20 percent of the material in the bin is smaller than neither the nominal size nor more than ten percent over size for that bin.

(11) *Hot Aggregate Bin. The plant shall be equipped with a minimum of four aggregate storage bins of sufficient capacity to supply the mixer when it is operating at full capacity. Bins shall be arranged to assure separate and adequate storage of appropriate fractions of the mineral aggregates. Separate dry storage shall be provided for mineral filler, and the plant shall be equipped to feed the material into the aggregate weigh hopper. Each bin shall be provided with overflow pipes, of such size and at such locations as to prevent backing up of material into other compartments or bins. Material from the overflow pipe shall not be returned to the hot elevator. Each compartment shall be provided with its individual outlet gate, constructed so that when the gate is closed, there shall be no leakage. Gates shall cut off quickly and completely. Bins shall be so constructed that samples can be readily obtained. A sampling device having the same width as the hot aggregate bin outlet gates shall be provided for this purpose. Hot aggregate bins shall not be modified in any manner nor shall divider plates be removed.*

(12) *Temperature Recording Instrument. The plant shall be equipped with either a recording pyrometer or a recording thermometer having at least two terminals when a single dryer is used, and at least three terminals when a dual dryer is used. The type and accuracy of the recording instrument shall be approved by the Engineer. Unless otherwise approved, one terminal shall be installed at a suitable location at the discharge of each dryer and the others near the discharge gate in each bin compartment used for fine aggregate. The temperature recording instrument shall be capable of making accurate charts of the temperatures during the day's run. The recording instrument shall be installed at a point free from the dust and vibration of the plant. If this instrument is not located as to indicate clearly to the plant operator the temperature of the mineral aggregates at the discharge of each dryer, a non-recording pyrometer shall also be installed in view of the plant operator. At the end of each days run, the record sheet of the recording instrument shall be submitted to the Engineer.*

(c) <u>Dryer Drum Plants. Dryer drum plants shall be according to the following</u>.

(1) General. General requirements shall be according to Article 1102.01(a), except a hotmix surge bin meeting the requirements of (5) shall be utilized.

The heated aggregates, mineral filler, asphalt binder, and RAP/RAS when used, shall be proportioned by electronic proportioning equipment and mixed to produce a homogenous mixture in which all particles of aggregate are coated uniformly. If a question as to the degree of coating should arise, AASHTO T 195 shall be used. If the Engineer ascertains that proper mixing is not being obtained, adjustments shall be made in the plant operation (production rate, dryer drum slope, etc.) to assure that these conditions are met.

(2) Vibrating Scalping Screen. The combined aggregates, and RAP/RAS if used, shall pass over a vibrating scalper that will remove all material and aggregate greater than the nominal top size gradation permitted by the specification for the mixture being produced, or as set by the Engineer, prior to the aggregates being placed on the weigh belt. The scalper shall be independent of other proportioning or weighing equipment.

(3) Aggregate/RAP/RAS Weighing Equipment. The combined aggregates, and RAP/RAS if used, shall be weighed on continuous belt weighing devices meeting the requirements of the NIST Handbook #44. The weigh belts shall be self-aligning with a gravity belt takeup and rigid wind guards at the weighing section. Sun screens may be required by the Engineer at the weighing section. Means shall be provided to divert the aggregate/RAP/RAS into a truck, after passing over the weigh belt scales.

(4) Mineral Filler System. Mineral filler shall be proportioned to the mixing zone of the HMA plant by a variable speed vane feeder and storage system or other systems approved by the Engineer. Means must be provided to divert material from the proportioning unit for purposes of calibration. The feeder shall be provided with an automatic cutoff system in the event the feeder is blocked or is devoid of material.

(5) Asphalt Binder System. The asphalt binder system shall consist of a temperature compensating meter and pump. Other asphalt binder systems may be used if approved by the Engineer. The pump and meter shall be installed as close to the asphalt binder storage tank(s) as possible using rigid pipe with a minimum of piping length and bends. The diameter of the pipe shall be consistent throughout the system. Means shall be provided to automatically stop the plant in the event asphalt binder ceases to flow through the meter.

(6) Dryer Drum Mixer. Dryer drum mixer components shall have a minimum capacity of 60 tons (55 metric tons) per hour of HMA. The units shall have a recording pyrometer or thermometer that records the discharge temperature of the mixture.

a. Single Unit Dryer Drum Mixers. The single unit dryer drum mixer shall be a revolving cylindrical drum capable of heating, drying, and mixing the combined aggregates, RAP/RAS if used, mineral filler when required, and asphalt binder to produce a uniformly coated, homogenous HMA meeting all applicable specifications. The dryer burner shall be equipped with automatic controls.

b. Dual Unit Dryer Drum Mixers. The dryer portion of the dual unit dryer drum mixer shall be a revolving cylindrical drum capable of heating and drying the combined aggregates to the required specifications. The mixer portion of the dual unit dryer drum mixer shall be either a revolving cylindrical drum or a continuous twin shaft pugmill with a compatible mixing capacity to the dryer production rating. The unit shall be capable of mixing the heated and dried combined aggregates, RAP/RAS if used, mineral filler when required, and asphalt binder to produce a uniformly coated, homogenous HMA meeting all applicable specifications.

(7) Secondary Dust Collector. The collected baghouse dust shall be returned to the dryer at a uniform rate at a point where the asphalt binder is added to the mixing zone of the HMA plant.

If positive dust control equipment (PDCE) is required, it shall consist of a system that is an integral part of the production process. The system shall accurately weigh all of the secondary dust collected in the baghouse, transfer the material to a storage silo, accurately weigh the required amount of fines to be returned from the storage silo, and transfer them back to the mixture. The PDCE weighing devices shall have an accuracy of 0.5 percent of the actual weight of the material. The system shall be capable of automatically monitoring the dust collection process and adjusting the amount of asphalt binder added to the mixture. The entire system shall be interlocked with the plant controls to respond to production rate changes, start up, and shut down situations. The weighing process shall be displayed and recorded in 0.1 units. The PDCE shall be capable of accurately wasting dust without having any adverse effects on the mixture.

(8) Proportioning Control Systems.

a. Aggregate/RAP/RAS Feed Control. Each feeder shall have an adjustable feed control, which can be locked, with a master control that will automatically increase or decrease the production rate of each feeder proportionately when the total rate of production is changed. The revolutions per minute (RPM), tons/hour (TPH), etc. of all feeders shall be measured at the tail shaft of the feeder. The aggregate/RAP feeders shall have an accuracy of ±1.0 percent of the actual quantity of material incorporated. RAS feeders shall have an accuracy of ± 0.5 percent of the actual quantity of material incorporated.

b. *Aggregate/RAP/RAS Weighing. The main proportioning weigh belt shall be electronically interfaced with the asphalt binder, RAP/RAS if used, and mineral filler system to proportion the required amount of each material simultaneously to the mixer. The aggregate, and RAP/RAS if used, weighing systems shall have an accuracy of ±0.5 percent of the actual material weighed by the belts. The weighing system shall also have a high-low adjustable tolerance indicator that will signal the operator audibly when the actual production rate differs from the preset rate by more than 3.0 percent.*

c. *Mineral Filler Control. Mineral filler shall be added to the mixer by a variable speed proportioning system interfaced with the aggregate weigh belt that will indicate total dry aggregate combined (aggregates + mineral filler) weight (mass) to the asphalt proportioning system. The mineral filler system shall have an accuracy of ±0.5 percent if the mineral filler is measured by weight (mass), or ±8.0 percent if the mineral filler is measured solely by volume of the actual material measured by the system. The mineral filler shall be added in the mixer at the same point the asphalt binder is added such that no mineral filler is lost as fugitive dust. Other systems will be permitted if approved by the Engineer.*

d. *Asphalt Binder Control. The required quantity of asphalt binder shall be proportioned to the mixer via a temperature compensating meter that will correct the quantity of asphalt binder to 60 °F (15 °C), or a system approved by the Engineer. This system shall be electronically interfaced with the combined dry aggregates, RAP/RAS if used, and mineral filler. The meter shall have an accuracy of ±0.4 percent of the actual material metered.*

e. *Aggregate/RAP/RAS Moisture Compensators. The moisture compensation devices shall be capable of electronically converting the wet aggregate/RAP/RAS weight (mass) to dry aggregate/RAP/RAS weight (mass). Other systems will be permitted if approved by the Engineer.*

(9) *Control Console. The following items shall be part of the operator's control console.*

a. *Aggregate/RAP/RAS Feed Controls. The variable speed controls, both total and proportional for each feeder and combined aggregates or RAP/RAS if used, shall be indexed in units with a minimum unit of 0.1. The rate in RPM or TPH, etc. shall be displayed by a digital readout for each feeder with a minimum unit of 0.1 RPM or 1 TPH, etc.*

b. *Aggregate/RAP/RAS Weight (Mass) Indicator. The accumulated wet weight (mass) of material in tons (metric tons) that passes over each weigh belt shall be available at the control console with a minimum unit of 0.1 ton (0.1 metric ton). The dry weight (mass) of material, in TPH, passing over each weigh belt shall be displayed by digital readouts with a minimum unit of 1 TPH.*

c. Mineral Filler Control. Mineral filler shall be controlled by a variable speed control with a minimum unit of 0.1 and shall be displayed in RPM, or TPH, etc. with a minimum unit of 0.1 RPM or 0.1 TPH, etc.

d. Asphalt Binder Control. The asphalt binder control shall be capable of presetting the actual asphalt binder content directly as a percent of the total weight (mass) of mixture with a minimum unit of 0.1 percent. The asphalt binder rate shall be displayed to a minimum unit of 0.1. A control shall be provided to set the specific gravity or weight/gallon (mass/liter) of the asphalt binder. The temperature of the asphalt binder shall be recorded by a recording pyrometer or thermometer at the console.

e. Aggregate/RAPRAS Moisture Compensators. The compensators shall be part of the operator's console and shall have a minimum unit of 0.1 percent. The control shall be lockable if the moisture setting is not printed as part of the record.

f. HMA Temperature. The temperature of the mixture shall be recorded in °F (°C) by a recording pyrometer or thermometer at the console.

(10) Recording of Proportions. The plant shall be equipped with a digital printer that will automatically print the following data at six minute intervals during production time and on demand. All readings shall show the date, month and year, and time to the nearest minute for each print.

a. Accumulated dry aggregate/RAP/RAS in tons (metric tons) to the nearest 0.1 ton (0.1 metric ton).

b. Accumulated mineral filler in revolutions, tons (metric tons), etc., to the nearest 0.1 unit.

c. Accumulated asphalt binder in gallons (liters), tons (metric tons), etc., to the nearest 0.1 unit.

d. Aggregate/RAP/RAS Moisture Compensators in percent as set at the panel. (Required when accumulated dry aggregate/RAP/RAS is printed in wet Aggregate/RAP/RAS weight (mass)).

Another system approved by the Engineer, such as a fully computerized system, that will provide the control and documentation of the above equipment, will be permitted."

End of the Standard Specification Section 1102 (Hot-Mix Asphalt Equipment)

SURGE AND STORAGE BINS

Surge and storage bins are designed to hold or store HMA mixtures at an asphalt plant. Because of the individual batching process at a batch plant, mix storage is not required but can be an option. A dryer-drum plant works in a continuous operation so the plant needs to have a means to retain HMA material in order to offset loading inconsistencies that might occur during the production day. A dryer-drum plant is not designed to shut down at a moment's notice except in an emergency. If a surge bin and/or storage silo system is to be utilized, prior to usage, the Central Bureau of Materials must approve the unit.

Surge and/or storage bins are to be designed and operated to prevent segregation and heat loss, so the systems are to be insulated and/or heated, as well as, being enclosed and weather-proof. Heating is normally accomplished by circulating hot oil or water through piping in the outer shell.

Surge bins are used to create a temporary accumulation of material to buffer the effects of inconsistent loading of trucks throughout the day that might occur due to various factors (traffic, etc.). In most cases, surge bins are usually designed to hold less than 100 tons of HMA but this could vary depending on the design and intended use of the equipment. A surge bin can hold HMA material up to eight (8) hours or longer with approval from the Engineer.

Storage silo/bins are normally used for long term or overnight storage of HMA materials. When approved by the Engineer, the producer may store HMA materials up to a maximum of twenty (20) hours from the time the first batch of HMA material is added to the silo/bin. After the silo/bin is filled, the top shall be closed or sealed until such time as the contractor is prepared to utilize all of the HMA material from the storage. The contractor shall keep the District office informed when they intend to store HMA material.

When HMA mixture is stored a small amount of material can become oxidized in the cone area of the silo/bin. This "plug" of HMA material generally indicates a hardening of the HMA material when tested and shall be wasted [approximately 1 to 2 thousand pounds] before the HMA material is drawn from the bin for use on a project.

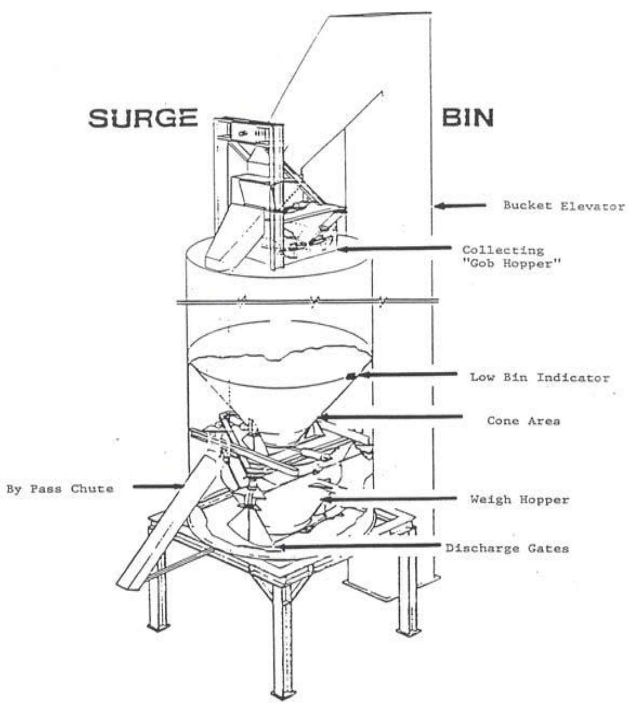
Another issue with storage systems is the storage of HMA mixtures that contain aggregate with water absorption greater than 2.75 percent. These types of materials should not be stored overnight.

Equipment

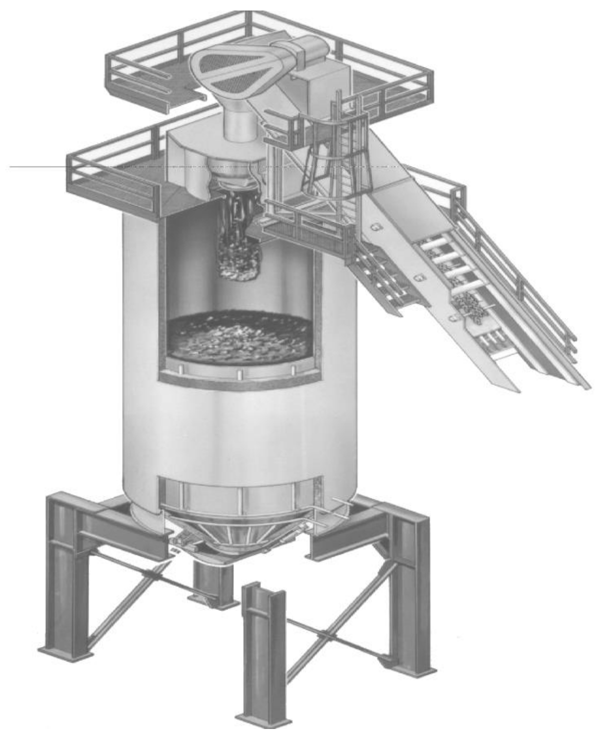
The complete surge system (Figure 1, page 3-2) shall be designed and operated to prevent segregation and loss of temperature. If segregation is detected, a listing of types, probable causes and possible solutions are covered in Chapter 5 of this manual.

Both, surge or silo system, will be equipped with low level indicator and an automatic cut-off system to prevent the bin from emptying below the discharge cone. The cut-off system will stop the discharge or flow of HMA material from the surge or silo bin in order to prevent possible segregation due to low levels of material. An alarm system, audible to personnel in the immediate plant area, shall be employed to signal if and when the system is being bypassed. Ideally, the only time a surge bin and/or a storage silo is emptied would be when production is finished for the day or when switching to a different type of mixture (binder to surface, etc.)

Storage Silos



Surge Bin (Figure 1)



Storage silo with a gob hopper

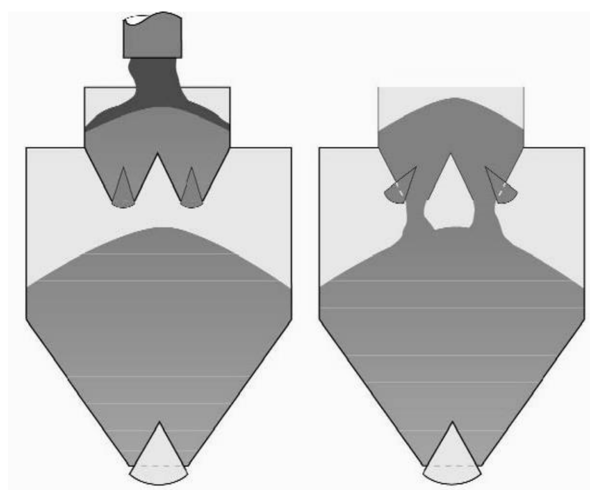
<u>Operation</u>

Proper operation levels of surge or silo systems should be around 1/2 to 3/4 full. Levels lower than 1/2 of the bin will create an inverted cone, while levels above 3/4 of the bin will create an upright cone, both of which will introduce the possibility of segregation in the bin.

Although not required by specifications, most surge/storage systems will include a collecting (gob) hopper on top of the surge or silo system (below). The collecting (gob) hopper enables the HMA mix to be deposited en mass into the bin helping to reduce or minimize the possibility of segregation. When a collecting (gob) hopper is used the possibility of segregation is greatly reduced. The Quality Control Manager/Level 2 HMA Technician is required to make sure that the collecting hopper discharge gates do not remain open after the hopper is empty.

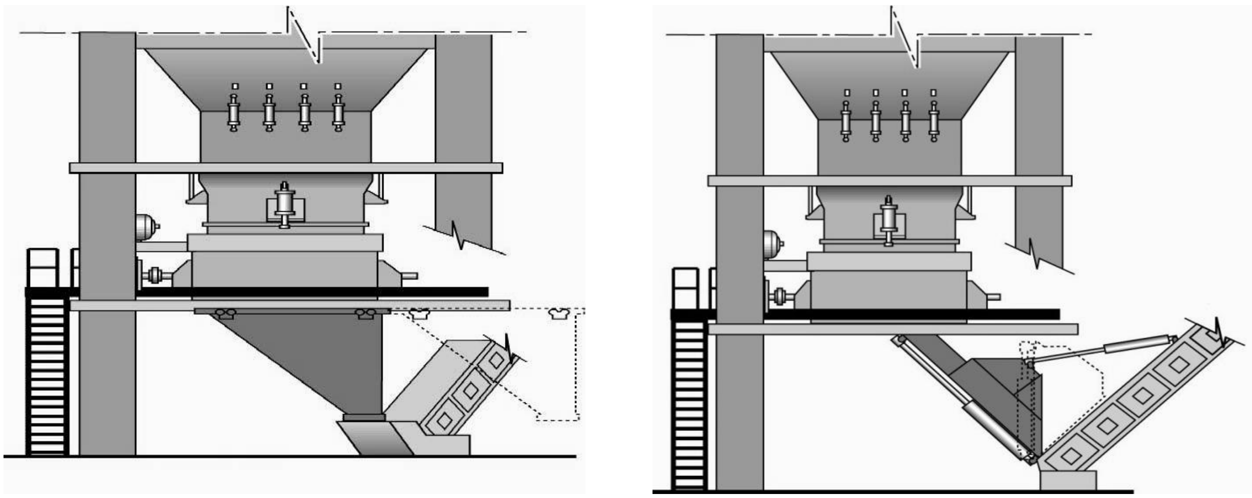
Silo Discharge Gate

Gob Hopper

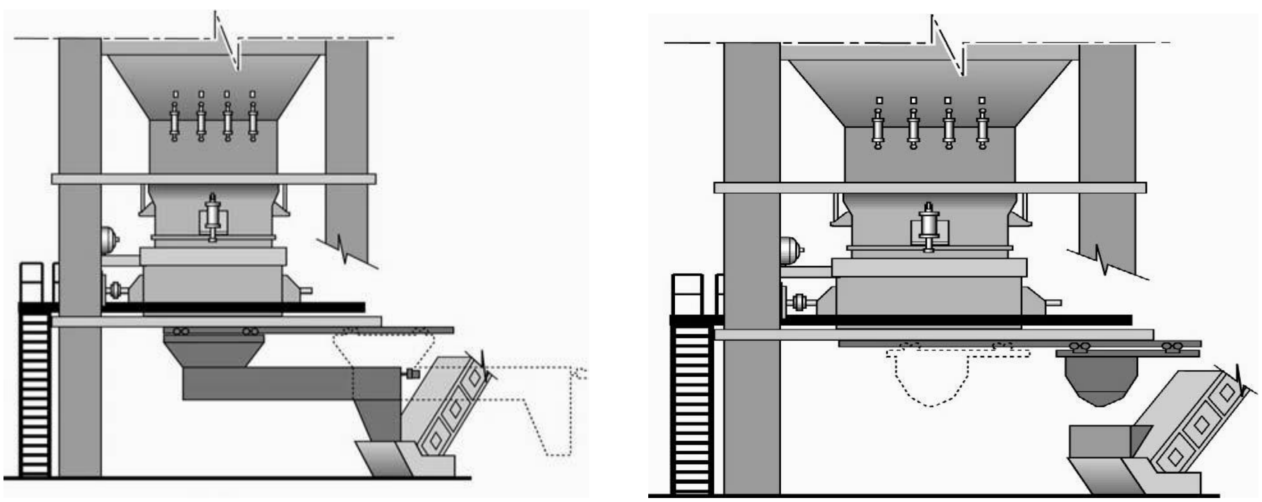


Surge bin pant-leg system

For **batch plants**, the conveying system used to transport the HMA mix from the pugmill or drum mixer to the bin(s) may be a continuous type or a skip hoist type. The continuous type shall be enclosed, heated and/or insulated. The skip hoist type must have sufficient capacity to transport an entire batch and mass dump it into the bin.



Continuous Conveying System



Skip Hoists Conveying System

Documentation of Material Weights

When surge/storage bins or continuous plants are used in the production of HMA mixtures, the HMA material must be weighed either on a platform (truck) scale, weigh hopper scale suspended below the surge/storage bin, load cells or with another approved system.

The weighing device shall be equipped with an automatic ticket printer conforming to current Illinois Department of Transportation specifications, and shall have been approved by the Illinois Department of Agriculture.

State of Illinois
Department of Transportation
Bureau of Materials and Physical Research
Springfield

POLICY MEMORANDUM

Revised: January 1, 2008	05-08.0
This Policy Memorandum supersedes number 07-26 dated July 15, 2007	

TO: *REGIONAL ENGINEERS AND HIGHWAY BUREAU CHIEFS*
SUBJECT: *STORAGE OF HOT-MIX ASPHALT*

1.0 SCOPE

1.1 To establish the requirements for granting a maximum storage time of 20 hours for hot mix asphalt silos.

2.0 **Purpose**

2.1 The January 1, 2007 Standard Specifications for Road and Bridge Construction, Section 1102.01(a)(6), allows for the storage of hot mix asphalt in surge systems designed and operated to prevent segregation and loss of temperature. The specification allows for a maximum retention of 8 hours. Longer retention times must be approved in writing by the Engineer.

3.0 PROCEDURE

3.1 Illinois Test Procedure 401, located in the "Manual of Test Procedures for Materials" shall be used to evaluate the effect of additional storage time on the mix.

4.0 APPROVAL PROCEDURE

4.1 Based on the Bureau's evaluation of the test data, permission for mixture storage for up to a maximum of 20 hours may be granted. In lieu of testing, the Bureau may grant approval based on satisfactory performance of other similar surge bin systems.

4.2 If overnight storage is permitted, the Bureau will send a letter to the Contractor, with a copy to the District, stating the conditions whereby the Contractor may store hot-mix asphalt.

David L. Lippert, P.E.
Engineer of Materials
and Physical Research

JST/dkt

Beginning of the Standard Specification Article 1102.01(a)(5)

(5) Hot-Mix Surge Bins. The Contractor may use a hot-mix surge system in the manufacture of HMA provided the bin(s) meet the following requirements and are operated to the satisfaction of the Engineer. The complete surge system shall be designed and operated to prevent segregation and loss of temperature of the mix. Maximum retention time shall be eight hours unless longer retention time is authorized in writing by the Engineer. When requested, longer retention time will be evaluated according to the current Bureau of Materials and Physical Research Policy Memorandum, "Storage of Hot-Mix Asphalt". The bin(s) shall be insulated and/or heated, and of an enclosed weatherproof type. A combination low level indicator and cutoff system shall be provided that will automatically stop the discharge of mix from the surge bin(s) when the mix falls below the top of the discharge cone. The conveying system used to transport the mix from the mixer to the bin(s) shall be enclosed, heated and/or insulated for effective control of mix temperature.

No surge system will be approved by itself but shall be considered as part of a complete operating HMA plant. The mix as discharged from the bin(s) shall meet all specification requirements for the mix being produced. Approval for the use of a surge system may be withdrawn at any time, by the Engineer, for unsatisfactory operation.

IL-4.75 and Stone Matrix Asphalt (SMA) mixtures which contain aggregate having absorptions greater than or equal to 2.5 percent, or which contain steel slag sand, shall have a minimum silo storage plus haul time of 1.5 hours.

End of the Standard Specification Article 1102.01(a)(5)

Beginning of the Standard Specification Article 1102.01(a)(7)

(7) Equipment for Weighing HMA. The HMA shall be weighed on an approved scale furnished by the Contractor meeting the requirements of The Weights and Measures Act of the State of Illinois. Each time the scale is moved, the accuracy shall be retested and certified. For dryer drum plants the load-out scale used to weigh HMA shall be equipped with an automatic printer. Batch plants shall have an automatic printer to record the weight of all ingredient materials. The automatic printer shall be an integral part of the scale equipment or the scale and printer shall be directly connected in a manner that will prohibit the manual entry of weights, except as provided in paragraph a., below.

a. If the platform scale equipment measures gross weight (mass), the printer shall record the gross weight (mass) as a minimum. Tare and net weights (masses) shall be shown on weigh tickets and may be printed automatically or entered manually.

b. If scale equipment on a platform scale zeros out the truck tare automatically, the printer shall record the net weight (mass) as a minimum.

c. If the scale equipment on a surge bin weigh hopper zeros automatically after discharging each batch, the printer shall record the net weight (mass) as a minimum.

d. If the scale equipment on surge bins automatically shuts down the feed system weighing and weighs the amount in the silo before and after discharge, the printer shall record the net weight (mass) as a minimum.

The automatic printer shall produce a weight ticket in triplicate. Weights (Masses) shall be shown in tons (metric tons) to the nearest 0.01 ton (0.01 metric ton).

End of the Standard Specification Article 1102.01(a)(7)

Beginning of the Standard Specification Article 1102.01 (c) (1)

(c) Dryer Drum Plants. Dryer drum plants shall be according to the following.

(1) General. General requirements shall be according to Article 1102.01(a), except a hotmix surge bin meeting the requirements of (5) shall be utilized.

The heated aggregates, mineral filler, asphalt binder, and RAP/RAS when used, shall be proportioned by electronic proportioning equipment and mixed to produce a homogenous mixture in which all particles of aggregate are coated uniformly. If a question as to the degree of coating should arise, AASHTO T 195 shall be used. If the Engineer ascertains that proper mixing is not being obtained, adjustments shall be made in the plant operation (production rate, dryer drum slope, etc.) to assure that these conditions are met.

End of the Standard Specification Article 1102.01 (c) (1)

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Chapter 4 - HMA Proportioning & Blending of Aggregates

Information pertaining to: **Page**

HMA Proportioning & Blending of Aggregates

Introduction

1. General

Cold feed blending of aggregates is an important part in the setup and production of HMA mixes. Improper setup of the cold feeds can cause an incorrect gradation of the combined belt samples (dryer-drum) or the hot bins (batch). Proper setting of the cold feeds will help cure gradation issues and helps to balance the overall production, as well as, reducing or eliminating waste material. Care should be taken, especially on wet or cold days, to adjust the feed rate in order to enable the drier to heat and dry the aggregates satisfactorily.

2. Blending of Two Fine Aggregates

Regardless of what type of plant is used, whenever a mixture calls for a sand blend or two or more aggregates products with similar gradations, the only place to proportion the materials are at the cold feeds. Once the materials become combined, neither plant offers a way to separate them. For example, in a batch plant, approximately 90% of the combined sands will be screened into #1 hot bin. With a dryer-drum plant, there is no screening of the materials so inaccurate gradations will show up directly on the roadway. Once combined, the gradation can't be changed and if they are in the wrong proportions, mixture attributes (density and air voids) will be adversely affected and can cause an unworkable, unstable mixture being placed on the roadway. The Contractor could loss contract money or be required to remove and replace the questionable materials at their own expense should variations in the design blends occur.

Because of this, it is necessary to properly set the feeders for those aggregates so that the combined material gradations will match that which was achieved in the HMA design. The Quality Control Manager and/or Level 2 HMA technician must ensure that once these blend percentages are set at the cold feeders, only the master control is used to increase or decrease the total amount of aggregates are being fed to the plant. **In no case,** shall one of the feeders be turned down or off to reduce the amount of material fed to the drier to balance the plant.

3. Gradation Target Values

One of the best results of the AGCS system is the requirement of the Master Bands for the aggregate products used in HMA. Since the aggregate producers are required to manufacture the aggregates with tighter gradation bands, the shelf gradations used to create HMA mixtures are more consistent. This consistency carries over to the proportioning process allowing the Quality Control Manager and/or Level 2 HMA technician to better manage the combined gradations. A byproduct is smoother running plants with less wasted materials. Once the cold feeds are properly calibrated and filled with reliable gradations of aggregates, the result is better, more dependable HMA mixtures that will perform longer on our roadways. This is due to the requirement of the Master Band Target values and the stringent limits applied to the values (± 8%).

When producing mixture, the producer of the aggregates, Quality Control Manager and/or Level 2 HMA technician, are responsible to make sure the materials adhere to the tight controls on the gradation as the aggregate materials are produced, handled and used in the HMA mixtures being placed on Illinois roadways. The overall benefit is longer lasting roadways for the taxpayers.

4. <u>Preliminary Information</u>

Before a mixture can be produced there is a lot of behind the scenes preparation that has to be completed. The first process is the HMA producer deciding which ingredients are to be used in the mixture. Due to transportation, availability of materials and cost factors, most HMA producers are already established in what aggregate products they will use in their mixtures. The HMA producer will gather representative materials to come up with an approved design, which establishes the materials needed to be used in the mixture.

Once the mix design is in place and ready to go, the HMA producer will decide the production rate at which they want to run for the job and the plant will be given the initial settings, based on current stockpile gradations and the mix design targets. The plant will run, producing mixture, then a combined gradation sample and hot mix sample will be taken to determine the mixture attributes, air voids and control sieves gradations. Any needed adjustment will be made to further meet specification requirements for the mixture being produced. Changes or adjustments will be reflected in the plant settings to continue to producing the mixture.

5. <u>Initial Plant Settings</u> (needed to maintain proper aggregate blending)

There are three common types of initial plant settings used by dryer-drum plant manufacturers. These initial settings are obtained with the mix design and stockpile gradations.

Two terms commonly used when determining initial plant settings:

a) **100% Aggregate** This term applies only to the aggregate portion of the mixture, including the mineral filler.

b) **100% Mixture** This term applies to the total mixture ingredients, including aggregates, mineral filler and liquid asphalt binder.

When determining the initial plant settings it will be necessary to convert 100% aggregate to 100% mixture and in some instances, the reverse, 100% mixture converted to 100% aggregate. The two calculations needed for these conversions are:

100% aggregates converted to 100% mixture = aggregate percent x correction factor

100% mixture converted to 100% aggregates = mixture percent ÷ correction factor

The three initial plants settings commonly used by the industry are:

<u>100% Aggregate</u> <u>All aggregate settings, including miner filler, will total 100%</u>. The liquid asphalt binder is treated as a separate ingredient setting in the plant.

Note: This is how mix designs are expressed and is used when determining the initial plant settings.

<u>100% Mixture</u> <u>All ingredients, aggregate, mineral filler and liquid asphalt binder, will total 100%</u>, nothing is separate.

<u>100% Agg w/o MF</u> <u>All aggregate settings, excluding mineral filler, will total 100%</u>. Mineral filler is treated like an additive and entered independently, as is the liquid asphalt binder.

For the following examples, information from the design on page 4-5 will be used.

100% Aggregate Method

Using the 100% aggregate method, the Quality Control Manager and/or Level 2 HMA technician will input the aggregate percents straight from the design. For the initial plant settings to work, the stockpiled materials gradations need to be in close proximity to the gradations used during the design process, otherwise adjustments will need to be made for any differences in the gradations.

Source	Material	Design Percentage	Initial Plant Settings	Corrected Settings**
Vulcan	032 CM16	48.8	48.8	N/A
Nokomis	032 CM16	16.2	16.2	N/A
Nokomis	038 FM20	14.2	14.2	N/A
CIM	037 FM01	19.5	19.5	N/A
Bm CR	004 MF02	1.3	1.3	N/A
Total		100.0	100.0	
Asp. Mt.	10127	5.4	5.4	

100% Mixture Method

Using the 100% mixture method, the Quality Control Manager and/or Level 2 HMA technician will need to convert the 100% aggregate percentages into mix percentages to make room for the asphalt binder percentage. And, like with the 100% aggregate method, the stockpile gradations need to be close to the mix design gradations or adjustments will need to be made.

To convert the aggregate percentages to mix percentages, a correction factor (**CF**) has to be determined using the total asphalt binder percentage with the following formula (3 decimal places):

$$\text{Correction Factor (CF)} = \frac{100.0 - \text{Mix Design Asphalt Binder \%}}{100} = \frac{100 - 5.4\%}{100} = 0.946$$

Once the correction factor (**CF**) has been determined, the mix design aggregate percent's are **multiplied** by the correction factor:

Mix Design Agg. Pcts.			CF		Initial Settings	Corrected Settings**
032CM16	48.8	*	0.946	=	46.2	46.3 **
032CM16	16.2	*	0.946	=	15.3	15.3
038FM20	14.2	*	0.946	=	13.4	13.4
037FM01	19.5	*	0.946	=	18.4	18.4
004MF01	1.3	*	0.946	=	1.2	1.2
	100.0				94.5	94.6 **
Asphalt Binder	5.4				5.4	5.4
					99.9	100.0 **

** **Adjusted +0.1% due to rounding errors**. Since the percentages are being rounded to the 10^{th} of a percent, a minor amount of "rounding error" can occur. This rounding error can only account for ±0.1%, if there is more than 0.1% of error then a mathematical mistake has been made and needs to be corrected.

This rounding error is added or removed from the **largest contributing percentage** of material of the mixture (not necessarily the largest size of material) since this will have the least overall effect on the mixture.

<u>100% Aggregate w/o Mineral Filler Method</u>

Using the 100% aggregate w/o mineral filler method, the Quality Control Manager and/or Level 2 HMA technician will input the aggregate percents straight from the design, like with the 100% aggregates method, except the mineral filler will be excluded and treated as an independent additive similar to the asphalt binder. Again, for the initial plant settings to work, the stockpiled materials gradations need to be in close proximity to the gradations used during the design process, otherwise adjustments will need to be made.

To go from 100% aggregate, the HMA design, to 100% aggregate without mineral filler, a correction factor will need to be determined for the mineral filler with the following formula (3 decimal places):

$$\text{MF Correction Factor} \quad \frac{100.0 - MF\%}{100.0} = \frac{100.0 - 1.3}{100.0} = 0.987$$

Once the correction factor has been determined the mix design aggregate percents, <u>except the mineral filler</u>, is **<u>divided</u>** by the mineral filler correction factor:

Mix Design Aggregate Pcts.			Factor		Initial Settings	Corrected Settings**
032CM16	48.8	÷	0.987	=	49.4	N/A
032CM16	16.2	÷	0.987	=	16.4	N/A
038FM20	14.2	÷	0.987	=	14.4	N/A
037FM02	19.5	÷	0.987	=	19.8	N/A
Total	98.7				100.0	
004MF01	1.3				1.3	
	100.0					
Asphalt Binder	5.4				5.4	

<u>Note</u>: In this case, no rounding error was created so no corrected percentages are needed.

6. <u>AGCS Gradation Targets</u>

When proportioning a plant, it is necessary to know the critical sieves of the aggregate products. This will help to understand what size of material controls the gradation or what product will furnish the needed changes for the combined gradation to meet the critical sieve requirements for HMA mixtures.

AGCS Master Band and Critical Sieve Designation		
Gradation	**Master Band Sieve**	**Master Band (%)**
CA/CM 07	**1/2" (12.5 mm)**	**± 8**
CA/CM 11	**1/2" (12.5 mm)**	**± 8**
CA/CM 13	**# 4 (4.75 mm)**	**± 8**
CA/CM 16	**# 4 (4.75 mm)**	**± 8**
FA/FM 01, 02	**- #8 (- 2.36 mm)**	**± 15**
FA/FM 20, 21, 22	**- #8 (- 2.36 mm)**	**± 15**

HMA Superpave Mix Design Example

Date: 12/07/2016

Design No. ---------→	84BIT1234	Producer & Number→	2251-05	Asphalt Products
Design Lab ---------→	PP	Material Code ------→	19523	HMA Surf CSE N70 C

Agg. No.	#1	#2	#3	#4	#5	#6	Asphalt
Size	032CM16	032CM16	038FM20	037FM02	004MF01		10127
(Prod #)	51912-02	51352-03	51352-03	50510-04	52102-07		2260-01
(Name)	Vulcan	Nokomis	Nokomis	CIM	Bm CR St		Asp. Mt.
(Loc)	Kankakee	Nokomis	Nokomis	Vandalia	Blom, IN		Urbana
Agg %	48.8	16.2	14.2	19.5	1.3		100.0

Agg # Sieve Size	#1	#2	#3	#4	#5	#6	Blend	Max Spec	Form	Range Min	Range Max
1											
3/4											
1/2	100.0	100.0	100.0	100.0	100.0		100.0	90-100	100		100
3/8	98.0	97.0	100.0	100.0	100.0		98.5	66-100	99	52	62
#4	37.0	34.0	100.0	100.0	100.0		58.6	24-65	59	28	38
#8	9.0	7.0	74.0	87.0	100.0		34.3	16-48	34		
#16	5.4	4.8	46.0	64.0	100.0		23.1	10-32	24		
#30	5.2	4.0	28.0	40.0	100.0		16.3		16	12	20
#50	4.0	3.5	16.0	15.0	100.0		9.0	4-15	9		
#100	3.8	3.3	9.0	3.0	98.0		5.5	3-10	6		
#200	3.5	3.0	5.9	1.6	88.0		4.5	2-6	4.5	3.2	6.2
					RAP AB %=====→						

	#1	#2	#3	#4	#5	#6	Blend	
Bulk Sp Gr	2.635	2.614	2.595	2.480	2.800		2.588	Bulk Sp Gr
Appr Sp Gr	1	1	1	1	1			Apparent Sp Gr
Absorp %	1.1	1.4	1.6	2.4	1		1.5	Absorption %
							1.030	AB Sp Gr
							0.87	Dust/AB Ratio

HMA Aging Time = 1 hour @ 154° C

Summary of Superpave Gyratory Test Data

	N-Initial 10				N-Design 70				Adjusted G_{se}			
PB	4.4	4.9	5.4	5.9	4.4	4.9	5.4	5.9	4.4	4.9	5.4	5.9
G_{mb} (Corr)	2.079	2.083	2.099	2.110	2.317	2.318	2.340	2.353	2.317	2.318	2.340	2.353
G_{mm}	2.473	2.455	2.437	2.420	2.473	2.455	2.437	2.420	2.473	2.455	2.438	2.420
P_a	15.9	15.2	13.9	12.8	6.3	5.6	4.0	2.8	6.3	5.6	4.0	2.8
VMA	23.2	23.5	23.3	23.3	14.4	14.8	14.5	14.4	14.4	14.8	14.5	14.4
Field VMA	24.8	25.1	24.9	24.9	16.2	16.6	16.3	16.3	16.2	16.6	16.3	16.3
VFA	31.4	35.4	40.4	44.9	56.4	62.3	72.4	80.8	56.2	62.3	72.4	80.8
V_{be}	7.3	8.3	9.4	10.5	8.1	9.2	10.5	11.7	8.1	9.2	10.5	11.7
P_{be}	3.6	4.1	4.6	5.1	3.6	4.1	4.6	5.1	3.6	4.1	4.6	5.1
G_{se}	2.643	2.644	2.644	2.644	2.643	2.644	2.644	2.644	2.644	2.644	2.644	2.644
P_{ba}	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8

Optimum Mixture Design Data

Slope: 9.9 Does design require Anti-Strip Additive (yes or no) No Anti-Strip Material Code #

Number of Revolutions 70

	AB%	G_{mm}	G_{mb}	% Voids P_a	VMA	Design Field VMA	VFA	G_{se}	G_{sb}	TSR	TSR W/Anti
Optimum Data	**5.4**	**2.438**	**2.340**	**4.0**	**14.5**	**16.3**	**72.2**	**2.644**	**2.588**	**0.75**	
Adj. Data	5.4	2.438	2.340	4.0	14.5	16.3	72.4	2.644	2.588	0.75	
Min. Requirements				4.0	14.5		65-75			0.75	0.75
State Results											

Dryer-drum Plant Set-up Step by Step Instructions

a) Copy information from the design over to the worksheet:

Design formula - job mix formula (JMF)
Mix design aggregate percents
Mix design optimum asphalt binder percentage

b) Determine the average stockpile gradations and place information on the worksheet

c) Multiply each gradation column by the respective Agg% to get the Bin% for each sieve size rounding answer to the nearest 0.1%

d) Calculate combined gradation for each sieve size rounding answers to the whole percent **EXCEPT** the #200 material (which is always rounded to the tenth of a percent)

e) Calculate the correction factor

f) Multiply each Agg% by the correction factor to obtain the respective Mix% and record to the nearest 10^{th} of a percent

g) Transfer the optimum AB% to the "New Bit" location

h) Total the Mix%s (this must total 100.0%), adjust as needed for rounding error**

** Rounding error can only account for 0.1 difference

i) Determine the production rate (TPH) for the mix

j) Calculate the TPH rate for each individual mix ingredient

IN CLASS or REAL WORLD

Adjustments are not normally made on a set-up

A plant set-up is the process of establishing plant settings to start making mix. Ideally, if the current stockpile gradations are close to what was used during the design process, the calculated combined gradation should be close enough to start making mix. If these calculated results don't match the targets exactly, but are within two to three of percent of the targets, adjusting the plant settings will typically be taken care of later after sampling and completion of some mixture plant tests (air voids, AB content, gradations, density, etc.). Once the tests are completed and the information is available, adjustments can then be made. In the unfortunate circumstance that the calculated information is significantly different from the mixture targets, the stockpile gradations, cold feed settings and/or calibrations should be rechecked.

Dryer-Drum Set-up Class Example #1

Date: 12/07/16

Design No. ---------→	84BIT1234	Producer & Number→	2251-05	Asphalt Products
Design Lab ---------→	PP	Material Code ------→	19513	HMA Surf CSE N50 C

Agg. No.	#1	#2	#3	#4	#5	#6	Asphalt
Size		032CM16		037FM02	004MF01		10127
(Prod #)		51912-02		50510-04	52102-07		2260-01
(Name)		Vulcan		CIM	Bm CR St		Asp. Mt.
(Loc)		Kankakee		Vandalia	Blom, IN		Urbana
Agg %		67.0		31.0	2.0		100.0

Agg # Sieve Size	#1	#2	#3	#4	#5	#6	Blend	Max Spec	Form	Range Min	Range Max
1											
3/4											
1/2		100.0		100.0	100.0		100.0	90-100	100		100
3/8		97.5		100.0	100.0		98.3	66-100	98	90	100
#4		38.6		100.0	100.0		58.9	24-65	59	28	65
#8		8.0		87.0	100.0		34.4	16-48	34	28	48
#16		5.6		60.0	100.0		24.0	10-32	24	10	32
#30		5.2		35.0	100.0		16.0		16		
#50		5.0		13.0	100.0		9.2	4-15	9	4	15
#100		4.7		7.0	98.0		7.3	3-10	7	3	10
#200		4.2		2.0	92.0		5.2	2-6	5.2	4	6

RAP AB %=====→

Optimum Mixture Design Data

Number of Revolutions: 50

	AB%	G_{mm}	G_{mb}	% Voids P_a	VMA	Design Field VMA	VFA	G_{se}	G_{sb}	TSR	TSR W/Anti
Optimum Data	**5.2**	**2.438**	**2.340**	**4.0**	**14.5**	**16.3**	**72.2**	**2.644**	**2.588**	**0.75**	

Average Stockpile Gradations

Sieve Size	CM11	CM16	FM20	FM02	MF01
1					
3/4					
1/2		**100**		**100**	**100**
3/8		**96**		**100**	**100**
# 4		**39**		**100**	**100**
# 8		**9**		**86**	**100**
# 16		**7**		**59**	**100**
# 30		**5**		**35**	**100**
# 50		**5**		**14**	**100**
# 100		**5**		**9**	**97**
# 200		**4.2**		**2.1**	**91.0**

Drier-Dryer-Drum Set-up Class Example #1

Feeder	RAP	#1	#2	#3	#4	------	New Bit			
Size			**CM16**		**FM02**	**MF01**				
Mix%								**= 100%**		
TPH								**Prod Rate TPH = 500**		
Agg%			**67.0**		**31.0**	**2.0**		**= 100%**		
Sieve Size	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	Comb Grad	Target	Control Limits Min	 Max
1										
3/4										
1/2			**100**		**100**	**100**		**100**		
3/8			**96**		**100**	**100**		**98**		
#4			**39**		**100**	**100**		**59**		
#8			**9**		**86**	**100**		**34**		
#16			**7**		**59**	**100**		**24**		
#30			**5**		**35**	**100**		**16**		
#50			**5**		**14**	**100**		**9**		
#100			**5**		**9**	**97**		**7**		
#200			**4.2**		**2.1**	**91.0**		**5.2**		
AB								**5.2**		

Dryer-Drum Set-up Class Example #2

Date: 12/07/16

Design No. ---------→	35BIT0000	Producer & Number→	1977-01	XYZ Asphalt
Design Lab ---------→	PP	Material Code ------→	19534	HMA Surf CSE N90 D

Agg. No.	#1	#2	#3	#4	#5	#6	Asphalt
Size		032CM16	038FM20		004MF01		10112
(Prod #)		51972-02	50972-02		52102-07		2260-01
(Name)		Material	Material		Bm CR St		Asp. Mt.
(Loc)		Service	Service		Blom. IN		Urbana
Agg %		66.3	31.5		2.2		100.0

Agg # Sieve Size	#1	#2	#3	#4	#5	#6	Blend	Max Spec	Formula	Range Min	Range Max
1											
3/4											
1/2		100.0	100.0		100.0		100.0	100	100		100
3/8		95.9	100.0		100.0		97.3	90-100	97	90	100
#4		36.3	98.1		100.0		57.2	28-65	57	28	65
#8		9.6	76.5		100.0		32.7	28-48	33	28	48
#16		6.6	52.0		100.0		23.0	10-32	23	10	32
#30		4.5	34.0		100.0		15.9		16		
#50		4.0	17.3		100.0		10.3	4-15	10	4	15
#100		3.7	9.8		98.0		7.8	3-10	8	3	10
#200		2.0	7.3		95.0		5.7	4-6	5.7	4	6

RAP AB %=====→

Optimum Mixture Design Data

Number of Revolutions: 90

	AB%	G_{mm}	G_{mb}	% Voids P_a	VMA	Design Field VMA	VFA	G_{se}	G_{sb}	TSR	TSR W/Anti
Optimum Data	**6.1**	**2.425**	**2.327**	**4.0**	**14.7**	**16.5**	**68.1**	**2.644**	**2.588**	**0.89**	

Average Stockpile Gradations

Sieve Size	CM11	CM16	FM20	FM02	MF01
1					
3/4					
1/2		**100**	**100**		**100**
3/8		**95**	**100**		**100**
# 4		**37**	**99**		**100**
# 8		**8**	**78**		**100**
# 16		**6**	**54**		**100**
# 30		**5**	**32**		**100**
# 50		**4**	**16**		**100**
# 100		**3**	**11**		**98**
# 200		**2.2**	**7.1**		**94.0**

Drier-Dryer-Drum <u>Set-up</u> Class Example #2

Feeder	RAP	#1	#2	#3	#4	------	-----			
Size			**CM16**	**FM20**		**MF01**	**New Bit**			
Mix%								**= 100%**		
TPH								**Prod Rate TPH = 500**		
Agg%			**66.3**	**31.5**		**2.2**		**= 100%**		
Sieve Size	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	Comb Grad	Target	Control Limits Min	Control Limits Max
1										
3/4										
1/2			**100**	**100**		**100**		**100**		
3/8			**95**	**100**		**100**		**97**		
#4			**37**	**99**		**100**		**57**		
#8			**8**	**78**		**100**		**33**		
#16			**6**	**54**		**100**		**23**		
#30			**5**	**32**		**100**		**16**		
#50			**4**	**16**		**100**		**10**		
#100			**3**	**11**		**98**		**8**		
#200			**2.2**	**7.1**		**94.0**		**5.7**		
AB								**6.1**		

This page is reserved

RAP/RAS Proportioning Procedures

HMA Mix Recycling

1. General

The asphalt industry remains the country's number one recycler. About 96 percent of the industry is reported to be using recycling materials and/or green procedures. This is due to a number of factors, including; economics, regulations and competition. The Federal Highway Administration, in cooperation with the National Asphalt Pavement Association, began focusing on three areas; RAP, RAS and WMA.

Because of this focus, the asphalt pavement industry is committed to environmental stewardship by increasing the use of recycled materials, RAP and RAS, and warm mix asphalt (WMA) technology helping to reduce energy, cut plant and paving emissions, improve working conditions and conserve natural resources.

Reclaimed **A**sphalt **P**avement (**RAP**) is one of the most recycled and reused highway construction materials consisting of the cold millings or crushed HMA mixtures removed from roadways. When HMA materials reach the end of their life expectancy on the roadways the material is roto-milled (ground off) to make room for new materials. The incorporation of RAP into HMA mixtures began in the 1970s due to the oil embargo and has continued to grow ever since. RAP will contribute to the HMA mixture a certain percentage of the coarse and fine aggregates, as well as mineral filler and liquid asphalt binder.

Reclaimed **A**sphalt **S**hingles (**RAS**) includes shingle manufacturer's waste and roof tear-off material. Although RAS was introduced to the asphalt industry in the mid-1980s the use of RAS has increased in recent years. RAS contains high levels of asphalt binder content, high-quality fine aggregate, mineral filler and fibers which is very compatible for use in HMA mixtures.

Warm-**M**ix **A**sphalt (**WMA**) is achieved by introducing certain types of additives and utilizing different production processes that reduce mixing and placement temperatures of conventional hot mix asphalt. Warm-mix technology began in Europe and was first introduced to the United States in 2004. The warm-mix technology continues to grow at a rapid rate because of economic, environmental and workplace benefits.

Only RAP and RAS will be discussed in this chapter.

RAP/RAS materials are commonly introduced into HMA mixture during the production process by heat transfer (batch plant), a direct heating method (dryer-drum plant) or an indirect heating method (both types of plants). Other acceptable methods, other than what is described here, may be used, with approval, for the incorporation of RAP/RAS into HMA mixtures.

In the **heat transfer method**, the recycled material is fed directly into the plant aggregate weigh hopper on top of the uncoated heated aggregates. Since the recycled materials are not normally heated prior to incorporation into the mixture, the heated virgin aggregates are required to be superheated in order to offset the cooling effect caused by the ambient-temperature of the recycled materials (See Table 2 on page 4-15). After all of the aggregates, heated and recycled, are weighed, they are deposited into the pugmill where the heat from the superheated aggregates will transfer to the cooler materials allowing the recycled materials to soften and be incorporated into the mixture during the "dry" mixing process. In order to meet the required asphalt binder mix percentage, additional "new" liquid asphalt binder is added to the batch during the "wet" mixing process. This method is commonly used in a batch plant.

In the **direct heating method**, the recovered asphalt pavement material is ‘directly’ added through a port located approximately half-way down the drier. This port is located where the recycled materials will be protected from the burner flame by the veil of tumbling aggregates inside the drier. The recycled materials will be heated and incorporated into the mixture when the hot virgin aggregates and gases soften the RAP/RAS and take advantage of the mixing action. Additional new liquid asphalt binder will be injected shortly after the introduction of the RAP. This method is commonly used in a dryer-drum plant.

In the **indirect heating method**, the recovered asphalt pavement is added to the drum behind the burner or in another chamber. The required amount of new asphalt binder is then added after the point of entry of the RAP.

NOTE: Some of the above information was obtained from the NAPA website (asphaltpavement.org) and from the “Asphalt Pavement Mix Production Survey; Reclaimed Asphalt Pavement, Reclaimed Asphalt Shingles, Warm-mix Asphalt Usage: 2009-2010” document.

2. General RAP Sampling Procedure

The first step in establishing a recycled HMA mix is to extract and analyze the RAP material. The analyzed RAP material data will permit the contractor to add ‘recycled’ aggregates and liquid asphalt binder to the mixture to meet the combined gradation and mix properties as allowed by the specifications. This may be done in the following manner:

a. A series of samples will be taken at random locations from the roadway during the milling process. Liquid asphalt binder content and aggregate gradations tests will be run on these samples.

b. Or, if the RAP material is being placed or is located in an existing stockpile, the stockpile can be sampled at random locations and the liquid asphalt binder content and aggregate gradations tests will be run on these samples.

c. The producer is required to obtain split samples for assurance testing purposes of the materials for IDOT.

d. After obtaining the average gradations and asphalt binder contents of the sampled RAP materials (See Table 1 example below), these values will be used in the design process and the information will be reported to IDOT.

Table 1 - RAP Stockpile Sample Gradation Example

	Sieves											
Test #	1”	3/4”	1/2”	3/8”	#4	#8	#16	#30	#50	#100	#200	Asphalt Binder
1	100	95	81	75	65	49	31	27	25	13	7.8	4.2
2	100	96	86	76	67	48	32	26	24	12	7.6	3.9
3	100	94	83	74	60	47	36	28	23	13	7.5	3.9
4	100	95	84	73	62	46	33	27	22	14	7.6	4.3
5	100	93	86	74	63	43	35	24	21	13	7.5	3.9
6	100	92	80	72	64	40	32	24	20	12	7.1	4.0
7	100	90	89	71	65	48	31	28	19	12	7.5	3.8
8	100	95	88	78	64	46	30	27	25	13	7.8	4.0
9	100	96	81	71	62	45	32	29	22	13	7.2	4.2
10	100	96	82	72	62	43	34	30	26	13	7.8	4.1
Average	100	94	84	74	63	46	33	27	23	13	7.5	4.0

TABLE 2
Temperature Suggested for Virgin Aggregates

Recycled Mix Discharge Temperature ºC (ºF)								
Moisture Content %	104ºC	(220ºF)	116ºC	(240ºF)	127ºC	(260ºF)	138ºC	(**280ºF**)
Ratio : **20%** Reclaimed Material / **80%** New Aggregate								
0	138	(280)	152	(305)	166	(330)	179	(355)
1	143	(290)	157	(315)	171	(340)	185	(365)
2	152	(305)	166	(330)	179	(355)	193	(380)
3	160	(320)	174	(345)	188	(370)	202	(395)
4	168	(335)	182	(360)	196	(385)	210	(410)
5	177	(350)	191	(375)	204	(400)	218	(425)
Ratio: **30%** Reclaimed Material / **70%** New Aggregate								
0	152	(305)	168	(335)	185	(365)	199	(390)
1	160	(320)	179	(355)	195	(385)	213	(415)
2	177	(350)	193	(380)	210	(410)	224	(435)
3	191	(375)	207	(405)	224	(435)	238	(460)
4	204	(400)	221	(430)	238	(460)	252	(485)
5	218	(425)	235	(455)	252	(485)	266	(510)
Ratio: **40%** Reclaimed Material / **60%** New Aggregate								
0	171	(340)	191	(375)	210	(410)	227	(440)
1	191	(375)	210	(410)	229	(445)	246	(475)
2	213	(415)	229	(445)	249	(480)	268	(515)
3	232	(450	252	(485)	271	(520)	288	(550)
4	254	(490)	271	(520)	291	(555)	310	(590)
5	277	(530)	293	(560)	313	(595)	332	(630)
Ratio: **50%** Reclaimed Material / **50%** New Aggregate								
0	199	(390)	221	(430)	243	(470)	266	(510)
1	229	(445)	252	(435)	274	(525)	296	(565)
2	260	(500)	282	(540)	304	(580)	327	(620)
3	291	(555)	313	(595)	335	(635)	357	(675)
4	324	(615)	346	(655)	368	(695)	391	(735)
5	354	(670)	377	(710)	399	(750)	421	(790)

Note: Procedures for sampling and testing of RAS materials are too extensive to be covered in this manual or class. Some information can be obtained by referring to the “Reclaimed Asphalt Pavement and Reclaimed Asphalt Shingles BDE document found on page 4-19 in this chapter and/or by contacting the appropriate District Materials Engineer.

Beginning of the Standard Specification Article 1031

"SECTION 1031. RECLAIMED ASPHALT PAVEMENT

1031.01 Description. *RAP is reclaimed asphalt pavement resulting from cold milling or crushing of an existing dense graded hot-mix asphalt (HMA) pavement. The Contractor shall supply written documentation that the RAP originated from routes or airfields under federal, state or local agency jurisdiction.*

1031.02 Stockpiles. *The Contractor shall construct individual, sealed RAP stockpiles meeting one of the following definitions. No additional RAP shall be added to the pile after the pile has been sealed.*

(a) Homogeneous. Homogeneous RAP stockpiles shall consist of RAP from Class I, Superpave (High ESAL), HMA (High ESAL), or equivalent, mixtures only and represent; 1) the same aggregate quality, but shall be at least C quality or better; 2) the same type of crushed aggregate (either crushed natural aggregate, ACBF slag, or steel slag); 3) similar gradation; and 4) similar asphalt binder content. If approved by the Engineer, combined single pass surface/binder millings may be considered "homogenous", with a quality rating dictated by the lowest coarse aggregate quality present in the mixture. Stockpiles shall meet the testing requirements of Article 1031.07. Stockpiles not meeting these requirements may be processed (crushing and screening) and retested.

(b) Conglomerate. Conglomerate RAP stockpiles shall consist of RAP from Class I, Superpave (High ESAL), HMA (High ESAL), or equivalent, mixtures only. The coarse aggregate in this RAP shall be crushed aggregate only and may represent more than one aggregate type and/or quality but shall be Reclaimed Asphalt Pavement Art. 1031.04 at least C quality or better. This RAP may have an inconsistent gradation and/or asphalt binder content prior to processing. All conglomerate RAP shall be processed prior to testing by crushing to where all RAP shall pass the 5/8 in. (16 mm) or smaller screen. Stockpiles shall not contain steel slag or other expansive material as determined by the Department. Stockpiles shall meet the testing requirements of Article 1031.07.

(c) Conglomerate "D" Quality (DQ). Conglomerate DQ RAP stockpiles shall consist of RAP containing coarse aggregate (crushed or round) that is at least D quality or better. Conglomerate DQ RAP stockpiles shall not contain steel slag or other expansive material as determined by the Department. Conglomerate DQ RAP shall meet the testing requirements of Article 1031.07.

Reclaimed Superpave (Low ESAL)/HMA (Low ESAL) IL-19.0L binder and IL-9.5L surface mixtures shall be placed in conglomerate DQ RAP stockpiles due to potential of rounded aggregate.

(d) Other. RAP stockpiles that do not meet the requirements of the stockpile categories listed above shall be classified as "Other". "Other" RAP stockpiles shall not be used in HMA.

1031.03 Contaminants. *RAP containing contaminants, such as earth, brick, sand, concrete, sheet asphalt, bituminous surface treatment (i.e. chip seal), pavement fabric, joint sealants, etc., will be unacceptable unless the contaminants are removed to the satisfaction of the Engineer. Sheet asphalt shall be stockpiled separately.*

1031.04 Quality Designation of Aggregate in RAP. *The use of RAP in HMA shall be set by the lowest quality of coarse aggregate in the RAP stockpile and are designated as follows.*

(a) RAP from Class I, Superpave (High ESAL) or HMA (High ESAL) surface mixtures are designated as containing Class B quality coarse aggregate only.

(b) RAP from Superpave (Low ESAL)/HMA (Low ESAL) IL-19.0L binder and IL-9.5L surface mixtures are designated as Class C quality coarse aggregate only.

(c) RAP from Class I, Superpave (High ESAL), or HMA (High ESAL) binder mixtures, bituminous base course mixtures, and bituminous base course widening mixtures are designated as containing Class C quality coarse aggregate only.

(d) RAP from bituminous stabilized subbase and BAM shoulders are designated as containing Class D quality coarse aggregate only.

The Contractor shall supply written documentation that the RAP meets the above quality designations.

Any mixture not listed above shall have the designated quality determined by the Department.

1031.05 RAP in HMA. *The use of RAP in HMA shall be as follows.*

(a) Coarse Aggregate Size. The coarse aggregate in all RAP shall be equal to or less than the nominal maximum size requirement for the HMA mixture to be produced using RAP.

(b) Steel Slag Stockpiles. RAP stockpiles containing steel slag or other expansive material, as determined by the Department, shall be homogeneous and will be approved for use in HMA (High ESAL and Low ESAL) surface mixtures only.

(c) Use in High and Low ESAL Mixtures. RAP stockpiles for use in HMA mixtures (High ESAL and Low ESAL) shall be either homogeneous or conglomerate, except conglomerate stockpiles shall not be used in HMA surface mixture Ndesign 50 or greater.

(d) Use in Shoulders and Subbase. RAP stockpiles for use in HMA shoulders and stabilized subbase (HMA) shall be homogeneous, conglomerate, or conglomerate DQ.

1031.06 RAP in Aggregate Surface Course and Aggregate Shoulders. *The use of RAP in Aggregate Surface Course and Aggregate Shoulders shall be as follows.*

(a) Stockpiles. RAP stockpiles may be any of those listed in Article 1031.02.

(b) Gradation. One hundred percent of the RAP material shall pass the 1 1/2 in. (37.5 mm) sieve. The RAP material shall be reasonably well graded from coarse to fine. RAP material that is gap-graded or single sized will not be accepted.

(c) Exclusion. The requirements of Article 1031.07 do not apply.

1031.07 Testing. *All RAP shall be sampled and tested either during or after stockpiling.*

For testing during stockpiling, washed extraction samples shall be run at the minimum frequency of one sample per 500 tons (450 metric tons) for the first 2000 tons (1800 metric tons) and one sample per 2000 tons (1800 metric tons) thereafter. A minimum of five tests shall be required for stockpiles less than 4000 tons (3600 metric tons).

For testing existing stockpiles, the Contract or shall submit a plan for approval to the District proposing a satisfactory method of sampling and testing the RAP pile either in-situ or by restockpiling. The sampling plan shall meet the minimum frequency required above and detail the procedure used to obtain representative samples throughout the pile for testing.

Each field sample shall be split to obtain two samples for testing. One of the test samples from the final split shall be labeled and stored for Department use. The Contractor shall extract the other test sample according to Illinois Modified AASHTO T 164. The Engineer reserves the right to test any sample (split or Department-taken) to verify Contractor test results.

All of the extraction results shall be compiled and averaged for asphalt binder content and gradation. Individual extraction test results, when compared to the averages, will be accepted if within the tolerances listed below.

Parameter	Homogeneous / Conglomerate	Conglomerate "D" Quality
1 in. (25 mm)		± 5%
1/2 in. (12.5 mm)	± 8%	± 15%
No. 4 (4.75 mm)	± 6%	± 13%
No. 8 (2.36 mm)	± 5%	
No. 16 (1.18 mm)		± 15%
No. 30 (600 µm)	± 5%	
No. 200 (75 µm)	± 2.0%	±4.0%
Asphalt Binder	± 0.4%	± 0.5%

If more than 20 percent of the individual sieves are out of the gradation tolerances, or if more than 20 percent of the asphalt binder content test results fall outside the appropriate tolerances, the RAP shall not be used in HMA unless the RAP representing the failing tests is removed from the stockpile. All test data and acceptance ranges shall be sent to the District for evaluation.

If additional RAP stockpiles are tested and found that no more than 20 percent of the results are outside of the control tolerances set for the original RAP stockpile and HMA mix design, the additional RAP stockpiles may be used in the original mix design at the percent previously verified.

With the approval of the Engineer, the ignition oven may be substituted for extractions according to the ITP, "Calibration of the Ignition Oven for the Purpose of Characterizing Reclaimed Asphalt Pavement (RAP)". "

<u>End of the Standard Specification Article 1031</u>

<u>Beginning of the Special Provision for Reclaimed Asphalt Pavement (RAP) and Reclaimed Asphalt Shingles (RAS) document</u>

To: *"Regional Engineers*

From: *Maureen M Addis.*

Subject: *Special Provision for Reclaimed Asphalt Pavement (RAP) and Reclaimed Asphalt Shingles (RAS)*

Date: *September 29, 2017*

This special provision was developed by the Bureau of Materials and Physical Research to combine the existing two BDE special provisions, Reclaimed Asphalt Pavement and Reclaimed Asphalt Shingles into one.

This special provision has been revised to remove RAS stone bulk specific gravity (G_{sb}) which is now contained in the Department's Manual of Test Procedures for Materials and to make minor corrections.

This special provision should be inserted in all HMA contracts.

The districts should include the BDE Check Sheet marked with the applicable special provisions for the January 19, 2018 and subsequent lettings. The Project Development and Implementation Section will include a copy in the contract.

This special provision will be available on the transfer directory September 29, 2017.

80306m

RECLAIMED ASPHALT PAVEMENT AND RECLAIMED ASPHALT SHINGLES (BDE)

Effective: November 1, 2012
Revise: January 1, 2018

Revise Section 1031 of the Standard Specifications to read:

"SECTION 1031. RECLAIMED ASPHALT PAVEMENT AND RECLAIMED ASPHALT SHINGLES"

1031.01 Description. *Reclaimed asphalt pavement and reclaimed asphalt shingles shall be according to the following.*

(a) Reclaimed Asphalt Pavement (RAP). RAP is the material produced by cold milling or crushing an existing hot-mix asphalt (HMA) pavement. The Contractor shall supply written documentation that the RAP originated from routes or airfields under federal, state, or local agency jurisdiction.

(b) Reclaimed Asphalt Shingles (RAS). Reclaimed asphalt shingles (RAS). RAS is from the processing and grinding of preconsumer or post-consumer shingles. RAS shall be a clean and uniform material with a maximum of 0.5 percent unacceptable material, as defined in Central Bureau of Materials Policy Memorandum "Reclaimed Asphalt Shingle (RAS) Sources", by weight of RAS. All RAS used shall come from a Central Bureau of Materials approved processing facility where it shall be ground and processed to 100 percent passing the 3/8 in. (9.5 mm) sieve and 93 percent passing the #4 (4.75 mm) sieve based on a dry shake gradation. RAS shall be uniform in gradation and asphalt binder content and shall meet the testing requirements specified herein. In addition, RAS shall meet the following Type 1 or Type 2 requirements.

(1) Type 1. Type 1 RAS shall be processed, preconsumer asphalt shingles salvaged from the manufacture of residential asphalt roofing shingles.

(2) Type 2. Type 2 RAS shall be processed post-consumer shingles only, salvaged from residential, or four unit or less dwellings not subject to the National Emission Standards for Hazardous Air Pollutants (NESHAP).

1031.02 Stockpiles. *RAP and RAS stockpiles shall be according to the following.*

(a) RAP Stockpiles. The Contractor shall construct individual, sealed RAP stockpiles meeting one of the following definitions. No additional RAP shall be added to the pile after the pile has been sealed. Stockpiles shall be sufficiently separated to prevent intermingling at the base. Stockpiles shall be identified by signs indicating the type as listed below (i.e. "Homogeneous Surface").

Prior to milling, the Contractor shall request the District provide documentation on the quality of the RAP to clarify the appropriate stockpile.

(1) Fractionated RAP (FRAP). FRAP shall consist of RAP from Class I, HMA (High and Low ESAL) mixtures. The coarse aggregate in FRAP shall be crushed aggregate and may represent more than one aggregate type and/or quality, but shall be at least C quality. All FRAP shall be fractionated prior to testing by screening into a minimum of two size fractions with the separation occurring on or between the #4 (4.75 mm) and 1/2 in. (12.5 mm) sieves. Agglomerations shall be minimized such that 100 percent of the RAP shall pass the sieve size specified below for the mix into which the FRAP will be incorporated.

Mixture FRAP will be used in:	*Sieve Size that 100% of FRAP Shall Pass*
IL-19.0	*1 1/2 in. (40 mm)*
IL-9.5	*3/4 in. (20 mm)*
IL-4.75	*1/2 in. (13 mm)*

(2) Homogeneous. Homogeneous RAP stockpiles shall consist of RAP from Class I, HMA (High and Low ESAL) mixtures and represent: 1) the same aggregate quality, but shall be at least C quality; 2) the same type of crushed aggregate (either crushed natural aggregate, ACBF slag, or steel slag); 3) similar gradation; and 4) similar asphalt binder content. If approved by the Engineer, combined single pass surface/binder millings may be considered "homogenous" with a quality rating dictated by the lowest coarse aggregate quality present in the mixture.

(3) Conglomerate. Conglomerate RAP stockpiles shall consist of RAP from Class I, HMA (High and Low ESAL) mixtures. The coarse aggregate in this RAP shall be crushed aggregate and may represent more than one aggregate type and/or quality, but shall be at least C quality. This RAP may have an inconsistent gradation and/or asphalt binder content prior to processing. All conglomerate RAP shall be processed prior to testing by crushing to where all RAP shall pass the 5/8 in. (16 mm) or smaller screen. Conglomerate RAP stockpiles shall not contain steel slag.

(4) Non-Quality. RAP stockpiles that do not meet the requirements of the stockpile categories listed above shall be classified as "Non-Quality".

RAP/FRAP containing contaminants, such as earth, brick, sand, concrete, sheet asphalt, bituminous surface treatment (i.e. chip seal), pavement fabric, joint sealants, etc., will be unacceptable unless the contaminants are removed to the satisfaction of the Engineer. Sheet asphalt shall be stockpiled separately.

(b) RAS Stockpiles. Type 1 and Type 2 RAS shall be stockpiled separately and shall not be intermingled. Each stockpile shall be signed indicating what type of RAS is present.

Unless otherwise specified by the Engineer, mechanically blending manufactured sand (FM 20 or FM 22) up to an equal weight of RAS with the processed RAS will be permitted to improve workability. The sand shall be "B Quality" or better from an approved Aggregate Gradation Control System source. The sand shall be accounted for in the mix design and during HMA production.

Records identifying the shingle processing facility supplying the RAS, RAS type, and lot number shall be maintained by project contract number and kept for a minimum of three years.

1031.03 Testing. *RAP/FRAP and RAS testing shall be according to the following.*

(a) RAP/FRAP Testing. When used in HMA, the RAP/FRAP shall be sampled and tested either during or after stockpiling.

(1) During Stockpiling. For testing during stockpiling, washed extraction samples shall be run at the minimum frequency of one sample per 500 tons (450 metric tons) for the first 2000 tons (1800 metric tons) and one sample per 2000 tons (1800 metric tons) thereafter. A minimum of five tests shall be required for stockpiles less than 4000 tons (3600 metric tons).

(2) After Stockpiling. For testing after stockpiling, the Contractor shall submit a plan for approval to the District proposing a satisfactory method of sampling and testing the RAP/FRAP pile either in-situ or by restockpiling. The sampling plan shall meet the minimum frequency required above and detail the procedure used to obtain representative samples throughout the pile for testing.

Each sample shall be split to obtain two equal samples of test sample size. One of the two test samples from the final split shall be labeled and stored for Department use. The Contractor shall extract the other test sample according to Department procedure. The Engineer reserves the right to test any sample (split or Department-taken) to verify Contractor test results.

(b) RAS Testing. RAS or RAS blended with manufactured sand shall be sampled and tested during stockpiling according to Central Bureau of Materials Policy Memorandum, "Reclaimed Asphalt Shingle (RAS) Source".

Samples shall be collected during stockpiling at the minimum frequency of one sample per 200 tons (180 metric tons) for the first 1000 tons (900 metric tons) and one sample per 250 tons (225 metric tons) thereafter. A minimum of five samples are required for stockpiles less than 1000 tons (900 metric tons). Once a ≤ 1000 ton (900 metric ton), five-sample/test stockpile has been established it shall be sealed. Additional incoming RAS or RAS blended with manufactured sand shall be stockpiled in a separate working pile as designated in the Quality Control plan and only added to the sealed stockpile when the test results of the working pile are complete and are found to meet the tolerances specified herein for the original sealed RAS stockpile.

Before testing, each sample shall be split to obtain two test samples. One of the two test samples from the final split shall be labeled and stored for Department use. The Contractor shall perform a washed extraction and test for unacceptable materials on the other test sample according to Department procedures. The Engineer reserves the right to test any sample (split or Department-taken) to verify Contractor test results.

If the sampling and testing was performed at the shingle processing facility in accordance with the QC Plan, the Contractor shall obtain and make available all of the test results from start of the initial stockpile.

1031.04 Evaluation of Tests. *Evaluation of tests results shall be according to the following.*

(a) Evaluation of RAP/FRAP Test Results. All of the extraction results shall be compiled and averaged for asphalt binder content and gradation, and when applicable G_{mm}. Individual extraction test results, when compared to the averages, will be accepted if within the tolerances listed below.

Parameter	FRAP/Homogeneous /Conglomerate
1 in. (25 mm)	
1/2 in. (12.5 mm)	± 8 %
No. 4 (4.75 mm)	± 6 %
No. 8 (2.36 mm)	± 5 %
No. 16 (1.18 mm)	
No. 30 (600 µm)	± 5 %
No. 200 (75 µm)	± 2.0 %
Asphalt Binder	± 0.4 % [1/]
G_{mm}	± 0.03

1/ The tolerance for FRAP shall be ± 0.3 %.

If more than 20 percent of the individual sieves and/or asphalt binder content tests are out of the above tolerances, the RAP/FRAP shall not be used in HMA unless the RAP/FRAP representing the failing tests is removed from the stockpile. All test data and acceptance ranges shall be sent to the District for evaluation.

With the approval of the Engineer, the ignition oven may be substituted for extractions according to the ITP, "Calibration of the Ignition Oven for the Purpose of Characterizing Reclaimed Asphalt Pavement (RAP)".

(b) Evaluation of RAS and RAS Blended with Manufactured Sand Test Results. All of the test results, with the exception of percent unacceptable materials, shall be compiled and averaged for asphalt binder content and gradation. Individual test results, when compared to the averages, will be accepted if within the tolerances listed below.

Parameter	*RAS*
No. 8 (2.36 mm)	*± 5 %*
No. 16 (1.18 mm)	*± 5 %*
No. 30 (600 µm)	*± 4 %*
No. 200 (75 µm)	*± 2.0 %*
Asphalt Binder Content	*± 1.5 %*

If more than 20 percent of the individual sieves and/or asphalt binder content tests are out of the above tolerances, or if the percent unacceptable material exceeds 0.5 percent by weight of material retained on the # 4 (4.75 mm) sieve, the RAS or RAS blend shall not be used in Department projects. All test data and acceptance ranges shall be sent to the District for evaluation.

1031.05 Quality Designation of Aggregate in RAP/FRAP.

(a) RAP. The aggregate quality of the RAP for homogenous, conglomerate stockpiles shall be set by the lowest quality of coarse aggregate in the RAP stockpile and are designated as follows.

(1) RAP from Class I, Superpave/HMA (High ESAL), or (Low ESAL) IL-9.5L surface mixtures are designated as containing Class B quality coarse aggregate.

(2) RAP from Class I binder, Superpave/HMA (High ESAL)binder, or (Low ESAL) IL-19.0L binder mixtures are designated as containing Class C quality coarse aggregate.

(b) FRAP. If the Engineer has documentation of the quality of the FRAP aggregate, the Contractor shall use the assigned quality provided by the Engineer.

If the quality is not known, the quality shall be determined as follows. Coarse and fine FRAP stockpiles containing plus #4 (4.75 mm) sieve coarse aggregate shall have a maximum tonnage of 5,000 tons (4,500 metric tons). The Contractor shall obtain a representative sample witnessed by the Engineer. The sample shall be a minimum of 50 lb. (25 kg). The sample shall be extracted according to Illinois Modified AASHTO T 164 by a consultant prequalified by the Department for the specified testing. The consultant laboratory shall submit the test results along with the recovered aggregate to the District Office. The cost for this testing shall be paid by the Contractor. The District will forward the sample to the Central Bureau of Materials Aggregate Lab for MicroDeval Testing, according to ITP 327. A maximum loss of 15.0 percent will be applied for all HMA applications.

1031.06 Use of RAP/FRAP and/or RAS in HMA. *The use of RAP/FRAP and/or RAS shall be the Contractor's option when constructing HMA in all contracts.*

(a) RAP/FRAP. The use of RAP/FRAP in HMA shall be as follows.

(1) Coarse Aggregate Size. The coarse aggregate in all RAP shall be equal to or less than the nominal maximum size requirement for the HMA mixture to be produced.

(2) Steel Slag Stockpiles. Homogeneous RAP stockpiles containing steel slag will be approved for use in all HMA (High ESAL and Low ESAL) Surface and Binder Mixture applications.

(3) Use in HMA Surface Mixtures (High and Low ESAL). RAP/FRAP stockpiles for use in HMA surface mixtures (High and Low ESAL) shall be FRAP or homogeneous in which the coarse aggregate is Class B quality or better. FRAP from Conglomerate stockpiles shall be considered equivalent to limestone for frictional considerations. Known frictional contributions from plus #4 (4.75 mm) homogeneous FRAP stockpiles will be accounted for in meeting frictional requirements in the specified mixture.

(4) Use in HMA Binder Mixtures (High and Low ESAL), HMA Base Course, and HMA Base Course Widening. RAP/FRAP stockpiles for use in HMA binder mixtures (High and Low ESAL), HMA base course, and HMA base course widening shall be FRAP, homogeneous, or conglomerate, in which the coarse aggregate is Class C quality or better.

(5) Use in Shoulders and Subbase. RAP/FRAP stockpiles for use in HMA shoulders and stabilized subbase (HMA) shall be FRAP, homogeneous, conglomerate.

(6) When the Contractor chooses the RAP option, the percentage of RAP shall not exceed the amounts indicated in Article 1031.06(c)(1) below for a given Ndesign.

(b) RAS. RAS meeting Type 1 or Type 2 requirements will be permitted in all HMA applications as specified herein.

(c) RAP/FRAP and/or RAS Usage Limits. Type 1 or Type 2 RAS may be used alone or in conjunction with RAP or FRAP in HMA mixtures up to a maximum of 5.0 percent by weight of the total mix.

(1) RAP/RAS. When RAP is used alone or RAP is used in conjunction with RAS, the percentage of virgin asphalt binder replacement shall not exceed the amounts listed in the Max RAP/RAS ABR table listed below for the given Ndesign.

RAP/RAS Maximum Asphalt Binder Replacement (ABR) Percentage

HMA Mixtures 1/, 2/	RAP/RAS Maximum ABR %		
Ndesign	Binder/Leveling Binder	Surface	Polymer Modified
30	30	30	10
50	25	15	10
70	15	10	10
90	10	10	10

1/ For Low ESAL HMA shoulder and stabilized subbase, the RAP/RAS ABR shall not exceed 50 percent of the mixture.

2/ When RAP/RAS ABR exceeds 20 percent, the high and low virgin asphalt binder grades shall each be reduced by one grade (i.e. 25 percent ABR would require a virgin asphalt binder grade of PG64-22 to be reduced to a PG58-28). If warm mix asphalt (WMA) technology is utilized and production temperatures do not exceed 275 °F (135 °C), the high and low virgin asphalt binder grades shall each be reduced by one grade when RAP/RAS ABR exceeds 25 percent (i.e. 26 percent RAP/RAS ABR would require a virgin asphalt binder grade of PG64-22 to be reduced to a PG58-28).

(2) FRAP/RAS. When FRAP is used alone or FRAP is used in conjunction with RAS, the percentage of virgin asphalt binder replacement shall not exceed the amounts listed in the FRAP/RAS table listed below for the given N design.

FRAP/RAS Maximum Asphalt Binder Replacement (ABR) Percentage

HMA Mixtures 1/, 2/	FRAP/RAS Maximum ABR %		
Ndesign	Binder/Leveling Binder	Surface	Polymer Modified 3/, 4/
30	50	40	10
50	40	35	10
70	40	30	10
90	40	30	10

1/ For Low ESAL HMA shoulder and stabilized subbase, the FRAP/RAS ABR shall not exceed 50 percent of the mixture.

2/ When FRAP/RAS ABR exceeds 20 percent for all mixes, the high and low virgin asphalt binder grades shall each be reduced by one grade (i.e. 25 percent ABR would require a virgin asphalt binder grade of PG64-22 to be reduced to a PG58-28). If warm mix asphalt (WMA) technology is utilized, and production temperatures do not exceed 275 °F (135 °C), the high and low virgin asphalt binder grades shall each be reduced by one grade when FRAP/RAS ABR exceeds 25 percent (i.e. 26 percent ABR would require a virgin asphalt binder grade of PG64-22 to be reduced to a PG58-28).

3/ For SMA the FRAP/RAS ABR shall not exceed 20 percent.

4/ For IL-4.75 mix the FRAP/RAS ABR shall not exceed 20 percent.

1031.07 HMA Mix Designs. *At the Contractor’s option, HMA mixtures may be constructed utilizing RAP/FRAP and/or RAS material meeting the detailed requirements specified herein.*

(a) RAP/FRAP and/or RAS. RAP/FRAP and/or RAS mix designs shall be submitted for verification. If additional RAP/FRAP and/or RAS stockpiles are tested and found that no more than 20 percent of the results, as defined under “Testing” herein, are outside of the control tolerances set for the original RAP/FRAP and/or RAS stockpile and HMA mix design, and meets all of the requirements herein, the additional RAP/FRAP and/or RAS stockpiles may be used in the original mix design at the percent previously verified.

(b) RAS. Type 1 and Type 2 RAS are not interchangeable in a mix design.

The RAP, FRAP< and RAS stone bulk specific gravities (G_{sb}) shall be according to the ”Determination of Aggregate Bulk (Dry) Specific Gravity (G_{sb}) of Reclaimed Asphalt Pavement (RAP) and Reclaimed Asphalt Shingles (RAS)” procedure in the Department’s Manual of Test Procedures for Materials.

1031.08 HMA Production. *HMA production utilizing RAP/FRAS shall be as follows.*

(a) RAP/FRAP. The coarse aggregate in all RAP/FRAP used shall be equal to or less than the nominal maximum size requirement for the HMA mixture being produced.

To remove or reduce agglomerated material, a scalping screen, gator, crushing unit, or comparable sizing device approved by the Engineer shall be used in the RAP feed system to remove or reduce oversized material.

If the RAP/FRAP control tolerances or QC/QA test results require corrective action, the Contractor shall cease production of the mixture containing RAP/FRAP and either switch to the virgin aggregate design or submit a new RAP/FRAP design.

(b) RAS. RAS shall be incorporated into the HMA mixture either by a separate weight depletion system or by using the RAP weigh belt. Either feed system shall be interlocked with the aggregate feed or weigh system to maintain correct proportions for all rates of production and batch sizes. The portion of RAS shall be controlled accurately to within ± 0.5 percent of the amount of RAS utilized. When using the weight depletion system, flow indicators or sensing devices shall be provided and interlocked with the plant controls such that the mixture production is halted when RAS flow is interrupted.

(c) RAP/FRAP and/or RAS. HMA plants utilizing RAP/FRAP and/or RAS shall be capable of automatically recording and printing the following information.

(1) Dryer Drum Plants.

a. Date, month, year, and time to the nearest minute for each print.

b. HMA mix number assigned by the Department.

c. Accumulated weight of dry aggregate (combined or individual) in tons (metric tons) to the nearest 0.1 ton (0.1 metric ton).

d. Accumulated dry weight of RAP/FRAP/RAS in tons (metric tons) to the nearest 0.1 ton (0.1 metric ton).

e. Accumulated mineral filler in revolutions, tons (metric tons), etc. to the nearest 0.1 unit.

f. Accumulated asphalt binder in gallons (liters), tons (metric tons), etc. to the nearest 0.1 unit.

g. Residual asphalt binder in the RAP/FRAP material as a percent of the total mix to the nearest 0.1 percent.

h. Aggregate and RAP/FRAP moisture compensators in percent as set on the control panel. (Required when accumulated or individual aggregate and RAP/FRAP are printed in wet condition.)

(2) Batch Plants.

a. Date, month, year, and time to the nearest minute for each print.

b. HMA mix number assigned by the Department.

c. Individual virgin aggregate hot bin batch weights to the nearest pound (kilogram).

d. Mineral filler weight to the nearest pound (kilogram).

e. RAP/FRAP/RAS weight to the nearest pound (kilogram).

f. Virgin asphalt binder weight to the nearest pound (kilogram).

g. Residual asphalt binder in the RAP/FRAP/RAS material as a percent of the total mix to the nearest 0.1 percent.

The printouts shall be maintained in a file at the plant for a minimum of one year or as directed by the Engineer and shall be made available upon request. The printing *system will be inspected by the Engineer prior to production and verified at the beginning of each construction season thereafter.*

1031.09 RAP in Aggregate Surface Course and Aggregate Wedge Shoulders, Type B. *The use of RAP in aggregate surface course (temporary access entrances only) and aggregate wedge shoulders Type B shall be as follows.*

(a) Stockpiles and Testing. RAP stockpiles may be any of those listed in Article 1031.02, except "Non-Quality" and "FRAP". The testing requirements of Article 1031.03 shall not apply. RAP used shall be according to the current Central Bureau of Materials Policy Memorandum, "Reclaimed Asphalt Pavement (RAP) for Aggregate Applications".

(b) Gradation. One hundred percent of the RAP material shall pass the 1 1/2 in. (37.5 mm) sieve. The RAP material shall be reasonably well graded from coarse to fine. RAP material that is gap-graded or single sized will not be accepted."

80306"

End of the Special Provision for Reclaimed Asphalt Pavement (RAP) and Reclaimed Asphalt Shingles (RAS) document

RAP or RAS Dryer-drum Proportioning Set-up Instructions

Given:

Given:	**RAP mix%**	**=**	**25.0% (from design)**
	AB% in the RAP	**=**	**4.5% (from design or sample averages)**
	AB% mix target	**=**	**5.7% (from design)**

RAP gradation (from the design or stockpile averages)
Aggregate material gradations (stockpile averages)
Mineral filler gradation, if needed (typically from the design)

Step 1 **Enter all Agg%s from the design including the "RAP%" in the respective Agg% locations**

Example: 25.0 (RAP), 53.5 (CM16), 20.8 (FM20), 1.2 (MF)

Step 2 **Multiply each respective gradation (% Pass) by the respective "Agg % then divide the answer by 100 and record as the % Bin**

(Round the answer to one decimal place)

Example: 1/2" Sieve (RAP) $\frac{100\% \text{ Pass} \times 25.0}{100} = 25.0$ **(%bin on 1/2" sieve)**

Example: 3/8" Sieve (RAP) $\frac{96\% \text{ Pass} \times 25.0}{100} = 24.0$ **(%bin on 3/8" sieve)**

Step 3 **For each respective gradation sieve, add the "%Bin" across the worksheet and record the answer in the combined gradation column**

(Round the answer to a whole number except for the #200 which is to the nearest 10th of a percent)

			Answer		Recorded
Example (1/2"):	**25.0 + 53.0 + 20.8 + 1.2**	**=**	**100.0**	**=**	**100**
Example (#200):	**2.0 + 0.9 + 0.8 + 1.1**	**=**	**4.8**	**=**	**4.8**

Step 4 **Determine the correction factor (CF) using the total "AB% mix target" (5.7%)**

(Answer to 3 decimal places)

Example: $\frac{100 - 5.7}{100} = \frac{94.3}{100} = 0.943$ **(CF)**

Step 5 **Calculate the "Mix%s" of all "Virgin" ingredients, <u>except the RAP and/or RAS</u>, by multiplying the respective "Agg%" by the "CF" (determined in Step 4). Record in the respective Mix% location**

(Round the answer to one decimal place)

Example: CM16 53.0 x 0.943 = 50.0

Step 6 **Determine the "RAP or RAS Mix%" with the following calculation:**
(<u>Round the answer to one decimal place</u>)

<u>RAP Mix%</u> = RAP Agg% ÷ (<u>100 – RAP AB%</u>) x Correction Factor
100 (from Step 4)

Example: 25.0 ÷ (100 – 4.5) x 0.943 = 24.7 (RAP Mix%)
100

Enter this answer in the respective RAP Mix% location

NOTE: RAS Mix% is calculated using the same formula using the RAS Agg% and RAS AB%

Step 7 **Total all of the Mix%s**

Example: 24.7 + 50.0 + 19.6 + 1.1 = 95.4

Step 8 **Subtract this total (Step 7) from 100.0 to achieve the New Bit of the mix**

Example: 100.0 - 95.4 = 4.6

Enter this answer in the New Bit location

NOTE: <u>There will be no rounding errors to check or correct on this work sheet</u>

Step 9 **Determine the rate of production**

Example: 300 TPH

Step 10 **Multiply each respective "Mix%" by the rate of production (TPH). Divide this answer by 100 and enter the answer in the respective location for each Mix%**
(Round answer to one decimal place)

Example: RAP Mix% (24.7 x 300 TPH) ÷ 100 = 74.1 (TPH)

Step 11 **Insure the proper settings are incorporated into the plant console**

<u>IN CLASS or IN REAL WORLD</u>

Adjustments are not normally made on a set-up

A plant set-up is the process of establishing plant settings to start making mix. Ideally, if the current stockpile gradations are close to what was used during the design process, the calculated combined gradation should be close enough to start making mix. If these calculated results don't match the targets exactly, but are within two to three of percent of the targets, adjusting the plant settings will typically be taken care of later after sampling and completion of some mixture plant tests (air voids, AB content, gradations, density, etc.). Once the tests are completed and the information is available, adjustments can then be made. In the unfortunate circumstance that the calculated information is significantly different from the mixture targets, the stockpile gradations, cold feed settings and/or calibrations should be rechecked.

Information for Recycle Dryer-drum Set-up using RAP

Example #1:

Mix Design Information					
Date: 12/07/16				Design #:	84BIT1234
Plant: 2251-01				Material Code:	19534R
Tech. : R. Watson				Type of Mix:	N90 'D' Surface
Agg. size: Prod. #: Name: Location:	032CM16 51352-03 Nokomis Nokomis	038FM20 50510-04 CIM Vandalia	004MF01 52102-07 Bm CR St Blom, In	RAP 50973-07 XYZ Asphalt Effingham, IL	Design Formula Gradation
Agg %	53.0	20.8	1.2	25.0	
Sieve					
1/2	100.0	100.0	100.0	100	100
3/8	93.0	100.0	100.0	96	96
#4	40.0	100.0	100.0	70	60
#8	16.0	92.0	100.0	46	40
#16	6.0	60.0	100.0	33	24
#30	4.0	45.0	100.0	20	17
#50	3.0	23.0	100.0	15	11
#100	2.0	6.0	100.0	10	7
#200	1.6	3.8	90.0	7.9	4.8
			AB	4.5	5.7

Average Stockpile Gradations

Sieve Size	CM11	CM16	FM20	FM02	MF01
1					
3/4					
1/2		100	100		100
3/8		95	100		100
# 4		37	100		100
# 8		17	91		100
# 16		6	64		100
# 30		5	43		100
# 50		3	21		100
# 100		2	5		100
# 200		1.7	4.0		90.0

Recycle Dryer-Drum <u>Set-up</u> using RAP - Problem #1										
Feeder	RAP	#1	#2	#3	#4	------	-----			
Size	RAP	CM11	CM16	FM20	FM02	MF01	New Bit			
Mix%								= 100%		
TPH								Prod Rate <u>300 TPH</u>		
Agg%	25.0		53.0	20.8		1.2		= 100%		
Sieve Size	% Pass	% Pass	% Pass	% Pass	% Pass	% Pass	Comb Grad	Target	Control Limits	
	% Bin	% Bin	% Bin	% Bin	% Bin	% Bin			Min	Max
1										
3/4										
1/2	100		100	100		100		100		
3/8	96		95	100		100		96		
#4	70		37	100		100		60		
#8	46		17	91		100		40		
#16	33		6	64		100		24		
#30	20		5	43		100		17		
#50	15		3	21		100		11		
#100	10		2	5		100		7		
#200	7.9		1.7	4.0		90.0		4.8		
AB	4.5							5.7		

Recycle Dryer-Drum Set-up Problem (RAP & RAS) #2

Date: 12/07/2016

No. ---------→	81BIT1234	Producer & Number→	165-06	HMA Production
Design Lab ---------→	PP	Material Code ------→	19523R	HMA Surf CSE N70 C REC

Agg. No.	#1	#2	#3	#4	#5	#6	Asphalt
Size	RAS	RAP	032CM16	038FM20			10127
(Prod #)	7483-01	165-06	55555-05	16414-06			2260-01
(Name)	RAS Mat	JFG Asp	Mat Ser	Joliet St			Asp. Mt.
(Loc)	Kankakee	Thornton	Chicago	Joliet			Urbana
Agg %	3.0	15.0	56.0	26.0			100.0

Agg # Sieve Size	#1	#2	#3	#4	#5	#6	Blend	Max Spec	Form	Range Min	Range Max
1											
3/4											
1/2	100	100	100.0	100			100.0	100	100		100
3/8	100	93	98	100			97.9	90-100	98	90	100
#4	100	67	36	100			59.3	28-65	59	28	65
#8	94	46	9	83			36.3	28-48	36	28	48
#16	75	34	5	58			25.3	10-32	25	10	32
#30	48	27	4	36			17.1		17		
#50	40	18	3	15			9.5	4-15	10	4	15
#100	34	12	3	5			5.8	3-10	6	3	10
#200	27.4	9.4	3.5	3.0			5.0	4-6	5.0	4.0	6.0
AB%	27.0	4.5									

Optimum Mixture Design Data

Number of Revolutions: 70

	AB%	G_{mm}	G_{mb}	% Voids P_a	VMA	Design Field VMA	VFA	G_{se}	G_{sb}	TSR	TSR W/Anti
Optimum Data	5.4	2.438	2.340	4.0	15.4	16.3	73.9	2.644	2.618		

Average Stockpile Gradations

Sieve Size	CM11	CM16	FM20	FM02	MF01
1					
3/4					
1/2		**100**	**100**		
3/8		**97**	**100**		
# 4		**38**	**100**		
# 8		**9**	**80**		
# 16		**5**	**60**		
# 30		**4**	**38**		
# 50		**4**	**15**		
# 100		**3**	**4**		
# 200		**3.0**	**3.9**		

Recycle Dryer-Drum Set-up using RAP & RAS - Problem #2

Feeder	R1	R2	#1	#2	#3	MF	New Bit			
Size	RAS	RAP		CM16	FM20					
Mix%								= 100%		
TPH								Prod Rate - 500 TPH		
Agg%	3.0	15.0		56.0	26.0			= 100%		
Sieve Size	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	Comb Grad	Target	Control Limits Min	Control Limits Max
1										
3/4										
1/2	100	100		100	100			100		
3/8	100	93		97	100			98		
#4	100	67		38	100			59		
#8	94	46		9	80			36		
#16	75	34		5	60			25		
#30	48	27		4	38			17		
#50	40	18		4	15			10		
#100	34	12		3	4			6		
#200	27.4	9.4		3.0	3.9			5.0		
AB	27.0	4.5						5.4		

Detailed Batch Plant Proportioning Procedures

Hot Bin Proportioning-Passing Method

1. General

This method of hot bin proportioning is used for batch and continuous type plants. A passing specification is used in the proportioning of HMA mixtures for State and Local Agencies. For ease of understanding, a HMA surface mix will be explained first and then a HMA binder mix.

2. IL-9.5 High ESAL HMA Surface Mixture

The mixture to be proportioned is a HMA surface mix as outlined in the standard specifications utilizing a three (3) hot bin system in the production of a surface mixture. There are 6 basic steps needed to obtain initial plant settings for a batch plant.

Step #1: Obtain **representative** hot bin samples and to perform a complete sieve analysis of each sample according to the ITP procedures referenced in the AGCS Policy Memorandum. The established target values are shown below on the "Proportioning Worksheet".

Proportioning Worksheet

Bin #	Bin 4	Bin 3	Bin 2	Bin 1	MF	New Bit			
Size	+ 1/2	1/2 - #4	#4 - #8	- #8	- #200				
Mix %							= 100 %		
lbs/Batch							Batch Size = 4000 lbs		
Agg %							= 100 %		
Sieve Sizes	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	Comb Grad	Target	Control Limits Min	Max
1"									
3/4"									
1/2"		**100**	**100**	**100**					
							100		100
3/8"		**70**	**100**	**100**					
							90	90	100
#4		**8.0**	**79.9**	**100**					
							59	32	69
#8		**1.0**	**6.9**	**98.0**					
							34	32	52
#16		**1.0**	**1.0**	**76.9**					
							24	10	32
#30		**1.0**	**1.0**	**43.7**					
							17		
#50		**1.0**	**1.0**	**30.1**					
							10	3	10
#100		**1.0**	**1.0**	**14.0**					
							6		
#200		**0.4**	**0.3**	**9.7**					
							3.5	4	6
AB							**5.5**	5.2	5.8

Step #2: After the sieve analysis is complete, it is necessary to **compute the Agg% needed from each hot bin**. To do this we first need to know the approximate size(s) of aggregate contained in each of the hot bins. In Chapter 2, "Batch Plant Operations”, the functions of the "screening unit" and "hot bins" are discussed. An example of a typical screening unit, screen sizes, and the approximate gradation of aggregate in each is shown below.

If totally efficient screening could be achieved, you can see that the primary size of material in Bin #1 would be minus #8 material, Bin #2 would consist essentially of material smaller than the #4 sieve but larger than the #8, and Bin #3 would be 1/2" to #4 in size. (NOTE: when Bin #4 is used, binder mixtures, the material would be plus 1/2 inch in size.) By utilizing this information in conjunction with our target values, we are able to approximate the initial aggregate percentage needed from each hot bin as follows:

In this example, the Target Values (from page 4-34) call for 34% passing the #8 sieve, so we would estimate that 34% would be required from the #1 hot bin since the #1 bin represents minus 8 material in the gradation.

For bin #2 [#4 to #8] the Target Values require 59% passing the #4, however 34% will pass the #8 sieve. Therefore, the amount needed from Bin #2 is the difference between 59% and 34% or 25%.

Similarly for Bin #3 [1/2" to #4]

Target Value 1/2"	=	100.0% passing
Target Value #4	=	- 59.0% passing
Bin #3 estimate	=	41.0%

For this example, it was determined that no mineral filler was needed, see minus #200 determination in Sec. 4, page 4-39 of this manual.

This information is then recorded in the appropriate slots (Agg%s) below.

Bin #	Bin 4	Bin 3	Bin 2	Bin 1	MF	New Bit			
Size	+ 1/2	1/2 - #4	#4 - #8	- #8	- #200				
Mix %							= 100%		
Lbs/Batch							Batch Size = 4000 lbs		
Agg %		**41.0**	**25.0**	**34.0**			= 100%		

Step #3: **Calculate the individual bin percent** (% Bin on the work sheet). To do this we simply take the Agg % (expressed as a decimal) and multiply it by each percent passing (% Pass) calculation obtained from the sieve analysis. Record the result to the nearest 10th of a percent.

For example in Bin #1: 34% (.34) x the amount passing the 1/2" sieve (100.0%) or 0.34 x 100.0% = 34.0% and is recorded on the worksheet in "% Bin" slot corresponding to the 1/2" and Bin #1. This procedure is followed for the remaining sieves in the Bin #1 column and repeated for Bins #2 and #3. The completed calculations are shown below.

Proportioning Worksheet

Bin #	Bin 4	Bin 3	Bin 2	Bin 1	MF	New Bit			
Size	+ 1/2	1/2 - #4	#4 - #8	- #8	- #200				
Mix %							= 100 %		
lbs/Batch							Batch Size = 4000 lbs		
Agg %		**41.0**	**25.0**	**34.0**			= 100 %		
Sieve Sizes	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	Comb Grad	Target	Control Limits Min	 Max
1"									
3/4"									
1/2"		**100**	**100**	**100**					
		41.0	**25.0**	**34.0**			**100**		100
3/8"		**70**	**100**	**100**					
		28.7	**25.0**	**34.0**			**90**	90	100
#4		**8.0**	**79.9**	**100**					
		3.3	**20.0**	**34.0**			**59**	32	69
#8		**1.0**	**6.9**	**98.0**					
		0.4	**1.7**	**33.3**			**34**	32	52
#16		**1.0**	**1.0**	**76.9**					
		0.4	**0.3**	**25.7**			**24**	10	32
#30		**1.0**	**1.0**	**43.7**					
		0.4	**0.3**	**14.9**			**17**		
#50		**1.0**	**1.0**	**30.1**					
		0.4	**0.3**	**10.2**			**10**	3	10
#100		**1.0**	**1.0**	**14.0**					
		0.4	**0.3**	**4.8**			**6**		
#200		**0.4**	**0.3**	**9.7**					
		0.2	**0.1**	**3.3**			**3.5**	4	6
AB							**5.5**	5.2	5.8

<u>Step #4</u>: **<u>Compute the combined gradation</u>** on the worksheet. This is done by adding horizontally the % Bins (calculated in Step #2) across for each individual sieve size.

For example; the combined gradation for the 1/2" sieve would be 41.0% (% in Bin #3) + 25.0% (% in Bin #2) + 34.0% (% in Bin #1) = 100% [combined gradation passing the 1/2" sieve].

This procedure is then followed for the remaining sieves through the combined gradation of the #200 sieve. The correct calculations are shown below.

NOTE: All combined gradation percents are rounded to the nearest whole percent, **<u>EXCEPT</u>** the minus #200% **<u>WHICH IS ALWAYS</u>** rounded to the nearest **<u>0.1%</u>.**

Proportioning Worksheet

Bin #	Bin 4	Bin 3	Bin 2	Bin 1	MF	New Bit			
Size	+ 1/2	1/2 - #4	#4 - #8	- #8	- #200				
Mix %							= 100 %		
lbs/Batch							Batch Size = 4000 lbs		
Agg %		**41.0**	**25.0**	**34.0**			= 100 %		
Sieve Sizes	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	Comb Grad	Target	Control Limits Min	Max
1”									
3/4”									
1/2”		**100**	**100**	**100**					
		41.0	**25.0**	**34.0**		**100**	**100**		100
3/8”		**70**	**100**	**100**					
		28.7	**25.0**	**34.0**		**88**	**90**	90	100
#4		**8.0**	**79.9**	**100**					
		3.3	**20.0**	**34.0**		**57**	**59**	32	69
#8		**1.0**	**6.9**	**98.0**					
		0.4	**1.7**	**33.3**		**35**	**34**	32	52
#16		**1.0**	**1.0**	**76.9**					
		0.4	**0.3**	**25.7**		**26**	**24**	10	32
#30		**1.0**	**1.0**	**43.7**					
		0.4	**0.3**	**14.9**		**16**	**17**		
#50		**1.0**	**1.0**	**30.1**					
		0.4	**0.3**	**10.2**		**11**	**10**	3	10
#100		**1.0**	**1.0**	**14.0**					
		0.4	**0.3**	**4.8**		**6**	**6**		
#200		**0.4**	**0.3**	**9.7**					
		0.2	**0.1**	**3.3**		**3.6**	**3.5**	4	6
AB							**5.5**	5.2	5.8

At this point the combined gradations should be compared to the target values for compliance (within allowable tolerances, reference to the applicable Standard Specifications). Minor aggregate percentage (Agg %) adjustments may be necessary at this time, due to screening inefficiency (screen carry-over). If further adjustments are made, this would require recalculation of the combined gradations to assure the desired HMA mixture will be produced. If the stockpiled material gradations are similar to the gradations used in the design process and the hot-bin gradations are representative of the combined material to be used, this step won't be necessary.

Step #5: After assurance that the correct Agg%s have been selected, **the Agg%s need to be converted into individual batch weights** which is required in order that the operator may weigh out the proper amount from each hot bin.

To do this, we first must convert each Agg% into a Mix%. Mix% is defined to include all ingredients of the total mixture; aggregates, recycle, MF and the asphalt binder. This conversion from 100% Agg% to 100% Mix% makes room for the AB%, proportionately. The total Mix%, which will include the AB%, must total 100.0%.

The procedure is as follows: Subtract the AB% (obtained from the HMA mix design, 5.5% in this example) from 100.0% (100.0% - 5.5% = 94.5%) to obtain a correction factor. Now multiply each Agg% by this correction factor percent (as a decimal), including the MF when used.

For example:

100.0% - 5.5 = 94.5%	Bin #1:	0.945 x 34.0%	=	32.1%	32.1%
	Bin # 2	0.945 x 25.0%	=	23.6%	23.6%
	Bin # 3	0.945 x 41.0%	=	38.7%	**38.8%***
	AB		=	5.5%	5.5%
		Total	=	99.9%	**100.0%**

***NOTE**: During the actual calculations, the Mix% from Bin # 3 was 38.7% but due to the fact that the total Mix% including the asphalt binder **must** add up to 100% it was necessary to adjust one of the bins by 0.1%. The bin with the largest Mix%, in this case Bin #3, is to be adjusted by 0.1% since this will have the least effect on the final mixture. This adjustment is only applied to 'virgin' aggregate materials, not recycle aggregates. This adjustment is due to a rounding error accrued during calculation of the Mix%s and is considered insignificant to HMA mixture quality. This normally has to be done because most HMA plant computer systems will require an entry totaling 100% Mix% in order to operate correctly.

These calculated Mix%s are then recorded in the appropriate Mix% slot on the worksheet as shown below.

Bin #	Bin 4	Bin 3	Bin 2	Bin 1	MF	New Bit		
Size	+ 1/2	1/2 - #4	#4 - #8	- #8	- #200			
Mix %		**38.8**	**23.6**	**32.1**		**5.5**	= 100%	
Lbs/Batch							Batch Size = 4000 lbs	
Agg %		**41.0**	**25.0**	**34.0**			= 100%	

<u>Step #6</u>: <u>Calculate the individual Pounds per Batch (Batch Weights)</u> for each of the hot bins. This is done by multiplying the approved batch size (4,000 lb. in this example) by each respective Mix% (expressed as a decimal).

For example:	Bin # 1	32.1 %	(0.321) x 4,000 lbs.	=	1,284 lbs.
	Bin # 2	23.6 %	(0.236) x 4,000 lbs.	=	944 lbs.
	Bin # 3	38.8 %	(0.388) x 4,000 lbs.	=	1,552 lbs.
	Asphalt Binder	5.5 %	(0.055) x 4,000 lbs.	=	220 lbs.
	Total	100.0 %			4,000 lbs.

Record these weights in the appropriate spot as shown below.

Bin #	Bin 4	Bin 3	Bin 2	Bin 1	MF	New	
Size	+ 1/2	1/2 - #4	#4 - #8	- #8	- #200	Bit	
Mix %		**38.8**	**23.6**	**32.1**		**5.5**	= 100%
Lbs/Batch		**1552**	**944**	**1284**		**220**	Batch Size = 4000 lbs
Agg %		**41.0**	**25.0**	**34.0**			= 100%

3. <u>HMA Binder Mixture Proportioning</u>

When proportioning a HMA binder mixture, the same procedure is utilized with one additional step. As shown on page 4-40, "Aggregate Stream-flow for a Typical Batch Plant Screen Deck", Bin #4 will contain +1/2" material (see Step #2 on page 4-36). Therefore, the Agg% needed for Bin #4 is computed by subtracting the Target Value percent passing for the 1/2" sieve from 100%. The Agg% for Bin #4 would be included in each previously described step.

4. <u>Minus #200 Determination</u>

To determine whether or not to add mineral filler, and at what percent, is based on experience with the aggregate materials being used and a thorough knowledge of the specific characteristics and capabilities of the plant. When proportioning the minus #200 material, the dust percent **<u>should never be greater than the job mix formula</u>** and is normally proportioned 1.0%-1.5% below the job mix formula. Consequently, the established Target Value shall reflect this adjustment during the evaluation process during start-up. This adjustment is commonly referred to as a “windage factor”, which is due to additional minus #200 generated during the handling and production process.

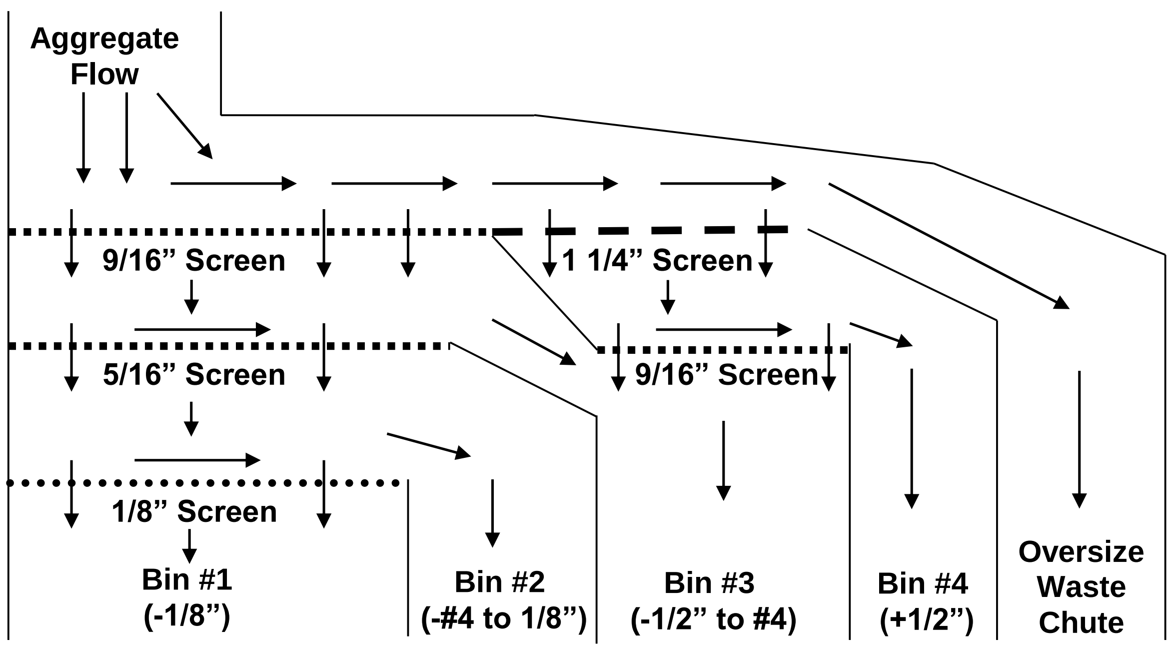
Once the Agg%s have been determined (Step #2),the process to add dust to meet the #200 target is to multiply each Bin% only for each #200 sieve for Bins #2, #3 (& #4) gradations. Total the results to determine the combined gradation for the #200 sieve for the mixture and compare the sum to the #200 target. Normally, if there is a 0.8% or greater difference then **<u>1.0% of dust or more</u>** needs to be added. Most HMA Batch plants cannot accurately handle dust in amounts less than 1.0%. The amount determined will be added as Agg% for the MF. The respective amount added needs to be subtracted from the Bin #1 Agg% to insure all of the Agg%s total 100%. This subtraction is **<u>only</u>** from Bin #1 because both Bin #1 and the MF represents minus 8 material and will only affect the finer (sand) portion of the mixture gradation. The sum of the Bin #1 Agg% and the MF Agg% **<u>has to equal</u>** the target for the #8 sieve. Once the dust has been determined, the rest of the steps will be completed and the other targets (1/2”, #4, #8 & #30) will be left as calculated, **<u>no further adjusting is done</u>**. Agg %s for Bins #2, #3 (& #4) are left as originally determined.

Controlling Elements for Hot Bins

BIN #	CONTROLS
4	+ 1/2” (retained above the 1/2”)
3	% Passing the 1/2” to the #4
2	% Passing the # 4 to the #8
1	% Passing the # 8
MF	% Passing the #200

Controlling elements may vary dependent upon the plant screen deck arrangement

Aggregate Stream-flow for a Typical Batch Plant Screen Deck



9. Batch Plant Set-up Step by Step Instructions

a) Run representative hot bin samples and record the gradations on the worksheet
b) Copy information from the design over to the worksheet:

Design formula - job mix formula (JMF)
Adjust the JMF MF% for windage (real world **NOT** in this class)
Mineral Filler gradation
Mix design optimum asphalt binder percentage

c) Copy the #8 mix design target to the #1 bin Agg%
d) Determine the difference between the #4 and #8 mix design targets and copy the answer to the #2 bin Agg% (once determined this value will not change)
e) Determine the difference between the 1/2" and #4 mix design targets and copy the answer to the #3 bin Agg% (once determined this value will not change)
f) Determine the +1/2" material (1" mix design target minus the 1/2" mix design target) and copy the answer to the #4 bin Agg% (binder mixtures only) (once determined this value will not change)
g) Determine the amount of #200 material being contributed to the mix by each bin and compare to the #200 target (with the windage factor applied)
h) Add MF to the mix as needed (see step 'g' above) to meet the #200 target
i) If MF is needed, subtract the percentage amount from the #1 bin **ONLY** so the Agg%s total 100% (the Agg %s is required to total 100%)
j) Multiply the gradations by the respective Agg%s (Bin #1, #2, #3, #4 & MF) rounding answer to the nearest 0.1%
k) Calculate combined gradation for each sieve size rounding answers to the whole percent **EXCEPT** the #200 material (which is always rounded to the tenth of a percent)
l) Calculate the correction factor
m) Multiply each Agg% by the correction factor to obtain the respective Mix% and record to the nearest 10^{th} of a percent
n) Transfer the optimum AB% to the "New Bit" location
o) Total the Mix%s, adjust as needed for any rounding error (this must total 100.0%)
p) Determine the production rate (#s per batch) for the mix
q) Calculate the individual #s per batch for each mix ingredient

IN CLASS or REAL WORLD adjustments are not normally made on a set-up

A plant set-up is the process of establishing plant settings to start making mix. Ideally, if the current stockpile gradations are close to what was used during the design process, the calculated combined gradation should be close enough to start making mix. If these calculated results don't match the targets exactly, but are within two to three of percent of the targets, adjusting the plant settings will typically be taken care of later after sampling and completion of some mixture plant tests (air voids, AB content, hot-bins, density, etc.). Once the tests are completed and the information is available, adjustments can then be made. In the unfortunate circumstance that the calculated information is significantly different from the mixture targets, the stockpile gradations, cold feed settings and/or calibrations should be rechecked.

On a batch plant set-up, **the only decision that needs to be made** is whether extra dust needs to be put into the mix or not, and if so, how much will be added. The minimum amount of dust to be added is 1% (there has to be at least 1% dust in the dust Agg% or more). No dust can be added if less than 1% is needed (MF Agg%). If dust is added to the mix, the amount added (MF Agg%) will be removed (subtracted) from the #1 bin Agg% (**#1 bin only**) so all of the Agg%s can total 100%. The sum of Bin #1 Agg% and the MF Agg% **has to equal** the mix design target for the #8 sieve. Once the dust has been determined, the remaining critical sieve targets will be calculated and left as is, **no further adjusting is done**.

_HMA Superpave Mixture Design Example #1	Date: 12/07/2016

Design No. ---------→	35BIT0000	Producer & Number→	1977-01	XYZ Asphalt
Design Lab ---------→	PP	Material Code ------→	19534	HMA Surf CSE N90 D

Agg. No.	#1	#2	#3	#4	#5	#6	Asphalt
Size		032CM16	038FM20	037FM01	004MF01		10112
(Prod #)		51972-02	50972-02	50510-04	52102-07		2260-01
(Name)		Material	Material	CIM	Bm CR St		Asp. Mt.
(Loc)		Service	Service	Vandalia	Blom. IN		Urbana
Agg %		66.3	19.9	11.6	2.2		100.0

Agg # Sieve Size	#1	#2	#3	#4	#5	#6	Blend	Max Spec	Formula	Range Min	Range Max
1											
3/4											
1/2		100.0	100.0	100.0	100.0		100.0	100	100		100
3/8		97.9	100.0	100.0	100.0		98.6	90-100	99	90	100
#4		36.3	98.1	100.0	100.0		57.4	28-65	57	28	65
#8		9.6	70.0	91.0	100.0		32.5	28-48	33	28	48
#16		6.6	42.0	70.0	100.0		23.1	10-32	23	10	32
#30		5.5	30.1	60.0	100.0		18.6		19	15	23
#50		5.0	14.3	16.0	100.0		9.9	4-15	10	4	15
#100		4.7	10.2	1.2	99.0		7.4	3-10	7	3	10
#200		3.5	6.8	1.0	88.8		5.7	4-6	5.7	4.2	7.2
					RAP AB %=====→						

Optimum Mixture Design Data

Number of Revolutions: 90

	AB%	G_{mm}	G_{mb}	% Voids P_a	VMA	Design Field VMA	VFA	G_{se}	G_{sb}	TSR	TSR W/Anti
Optimum Data	**6.1**	**2.425**	**2.327**	**4.0**	**14.7**	**16.5**	**68.1**	**2.644**	**2.588**	**0.89**	

Average Hotbin Gradations

Sieve Size	Bin #4	Bin #3	Bin #2	Bin #1
1				
3/4				
1/2		100	100	100
3/8		96	100	100
# 4		6	90	100
# 8		1	6	95
# 16		1	1	70
# 30		1	1	54
# 50		1	1	30
# 100		1	1	18
# 200		1.0	1.0	10.0

Batch Plant Set-up Example 1							Surface Mixture		
Bin #	Bin #4	Bin #3	Bin #2	Bin #1	MF	New Bit			
Size	+ 1/2	-1/2 +#4	-4 +#8	- #8	- #200				
Mix%							= 100%		
#'s							**Batch Size - Lbs.** = **2000**		
Agg%						[redacted]	= 100%		
Sieve Size	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	Comb Grad	Target	Control Limits Min	Control Limits Max
1									
3/4									
1/2		100	100	100	100		**100**		
3/8		96	100	100	100		**99**		
#4		6	90	100	100		**57**		
#8		1	6	95	100		**33**		
#16		1	1	70	100		**23**		
#30		1	1	54	100		**19**		
#50		1	1	30	100		**10**		
#100		1	1	18	99		**7**		
#200		1.0	1.0	10.0	88.8		**5.7**		
AB							**6.1**		

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Batch Plant Set-up Example 2							**Binder Mixture**		
Bin #	Bin #4	Bin #3	Bin #2	Bin #1	MF	New			
Size	+ 1/2	-1/2 +#4	-4 +#8	- #8	- #200	Bit			
Mix%							= 100%		
#'s							**Batch Size - Lbs.** = **10000**		
Agg%							= 100%		
Sieve	% Pass	% Pass	% Pass	% Pass	% Pass	Comb		Control Limits	
Size	% Bin	% Bin	% Bin	% Bin	% Bin	Grad	Target	Min	Max
1	100	100	100	100	100		**100**		
3/4	90	100	100	100	100		**95**		
1/2	20	80	100	100	100		**71**		
3/8	18	39	95	100	100		**59**		
#4	1	5	82	100	100		**40**		
#8	1	1	11	93	100		**27**		
#16	1	1	1	50	100		**16**		
#30	1	1	1	35	100		**11**		
#50	1	1	1	17	100		**7**		
#100	1	1	1	11	99		**5**		
#200	0.3	0.3	0.2	6.9	87.7		**3.1**		
AB							**5.9**		

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10. Mixture Adjustment Procedures

a) Insure the gradation samples are representative (resample if necessary).

b) Isolate the problem areas by comparing the combined gradations to the target values.

c) Determine what change(s), the amount of change, and the effect that the changes will have on the overall gradation. Is the mixture coarse or fine?

d) Work the combined gradation values to the nearest tenth of a percent and allow for rounding to help achieve the desired results

(i.e. - 34.5 = 35, 34.4 = 34).

When all of the changes are completed, **round the final combined gradation values to the whole percent** except for the #200 material, which is always rounded to the nearest tenth of a percent.

e) Increase/decrease the appropriate aggregate percentages to insure the new aggregate percentages total l00% when making an adjustment.

f) Recalculate the combined gradations, using the new adjusted percentages and compare the new combined gradation with the target values.

g) If changes are acceptable, recalculate the new rates, TPH (dryer-drum) or batch weights (batch plant) and insure the changes are incorporated into the plant settings.

h) If changes are not acceptable, make further adjustments to the bin percentages, and repeat the process.

i) Once the adjustments have been made and the plant has operated for a little while, take some 'check' gradation samples to verify the changes made were right to obtain the desired results.

j) It is important to understand where your size of material comes from:

1/2" material	Binder	CM11, CM07, etc.
#4 material	Surface	CM16, CM13, etc.
- #8 material	Sand	FM01, FM02, FM20, FM21, FM22
- #200 material*****	Dust	MF (purchased or plant generated)

***** Can be contributed by certain aggregate products

AGCS Master Band and Critical Sieve Designation		
Gradation	**Critical Sieve**	**Master Band (%)**
CA/CM 07	**1/2" (12.5 mm)**	**± 8**
CA/CM 11	**1/2" (12.5 mm)**	**± 8**
CA/CM 13	**# 4 (4.75 mm)**	**± 8**
CA/CM 16	**# 4 (4.75 mm)**	**± 8**
FA/FM 01, 02	**- #8 (- 2.36 mm)**	**± 15**
FA/FM 20, 21, 22	**- #8 (- 2.36 mm)**	**± 15**

Binder mix example:

Material	MB Sieve/Target		Range	Mix Percentage
CM11	1/2”	55%	47% – 63% (± 8%)	50% (typical)

0.50 X 47 = 23.5 Coarse

0.50 X 55 = 27.5 Middle → 31.5 – 23.5 = **8.0% possible change in the gradation**

0.50 X 63 = 31.5 Fine

Control limits for the 1/2” sieve (from chapter 1)	Individual tests	Moving Ave. (of 4)
	± 6	± 4

Surface mix example:

Material	MB Sieve/Target		Range	Mix Percentage
CM16	#4	32%	24% – 40% (± 8%)	60% (typical)

0.60 X 24 = 14.4 Coarse

0.60 X 32 = 19.2 Middle → 24.0 – 14.4 = **9.6% possible change in the gradation**

0.60 X 40 = 24.0 Fine

Control limits for the #4 sieve (from chapter 1)	Individual tests	Moving Ave. (of 4)
	± 5	± 4

Dryer-drum Plant Adjustment Step by Step Instructions

a) Determine if the mix is coarse or fine

b) Start with the #8 sieve. Add or remove minus #8 material (sand) as needed to meet the #8 target

c) Any adjustment made (±) to the sand (Bin #1) Agg%, it is then corrected oppositely in the material farthest to the left (always make the opposite adjustment to the far left) so the Agg% totals 100% (if #8 material is added an equal amount is subtracted from the farthest left bin)

d) Recalculate all #8 sieve gradations that have changed due to the adjustments (repeat steps 'b' & 'c' as necessary to meet the #8 target)

e) Calculate all changes to the #200 sieves and check to see if the target is met

f) Add or remove MF as needed to meet the #200 target (any changes is added or subtracted to the farthest left material so the Agg% total 100%)

g) Recheck the #8 target if dust was added or subtracted to make sure it still meets the #8 target (repeat steps 'b' thru 'g' until the #8 and #200 targets have been met)

h) Calculate all changes affecting the #30 sieve (make adjustments with the sand and/or MF as needed)

i) If any changes were made to meet the #30 target, recheck all changes that affected the #8, #30 & #200 targets

j) Once the minus #8 material targets (#8, #30 & #200) have been met, **typically**, any remaining adjustments will be made only with the coarse aggregate materials

k) Calculate all changes to all of the affected #4 sieves and check to see if the target has been met

l) **Surface mixtures** - Make adjustments by adding or removing CM16s (#4 material) and correcting the Agg% (100% total) with the sand(s) as necessary

m) **Binder mixtures** - If the mixture is coarse, add CM16s (#4 material) as necessary correcting the Agg% total with the CM11s (1/2" material)

n) **Binder mixtures** - If the mixture is fine, add CM11s as necessary to meet the 1/2" target, recalculating all sieves affected by the changes correcting with the CM16s Agg%

o) Once you have the mix adjusted, recalculate all critical sieves and Agg% total to determine if the combined gradation meets the mix targets and the Agg% totals 100%

p) If all targets have been met, complete a new blank worksheet calculating **all** sieves for the mixture

q) Finish completing the worksheet (calculate the non-critical sieves, the Mix%s, AB and rate of production)

Dryer-Drum Adjustment Problem #1 Coarse Example										
Feeder	RAP	#1	#2	#3	#4	------	-----			
Size		CM11	CM16		FM01	MF01	New Bit			
Mix%								= 100%		
TPH								Production Rate 600 TPH		
Agg%		51.3	17.0		29.4	2.3		= 100%		
Sieve Size	% Pass	% Pass	% Pass	% Pass	% Pass	% Pass	Comb Grad	Target	Control Limits	
	% Bin	% Bin	% Bin	% Bin	% Bin	% Bin			Min	Max
1										
3/4										
1/2		41	100		100	100	70	73		
		21.0	17.0		29.4	2.3				
3/8										
#4		3	32		99	100	38	43		
		1.5	5.4		29.1	2.3				
#8		2	8		92	100	32	36		
		1.0	1.4		27.0	2.3				
#16										
#30		2	3		57	100	21	23		
		1.0	0.5		16.8	2.3				
#50										
#100										
#200		1.5	2.4		0.5	90.0	3.4	3.5		
		0.8	0.4		0.1	2.1				
AB								4.0		

Dryer-Drum Adjustment Problem #1 Coarse Example										
Feeder	**RAP**	**#1**	**#2**	**#3**	**#4**	**------**	**-----**			
Size		**CM11**	**CM16**		**FM01**	**MF01**	**New Bit**			
Mix%								**= 100%**		
TPH								**Production Rate 600 TPH**		
Agg%								**= 100%**		
Sieve Size	**% Pass**	**% Pass**	**% Pass**	**% Pass**	**% Pass**	**% Pass**	**Comb Grad**	**Target**	**Control Limits**	
	% Bin	**% Bin**	**% Bin**	**% Bin**	**% Bin**	**% Bin**			**Min**	**Max**
1										
3/4										
1/2		41	100		100	100		73		
3/8										
#4		3	32		99	100		43		
#8		2	8		92	100		36		
#16										
#30		2	3		57	100		23		
#50										
#100										
#200		1.5	2.4		0.5	90.0		3.5		
AB								4.0		

Dryer-Drum Adjustment Problem #2 Fine Example

Feeder	RAP	#1	#2	#3	#4	------	-----			
Size		CM11	CM16		FM01	MF01	New Bit			
Mix%								= 100%		
TPH								Production Rate 300 TPH		
Agg%		40.0	18.0		39.0	3.0		= 100%		
Sieve Size	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	Comb Grad	Target	Control Limits Min	Control Limits Max
1										
3/4										
1/2		40	100		100	100	76	73		
		16.0	18.0		39.0	3.0				
3/8										
#4		3	32		99	100	49	43		
		1.2	5.8		38.6	3.0				
#8		3	7		92	100	41	36		
		1.2	1.3		35.9	3.0				
#16										
#30		2	3		58	100	27	23		
		0.8	0.5		22.6	3.0				
#50										
#100										
#200		1.5	2.2		0.5	90.0	3.9	3.5		
		0.6	0.4		0.2	2.7				
AB								4.0		

Dryer-Drum Adjustment Problem #2 Fine Example

Feeder	RAP	#1	#2	#3	#4	------	-----			
Size		CM11	CM16		FM01	MF01	New Bit			
Mix%								= 100%		
TPH								Production Rate 300 TPH		
Agg%								= 100%		
Sieve Size	% Pass	% Pass	% Pass	% Pass	% Pass	% Pass	Comb Grad	Target	Control Limits	
	% Bin	% Bin	% Bin	% Bin	% Bin	% Bin			Min	Max
1										
3/4										
1/2		40	100		100	100		73		
3/8										
#4		3	32		99	100		43		
#8		3	7		92	100		36		
#16										
#30		2	3		58	100		23		
#50										
#100										
#200		1.5	2.2		0.5	90.0		3.5		
AB								4.0		

Dryer-Drum <u>Adjustment</u> Class Problem #3

Feeder		#1	#2	#3	#4	MF	New Bit			
Size			CM 11	CM 16	FM 20	MF 01				
Mix%								= 100%		
TPH								Production Rate 200 TPH		
Agg%			37.0	25.0	38.0			= 100%		
Sieve Size	% Pass	% Pass	% Pass	% Pass	% Pass	% Pass	Comb Grad	Target	Control Limits	
	% Bin	% Bin	% Bin	% Bin	% Bin	% Bin			Min	Max
1										
3/4										
1/2			36	100	100	100	76	**80**		
			13.3	25.0	38.0					
3/8										
#4			3	49	80	100	44	**47**		
			1.1	12.3	30.4					
#8			1	16	75	100	33	**35**		
			0.4	4.0	28.5					
#16										
#30			1	3	28	100	12	**13**		
			0.4	0.8	10.6					
#50										
#100										
#200			0.5	2.3	8.2	90.0	3.9	**4.1**		
			0.2	0.6	3.1					
AB								**4.7**		

Dryer-Drum Adjustment Class Problem #3

Feeder		#1	#2	#3	#4	MF	New Bit			
Size			**CM 11**	**CM 16**	**FM 20**	**MF 01**				
Mix%								**= 100%**		
TPH								**Production Rate 200 TPH**		
Agg%								**= 100%**		
Sieve Size	% Pass	% Pass	% Pass	% Pass	% Pass	% Pass	**Comb Grad**	**Target**	**Control Limits**	
	% Bin	% Bin	% Bin	% Bin	% Bin	% Bin			**Min**	**Max**
1										
3/4										
1/2			36	100	100	100		**80**		
3/8										
#4			3	49	80	100		**47**		
#8			1	16	75	100		**35**		
#16										
#30			1	3	28	100		**13**		
#50										
#100										
#200			0.5	2.3	8.2	90.0		**4.1**		
AB								**4.7**		

Batch Plant Adjustment Example							Surface Mixture		
Bin #	Bin #4	Bin #3	Bin #2	Bin #1	MF	New Bit			
Size	+ 1/2	-1/2 +#4	-4 +#8	- #8	- #200				
Mix%							= 100%		
#'s							**Batch Size - Lbs.** = **10000**		
Agg%		41.0	25.0	34.0	0.0		= 100%		
Sieve Size	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	Comb Grad	Target	Control Limits Min	 Max
1									
3/4									
1/2		100	100	100	100	100	**100**		
		41.0	25.0	34.0					
3/8		88	100	100	100	95	**96**		
		36.1	25.0	34.0					
#4		8	92	100	100	60	**65**		
		3.3	23.0	34.0					
#8		1	2	98	100	34	**38**		
		0.4	0.5	33.3					
#16		1	1	70	100	25	**27**		
		0.4	0.3	23.8					
#30		1	1	49	100	17	**20**		
		0.4	0.3	16.7					
#50		1	1	25	100	9	**10**		
		0.4	0.3	8.5					
#100		1	1	12	100	5	**7**		
		0.4	0.3	4.1					
#200		0.2	0.4	8.9	87.7	3.2	**4.6**		
		0.1	0.1	3.0					
AB							**5.5**		

Note: This example has been adjusted for windage

Batch Plant Adjustment Example						Surface Mixture			
Bin #	Bin #4	Bin #3	Bin #2	Bin #1	MF	New Bit			
Size	+ 1/2	-1/2 +#4	-4 +#8	- #8	- #200				
Mix%							= 100%		
#'s							**Batch Size - Lbs.** = **10000**		
Agg%							= 100%		
Sieve Size	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	Comb Grad	Target	Control Limits Min	Control Limits Max
1/2		100	100	100	100		**100**		
3/8		88	100	100	100		**96**		
#4		8	92	100	100		**65**		
#8		1	2	98	100		**38**		
#16		1	1	70	100		**27**		
#30		1	1	49	100		**20**		
#50		1	1	25	100		**10**		
#100		1	1	12	100		**7**		
#200		0.2	0.4	8.9	87.7		**4.6**		
AB							**5.5**		

Note: This example has been adjusted for windage

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Chapter 4 Homework

The homework won't help you

If you don't try to work the problems!

Don't spend a long time on any one problem
but work on each problem.

Give each problem a fair try.

The problems are designed to help you
understand the concepts of proportioning.

On the dryer-drum set-up problem,
if you can get close to the targets then you have done well.

You are not expected to be an expert at proportioning or adjusting mixes when you leave this class

but

You should be able to understand the concepts that have been presented so as to do well in the "real world" and prepare for the test.

Given information for
Dryer-Drum Set-up Homework Problem #1

Aggregate Stockpile & Mixture Design Information						
Feeder	#1	#2	#3	#4		Design
Agg. size:	032CM11	032CM16	038FM20	037FM02	004MF01	Gradation
Agg %	49.0	23.5	13.0	13.0	1.5	
Sieve						
1	100	100	100	100	100	100
3/4	85	100	100	100	100	94
1/2	44	100	100	100	100	73
3/8	19	97	100	100	100	60
#4	10	34	100	100	100	39
#8	7	9	75	92	100	27
#16	4	6	42	65	100	18
#30	3	5	29	40	100	13
#50	2	4	16	14	100	7
#100	2	3	8	3	97	5
#200	1.8	1.9	5.8	1.7	90.0	3.7
AB						4.0

Drier-Dryer-Drum Set-up Homework Problem #1										
Feeder		#1	#2	#3	#4	MF	-----			
Agg							**New Bit**			
Mix%								**= 100%**		
TPH								**Prod Rate TPH = 700**		
Agg%								**= 100%**		
Sieve Size	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	Comb Grad	Target	Control Limits Min	Control Limits Max
1										
3/4										
1/2										
3/8										
#4										
#8										
#16										
#30										
#50										
#100										
#200										
AB										

Given information for
Recycle Dryer-drum Set-up Homework Problem #2:

Average Stockpile Gradation & Design Information						
Feeder	**RAP**	**#1**	**#2**	**#3**	**MF**	
Agg. size:	**RAP**	**042CM11**	**032CM16**	**037FM02**	**004MF01**	**Design Formula**
Agg %	**25.0**	**33.0**	**20.0**	**21.0**	**1.0**	
Sieve						
1”	100	100	100	100	100	100
3/4”	94	91	100	100	100	96
1/2	85	40	100	100	100	75
3/8	79	15	92	100	100	66
#4	63	3	40	99	100	47
#8	46	2	15	92	100	36
#16	37	2	6	60	100	24
#30	31	2	4	45	100	19
#50	23	1	4	14	100	10
#100	13	1	4	3	98	6
#200	7.6	1.0	4.0	2.2	88.0	4.3
AB	4.5					4.0

Drier-Recycle Dryer-Drum Set-up Homework Problem #2

Feeder		**R1**	**#1**	**#3**	**#3**	**MF**	**New Bit**			
Agg		**RAP**	**CM11**	**CM16**	**FM02**	**MF**				
Mix%								**= 100%**		
TPH								**Prod Rate TPH = 700**		
Agg%								**= 100%**		
Sieve Size	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	Comb Grad	Target	Control Limits Min	Control Limits Max
1										
3/4										
1/2										
3/8										
#4										
#8										
#16										
#30										
#50										
#100										
#200										
AB										

Given information for
Batch Plant Set-up Homework Problem #3:

Average Hotbin Gradation & Design Information

Hotbin	Gradations	Batch Size – 8000 lbs.				Design
Sieve		Bin #3	Bin #2	Bin #1	MF	Gradation Formula
1/2		100	100	100	100	100
3/8		93	100	100	100	97
#4		4	94	100	100	55
#8		2	6	92	100	33
#16		2	1	74	100	27
#30		1	1	45	100	17
#50		1	1	23	100	10
#100		1	1	14	99	7
#200		0.5	0.4	5.9	88.0	3.7
AB						5.3

Batch Plant Set-up Homework Problem #3									
Bin #	Bin #4	Bin #3	Bin #2	Bin #1	MF	New Bit			
Size	**+ 1/2**	**-1/2 +#4**	**-4 +#8**	**- #8**	**- #200**				
Mix%							= 100%		
#'s							**lbs/ Batch** = **8000**		
Agg%							= 100%		
Sieve Size	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	Comb Grad	Target	Control Limits	
								Min	Max
1									
3/4									
1/2									
3/8									
#4									
#8									
#16									
#30									
#50									
#100									
#200									
AB									

Dryer-Drum Adjustment Homework Problem #4									
Feeder		#1	#2	#3	MF	**New Bit**			
Agg		**CM 11**	**CM 16**	**FM 20**	**MF 01**				
Mix%							= 100%		
TPH							**Prod Rate - TPH = 300**		
Agg%		37.0	29.0	33.0	1.0		= 100%		
Sieve Size	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	Comb Grad	Target	Control Limits Min	Control Limits Max
1									
3/4									
1/2		34	100	100	100	76	**74**		
		12.6	29.0	33.0	1.0				
3/8									
#4		3	32	99	100	44	**43**		
		1.1	9.3	32.7	1.0				
#8		2	9	96	100	36	**36**		
		0.7	2.6	31.7	1.0				
#16									
#30		1	8	42	100	18	**17**		
		0.4	2.3	13.9	1.0				
#50									
#100									
#200		1.0	5.5	3.8	85.0	4.2	**3.1**		
		0.4	1.6	1.3	0.9				
AB							**4.4**		

Drier-Drum Adjustment Homework Problem #4

Feeder		#1	#2	#3	MF	**New Bit**			
Agg		**CM 11**	**CM 16**	**FM 20**	**MF 01**				
Mix%							= 100%		
TPH							**Prod Rate - TPH =** **300**		
Agg%							= 100%		
Sieve Size	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	Comb Grad	Target	Control Limits Min	Max
1		100	100	100	100		**100**		
3/4		91	100	100	100		**96**		
1/2		34	100	100	100		**74**		
3/8		14	97	100	100		**64**		
#4		3	32	99	100		**43**		
#8		2	9	96	100		**36**		
#16		1	8	56	100		**23**		
#30		1	8	42	100		**17**		
#50		1	7	16	100		**10**		
#100		1	6	6	100		**5**		
#200		1.0	5.5	3.8	85.0		**3.1**		
AB							**4.4**		

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Segregation of HMA Materials

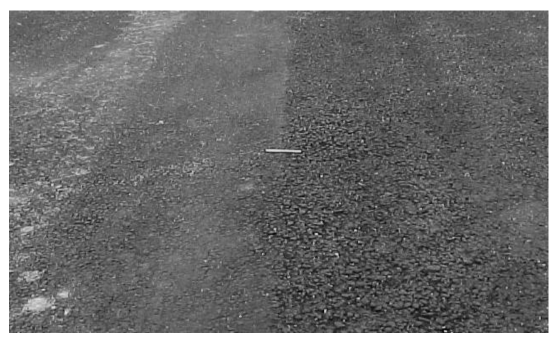
Segregation is a #1 cause of pavement destruction and is required to be addressed by the contractor by specification

Segregation can reduce pavement life by 3-5 years or more depending on the severity of the segregation

The state will impose penalties on contracts/jobs to reduce segregation and make the contractor responsible for problems

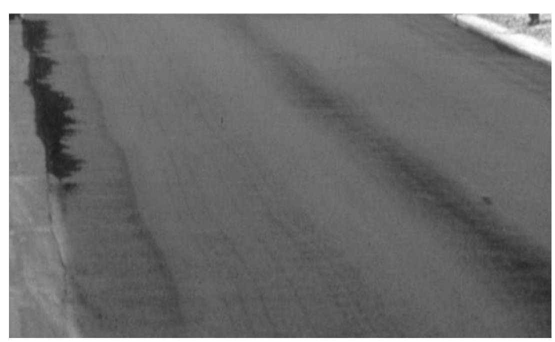
Segregation can cause:
- Smoothness problems
- Density below specification
- Loss of overall mat durability
- Moisture damage & raveling
- Cracking of the pavement
- Streaky pavement surfaces

Segregation can be caused by:
- Mix designs
- Aggregate handling
- HMA plant operations
- Truck loading & unloading
- Paver operations



Pavement Segregation

End of Load Segregation



Pavement Streaking

Segregation Control for HMA Materials document from the Standard Specifications Article 406.06 (f)

(f) Segregation Control. Paving operations shall be conducted in a manner to prevent medium or high segregation.

Plant operations, hauling of the mixture, paver operations, and the compacted mat shall be continually monitored for segregation.

The in-place HMA shall be evaluated daily for segregation according to the QC/QA document "Segregation Control of Hot-Mix Asphalt".

The Contractor's Annual Quality Control Plan or Addendum shall identify the individual(s) responsible for performing and documenting the daily evaluations. Quality Control Plans and Addendums for subsequent projects shall reflect the corrective actions taken, whether the corrective action was initiated by the Contractor or the Engineer.

QC/QA Segregation Control Document from the Manual of Test Procedures

Illinois Department of Transportation

QC/QA Document Segregation Control of Hot-Mix Asphalt
Appendix B20

Effective: May 1, 2007

1.0 SCOPE

1.1 This work shall consist of the visual identification and corrective action to prevent and/or correct segregation of hot-mix asphalt.

2.0 ***DEFINITIONS***

2.1 Segregation. Areas of non-uniform distribution of coarse and fine aggregate particles in a hot-mix asphalt pavement.

2.2 End-of-Load Segregation. A systematic form of segregation typically identified by chevron-shaped segregated areas at either side of a lane of pavement, corresponding with the beginning and end of truck loads.

2.3 Longitudinal Segregation. A linear pattern of segregation that usually corresponds to a specific area of the paver.

2.4 Severity of Segregation.

2.4.1 Low. A pattern of segregation where the mastic is in place between the aggregate particles; however, there is slightly more coarse aggregate in comparison with the surrounding acceptable mat.

2.4.2 Medium. A pattern of segregation that has significantly more coarse aggregate in comparison with the surrounding acceptable mat and which exhibits some lack of mastic.

2.4.3 High. A pattern of segregation what has significantly more coarse aggregate in comparison with the surrounding acceptable mat and which contains little mastic.

Illinois Department of Transportation

QC/QA Document Segregation Control of Hot-Mix Asphalt
Appendix B20
(continued)

Effective: May 1, 2007

3.0 ***PROCEDURE***

3.1 When medium or high segregation of the mixture is identified by the Contractor, the Engineer, or the daily evaluation, the following specific corrective actions shall be taken as soon as possible. The corrective actions shall be reported to the Engineer before the next day's paving proceeds.

3.1.1 End of Load Segregation. When medium or high end of load segregation is identified, the following actions as a minimum shall be taken.

3.1.1.1 Trucks transporting the mixture shall be loaded in multiple dumps. The first against the front wall of the truck bed and the second against the tailgate in a manner which prevents the coarse aggregate from migrating to those locations.

3.1.1.2 The paver shall be operated so the hopper is never below 30 percent capacity between truck exchanges.

3.1.1.3 The "Head of Material" in the auger area shall be controlled to keep a constant level, with a 1 inch $\pm$ 25 mm tolerance.

3.1.2 Longitudinal Segregation. When medium or high longitudinal segregation is identified, the Contractor shall make the necessary adjustment to the slats, augers or screeds to eliminate the segregation.

3.2 When the corrective actions initiated by the Contractor are insufficient in controlling medium or high segregation, the Contractor and Engineer will investigate to determine the cause of the segregation.

When an investigation indicates additional corrective action is warranted, the Contractor shall implement operational changes necessary to correct the segregation problems.

Any verification testing necessary for the investigation will be performed by the Department according to the applicable project test procedures and specification limits.

3.3 The District Construction Engineer will represent the Department in any dispute regarding the application of this procedure.

Daily Segregation Evaluation Form Example

Date	______________	County	______________
Job #	______________	Section #	______________
Plant #	______________	Route	______________
Material	______________	District	______________
Name	______________	Contract #	______________
HMA Mix #	______________	Job #	______________
Lot #	______________	Project #	______________
Station	______________		

Check the boxes which apply the most:

Type of Segregation

☐	None	No segregation of any appreciable amount is present
☐	Segregation	Areas of non-uniform distribution of coarse and fine aggregates
☐	End of Load	Systematic form of segregation typically defined by chevron-shaped segregated areas at either side of the lane, corresponding with beginning and end of truck loads
☐	Longitudinal	A linear pattern of segregation that usually corresponds to a specific area of the paver

Remarks: ____

____

____

Severity of Segregation

☐	Low	A pattern of segregation where the mastic is in place between the aggregate particles, however, there is slightly more coarse aggregate in comparison with the surrounding acceptable mat
☐	Medium	A pattern of segregation that has significantly more coarse aggregate in comparison with the surrounding acceptable mat which exhibits some lack of mastic
☐	High	A pattern of segregation that has significantly more coarse aggregate in comparison with the surrounding acceptable mat and which contains little mastic

If medium or high severity of segregation is present, specify corrective actions in remarks.

Remarks: ____

____

____

____

______________________ ______________________

Contractors Representative IDOT Representative

All daily evaluations shall be stored at the mix plant where the material was produced. Copies are available upon request.

To: *All Regional Engineers*

From: *Omer M. Osman, P.E.*

Subject: *Special Provision for Material Transfer Device*

Date: *April 18, 2014*

This special provision was developed by the Bureau of Materials and Physical Research. It has been revised to increase the roadway contact pressure in which the use of a Material Transfer Device (MTD) is allowed for partially completed segments of full-depth HMA pavements where the thickness of in place pavement is less than 10 in..

This special provision shall be inserted into interstate hot-mix asphalt (HMA) paving and full depth contracts. For full depth HMA contracts the MTD shall be used for constructing all lifts of pavement. It should be inserted in other HMA paving contracts at the district's discretion.

The special provision contains three fill in the blank areas, which must be determined by the district and are considered project specific requirements. The following guidelines should be considered:

(1) Type of materials to be placed with the MTD (to be determined by the district). Example wording: This work shall consist of placing HMA binder and surface course mixtures according to Section 406 of the Standard Specifications, except that these materials shall be placed using a material transfer device.

(2) Location where the MTD will be used on the project (to be determined by the district). Example wording: The material transfer device shall be used for the placement of all HMA binder and surface course mixtures placed with a paver including ramps but excluding shoulders.

(3) Based on (1) above, the designer must restate, which materials are placed with the MTD (to be determined by the district). If square yard pay items are placed with the MTD, conversion factors must be shown on the plans. Example wording: This work will be measured for payment in tons (metric tons) for all HMA binder and surface course materials placed with a material transfer device.

The operation or transportation of heavy equipment on pavement or structures within contract limits is governed by Article 107.16 of the Standard Specifications and implemented through Construction Memorandum No. 39.

Additionally, this special provision contains specific restrictions regarding travel on bridges and full depth pavements. The designer shall submit information to the Bureau of Bridges and Structures identifying the structures that will be crossed by the MTD. The Bureau of Bridges and Structures will analyze the structures to verify that they have the capacity to safely carry an emptied MTD and will provide the designer with recommendations. The recommendations provided by the Bureau of Bridges and Structures will identify any structure, which due to general deterioration or insufficient load carrying capacity, cannot be crossed by an emptied MTD. The plans shall include notice to the contractor of special requirements and restrictions for structures that cannot be crossed by an emptied MTD. The notice shall indicate to the contractor that the emptied MTD must be transported over the identified structures on a transport vehicle and that information describing axle loads and axle spacing of the transport vehicle must be provided to the Engineer for review by the Bureau of Bridges and Structures.

The districts should include the BDE Check Sheet marked with the applicable special provisions for the August 1, 2014 and subsequent lettings. The Project Development and Implementation Section will include a copy in the contract.

This special provision will be available on the transfer directory April 18, 2014.

80045m

MATERIAL TRANSFER DEVICE (BDE)

Effective Date: June 15, 1999
Revised Date: August 1, 2014

Description. *This work shall consist of placing ______________(1)_____________ , except that these materials shall be placed using a material transfer device (MTD).*

Materials and Equipment. *The MTD shall have a minimum surge capacity of 15 tons (13.5 metric tons), shall be self-propelled and capable of moving independent of the paver, and shall be equipped with the following:*

(a) Front-Dump Hopper and Conveyor. The conveyor shall provide a positive restraint along the sides of the conveyor to prevent material spillage. MTDs having paver style hoppers shall have a horizontal bar restraint placed across the foldable wings which prevents the wings from being folded.

(b) Paver Hopper Insert. The paver hopper insert shall have a minimum capacity of 14 tons (12.7 metric tons).

(c) Mixer/Agitator Mechanism. This re-mixing mechanism shall consist of a segmented, anti-segregation, re-mixing auger or two full-length longitudinal paddle mixers designed for the purpose of re-mixing the hot-mix asphalt (HMA). The longitudinal paddle mixers shall be located in the paver hopper insert.

CONSTRUCTION REQUIREMENTS

General. *The MTD shall be used for the placement of _____________(2)____________. The MTD speed shall be adjusted to the speed of the paver to maintain a continuous, non-stop paving operation.*

Use of a MTD with a roadway contact pressure exceeding 25 psi (172 kPa) will be limited to partially completed segments of full-depth HMA pavement where the thickness of binder in place is 10 in. (250 mm) or greater.

Structures. *The MTD may be allowed to travel over structures under the following conditions:*

(a) Approval will be given by the Engineer.

(b) The vehicle shall be emptied of HMA material prior to crossing the structure and shall travel at crawl speed across the structure.

(c) The tires of the vehicle shall travel on or in close proximity and parallel to the beam and/or girder lines of the structure.

Method of Measurement. *This work will be measured for payment in tons (metric tons) for _____________ ____________(3)____________ materials placed with a material transfer device.*

Basis of Payment. This work will be paid for at the contract unit price per ton (metric ton) for MATERIAL TRANSFER DEVICE.

The various HMA mixtures placed with the MTD will be paid for as specified in their respective specifications. The Contractor may choose to use the MTD for other applications on this project; however, no additional compensation will be allowed.

80045

Material Transfer Devices (Vehicles)

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Technical Paper T-117

SEGREGATION: Causes and Cures

by J. Don Brock, PhD., P.E.
and James G. May
and Greg Renegar

ASTEC encourages its engineers and executives to author articles that will be of value to members of the hot mix asphalt (HMA) industry. The company also sponsors independent research when appropriate and has coordinated joint authorship between industry competitors. Information is disbursed to any interested party in the form of technical papers. The purpose of the technical papers is to make information available within the HMA industry in order to contribute to the continued improvement process that will benefit the industry.

CONTENTS

INTRODUCTION

Hot mix asphalt mixtures that are properly designed, produced and placed provide a durable, long lasting pavement that requires very little maintenance.

However, there are a number of potentially damaging problems that can occur in the design, production and placement of hot mix paving mixtures. Of these problems, perhaps the most serious is segregation. Segregation is a frequently recurring problem that has caused concern within the paving industry for decades and receives widespread attention by contractors, state highway departments and equipment manufacturers.

When segregation is present in a mixture, there is a concentration of coarse materials in some areas of the paved mat, while other areas contain a concentration of finer materials. Segregation creates non-uniform mixes that do not conform to the original job mix formula in gradation or asphalt content. The resulting pavement exhibits poor structural and textural characteristics and has a shorter life expectancy.

Problems associated with segregation are serious. Their elimination is essential to the production of high quality paving mixtures. Elimination of segregation is the responsibility of those who produce and lay asphalt mix, those state highway departments who design the mix and inspect the final product, and those manufacturers who design and market machinery for the paving industry.

This paper was written to help designers, plant operators and paving crews be aware of the causes of segregation and known solutions. Each portion of the plant, paver and trucking operation known to cause segregation is discussed separately. In addition, a diagnostic chart accompanies this paper to help identify types of segregation and probable causes.

MIX DESIGNS

Proper mix design is important in the effort to eliminate segregation. Mixes that are uniformly designed with no gap-grading are generally very forgiving. They allow mistakes in other areas of the plant operation or laydown operation without affecting the mix performance significantly.

Gap-graded mixes are unforgiving. Consequently, any slight error in the plant, trucking or layout process can result in non-uniform surfaces. If the mix is gap-graded to a sufficient degree with a low asphalt content, it simply cannot be produced without segregation, regardless of the techniques used.

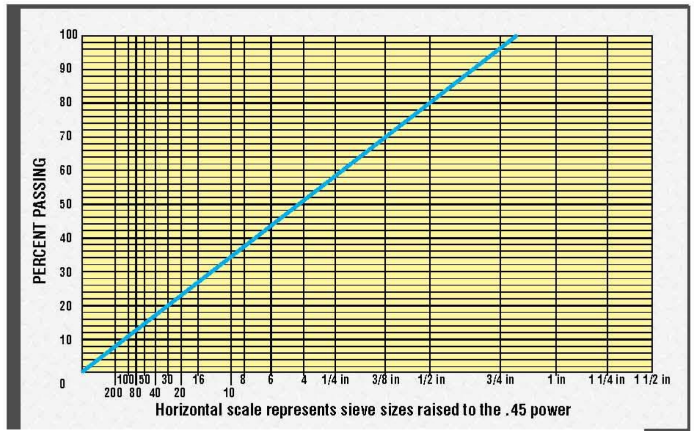
Gap graded mixes have been successfully used in England and throughout Europe. However, these mixes often have fibers or polymers, enabling the use of a higher asphalt content that makes the film thicker. In many mixes a slight increase in asphalt content (often as little as 0.2 percent) will reduce segregation significantly. Increased film thickness dampens particle-to-particle contact and reduces the tendency to separate at transfer points throughout the process. The new SMA and Superpave mixes in the U.S. are gap-graded. However, the addition of fibers and polymers make them less sensitive to segregation.

A maximum density line similar to the one shown in **Figure 1** can be utilized as a guide to uniform grading. To make a chart with a maximum density line for your operation, use a FHWA 0.45 Power Gradation Chart as shown in **Figure 1**. Draw a straight line between the lower left corner of the chart and the percent point for your largest sieve size that retains material.

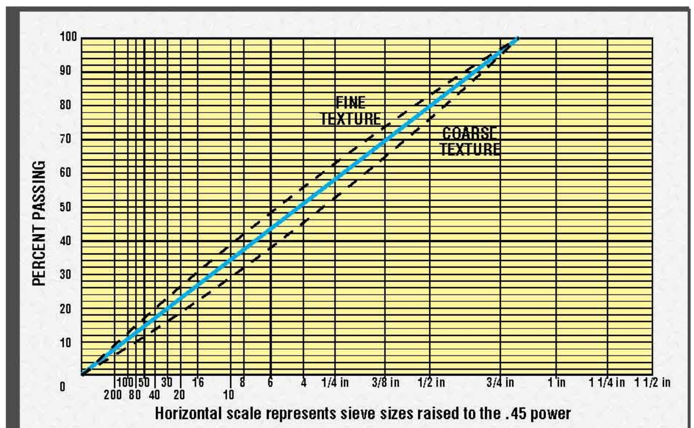
Experience dictates that mixes with gradations that fall directly on the maximum density line should not be produced. Often there is insufficient room in the mixture for the liquid asphalt, and a plastic type material results. Another problem arises when the mix design is near the maximum density line. Gradation variations in stockpile material cause the curve to vary back and forth across the maximum density line, thereby gap-grading the mix. It is suggested that the mix designer select approximately two to four percentage points above the maximum density curve if he desires a fine texture. He should select two to four points below the curve if he desires a coarse texture, see **Figure 2**. These bowed up and bowed down curves usually result in a good, forgiving mix.

Rarely does a mix that lies on the maximum density line contain sufficient *voids in the mineral aggregate* (VMA), especially if the design has a relatively high percentage of minus 200 material. A grading selected on a line approximately parallel to the maximum density line will produce a uniformly graded mix that will be very forgiving. However, the maximum density line should be used only as a guideline for uniform grading. Other criteria such as VMA, stability and other specifications must also be met.

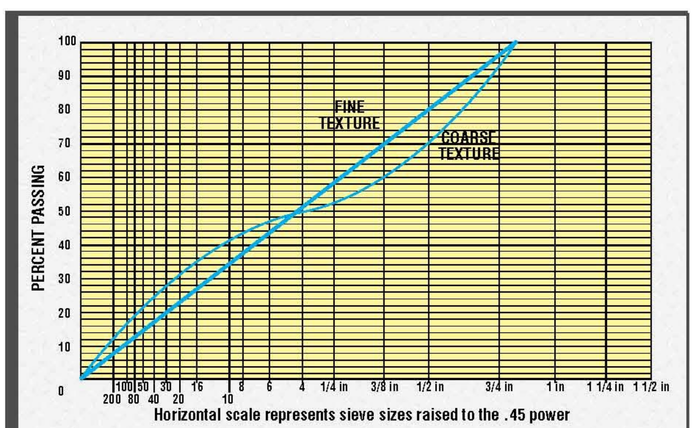
A mix design that makes an "S" across the maximum density line, as shown in **Figure 3**, can result in segregation problems.



MAXIMUM DENSITY LINE F1

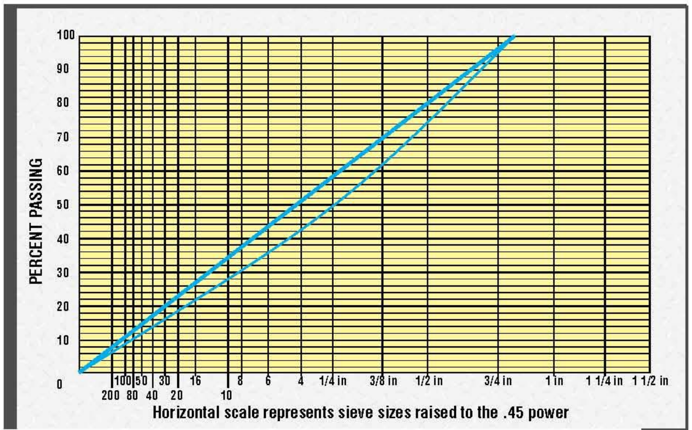


SELECTING MIXES F2

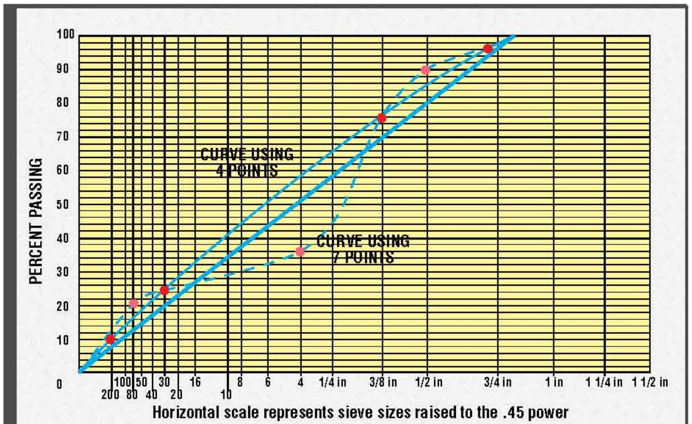


"S" CURVES TEND TO SEGREGATE F3

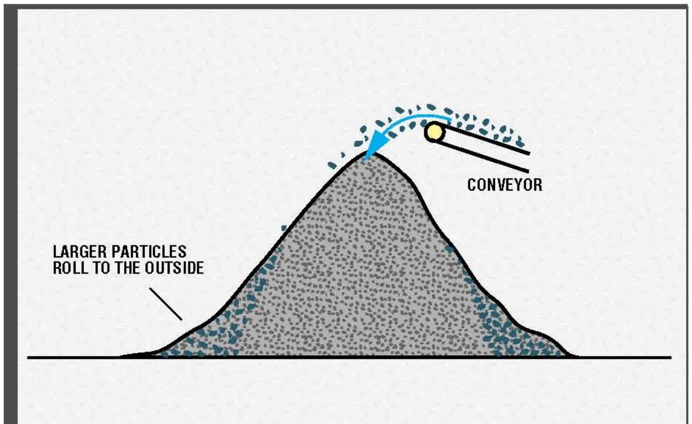
3



SLIGHTLY BOWED CURVES MAY DO WELL F4



SAME MIX 4 vs 7 POINTS F5



SEGREGATION IN A PILE F6

4

The slightly bowed curve shown in **Figure 4** could result in good performance. But the potential benefit that a designer tries to achieve by gap-grading is too often negated by segregation problems.

When plotting a mix gradation, plot as many sieve sizes as possible. **Figure 5** illustrates how plotting to only a few points can result in a misleading graph. When only 4 sieve sizes are plotted as shown in **Figure 5** the curve may indicate a "forgiving" mix. But when seven sieve sizes are plotted, also shown in **Figure 5**, it is easy to see that the mix is actually gap-graded.

STOCKPILING

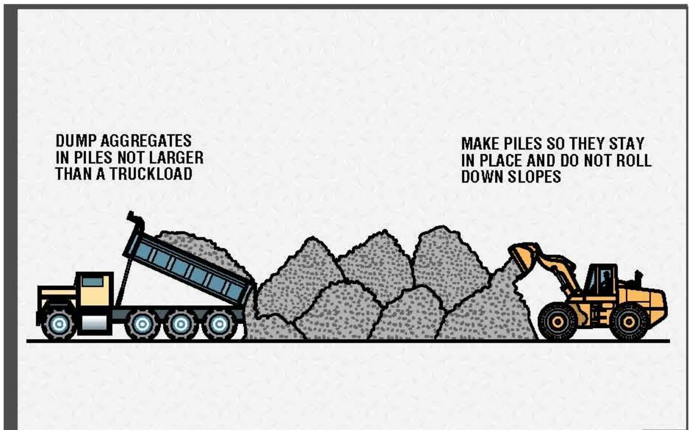
Proper stockpiling techniques are needed to insure that the material will be uniform when fed to the hot mix plant. Large stockpiles are very sensitive to single aggregate blends. **Figure 6** shows a typical example of a single aggregate stockpile. In this example, segregation has occurred because a conveying system was used to form the stockpile. Large particles have rolled to the outside of the pile thereby segregating the material. Subsequently, segregated material is fed to the plant.

Generally, different-sized materials are stockpiled separately for feeding to an asphalt plant. This makes segregation less likely because the material is more evenly sized in each pile. However, segregation can occur in smaller aggregates if a wide variation in gradation exists. Stockpile techniques shown in **Figures 7** and **8** assure uniformity of material and significantly reduce stockpile segregation. Dozer operation should be monitored to assure degradation is not occurring. Monitoring is especially critical when dealing with softer aggregates. NAPA Publication IS-69, *Stockpiling and Cold Feed For Quality,* gives good guidelines for proper stockpiling techniques.

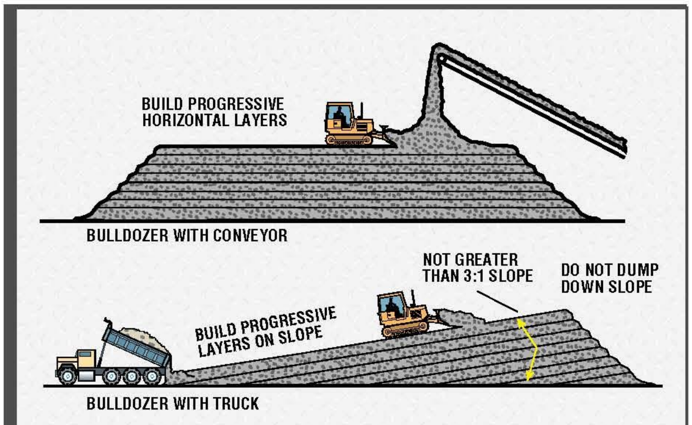
When sampling stockpile material to set up cold feed bin ratios, it is important to take several samples and use the median result as shown in **Figure 9**.

ASPHALT FACILITIES

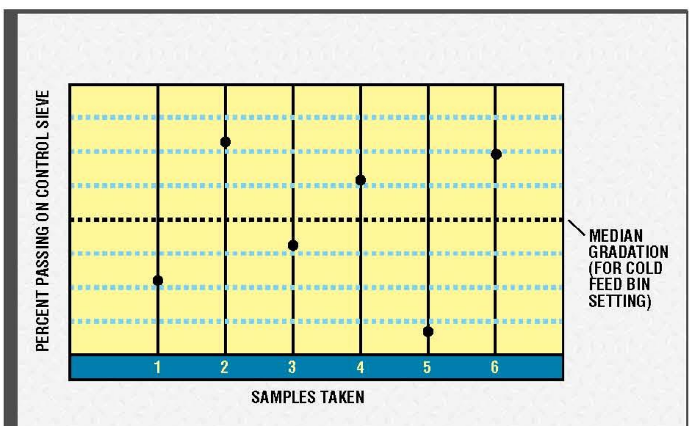
Segregation can occur at numerous points in a hot mix asphalt plant. The location at which segregation is likely to occur in a plant depends on what type of facility it is. On a batch plant, the points of most concern are cold feed bins and hot bins. On drum mix plants, surge bins and storage bins are the points of most concern.



USE NUMEROUS SMALL PILES F7



BUILD STOCKPILES IN LAYERS F8



STOCKPILE SAMPLING F9

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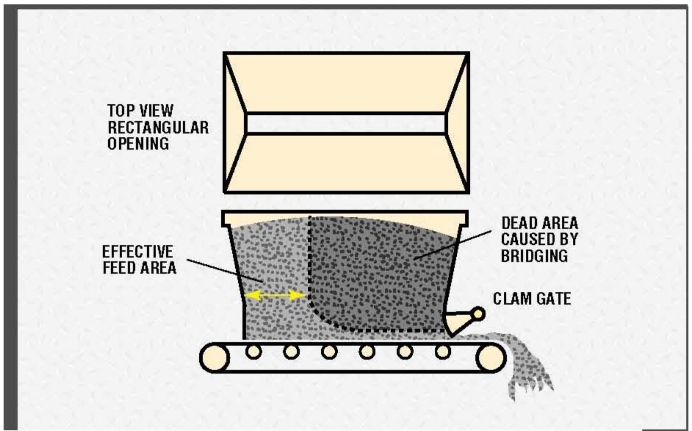
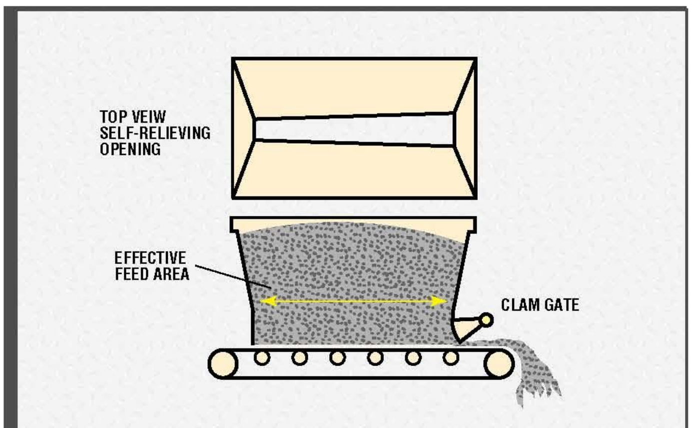
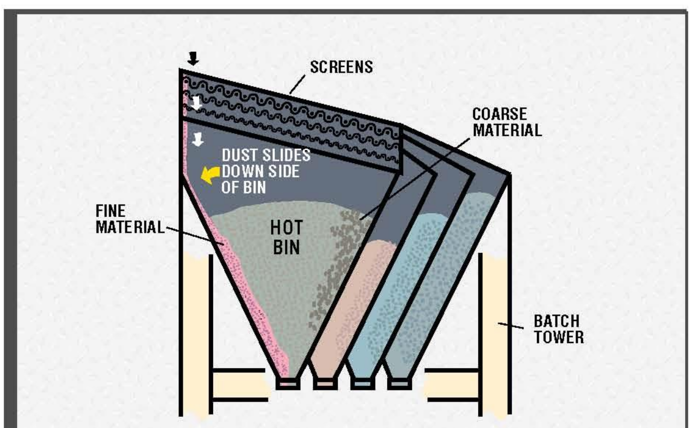


FEEDER BIN WITH RECTANGULAR OPENING F10



SELF-RELIEVING FEEDER BIN F11



HOT BIN SEGREGATION F12

COLD FEED BINS

Segregation in cold feed is usually not a problem unless the aggregate material consists of several sizes. Segregation should not occur when a single size of aggregate is placed in each feeder bin because there are no different sizes to segregate. However, if bridging of material occurs in the hopper, see **Figure 10**, non-uniform feeding takes place, resulting in a segregated mix.

By utilizing a self-relieving bottom shown in **Figure 11**, uniform feeding will occur all along the opening of the cold feed bin, eliminating bridging as a source of segregation.

When working with a crusher-run aggregate, it can be beneficial to use two cold feed bins to feed the same material. This practice tends to minimize wide variations by feeding smaller amounts of material from two bins, thus minimizing variations in gradation.

HOT BINS ON A BATCH PLANT

As mentioned, segregation can occur with all sizes of material. Segregation often occurs in the No. 1 hot bin due to the size and shape of the large bin and the wide size range of materials in that bin. The size variation in material in Bin 1 is potentially greater than any other part of the asphalt plant because its material size varies from as large as 3/16-inch all the way down to one micron.

In recent years some have voiced concern about uniform dust return from baghouses to batch plants. Generally, material is uniformly collected in baghouses and is uniformly returned, but the material may actually be segregating in Bin 1. The ultra-fine material discharged from the bucket elevator may fall directly through the screen and lay on a sloping bin wall, **Figure 12**. It may lay there until the bin is about empty. Then a large slug of the dust may break loose and feed into the weigh hopper, producing an

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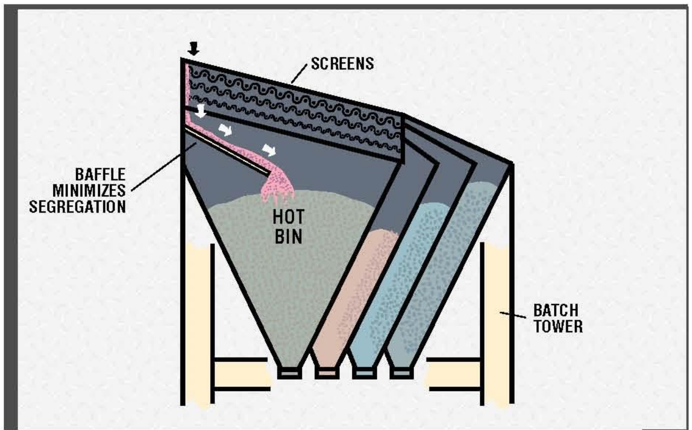
ultra-fine batch that is segregated, and uncoated.

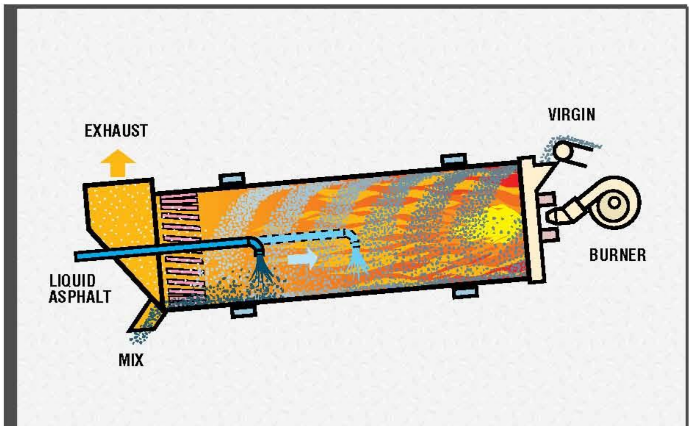
In many cases non-uniform feed from the baghouse was incorrectly suspected to be the cause of segregation in the hot bin and resulted in the addition of expensive and unnecessary equipment. There was simply an improper analysis of the problem. The proper solution should be to install a baffle as shown in **Figure 13**. The baffle causes the dust to slide to the center of the bin where it is uniformly mixed with the coarse materials.

The same results can be achieved by using a baffle to force the coarse material back to the sloping bin wall. There, it can be intermixed with the fine material. The method used depends on the head room and space available in the hot bins.

Utilizing a dust blower at the baghouse and a cyclone type dust receiver properly located in Bin 1 has also proved effective in eliminating segregation in this area. However, many prefer to use baffles because of relatively high maintenance costs for airlocks that handle abrasive materials such as granite.



HOT BIN WITH BAFFLE **F13**

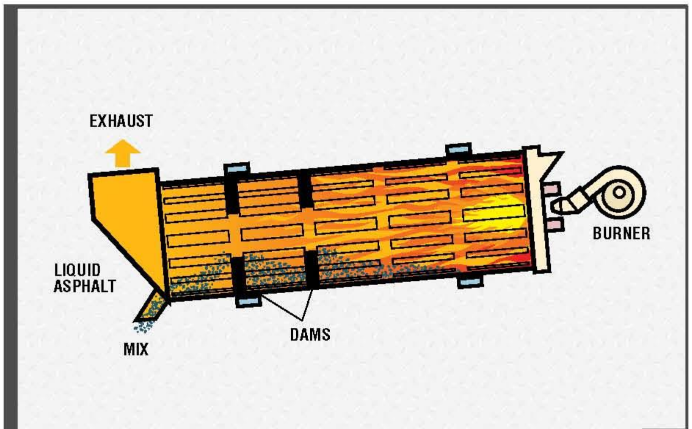


INCREASING MIXING TIME IN A DRUM MIXER **F14**

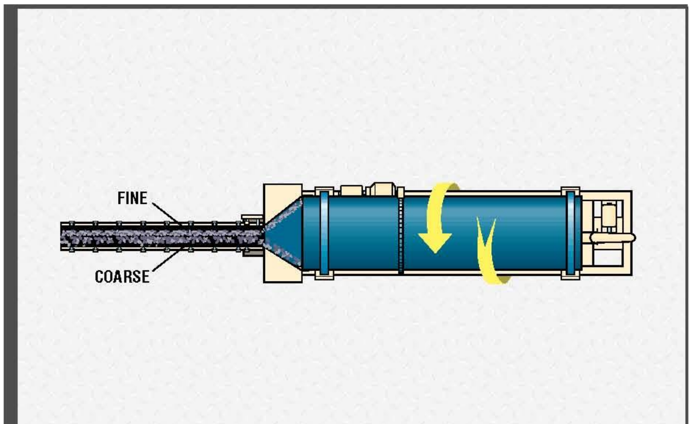
DRUM MIXER

Large particles will generally flow through a drum mixer at a slightly faster rate than small particles during initial start up and at plant shut down. Negative effects associated with this characteristic can be eliminated by adjusting the start/stop time intervals between the cold feed bins. Due to the continuous flow process that occurs after start-up, this characteristic does not produce segregation. The potential to segregate is also of little significance unless the material is gap-graded.

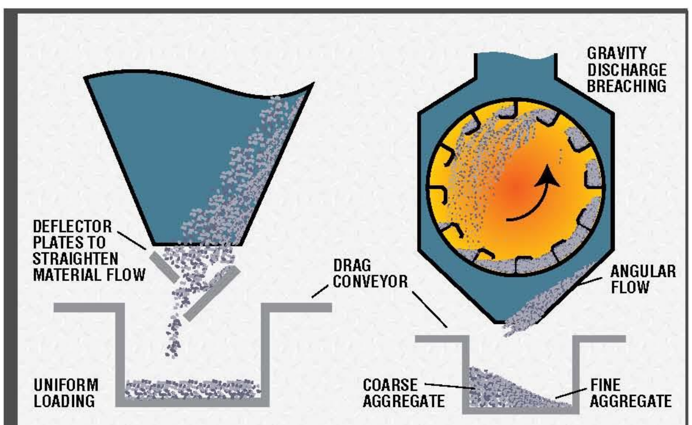
When gap-graded mixes are processed in a drum mixer, it becomes more difficult to achieve a thorough coating with a uniform thickness. The uncoated or thinly coated coarser materials are more likely to segregate. Such segregation can be reduced or eliminated through better coating. This can be accomplished by increasing the mixing time by extending the asphalt line farther up into the drum mixer as shown in **Figure 14**. For hard-to-coat materials, kick-back flights as shown in **Figure 14** can be used, or a dam (donut) can be installed in the drum to increase the mixing time, **Figure 15**.



DRUM MIXER DAMS RETARD FLOW F15



DRUM DISCHARGE SEGREGATION F16



GRAVITY DISCHARGE F17

An alternate method is to decrease the drum slope, which increases the dwell time and provides additional mixing. Increased dwell time, whether due to the addition of dams or due to decreasing the drum slope, increases the drum load. This may reduce the production rate if the drum drive motor is a limiting factor.

An often overlooked factor which can significantly affect coating quality and film thickness is the amount of minus 200 material in the mix. Coating quality will be adversely affected if the amount of minus 200 material exceeds specifications or even if it is within specifications, but on the high side of the tolerance allowed. Because of the large amount of surface area present in fine material and because of its affinity for the liquid asphalt, coarser material in the mix will have a reduced film thickness even though it may appear to be fully coated. Reduced film thickness makes the coarse material less sticky and increases its tendency to segregate. Reducing the amount of minus 200 material to the low side of the allowable tolerance will usually correct this problem. Moreover, it will be easier to produce a uniform mix and easier to handle the mix throughout the trucking and laydown operations.

INTERNAL MOISTURE

Retained internal moisture is rarely a problem while running RAP since the virgin aggregate containing the internal moisture is superheated above the mix termperature. The degree of superheat depends on the percent RAP, RAP moisture and the mix termperature. For example, with 30% RAP containing 5% moisture, the virgin aggregate is heated to 512°F to produce 300°F mix. If retained internal moisture is a problem while producing a virgin mix, one of the aggregates, not containing internal moisture, can be added into the plant process

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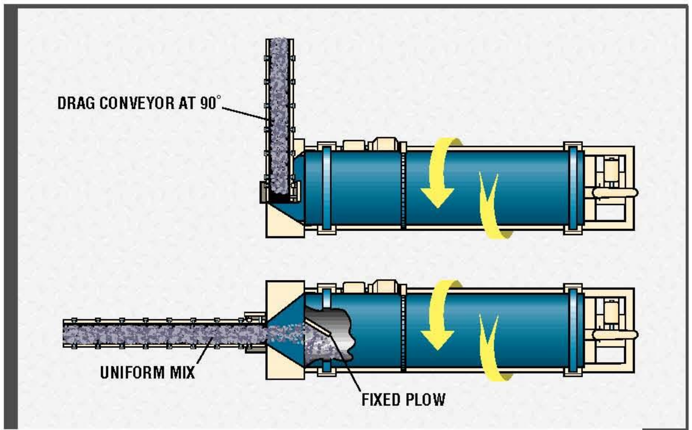


DRUM DISCHARGE FLOW F18

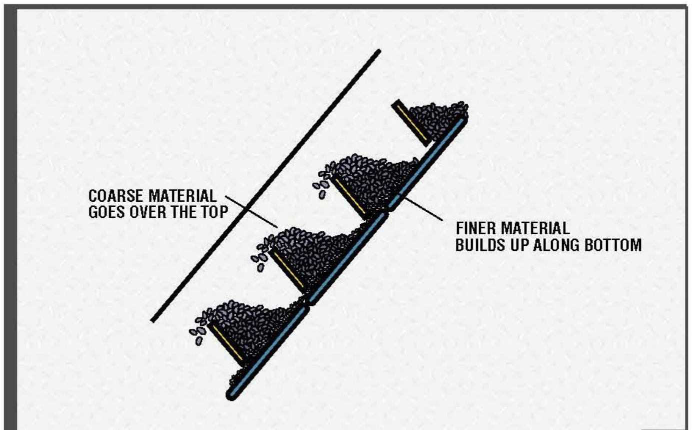
through the RAP system. This induces the plant to superheat the aggregate containing internal moisture, thus removing the internal moisture before the liquid AC is added. This helps coating and mimimizes AC absorption. An Alabama contractor reduced the moisture retained in a slag mix from 0.22% to .06% by adding 15% screenings through the RAP bin.

The coating of large stones can also be affected by internal moisture and absorption. When internal moisture is present in large aggregate its temperature tends to be cooler than finer material. Cooler stones will not coat readily until they have given up their moisture and reached a uniform elevated temperature comparable to the temperature of the rest of the mixture. Internal moisture can be eliminated by increasing drying and mixing times using the methods described above.

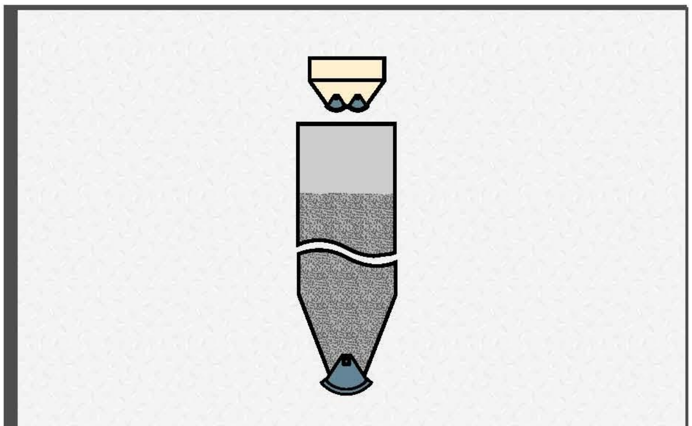
Asphalt absorption problems are related to internal moisture problems. This is because the same pores that contain the moisture in the stone will absorb a portion of the available asphalt. This absorption reduces the actual film thickness on the outside surfaces. If absorption is suspected, break open several larger stones and examine them under a magnifying glass. A dark band ranging from a few thousands of an inch to 1/32-inch wide from the surface inward indicates that absorption is occurring. The solution to attaining the film thickness originally desired is to increase the asphalt content to make up for the portion being absorbed.

Mix discharged from drums by gravity is more sensitive than mix discharged from drums with a high lift where the material is required to make a 90 degree turn prior to discharge. With gravity discharge, coarse material often discharges on one side and fine material on the other. The segregated material drops directly onto a drag conveyor and continues to segregate right on through the batcher and bin as shown in **Figure 16**. The problem can be improved by restricting the discharge chute from the drum to a smaller opening, forcing the mix into the center of the drag conveyor. Adding deflector plates or straightening vanes is also an effective way to make sure the drag conveyor is properly loaded from a gravity type discharge see **Figure 17**.

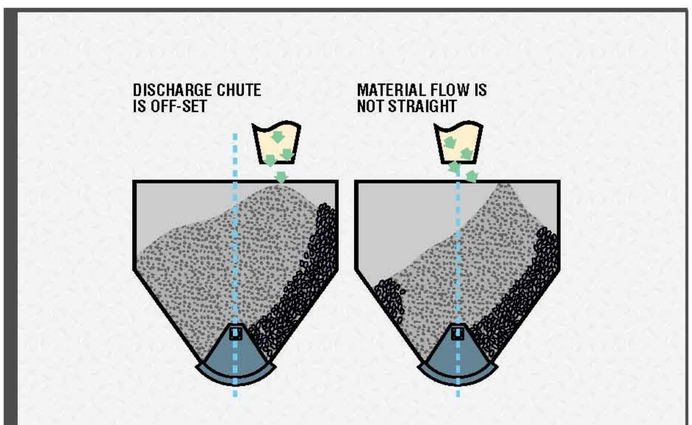
Another solution is to install a plow or single discharge point in the drum as shown in **Figure 18**, forcing all mix to come out at one point. However, experience shows it is difficult to design and install an effective plow on most drum mixers. When possible it is best to set the drag conveyor at a 90 degree angle to the drum discharge to create a right angle change in material flow. This setting reduces or eliminates drum discharge segregation.



HYDROPLANING IN A DRAG CONVEYOR F19



BIN LOADING BATCHER F20



CHUTES THAT CAUSE UNSATISFACTORY MATERIAL FLOW F21

SURGE AND STORAGE BINS

Drag Conveyors

Segregation will usually not occur in a drag conveyor unless it is "hydroplaning." Hydroplaning occurs as a result of a material buildup in the bottom of the drag conveyor. Cold conveyors that do not have floating hold-downs are prone to build-up on the bottom liners. The build-up creates a high friction drag surface that results in material spilling backwards over the drag flights as shown in **Figure 19**, even at very low production rates. This condition is easily observed. Material falls backwards down the drag conveyor instead of moving uniformly in one mass with full material from flight-to flight.

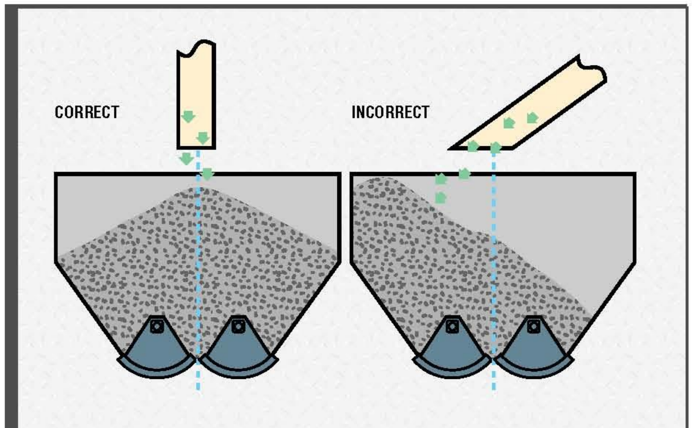
When the drag conveyor is hydroplaning, considerable segregation can occur, especially at the beginning and end of each run. Hydroplaning is more prevalent on batch plants where the segregation can be carried from batch to batch. Drag conveyors should be equipped with floating hold downs and heated bottoms for cold start-ups.

Segregation is minimized when the drag conveyor is as full as possible. When the slats are only partially filled, the larger aggregate is apt to roll to each side within the drag conveyor. So, it's better to run at higher production rates to keep the drag conveyor full. When producing a segregation prone mix at production rates higher than the rate used by paving operations, store the extra mix and shut down production earlier than usual.

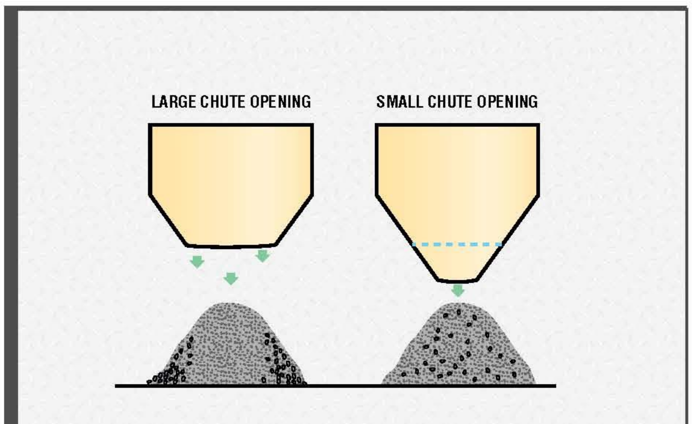
Storage Bins

The most sensitive area for segregation on a hot mix plant is in surge and storage bins. The large sizes of the bins contributes to segregation problems. Since the first surge and storage bins were developed many years ago, considerable improvement has been made on bin equipment to prevent segregation. Once of the most detailed and complete studies of hot mix surge and storage segregation was conducted by the University of Texas in the early 70's. From their investigation, various techniques were devised for eliminating segregation.

The result of the study revealed that the bin loading batcher was a good device for eliminating segregation in surge and storage bins, **Figure 20**. The study also addressed various gate openings and showed that if the bin was properly loaded with uniform mix, the gate configuration was not of significant importance. However, the batcher is not an absolute "cure all". It can create problems of its own and it's best to understand how and why.



BATCHER CHARGING **F22**



LESS SEGREGATION WITH SMALLER CHUTE OPENING **F23**

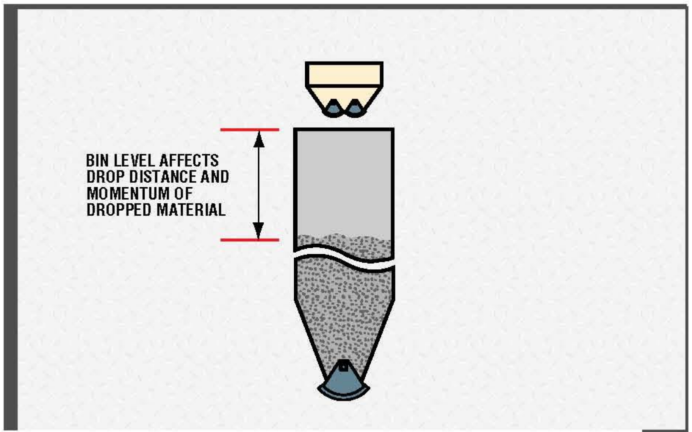
Bin Loading Batchers

Perhaps the most popular device for eliminating segregation on surge or storage bins is the bin-loading batcher. The following observations and practices should be followed when using a batcher:

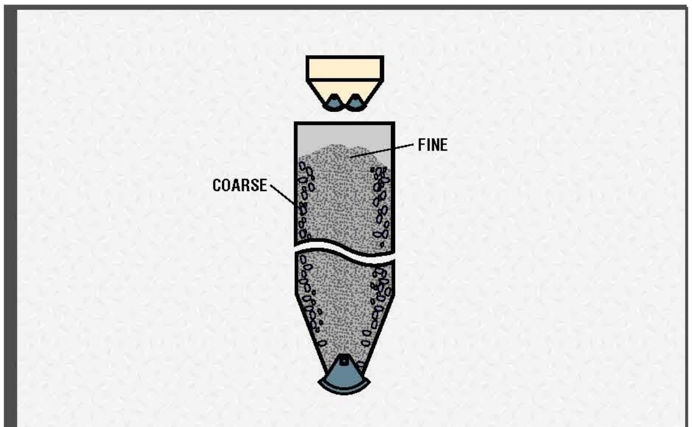
a. The batcher should be filled to its maximum capacity (at least 5,000 lbs.) And have a relatively large diameter gate opening to insure rapid discharge of material into the storage bin.

b. The batcher must be loaded directly in the center and the material from the chute loading the batcher should have no horizontal trajectory, **Figure 21** and **22**. Also, whenever mix is discharged through a chute, a small chute opening minimizes segregation, **Figure 23**. Remember, if the material segregates in the batcher, it will remain segregated throughout the bin.

c. The batcher should be filled completely before each drop. Normally, two high bin indicators are utilized. One dumps the gates and the other insures the gates will dump if the first indicator fails. When the batcher gates fail to open, mix backs up in the drag conveyor all the way into the drum. This possibility makes operators want to leave the gates open, totally defeating the batcher's purpose. If at all possible, timers should not be used on batchers except to control the gate open-time. The production rate of the plants will vary, and different amounts of time should not be used on batchers except to control the gate open-time. The production rate of plants will vary, and different times are required to fill the batcher. Remember, it is essential that the batcher be filled each time so that an adequate slug or a single mass drops into the bin.



BIN CHARGING BATCHER F24



BIN KEPT TOO FULL F25

1. Batch size should be at least 5,000 lbs. (more is better).
2. Batcher should be loaded in the center.
3. Material should flow straight down into the batcher. (no horizontal trajectory).
4. Batcher gate timers should be adjusted so that gates shut with 6-8 inches of material left in the batcher. Do not allow any free flow through the batcher.
5. Batcher should be maintained so that the mix drops out rapidly as a slug.

BATCHER RULES F26

d. The batcher should never be completely emptied. The gate-open-time should be adjusted so that a small amount of material (approximately 6 inches) remains in the batcher after the discharge cycle is completed. If the gate remains open too long, new material falls straight through the batcher and goes directly into the bin, resulting in random segregation.

e. When utilizing a bin-loading batcher, the emptier the bin, the farther the fall of the material and the more likely a level, uniform bin-loading will occur, **Figure 24**. The worst situation when operating a bin loading batcher is to have the bin material level consistently near the top, **Figure 25**. The mix drop then has insufficient momentum and results in peaks of material instead of splattering the material to form a level surface. The rules for correct batcher operation are summarized in **Figure 26**.

Loadout From Surge or Storage Bins

If the surge or storage bin is uniformly filled, loadout of hot mix asphalt from the bin is not of great concern. Pulling material below the cone is not as sensitive as with the old type center-loaded bins. This is due in part to improved bin loading with batchers and rotating chutes, but results primarily from utilizing a steep cone angle that produces a mass flow of material from the bin. With most non-gap-graded materials, the bin can be emptied without any appreciable segregation. However, with gap-graded material the bin level should still not be allowed to drop below the cone. Also, constantly running with the cone empty will accelerate cone wear.

Rapid discharge from the silo gate helps eliminate segregation in trucks. This reduces the chance of segregation in the truck bed by minimizing the rolling action of the mix as it is flowing into the truck bed.

In cold weather, bins should be insulated, at least on the cone. Could surfaces can cause the mix to stick the cone and under these conditions the material can plug flow instead of discharging in a uniform mass flow.

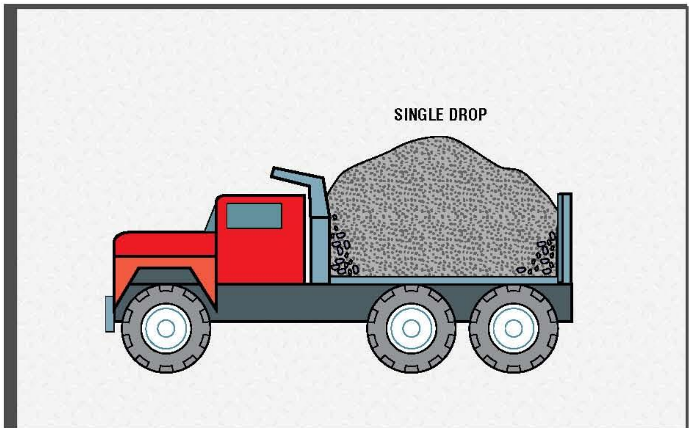
TRUCK LOADING AND UNLOADING

Due to rapid truck loading underneath surge or storage bins, truck drivers often tend to pull the truck under the bin and not move it while loading. If the mix is sensitive to segregation, larger stones will roll to the front of the truck, to the rear, and to the side, resulting in the coarse material being the first and last material to be discharged from the truck bed. The coarse material on each side will then be trapped in the wings of the paver to be discharged between truck loads. This discharging results in coarse areas of pavement between each truck load. This type of loading is shown in **Figure 27**.

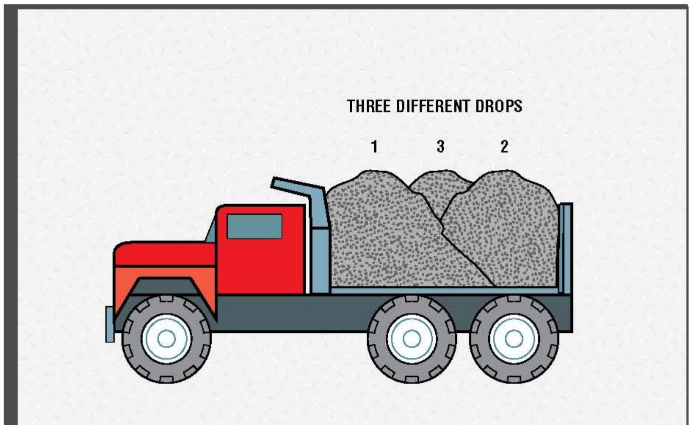
By loading the truck in at least three different drops, with the first drop being very near the front of the truck bed, the second drop extremely close to the tail gate, and the third drop in the center, segregation caused by incorrect truck loading is eliminated. This type of loading is shown in **Figure 28**.

Bins equipped with weight batchers as shown in **Figure 29** tend to batch material directly into the trucks in a manner similar to the bin loading batcher. The weigh batcher, if designed properly, greatly insures uniform loading of the truck and improves the chance of avoiding segregation with a sensitive mix.

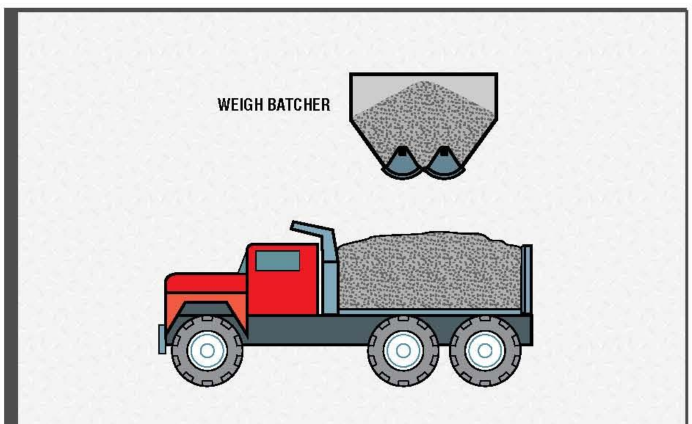
When unloading a truck into a paver hopper it is important to discharge the material as a mass instead of dribbling the material into a paver. To do this, the bottom of the truck bed needs to be in good condition and lubricated so that the entire load will slide rearward. To further assure that the material is discharged as a mass, elevate the truck bed to a large, but safe angle, **Figure 30**.



IMPROPER TRUCK LOADING F27



PROPER TRUCK LOADING F28



BIN WITH WEIGH BATCHER F29

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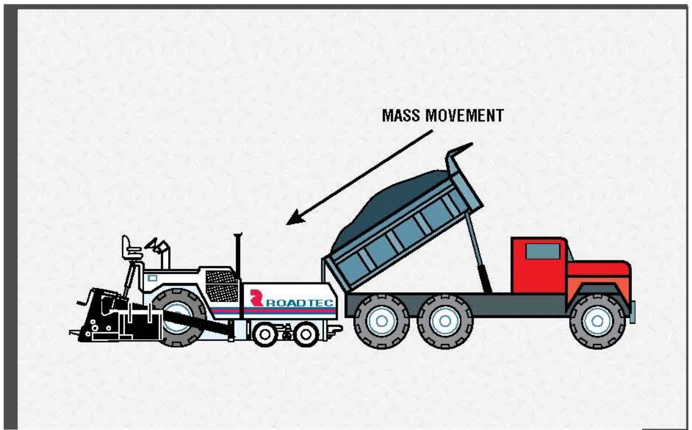
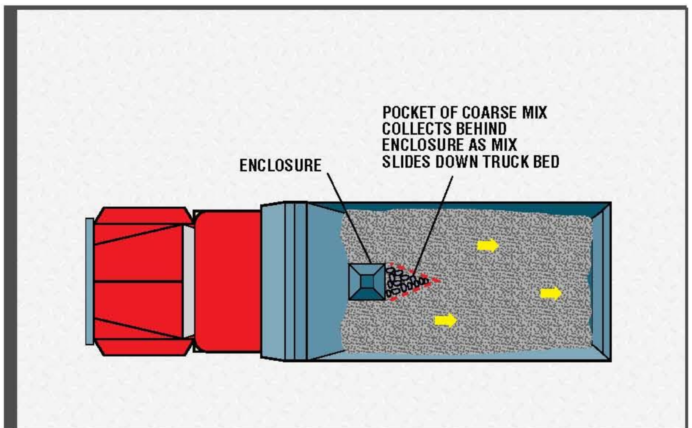


LARGER DUMPING ANGLE ASSURES MASS DISCHARGE F30



CYLINDER ENCLOSURE CAUSES "END OF LOAD" SEGREGATION F31

Rapid truck discharge floods the paver hopper and minimizes material-run-around that often occurs at the tail gate. Rapid discharge prevents an accumulation of coarse material at the outside portion of the paver wings.

With sensitive mixes it is often necessary to modify the forward portion of the truck bed to eliminate undesirable effects caused by the hydraulic cylinder enclosure. If the mix has a tendency to segregate, a pocket of coarse mix can occur as the mix slides away from the cylinder enclosure. As the load moves rearward, the mix caves in forcing large stones to accumulate in the center of the bed at the front of the truck. Then as the load moves into the paver, “end of the load” segregation occurs, **Figure 31.** Adding a plywood or light gauge metal cover across the entire front of the bed from side-to-side will mimimize this problem.

PAVER

Even though material has been successfully processed through the cold feed bin, through the plant, through the surge or storage bin, then uniformly loaded on the truck, segregation can still occur in the paver. Improper operation of a paver can cause segregation in varying degrees. Here are suggestions that should be considered when segregation occurs at the paver.

a. Do not completely empty the hopper between each truck load. Coarse material tends to roll to each side of the truck bed and thus roll directly into the wings of the hopper. By leaving material in the hopper the coarse material has a better chance of being mixed with finer material before being placed on the road.

b. Dump hopper wings only as required to level the material load in the hopper. Dumping eliminates the valleys in the material bed, thereby minimizing rolling that occurs when unloading. It allows the truck tailgate to swing open fully to flood the hopper with mix, **Figure 32**.

c. Dump the truck so as to flood the hopper. With the hopper as full as possible, material tends to be conveyed out from under the truck and minimizes the tendency to roll as it is dumped into the hopper.

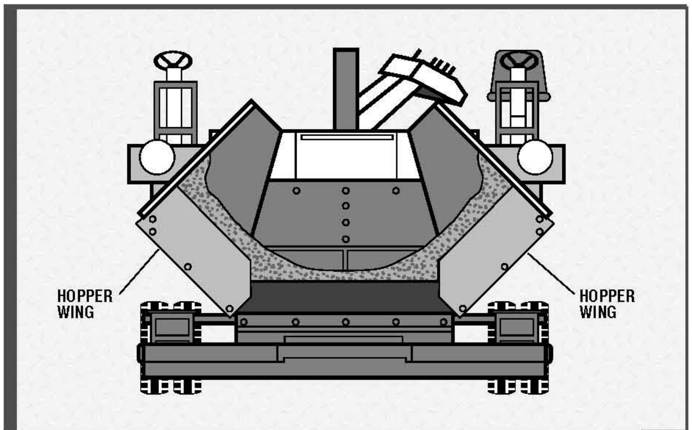
d. Open hopper gates as wide as possible to insure that the augers are full. By closing the gates and starving the augers for mix, fine material will drop directly on the ground causing coarse material to be augured to each side, **Figure 33**.

e. Run the paver as continuously as possible. Start and stop only as necessary. Adjust the paver speed to balance paver production with plant production.

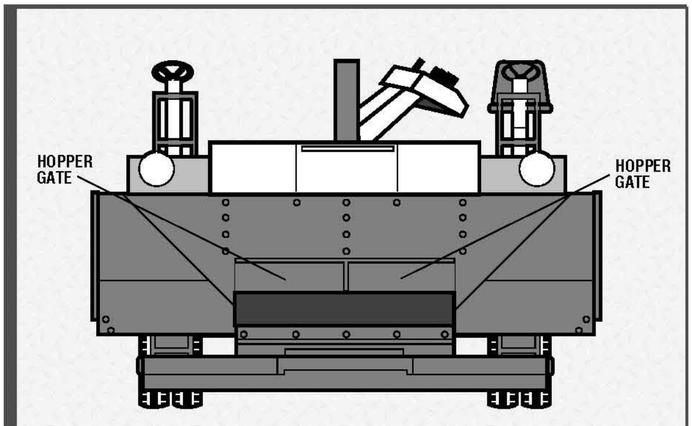
e. Run the paver as continuously as possible. Start and stop only as necessary. Adjust the paver speed to balance paver production with plant production.

f. Run augers continuously. Auger speed should be adjusted so that a continuous, slow flow of material occurs. Augers that run at high speeds are cycling on and off continuously and contribute significantly to segregation at the paver.

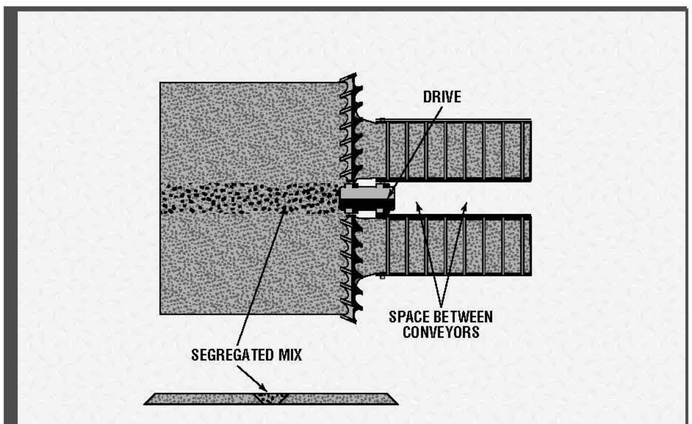
g. If augers are running too fast, the center of the mat will be deficient of material and this will generally result in a coarse strip, **Figure 34**.



PAVER HOPPER WINGS F32



PAVER HOPPER GATES F33



CONVENTIONAL PAVER DESIGN F34

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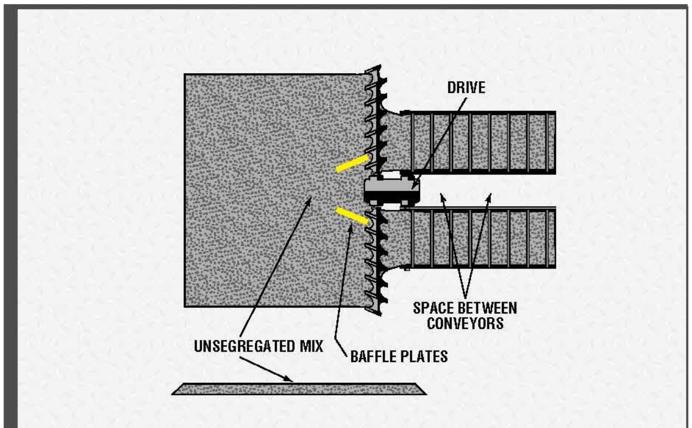
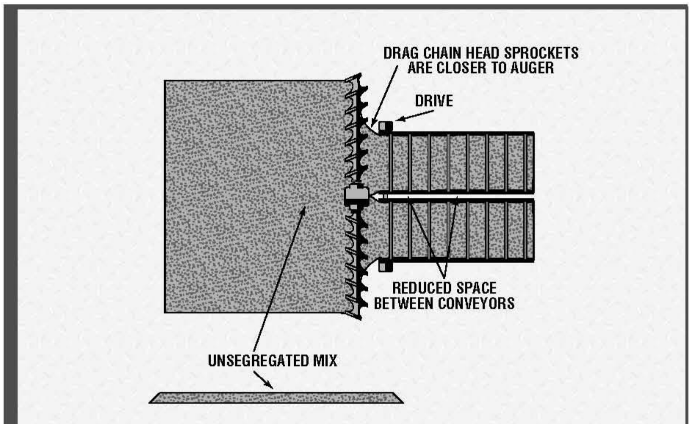


CONVENTIONAL PAVER DESIGN WITH BAFFLES F35



ROADTEC PAVER DESIGN F36

SHUTTLE BUGGY MATERIAL TRANSFER VEHICLE BY GRAVITY AUGER F37

Baffle plates, as shown in **Figure 35**, will also prevent coarse materials from rolling in front of the auger gear box and causing center line segregation.

With the installation of the baffles, the augers then divert material uniformly to the center. **Figure 34** shows a conventional design where space between conveyors causes center line segregation. **Figure 36** shows the Roadtec design with two important changes made on newer Roadtec pavers to minimize segregation and eliminate the need for baffles:

1. Flight chains now have less space between them at the center of the hopper.

2. Head sprockets of the flight chains are now closer to the auger.

Another Roadtec Paver design feature which further reduces segregation is a gravity fed auger. Instead of the paver auger being fed by drag chains pulling hot mix from the bottom of the paver hopper, the hot mix in the paver hopper mass flows directly into the paver auger by gravity and is metered by hydradraulically activated clam gates. Paver maintenance is also reduced due to elimination of the drag chains, **Figure 37**.

h. If the outer edges of the paver auger are deficient of material, coarse strips along the outsides can occur as the coarse aggregate rolls to the outsides.

i. If possible, adjust paver extensions so that the paver pulls the same amount of material from each side of the hopper. If one side is pulling more material, a valley will form in that side of the paver hopper, causing segregation to occur in sensitive mixes. If correction cannot be made by adjusting the extension, offset the truck slightly towards the side requiring more material to even out the material bed in the hopper.

16

j. Pavers without auger extensions can cause outside edge segregation. A segregation prone mix can segregate without auger extensions as the mix piles up at the end of the auger and the larger aggregate rolls off toward the outside edge of the road.

SHUTTLE BUGGY® MATERIAL TRANSFER VEHICLE

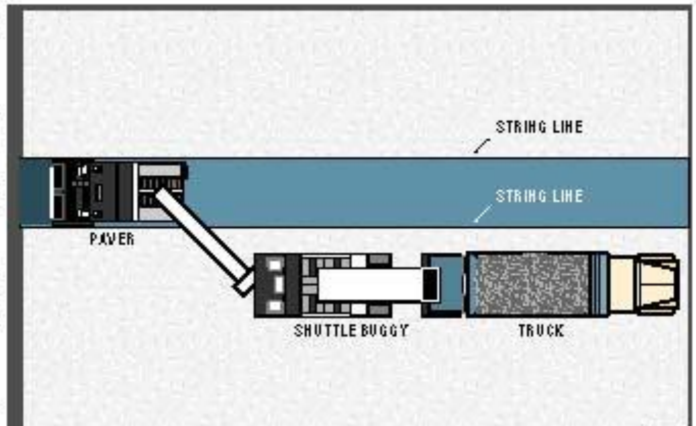
The difficulty of dumping mix from the truck into the paver while deepening the paver moving continuously should be apparent from our earlier discussion. **Figure 38** shows a Shuttle Buggy material transfer vehicle that allows the truck to stop at a suitable distance ahead of the paver, then dump its entire load without moving. The shuttle Buggy carries 30 to 35 tons of mix.

The drag conveyor on the front of the Shuttle Buggy is sufficiently wide to accept the full width of the mix load from the truck (uninterrupted) and convey it up and into the holding hopper of the Shuttle Buggy. Two variable pitch augers in the bottom of the holding hopper re-mix the material as it moves into the rear swivel discharge conveyor.

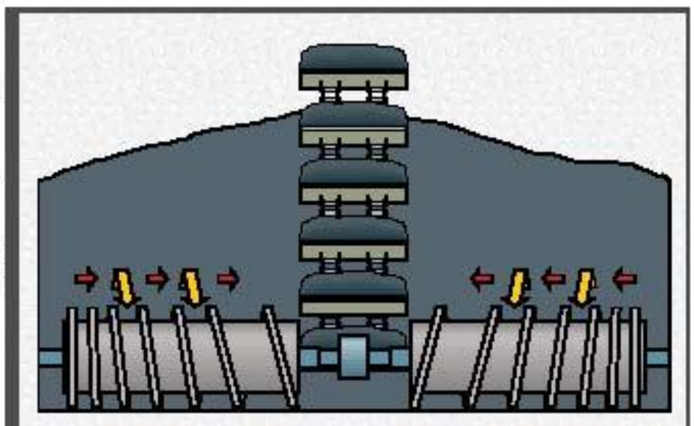
A holding hopper is installed on the paver, allowing storage of approximately 20 tons of material. The swivel conveyor from the Shuttle Buggy fills the hopper from the top. **Figure 39** shows loading from an adjacent line. This new concept allows continuous operation of the paver, re-blends the material and allows the use of large, long trailers.

Moreover, the holding hopper on the paver eliminates the accumulation of coarse material in the wings. Accumulation of coarse material and dumping of the wings is a major cause of end-of-the-load segregation.

SHUTTLE BUGGY MATERIAL TRANSFER VEHICLE F38



SHUTTLE BUGGY OPERATING IN ADJACENT LANE F39



SHUTTLE BUGGY MIXING AUGERS F40

17

These units have proven to completely eliminate end-of-load and random segregation due to three-blending of material by the mixing augers, **Figure 40**. The resulting pavement smoothness exceeds anything pre-viously accomplished on a consistent basis.

DIAGNOSTIC SYSTEM

The Segregation Diagnostic Chart accompanying this technical paper shows five different kinds of segregation. It provides a diagnostic system for analyzing the potential causes of segregation based on these types of segregation as they occur on the road. This, the most likely causes of segregation can be quickly identified in the chart. Then this paper can be consul ted for more detailed information regarding causes and remedies.

TESTING

Segregation and asphalt content go hand-in-hand. If mix uniformly produced and uniformly produced and uniformly coated and the material segregates after mixing, a sample of coarse material will reveal low asphalt content while a sample of fine material will show high asphalt content. NAPA Publication QIP109 shows methods of analyzing asphalt content and extraction problems. Refer to this publication if segregation is occurring in the sampling or in the splitting of the material prior to running extraction tests.

In summation, segregation in hot mix bituminous mixtures is a common and persistent problem. However, the problem can be controlled and even eliminated through proper mix design and through proper maintenance and operation of plants, trucks, and paving equipment. It is hoped this paper will assist in analyzing the problems and will be helpful in the selection of an effective cure.

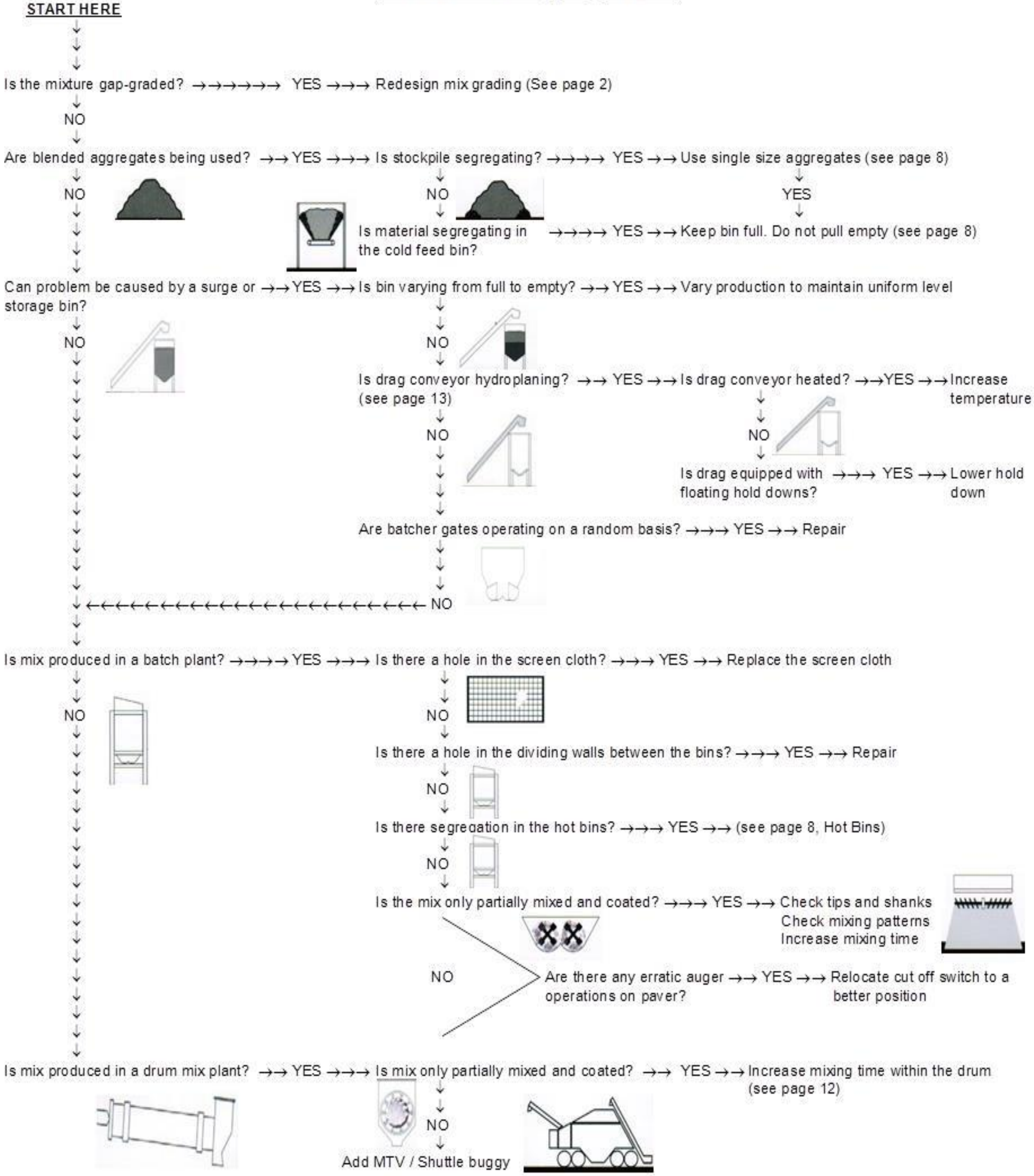
ASTEC a subsidiary of Astec Industries, Inc.
PO BOX 72787 • 4101 JEROME AVE. • CHATTANOOGA, TN 37407 U.S.A. • 423-867-4210 • FAX 423-867-4636 • www.astecinc.com

1M WMS 11/03 Printed in USA.

Astec Technical Paper T-117

Segregation: Causes and Cures
By: J. Don Brock, PhD. and Greg Renegar

Random Segregation



Each Side Segregation (periodic)

START HERE

Is the mixture gap-graded? →→→→→→ YES →→→ Redesign mix grading (See page 2)

↓ NO

Can problem be caused by a surge or storage bin? →→→ YES →→ Is mix coarse in front and rear of truck? →→→→→→ YES →→ Correct improper truck loading (see page 16)

↓ NO

Are gates on batcher operating improperly? →→→→ YES →→ Repair

↓ NO

Are gates staying open so that all material is discharged →→→→→→→→→ YES →→ Decrease batcher gate time so that some material stays in batcher

↓ NO

Is batcher filling only partially? →→→→→→→→→→→ YES →→ Adjust bin indicator or timer to fill batcher completely

↓ NO

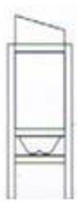
Is material dropping into the batcher at an angle? →→ YES →→ Add length to chute to divert material straight down

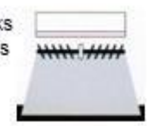
↓ NO

Is bin operating at near full? →→→→→→→→→→ YES →→ Operate bin at a lower level to allow batch to splatter (see page 14)

↓ NO (→ to "Is mix produced in a batch plant?")

Is mix produced in a batch plant? →→→ YES →→ Is mix only partially mixed and coated? →→→→→→→ YES →→ Check tips and shanks; Check mixing patterns; Increase mixing time



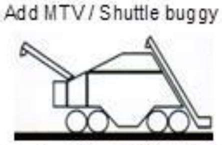


↓ NO

Are wings of paver being dumped between each load? →→→→→→→→→ YES →→ Relocate cutoff switch into a better position

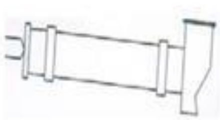
↓ NO

Add MTV / Shuttle buggy



↓ NO (from "Is mix produced in a batch plant?")

Is mix produced in a drum mix plant? →→ YES →→ Is mix only partially mixed and coated? →→→→→→ YES →→ Check tips and shanks; Check mixing patterns; Increase mixing time

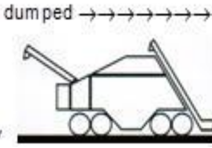


↓ NO

Are wings of paver being dumped between each load? →→→→→→→→→ YES →→ Relocate cutoff switch into a better position

↓ NO

Add MTV / Shuttle buggy



Centerline Segregation

START HERE
↓
↓
Is the mixture gap-graded? →→→→→→→ YES →→→ Redesign mix grading (See page 2)
↓
NO
↓
Can problem be caused by a surge →→→ YES →→ Is there a hole in the batcher? →→→→→→→→ YES →→ Repair
or storage bin? ↓
↓ ↓
NO NO
↓ →→→→→→→→→→→→→→←←←←←←←←←←←←← ↓

Is large material rolling in front of auger gear box as it is dumped from tunnel conveyor? →→→→→→→YES →→ Slow augers. Center is deficient of mix.
↓ ↓
↓ Or, add MTV / Shuttle buggy
↓
NO →→→ If none of the above locates the problem, see random segregation, or each side segregation (evenly spaced)
↓
Or, add MTV / Shuttle buggy

Each Side Segregation (continuous)

START HERE
↓
↓
Is the mixture gap-graded? →→→→→→→ YES →→→ Redesign mix grading (See page 2)
↓
NO
↓
Can problem be caused by a surge →→ YES →→ Is bin equipped with a batcher? →→ YES →→ Are batcher gates →→ YES →→ Repair
or storage bin? ↓ remaining open?
↓ ↓ ↓
NO NO NO
↓ →→→→→→→→→→→→→→→→→→→→→→→→ ↓ ←←←←←←←←←←←←←←←←←← ↓
↓
Are augers on paver running too slow? →→→→→→→ YES →→ Speed up augers. Readjust auger unit switches.
↓ Raise hopper gates. (see page 18)
NO
↓
If none of the above locates the problem, see random segregation or each side segregation

One Side Segregation

START HERE
↓
↓
Is the mixture gap-graded? →→→→→→→ YES →→→ Redesign mix grading (See page 2)
↓
NO
↓
Is mix produced in a drum mix plant? →→ YES →→ Is drum equipped with a gravity discharge? →→→→ YES →→ Install a fixed plow (see page 12)
↓ ↓
↓ ↓
NO NO
↓ ←←←←←←←←←←←←←←←←←←←←←←←← ↓
↓
↓
Is mix loaded from a surge or storage silo? →→→→→→→ YES →→→ Install a fixed plow (see page 12)
↓
NO
↓
If none of the above locates the problem, see random segregation, or each side segregation (evenly spaced)
↓
↓
Or, add MTV / Shuttle buggy

HMA MIXTURE EVALUATION

Defining a "Good" HMA Mix

A "Good" HMA mix is defined as an economical blend of aggregates and asphalt binder which produce the following results:

Asphalt Binder

The HMA mix has sufficient asphalt binder to thoroughly coat all the aggregate particles and ensure a durable pavement.

Stability

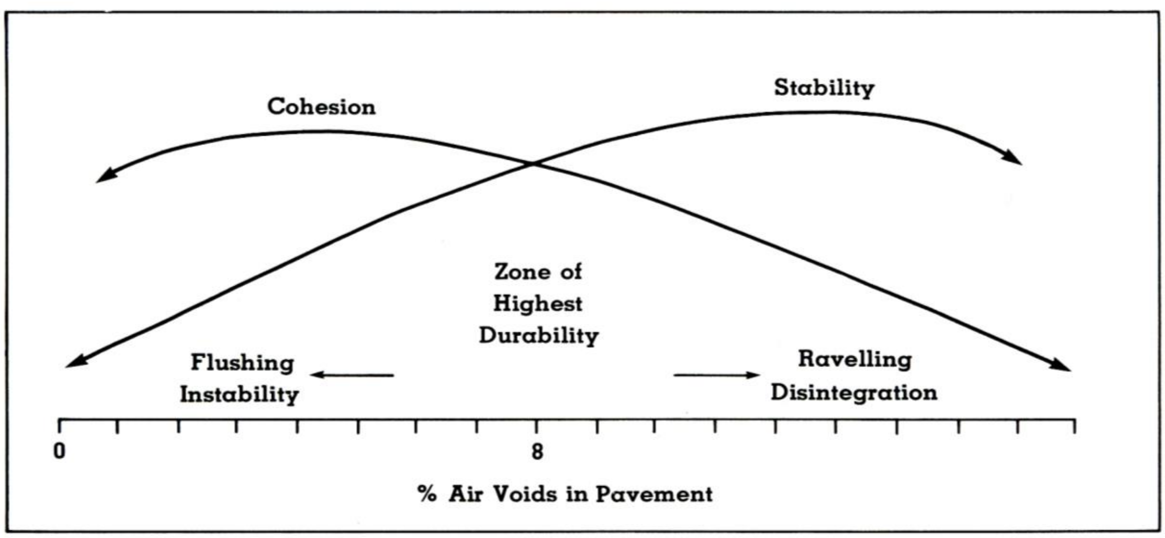
The HMA mix has sufficient stability to satisfy the demands of traffic without distortion or displacement (refers to rutting, shoving, etc.).

Voids

There has to be sufficient air voids in the compacted HMA mix to allow for a slight amount of additional compaction under traffic without flushing, bleeding or loss of stability, but low enough to keep out harmful effects like air and moisture, which cause premature aging and stripping.

a. Below 3% causes rutting. There is no place for the asphalt binder and aggregate to move except outward.

b. Above 7% - 8% the HMA mix is permeable. Water easily runs through the compacted HMA causing oxidation, cracking and raveling of the mixture.



Workability

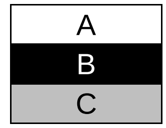
The HMA mix needs sufficient workability to permit efficient placement of the HMA mix without segregation or other placement problems.

Level I Asphalt Calculation Review

Terms from Level I:

A. Gmb ("d") Bulk Specific Gravity of the mixture — Volume = 0.3 m³ (1 ft.³)

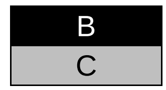
Gmb ("d") Involves A, B, & C



Where: A = Volume of Air
B = Volume of Asphalt Binder
C = Volume of Aggregate

B. Gmm ("D") Maximum Theoretical Gravity — Volume = 0.3m³ (1 ft.³)

Gmm ("D") Involves only B & C



Where: B = Volume of Asphalt Binder
C = Volume of Aggregate

The volume of air (A) is removed

Conversion factors: **EXAMPLE**:

Metric - Convert G_{mm} (“D”) or G_{mb} (“d”) to a metric unit weight (kg/m³) by multiplying by 1000.0 — 2.541 x 1000 = 2541 kg/m^3

English - Convert G_{mm} (“D”) or G_{mb} (“d”) to an English unit weight (lbs./ft³) by multiplying by 62.4 — 2.541 x 62.4 = 158.6 lb/ft^3

Review of Calculations: **EXAMPLE**:

% Density = (G_{mb}/G_{mm}) x 100 or (“d” / ”D”) x 100 — (2.434 ÷ 2.572) x 100 = 94.6%

A. % Density is the measurement of compactive effort by:

1) Lab – Using gyratory samples at N_{des} (30 – 90 gyrations which correlates to expected traffic levels for 20 years)
2) Field - Developed by a rolling pattern measured by:
   (a) Cores
   (b) Adjusted nuclear density gauge

EXAMPLE:

% Voids = (1 – (G_{mb}/G_{mm})) x 100 — (1 – (2.434 ÷ 2.572)) x 100 = 5.4%
or (1 – (“d”/”D”)) x 100

or

(100% - % Density) — 100.0% – 94.6% = 5.4%

B. Voids is the measurement of the volume of air in:

1) Compacted briquette (In lab by gyratory method)
2) Cores (In-Place mat density)

NOTE: "% Density" will refer to the In-Place Roadway Density; “% Voids" will refer to lab voids.

Standardized Nomenclature for Asphalt Mixture Parameters

Illinois Department of Transportation has adopted standardized nomenclature for asphalt mixture related parameters in reference to the terms used to describe different Superpave mixture attributes. The following terms will assist the technician when referring to documents that have been revised to reflect this new format:

G = Bulk specific gravity of an aggregate

G_b = Specific gravity of asphalt binder

G_{sb} = Bulk specific gravity of combined aggregates

G_{se} = Effective specific gravity of an aggregate

G_{sa} = Apparent specific gravity of combined aggregate

G_{mb} = ("d") Bulk specific gravity of compacted mixture

G_{mm} = ("D") Maximum theoretical specific gravity of mixture

P = Percentage by weight of aggregates

P_b = Asphalt, percent by total weight of mixture

P_s = Aggregate, percent by total weight of mixture

P_{mm} = Loose mix, percent by total weight of mixture (=100%)

P_{be} = Effective asphalt binder, percent by total weight of mix

P_a = Air voids in compacted mix, percent of total volume

P_{ba} = Absorbed asphalt binder, percent by total weight of aggregates

NOTE: The first letter denotes the following:

G = gravity P = percent

The first letter of the subscript denotes the following:

m = mix s = stone (aggregate) b = binder (asphalt) a = air voids

The second letter of the subscript denotes the following:

b = bulk m = maximum a = apparent e = effective

The following is common terms, conversions and sieve designations:

Common English and Metric Terms

Type	English	Metric (SI)
Length	Inches, feet yards	millimeters, meter, kilometer
Area	$Inches^2$, $feet^2$, $yards^2$	$millimeters^2$, $meter^2$, $kilometer^2$
Volume	Ounces, quarts, gallons	Liters, $meters^3$
Mass	Ounces, pounds, tons	Grams, kilograms, metric tons
Energy	Foot pounds	Joules (J)
Force	pounds, kips	Newtons (N), kilo Newtons (kN)
Pressure, stress	pounds per $inch^2$, $\#/ft^2$	Pascal (Pa), kilo Pascal (kPa)
Speed, velocity	Feet/second, miles/hour	meter/second, kilometers/hour
Acceleration	$(Feet/second)^2$, $(miles/hour)^2$	$(meter/second)^2$, $(kilometers/hour)^2$
Density	Pounds per ft^3	$kg/meter^3$
Temperature	Fahrenheit	Celsius

English Sieve Designations with Metric Equivalent

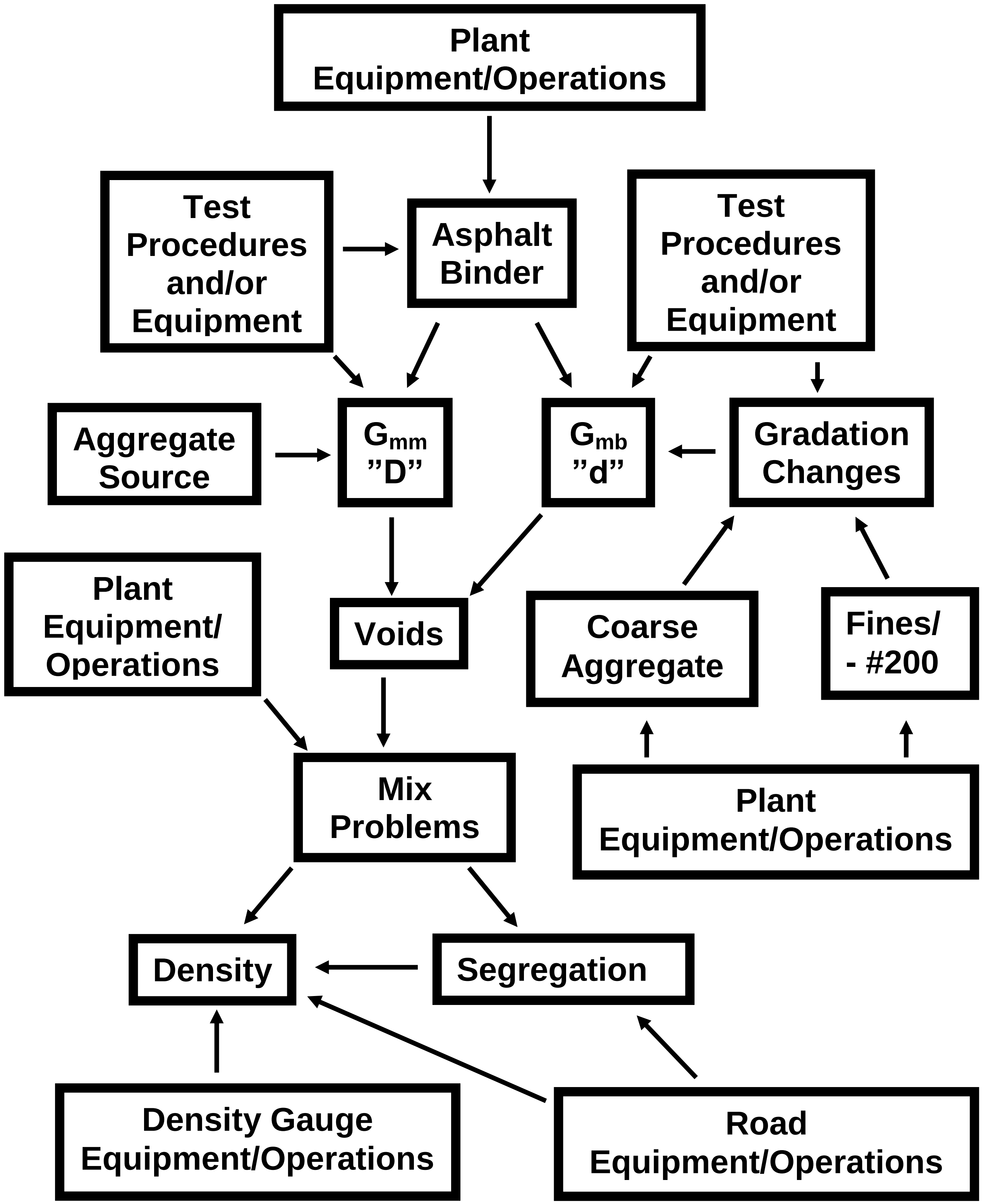
English	**Metric**	**English**	**Metric**
2 in.	50 mm	**No. 8**	**2.36 mm**
1 3/4 in.	45 mm	No. 10	2.00 mm
1 1/2 in.	**37.5 mm**	No. 12	1.70 mm
1 1/4 in.	31.5 mm	No. 14	1.40 mm
1.06 in.	26.5 mm	**No. 16**	**1.18 mm**
1 in.	**25.0 mm**	No. 18	1.00 mm
7/8 in.	22.4 mm	No. 20	850 µm
3/4 in.	**19.0 mm**	No. 25	710 µm
5/8 in.	**16.0 mm**	**No. 30**	**600 µm**
0.530 in.	13.2 mm	No. 35	500 µm
1/2 in.	**12.5 mm**	No. 40	425 µm
7/16 in.	11.2 mm	No. 45	355 µm
3/8 in.	**9.5 mm**	**No. 50**	**300 µm**
5/16 in.	8.0 mm	No. 60	250 µm
0.265 in.	6.7 mm	No. 70	212 µm
1/4 in.	**6.3 mm**	No. 80	180 µm
No. 3 1/2	5.6 mm	**No. 100**	**150 µm**
No. 4	**4.75 mm**	No. 120	125 µm
No. 5	4.00 mm	No. 140	106 µm
No. 6	3.35 mm	No. 170	90 µm
No. 7	2.80 mm	**No. 200**	**75 µm**

NOTE: Sieve designations in **underlined bold type** are commonly used for testing of HMA mixtures.

Common English to Metric Conversions

Type	From English	To Metric	Multiply by
Lengths	Inch	millimeter (mm)	25.4
	Feet	millimeter (mm)	304.8
	Feet	meter (m)	0.3048
	Yard	meter (m)	0.9144
	Mile	kilometer km	1.609344
	Mile	meter (m)	1609.344
	Inches/mile	mm/km	15.7828
Areas	$Inch^2$	mm^2	645.16
	$Feet^2$	m^2	0.092903
	$Yard^2$	m^2	0.836127
	Acre	m^2	4046.856
	Acre	hector acre (ha)	0.404685
	$Mile^2$	km^2	2.59
Volume	$Inch^3$	mm^3	16387.06
	$Feet^3$	m^3	0.028316
	$Yard^3$	m^3	0.764555
	Gallon	Liter (L)	3.78541
	Gallon/Yard	L/m	4.1398
	$Gallon/Yard^2$	L/m^2	4.5273
	$Gallon/Yard^3$	L/m^3	4.9511
	Gallon/Acre	L/ha	9.354
	Gallon/Ton	L/metric ton	4.1726
Mass	Ounces	gram (g)	28.349523
	Pound	kilogram (kg)	0.453592
	kip (1000 lbs.)	metric ton	0.453592
	Ton	metric ton	0.9072
Force	Pound	Newton (N)	4.44822
	kip	kilo Newton (kN)	4.44822
Force/Unit Length	Pound/Foot	N/m	14.5939
	Pound/Inch	N/mm	0.1751
Pressure, Stress	$Pound/Feet^2$	Pascals (Pa)	47.8803
	$kips/Feet^2$	kPa	47.8803
	$Pound/Inch^2$	kPa	6.89476
	$Pound/Inch^2$	Mega Pascals (MPa)	
	$kips/Inch^2$	MPa	
Energy	Foot Pound	Joules (J)	1.35582
Mass/Length	$Ounces/Yard^2$	kg/m^2	0.0339057
	$Pounds/Feet^2$	kg/m^2	4.8824
	$Pounds/Yard^2$	kg/m^2	0.5425
	$Pounds/Feet^3$	kg/m^3	16.01894
	$Pounds/Yard^3$	kg/m^3	0.5933
	Pounds/Acre	kg/ha	1.1208
	Ton/Acre	metric ton/ha	2.2417
Temperature	Fahrenheit (F)	Celsius (C)	(F- 32)/1.8 = C

Troubleshooting Flow Chart



Proportionality Rules

General

α **Proportional** - Each variable reacts in the same direction. One increases the other increases, etc.

$1/\alpha$ **Inversely Proportional** - Each variable reacts in the opposite direction. One increases the other decreases, etc.

Proportionality Rules of H.M.A.

a)	Voids	$1/\alpha$	Density
b)	Voids	α	G_{mm} ("D")
c)	Voids	$1/\alpha$	G_{mb} ("d")
d)	Voids	$1/\alpha$	Asphalt Binder Content
e)	Voids	$1/\alpha$	Minus #200 material
f)	Voids	α	Coarseness of mix (except sand mix)
g)	Voids	$1/\alpha$	Temperature
h)	Voids	α	Manufactured sand / Natural sand blend

Additional Rules

a) 1% change in minus #200 material generally creates about 1% change in voids.

b) Too much or not enough minus #200 material can create a tender mix.

c) A sandy mix [very fine on the # 4 or # 8 sieves] can create a tender mix.

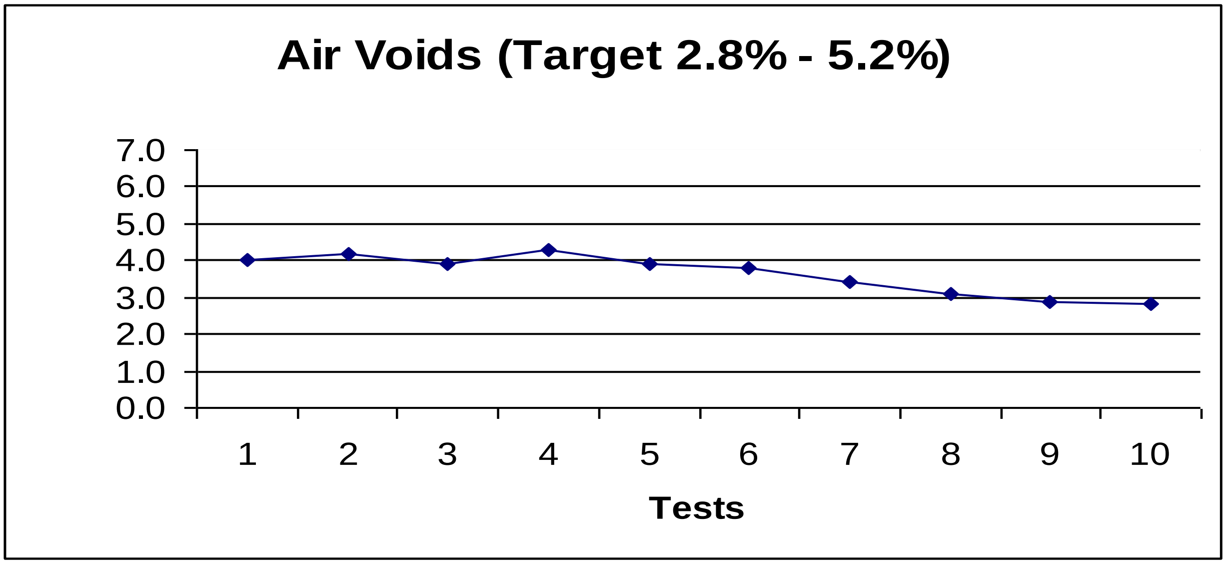
d) The manufactured sand / natural sand blend controls the #30 sieve. If the #30 material is too high this can create a tender mix.

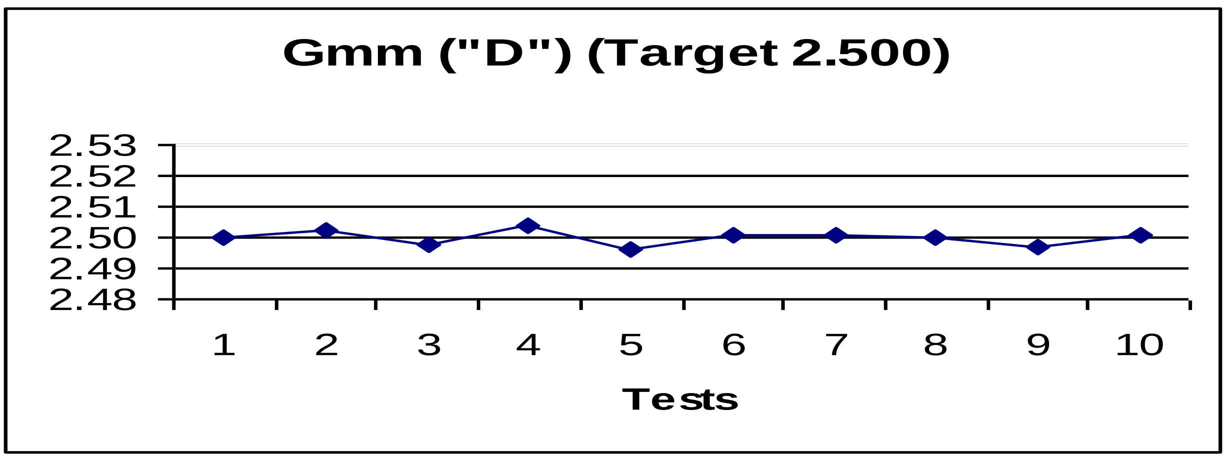
e) Segregation of a sample (coarse or fine) can correlate to the asphalt binder content, air voids or density being low or high for an individual sample.

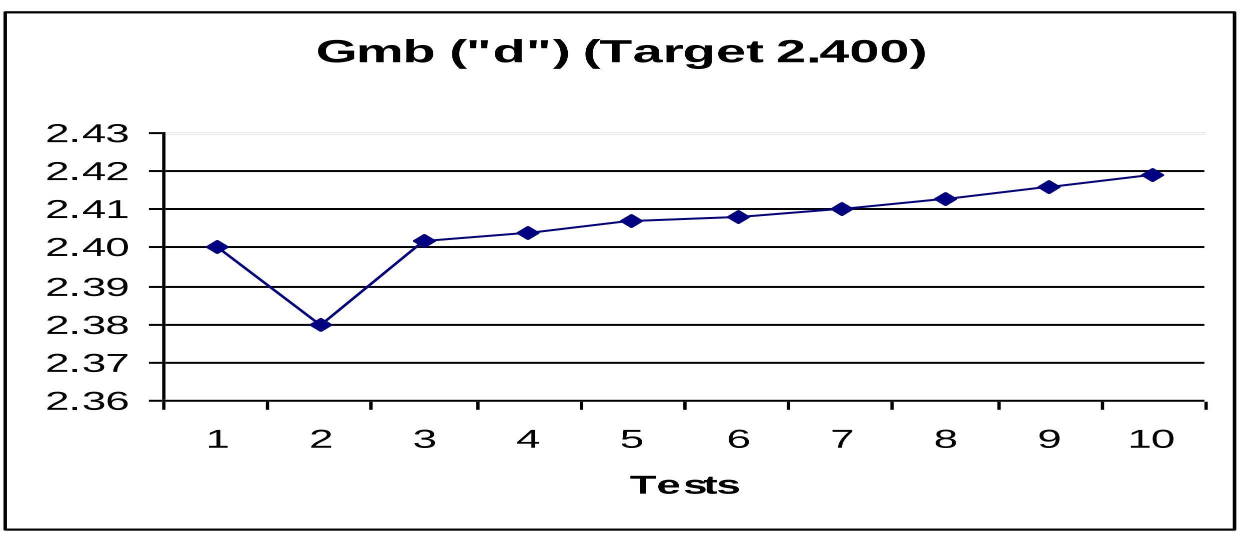
f) HMA mixture compaction temperature for the breakdown and pneumatic (rubber tired) rollers should be 285°F ± 15° F. The mat temperature for a finish roller should be about 120° F or cool enough to place your hand on the mat and leave it.

Problem #1Control Charts

Is there a problem according to these control charts?







MOVING AVERAGE TREND PROBLEMS

Problem 1

A) Is there a problem according to the 3 charts shown? (Page 6-8)

B) Are we required to take corrective action?

C) What or where is the Problem?

D) What influences G_{mb} ("d")?

Problem 1 Investigation

Define the problem:

a) Test Procedure/Equipment?

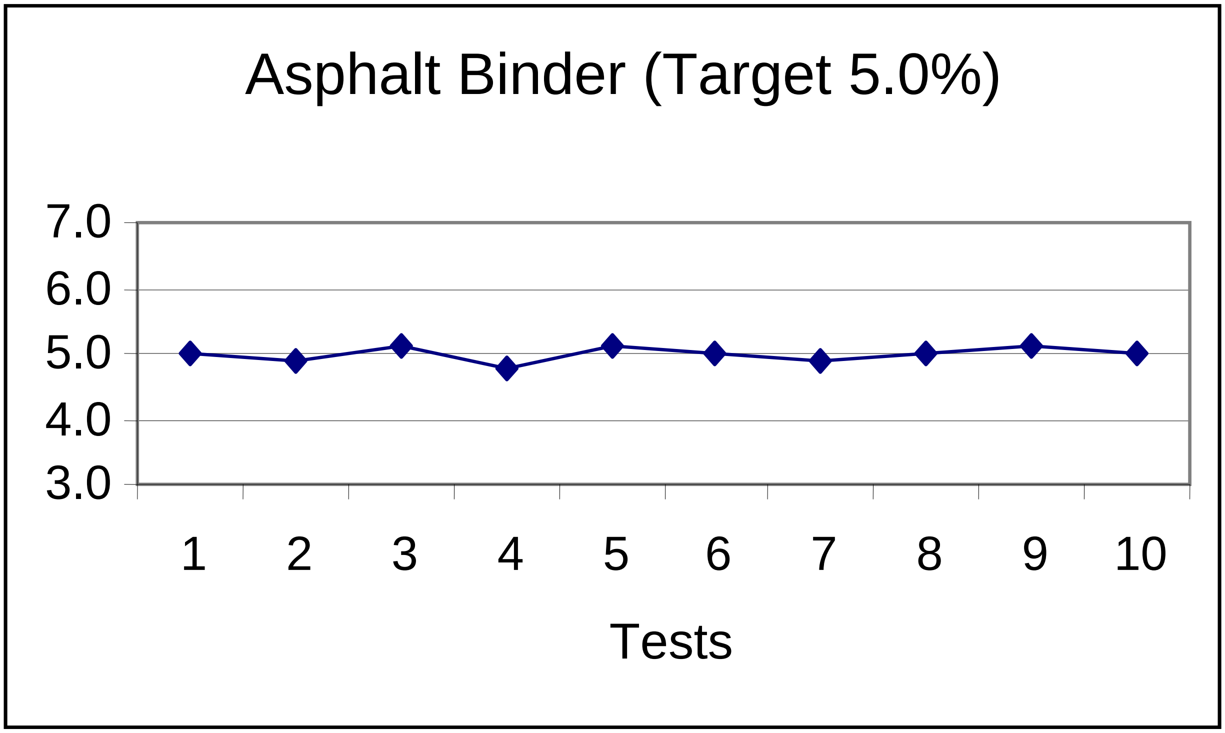
b) Asphalt Binder Content?

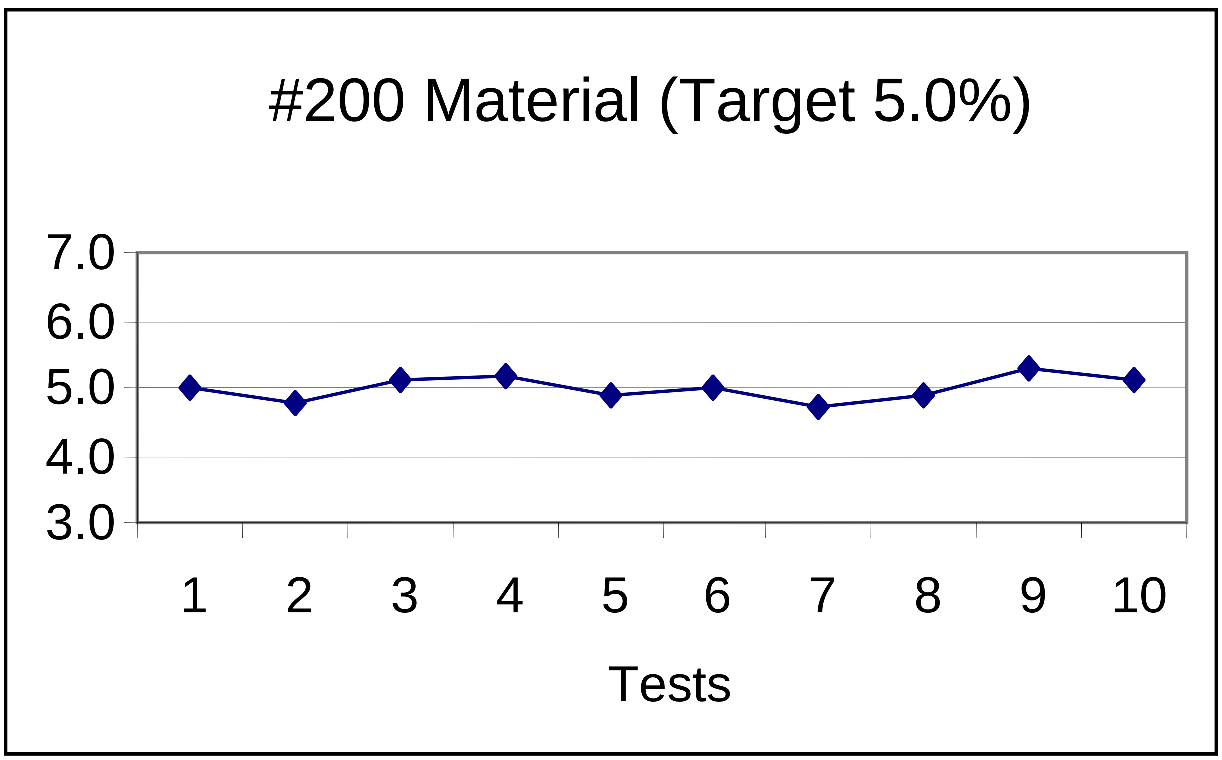
c) Minus #200 Content?

d) Aggregate Gradation? (coarse or fine)

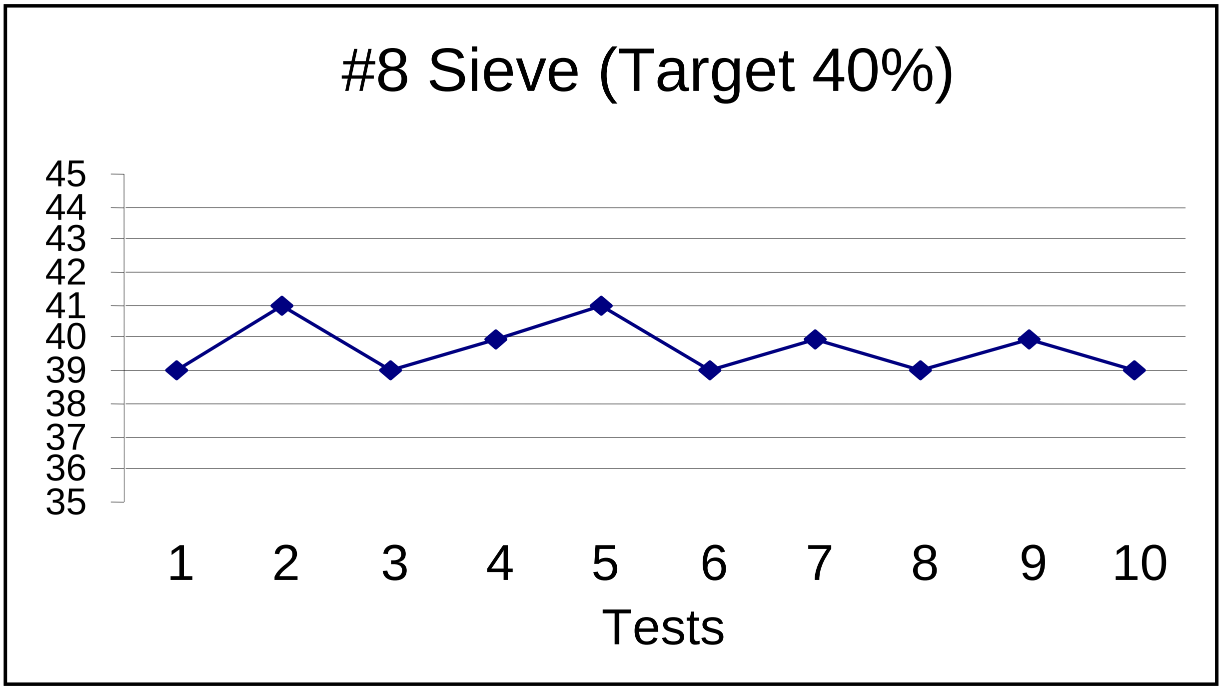
Based on what information given, is there enough information to make a decision?

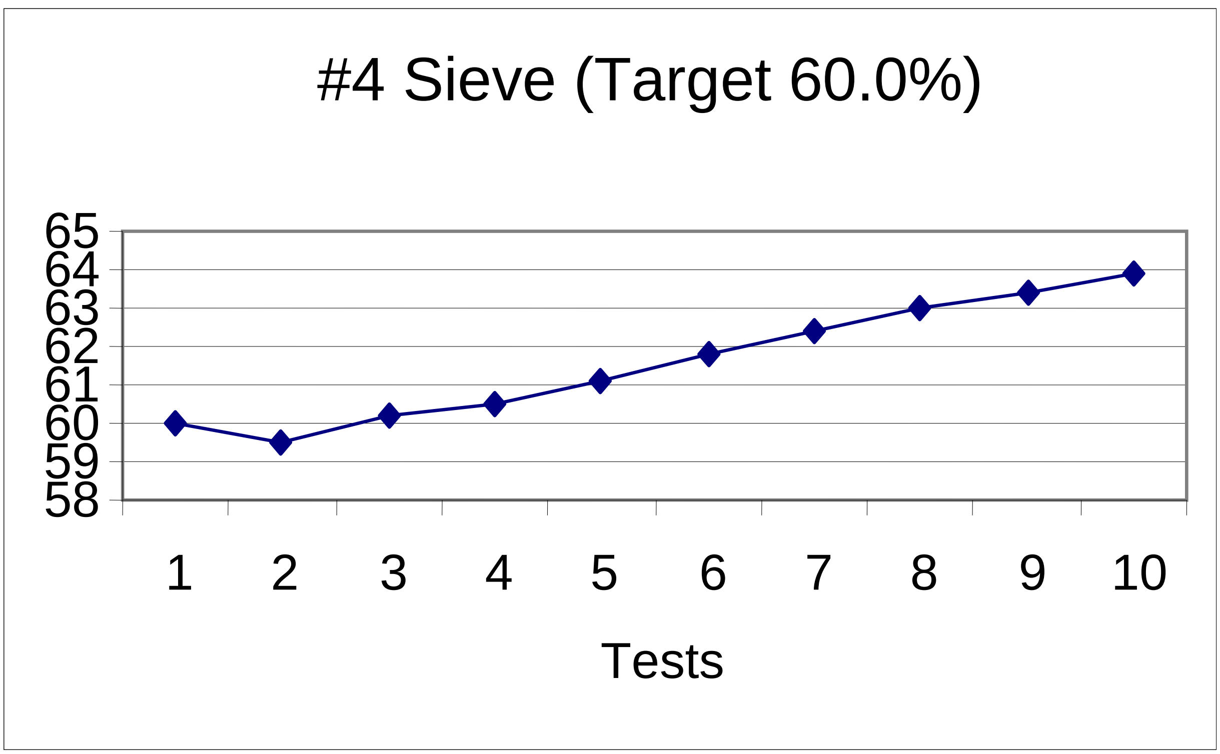
Problem #1 Control Charts





Problem #1 Control Charts





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Problem 1- Solution

Eleven different control charts need to be created based on the test results to the mixture.

By analyzing all of the test results, certain mixture controls can be eliminated, such as the asphalt binder and #200 dust content, in this case.

Since the evidence points to a mixture problem, and because there are a number of different test procedures and testing equipment being used, this will help to rule out individual test procedures and/or equipment. Test procedures normally can only be responsible for an immediate cause of a problem and will not carry to different areas (stockpiles, road, etc.) or influence other mixture aspects. Incorrect calculations could indicate problems throughout production but the influence would only be seen in the results not the actual mixture performance.

Examples:

a) A hole in a sieve will only affect the test results for that gradation and will/can have no effect on the air voids, asphalt binder content, density, etc. of the actual mixture. Only if there is an actual material problem can it effect other mixture attributes (too much actual #200 material in the mixture will affect the air voids, asphalt binder content, density, etc.).

b) If the G_{mb} or G_{mm} test was performed incorrectly or the test equipment was used incorrectly or malfunctioned during the test, the results would show the air voids to be affected but the actual mixture would/could still be good. The density test on the road would/could corroborate that the air voids were actually good (as long as that test was performed correctly).

   In other words, if two or more different test results show problems with the mixture, this should indicate something **is wrong with the mixture**, not the testing equipment or test procedures.

   In order for the test procedures and/or test equipment to be faulty for numerous mixture aspects, **at the same time**, everything would have to match up and happen at the same exact time; gradation (plant), air voids (plant) and density (road).

So proper investigation should include analyzing all of the control charts and information for the mixture, which in this case, will show that the #4 material is at fault and needs to be checked out further.

Where does the #4 material come from?

The # 4 size of material generally comes from the CM16 aggregate materials.

This is where we should start our investigation.

Prior to a proportioning change we should check a number of items to determine the cause of the problem.

a) Drier Drum Plant - Is the cold feed belt for the CM16 aggregates slipping, blocked, or plugged? Is the material being fed correctly as determined by a weigh belt sample or cold feed calibration? Is the sand being introduced at the proper feed rate? Properly proportioned material at the cold feeds is necessary to meet the mixture gradation.

b) Batch or Continuous Plant - Is carry-over being experienced in Bins #1 and/or #2. This can be due to a blinded sand screen or feeding the plant at too high of a production rate? Does the plant need to be slowed down or the screens cleaned or replaced? Is material leaking between bins (plugged waste chute, hole in the bin partition walls, etc.)? Are the proper individual aggregate weights being met during the batching process?

c) Has the stockpile gradations changed (weekly stockpile or incoming gradation samples)? Has the loader operator gotten into a fine area of the stockpiles (ramp areas, scrapping into the base material, etc.)? Is the loader operator feeding the right products into the plant or ‘cleaning up’ around the stockpile areas?

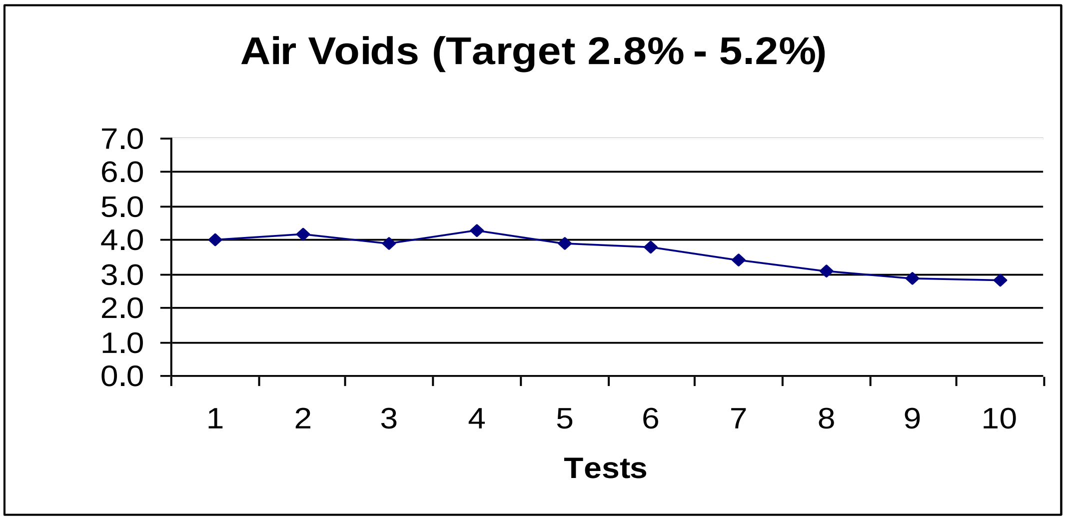
d) Are the plant scales in proper adjustment and working correctly?

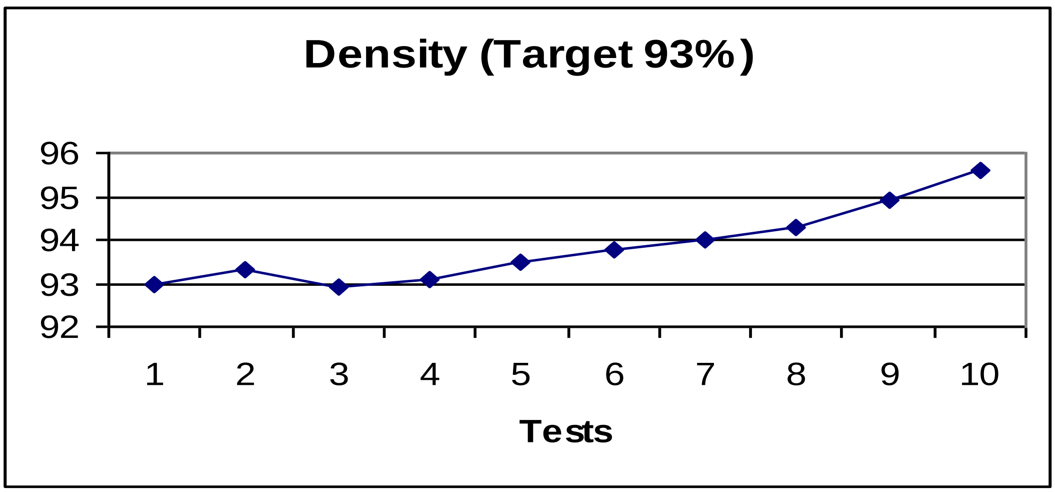
e) Are the cold feed gates set at the proper openings? Are the cold feeds motors set at the correct settings (based on the cold feed calibrations)? Are the cold feed calibrations still usable or has something changed (motor replacement, cold feed repair, etc.)? Do the cold feeds have the proper dividers preventing contamination?

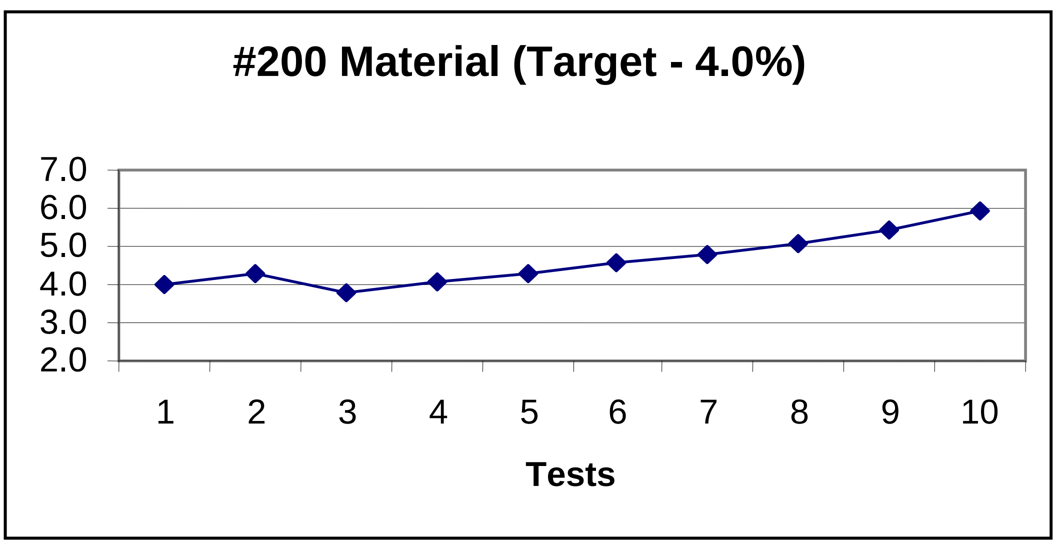
f) Are the plants settings for the mixture being produced correct and for the right mixture?

Problem #2 Control Charts

Is there a problem according to these control charts?







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Problem #2

A. Is there a problem according to the 3 charts shown? (Page 6-15)

B. Are we required to take corrective action?

C. What or where is the problem?

D. What influences minus # 200 material?

1) Test procedure/equipment/calculation?

2) Poor sampling technique?

3) Minus # 200 material change in any of the stockpiles?

4) Dust slide occurred in the #1 hot bin?

5) Cold feeders for the sands have changed?

a) Gate opening has been changed?

b) Belt speed/tachometer working improperly?

6) Mineral filler system not working properly?

7) Bag house (secondary collector system) not working properly?

Problem 2 – Solution

Where does the dust come from that is going into the mixture? There are normally three sources for dust at a HMA plant:

1) Mixture ingredients

2) Plant generated

3) Purchased material

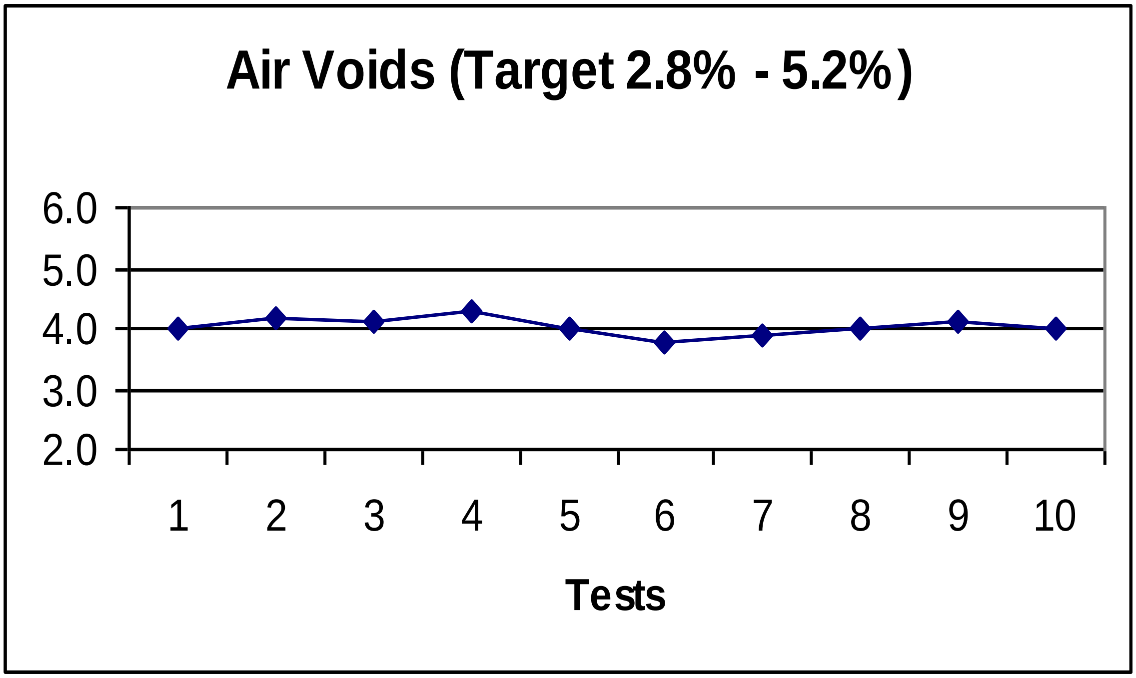
Checks should be done on the incoming material, existing stockpiles, cold feeds, mineral filler system, baghouse, as well as, the speed and efficiency of the plant.

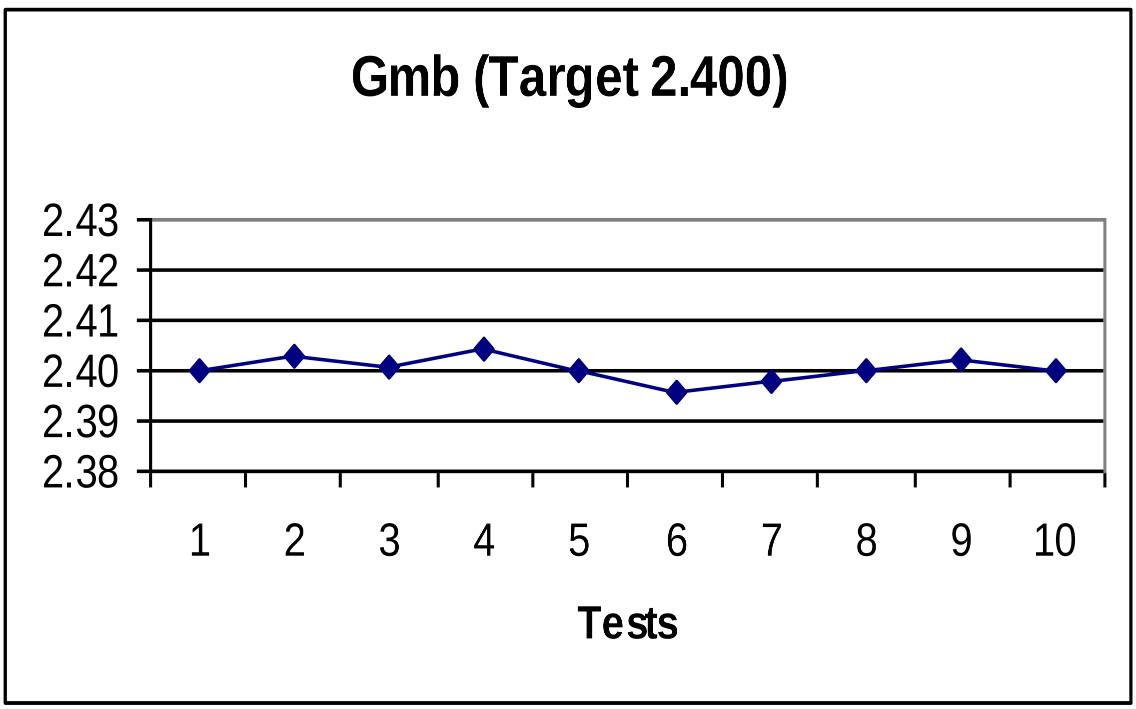
This particular mixture issue is probably not related to sampling and/or test procedures since the effects are showing up in the plant mixture test results and in the density tests from the road.

NOTE: Solutions based on the percentage of minus #200 material is to be determined by washed ignition burn gradation samples or washed hot bin gradation samples and/or combined belt gradation samples. Stockpile samples can be used to determine minus 200 material but isn't effective for plant control.

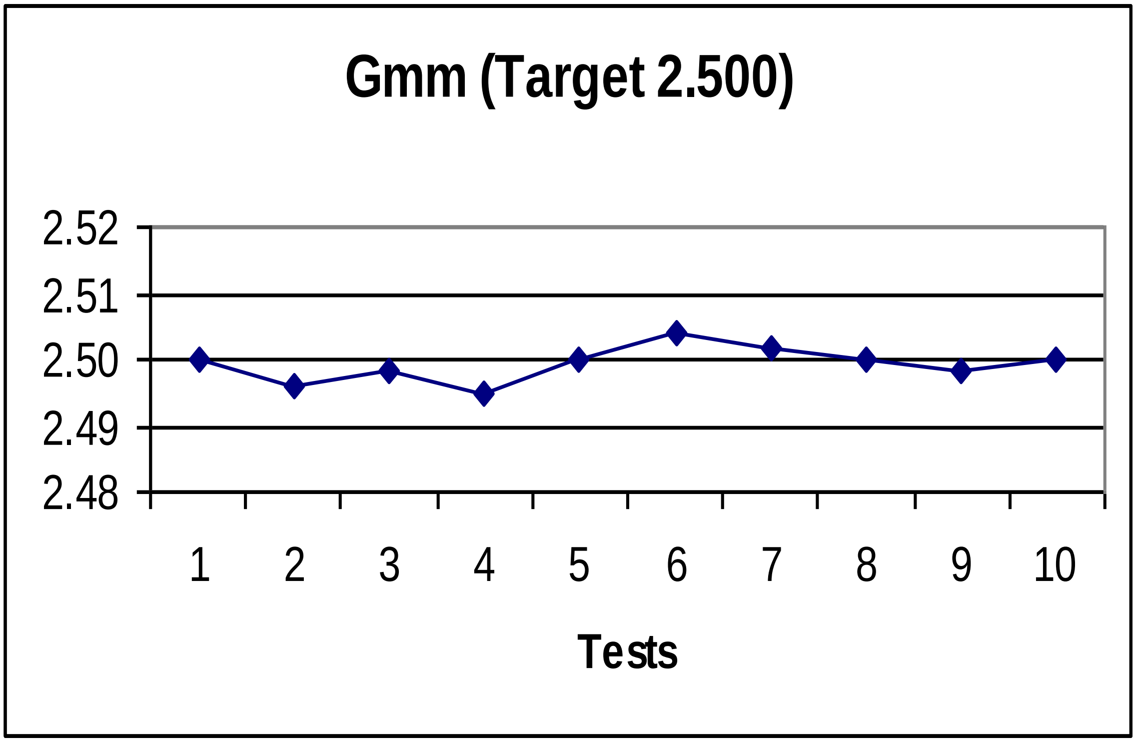
Problem #3 Control Charts

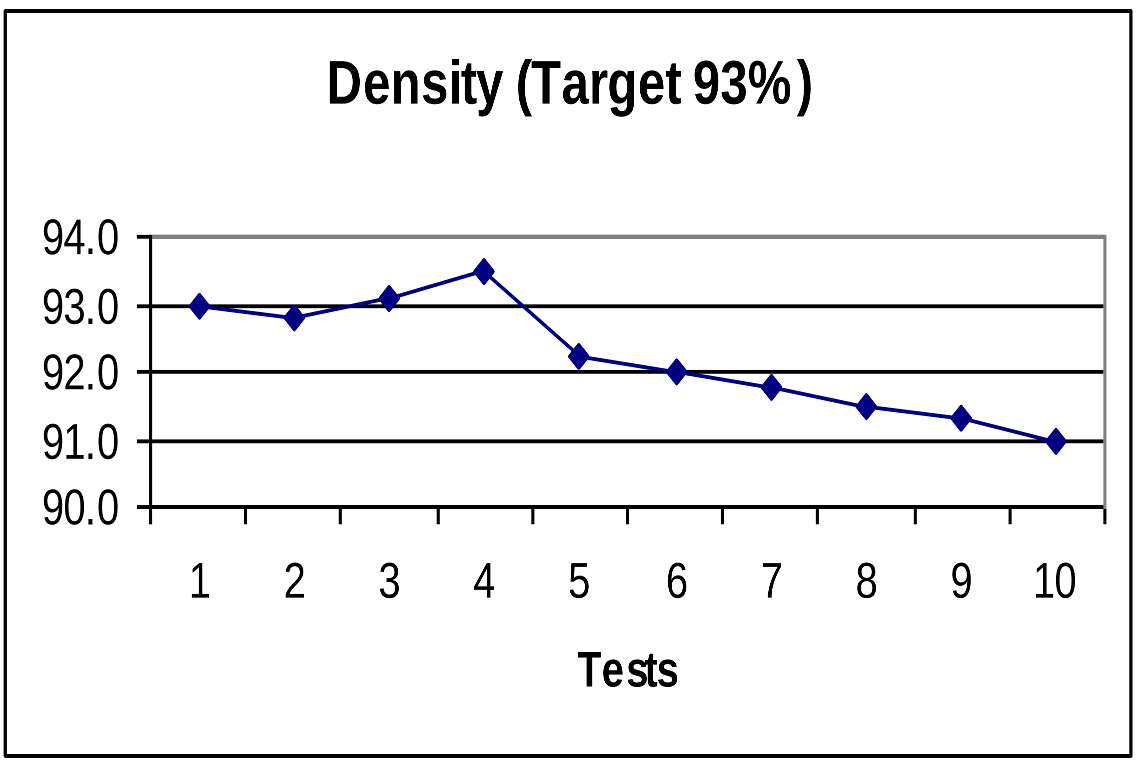
Is there a problem according to these 4 control charts?





Problem #3 Control Charts





Problem #3

A. Is there a problem with the 4 charts shown on pages 6-18 & 6-19?

B. Are we required to take corrective action?

C. What or where is the problem?

1) Road
2) Plant
3) HMA Mixture

D. What influences density?

1) Plant operations
2) Mixture
3) Road operations
4) Mat temperature
5) Compaction effort

    a) Rollers
    b) # of passes, etc.

6) Segregation
7) Underlying road conditions

    a) Correlation still valid

8) Nuclear density gauge?

    a) Gauge operator
    b) Gauge malfunctioning
    c) Inaccurate calculations

Problem 3 – Solution

First impressions indicate that this is a road density problem and all plant aspects can be ignored but looking at the flow chart on page 6-6 shows that plant operations/mixture aspects have a direct relationship with the road.

Problems from the plant can be carried out to the road, such as temperature or segregation, which will affect the ability to obtain proper mat density. Good communication between the plant and road is imperative and can help to expose potential problems.

Proper investigation will include verifying both proper plant and road operations to solve this situation. Testing procedures will probably not be the solution to this problem since the test results indicate a trending problem.

INDIVIDUAL TEST RESULTS

Isolated Tests

How a technician should respond to a "failed" individual test.

A. Don't take a knee-jerk reaction to a single test.

B. Always make sure all of the sampled material is completely and correctly blended before obtaining or running any test specimens.

The test samples must be representative of the material being tested! This starts with proper blending of plant and/or road samples.

C. Encountering defective material, you should:

a) Be able to visually see defective or poorly sampled material with practice and experience.

b) Need to take corrective action right away.

c) Still need to obtain samples and perform the test(s).

d) Be able to recognize when the test/sample is going to fail prior to completing the test (experience and practice).

e) Should immediately resample when encountering failing test results.

f) Monitor the material and/or operations.

C. Test termed as "flyers"

1) Typically doesn't match or correlate with other results (stands out like a sore thumb).

2) Could be a failed test due to incorrect test procedures, defective equipment or poor sampling methods.

3) A quick check of the equipment and calculations should be performed prior to resampling to determine possible equipment/operation or calculation errors.

4) Arrangements should be in place to replace any inoperable or malfunctioning equipment. Production shall stop or any lots of material produced and placed can be subject to rejection.

5) Resamples should be taken to verify mixture compliance whenever an adjustment or mixture change has been made.

Specialized Testing

"HMA testing for control (biased or check)."

A. If a potential problem is noticed, corrective action should be taken.

Example: If segregated stockpiles are found then additional gradation tests should be ran to determine the extent of the segregation.

Corrective action, as addressed per the AGCS program, will be needed to properly re-blend the material.

B. Prior to the start of production, run a few split samples with the District and/or another company to determine/help resolve differences in test results to identify and correct potential problems to avoid possible plant/job shutdown.

Participate in the Central Bureau of Materials round robin testing.

C. When test results are bouncing from top to bottom of the control limits, additional testing should be performed and the problem(s) identified and resolved.

D. In situations of improper quantities of materials, determine the cause of the shortages or overflow. Don't just tweak or change settings on the cold feeds or plant controls, as this will change the characteristics of the mix (gradations, air voids, density, etc.). Determine the cause and then fix the actual problem(s).

Resample Tests

A technician's response to a failed test:

A. Immediate resampling for a failed test.

B. Immediate resampling when obviously defective material is observed.

C. Immediate resampling after determination of a failed test for <u>any</u> unknown reason.

D. Samples should not be taken during the first 1/2 hour of start of mix production or within the last 1/2 hour of mixture shipment.

E. Do not wait to resample, a failed test should be resampled immediately to determine the cause of the failure.

<u>Exception</u>, if mixture production has been discontinued due to the suspension of operations (rain, production ended for the day, etc.) before a resample can be taken.

In this case, upon restarting of the mixture the next time, tests should be performed to determine any potential problems.

F. If a specific failed test parameter can be easily determined as to the cause of the test failure then a resample/retest can/should be taken only for that failed test parameter.

  1) Only the G_{mm} ("D"), G_{mb} ("d") for failed air voids.

  2) Only asphalt binder content for failed asphalt binder content.

  3) Only failed gradation test for individual hot bin(s), combined belt, cold feeds or stockpiles.

It is still good practice to keep an eye on all aspects of the mixture.

G. The resample test result(s) should be placed on the respective control chart(s) immediately to the right the failed test result(s) from which the resample test result originated. The retest results should be included when plotting the moving average.

Control Chart Documentation

A. Only randomly generated test results and resample test results should be placed on control charts.

  1) Individual test results are to be identified by an open circle symbol and connected by dashed lines.
  2) Moving average results are to be identified by an open square symbol and connected with solid lines.

B. State assurance test results and resample test results, can be posted on the contractors control charts, utilizing an open triangle symbol. State assurance test results and resample test results should be obtained from the state inspector within a reasonable time frame.

C. Control charts should be kept up to date.

D. It is good practice to make the control chart information available to the state inspector or other state representatives (DE, RE, etc.)

E. Check or bias test results or other extra test results obtained by the contractor should be kept in some type of filing system as determined by the contractor. Normally, these types of test are not included on control charts. Electronic data storage is highly recommended.

These types of tests are very important and are an effective tool used for the control process.

F. With practice and proficiency of testing and proportioning, the contractor should be able to keep the test results within 1 - 2% of the target. As stated at the beginning of this class, experience is vital for success and being able to control production and placement of HMA materials.

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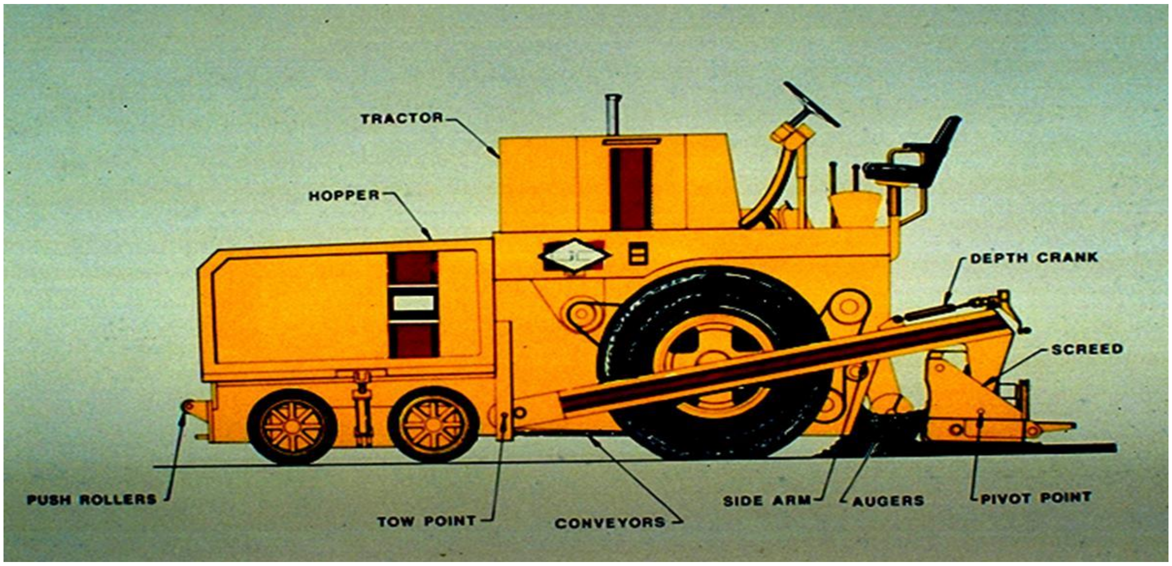
HMA LAYDOWN AND COMPACTION



Typical Paver

Old Time Pavers

New Modern Electronically Controlled Paver

The equipment has changed over the years but the paving operation principles are still the same.

When HMA is placed on the road a number of factors will determine the ability to compact the materials in order to meet density requirements. Different factors would include:

Material Properties

Aggregates	–	surface texture, particle shape, gradation
Asphalt binder	–	viscosity, VMA, percent of mix
Mixture temperature	–	optimum mix temperature, tenderness zone

Mat Thickness

Base conditions	–	Good (solid, strong, firm) or bad (soft, weak, giving)
Base thickness	–	Thick or thin mat

Weather Conditions

Ambient air temperature	–	Hot or cold
Wind speed	–	High or low, can have a cooling effect
Surface temperature	–	Hot or cold

Equipment (compaction forces)

Frequency and amplitude controls (low or high)
Maximum roller speed (fast or slow)
Matching paver speed (fast or slow)

This chapter will mainly focus on the factors pertaining to the equipment and compaction forces.

Guidelines for Selecting the Amplitude of Vibration

<table>
<tr><th></th><th>Parameter Level</th><th>◄ Parameter ►</th><th>Parameter Level</th><th></th></tr>
<tr><td rowspan="7">LOW Amplitude</td><td>Thin < 2” (50 mm)</td><td>Mat Thickness</td><td>Thin > 2” (50 mm)</td><td rowspan="7">HIGH Amplitude</td></tr>
<tr><td>Rigid</td><td>Base Support</td><td>Flexible</td></tr>
<tr><td>Low</td><td>AB Viscosity</td><td>High</td></tr>
<tr><td>Rounded</td><td>Aggregate</td><td>Angular</td></tr>
<tr><td>Smooth</td><td>Aggregate Surface Texture</td><td>Rough</td></tr>
<tr><td>Poorly Graded</td><td>Aggregate Gradation</td><td>Dense</td></tr>
<tr><td>High</td><td>Temperature Mixture, Base, or Air</td><td>Low</td></tr>
</table>

For very thin lifts, especially on rigid base supports, care should be exercised to avoid fracturing aggregate. It is possible to over compact a HMA mat.

LAYDOWN AND COMPACTION OUTLINE

1. BASE PREPARATION

a. Are you familiar with the base, its condition and preparation for bituminous surfacing? (Article 406.05(a))

b. Is the correct type of prime selected and applied at the proper rate? (Articles 406.02 (b, Note 1), 406.05 (b) & 1102.05)

c. Is the base dry and the air temperature in the shade at least 40° F and rising when laying leveling binder and binder courses? Is it 45° F and rising when placing surface course? (Article 406.06 (b)(1))

2. SPREADING & FINISHING MACHINE

a. Does the paver model meet requirements of Article 1102.03 per Construction Memorandum 08-11(see below)?

Illinois Department of Transportation
Division of Highways / Bureau of Construction
2300 South Dirksen Parkway, Springfield, Illinois 62764

Subject:
Hot Mix Asphalt (HMA) Spreading and Finishing Machines Approved For Use in Illinois Article 1102.03

CONSTRUCTION MEMORANDUM NO. 08-11

Effective: January 1, 2008

Expires: Indefinite

This memorandum superseded Construction Memorandum No. 06-11, dated April 1, 2006.

In the past, Hot Mix Asphalt (HMA) spreading and finishing machines have been approved by the Engineer of Construction for use in Illinois. Because of the wide variety of paving and finishing machines currently available, and modifications affecting their performance can easily be made to these machines, the Engineer of Construction will no longer maintain an approved list of these machines for use on our projects.

The Resident Engineer must ensure any paving and finishing machine the contractor proposes to use meets the requirements of Article 1102.03 of the specifications prior to its use.

Under certain operating conditions, HMA spreading and finishing machines otherwise acceptable for use on IDOT projects may exceed the legal axle load. The use of these machines for resurfacing highways must be approved in accordance with the requirement of Construction Memorandum No. 39.

The Resident should also assure the factory or field installed anti-segregation kits are in good working order and not excessively worn prior to paving. The district Materials Engineer can assist the Resident with this review.

Roger Driskell, P.E.
Engineer of Construction

b. Are you familiar with the mechanical features of the paver? (Article 1102.03)

c. Are you familiar with Extensions/Augers, Electronic Grade Control, and Screed? (Article 406.03 (e)(Note 1))

d. Is the spreading and finishing machine being operated at a speed that is mated with the required roller speed (special attention to the vibratory roller), which coincides with the average rate of delivery of bituminous materials to the paver? In no case shall the speed of the paver exceed 50 feet (15 m) per minute. (Article 406.06 (e))

Beginning of the Standard Specification Article 1102.03

"1102.03 Spreading and Finishing Machine. *Hot-mix asphalt (HMA) pavers shall be self-contained, power-propelled units equipped with augers, activated screed or a strike off assembly and be capable of being heated. The augers, activated screed or strike off assembly shall be adjustable either automatically or by adding additional sections so the paver will place, compact or strike off the HMA to the full width being placed. All width extensions shall have the same placement features and equipment functions as provided on the main body of the paver. Pavers with extendible type screeds shall have a minimum 10 ft (3 m) basic screed, except on projects with 7500 sq yd (6300 sq m) or less of HMA. For these smaller projects, a minimum 8 ft (2.4 m) basic screed will be permitted. Augers shall be extended as additional sections of screed are bolted on or automatically adjustable screeds are extended. The augers need not be extended when the screed extensions on each side of the machine are 1 ft (300 mm) or less if the finished surface of the mat is uniform. Pavers used for shoulders and similar construction shall be capable of Hot-Mix Asphalt Equipment Art. 1102.04 spreading and finishing HMA in widths shown on the plans. The use of any machine obsolete in design or in poor mechanical condition will not be permitted.*

The spreading and finishing machine shall be equipped with an automatic electronic grade control device. The device shall be effective in leveling depressions in the surface of the existing pavement, the leveling course and the binder course.

The automatic electronic grade control device shall be capable of controlling the elevation of the screed relative to either a preset grade control stringline or a grade reference device traveling on the adjacent pavement surface. The traveling grade reference device shall be not less than 30 ft (9 m) in length.

The paver shall be equipped with a receiving hopper having sufficient capacity for a uniform spreading operation. The hopper shall be equipped with a distribution system to uniformly place a non-segregated mixture in front of the screed. The distribution system shall have chain curtains, deflector plates, and/or other devices designed and built by the paver manufacturer to prevent segregation during distribution of the mixture from the hopper to the paver screed. The Contractor shall submit a written certification that the devices recommended by the paver manufacturer to prevent segregation have been installed and are operational. Prior to paving, the Contractor, in the presence of the Engineer, shall visually inspect paver parts specifically identified by the manufacturer's check list for excessive wear and the need for replacement. The Contractor shall supply the completed check list to the Engineer noting the condition of the parts. Worn parts shall be replaced. The Engineer may require an additional inspection prior to placement of the surface course or at other times throughout the work.

The screed or strike off assembly shall effectively produce a finished surface of the required evenness and texture without tearing, shoving or gouging the mixture.

The paver shall be capable of being operated at forward speeds consistent with satisfactory placement of the mixture.

A straightedge at least 4 ft (1 m) in length and equipped with a carpenter's level shall be available at the spreading and finishing machine to check the surface of the HMA for transverse slope and longitudinal surface variations."

<u>End of the Standard Specification Article 1102.03</u>

3. <u>ROLLERS</u>


Vibratory Rollers

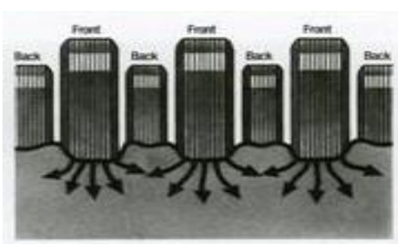

Vibratory Rollers


Steel Wheel Rollers


End of Pass


Pneumatic Tire Roller

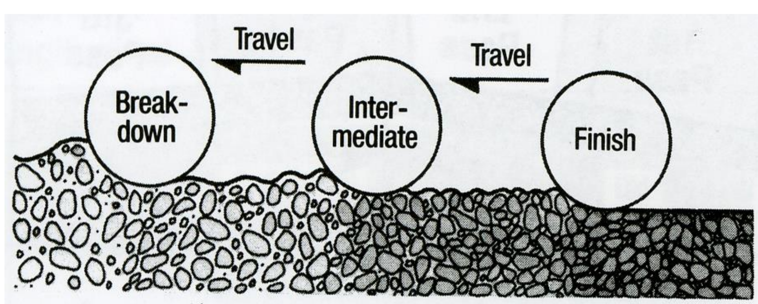

Pneumatic Roller Pass



Exerted Force


Finish Roller


3-Wheel Roller



Compaction Phases

a. Are the required rollers on the jobsite, prior to the start of the paving operation? (Article 406.07 (a) Table 1)

b. Have the rollers been checked to meet the requirements of Article 1101.01(g) per Construction Memorandum 06-10 (see below)?

Illinois Department of Transportation
Division of Highways / Bureau of Construction
2300 South Dirksen Parkway, Springfield, Illinois 62764

“Subject:
Vibratory Rollers Approved
For Use in Illinois
Article 1101.01(g)

CONSTRUCTION MEMORANDUM NO. 06-10

Effective: April 1, 2006

Expires: Indefinite

This memorandum supersedes Construction Memorandum No. 00-10 dated January 4, 2000.

Because of the wide variety of rollers currently available, and modifications which affect their performance can easily be made to these rollers, the Engineer of Construction will no longer maintain an approved list of vibratory rollers for use on IDOT projects. The Resident Engineer should ensure any vibratory roller the contractor proposes to use on IDOT projects meets the requirements of Article 1101.01(g) of the specifications prior to its use.

To accomplish this task, the Resident must check that the drum is at least 48” in diameter, at least 66” wide, minimum vibrations per minutes (VPM) of 1600, static force of 125 lbs./inch, and a total applied force of 325 lbs./inch.

If not directly shown on the contractor’s specification sheet, the forces for the equipment can be calculated as follows. The static unit force is calculated by dividing the weight of the drum (in pounds) by the width of the drum (in inches). The dynamic force of each drum must be provided by the equipment specification sheet for each amplitude setting. The dynamic force (in pounds) is divided by the drum width (in inches). The total applied force is calculated by adding a dynamic force to the static force.

If the contractor’s equipment satisfies the requirements of Article 1101.01(g), it may be used on IDOT projects. The project inspectors should monitor the equipment to ensure it provides the required results. Any equipment which does not provide satisfactory field performance must be removed from the project.

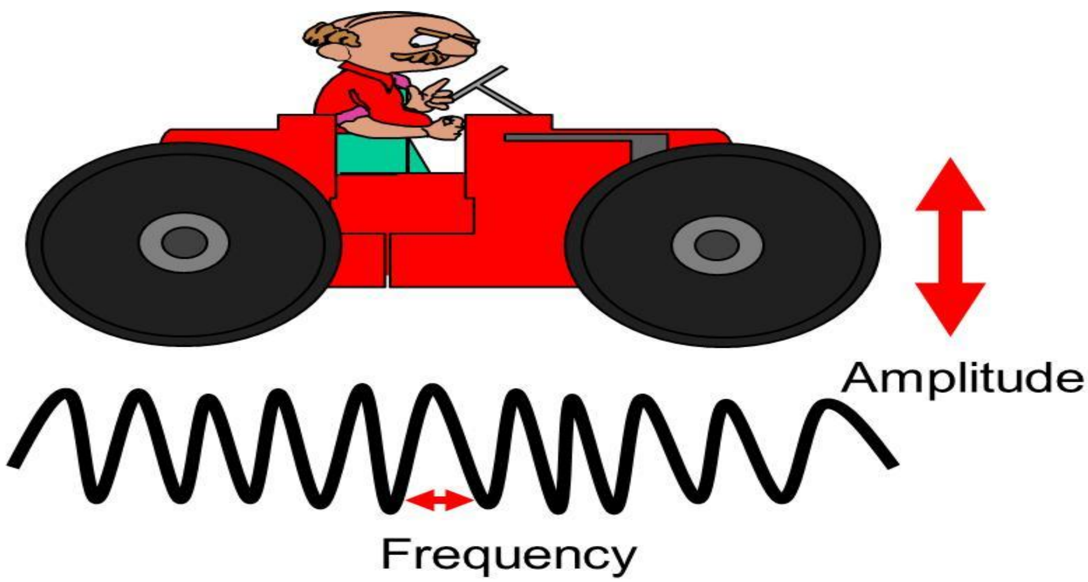
In addition to these requirements, on thin (<2.5”) bituminous lifts, IDOT inspectors should restrict the total applied forces to not more than 450 lbs/linear inch. Greater applied forces tend to crush the coarse aggregate.

Roger L. Driskell

Roger L. Driskell, P.E.
Engineer of Construction”

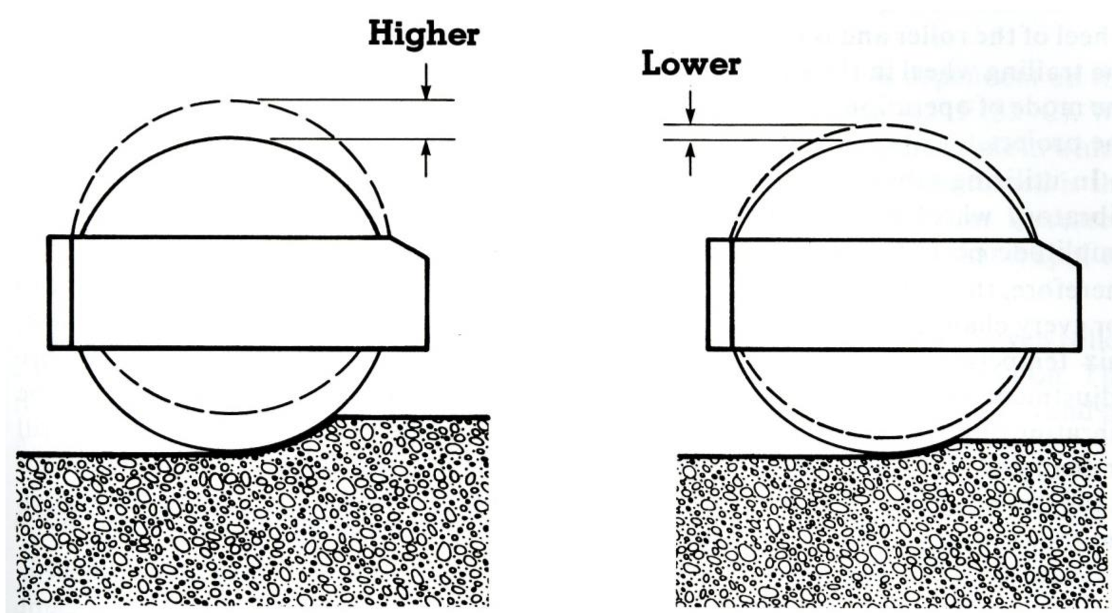
c. Have the vibratory roller settings been determined and the rollers checked to see that they are performing as desired? (Article 1101.01 (g)).

Check the roller VPMs using a reed tachometer.



Amplitude is the force (by vibrations or ballast weight) pounding on the mat.

Frequency is the distance in between the poundings.



The thickness of the mat is a major factor to determine how much amplitude is needed.

Beginning of the Standard Specification Article 1101.01

*"**1101.01 Rollers.** No roller shall be used that has in any way been thrown out of its original balance by the application of attachments not approved by the Engineer. All bearings shall be tight.*

(a) Pneumatic-Tired Rollers. The roller shall consist of not less than nine pneumatic tires revolving on two axles. The tires on the front and rear wheels shall be staggered so that they will cover the entire area over which the roller travels. Under working conditions, the roller shall develop a compression of not less than 225 lb/in. (40 N/mm) width of tire tread.

(b) Heavy Pneumatic-Tired Rollers. The roller shall have a gross weight (mass) of not less than 25 tons (23 metric tons) and shall consist of not less than four pneumatic-tired wheels revolving in one transverse line. The width of the roller shall be not less than 8 ft (2.4 m), and it shall be constructed in two or more sections in such a manner that each section is free to oscillate or move independently. Under working conditions, the roller shall develop a compression of not less than 650 lb/in. (114 N/mm) width of tire tread.

(c) Self-Propelled Pneumatic-Tired Roller. The roller shall be of the oscillating wheel type consisting of not less than seven pneumatic-tired wheels revolving on two axles, and capable of being ballasted to the weight (mass) required. The tires on the front and rear wheels shall be staggered so that the tire sidewalls will have a minimum overlap of 1/2 in. (13 mm). The roller shall provide for a smooth operation when starting, stopping or reversing direction.

The tires shall withstand inflation pressures between 60 and 120 psi (415 and 825 kPa). The roller shall be equipped with an adequate scraping or cleaning device on each tire to prevent the accumulation of material on the tires. When used for the compaction of hot-mix asphalt, the roller shall be equipped with a water system which will keep all tires uniformly wet to prevent material pickup.

The Contractor shall provide means for determining the weight (mass) of the roller as distributed on each wheel. Ballast shall be included in determining the weight (mass).

(d) Tamping Rollers. The roller shall have a minimum weight (mass) of 90 lb/in. (16 N/mm) width of drum, and each individual tamper shall develop a compression of not less than 100 psi (690 kPa) of its tamping face area. The width of the tamping roller shall be not less than 8 ft (2.4 m), and it shall be constructed in two or more sections in such a manner that each section is free to oscillate or move independently. It shall be equipped with cleaning teeth at the rear.

(e) Steel Wheel Rollers. The roller shall be self-propelled and provide a smooth operation when starting, stopping, or reversing directions. The steering mechanism shall provide for positive control of the roller. Roller wheels shall be smooth and free from openings or projections which will mar the surface on which the roller is operated. Motor rollers shall be equipped with drip pans to contain oil, grease, or gasoline drips generated by the roller operation. The roller shall be provided with adjustable scrapers which shall be used when necessary to keep the surface of the wheels clean.

When used on a hot-mix asphalt surface, the roller shall be equipped with water tanks and sprinkling devices which shall be used to wet the wheels and prevent material pickup.

(1) Tandem Rollers. The Contractor shall provide means for determining the weight (mass) of the roller as distributed on each axle. Ballast shall be included in determining the weight (mass).

The rear wheel may be crowned at the rate of not more than 3/16 in. in 4 1/2 ft (5 mm in 1.4 m). The front wheel shall be divided into at least two sections and shall show no noticeable crown. The weight (mass) of the roller shall meet requirements of the specific item of work being constructed.

(2) Three-Wheel Rollers. The rear wheels of three-wheel rollers may be crowned at the rate of not more than 1/16 in. in 20 in. (2 mm in 500 mm) and shall be propelled with a differential gear. The front wheel shall be divided into at least two sections, shall show no noticeable crown, and shall overlap the compression area of each rear wheel by not less than 1 1/2 in. (38 mm). The weight (mass) of the roller shall meet requirements of the specific item of work being constructed.

(f) Trench Roller. The roller shall be self-propelled, and provide a smooth operation when starting, stopping or reversing directions. The width of the compaction roller shall be not less than 20 in. (500 mm). The diameter of the compaction roller shall be not less than 60 in. (1500 mm). The roller wheels shall be smooth and free from openings or projections which will mar the surface on which the roller is operated. Motor rollers shall be equipped with drip pans to contain oil, grease or gasoline generated by the roller operation. The roller shall be provided with adjustable scrapers which shall be used when necessary to keep the surface of the wheels clean.

When used on a hot-mix asphalt (HMA) surface, the roller shall be equipped with water tanks and sprinkling devices which shall be used to wet the wheels and prevent material pickup.

The weight (mass) of the roller shall meet requirements of the specific item of work being constructed. The Contractor shall provide means for determining the weight (mass) of the roller as distributed on the compression wheel. Ballast shall be included in determining the weight (mass).

The balance wheel of the roller shall be adjustable in height to provide the slope of the surface of the specific item of work being constructed.

(g) Vibratory Roller. The vibratory roller shall be self-propelled and provide a smooth operation when starting, stopping or reversing directions. The vibrating drum(s) amplitude and frequency shall be approximately the same in each direction and meet the following minimum requirements: drum diameter 48 in. (1200 mm), length of drum 66 in. (1650 mm), vibrators 1600 vibrations per minute (VPM), unit static force on vibrating drum(s) 125 lb/in. (22 N/mm), total applied force 325 lb/in. (57 N/mm), adjustable eccentrics, and reversible eccentrics on nondriven drum(s). The total applied force for various combinations of VPM and eccentric positions shall be shown on decals on the vibrating roller or on a chart maintained with the roller.

The vibratory roller shall be equipped with water tanks and sprinkling devices, or other approved methods, which shall be used to wet the wheels to prevent material pickup.

A vibrating reed tachometer (hand type) shall be furnished with each vibratory roller. The vibrating reed tachometer shall have a range of 1000 to 4000 VPM. The vibrating reed tachometer shall have two rows of reeds, one ranging from 1000 to 2000 VPM and the other from 2000 to 4000 VPM."

End of the Standard Specification Article 1101.01

d. Has the location and procedure for the test strip/growth curve been determined? (Article 1030.06 (a) & (b) and "Hot-Mix Asphalt QC/QA Test Strip Procedures - Appendix B4" located in the Manual of Test Procedures)

e. Is the proper rolling procedure being performed following the test strip and the establishing of a rolling pattern? (Article 406.07 (a), Table 1 and "Hot-Mix Asphalt QC/QA Test Strip Procedures - Appendix B4" located in the Manual of Test Procedures)

Beginning of the Standard Specification Article 406.07

"406.07 Compaction. *The HMA shall be compacted according to the following requirements.*

(a) Rollers. Immediately after each lift of level binder, binder, or surface course mixture is placed, each lift shall be compacted with equipment meeting the requirements listed in the following Table 1.

TABLE 1 – MINIMUM ROLLER REQUIREMENTS FOR HMA [4/]

	Breakdown Roller (one of the following)	*Intermediate Roller*	*Final Roller (one or more of the following)*	*Density Requirement*
Level Binder: (When density requirements of Article 406.05(c) do not apply)	*P* [3/]	---	V_S, $P, T_B, T_F, 3W$	*To the satisfaction of the Engineer*
Binder and Surface [1/] *Level Binder* [1/] *(When density requirements of Article 406.05(c) apply)*	V_D, $P, T_B, 3W$	*P* [3/]	V_s, T_B, T_F	*As specified in Articles: 1030.05(d)(3), (d)(4), and (d)(7)*
IL-4.75 and SMA [4/5/]	T_B, 3W	- -	T_F, 3W	
Bridge Decks [2/]	T_B	- -	T_F	*As specified in Articles: 582.05 and 582.06*

NOTE: Footnotes and definitions for Table 1 are found on the following page.

1/ If the average delivery at the job site is 85 ton/hr (75 metric tons/hr) or less, any roller combination may be used provided it includes a steel wheeled roller and the required density and smoothness is obtained.

2/ One T_B may be used for both breakdown and final rolling on bridge decks 300 ft (90 m) or less in length, except when the air temperature is less than 60ºF (15ºC).

3/ A vibratory roller (V_D) may be used in lieu of the pneumatic-tired roller on mixtures containing polymer modified asphalt binder.

4/ For mixture IL-4.75, a minimum of two T_B rollers and one T_F roller shall be provided. Both the T_B and T_F rollers shall be a minimum of 280 lb/in (49 N/mm). P and V rollers will not be permitted.

Equipment Definition

V_S - *Vibratory roller, static mode, minimum 125 lb/in. (2.2 kg/mm) of roller width. Maximum speed = 3 mph (5 km/h) or 264 ft/min (80 m/min). If the vibratory roller does not eliminate roller marks, its use shall be discontinued and a tandem roller, adequately ballastedto remove the marks, shall be used.*

V_D - *Vibratory roller, dynamic mode, operated at a speed to produce not less than 10 impacts/ft (30 impacts/m).*

P - *Pneumatic-tired roller, max. speed 3 1/2 mph (5.5 km/h) or 308 ft/min (92 m/min). The pneumatic-tired roller shall have a maximum tire pressure of 80 psi (550 k/Pa) and shall be equipped with heat retention shields. The self propelled pneumatic-tired roller shall develop a compression of not less than 300 lb (53 N) nor more than 500 lb (88 N) per in. (mm) of width of the tire tread in contact with the HMA surface.*

T_B - *Tandem roller for breakdown rolling, 8 to 12 tons (7 to 11 metric tons), 250 to 400 lb/in (44 70 N/mm) of roller width, max. speed = 3 1/2 mph (5.5 km/h) or 308 ft/min (92 m/min).*

T_F - *Tandem roller for final rolling, 200 to 400 lb/in (35 70 N/mm) of roller width with a minimum roller width of 50 in (1.25 m). Ballast shall be increased if roller marks are not eliminated. Ballast shall be decreased if the mat shoves or distorts.*

3W - *Three wheel roller, max. speed = 3 mph (5 km/h) or 264 ft/min (80 m/min), 300 to 400 lb/in (53 to 70 N/mm) of roller width. The three-wheeled roller shall weigh 10 to 12 tons (9 to 11 metric tons).*

(b) Rolling. When initial rolling causes undue displacement, haircracking, or checking in either the binder course or the surface course, the time of rolling will be adjusted by the Engineer to correct these conditions.

Rolling of the first lane of binder and surface course shall start longitudinally at the edge having the lower elevation and progress to the other edge, overlapping on successive trips to obtain uniform coverage. The roller shall not pass over an *unprotected edge of the freshly laid HMA, unless directed by the Engineer. When directed by the Engineer, the edge shall be rolled with a pneumatic-tired roller.*

When laying the HMA adjacent to a previously placed lane, the first pass of the roller shall be along the longitudinal joint on the fresh mixture with the compression wheel not more than 6 in. (150 mm) from the joint. The second pass of the roller shall overlap the longitudinal joint not more than 12 in. (300 mm) on the previously placed lane, after which the rolling shall proceed from the low side of the transverse slope to the high side, overlapping uniformly. Each stop shall be regulated to prevent trapping of water on the rolled surface. The steel-wheeled rollers shall be operated with the compression wheels toward the direction of paving.

The speed of the roller at all times shall be slow enough to avoid displacement of the HMA. If displacement occurs, it shall be corrected at once by raking and applying fresh HMA where required. To prevent adhesion of the HMA to the roller, the wheels shall be kept properly moistened without an excess of water.

Rolling of the binder and surface courses shall be continued until all roller marks are eliminated and the HMA is satisfactorily compacted. When required by the Engineer, the surface course shall be rolled diagonally in two directions with a tandem roller, the second rolling crossing the lines of the first, and, if the width of the pavement permits, it shall also be rolled at right angles to the centerline.

In all places inaccessible to the rollers, such as locations adjacent to curbs, gutters, headers, manholes, and similar structures, the required compaction shall be secured with tampers.

Any HMA that becomes loose, broken, mixed with foreign material, or is in any way defective shall be removed and replaced with fresh HMA and compacted to conform to the surrounding area.

(c) Density. The density of the compacted HMA shall be according to Articles 1030.05(d)(3), (d)(4), and (d)(7)."

End of the Standard Specification Article 406.07

4. MIXTURE DELIVER AND LAYDOWN

a. Do the trucks hauling the mixtures meet the specification requirements? (Article 1030.08).

Beginning of the Standard Specifications Article 1030.08

"1030.08 Transportation. *Vehicles used in transporting HMA shall have clean and tight beds. The beds shall be sprayed with asphalt release agents from the Department's qualified product list. In lieu of a release agent, the Contractor may use a light spray of water with a light scatter of manufactured sand (FA 20 or FA 21) evenly distributed over the bed of the vehicle. After spraying, the bed of the vehicle shall be in a completely raised position and it shall remain in this position until all excess asphalt release agent or water has been drained.*

When the air temperature is below 60 °F (15 °C), the bed, including the end, endgate, sides and bottom shall be insulated with fiberboard, plywood, or other approved insulating material and shall have a thickness of not less than 3/4 in. (20 mm). When the insulation is placed inside the bed, the insulation shall be covered with sheet steel approved by the Engineer. Each vehicle shall be equipped with a cover of canvas or other suitable material meeting the approval of the Engineer which shall be used if any one of the following conditions is present.

(a) Ambient air temperature is below 60 °F (15 °C).

(b) The weather is inclement.

(c) The temperature of the HMA immediately behind the paver screed is below 250 °F (120 °C).

The cover shall extend down over the sides and ends of the bed for a distance of approximately 12 in. (300 mm) and shall be fastened securely. The covering shall be rolled back before the load is dumped into the finishing machine."

End of the Standard Specification Article 1030.08

b. Are occasional temperature checks being taken on the mixture and recorded? (Article 406.06 (b)(1) & (2))

c. Is there a copy of the mix design (Big "D" Notification Form) on the job and does it match what is on the delivery ticket? Is a ticket recording the net weight of material and all other required information being submitted with each load? (Article 406.13). A copy of the Big "D" Notification Form can be found in chapter 10 of this manual.

d. Are weigh checks of full truck loads being done at least once a week? (Articles 1102.01 (a)(7) & 1102.01 (b)(5) & 1102.01 (c)(3) & 1102.01 (c)(8)(b))

e. Are frequent yield test being performed to ensure mat thickness and final tonnage, not to exceed l03% of approved quantities? (Article 406.13(b))

f. Are density checks being performed in a timely manner and documented? (Article 1030.05 (d)(3))

5. DOCUMENTATION

a. Are all tickets, field checks, reports and supporting documentation being recorded and submitted in a timely fashion? (Article 1030.05 (g))

6. Use of Self-Propelled Vibratory Rollers for Compaction of HMA

Effective use of vibratory rollers for compaction of HMA depends on the following factors:

1. Lift Thickness
2. Roller and Paver Speeds
3. Frequency
4. Amplitude
5. Condition of Equipment
6. Total Applied Force (Sum of Static and Dynamic)

To obtain optimum results of density and smoothness requires an understanding of the interaction of the above factors. For example, an improper balance of amplitude and frequency can result in a marginal density and/or a rough surface.

The total applied force required to obtain density on HMA high ESAL mixtures with a minimum number of passes should normally be between 325 and 400 pounds per inch of roller (total applied force). The total applied force is the sum of the dynamic force and the static weight force. For most rollers the static force is 125 to 150 pounds/inch and the dynamic force 200 to 400 pounds/inch. The amplitude is adjusted by changing the weight of the eccentric.

7. Frequency Control

The frequency vibration is controlled by engine speed not roller speed. Manufacturers show frequency as a function of engine rpm and is shown normally on the rpm dial. Frequency should be set at least 1,600 vpm, the specification minimum, and preferably at 2,000 to 2,400, the maximum for most rollers. High frequency is essential to provide a smooth surface and it has a secondary effect on density.

Beginning of the Standard Specifications Article 1101.01 (g), in part

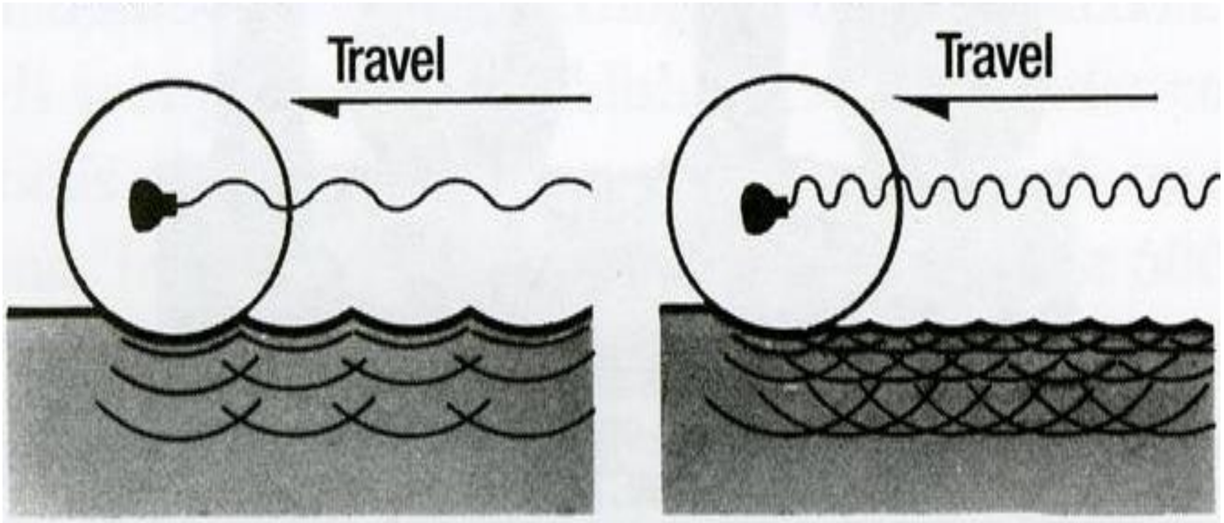
> " Vibrating Roller… *A vibrating reed tachometer (hand type) shall be furnished with each vibratory roller. The vibrating reed tachometer shall have a range of 1000 to 4000 VPM. The vibrating reed tachometer shall have two rows of reeds, one ranging from 1000 to 2000 VPM and the other from 2000 to 4000 VPM."*

End of the Standard Specifications Article 1101.01 (g), in part

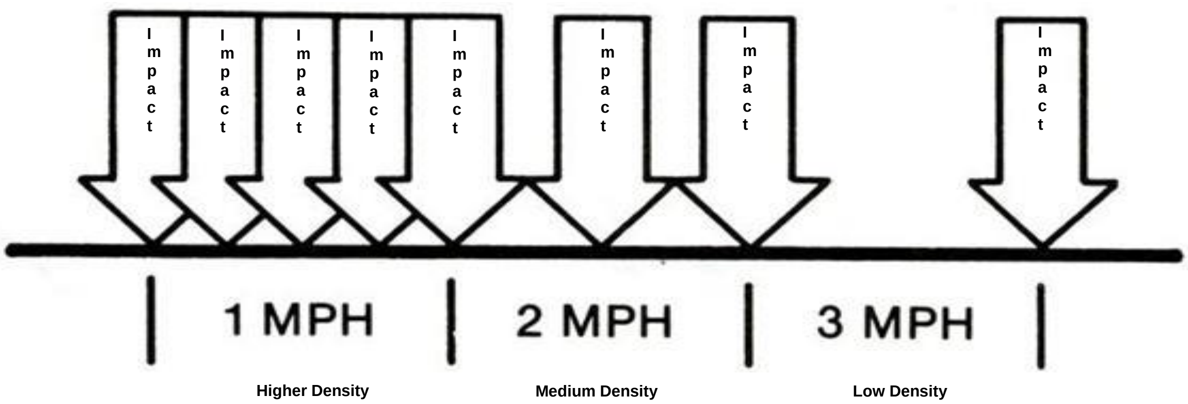
8. Maximum Vibratory Roller Speed

To determine the proper roller speed, divide the measured frequency (VPM) by 10 impacts/ft. (30 impacts/m) [Article 406.07 (a) Table 1 Equipment Definition (V_D)]

Thus, a roller with 2400vpm/10 impacts/foot could operate at a speed of 240 feet/min. So if a roller was operated at 400 feet/min with a 1600 vpm frequency, the spacing of impacts would be 4 per foot which would result in ripples and lower density because the dynamic energy into each square yard would be reduced by 2/3. This would create a 'washboard' effect on the driving surface resulting in a rough bumpy ride for the motorist.



Improper spacing Proper spacing



Increasing roller speed creates wider spacing between impacts

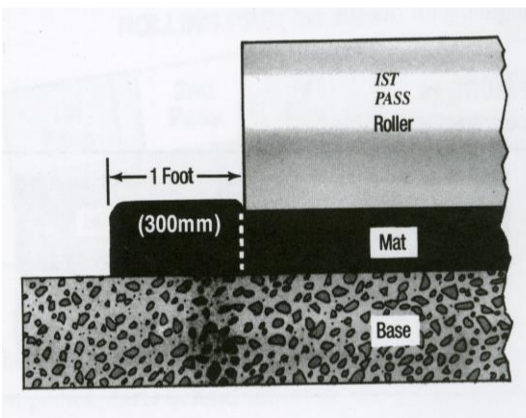
The improper spacing will create a washboard effect on the surface of the mat.

9. Maximum Paver Speed

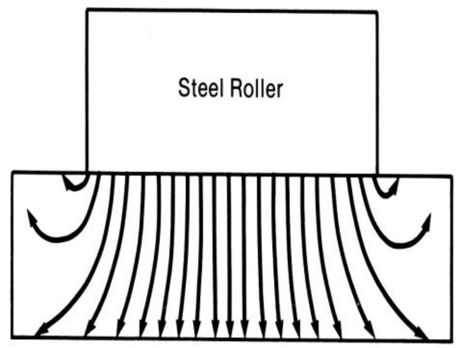
Article 406.06(e) limits the maximum speed of the paver to 50 feet per minute. The paver speed is further constrained by the maximum roller speed to the extent that the vibratory roller is able to perform the required number of passes and still keep up with the paver.

A pass of the roller is defined as one trip of the roller in one direction over any one spot.

Normally, the number of passes will normally be an odd amount to keep the roller moving forward on the mat. Each pass of the roller will be staggered across the mat to provide even coverage. The passes on the outside edges (unconfined) are usually rolled last to keep from pushing the mat outward. The Contractor is still required to achieve proper compaction on the mat edges (confined or unconfined) per the "*HMA – Density Testing of Longitudinal Joints (BMPR)*" document (located in chapter 9 in this manual).



Edge Compaction



Exerted Force

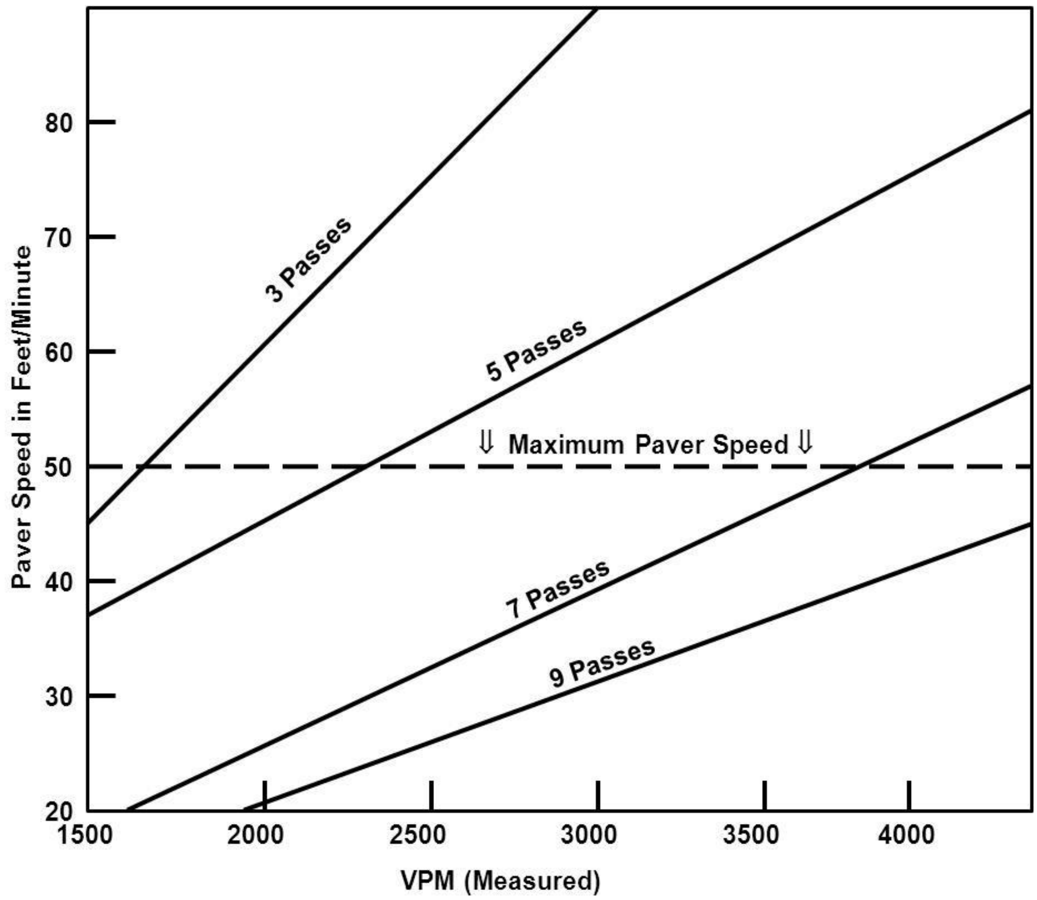
Typical number of roller passes needed to achieve density (see note below):

Type of Mixture	# of passes
High ESAL mixes	7 – 9
Low ESAL mixes	3 – 7

Appropriate mix evaluation is required to determine the actual number of passes needed to achieve the proper density of a mixture. The proper method of mixture evaluation is discussed in Chapter 8 of this manual.

NOTE: **This information only is intended to be a guideline**.

Maximum Paver Speed Permitted to Maintain at least 10 Impacts/Foot with a Vibratory Roller



Maximum Vibratory Roller Speed = $\frac{\text{Measured Frequency}}{10}$

Maximum Paver Speed = $\frac{\text{Measured Frequency}}{10(\text{\# of req. passes})} \times 0.9$

Example: Measured frequency is 2200 VPM at 5 passes

Maximum Vibratory Roller Speed (2.5 mph) = $\frac{2200}{10}$ = **220'/min**

Maximum Paver Speed = $\frac{2200}{(10x5)} \times 0.9$ = **39.6'/min**

Class Example:

To determine roller and paver speed using a 7 pass pattern:

Check the VPM of the roller:

	Front Drum	Rear Drum
Forward	2200	2100
Backward	2000	2150

$$\text{Roller speed} = \frac{\text{Measured frequency}}{10\ (\text{impacts /ft.})}$$

$$\text{Max. Paver Speed} = \frac{\text{Measured Frequency}}{10\ (\text{Number of passes})} \times (.9)$$

10. <u>HMA Surfacing Yield Test Determination</u>

Of the many duties of the HMA surfacing inspector, the requirement of checking the rate of surfacing, or tons per station, is probably one of the most important functions he/she must perform. This check, called the yield test, is performed to help determine proper mixture quantities of ingredients which will affect the properties of the mixture.

Yields checks should be performed throughout the workday. Imagine the amount of displeasure that would be experienced by the Contractor waiting until all resurfacing is completed before discovering that the planned HMA mixture quantities had been exceeded by more than 3%. **<u>The contractor should discuss the plan quantities with the Engineer so that there are no misunderstandings.</u>**

This information on yield has been written to present to two simple calculations which should be performed throughout the day to inform the technician immediately of possible quantity issues, over or under on planned quantities.

Probing of the uncompacted HMA behind the paver is a rather inaccurate method of thickness quantity determination, the technician has to seek more reliable methods of checking quantity placement. Yield calculations should be retained in a hard back field book and should become part of the permanent project file.

Note: Use of Material Transfer Devices (MTD) restricts the ability to check yields on a truck by truck basis unless extra steps are taken to determine as to when the beginning and end of a load has passed through the MTD.

<u>Beginning of the Documentation of Contract Quantities FY 2016 - page A-15 & A-16</u>

"Daily yield checks should be run on these items so that the Contractor can be notified when he/she is exceeding the maximum specified amounts of quantity. The limit of the final amount paid shall be plan quantity plus (or minus) theoretical quantities approved by authorization, multiplied by the above percentage.

YIELD CHECKS: *A yield check is a calculation to determine if the correct amount of material was used in the work:*

$$\text{Yield (\%)} = \frac{\text{Quantity of material delivered}}{\text{Theoretical quantity required}} \times 100$$

Frequent yield checks are a good engineering practice, and they may help uncover problems in the work early in the project. Yield checks documented by inspectors provide a timely and valuable source of information to the Resident.

While performing yield checks are highly recommended for all materials used in the work, they are required to be documented for the following items:

<u>Item</u>	*<u>Frequency</u>*
HMA Paving	*Frequently, each day of paving"*

<u>End of the Documentation of Contract Quantities FY 2016 - page A-15 & A-16</u>

11. Yield Calculations

Two common **calculations** used to check the rate of tonnage placement are:

1. Theoretical Tons per Station (100 ft.)
2. Theoretical Lineal Feet of Mat per Truck Load

A. Determination of Theoretical Tons per Station (100 feet):

$$\mathbf{T} = \frac{RWN}{180}$$

WHERE:
- **T** = Theoretical tons of HMA per station (100 feet)
- **W** = Width of mat in feet
- **N** = Number of 100 foot stations
- **R** = 112* x inches of mat thickness

* Rate of application in lbs. per yd^2.
(One yd^2 of HMA, one inch thick is determined to be 112 lbs.)

EXAMPLE: GIVEN:

Actual mat width	=	13.5 ft	(**W**)
Theo. mat thickness	=	1.5 inches	
Actual tonnage per station	=	13.1 tons laid	

Find: **Tons per 100 ft station**

$$\mathbf{T} = \frac{(112 \times 1.5)(13.5)(1)}{180}$$

T = 12.6 Tons per 100 ft station

Yield using Tons per Station (100 ft)

Yield: $\frac{\text{Actual Tonnage}}{\textbf{Theoretical Tonnage (T)}} \times 100 = \%\ \text{Yield} \quad \frac{13.1}{12.6} \times 100 = 104.0\%$

NOTE: Actual tonnage greater (over yield) or less (under yield) than this figure would indicate thick or thin mat thickness and appropriate screed adjustments would be warranted.

Class Problem #1: At 1:00pm you have paved 7210 feet at a width of 14 feet (**W**), at a depth of 2 inches with 1287 tons. What is the yield?

Theoretical Tonnage (T) = $\frac{RWN}{180}$ =

% Yield = $\frac{\text{Actual Tonnage}}{\textbf{Theoretical Tonnage (T)}} \times 100$ =

B. Determination of Theoretical Lineal Feet of Mat per Truck Load:

$$D = \frac{18000\mathbf{L}}{\mathbf{RW}}$$

WHERE:

- **D** = Theoretical distance one truck load should go in lineal feet
- **L** = Tons of material in the load
- **W** = Width of mat in feet
- **R** = 112* x inches of mat thickness

***** Rate of application in lbs. per yd^2.
(One yd^2 of HMA, one inch thick is determined to be 112 lbs.)

EXAMPLE GIVEN:

Actual mat width	=	13.5 ft	(**W**)
Theo. Mat thickness	=	1.5 inches	
Truck Ticket	=	12.0 tons	(**L**)
Actual distance per load	=	92.2 ft	

Find: How far should the truck go in lin. ft?

$$\mathbf{D} = \frac{18000\ (12)}{112\ \ (1.5)\ \ 13.5}$$

D = 95.2 Lineal Feet

Yield using Lineal Feet per Truck Load

Yield: $\frac{\text{Theoretical Distance (D)}}{\text{Actual Distance}} \times 100$ = % Yield $\quad \frac{95.2}{92.2} \times 100 = 103.3\%$

NOTE: This distance should be paced or measured for random trucks. Dumping distances more or less than your calculations would indicate thin or thick mat thickness and appropriate screed adjustments would be warranted.

Class Problem #2: On a job, we are laying a mat 15 feet wide (**W**) at 3 inches thick. The truck ticket recorded a 21 ton load (**L**). This load paved a distance of 77 feet, what is the yield?

Theoretical Distance (D) $= \frac{18000\mathbf{L}}{\mathbf{RW}} =$

% Yield $= \frac{\textbf{Theoretical Distance (D)}}{\text{Actual Distance}} \times 100 =$

Beginning of the Standard Specification Article 406.13 (b), in part - 4th para.

"…Mixture for cracks, joints, and flange ways, leveling binder (machine method), leveling binder (hand method), and binder course in excess of 103 percent of the quantity specified by the Engineer will not be measured for payment.

Surface course mixture in excess of 103 percent of the adjusted plan quantity will not be measured for payment. The adjusted plan quantity for surface course mixtures will be calculated as follows.

Adjusted Plan Quantity = C x quantity shown on the plans or as specified by the Engineer

where C = : *English:* $C = \frac{G_{mb} \times 46.8}{U}$ *Metric:* $C = \frac{G_{mb} \times 24.99}{U}$

and where:	G_{mb}	=	*average bulk specific gravity from approved mix design*
	U	=	*unit weight of surface course shown on the plans in lb./sq. yds./in (kg/sq. m/25 mm), used to estimate plan quantity*
	46.8	=	*English constant*
	24.99	=	*metric constant*

If project circumstances warrant a new surface course mix design, the above equations shall be used to calculate the adjusted plan quantity for each mix design using its respective average bulk specific gravity…."

End of the Standard Specification Article 406.13 (b), in part - 4th para.

12. Example of quantity adjustment:

Mix design G_{mb}	=	2.345 @ 4.0% air voids
Unit weight (from plan sheets)	=	112 #/sq yd/ in
Mixture	=	19534 Surface mixture
Job plan quantities	=	10,000 tons

$$C = \frac{2.345\ (46.8)}{112} = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \text{ (3 decimal places)}$$

Maximum amount before correction	=	10,000 x 103%	=
Corrected plan quantities	=	10,000 x ______ (CF)	=
Maximum amount to be laid @ 103%	=	______ x 103%	=

Class problem for quantity adjustment:

Mix design G_{mb}	=	2.517 @ 4.0% air voids
Unit weight (from plan sheets)	=	112 #/sq yd/ in
Mixture	=	19544 Surface mixture
Job plan quantities	=	24,575 tons

Corrected plan quantities	=
Maximum amount to be laid @ 103%	=

NOTE: The rest of this chapter provides check lists that IDOT uses to determine Contractor compliance on jobs. The check lists can be beneficial in deciding what work is required to be completed on contracts.

Illinois Department of Transportation

Construction Inspector
Project Start Up Checklist

Contractor: ________________ Date: ________________________________

Bridge ID: _________________ QA Inspector's Name: __________________

Location: __________________

Contract No.: ______________ Signature: ___________________________

Project Start-Up Items	Yes	No	NA	Comments
1. Special Provisions Reviewed	☐	☐	☐	
2. Contractor's Qualifications submitted?	☐	☐	☐	
a. QP1/QP2 certifications	☐	☐	☐	
b. QC Manager qualifications	☐	☐	☐	
c. QC Technician qualifications	☐	☐	☐	
3. Submittals onsite and reviewed?	☐	☐	☐	
a. Contractor's Quality Control (QC) Program	☐	☐	☐	
b. Contractor's Inspection Access Plan	☐	☐	☐	
c. Contractor's Surface Preparation/Painting Plan	☐	☐	☐	
d. Abrasive Information	☐	☐	☐	
e. Contractor's Protective Covering Plan	☐	☐	☐	
f. Progress Schedule	☐	☐	☐	
g. Contingency Plan	☐	☐	☐	
h. Containment Plan (Lead Projects Only)	☐	☐	☐	
i. Environmental Monitoring Plan (Lead Projects Only)	☐	☐	☐	
j. Waste Management Plan (Lead Projects Only)	☐	☐	☐	
4. Contractor's inspection equipment onsite?	☐	☐	☐	
5. Specified coating materials onsite?	☐	☐	☐	
6. Test sections prepared and accepted?	☐	☐	☐	

BBS 2561 (0603)

Subject:
Placement of
Hot Mix Asphalt
Article 406.06

CONSTRUCTION MEMORANDUM 08-55

Effective: January 1, 2008

Expires: Indefinite

This Construction Memorandum supersedes Construction Memorandum No. 02-55, dated May 31, 2002.

Quality in Hot Mix Asphalt (HMA) construction can be achieved if field personnel have a full understanding of the mixtures being produced, the specification requirements for each mixture, the tests that are required to be taken, and how to identify and correct problems as they develop.

The purpose of this memorandum is to present to District field personnel many of the tools and procedures with which they need to be familiar to properly supervise the placement of HMA.

REFERENCES

Prior to the start of work, the Resident and staff should review the following documents:

- HMA pay item references in the Standard and Supplemental Specifications, special provisions, plan details and Construction Manual
- Manual of Test Procedures for Materials
- Bureau of Materials and Physical Research Policy Memoranda:

  Storage of Hot Mix Asphalt
  Approval of Hot Mix Asphalt Plants and Equipment

ASPHALT CONTENT & DENSITY

It is important that the Contractor, Resident, and Proportioning Technician know the percentage of asphalt to be used in each HMA mixture included in any particular project.

START-UP TEAM

The day prior to the HMA laydown, a meeting should be held with the Supervising Field Engineer, Resident and Contractor to discuss the procedures, guidelines and equipment to be used and to ensure that the rollers meet contract requirements.

If the test strip evaluation indicates changes need to be made in the mix, another test strip may be required. If the evaluation shows the mix to be satisfactory, the roller pattern will then be established.

Less compactive effort is not a proper answer to too much density. A mix with excess density potential, as identified by a growth curve, should not be used. Data associated with development of the growth curve should be clearly documented.

PAVER SPEED

The asphalt construction industry has recognized that continuous paver speed is essential to a smooth riding surface. Paver speed must be coordinated with both roller speed and plant production. Frequent start-stop operation of the paver should not be permitted. The Resident should check the speed of the paver and limit its maximum speed to that which is allowed by the Standard Specifications.

Bursts of paver speed to empty waiting truckloads of material makes it difficult to cover the mat with the established roller pattern. Usually, the faster the paver runs the lower the mat density will be behind the paver with a given rolling pattern/speed. Therefore, if a paver is permitted to run faster, additional compactive effort will be needed to achieve density.

AUTOMATIC GRADE CONTROL

The present Specifications (Article 406.06) for automatic grade control for asphalt pavers are based upon research which shows that a 30-foot (9 m) or longer ski provides a riding quality superior to that of the reference surface, a 10 ft (3 m) ski provides a riding quality equal to that of the reference surface, and a 6 in (150 mm) joint matching shoe provides a riding quality substantially poorer than that of the reference surface.

The Specifications reflect the results of the research data by requiring a minimum 30 ft (9 m) long ski on all lifts and passes except a 10 ft (3 m) long ski is permitted when placing HMA where traffic interference or sharp curves make the minimum 30-foot (9 m) ski impractical. While the use of a ski is mandatory, there are areas where it is impractical and/or impossible to use a ski. The Contractor may then be permitted to use manual grade control or a matching shoe. Such areas would include short-length low-speed intersection improvements, side street returns, entrances, and other miscellaneous areas where the Resident determines that neither length ski can be practically used.

When placing HMA within 200 ft (60 m) of a bridge abutment, Article 406.06 requires that the automatic grade control be operated from a present grade control stringline. This requirement should be strictly followed to ensure a smooth transition between pavement and bridge deck.

ROLLERS

Prior to the start of laydown operations, each roller shall be checked for compliance with the Specifications. Roller patterns shall be established during start-up operations on all HMA mixtures. The breakdown roller should be kept reasonably close to the paver. When HMA shoulders are placed simultaneously with the adjacent lane compaction on both the pavement and shoulder must be considered when establishing the rolling pattern. An additional roller may be required on the shoulder to obtain density at the paver's operating speed.

Vibratory roller speed and frequency of vibration must be matched to prevent transverse ridges which result from widely-spaced impacts. A vibratory roller operated at excessive speeds, producing impacts less than l0 blows per foot (30 blows per meter), results in a rough choppy surface.

Maximum vibratory roller speed can be calculated using the following formula:

$$\text{Max. Roller Speed} = \text{ft/min (m/min)} = \frac{\text{V.P.M.}}{\text{10 impacts/foot (30 impacts/meter)}}$$

V.P.M. = vibrations per minute (measured in field by reed tachometer)

Pneumatic-tired rollers should have a uniform tire pressure of not less than 80 p.s.i. (550 kPa)

DENSITY TESTS

We now recognize that over densification is one major cause of HMA problems. Mixtures that are over compacted will likely result in channeling and flushing under traffic. Fortunately, a nuclear density device can give us a quick indication of mix problems.
The proper density for a given mixture is dependent on the gradation and Ndesign used. These are listed in Section 1030 of the Standard Specifications.

HMA SHOULDERS

The top lift of HMA shoulders does not receive the kneading action of wheel loads to keep them "live." The durability of the top lift of the mixture is increased by adding 0.5% additional asphalt as that required by the approved mix design.

If a flushed condition is observed after the increase in asphalt content, the asphalt content shall be promptly lowered by 0.2% from the flushed condition. Coordination between the Resident and QC/QA personnel is needed to assure the top lift contains the required amount of asphalt.

The Contractor has the option of using HMA binder and surface course mixtures used for the mainline paving in lieu of HMA shoulder mixture for resurfacing of shoulders. If this option is used, the 0.5% increase in asphalt content for the top lift is not required.

Shoulder resurfacing widths of 6 ft (2 m) or less may be placed, at the Contractor's option, simultaneously with the adjacent traffic lane for both the binder and surface courses provided the specified density, thickness and cross slope can be satisfactorily constructed. The paver shall operate with both tracks/drive wheels on the traffic lane.

Shoulder resurfacing widths greater than 6 ft (2 m) shall be placed in a separate operation.

The quantity of HMA placed on the traffic lane will be limited to a calculated tonnage based upon actual mat width and length, plan thickness and design mix weight per inch (millimeter) of thickness. The difference between the total actual tonnage placed and the calculated tonnage used on the traffic lane will be paid for as HMA Shoulders.

Roger L. Driskell
Engineer of Construction

SAMPLE NOTIFICATION LETTER

Example Construction Company
101 Example Street
Example, Illinois 00000

Gentlemen:

On ___________________, the Hot Mix Asphalt (HMA) produced by your company had an asphalt content of _________ percent and/or a density of __________ percent. This does not meet the specification requirements contained in the contract.

Please bring this matter to the attention of the supervisory personnel of your company who are involved in the manufacture or placement of this material. Compliance with the contract requirements is the responsibility of your company and it is therefore important that your company take corrective action at the earliest possible moment.

Failure to take corrective action could result in suspension of the work, removal of the deficient material, or a reduction in contract price for the material in accordance with Article 105.03 of the Standard Specifications for Road and Bridge Construction.

We will cooperate with you in every way possible to eliminate this problem.

Very truly yours,

REGIONAL ENGINEER

By: ____

cc: (As applicable):
District Construction Engineer
Resident Engineer
Proportioning Technician
Supervising Field Engineer
District Materials Engineer
District Mixtures Control Engineer
District Laboratory Technician

State of Illinois
Department Of Transportation

CONSTRUCTION INSPECTOR'S CHECKLIST
FOR
HOT- MIX ASPHALT (HMA) BINDER AND SURFACE COURSE

While its use is not required, this checklist has been prepared to provide the field inspector a summary of easy-to-read step-by-step requirements relative to the proper construction of HMA Binder and Surface Courses (Section 406 of the Standard Specifications). The following questions are based on information found in the Standard Specifications, Highway Standards, Project Procedures Guide, and Construction Manual, Manual of Test Procedures for Materials, and current policy memorandums and letters.

Have you checked the contract Special Provisions, Supplemental Specifications and plans to see if any modifications have been made to the requirements listed herein? ____

1. **PRELIMINARY MEASUREMENTS & STATIONING**

Prior to any of the contractor's operations are you marking the pavement for beginning and ending stations? ____

Are you establishing and painting stations on the pavement and placing lath or white paint marks adjacent to the pavement wherever you will be imprinting stations in the surface course later? ____

2. **TRAFFIC CONTROL**

If the road is to remain open to traffic during the surfacing operations, is Article 701.17(c) being enforced? (Art. 406.04) ____

Are you studying the plan Traffic Control Standards, Traffic Control Plan, and pre-construction conference minutes to determine the positioning of signs and flaggers and how the contractor is to be paid for this work? ____

Has the resident submitted Form OPER 725, "Traffic Control Authorization Request"? ____

When shoulders are specified to be placed adjacent to the proposed resurfacing and the road will remain open to traffic, there shall be no more than 4 lane miles of new resurfacing adjacent to the shoulder without either:

- completing the shoulder
- providing barricades or vertical panels
- erecting "LOW SHOULDER" signs at 2 mile intervals

or

- constructing a temporary earth wedge against the edge of pavement and compacting it to the satisfaction of the Engineer. (Art. 701.07) ____

For edge of pavement/shoulder drop-offs exceeding 3 inches (75 mm), the contractor shall provide barricades or vertical panels according to Article 701.07). ____

Is the contractor keeping all vehicles and/or non-operating equipment parked away from the moving traffic stream in conformance with Article 701.11?

a. During working hours, 8 feet (2.5 m) from pavement if parked for 2 hours or less. ____

b. For equipment and vehicles parked during other working hours, and for all non-working hours, 30 feet (9 m), ROW permitting. When ROW doesn't permit, minimum of 15 feet (4.5 m). ____

Is the contractor keeping all equipment, materials and vehicles off the pavement and shoulder on the side of the pavement that is open to traffic? (Art. 701.08) ____

Flaggers shall be certified and provided as follows to direct traffic and protect the workers. (Art. 701.13)

a. Two Lane Highways – Two flaggers shall be required for each separate operation. Work operations controlled by flaggers shall be no more than 1 mile in length. ____

b. Multilane Highways – Flaggers shall be provided when traffic is restricted to less than the normal number of lanes with a posted speed limit greater than 40 mph and workers are present. One flagger shall be required for each separate activity of an operation that requires frequent encroachment in a lane open to traffic. ____

Are you periodically driving through the contract limits to check the effectiveness of the contractor's traffic control devices? ____

3. PREPARATION FOR EXISTING BRICK, PCC OR HMA BASES (Art. 406.05(a) , (Art. 406.05(c)& Art. 358.05)

If the HMA surfacing is to be placed on an existing PCC, brick or HMA concrete, the base shall be prepared as follows:

a. Remove all excess crack filler (tar) on the pavement and all crack filler from cracks and joints more than 1.5 inches (38 mm). ____

b. Soft and unstable HMA patches should be removed. ____

c. Areas of deep spalling and heavy disintegration shall be cleaned of all loose and unsound material with pneumatic tools or other approved equipment. ____

NOTE: The above "pavement cleaning" may be paid for at the contract unit price per square yard for PREPARATION OF BASE (Art. 358.07), but usually a pay item isn't included and the work is performed as extra work in accordance with Article 109.04. The pavement cleaning operation is a very labor-intensive process. Consult with your supervising field engineer to determine the exact scope of work to be performed as extra work.

Form BC 635, Extra Work Daily Report, must be prepared when extra work for pavement preparation is performed. Send copies to the contractor and your office. ____

Prior to placing prime and first course of bituminous concrete, are all open cracks and expansion joints having a width of 0.5 inch (13 mm) or more, and cracks and expansion joints which have been cleaned, being filled with Mixture for Cracks, Joints and Flangeways. (Art. 406.05(a)) ____

Deep spalls and heavily disintegrated areas that have been cleaned shall be filled with Leveling Binder (Hand Method). ____

4. BASE PREPARATION FOR AGGREGATE BASES

The base shall be prepared in accordance with Article 358.04. ____

5. BITUMINOUS MATERIAL SELECTION FOR PRIME COAT

Is the type of bituminous material that is used for the prime coat being selected from the table in Article 406.02? ____

6. PRESSURE DISTRIBUTOR

Is the prime being applied with a pressure distributor (Art. 1102.05) which is heated, equipped with clean spray nozzles of such design and size orifice as to ensure uniform distribution, and has been calibrated so as to apply the material at the specified rate? (Art. 403.10) ____

Is a hand spray bar being provided for applying material at places which are not covered by the distributor? (Art. 403.10) ____

7. DIRT ON PAVEMENT

Just before the prime is applied, is the existing base and gutter (if present) cleaned of all dust, dirt and foreign material? (Art. 406.05(b) Art. 358.05(b)) ____

Prior to all subsequent courses of construction, is the pavement being cleaned of all dirt, debris and loose material? The cost of this work is considered included in the various pay items involved. (Art. 406.06) ____

8. PLACING PRIME ON EXISTING PCC, BRICK OR HMA BASES (Art. 406.05(b))

Traffic will not be allowed on the primed surfaces of multi-lane pavements and the traffic control shall be according to Article 701.18(e)(2). ____

Is the prime applied at a rate of 0.05 to 0.10 gal/sy (0.2 to 0.5 L/m^2) for concrete, brick and HMA bases? (Art. 406.05(b)) ____

Is the pavement primed one lane at a time? ____

The following items should be followed when placing **non-emulsion** type prime:

a. Is the prime coat placed not less than one hour in advance of placement of HMA, and no prime coat shall be placed more than five days in advance of HMA resurfacing? ____

b. If the lane is to be opened to traffic is the prime coat covered immediately with fine aggregate, mechanically spread at a uniform rate of 2 to 4 lb./sy (1 to 2 kg./m^2)? ____

The following items should be followed when placing **emulsion** asphalt prime:

a. Is the temperature in the shade 60°F (15°C) or higher at the time of application? ____

b. Is HMA not placed over emulsified asphalt primer until the emulsion has broken and all free moisture has evaporated or drained off the surface? ____

c. Is the area primed limited to that which can be covered with HMA the same day? ____

9. PLACING PRIME ON AGGREGATE BASES (Art. 406.05(b)

Is the prime applied at the rate of 0.25 to 0.50 gal/sy (1 to 2 L/m^2)? ____

Is the prime coat permitted to cure until the penetration has been approved by the engineer, but a minimum of 24 hours? ____

Are pools of prime occurring in depressions being broomed or squeegeed over the surrounding surface the same day of application? ____

Is the base primed ½ width at a time? ____

If the lane is to be opened to traffic is the prime coat covered immediately with fine aggregate mechanically spread at a rate of 4 to 6 lb/sy (2 to 3 kg/m^2)? ____

10. PLANT & MATERIALS APPROVAL

Has the plant where the HMA is to be produced been approved? (Art. 1102.01) ____

Has the contractor notified you of proposed sources of materials prior to delivery? (Art. 106.01) ____

Has all material been inspected, tested and approved before incorporation in the work? (Art. 106.03) ____

Have mixture designs been verified and approved by the department? (Art.1030.04) ____

11. MINIMUM AIR TEMPERATURE

Is the air temperature in the shade at least 40° F (5°C) and rising when laying leveling binder and binder courses? 45° F (10°C) and rising when placing surface course? (Art. 406.06) ____

12. LEVELING BINDER (MACHINE METHOD)

When specified as a pay item in the contract, Leveling Binder (Machine Method) will be placed prior to the HMA binder or surface course and placed in accordance with the following:

a. Placed with a finishing machine. (Art. 1102.03) ____

b. Finishing machine shall be operated at a speed that shall ensure continuous operation (Art. 406.06(e)). ____

c. Placed and compacted in layers not exceeding a maximum depth of 2 in. (50 mm) (Art. 406.05(c)). ____

d. Total thickness placed in one day limited to 4 in. (100 mm) (Art. 406.05(c)). ____

e. Leveling Binder (Machine Method) will be compacted to the following density requirements: (406.05(c)(1))

(1) Lift thickness less than 1.25 in. (32 mm) will be compacted to he satisfaction of the engineer. (Art. 406.07) ____

(2) Lift thickness equal to or greater than 1.25 in. (32 mm) will be compacted to the density requirements of Article 406.07(c). ____

f. Refer to Article 406.07 (a), Table 1, for roller requirements. ____

13. SPREADING AND FINISHING MACHINE

Did you familiarize yourself with the mechanical features of the paver? (Art. 1102.03). ____

Is the HMA paver equipped with an automatic electronic grade control device for all courses of construction? ____

a. Capable of controlling the elevation of the screed relative to either a preset grade control stringline or a grade reference device traveling on the adjacent pavement surface (Art. 1102.03). ____

b. Traveling grade reference device shall not be less than 30 ft. (9m) in length. (Art. 1102.03) ____

c. The grade reference device may be shortened to no less than 10 ft. (3 m) when traffic interference or sharp curves make the minimum of 30 ft. (9 m) impractical. (Art. 406.06(e)) ____

d. When placing bituminous mixtures within 200 ft. (60 m) of a bridge abutment, the automatic grade control shall be operated from a present grade control stringline. (Art. 406.06(e)) ____

Pavers shall have a minimum 10 ft. (3 m) basic screed width for projects with greater than 7500 sy (6300 m^2). (Art. 1102.03) ____

Basic paver screed width of 8 ft. (2.4 m) minimum will be allowed for smaller projects with less than or equal to 7500 sy (6300 m^2). (Art. 1102.03) ____

Width extensions of the basic paver screed will have the same placement features and equipment functions as provided on the main body of the paver. (Art. 1102.03) ____

Augers shall be extended as additional sections of screed are bolted on or automatically adjustable screeds are extended. (Art. 1102.03) ____

14. PAVER OPERATING SPEED (Art. 406.06(e))

The operating speed of the paver shall not exceed the speed which is necessary to produce a uniformly spread and struck off mat having a smooth texture without tearing or segregation. ____

Paver speed shall not exceed the average rate of delivery of bituminous material to the paver providing continuous operation. ____

Paver speed shall be mated with the required roller speed. ____

Maximum paver speed of 50 ft. (15 m) per minute. ____

15. COMPACTION

Roller equipment shall meet the requirements of Article 1101.01. The minimum roller requirements for HMA construction are shown in Article 406.07(a), Table 1.

TABLE 1 - MINIMUM ROLLER REQUIREMENTS FOR HMA				
	Breakdown Roller (one of the following)	Intermediate Roller	Final Roller (one or more of the following)	Density Requirement
Level Binder: (When the density requirements of Article 406.05(c) do not apply.)	P 3/	- -	V_S, P 3/, T_B, T_F, 3W	To the satisfaction of the Engineer.
Binder and Surface 1/ Level Binder 1/: (When the density requirements of Article 406.05(c) apply.)	V_D, P 3/, T_B, 3W	P 3/	V_S, T_B, T_F	As specified in Articles: 1030.05(d)(3), (d)(4), and (d)(7).
Bridge Decks 2/	T_B	- -	T_F	As specified in Articles: 582.05 and 582.06.

1/ If the average delivery at the job site is 85 ton/hr (75 metric ton/hr) or less, any roller combination may be used provided it includes a steel wheeled roller and the required density and smoothness is obtained.

2/ One T_B may be used for both breakdown and final rolling on bridge decks 300 ft (90 m) or less in length, except when the air temperature is less than 60 °F (15 °C).

3/ A vibratory roller (V_D) may be used in lieu of the pneumatic-tired roller on mixtures containing polymer modified asphalt binder.

EQUIPMENT DEFINITION

V_s - Vibratory roller, static mode, minimum 125 lb/in. (2.2 kg/mm) of roller width. Maximum speed = 3 mph (5 km/h) or 264 ft/min (80 m/min). If the vibratory roller does not eliminate roller marks, its use shall be discontinued and a tandem roller, adequately ballasted to remove roller marks, shall be used.

V_D - Vibratory roller, dynamic mode, operated at a speed to produce not less than 10 impacts/ft (30 impacts/m).

P - Pneumatic-tired roller, max. speed 3 1/2 mph (5.5 km/h) or 308 ft/min (92 m/min). The pneumatic-tired roller shall have a minimum tire pressure of 80 psi (550kPa) and shall be equipped with heat retention shields. The self propelled pneumatic-tired roller shall develop a compression of not less than 300 lb (53 N) nor more than 500 lb (88 N) per in. (mm) of width of the tire tread in contact with the HMA surface.

T_B - Tandem roller for breakdown rolling, 8 to 12 tons (7 to 11 metric tons), 250 to 400 lb/in. (44 to 70 N/mm) of roller width, max. speed = 3 1/2 mph (5.5 km/h) or 308 ft/min (92 m/min).

T_F - Tandem roller for final rolling, 200 to 400 lb/in. (35 to 70 N/mm) of roller width with minimum roller width of 50 in. (1.25 m). Ballast shall be increased if roller marks are not eliminated. Ballast shall be decreased if the mat shoves or distorts.

3W - Three wheel roller, max. speed = 3 mph (5 km/h) or 264 ft/min (80 m/min), 300 to 400 lb/in. (53 to 70 N/mm) of roller width. The three-wheel roller shall weigh 10 to 12 tons (9 to 11 metric tons).

Is the contractor performing the start of HMA production in accordance with "Hot-Mix Asphalt QC/QA Start-up Procedures"? (Art. 1030.06) ____

a. A rolling pattern shall be established after an acceptable test strip is done, and within the first 200 tons (180 metric tons) after production resumes. If a mixture start-up is not required, an acceptable rolling pattern shall be developed during the first 300 tons (275 metric tons) of mixture produced. ____

16. <u>DENSITY REQUIREMENTS</u>

Is the contractor checking the density of the compacted HMA according to Articles 1030.05(d)(3), (d)(4) and (d)(7)? (Art. 406.07(c)) ____

17. <u>MIXTURE DELIVERY TEMPERATURE</u>

Are occasional temperature checks being taken from the delivered bituminous material while in the truck and recorded? ____

Temperature must be from 250°F – 350°F (120°C – 175°C) (Art. 406.06(b)) ____

18. <u>TRUCK REQUIREMENTS</u>

Do the trucks hauling the mixtures meet the following requirements? (Art. 1030.08)

a. Tight and clean dump bodies. ____

b. Completely insulated with at least $^3/_4$ inches (20 mm) insulating material on all sides, end and bottom of dump body when the air temperature is below 60°F (15°C)? ____

c. Equipped with a cover of canvas or other suitable material which shall be used if any one of the following conditions are met:

1. Ambient air temperature is below 60°F (15°C). ____
2. The weather is inclement. ____
3. The mat temperature behind paver is below 250°F (120°C). ____

d. The canvas shall be rolled back before dumping the bituminous mixture into the paver. ____

19. <u>BATCH PLANTS</u> (without a surge bin)

When the bituminous material is coming from a batch plant (Art. 1102.01), are the following requirements being met?

a. Is a load ticket recording the net weight of the material in the truck being submitted with each delivery? (Art. 406.13) ____

b. Are all load tickets picked up and initialed by the inspector at the jobsite? (Documentation Section of the Construction Manual) ____

c. Are check weights of full truckloads being done not more than once a week? (1102.01(b)(4)) (Documentation Section of the Construction Manual) ____

d. Are the tolerances falling within the percentages allowed? (Scale Accuracy = 0.5%; Weighman Accuracy = 0.5%) ____

e. Are all truck weight checks being reported in accordance with the Documentation Section of the Construction Manual? ____

20. **WITH SURGE CONTINUOUS, DRIER DRUM & BATCH PLANT BINS**

When the bituminous material is coming from a continuous plant, drier drum or a surge bin, are the following requirements being met? (Art. 1102.01)

a. Are the contents of each truck being determined by weighing on an approved scale equipped with automatic printers to the nearest 0.01 ton (0.01 metric tons)? (Art.406.13) Record Department of Agriculture scale certification date and number in Quantity Book. ____

b. Is the length of the platform scale long enough to accommodate all axles of the longest truck? ____

c. Are independent vehicle weight checks being made at least once a week? (Art. 109.01) ____

d. Are all load tickets being picked up and initialed by the inspector at the jobsite? (Documentation Section of the Construction Manual) ____

21. **ALIGNMENT CONTROL**

Is a stringline, offset from the edge of pavement, or other approved method being used to maintain a uniform edge alignment? (Art. 406.06(e)) ____

22. **LONGITUDINAL JOINTS**

Unless prohibited by stage construction, any bituminous concrete course lift shall be complete before construction of the subsequent lift. (Art. 406.06(g)) ____

Unless prohibited by stage construction, are longitudinal joints in all lifts being placed at the centerline of the pavement? (Art.406.06(g)) ____

When stage construction prohibits the total completion of a particular lift, the longitudinal joint in one lift shall be offset at least 3 inches (75 mm) from the longitudinal joint in the preceding lift. The longitudinal joint in the surface course will be at the centerline of two lane roadways. (Art. 406.06(g)) ____

23. TRANSVERSE CONSTRUCTION JOINTS

Is the transverse joint of previously-laid material cut back or formed with a header to expose a fresh vertical face that is at right angles to the centerline and to the specified thickness of the layer? (Art.406.06) ____

24. ROLLING

a. First lane:

Is the first lane of binder and surface course being rolled longitudinally by starting at the low edge and working towards the high edge, overlapping on successive trips to obtain uniform coverage? (406.07(b)) ____

b. Adjacent lanes:

Is the first pass of the roller, when placing an adjacent mat, made along the longitudinal joint on the fresh mixture with the compression wheel not more than 6 inches (150 mm) from the joint, the second pass of the roller not more than 12 inches (300 mm) on the previously-placed lane? (Art.406.07(b)) ____

Are the following passes being made from the low edge of pavement to the high edge, overlapping on successive trips to obtain uniform coverage? (Art.406.07(b)) ____

Note: Overlapping of success trips will be minimized when using vibratory rollers in the dynamic mode. Refer to the rolling pattern established during the bituminous start-up.

25. ROLLER TECHNIQUES

Are all steel-wheeled rollers being operated with the compression wheels toward the direction of paving? (Art.406.07(b)) ____

Are the speed and the time of rolling being watched to avoid undue displacement of the HMA? (Art.406.07(b)) ____

26. YIELD TESTS

In order to ensure that the mat thickness is running uniform and to ensure that the final tonnage will not be in excess of 103% (Art.406.13) of the authorized amount, are you performing frequent yield tests? ____

27. SHORT TERM PAVEMENT MARKINGS

Is pavement marking tape or paint being placed between all lanes that are open to traffic prior to the end of the day's work? (Art.703.04) ____

a. Yellow tape or paint, 48 inches (1.2 m) at 40-foot (12 m) intervals, is to be placed along the centerline of 2-lane highways. ____

b. White tape or paint, 48 inches (1.2 m) at 40-foot (12 m) intervals, is to be placed along the lane lines separating two or more lanes of traffic moving in the same direction. ____

c. Yellow tape or paint, 48-inch (1.2 m) sections at 40-foot (12 m) intervals, is to be placed along the centerline of undivided multi-lane highways. ____

d. Edge line markings will be required on multilane divided highways and other highways with a paved shoulder greater than 4 ft. (1.2m) wide. The markings shall consist of 48 inch (1.2m) stripes on 100 ft. (30m) centers installed at a 45° angle pointing in the direction of traffic. The color will match with proposed permanent striping. ____

Note: The paint option is not permitted on the final wearing surface. Also, the tape shall be transversely offset from the permanent markings and must be removed from the final wearing surface within 5 days after permanent pavement markings are placed.

28. FRAME AND GRATE ADJUSTMENT

When resurfacing existing pavement which has frames and grates of drainage and utility structures present at grade, is the adjustment of the casting to the finished elevation being performed prior to the surface course being placed? (Art. 603.03, 603.04) ____

29. SURFACE COURSE STATIONING

Are stationing imprints being placed in the surface course at the interval specified by your Construction office? ____

30. BUTT JOINTS

For locations specified in the plans, are butt joints being constructed as follows? (Art.406.08)

a. The contractor shall not begin construction of butt joints prior to beginning general operations on the project. ____

b. Temporary bituminous ramps shall be constructed immediately at all cut faces and they shall have a minimum taper rate of 1:40 (V:H). ____

c. Temporary rubber ramps may be used on roadways with permanent posted speeds of 55 mph or less at a minimum taper rate of 1:30 (V:H). ____

d. Temporary ramps shall be removed prior to placing the proposed surface course.

31. TAPERS

When butt joints aren't specified, are all tapers at the ends of the resurfacing section and at all railroad crossings being diminished uniformly to a featheredge at a rate of 1:240 (V:H)? At paved intersections, the bituminous resurfacing shall be feathered out in a distance of 10 ft. (3m) (Art.406.09) ____

Is the last 5 feet (1.5 m) of the taper getting an additional application of prime as specified in Article 406.02? (Art.406.09) ____

32. SURFACE COURSE SURFACE VARIATIONS

Each wheel lane in the completed surface course shall be tested for smoothness with a 16 ft (5 m) straightedge. The contractor shall furnish the straightedge and provide for its jobsite transportation. (Art.406.11) ____

The straightedge bolts shall be set at $^{3}/_{16}$ inch (5 mm) for all mainline pavement and also ramps which are posted over 40 mph (70 km/h). ____

The straightedge bolts shall be set at $^{3}/_{8}$ in. (10mm) for ramps which are posted for 40 mph (70 km/h) or less, acceleration and deceleration lanes, crossovers, side street returns and other miscellaneous pavement surfaces. ____

Prepare a report for your Construction Office which includes: the location of each bump, the total design thickness of binder and surface course, and whether or not re-profiling was performed. ____

Tonnage deductions shall be assessed in accordance with the following: ____

Binder and/or Surface Course Plan Thickness, inches (mm)	Surface Course Mixture Deduction Per Variation, ton (metric ton)
(Existing Surface Not Re-profiled)	
2 ¾ (70) or more Less than 2 ¾ (70)	2 (2) 1 (1)
(Existing Surface Re-profiled)	
All	2 (2)

Removal and replacement of the HMA shall be performed when the variation in surface course equals or exceeds $^{3}/_{4}$ in. (20mm) ____

Note: Leveling Binder (Machine Method) shall not be considered in determining the bituminous thickness for deductions.

33. <u>SEGREGATION</u> Art. 406.06(f)

The contractor and the engineer will evaluate the in place mat daily for segregation according to QC/QA document "Segregation Control of Hot-Mix Asphalt". ____

If medium or high segregation is identified, the contractor will implement corrective action. ____

34. <u>VERTICAL CLEARANCE</u>

Have you notified your district office of reduced vertical clearances under structures due to resurfacing? ____

35. <u>DOCUMENTATION OF FINAL CONTRACT QUANTITIES</u>

BITUMINOUS MATERIALS (PRIME COAT) will be documented as follows:

1. The specific gravity will be obtained from an approved Bill of Lading. Payment by volume (V) from weight tickets:

   a. $$V(Gal) = \frac{\text{Net Weight (Lbs.)}}{8.328 \times \text{Specific Gravity}}$$ ____

   b. $$V(L) = \frac{\text{Net Weight (kg)}}{\text{Specific Gravity}}$$ ____

2. Payment by volume from a meter ticket must be made using a Department of Agriculture approved meter ticket corrected for temperature. The truck distribution meter will not be accepted.

   V (Gallon or Liter) = Approved meter ticket with temperature correction ____

3. Payment by weight will be the net weight in tons (metric tons) from approved weight ticket. Record D.O.A. decal date, ID number and scale location. ____

Note: Payment will not be made for material in excess of 105% of the amount specified by the engineer. (Art.1032.02)

The following items will be paid for by the ton (metric ton) determined by weight tickets tabulated daily. Payment will not be made for bituminous mixtures in excess of 103% of the amount specified by the engineer.

MIXTURE FOR CRACKS, JOINTS AND FLANGEWAYS
LEVELING BINDER (MACHINE METHOD)
LEVELING BINDER (HAND METHOD)
BITUMINOUS CONCRETE BINDER COURSE
BITUMINOUS CONCRETE SURFACE COURSE

Note: The BITUMINOUS CONCRETE SURFACE COURSE is subject to an adjusted plan quantity based on the specific gravity of the mixture being used.

SHORT TERM PAVEMENT MARKING will be measured for payment as follows:

1. Placement will be paid at the contract unit price per foot (meter) for SHORT TERM PAVEMENT MARKING of the line width specified. (Art.703.07)

2. Removal of the markings will be paid for at the contract unit price per square foot (square meter) for WORK ZONE PAVEMENT MARKING REMOVAL. (Art.703.07)

Revised to conform with the
Standard Specifications for Road and Bridge Construction
Adopted January 1, 2007

State of Illinois
Department of Transportation

CONSTRUCTION INSPECTOR'S CHECKLIST
FOR
STABILIZED SUBBASE, BAM, CAM, PAM & CAM II

While its use is not required, this checklist has been prepared to provide the field inspector a summary of easy-to-read step-by-step requirements relative to the proper construction of Stabilized Subbase, BAM, CAM, PAM & CAM II (Section 312 of the Standard Specifications). The following questions are based on information found in the Standard and Supplemental Specifications, appropriate sections of the Construction Manual and current policy memorandums and letters.

Have you reviewed the Contract Special Provisions, Standard Specifications, Supplemental Specifications and Plans? ____

GENERAL - THE FIRST 7 QUESTIONS APPLY TO ALL BAM, CAM, PAM & CAM II STABILIZED SUBBASES.

1. <u>WIDTH DETERMINATION</u>

Is the stabilized subbase constructed to the width shown on the plans? ____

Example: The width of the subbase will be shown on the Highway Standard Drawing or plan detail for the pavement being constructed. The table below provides an example to determine the maximum pay width. The table is using 24 ft (7.2 m) wide pavement as the example.

METHOD OF PAVEMENT CONSTRUCTION	REQUIRED SUBBASE WIDTH	PAY WIDTH
Paving forms	18" + 24' + 18" = 450 mm + 7.2 m + 450 mm =	27 ft 8.2 m
Slipform paver	out-to-out of paver tracks + 3" (75 mm) each side	27 ft (8.2m) max.

Note: The additional width of subbase required for slip form paving shall be provided at no additional cost to the Department. (Article 420.14)

2. <u>SUBGRADE DENSITY</u>

Are in-place density tests being taken in the completed subgrade at the frequency of at least 1/1500 ft (1/450 m) of subgrade (Sampling Schedule 1, PPG) to ensure that not less than 95% density is being achieved? (Art. 301.04) ____

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3. **UNSTABLE SUBGRADE**

In cut sections and if necessary, is the Contractor being required to make the determined effort of obtaining density as outlined in Article 301.04? ____

Sometimes it may be necessary to undercut the unstable area. Is the excavation for removal and replacement of material being paid for in accordance with Article109.04? (Articles 301.04 & 301.12) ____

4. **PAVING STAKES**

Are paving stakes set prior to the fine grading of the earth subgrade left and right at 50 ft (15 m) intervals; 25 ft (7.5 m) intervals when any radius is less than 1000 ft (300 m)? ____

5. **TRIMMING**

Is the subgrade brought to true shape according to Article 301.07? ____

6. **SUBGRADE FIELD CHECK**

Is the fine-graded earth subgrade being checked for required grade and cross section before placing the stabilized subbase? ____

7. **DRAINAGE**

Is earth subgrade being kept drained by having lateral ditches cut through all adjacent berms of earth paralleling the subgrade? (Art. 301.08) ____

THE FOLLOWING IS A LISTING OF THE SPECIFIED FIELD REQUIREMENTS FOR EACH OF THE STABILIZING MATERIALS, BAM, CAM, PAM & CAM II.

8. **HMA, HOT-MIX ASPHALT**

Note: HMA is produced and tested according to the QC/QA specifications in Section 1030.

a. Delivery Temperature. Is the bituminous aggregate mixture being delivered at a temperature of 250 °F (120°C) to 350 °F (180°C) (Art. 312.05)? ____

b. Mechanical Spreader. Is the HMA mixture being deposited with a spreading and finishing machine? (Art. 312.05) ____

c. Transporting. Are you checking the temperature of the mixture behind the spreading and finishing machine? ____

Note: If the air temperature falls below 60° F, insulated and covered trucks will be required. (Art. 1030.08)

If the weather is inclement or if a mat temperature of 250° F (120° C) or higher cannot be maintained behind the paver screed, the truck shall be covered. (Article 1030.08)

e. Temperature Records. Is a record being kept of all temperature checks being made by the inspector? ____

f. Compaction Equipment. Is each lift being compacted to the required density with a vibratory roller and another type roller meeting the following requirements? (Art. 312.04) ____

(1) Vibrating rollers and vibrating compactors shall meet with the requirements of Article 1101.01(g).

(2) Three-wheel or tandem rollers: 6 tons (5.5 metric tons) to 12 tons (11 metric tons) total weight; 190 lbs. per inch (33N/mm) to 400 lbs. per inch (70 N/mm) of width of roller.

(3) Pneumatic-tired rollers: shall develop a compression of not less than 300 lbs. per inch (53 N/mm) width of tire tread.

(4) Trench rollers: 300 lbs. per inch (53 N/mm) to 400 lbs. per inch (70 N/mm) width on the compaction wheel.

g. Density Specimens. Are tests being taken at least once every 1/4 mile (0.4 km), per lift with a nuclear testing device? (Article 1030.05(d)(3)) ____

Note: The contractor and the engineer may agree density testing may be accomplished by cores.

Are all holes created by coring being refilled immediately with a bituminous mixture meeting the approval of the Engineer? ____

h. Density Requirements. Is the subbase being compacted to the following densities? (Art. 1030.05(d)(4))

(1) 93% to 97.4% ____

(2) 92% to 97.4% if placed on an unimproved subgrade. ____

i. Thickness Test. Are you taking a thickness test at every 250 ft (75m)? (Section A, Documentation Section of the Construction Manual) ____

9. <u>CAM, CEMENT AGGREGATE MIXTURE</u>

a. Air Temperature. Is the air temperature in the shade over 40 °F (4°C) when placing the CAM mixture? (Art. 312.09) ____

b. Moisture Content. Is the moisture content of the delivered CAM mixture within 80% to 110% of the optimum moisture determined? (Art. 312.11) ____

c. Placing. Is the CAM mixture being deposited, full subbase width, with a mechanical spreader or spreader box of a type approved by the Engineer, in a manner which will not cause segregation and which will require minimum blading or manipulation? (Art. 311.05(a) & 312.12) ____

d. Time Limits. Is compaction started within 60 minutes from the time water is added to the mixture? ____

Is compaction started within 30 minutes from the time the material is deposited on the roadbed? (Art. 312.12) ____

e. Thickness. Is the CAM subbase being constructed in one lift? ____

If the Contractor elects or if density cannot be complied with is the mixture being placed and compacted in two equal lifts? ____

If so, is the lower lift being maintained in a moist condition by means of a fine spray until the second lift is placed? ____

Just prior to placing the second lift, is the top 13 mm ($^1/_2$ inch) of the lower lift being scarified? (Art. 312.12) ____

f. Compaction. Is each lift being fully compacted within 2 hours of the time that the water is added to the mixture with any of the compaction equipment meeting the following requirements? (Art. 312.12) ____

(1) Three-wheel and tandem rollers: 6 tons (5.5 metric tons) to 12 tons (11 metric tons) total weight; 190 lbs. per inch (33 N/mm) 400 lbs. per inch (70 N/mm) of width. (Article 1101.01(e)) ____

(2) Pneumatic-tired rollers: shall develop a compression of not less than 225 lbs. per inch (40 N/mm) width of tire tread.(Article 1101.01(c)) ____

(3) Vibratory rollers: shall meet the requirements of Artricle 1101.01(g). ____

(4) Tamping rollers: (Sheeps-foot type) shall not be less than 8 ft (2.4 m) in width constructed in two or more independent sections having a minimum weight of 90 lbs. per inch (16 N/mm) width of drum. Must penetrate within 1 inch (25 mm) of the prepared subgrade on the initial rolling. (Articles 1101.01(d) &312.08 Note 2) ____

(5) Trench rollers: 300 lbs. per inch (53 N/mm) to 400 lbs. per inch (70N/mm) width of compaction wheel. (Article 1101.01(f) ____

g. Finishing. Is the surface of the compacted CAM being trimmed and finished when the initial compaction of the toplift is nearing completion? (Article (312.13) ____

Is the surface being sprayed with a fine mist to maintain the optimum moisture content during all finishing operations and until curing material is applied? (Art. 312.13) ____

h. Density Test. Are you taking density tests in the finished subbase? (The test should be taken at least every 1000 ft (300m) of subbase, Sampling Schedule 2, PPG) ____

i. Density Requirement. Are all areas that are found to have densities less than 100% being corrected or replaced? (Article 312.12) ____

j. Thickness Test. Are you taking a thickness test at every 250 ft (75m)? (Section A, Documentation Section of the Construction Manual) ____

k. Curing. Within 24 hours of the finishing operations, is the subbase surface being protected and covered 7 days by a uniform application of bituminous material at an application rate of approximately 1 L/m^2 (0.20 gal. per sq. yd)? (Art. 312.14) ____

i. Construction Joints. Are straight and vertical transverse construction joints being formed by cutting into the completed work at the end of each day's construction? (Art. 312.15) ____

10. <u>PAM, POZZOLANIC AGGREGATE MIXTURE</u> (312.21- 312.28)

a. Air Temperature. Is the PAM subbase being constructed within the dates shown in Article 312.18 of the Standard Specifications and only when the air temperature in the shade is above 40 °F (4°C)? (Article 312.18) ____

b. Placing. Is the PAM mixture being deposited, full subbase width, with a mechanical spreader or spreader box of a type approved by the Engineer, in a manner which will not cause segregation and which will require minimum blading or manipulation? (Art. 312.21) ____

c. Thickness. Is the PAM subbase being constructed in lifts of not more than 100 mm (4 inches) when compacted or as otherwise provided for in accordance with Article 312.21? ____

Is the lower lift being maintained in a moist condition by means of a fine spray until the second lift is placed? (Art. 312.21) ____

d. Compaction. Is each lift being fully compacted within 3 hours of the time water is added to the mixture (90 minutes if using cement flyash) with any of the compaction equipment meeting the following requirements? (Art. 312.21) ____

(1) Three-wheel and tandem rollers: 6 tons (5.5 metric tons) to 12 tons (11 metric tons) total weight; 190 lbs. per inch (33 N/mm) to 400 lbs. per inch (70 N/mm) of width. (Article 1101.01(e) ____

(2) Pneumatic-tired rollers: shall develop a compression of not less than 225 lbs. per inch (40N/mm) width of tire tread. (Article 1101.01(c)) ____

(3) Vibratory rollers: shall meet the requirements of Article 1101.01(g). ____

(4) Tamping rollers: (Sheeps-foot type) shall not be less than 8 ft (2.4 m) in width constructed in two or more independent sections having a minimum weight of 90 lbs. per inch (15 N/mm) width of drum. Must penetrate within 1 inch (25 mm) of the prepared subgrade on the initial rolling. (Articles 1101.01(d) & 312.17 Note 2) ____

e. Finishing. Is the surface of the compacted PAM being trimmed and finished within the initial compaction is nearing completion? (Article 312.21) ____

Is the surface being sprayed with a fine mist to maintain the optimum moisture content during all finishing operations and until curing material is applied? (Article 312.21) ____

f. Density Test. Are density tests being taken in the finished sub-base? (The test must be taken at least every 1500ft. (450m) of subbase, Sampling Schedule 2, PPG) ____

g. Density Requirements. Is the subbase being compacted to at least the following densities?

(1) If placed in one lift, 97% ____

(2) If placed in 2 lifts, 97% 1st lift; 100% 2nd lift. ____

h. Thickness Test. Are you taking a thickness test at every 250 ft (75m)? (Section A, Documentation Section of the Construction Manual) ____

i. Curing. Within 24 hours of the finishing operations, is the subbase surface being protected and covered 7 days by a uniform application of bituminous material at an application rate of approximately 0.20 gallons per sq. yd. ($1L/m^2$)? (Art. 312.22) ____

j. Construction Joints. Are straight and vertical transverse construction joints being formed by cutting back into the completed work at the end of each day's construction? (Art. 312.23) ____

11. CAM II, PLASTIC PORTLAND CEMENT

a. Air Temperature. Is the air temperature in the shade above 40°F (4°C) when placing CAM II? (Article 312.27) ____

b. Placing. CAM II may be placed in one lift by the use of either forms or slipform methods. (Article 312.27)

If forms are used, are the requirements of Article 420.06 regarding base support, setting, alignment and forms being followed? (Article 312.27) ____

Note: When forms are used, strikeoff may be with a vibratory screed.

If slipform methods are used, are the requirements of Article 420.14(c), being met? ____

Note: The slipform paver shall meet the requirements of Article 1103.16(b)

c. Time Limits. Is the CAM II being deposited in place within 30 minutes after mixing when hauled in nonagitating trucks and within 60 minutes when hauled in agitator trucks? (Art. 1020.11(a)(7)) ____

Note: The haul may be increased to 90 minutes if the air temperature is between 50 °F through 64 °F (10 °C through 17.5 °C) or a retarder is used.

d. Finishing and Testing. Are finishers checking the plastic CAM II with a 10 ft. (3 m) straightedge? ____

Are all surface variations greater than 3/16 inch (5 mm) being corrected? (Art. 312.28) ____

e. Air Content. Are you testing the delivered unconsolidated mixture for air (7 to 10%) at least every 1000 ft. (300 m) of subbase? Record and retain in job records. (Art. 312.26 & Sampling Schedule 2 of the PPG) ____

f. Slump. Are you periodically testing the delivered unconsolidated material for slump 1 inch - 3 inches (25 mm - 75 mm) at least every 1000 ft. (300 m)o f subbase (1 per day when slipforming)? Record and retain in job records. (Art. 312.26 & Sampling Schedule 2 of the PPG) ____

g. Curing. Is the entire surface of the subbase being given two separate uniform applications, separated by at least one minute, of agitated Type III (white) membrane curing compound? Application rate = 1 gal/ 250 sq ft (0.16 L/ sq m) (Articles 312.29 & 1020.13(a)(4)) ____

Is the spraying equipment self-propelled and does it meet the additional requirements of Article 1101.09? ____

GENERAL - THE LAST FOUR QUESTIONS APPLY TO ALL BAM, CAM, PAM & CAM II STABILIZED SUBBASES:

12. THICKNESS TEST

Are you cross sectioning or probing the stabilized subbase at intervals of at least every 250 ft. (75 m)? (Section A, Documentation Section of the Construction Manual) ____

13. NOMINAL THICKNESS

Is the thickness of completed stabilized subbase constructed to the nominal plan thickness? If not, corrective action must be taken prior to the pavement construction. (312.31) ____

14. DOCUMENTATION OF CONTRACT QUANTITIES

a. If the Contractor and the Engineer agree in writing (Form BC-981) that the plan quantity of STABILIZED SUBBASE is accurate, no surface area measurements will be required. (Articles 312.32(a) & 202.07(a)) ____

In the absence of the written agreement, documentation shall be provided as follows:

b. The subbase shall be measured in place and the area computed in square yards (square meters). The width dimension used shall not exceed the width determined in Question #1 of this checklist. (Article 312.32(b)) ____

Revised to conform with the
Standard Specifications for Road and Bridge Construction
Adopted January 1, 2007

State of Illinois
Department Of Transportation

CONSTRUCTION INSPECTOR'S CHECKLIST
FOR
HOT- MIX ASPHALT (HMA) PAVEMENT (FULL DEPTH)

While its use is not required, this checklist has been prepared to provide the field inspector a summary of easy-to-read, step-by-step requirements relative to the proper construction of Hot-Mix Asphalt Pavement (Full Depth). The following questions are based on and referenced to information found in the Standard Specifications, Construction Manual, and current policy memorandums and letters.

Have you reviewed the contract Special Provisions, Supplemental Specifications and Plans? ____

1. GENERAL

Is the HMA Pavement (Full-Depth) being constructed according to the applicable portions of Section 406 of the Standard Specifications? Review the applicable requirements in the Construction Inspector's Checklist for HMA Binder and Surface Course. ____

2. SUBGRADE

Is the subgrade prepared according to Section 301 of the Standard Specifications except Articles 301.05 and 301.06 will not apply? (Art. 407.05) ____

If a lime modified soil layer is specified, is it constructed in accordance with Section 302 of the Standard Specifications? ____

a. The lime-modified soil layer shall be compacted to not less than 95% of the standard dry density. The in place density of the completed subgrade will be tested at least every 1500 ft (450 m). ____

b. The surface of the lime-modified soil shall be brought to true shape and correct elevation according to Article 301.07. ____

c. Trimmings from the lime treated subgrade shall be removed prior to placement of the binder course. (Art. 407.06) ____

3. PLACEMENT

Is the HMA binder and surface courses placed according to Article 406.06 and the following?

The compacted thickness of the initial lift of binder course shall be 4 inches (100 mm) thick. ____

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Succeeding binder lifts shall be the minimums specified in Article 406.06(d) but no more than 4 inches (100 mm) thick when compacted. ____

The compacted lift thickness of the layers of binder excluding the top lift may be increased to 6 inches (150 mm) if a vibratory roller is used for breakdown, and the required density is obtained. ____

Longitudinal joints shall be constructed in accordance with Article 406.06(g). ____

Each lift of compacted HMA mixture shall be clean when the next lift is placed. ____

A light fog of prime coat shall be applied between lifts of HMA, when directed by the Engineer. ____

a. The application rate shall be 0.02 gal./square yard (0.1 L/m^2) ____

4. **HAULING ON PARTIALLY COMPLETED PAVEMENT**

Are trucks only permitted on partially completed pavement only to deliver bituminous mixture to the paver, except that hauling on partially completed segments will be permitted according to the following table. (Art. 407.08) ____

Load Limit Restrictions		
	Type of Hauling Traffic	
Total Lift Thickness in (mm)	Below 85^{O}F (30^{o}C)	85^{o}F (30^{o}C) & above
4-7 inches (100-180 mm)*	Unloaded	None
7-9.5 inches (180-240 mm)*	Legally Loaded	Unloaded
Greater than 9.5 inches (240 mm)**	Legally Loaded	Legally Loaded

* With the last lift having cooled a minimum of 24 hours.

** With the last lift having cooled a minimum of 12 hours.

A traffic pattern shall be established that prevents "tracking" of vehicles one directly behind the other. ____

Crossovers shall be used to transfer haul trucks between roadways. ____

a. Spaced not less than 1000 ft (300 m) apart. ____

b. Constructed of a material that prevents tracking dust or mud on the completed HMA layers. ____

c. Constructed, maintained and removed at the contractor's expense. ____

5. PIPE UNDERDRAINS

Placement of underdrains, when specified, should be in accordance with Section 601 of the Standard Specifications and Standard 601001. ____

Construction of underdrains shall not be started until at least 9.5 in (240 mm) of bituminous concrete binder is placed. (Art. 407.07) ____

Material excavated from the underdrain trench shall not be deposited or windrowed on any portion of the full-depth pavement. (Art. 407.07) ____

6. SURFACE TESTS

The finished surface of the pavement shall be tested using a California Profilograph or a 16 ft (5 m) straightedge. (Art. 407.09)

16 ft (5 m) straightedge will be used on the following pavement surfaces:

a. Locations listed in the following Table shall be tested in the wheel path with the 16 ft (5 m) straightedge set to the tolerance specified. ____

Location	Tolerance
Ramps, Loops and Climbing Lanes	$^1/_4$ in (6 mm)
Mainline Gaps ≤ 0.1 mile (160 m)	$^1/_4$ in (6 mm)
Bridge Approaches	$^1/_4$ in (6 mm)
Side Roads & Side Streets > 600 ft (180 m) in length	$^1/_4$ in (6 mm)
50 ft (15 m) from Bridge Approaches, Wideflange Beam Terminal Joint, Existing Pavement or Mainline Gaps	$^1/_4$ in (6 mm)
All curves ≤ 1000 ft (300 m) radius including SE transitions	$^3/_8$ in (10 mm)
Acceleration Deceleration Lanes	$^3/_8$ in (10 mm)
Side Streets ≤ 600 ft (180 m) in length	$^3/_8$ in (10 mm)
Turn Lanes, Storage Lanes and Crossovers, Etc.	$^3/_8$ in (10 mm)
Intersections	$^3/_8$ in (10 mm)

b. Mainline pavements with less than or equal to 40 mph (70 km/h) will be tested in the wheel paths with a 16 ft (5 m) straightedge set to a $^3/_{16}$ in (5 mm) tolerance. ____

c. Mainline pavements with greater than 40 mph (70 km/h) with a net project length of less than 1 mile (1600 m) will be tested in the wheel path with a 16 ft (5 m) straightedge set to a $^3/_{16}$ in (5 mm) tolerance. ____

d. All surface variations that exceed the above tolerance shall be removed with an approved grinding device consisting of multiple saws. ____

e. The contractor will furnish and provide jobsite transportation for the 16 ft (5 m) straightedge. ____

Profilograph – All mainline pavement shall be tested with a California Profilograph, except the mainline pavement previously specified for testing with a16 ft (5 m) straightedge. ____

a. The Profile Index and Price Adjustments will be determined in accordance with Article 407.09(b)(1). ____

b. Corrective work will be in accordance with Article 407.09(b)(2). ____

7. **THICKNESS TESTS**

Is the determination of the pavement thickness performed in accordance with Article 407.10? ____

8. **DOCUMENTATION OF FINAL QUANTITIES**

HMA Pavement (Full-Depth) will be paid for at the contract unit price per square yard (square meter) of the type and thickness specified.

a. Contract Quantities – The requirements for the use of contract quantities shall conform to Article 202.07(a). Form BC 981, Agreement on Accuracy of Plan Quantities, must be signed and on file prior to starting work. (See Documentation Section of the Construction Manual). ____

b. Measured Quantities – Pavement will be measured in place and the quantity for payment shall be computed in square yards (square meters). The maximum width for payment shall be the top width of the HMA course as shown on the plans. (Art. 407.11(b)) ____

Light fog tack coat of prime, when required between lifts, shall be paid according to Article 109.04. ____

If the contract requires the contractor to furnish a profilograph, all costs associated with maintenance and jobsite transportation will be paid for at the lump sum price for FURNISH PROFILOGRAPH. (Art. 407.12) ____

Revised to conform with the
Standard Specifications for Road and Bridge Construction
Adopted January 1, 2007

State of Illinois
Department of Transportation

CONSTRUCTION INSPECTOR'S CHECKLIST FOR HOT- MIX ASPHALT (HMA) SHOULDERS

While its use is not required, this checklist has been prepared to provide the field inspector a summary of easy-to-read step-by-step requirements relative to the proper construction of Hot-Mix Asphalt Shoulders (Section 482). The following questions are based on information found in Standard Specifications, Highway Standards and Construction Manual.

Have you checked the contract Special Provisions, Supplemental Specifications and Plans?. ____

1. GENERAL

The work shall consist of constructing a HMA shoulder on a prepared subgrade, existing paved shoulder, or subbase. ____

HMA shoulders shall not be placed on frozen or muddy subgrade. ____

For pavement and shoulder resurface projects, HMA binder and surface course mixtures the same as that specified for the mainline pavement may be used in lieu of HMA shoulder mixture for the resurfacing of shoulders at the option of the contractor. ____

Shoulder strips (12 in (300mm)) shall be constructed of the HMA binder and surface course mixtures as that specified for the mainline pavement. ____

2. SHOULDER GRADES

a. Calculate and mark on the pavement edge, for both tangent and superelevated areas, the subgrade cut and offset for the shoulder structure shown on the plans. ____

b. Prior to bituminous placement, the earth subgrade should be checked with an instrument or hand template to ensure the required depth and cross section of the completed shoulder will be obtained. Refer to THICKNESS TESTS. ____

3. SUBGRADE

The subgrade shall be prepared according to Section 301. ____

The subgrade shall be compacted to not less than 95% of the standard dry density and have a minimum IBV of 8.0. The in place density of the completed shoulder subgrade will be tested every 1500 ft (450 m) (Sampling Schedule I, PPG). ____

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When HMA shoulders are constructed adjacent to a pavement constructed on an improved (lime-modified) subgrade and additional material is needed to extend the improved subgrade to the bottom of the HMA shoulder, the additional material shall be subbase granular material, Type C, conforming to Section 311 (Art. 482.04 and Standard 482001). ____

The subgrade shall be drained during the placing and compacting of the bituminous shoulder by cutting lateral ditches through any adjacent berms of earth. ____

4. PLANT AND MATERIALS

HMA Mixtures will meet the following requirements:

a. Materials will meet the requirements of Section 1030. ____

b. Hot-Mix Plant will meet the requirements of Article 1102.01. ____

c. The amount of asphalt binder used in the top lift of HMA shoulder mixture shall be increased 0.5 percent more than required in the mix design. (Art. 482.02) ____

d. The HMA shall be delivered at a temperature of 250° to 350° F (120° - 175° C) (Art. 312.05)

5. EQUIPMENT REQUIREMENTS

a. The transportation of the HMA mixture shall conform to Article 1030.08. ____

b. Spreading and finishing machine. (Art. 312.04) ____

c. Tandem rollers shall be 6 to 12 tons (5.5 to 11 metric tons) total weight; 190 to 400 pounds per inch (33 to 70 N/mm) of width on drive wheel(s). (Art. 312.04) ____

d. Self-propelled pneumatic-tired roller; not less than 300 pounds per inch (53 N/mm) of width of tire tread in contact with the HMA surface, tire pressure, 60 to 120 psi (415 to 825 kPa). (Art. 312.04) ____

e. Vibrating rollers shall meet the requirements of Article1101.01(g). ____

f. Trench roller, 300 to 400 pounds per inch (53 to 70 N/mm) of width on the compaction wheel. (Art. 312.04) ____

6. **TEMPERATURE RECORDS**

Occasional temperature checks shall be taken and recorded from the delivered material in the truck and behind the spreading machine. ____

7. **PLACING AND COMPACTING**

The bottom lifts shall be placed with a mechanical spreader approved by the Engineer. The machine shall be operated from the mainline pavement. (Art. 482.05) ____

When the shoulder width is 10 ft (3m) or greater, the top lift shall be placed with a spreading and finishing machine. (Art. 482.05) ____

The HMA mixture shall be spread to provide a minimum compacted lift in accordance with the table below. A maximum compacted lift of 6 in (150 mm) is allowed provided the required density is obtained. (Art. 312.05) ____

Nominal Maximum Aggregate Size of Mixture	Minimum Compacted Lift Thickness
CA 12 – ½ in (12.5 mm)	1 ½ in (38 mm)
CA 10 – ¾ in (19 mm)	2 ¼ in (57 mm)
CA 6 – 1 in (25 mm)	3 in (75 mm)

The top lift shall be a maximum 3 in (75 mm) compacted layer. (Art. 482.05) ____

Each layer shall be compacted using a vibratory compactor and a tandem roller. ____

On resurfacing projects with shoulder width of 6 ft (1.8 m) or less, the shoulder resurfacing may be placed simultaneously with the traffic lane. ____

Shoulder resurfacing with widths greater than 6 ft (1.8 m) shall be placed in a separate operation. ____

8. **DENSITY REQUIREMENTS**

The HMA shoulder shall be compacted to meet the following density requirements (Art. 1030.05 (3) (4)):

a. The first layer shall be compacted to not less than 92% of the theoretical density. ____

b. Subsequent layers shall be compacted to 93% to 97.4% of the theoretical density. ____

c. The density of each layer will be obtained by approved nuclear methods or from specimens furnished by the contractor.

d. Density testing frequency is one test per 1/2 mile (800 m) per lift, per side, randomly located. (Sampling Schedule 4, PPG). ____

9. <u>THICKNESS TEST</u> (Art. 482.06)

The thickness of the bituminous shoulder will be checked at least every 1000 ft (300 m) when the shoulder is constructed and paid for as a square yard (square meter) unit of measure. (See Documentation Section of the Construction Manual)

a. Before and after cross sections with a rod and level, or before and after measurements taken from an established reference elevation such as a stringline or edge of pavement. ____

b. Shoulder areas less than 90% of the plan nominal thickness shall be brought to the proper thickness by placing additional shoulder material or by complete removal and replacement of the deficient shoulder area. ____

c. If corrective action is needed, the final shoulder elevation shall not exceed the plan elevation or elevation established by the engineer by more than 1/8 in (3 mm). ____

10. <u>RUMBLE STRIPS</u> (Section 642)

a. Rumble strip pattern will be as shown on the plans or Standard 642001. ____

b. Corrugations shall be omitted when falling within the limits of a structure, sideroad, entrance or ramp entrance and exit. ____

c. Equipment shall be a self-propelled milling machine with a rotary-type cutting head(s). ____

11. <u>DOCUMENTATION OF FINAL CONTRACT QUANTITIES</u>

When HMA shoulders are constructed along the edges of the completed pavement structure, the HMA shoulder will be paid for at the contract unit prices per square yard (square meter) for HMA Shoulders of the thickness specified. The method of measurement shall be as follows:

a. Contract Quantities – The requirements for the use of contract quantities shall conform to Article 202.07(a). ____

b. Measured Quantities – The shoulder shall be measured in place and the area completed in square yards (square meters). The width for measurement will be from the edge of the pavement to the top edge of the HMA shoulder as shown on the plans or as directed by the engineer. ____

When existing shoulders are overlaid in conjunction with a pavement and shoulder resurfacing project, HMA shoulders will be measured for payment in tons (metric tons), according to Article 406.13, except the requirement that payment will not be made for any HMA mixture in excess of 103% of the quantity specified by the engineer will not apply.

When the contractor chooses the option to place HMA shoulders using HMA binder and surface mixture simultaneously with the traffic lane, the following shall apply (Art. 406.13):

a. The quantity of HMA mixture placed on the traffic lane will be limited to a calculated tonnage based upon actual mat width and length, plan thickness or a revised thickness authorized by the engineer, and design mix weight per inch (millimeter) of thickness.

b. The difference between the total actual tonnage placed and the calculated tonnage used on the traffic lane will be measured and paid for as HMA Shoulders according to Section 482.

When a HMA wedge is placed simultaneously with the binder course as specified in Article 406.10, the quantity of binder course placed on the traffic lane will be limited to 103% of the quantity specified by the engineer. The difference between the total actual tonnage placed and 103% of the tonnage specified by the engineer will be measured and paid for as Bituminous Shoulders according to Section 482.

The HMA binder and surface course mixtures used in construction of shoulder strips for pavement resurfacing will be measured for payment in tons (metric tons) as specified in Article 406.13, except that the thickness of surface course will be limited to that specified for the adjacent resurfacing. Surface course used in excess of this amount will be measured for payment as binder course.

Revised to conform with the
Standard Specifications for Road and Bridge Construction
Adopted January 1, 2007

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HMA TEST STRIP GUIDELINES

I. Purpose

A. Verification of HMA Lab Design in Field

B. Determine the characteristics and density potential of the HMA

II. Test Strip

A. Growth Curve - Density Potential – on mixture quantities exceeding 3000 ton

1. HMA Mix

a. Approved mix design

b. Prior usage of mixture

c. Adjusted gradation prior to production - AJMF and Target Values

d. Selection of sites (based on tonnage)

e. Evaluate 300 tons of mixture

f. Plant production does not shut down

g. No pay item (incidental to the contract)

2. Compaction Equipment

a. Vibratory roller – 1101.01(g)

- Speed & frequency (10 impacts/ft) mated to paver

b. State checks/verification

3. Constructing Test Strip

a. Best/Ideal Conditions

- HMA temperature - 280° F minimum

- Tarped & insulated trucks

- Rollers filled with water and caught up

- Best location

- Batch plant (from pug mill)

b. Procedure

- Use of nuclear gauge/experienced operator

  1 minute readings

- Single passes of vibratory roller

- Plot results – identify a double break

- Completion

  3 tests show no upward trend

  Evidence of mat destruction

c. MF and cores after completion

4. Evaluation of Growth Curve

a. Nuclear gauge - past history

b. Density potential

- Article 1030.05(d)(4)

c. Evaluate other mix parameters (visual characteristics and plant tests)

d. Agreement of Contractor/Engineer

B. Rolling Pattern

1. Contractor determines number of passes and roller train

a. Based on agreement of AJMF and Targets

b. Engineer in agreement

c. State and Contractor spot checks for density

2. Nuclear/Core correlation location

a. 3 locations

b. Contractor & State correlations performed jointly

c. Correlation completed prior to next production day

C. Documentation

1. Contractor will provide all test strip information

III. Finalized Test Strip

A. Agreement between Contractor and State

1. Plant test results

2. Growth curve results

3. Additional adjustments = additional growth curve/testing

B. Resume production for the rest of the day at Contractor’s own risk

C. JMF adjustment limits/new mix design

- Article 1030.06 (a) paragraph 4

D. Hamburg Wheel test

E. I-FIT (Illinois Flexibility Index Test)

<u>Beginning of Standard Specification Article 1030.06</u>

"*1030.06 Start of HMA Production and Job Mix Formula (JMF) Adjustments.* *The start of HMA production and JMF adjustments shall be as follows.*

(a) High ESAL, IL-4.75, WMA, and SMA Mixtures. For each contract, a 300 ton (275 metric tons) test strip will be required at the beginning of HMA production for each mixture with a quantity of 3000 tons (2750 metric tons) or more according to the Manual of Test Procedures for Materials "Hot Mix Asphalt Test Strip Procedures".

Before start-up, target values shall be determined by applying gradation correction factors to the JMF when applicable. These correction factors shall be determined from previous experience. The target values, when approved by the Engineer, shall be used to control HMA production. Plant settings and control charts shall be set according to target values.

Before constructing the test strip, target values shall be determined by applying gradation correction factors to the JMF when applicable. After any JMF adjustment, the JMF shall become the Adjusted Job Mix Formula (AJMF). Upon completion of the first acceptable test strip, the JMF shall become the AJMF regardless of whether or not the JMF has been adjusted. If an adjustment/plant change is made, the Engineer may require a new test strip to be constructed. If the HMA placed during the initial test strip is determined to be unacceptable to remain in place by the Engineer, it shall be removed and replaced.

The limitations between the JMF and AJMF are as follows.

Parameter	*Adjustment*
1/2 in.	*± 5.0 %*
No. 4	*± 4.0 %*
No. 8	*± 3.0 %*
No. 30	***
No. 200	***
Asphalt Binder Content	*± 0.3 %*

** In no case shall the target for the amount passing be greater than the JMF.*

Any adjustments outside the above limitations will require a new mix design.

Mixture sampled to represent the test strip shall include additional material sufficient for the Department to conduct Hamburg Wheel testing according to Illinois Modified AASHTO T324 (approximately 60 lb. (27 kg) total).

The Contractor shall immediately cease production upon notification by the Engineer of failing Hamburg Wheel test. All prior produced material may be paved out provided all other mixture criteria is being met. No additional mixture shall be produced until the Engineer receives passing Hamburg Wheel tests.

The Department may conduct additional Hamburg Wheel tests on production material as determined by the Engineer.

(b) Low ESAL Mixtures. In the field, slight adjustments to the gradation and/or asphalt binder content may be necessary to obtain the desired air voids, density, uniformity, and constructability. These adjustments define the Adjusted Job Mix Formula (AJMF) and become the target values for quality control operations. Limitations between the JMF and AJMF are as follows. Any adjustments outside the limitations will require a new mix design.

Parameter	Adjustment
1/2 in. (2.5 mm)	± 6 %
No. 4 (4.75 mm)	± 5 %
No. 200 (75 µm)	± 2.5 %
Asphalt Binder Content	± 0.5 %

Production is not required to stop after a growth curve has been constructed. The test results shall be available to both the Contractor and Engineer before production may resume the following day.

During production, the Contractor and Engineer shall continue to evaluate test results and mixture laydown and compaction performance. Adjustments within the above requirements may be necessary to obtain the desired mixture properties. If an adjustment/plant change is made, the Engineer may request additional growth curves and supporting plant tests."

End of Standard Specification Article 1030.06

Beginning of Hot Mix Asphalt Test Strip Procedures Appendix B4

"Illinois Department of Transportation

Hot Mix Asphalt Test Strip Procedures
Appendix B4

Effective: May 1, 1993
Revised: December 1, 2017

For mixtures where the quantity exceeds 3000 tons (2750 metric tons), the Contractor and the Department shall evaluate the mixture to be produced for each contract using a 300 ton test strip. The Contractor shall follow the following procedures for constructing a test strip.

A. Contractor/Department Test Strip Team

A team of both Contractor and Department personnel shall construct a test strip and evaluate mix produced at the plant.

The test strip team may consist of the following, as necessary:

1. *Resident Engineer*
2. *District Construction Supervising Field Engineer, or representative*
3. *District Materials Mixtures Control Engineer, or representative*
4. *Contractor's QC Manager, required*
5. *Contractor's Density Tester*
6. *Central Bureau of Materials representative when requested*
7. *Bureau of Construction representative when requested*

B. Communications

The Contractor shall advise the team members of the anticipated start time of production for the mix. The QC Manager shall direct the activities of the test strip team. A Department-appointed representative from the test strip team will act as spokesperson for the Department.

C. Acceptance Criteria

1. *Mix Design and Plant Proportioning - The mix design shall be approved by the Department prior to the test strip. Target values shall be provided by the Contractor and will be approved by the Department prior to constructing the test strip.*

2. *Evaluation of Growth Curves - Mixtures which exhibit density potential less than or greater than the density ranges specified in Article 1030.05(d)(4) shall be considered to have a potential density problem which is normally sufficient cause for mix adjustment.*

   If an adjustment has been made, the Engineer may require an additional test strip be constructed and evaluated. This information shall then be compared to the AJMF and required design criteria for acceptance.

3. *Evaluation of Required Plant Tests - If the results of the required plant tests exceed the JMF target value control limits, the Contractor shall make allowable mix adjustments/plant changes, resample, and retest. If the Engineer determines additional adjustments to the mix will not produce acceptable results, a new mix design may be required.*

D. Test Strip Method

The Contractor shall produce 300 tons (275 metric tons) of mix for the test strip.

The test strip will be included in the cost of the mix and will not be paid for separately since the Contractor may continue production, at their own risk, after the test strip has been completed.

The procedures listed below shall be followed to construct a test strip.

a. *Location of Test Strip - The test strip shall be located on a relatively flat portion of the roadway. Descending/ascending grades or ramps should be avoided.*

b. *Constructing the Test Strip - After the Contractor has produced and placed approximately 225 to 250 tons (200 to 225 metric tons) of mix, paving shall cease and a growth curve shall be constructed. After completion of the first growth curve, paving shall resume for the remaining 50 to 75 tons (45 to 70 metric tons), and the second growth curve shall be constructed within this area.*

   The Contractor shall use normal rolling procedures for all portions of the test strip except for the growth curve areas which shall be compacted solely with a vibratory roller as directed by the QC Manager.

c. *Required Plant Tests - A set of mixture samples shall be taken at such a time as to represent the mixture in between the two growth curve trucks.*

   The mixture sampled to represent the test strip shall also include material sufficient for the Department to conduct a Hamburg Wheel test according to Illinois modified AASHTO T 324.

E. <u>Compaction Requirements</u>

1. *Compaction Equipment - The Contractor shall provide a vibratory roller meeting the requirements of Article 1101.01(g) of the Standard Specifications. It shall be the responsibility of the test strip team to verify specification compliance before commencement of growth curve construction. An appropriate amplitude shall be selected on the basis of roller weight and mat thickness to achieve maximum density. The vibratory roller speed shall be balanced with frequency so as to provide compaction at a rate of not less than 10 impacts per 1 ft. (300 mm).*

2. *Compaction Temperature - In order to make an accurate analysis of the density potential of the mixture, the temperature of the mixture on the pavement at the beginning of the growth curve shall not be less than 280° F (140° C).*

3. *Compaction and Testing - The Contractor shall direct the roller speed and number of passes required to obtain a completed growth curve. The nuclear gauge shall be placed near the center of the hot mat and the position marked for future reference. With the bottom of the nuclear gauge and source rod clean, a 1-minute nuclear reading (without mineral filler) shall be taken after each pass of the roller. Rolling shall continue until a growth curve can be plotted, the maximum density determined, and three consecutive passes show no appreciable increase in density or evident destruction of the mat.*

4. *Final Testing - A core shall be taken and will be secured by the Department from each growth curve to represent the density of the in-place mixture. Additional random cores may be required as determined by the Engineer.*

F. Nuclear/Core Correlation

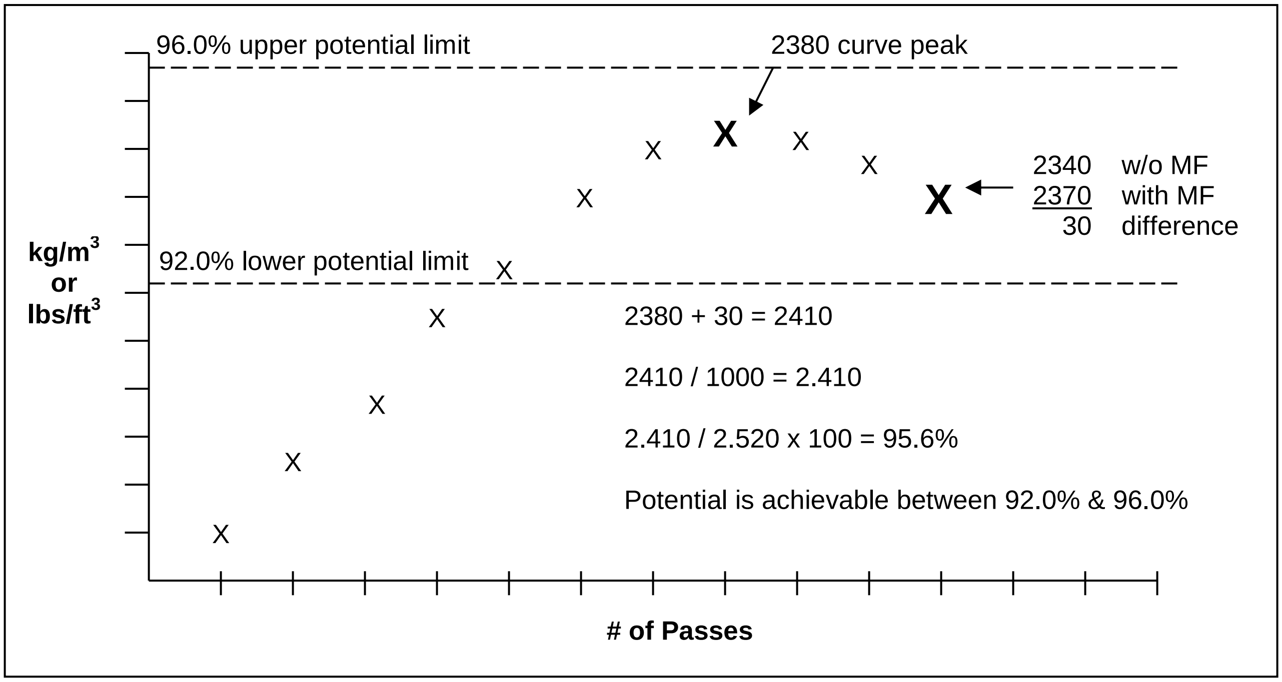
A correlation of core and nuclear gauge test results may be performed on-site as defined in the Department's "Standard Test Method for Correlating Nuclear Gauge Densities with Core Densities". All correlation locations should be cooled with ice or dry ice so that cores can be taken as soon as possible. Three locations should be selected. Two sites should be located on the two growth curves from the first acceptable test strip. The third location should be in an area corresponding to the second set of mixture samples taken at the plant. This correlation should be completed at the same time by the Contractor prior to the next day's production. Smoothness of the test strip shall be to the satisfaction of the Engineer.

H. Documentation

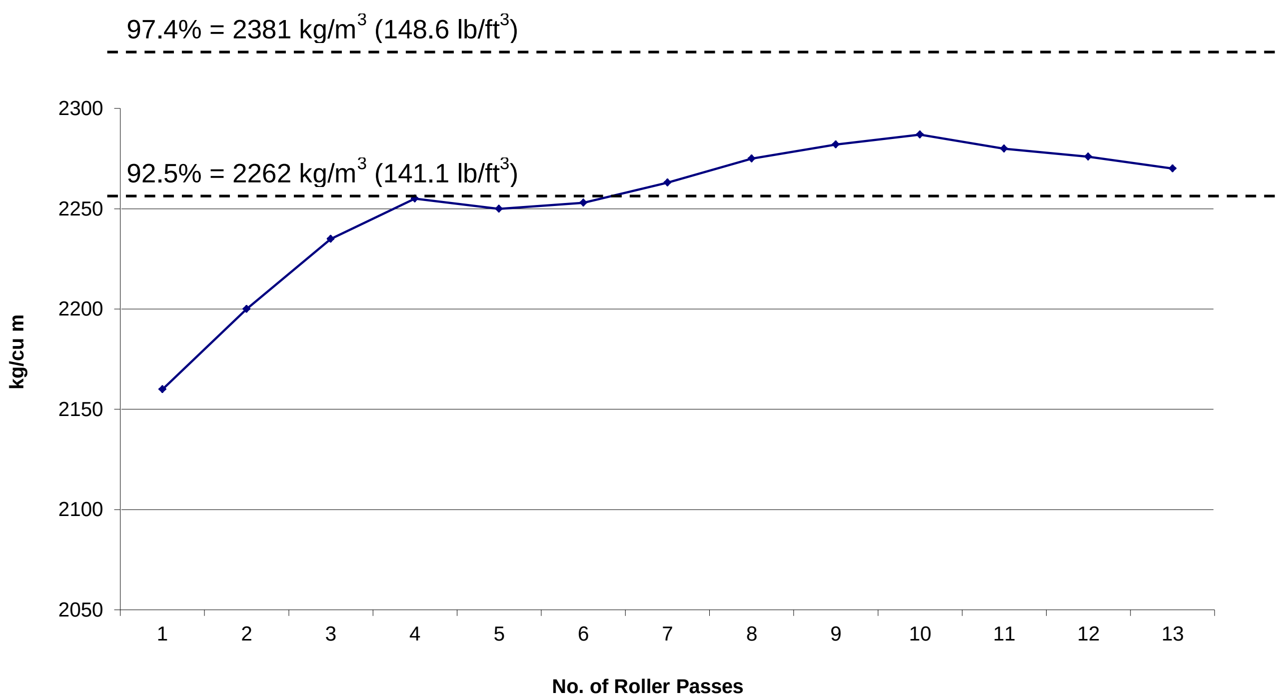
All test strips, required plant tests, and rolling pattern information (including growth curves) will be tabulated by the Contractor with a copy provided to each team member and the original retained in the project files."

End of Hot Mix Asphalt Test Strip Procedures Appendix B4

HMA Growth Curve Example **19535 mixture** ('D' = 2.520)



HMA Growth Curve Example **19523 mixture** ('D' = 2.445)



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Typical Test Strip Sequence

Tons	Truck Load #
???	???
500	25
400	20
300	15
280	14
260	13
250	
240	12
225	
220	11
40	2
20	1
0	0

Plant start-up

Prior to start of test strip:
1) Approved design in place
2) Targets established for JMF
3) Corrections factors applied to JMF targets
4) Locate a good location for test strip
5) Normal roller procedures except in the growth curve areas

The **1st growth curve** is to be performed in the area represented by truck load #12 (225 - 250 T)

Paving will cease until the growth curve has been completed

A core will be cut to determine if the density potential has been met

If a nuclear core correlation is performed, the **1st set of cores** will be cut from this growth curve

The **1st mixture sample** will be taken at the plant from truck load #13

The **2nd growth curve** is to be performed in the area represented by truck load #14 (250 - 300 T) (Paving can continue from this point)

A core will be cut to determine if the density potential has been met

If a nuclear core correlation is performed, the **2nd set of cores** will be cut from this growth curve

End of test strip (300)

Each plant sample will include enough material to run all test parameters including the Hamburg Wheel test & IDT

If mixture adjustments are needed, after the initial test strip, an additional test strip(s) may be ordered by the Engineer

If things are good, a roller pattern will be established and a **2nd plant sample** will be taken

If a nuclear core correlation is performed, the **3rd set of cores** will be cut from the location corresponding to the truck load from which the 2nd plant sample was taken

Once the test strip has been completed, the contractor can continue paving the rest of the day **at their own risk** (???)

On this example, a truckload is equivalent to 20 tons

NOTE: When different truck load sizes are utilized, the load sequence will have to be adjusted accordingly to the tonnage requirements

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Bituminous Mixture Design

Date: 12/07/16

Design Number:----->	84Bit1234	cer Name & Number>	2251-05	Asphalt Products
n Lab ?(PP,PL,IL ect.)	PP	erial Code Number--->	19523	BIT CONC SURF CSE N70 C

Agg No.	#1	#2	#3	#4	#5	#6	#7	ASPHALT	
Size		032CM16D	032CM16C	038FA20	037FA01	004MF01		10127	ACPG 64-22
(PROD#)		50912-02	51352-03	51352-03	50510-04	52102-07		2260-01	
(NAME)		Vulcan	Nokomis	Nokomis	C I M	Blom. Cr. St.		Aspt Mts	
(LOC)		Kankakee	Nokomis	Nokomis	Vandalia	Blom. , Ind		Urbana	
gg Blend %	0.0	48.8	16.2	14.2	19.5	1.3	0.0	100.0	

Agg No. Sieve Size	#1	#2	#3	#4	#5	#6	#7	Blend	Mix Spec.	Formula	Range Min	Range Max
1		100.0	100.0	100.0	100.0	100.0		100.0	100	100		
3/4		100.0	100.0	100.0	100.0	100.0		100.0	100	100		
1/2		100.0	100.0	100.0	100.0	100.0		100.0	90-100	100		
3/8		98.0	97.0	100.0	100.0	100.0		98.5	66-100	99		
#4		37.0	34.0	100.0	100.0	100.0		58.6	24-65	59	52	62
#8		9.0	7.0	74.0	87.0	100.0		34.3	16-48	34	28	38
#16		5.4	4.8	46.0	64.0	100.0		23.7	10-32	24		
#30		5.2	4.0	28.0	40.0	100.0		16.3	0	16	12	20
#50		4.0	3.5	16.0	15.0	100.0		9.0	4-15	9		
#100		3.8	3.3	9.0	3.0	98.0		5.5	3-10	6		
#200		3.5	3.0	5.9	1.6	88.0		4.5	2-6	4.5	3.2	6.2

Rap AC ==========> 0

								Blend	
Bulk Sp Gr	2.618	2.635	2.614	2.595	2.48	2.8	2.8	2.588	Bulk Sp Gr
pparent Sp	1	1	1	1	1	1	1		Apparent Sp Gr
bsorption, %	2.4	1.1	1.4	1.6	2.4	1	1	1.5	Absorption, %
								1.030	AC Specific Gravity
								0.87	Dust/AC Ratio

BITUMINOUS MIXTURE AGED HOW LO 1 HOURS @ 154 C

SUMMARY OF SUPERPAVE GYRATORY TEST DATA

	N-initial		10		N-design			70	Adjusted Gse			
PB:	4.4	4.9	5.4	5.9	4.4	4.9	5.4	5.9	4.4	4.9	5.4	5.9
mb (corr):	2.079	2.083	2.099	2.110	2.317	2.318	2.340	2.353	2.317	2.318	2.340	2.353
Gmm:	2.473	2.455	2.437	2.420	2.473	2.455	2.437	2.420	2.473	2.455	2.438	2.420
Pa:	15.9	15.2	13.9	12.8	6.3	5.6	4.0	2.8	6.3	5.6	4.0	2.8
VMA:	23.2	23.5	23.3	23.3	14.4	14.8	14.5	14.4	14.4	14.8	14.5	14.4
ELD VMA:	24.8	25.1	24.9	24.9	16.2	16.6	16.3	16.3	16.2	16.6	16.3	16.3
VFA:	31.4	35.4	40.4	44.9	56.4	62.3	72.4	80.8	56.2	62.3	72.4	80.8
Vbe:	7.3	8.3	9.4	10.5	8.1	9.2	10.5	11.7	8.1	9.2	10.5	11.7
Pbe:	3.6	4.1	4.6	5.1	3.6	4.1	4.6	5.1	3.6	4.1	4.6	5.1
Gse:	2.643	2.644	2.644	2.644	2.643	2.644	2.644	2.644	2.644	2.644	2.644	2.644
Pba:	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8

Slope: 9.9 Does Design Require Anti-Strip Additive (Yes No Material Code for Anti-Strip---

BER OF REVOLUTIO 70

	% AC	Gmm	Gmb	Voids Pa	VMA	Design Field VMA	VFA	Gse	Gsb	TSR	TSR W/Anti
PTIMUM DESIGN DAT	5.4	2.438	2.340	4.0	14.5	16.3	72.2	2.644	2.588	0.75	
Adjusted Design Data:	5.4	2.438	2.340	4.0	14.5	16.3	72.4	2.644	2.588		
Minimum Requirements				4.0	14.5		65-75			0.75	0.75
State Results:											

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NUCLEAR GAUGES

NUCLEAR/CORE CORRELATION

I. Nuclear Gauge

A. Training

1. Apprentice training (observe someone experienced)
2. Nuclear safety HazMat training (available on-line)
3. Department's QC/QA Nuclear Density Class
4. Prior use and practice
5. Direct read or count ratio gauge
6. Density determination in kg/m^3 or pcf

B. Preparation of the Gauge

1. Calibration check of gauge
    a) 5 block calibration
    b) Done yearly
2. 20 minute gauge warm-up
3. Standard count determination
    a) Handle in safe position
    b) Clean gauge and standard block
    c) Proper gauge placement and seating of standard block
    d) Record results
4. Test mode – backscatter & direct transmission
5. Use fines/dust on all final measurements
6. Extra and/or back-up gauges

II. Purpose of Start-Up and Core Correlation

A. HMA projects w/+3,000 tons or when deemed necessary

B. Contractors Quality Control

1. Acceptance testing
2. Correlate nuclear gauge densities to core densities
3. Documentation and reporting

C. State Assurance

1. IND and INV testing
    a) Test 20% of the contractor's random test locations
    b) Test any time
2. Correlate state gauge at same time as contractor
3. Use the same 15 core densities for correlation
    a) Extra cores for assurance testing
4. Documentation and reporting

D. When/where a correlation should be used

1. Each type mix
2. Testing mode (backscatter vs. direct transmission)
3. Change in underlying base material
4. Change of gauges
5. AJMF change
6. Significant change in HMA ingredients
7. Change in source of HMA materials
8. Limits of testing precision is exceeded between gauges
9. When required by Engineer

III. Nuclear Gauge Operation

A. Random test site location

1. Specification requirements:

a) “Hot-Mix Asphalt - Density Testing of Longitudinal Joints” BDE

b) “Standard Test Method for Correlating Nuclear Gauge Densities with Core Densities” Appendix B3 (MoTP)

c) Standard Specifications for Road and Bridge Construction Article 1030.05 (d)(3) “Required Field Tests” except PFP or QCP projects

d) “Determination of Random Density Test Site Locations” Appendix B7 (MoTP)

2. Determination of offsets (Confined/Unconfined edges)

3. Diagonally across the mat

4. Average of two or three readings (gauge rotated 180°)

5. Mineral filler is used on acceptance tests

B. Start-up/Nuclear Core Correlation Location

1. Specification requirements:

a) “Hot-Mix Asphalt Test Strip Procedures" Appendix B4 (MoTP)

b) “Standard Test Method for Correlating Nuclear Gauge Densities with Core Densities” Appendix B3 (MoTP)

c) Standard Specifications for Road and Bridge Construction Article 1030.06 “Start of HMA Production and Job Mix Formula (JMF) Adjustments” except PFP or QCP projects

2. First site is in the first growth curve area

3. Second site is in the second growth curve area

4. Third site is in a normal roller pattern area

5. 1 ft. from edge of pavement

6. Mineral filler is used on all final measurements

IV. Nuclear Gauge and Core Test Results

A. Gauge and cores

1. pcf vs. kg/m^3

2. No additional compaction on test sites

3. Good equipment = good cores = good results

4. Accurate labeling of cores to gauge measurements

5. All cored pavement locations are to be repaired

B. Acceptability of test results

1. Random tests

a) Determine of bulk SPG - G_{mb} ("d")

b) Determine percent density

c) Determine compliance to specifications

d) Submit daily reports

C. Core density determination

1. Use method ‘A’

2. Use method ‘C’

D. Correlation

1. Linear regression formula

a) Y = mX + b

Where: Y = Adjusted density

m = Slope

X = Average test location density measurement

b = Slope intercept

2. Minimum reliability factor "r"

3. Optional standard error of “Y”

<u>Beginning of Standard Specification Article 1030.05 (d)(3)</u>

(3) ***<u>Required Field Tests</u>****. The Contractor shall control the compaction process by testing the mix density at random locations as determined according to the QC/QA document, "Determination of Random Density Test Site Locations", and recording the results on forms approved by the Engineer. The Contractor shall follow the density testing procedures detailed in the QC/QA document, "Illinois-Modified ASTM D 2950, Standard Test Method for Determination of Density of Bituminous Concrete In-Place by Nuclear Method".*

The Contractor shall be responsible for establishing the correlation to convert nuclear density results to core densities according to the QC/QA document, "Standard Test Method for Correlating Nuclear Gauge Densities with Core Densities". The Engineer may require a new nuclear/core correlation if the Contractor's gauge is recalibrated during the project.

If the Contractor and Engineer agree the nuclear density test method is not appropriate for the mixture, cores shall be taken at random locations determined according to the QC/QA document "Determination of Random Density Test Site Locations". Three cores shall be taken at equal distances across the test site. These cores shall be averaged to provide a single test site result. Core densities shall be determined using the Illinois-Modified AASHTO T 166 or T 275 procedure.

Quality control density tests shall be performed at randomly selected locations within 1/2 mile (800 m) intervals and for each lift of 3 in. (75 mm) or less in thickness. For lifts in excess of 3 in. (75 mm) in thickness, a test shall be performed within 1/4 mile (400 m) intervals. Testing of lifts equal to or greater than 4 in. (100 mm) compacted thickness shall be performed in the direct transmission mode according to the QC/QA document "Illinois-Modified ASTM D 2950, Standard Test Method for Determination of Density of Bituminous Concrete In-Place by Nuclear Method". Density testing shall be accomplished intermittently throughout the day. In no case shall more than one half day's production be completed without performing density testing.

Density tests shall be performed each day on patches located nearest the randomly selected location. The daily testing frequency shall be a minimum of two density tests per mix. Density testing shall be accomplished intermittently throughout the day. In no case shall more than one half day's production be completed without performing density testing.

<u>End of Standard Specification Article 1030.05 (d)(3)</u>

<u>NOTE</u>: This specification doesn't apply to PFP or QCP projects.

Beginning of Correlating Nuclear Gauge Densities with Core Densities

Illinois Department of Transportation
QC/QA PROCEDURE

Standard Test Method for Correlating Nuclear Gauge Densities with Core Densities Appendix B3

Effective: May 1, 2001
Revised: December 1, 2017

A. Scope

1. *This method covers the proper procedures for correlating nuclear gauge densities to core densities. Procedures are applicable to both direct transmission and backscatter techniques.*

2. *The procedure shall be used on all projects containing 3000 tons (2750 metric tons) or more of any hot-mix asphalt mixture. It may also be used on any other project where feasible. The direct transmission method shall be used for thick-lift layers. "Thick-lift" is defined as a layer 6 in (152.4 mm) or greater in compacted thickness.*

B. Applicable Documents

1. *Illinois Department of Transportation Standard Test Methods*

   Illinois-Modified AASHTO T 166, "Bulk Specific Gravity of Compacted Asphalt Mixtures Using Saturated Surface Dry Specimens"

   Illinois-Modified AASHTO T 275, "Bulk Specific Gravity of Compacted Asphalt Mixtures Using Paraffin-Coated Specimens"

2. *The density test procedure shall be in accordance with the Department's "Illinois-Modified ASTM D 2950, Standard Test Method for Determination of Density of Bituminous Concrete In-Place by Nuclear Method".*

C. Definitions

Test location: The station location used for density testing.

Test site: Individual test site where a single density is determined. Five (5) test sites are located at each test location.

Nuclear Density: The average of 2 or possibly 3 density readings on a given test site.

Core Density: The core density result on a given test site.

Illinois Department of Transportation
QC/QA PROCEDURE

Standard Test Method for Correlating Nuclear Gauge Densities with Core Densities Appendix B3

Effective: May 1, 2001
Revised: December 1, 2017

D. Significance and Use

1. *Density results from a nuclear gauge are relative. If an approximation of core density results is required, a correlation must be developed to convert the nuclear density to core density.*

2. *A correlation developed in accordance with these procedures is applicable only to the specific gauge being correlated, the specific mixture, each specific thickness (direct transmission only), and the specific project upon which it was correlated. A new correlation should be determined within a specific project if there is a significant change in the underlying material.*

E. Site Selection

1. *The nuclear density tests and cores necessary for nuclear/core correlation shall be obtained during the start-up of each specific mixture for which a density specification is applicable.*

2. *Three correlation locations shall be selected. Two sites will be located on the two growth curves from the first acceptable test strip. The third location shall be chosen after an acceptable rolling pattern has been established and within the last 90 metric tons (100 tons) of material placed during start-up. The material from the third site shall correspond to the same material from which the second hot-mix sample was taken.*

3. *If a mixture start-up is not required, two of the three correlation locations shall be in an area containing a growth curve.*

F. Procedures for Obtaining Nuclear Readings and Cores

1. *Backscatter Mode*

   a. *At each of the three correlation locations, five individual sites shall be chosen and identified as shown in Figure 1.*

   b. *Two nuclear readings shall be taken at each of the 15 individual sites. (See Figure 1). The gauge shall be rotated 180 degrees between readings at each site. (The two uncorrected readings taken at a specific individual site shall be within 1.5 lbs./ft^3 [23 kg/m^3]. If the two readings do not meet this criterion, one additional reading shall be taken in the desired direction. The nuclear densities are to be recorded on the correlation form (Figure 3).*

Illinois Department of Transportation
QC/QA PROCEDURE

Standard Test Method for Correlating
Nuclear Gauge Densities with Core Densities
Appendix B3

Effective: May 1, 2001
Revised: December 1, 2017

c. *One core in good condition shall be obtained from each of 15 individual sites (Figure 1). Care should be exercised that no additional compaction occurs between the nuclear testing and the coring. The cores shall be tested for density in accordance with Illinois-Modified AASHTO T 166 or T 275. The core densities are to be entered on the correlation form.*

   For quality assurance purposes, the Department may direct the Contractor to take additional cores adjacent to those above or to submit the quality control cores for Department testing.

d. *Extreme care shall be taken in identifying which location each of the density readings represents. The data points have to be paired accurately or the correlation process will be invalid.*

2. *Direct Transmission Mode*

   a. *At each of the three correlation locations, five individual sites shall be chosen across the mat as shown on Figure 1.*

   b. *A smooth hole in the pavement, slightly larger than the probe, shall be formed to a depth 2 in (50 mm) greater than the test depth. The probe shall be inserted so that the side of the probe facing the center of the gauge is in intimate contact with the side of the hole. Two nuclear readings shall be taken at each of the 15 individual sites. (See Figures 1 and 2.)*

      The gauge shall be rotated 180 degrees around the core area at each site. (The 2 uncorrected readings taken at a specific individual site shall be within 2.0 lbs./ft^3 [30 kg/m^3]. If the two readings do not meet this criterion, one additional reading shall be taken in the desired direction. The nuclear densities are to be recorded on the correlation form (Figure 3).

   c. *One core in good condition shall be obtained from each of the 15 individual sites. (See Figures 1 and 2.) The cores shall be obtained from beneath the center of the gauge no closer than 3-1/2 in (87.5 mm) from either access hole. The thickness of the core should represent the thickness of the layer being tested. The layer shall be carefully separated for testing in accordance with Illinois-Modified AASHTO T 166. Care should be exercised that no additional compaction occurs between the nuclear testing and the coring. The cores shall be tested for density in accordance with Illinois-Modified AASHTO T 166 or T 275.*

Illinois Department of Transportation
QC/QA PROCEDURE

Standard Test Method for Correlating
Nuclear Gauge Densities with Core Densities
Appendix B3

Effective: May 1, 2001
Revised: December 1, 2017

For quality assurance purposes, the Department may direct the Contractor to take additional cores adjacent to those above or to submit the quality control cores for Department testing.

The core densities are to be entered on the correlation form.

d. Extreme care shall be taken in identifying which location each of the density readings represents. The data points have to be paired accurately or the correlation process will be invalid.

G. Mathematical Correlation -- Linear Regression

1. *The two (or possibly three) nuclear readings at each individual site shall be entered on the correlation form and then averaged. The core density taken at each individual site shall be entered on the correlation form. After the averaging, there will be 15 paired data points, each pair containing the average nuclear density and core density for each of the 15 individual sites.*

2. *The paired density values shall be correlated using the Department's linear regression program (Disks are available from the Central Bureau of Materials) or an approved and equivalent calculating method.*

3. *For the purpose of this procedure, standard statistical methods for measuring the "best fit" of a line through a series of 15 paired data points consisting of core density and nuclear density shall be used.*

4. *It should be recognized that correlations obtained by this or similar procedures may or may not be valid; each attempt should be judged on its merit. In general, a correlation coefficient for each correlation linear regression should be calculated.*

5. *Correlation coefficients (r) may range from minus 1.0 to plus 1.0. An "r" value greater than 0.715 is considered acceptable.*

6. *The correlation shall be stated and used in the form:* $y = mx + b$

where:

y = *core density*

x = *nuclear gauge density*

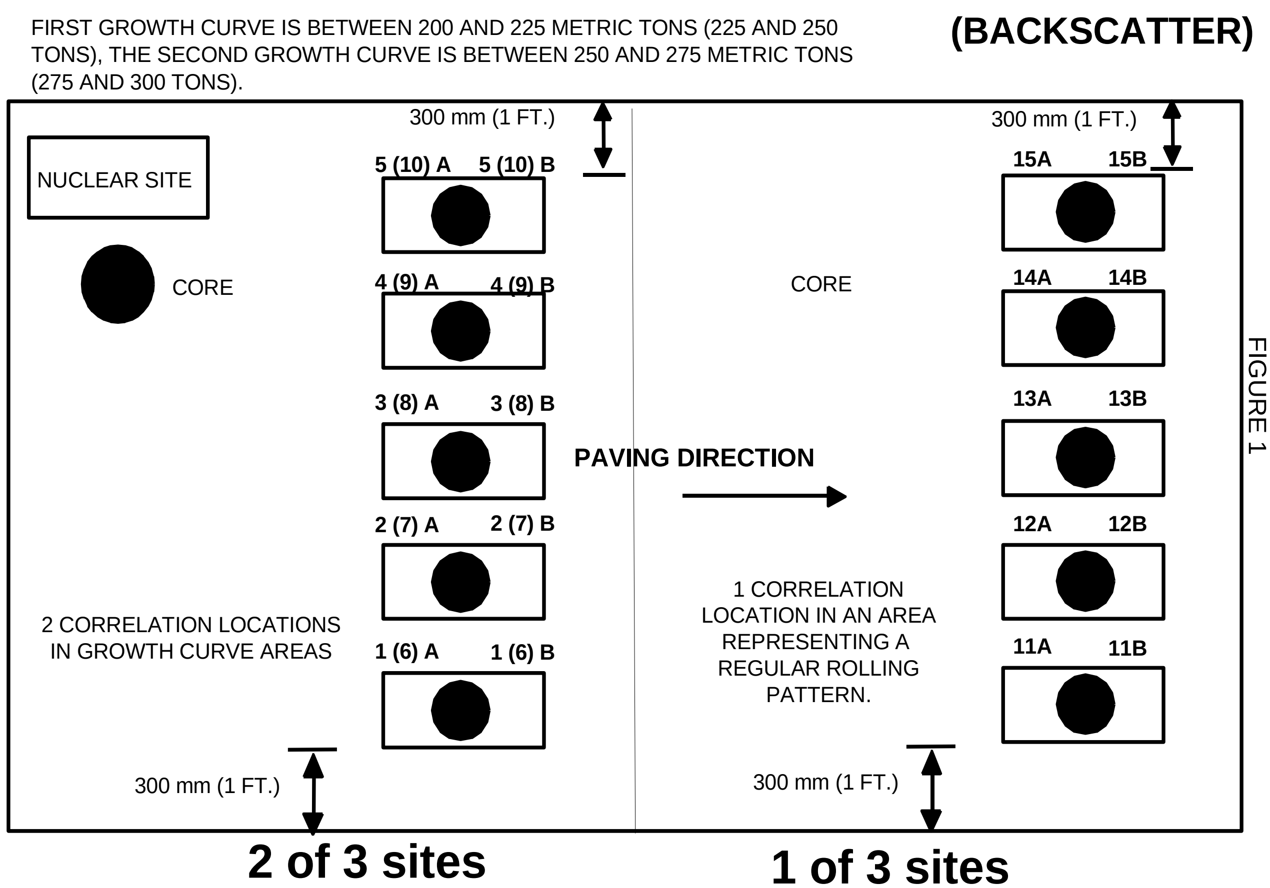
b = *intercept*

m = *slope of linear regression ("best fit") line*

Illinois Department of Transportation
QC/QA PROCEDURE

Standard Test Method for Correlating Nuclear Gauge Densities with Core Densities Appendix B3

Effective: May 1, 2001
Revised: December 1, 2017



NUCLEAR/CORE CORRELATION TEST LOCATIONS

Illinois Department of Transportation
QC/QA PROCEDURE

Standard Test Method for Correlating
Nuclear Gauge Densities with Core Densities
Appendix B3

Effective: May 1, 2001
Revised: December 1, 2017

DIRECT TRANSMISSION MODE

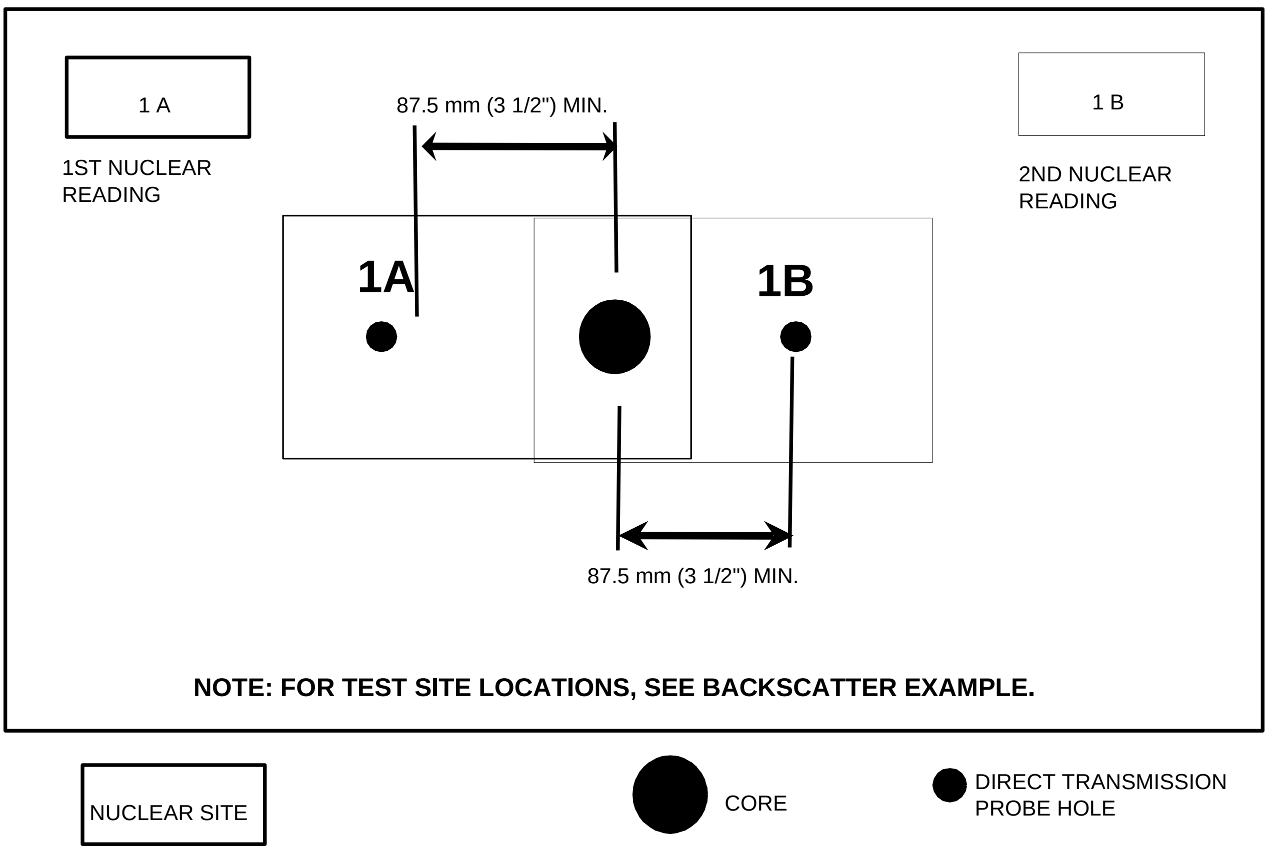


FIGURE 2

NUCLEAR/CORE CORRELATION

NUCLEAR / CORE CORRELATION FIELD WORKSHEET

DATE: ____________________

CONTRACT: ____________________ **Gauge #** ____________

JOB #: ____________________ **Layer Thickness** ____________

ROUTE: ____________________ **Gmm** ____________

BASE MATERIAL: ____________________ (milled, binder, aggregate)

MIX #: ____________________ **NUCLEAR**

MIX CODE: ____________________ **DENSITIES**

USE: ____________________ (surf., 1st lift binder...)

Reading 1	**Reading 2**	**(23 kg/m3 tol.) Reading 3 (if applicable)**		**Average Nuc.**	**Core Density**

STATION: ____________________

1A)	1B)	1A)	1B)	1)	1)
2A)	2B)	2A)	2B)	2)	2)
3A)	3B)	3A)	3B)	3)	3)
4A)	4B)	4A)	4B)	4)	4)
5A)	5B)	5A)	5B)	5)	5)

STATION: ____________________

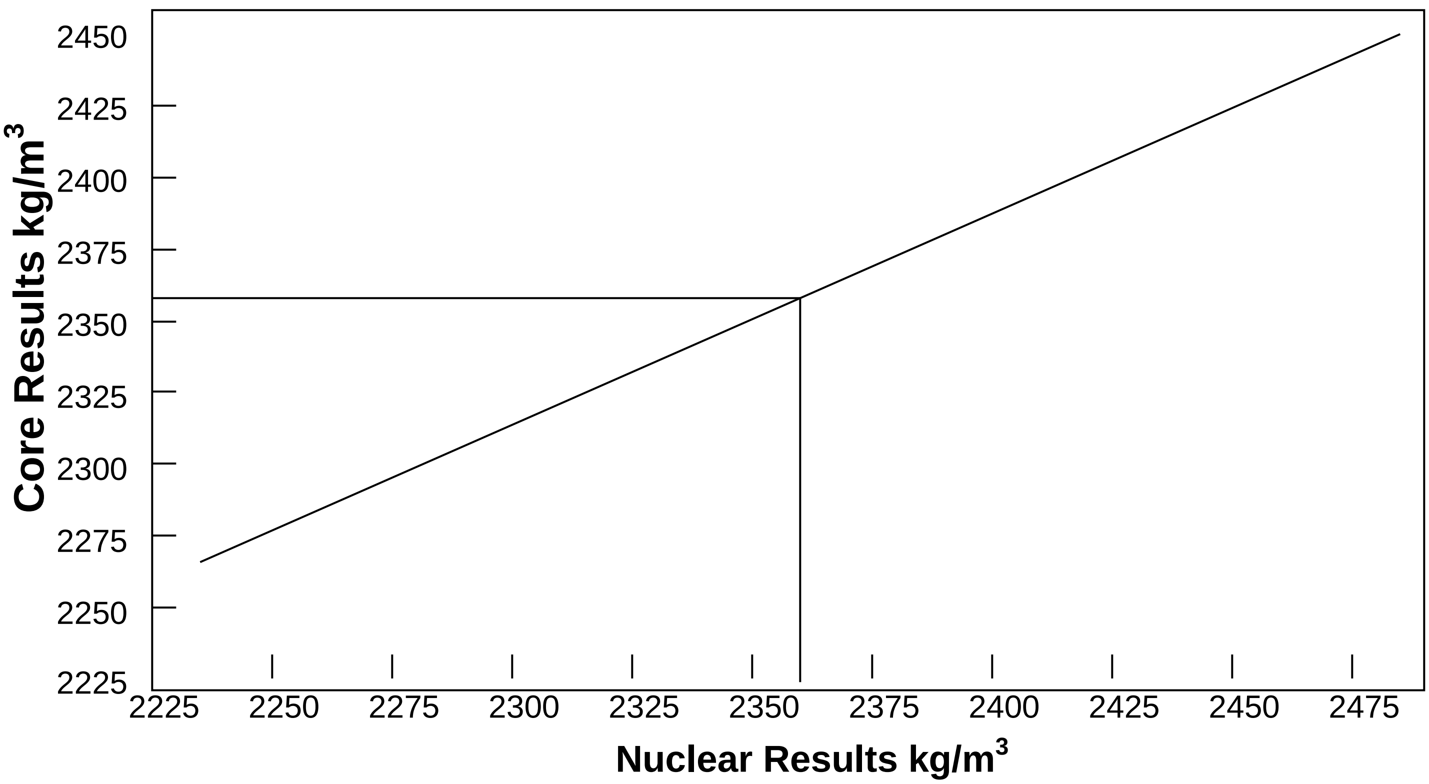
6A)	6B)	6A)	6B)	6)	6)
7A)	7B)	7A)	7B)	7)	7)
8A)	8B)	8A)	8B)	8)	8)
9A)	9B)	9A)	9B)	9)	9)
10A)	10B)	10A)	10B)	10)	10)

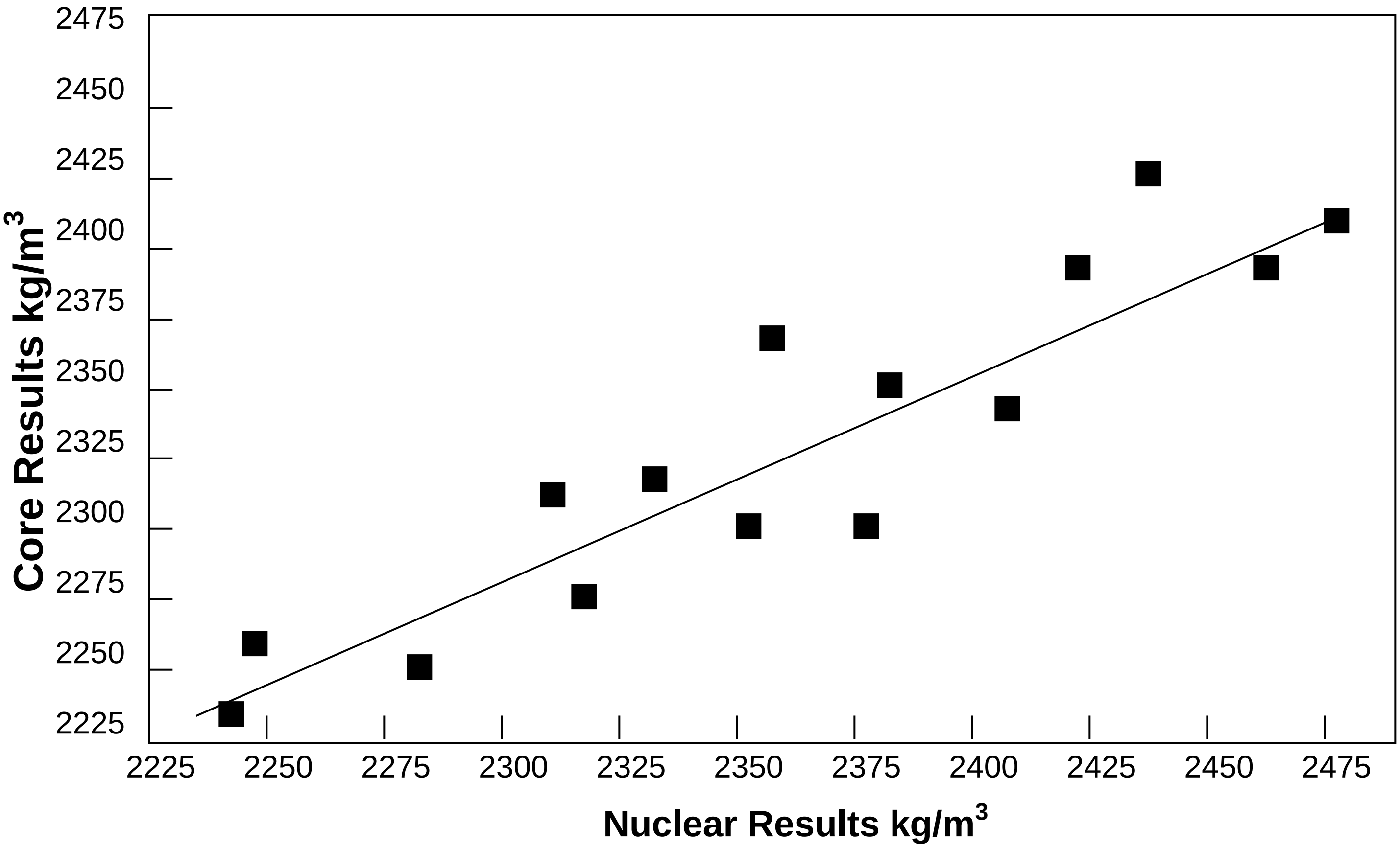
STATION: ____________________

11A)	11B)	11A)	11B)	11)	11)
12A)	12B)	12A)	12B)	12)	12)
13A)	13B)	13A)	13B)	13)	13)
14A)	14B)	14A)	14B)	14)	14)
15A)	15B)	15A)	15B)	15)	15)

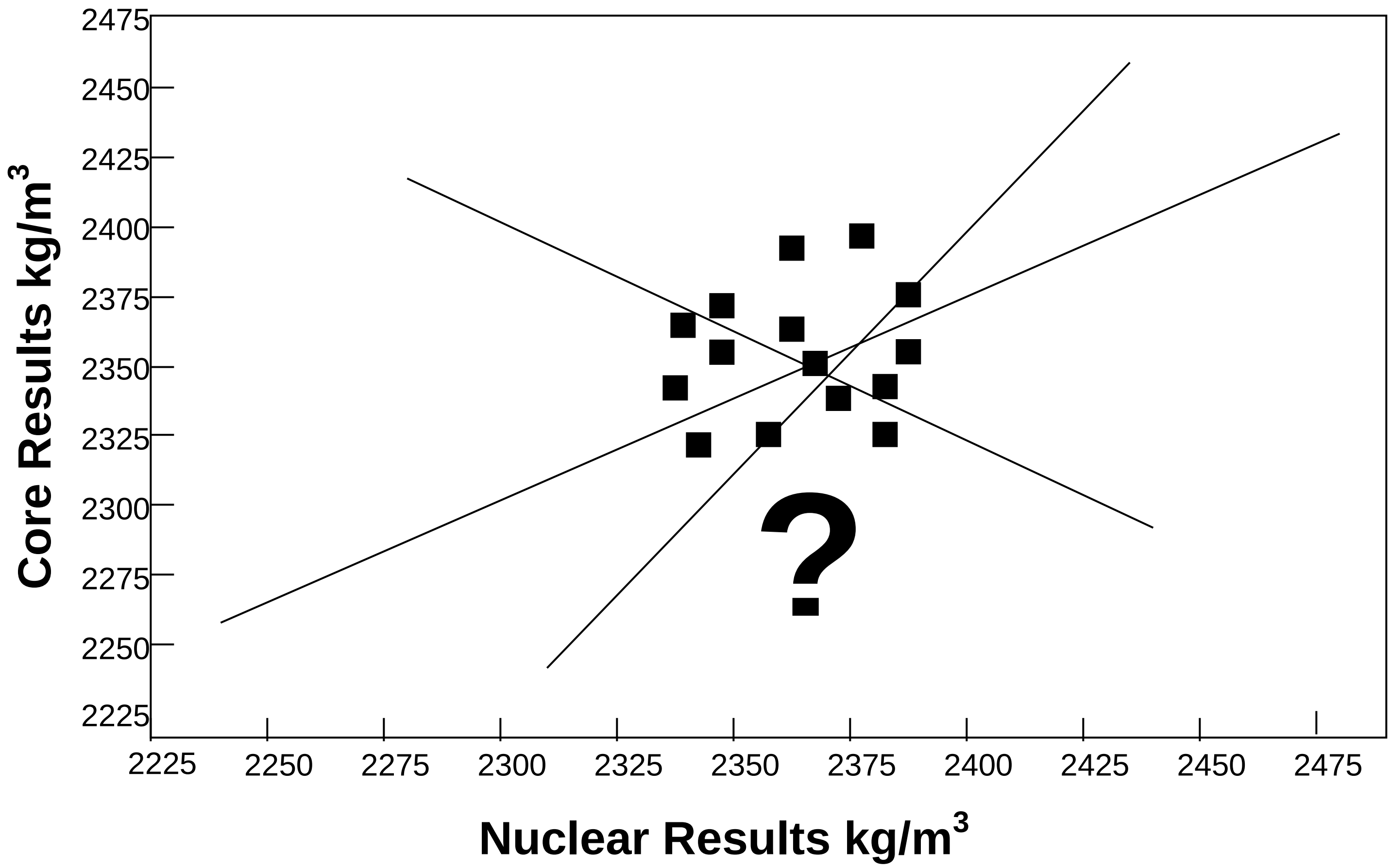
End of Correlating Nuclear Gauge Densities with Core Densities

Nuclear Core Correlation





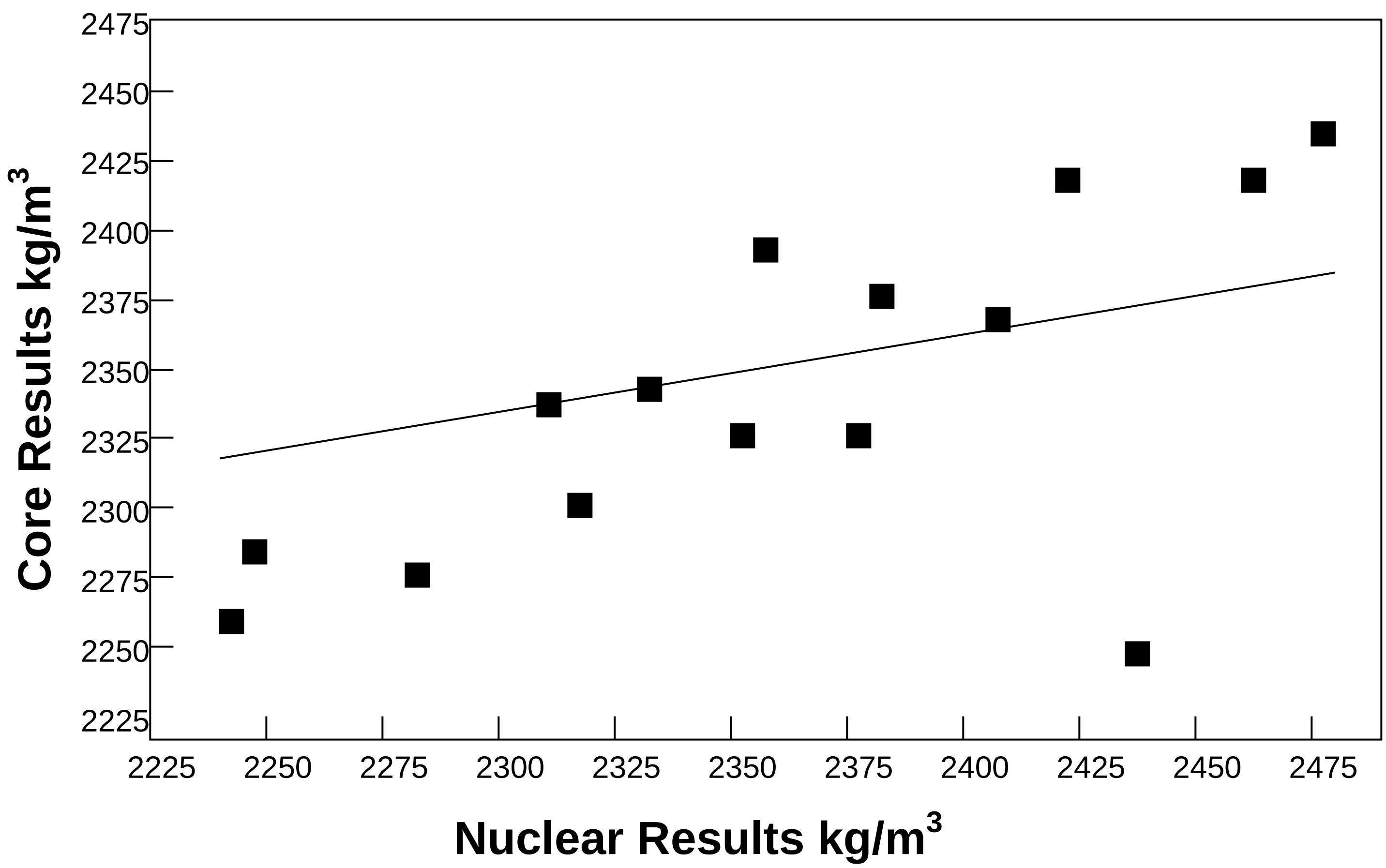
Nuclear Core Correlation



When the measurements are all bunched up this will typically result in a low or inaccurate ‘r’ value (reliability factor) and/or an elevated standard error of ‘Y’ which will affect the overall ability of the correlation to provide usable or reliable information.

The linear regression computer program **will** calculate a ‘best-fit’ straight line based on the input information but the reliability of the ‘best-fit’ line will be adversely affected and create ‘unreliable’ information with the potentially bunched up data.

Nuclear Core Correlation



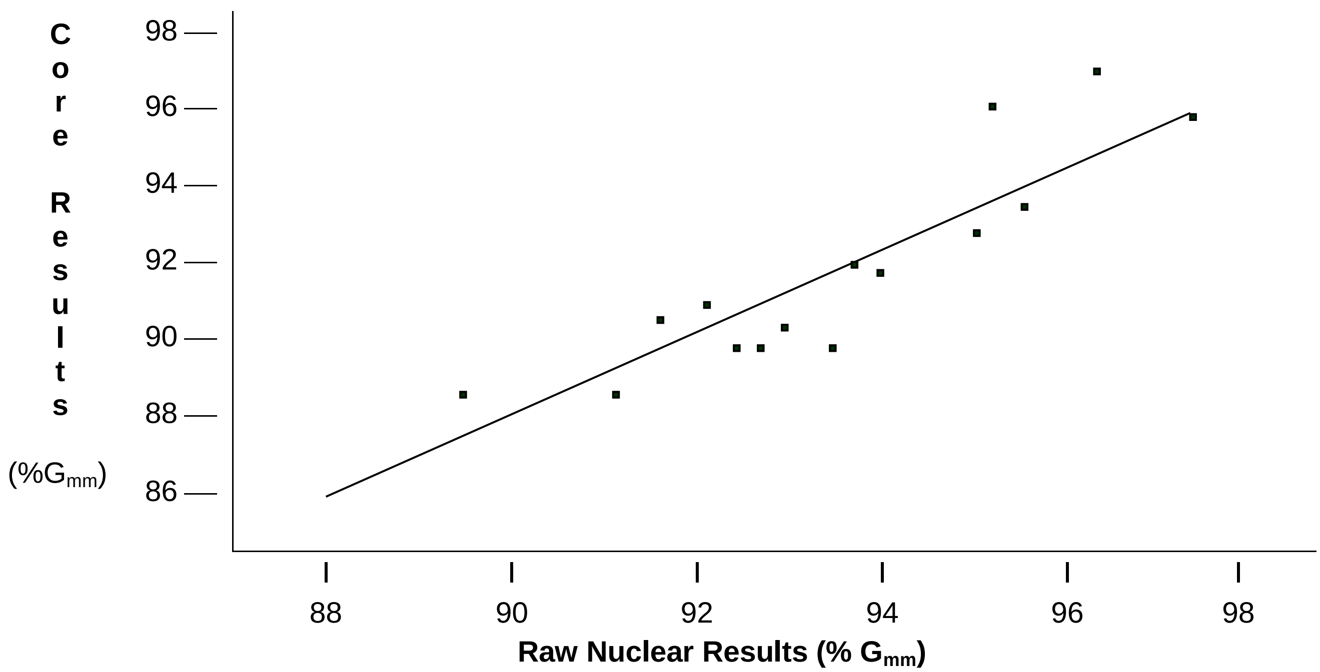
It is permissible to throw out or adjust a point that appears to be invalid or skewed information. The object is **not to get a passing correlation** but to get a passing **workable** correlation that allows the nuclear density measurements to correctly adjust the gauge readings to the in-place mat density.

Nuclear Core Correlation Example using Metric Units

NUC	RAW NUC	CORE	SLOPE m∗x+b
	94.1	92.2	92.7
MAX	95.9	96.7	94.5
97.5	97.0	97.1	95.7
MIN	92.3	91.8	90.7
89.5	89.5	89.0	87.9
	95.2	93.2	93.8
	97.5	96.1	96.2
CORE	95.6	93.7	94.4
	91.0	88.9	89.4
	91.7	91.2	90.2
MAX	92.7	90.7	91.2
97.1	93.3	91.2	91.9
MIN	93.9	90.7	92.4
88.9	93.9	92.3	92.4
	93.1	90.8	91.7

Gauge No:	27622
Route:	FAP 353
Section:	11-5RS-1
County:	Cook
Proj. No:	
Job No:	C-91-001-02
Cont. No:	62363
RE:	Mark Kopiec
Mat. Code:	19524
Mat. Desc:	Bit Conc. SC N70 D
Field Mix#:	91BIT007G
Test Date:	06/07/07
Base Mat:	Milled surface on concrete
Lift #:	.1
G_{mm}:	2.450

Nuclear Core Correlation



Regression Output

Slope/Intercept Formula Y = m ∗ X + b

Statistical Data

m = 0.8252

b = 423.078 kg/m^3

p = 0.99

Std. Err of Y Est = 27.8

Reliability Factor = 0.9423

Gauge Number:	27622

m =	0.8252
b =	423.078 kg/m^3

Formula: Y = m ∗ X + b

Material Code:	19524
Mat. Desc:	Bit Conc. SC N70 D
Field Mix #:	91BIT007G
Lift No:	.1

Route:	FAP 353
Section:	11-5RS-0
County:	Cook
Job No:	C-91-001-02
Cont. No:	62363
RE:	Mark Kopiec

Actual Nuclear Reading	Adjusted Nuclear Reading	Actual Nuclear Reading	Adjusted Nuclear Reading	Actual Nuclear Reading	Adjusted Nuclear Reading	Actual Nuclear Reading	Adjusted Nuclear Reading
2246	2204	2296	2256	2346	2309	2396	2361
2247	2205	2297	2257	2347	2310	2397	2362
2248	2206	2298	2259	2348	2311	2398	2363
2249	2207	2299	2260	2349	2312	2399	2364
2250	2208	2300	2261	2350	2313	2400	2366
2251	2209	2301	2262	2351	2314	2401	2367
2252	2210	2302	2263	2352	2315	2402	2368
2253	2211	2303	2264	2353	2316	2403	2369
2254	2212	2304	2265	2354	2317	2404	2370
2255	2213	2305	2266	2355	2318	2405	2371
2256	2214	2306	2267	2356	2319	2406	2372
2257	2215	2307	2268	2357	2320	2407	2373
2258	2217	2308	2269	2358	2321	2408	2374
2259	2218	2309	2270	2359	2322	2409	2375
2260	2219	2310	2271	2360	2324	2410	2376
2261	2220	2311	2272	2361	2325	2411	2377
2262	2221	2312	2273	2362	2326	2412	2378
2263	2222	2313	2274	2363	2327	2413	2379
2264	2223	2314	2275	2364	2328	2414	2380
2265	2224	2315	2276	2365	2329	2415	2381
2266	2225	2316	2277	2366	2330	2416	2382
2267	2226	2317	2278	2367	2331	2417	2383
2268	2227	2318	2279	2368	2332	2418	2384
2269	2228	2319	2281	2369	2333	2419	2385
2270	2229	2320	2282	2370	2334	2420	2386
2271	2230	2321	2283	2371	2335	2421	2388
2272	2231	2322	2284	2372	2336	2422	2389
2273	2232	2323	2285	2373	2337	2423	2390
2274	2233	2324	2286	2374	2338	2424	2391
2275	2234	2325	2287	2375	2339	2425	2392
2276	2235	2326	2288	2376	2340	2426	2393
2277	2236	2327	2289	2377	2341	2427	2394
2278	2238	2328	2290	2378	2342	2428	2395
2279	2239	2329	2291	2379	2343	2429	2396
2280	2240	2330	2292	2380	2345	2430	2397
2281	2241	2331	2293	2381	2346	2431	2398
2282	2242	2332	2294	2382	2347	2432	2399
2283	2243	2333	2295	2383	2348	2433	2400
2284	2244	2334	2296	2384	2349	2434	2401
2285	2245	2335	2297	2385	2350	2435	2402
2286	2246	2336	2298	2386	2351	2436	2403
2287	2247	2337	2299	2387.	2352	2437	2404
2288	2248	2338	2300	2388	2353	2438	2405
2289	2249	2339	2302	2389	2354	2439	2406
2290	2250	2340	2303	2390	2355	2440	2407
2291	2251	2341	2304	2391	2356	2441	2409
2292	2252	2342	2305	2392	2357	2442	2410
2293	2253	2343	2306	2393	2358	2443	2411
2294	2254	2344	2307	2394	2359	2444	2412
2295	2255	2345	2308	2395	2360	2445	2413

HMA Mix Correlation Problems

Determine the following for the two class problems below:

1. The required percent density by specification of the mixture
2. The percent density of the random test location
3. The theoretical air voids of the mixture at the random test location
4. Determine if the percent density is within specification

Problem #1: When placing a 19514 mixture at a random test location, with the given information, determine the following:

Given:	'r'	=	0.9423	m	=	0.8252
	b	=	423.078 kg/m^3	"D"	=	2.450

X = 2358 kg/m^3 (the individual test result (average of readings) at a random density test site location)

Adjusted Density formula: $Y = mX + b$

Final % density = ________________ Theo. Air Voids = ________

Required % density = ________________ Meets Density = YES NO

Problem #2: Use the following given data and determine the following for a 19535 HMA mix.

Given:	'r'	=	0.7154	m	=	0.8977
	b	=	–199.234 kg/m^3	"D"	=	2.510

X = 2917 kg/m^3 (the individual test result (average of readings) at a random density test site location)

Final % density = ________________ Theo. Air Voids = ________

Required % density = ________________ Meets Density = YES NO

Beginning of Special Provision for HMA – Density Testing of Longitudinal Joints

All Regional Engineers

Omer M. Osman

Special Provision for Hot-Mix Asphalt – Density Testing of Longitudinal Joints

January 8, 2016

This special provision was developed by the Bureau of Materials and Physical Research to improve the performance of longitudinal joints in HMA pavements. It has been revised to fit with the 2016 Standard Specifications.

It should be inserted in HMA contracts utilizing Quality Control/Quality Assurance as the Quality Management Program for the pavement/resurfacing.

The districts should include the BDE Check Sheet marked with the applicable special provisions for the April 22, 2016 letting and subsequent lettings. The Project Development and Implementation Section will include a copy in the contract.

This special provision will be available on the transfer directory January 8, 2016.

80246m

HOT-MIX ASPHALT - DENSITY TESTING OF LONGITUDINAL JOINTS (BDE)

Effective: January 1, 2010
Revised: April 1, 2016

Description. This work shall consist of testing the density of longitudinal joints as part of the quality control/quality assurance (QC/QA) of hot-mix asphalt (HMA). Work shall be according to Section 1030 of the Standard Specifications except as follows.

Quality Control/Quality Assurance (QC/QA). Delete the second and third sentence of the third paragraph of Article 1030.05(d)(3) of the Standard Specifications.

Add the following paragraphs to the end of Article 1030.05(d)(3) of the Standard Specifications:

> *"Longitudinal joint density testing shall be performed at each random density test location. Longitudinal joint testing shall be located at a distance equal to the lift thickness or a minimum of 4 in. (100 mm), from each pavement edge. (i.e. for a 5 in. (125 mm) lift the near edge of the density gauge or core barrel shall be within 5 in. (125 mm) from the edge of pavement.) Longitudinal joint density testing shall be performed using either a correlated nuclear gauge or cores.*
>
> *a. Confined Edge. Each confined edge density shall be represented by a one minute nuclear density reading or a core density and shall be included in the average of density readings or core densities taken across the mat which represents the Individual Test.*
>
> *b. Unconfined Edge. Each unconfined edge joint density shall be represented by an average of three one-minute density readings or a single core density at the given density test location and shall meet the density requirements specified herein. The three one-minute readings shall be spaced 10 ft (3 m) apart longitudinally along the unconfined pavement edge and centered at the random density test location."*

Revise the Density Control Limits table in Article 1030.05(d)(4) of the Standard Specifications to read:

"Mixture Composition	Parameter	Individual Test (includes confined edges)	Unconfined Edge Joint Density Minimum
IL-4.75	Ndesign = 50	93.0 – 97.4 % [1/]	91.0 %
IL-9.5	Ndesign = 90	92.0 – 96.0 %	90.0 %
IL-9.5,IL-9.5L	Ndesign < 90	92.5 – 97.4 %	90.0 %
IL-19.0	Ndesign = 90	93.0 – 96.0 %	90.0 %
IL-19.0, IL-19.0L	Ndesign < 90	93.0 [2/] – 97.4 %	90.0 %
SMA	Ndesign = 50 & 80	93.5 – 97.4 %	91.0 %

80246

<u>End of Special Provision for HMA – Density Testing of Longitudinal Joints</u>

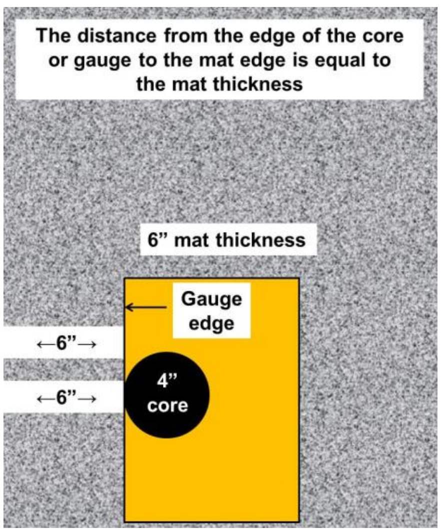
Class Information Summation

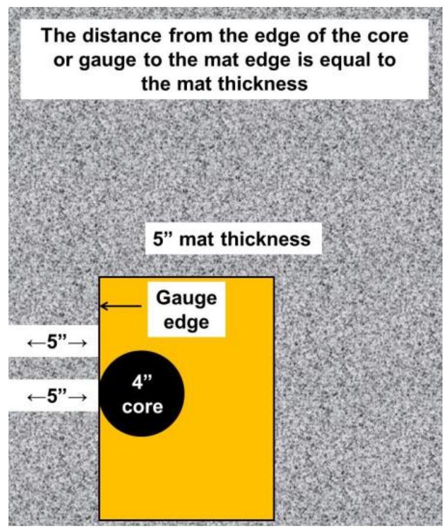
Of the Nuclear Density Test Site Locations Specification

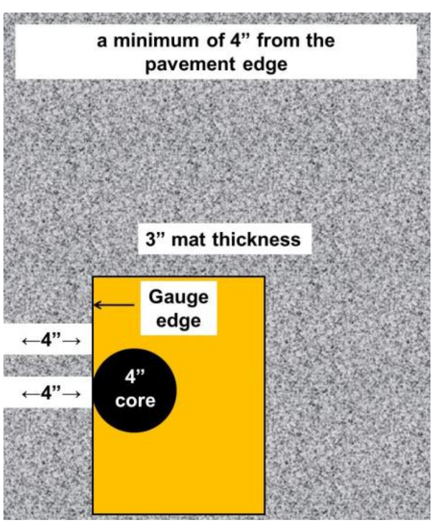
A) Random Test Determination Layout

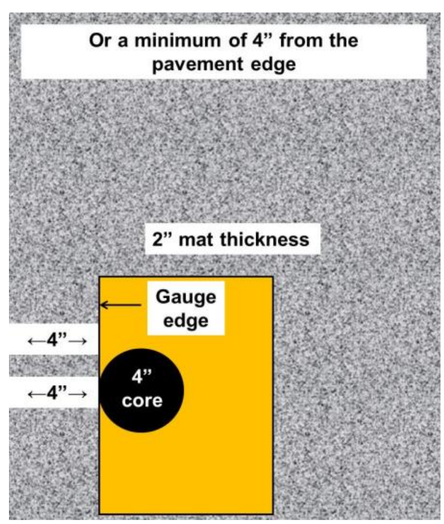
Density testing will be completed by cutting cores or using a correlated nuclear density gauge at random locations provided by the contractor or IDOT inspector. Density testing will include determinations diagonally across the center of the mat and longitudinally on the outside edges. The layout configuration and density control limits at each test location is dependent upon whether the lifts of HMA being placed have confined (typically an inlay) or unconfined edges.

All density longitudinal test determinations, confined or unconfined, will be located at a distance equal to the lift thickness, or a minimum of 4 in. (100 mm), from the edge of pavement to the edge of the nuclear density gauge or edge of the core. See examples below:





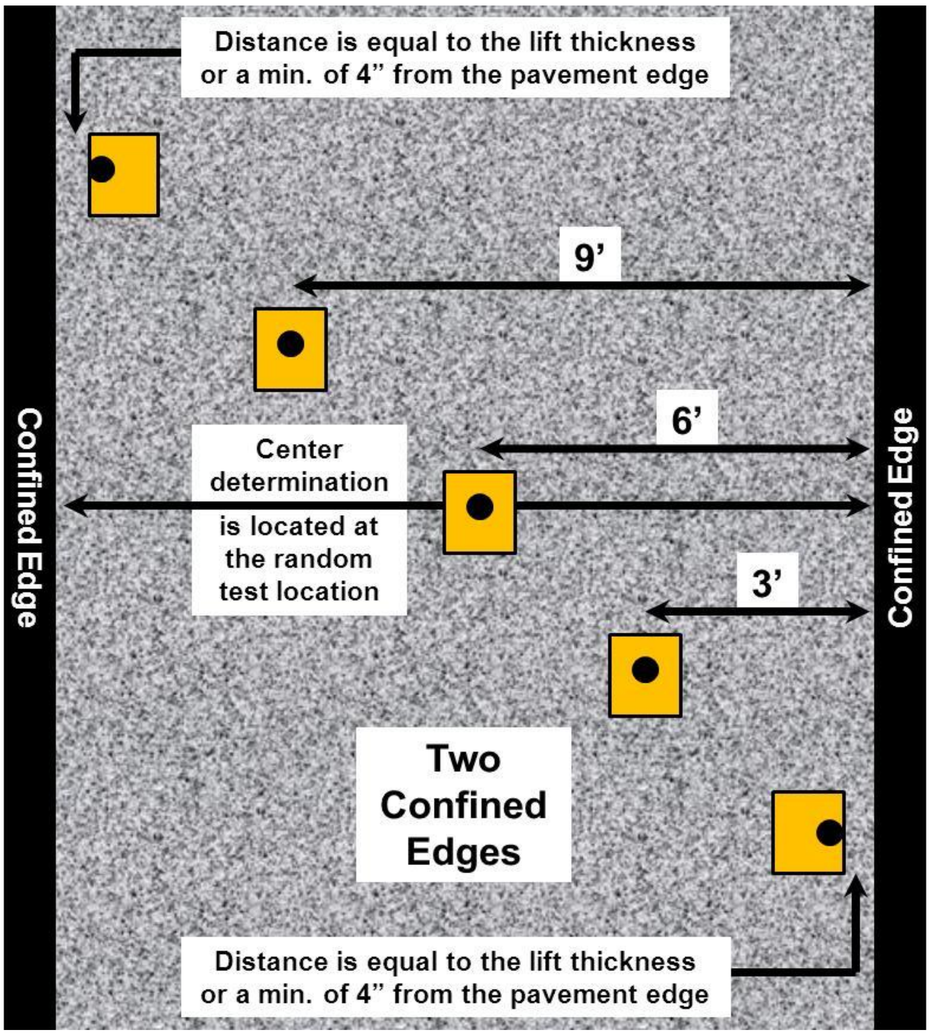




B) Random Test Determination Layout for Two Confined Edges (Inlay)

When testing a random test location located in an inlay or in an area with two confined edges, a total of five determinations will be taken or five cores will be cut diagonally across the mat at the required layout locations. The results of all five determinations or cores are averaged to achieve one individual test which is required to meet the Density Control Limits for the mixture being tested.

A total of five nuclear density determinations will be taken or five cores will cut at this location. One density requirement is to be met in this situation.



C) Random Test Determination Layout for One Confined Edge

When testing a mat with one confined edge:

1. Either four determinations will be taken or four cores will be cut, diagonally across the mat, at the required layout locations on the side nearest to the confined edge.

   The results of these four nuclear density determinations or cut cores will be averaged to achieve one individual test result which is required to meet the Density Control Limits for the mixture being tested as an "Individual Test (includes confined edges)" specification.

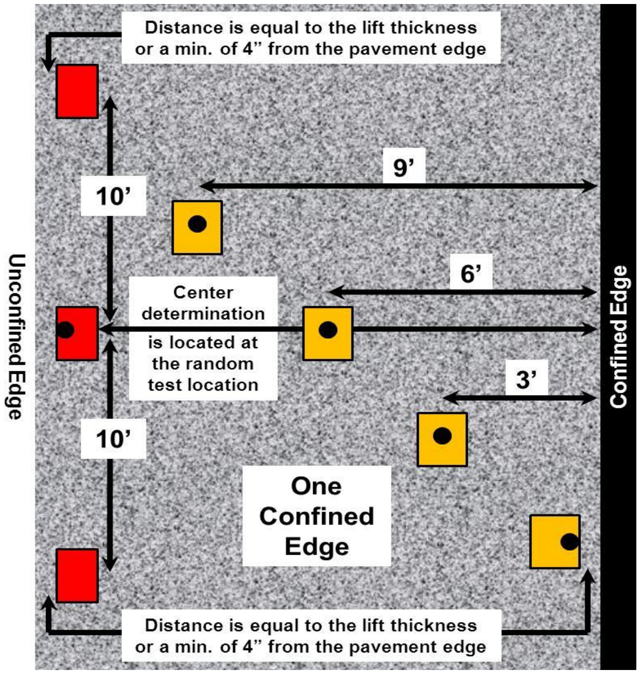
2. When testing with a nuclear density gauge, a total of three determinations will be taken longitudinally along the unconfined edge of the pavement at the required layout locations.

   The middle determination will be located at the random test location and the other two determinations will be spaced longitudinally apart in line with the middle determination at the required layout locations.

   The results of the three determinations will be averaged to achieve one individual test which is required to meet the Density Control Limits for the mixture being tested for as an "Unconfined Edge Joint Density Minimum" specification.

3. When cutting cores, a single core (the middle determination from #2) will be cut at the required layout location. This single core will be required to meet the Density Control Limits for the mixture being tested for as an "Unconfined Edge Joint Density Minimum" specification.

A total of seven nuclear density determinations or five cores will be taken at this location. Two separate density requirements are to be met in this situation, one for the four confined locations and one the unconfined edge.



D) Random Test Determination Layout for Two Unconfined Edges

When testing a mat with two unconfined edges:

1. Either three nuclear density determinations will be taken or three cores will be cut, diagonally, at the required layout locations in the center of the mat.

   The results of these three nuclear density determinations or cut cores will be averaged to achieve one individual test result which is required to meet the Density Control Limits for the mixture being tested as an "Individual Test (includes confined edges)" specification.

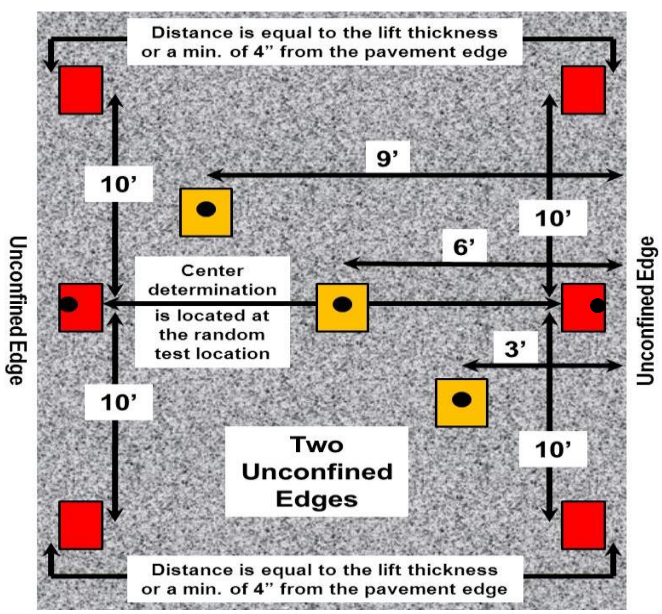
2. When testing with a nuclear density gauge, a total of three determinations will be taken longitudinally along each unconfined edge of the pavement at the required layout locations.

   The middle determination will be located at the random test location and the other two determinations will be spaced longitudinally apart in line with the middle determination at the required layout locations on the pavement edges.

   The results of the three determinations, on one side of the pavement, will be averaged to achieve one individual test which is required to meet the Density Control Limits for the mixture being tested for as an "Unconfined Edge Joint Density Minimum" specification. Each unconfined edge has its own requirement to meet.

3. When cutting cores, a single core (the middle determination) will be cut at the required layout location on each pavement edge. Each single core will be required to meet the Density Control Limits for the mixture being tested for as an "Unconfined Edge Joint Density Minimum" specification separately for each pavement edge.

A total of nine nuclear density determinations or five cores will be taken at this location. Three separate density requirements are to be met in this situation, one for the center pavement location and one on each of the unconfined edges.



Beginning of Determination of Bituminous Concrete Density In Place by Nuclear Methods

Illinois Modified Test Procedure
Effective Date: January 1, 2002
Revised: January 1, 2017

Standard Test Method
for
Determination of Density of Bituminous Concrete in Place by Nuclear Methods

Reference ASTM D 2950-14

ASTM Section	Illinois Modification
2.1	*Replace the individual Standards as follows: IL Modified ASTM Standards in the Illinois Department of Transportation Manual of Test Procedures for Materials (current edition)*
3.5	*Replace with the following: The density results obtained by this test method are relative. If an approximation of core density results is required, a correlation factor will be developed to convert nuclear density to core density by obtaining nuclear density measurements and core densities at the same locations. The Department's "Standard Test Method for Correlating Nuclear Gauge Densities with Core Densities" shall be used to determine the appropriate correlation. It may be desirable to check this factor at intervals during the course of the paving project. A new correlation factor should be determined when there is a change in the job mix formula (outside the allowable adjustments); a change in the source of materials or in the materials from the same source; a significant change in the underlying material; a change from one gauge to another; or a reason to believe the factor is in error.*
3.6 New Section	*All projects containing 2750 metric tons (3000 tons) or more of a given mixture will require a correlation factor to be determined and applied for measurement and acceptance of density testing.*
3.7 New Section	*Definitions:* *Density Test Location: The random station location used for density testing.* *Density Reading: A single, one minute nuclear density reading.* *Individual Test Result: An individual test result is the average of the three to five nuclear density readings obtained at each random density test site location. One to three "individual test results" will be required per "density test location" depending on the following conditions:* • *If two confined edges are present, one "individual test" result representing all five density readings across the mat shall be reported. (Confined edge density readings are included in the average.)* • *If one confined and one unconfined edge is present, two "individual test results" shall be reported for each density test location.* o *One "individual test result" representing the average of four density readings across the mat, including the one confined edge and excluding the unconfined edge density readings.* o *One "individual test result" representing the average of three density readings on the unconfined edge.*

Illinois Modified Test Procedure
Effective Date: January 1, 2002
Revised: January 1, 2017

Standard Test Method
for
Determination of Density of Bituminous Concrete in Place by Nuclear Methods

Reference ASTM D 2950-14

ASTM Section	Illinois Modification
3.7 New Section (Continued)	• If two unconfined edges are present, three "individual test" results shall be reported for each density test location. o One "individual test result" representing the average of three density readings across the mat, excluding the unconfined edge density readings. o One "individual test result" representing the average of three density readings on the unconfined edge. o One "individual test result" representing the average of three density readings on the opposite unconfined edge. Daily Average Density Value: The "daily average density" is the average of the "density readings" of a given offset for the given days production. Density Test Site: Correlation term used to describe each physical location the nuclear density gauge is placed where a density value is determined. Density Value: Correlation term used to describe the density determined at a given density test site from the average of two or potentially three readings
3.8 New Section	When the "Hot Mix Asphalt (HMA) Individual Density Site Modified QC/QA" special provision **is** included, "daily average density values" shall also be determined.
4.2.1	Add the following at the end: The user should recognize that density readings obtained on the surface of thin layers of bituminous concrete may be erroneous if the density of the underlying material differs significantly from that of the surface course.
4.2.2	Add the following at the end: Accuracy of the nuclear test modes (Backscatter vs. Direct Transmission) is not equal and is affected by the surface texture and thickness of the mixture under test. The nuclear test mode to be used and the number of tests required to determine a satisfactory factor are dependent on the conditions stated above.
4.5	Replace with the following: If samples of the measured material are to be taken for purposes of correlation with other test methods, the procedures described in the Department's "Standard Test Method for Correlating Nuclear Gauge Densities with Core Densities" shall be used.
5.5 New Section	Readout Instrument, such as scaler or direct readout meter.
7.1	Add the following at the end: Dated inspection reports shall be kept and be made available to the Engineer upon request.

Illinois Modified Test Procedure
Effective Date: January 1, 2002
Revised: January 1, 2017

Standard Test Method
for
Determination of Density of Bituminous Concrete in Place by Nuclear Methods

Reference ASTM D 2950-14

ASTM Section	***Illinois Modification***
7.1.1 *New Section*	The calibration check shall provide proof of five-block calibration. Calibration standards shall consist of magnesium, magnesium/aluminum, limestone, granite, and aluminum. All calibration standards should be traceable to the U.S. Bureau of Standards. Proof shall consist of documented and dated calibration counts accompanied by copies of an invoice from the calibrating facility.
7.1.2 New Section	At least once a year and after all major repairs which may affect the instrument geometry, the calibration curves, tables, or equation coefficients shall be verified or reestablished.
8.2.1	*Replace with the following:* *The reference standard count shall be taken a minimum of 10 m (30 ft.) from another gauge and a minimum of 5 m (15 ft.) away from any other masses or other items which may affect the reference count rate. In addition, the reference count shall be taken on material 1510 kg/m^3 (100 lbs./ft.^{3}) or greater.*
8.2.2	*Revise the first sentence as follows:* *Turn on the apparatus prior to standardization and allow it to stabilize, a minimum of 20 minutes.*
8.2.3	*Replace with the following:* *All reference standard counts shall consist of a 4-minute count.*
8.2.4	*Replace with the following:* *The density reference standard count shall be within 1 percent of the average of the last four daily reference standard counts.*
8.2.5 *New Section*	*If four reference standard counts have not been established, then the reference standard count shall be within 2 percent of the standard count shown in the count ratio book.*
8.2.6 *New Section*	*If the reference standard count fails the established limits, the count may be repeated. If the second count fails also, the gauge shall not be used. The gauge shall be adjusted or repaired as recommended by the manufacturer.*
8.2.7 *New Section*	*Record all daily reference standard counts in a permanent-type book for a gauge historical record. This also applies to direct readout gauges.*
8.3	*Delete the first sentence.*

Illinois Modified Test Procedure
Effective Date: January 1, 2002
Revised: January 1, 2017

Standard Test Method
for
Determination of Density of Bituminous Concrete in Place by Nuclear Methods

Reference ASTM D 2950-14

ASTM Section	***Illinois Modification***
9.1	Revise as follows: In order to provide more stable and consistent results: (1) turn on the instrument prior to use to allow it to stabilize, a minimum of 20 minutes; and (2) leave the power on during the day's testing.
9.3	*Replace with the following:* *Select a test location, using the Department's "Determination of Random Density Test Site Locations". Each random density test site location shall consist of five equally spaced nuclear density offsets across the mat. These density offsets shall be positioned to provide a diagonal configuration across the mat. The outer density offsets shall be located at a distance equal to the lift thickness or a minimum of 2 in. (50 mm) from the edge of the mat, whichever is greater.* • *If the edge is unconfined, an "individual test result" shall represent the average of three "density readings" spaced 10 feet apart longitudinally along the unconfined edge.* • *If the edge is confined, the density reading will be averaged with the remaining offset "density readings" to provide an "individual test result" representing everything except unconfined edges.*
9.4	*Replace with the following:* *Maximum contact between the base of the instrument and the surface of the material under test is critical. Since the measured value of density by backscatter is affected by the surface texture of the material immediately under the gauge, a smoothly rolled surface should be tested for best results. A filler of limestone fines or similar material, leveled with the guide/scraper plate, shall be used to fill open surface pores of the rolled surface.*
9.5	*Replace with the following:* *For the Direct Transmission Method use the guide/scraper plate and drive the steel rod to a depth of at least 50mm (2 in.) deeper than the desired measurement depth.*
9.6	*Add the following at the end:* *All other radioactive sources shall be kept at least 10 m (30 ft.) from the gauge so the readings will not be affected.*
9.7	*Delete*
9.8	*Delete.*
Note 6	*Delete*
Note 7	*Delete*

Illinois Modified Test Procedure
Effective Date: January 1, 2002
Revised: Revised: January 1, 2017

Standard Test Method
for
Determination of Density of Bituminous Concrete in Place by Nuclear Methods
Reference ASTM D 2950-14

ASTM Section	***Illinois Modification***
10.1	*Delete.*
10.1.1	*Delete.*
10.2	*Delete.*
11.1.1	*Replace with the following:* *Gauge number,*
11.1.2	*Revise as follows:* *Date of calibration data,*
11.1.5	*Revise as follows: Density test site description as follows:* *(1) project identification number, (2) location, including station and reference to centerline, (3) mixture type(s), including mix design number and surface texture, e.g., open, smooth, roller-tracked, etc., and (4) number and type of rollers.*
11.1.6	*Replace with the following:* *Layer (bottom lift = .1, second lift = .2, etc.) and thickness of layer,*

End of Determination of Bituminous Concrete Density In Place by Nuclear Methods

Beginning of Hot Mix Asphalt quality control for Performance (CBM)

"... *All core holes shall be filled immediately upon completion of coring. All water shall be removed from the core holes prior to filling. All core holes shall be filled with a rapid hardening mortar or concrete which shall be mixed in a separate container prior to placement in the hole. Any depressions in the surface of the filled core holes greater than 1/4 inch at the time of final inspection will require removal of the fill material to the depth of the lift thickness and replacement..."*

End of Hot Mix Asphalt quality control for Performance (CBM)

This Page is Reserved

Documentation

Required paperwork is to be submitted by the producer to IDOT in a ‘timely’ fashion. Payment for completed contract items is made when the correctly filled out paperwork is submitted and approved by IDOT.

Payment can/will be held up if the required paperwork is incomplete, inaccurate, or missing. All paperwork is required to be submitted on the proper forms.

IDOT is using and providing a computer program, available for use by the Producer. This program is capable of producing the required documentation/paperwork utilizing Microsoft Office and is capable of transmitting reports electronically. This program has replaced the original Care-AC computer program and/or other programs previously used by some producers and/or districts.

Producers can go online to the IDOT website to down load this program free of charge.

Go to: **http:www.Illinois.gov**. Then click on “**Doing Business**” to reveal a drop-down menu (instead of the drop-down menu, on the left side is a ‘links-menu’). Click on “**Material Approvals**” in the drop-down menu on in the ‘links-menu’. In the ‘links-menu’ (on the left side of the screen), click on the “**Hot Mix Asphalt**” link. Then in the center of the screen is a horizontal ‘links- bar’, click on “**References**”. Then click on the “**Guide/Spreadsheets**” link. This will expose a “**QC/QA Package Downloads**” link that will allow you to down load the program.

You can also sign up to have new updates sent to an e-mail address.

"MISTIC" Reference Codes

ATTACHMENT "A"

LABORATORY LOCATIONS	LAB CODES	
PRODUCER PLANT SITE LABORATORY	PP	
PRODUCER NON-PLANT SITE LABORATORY	PL	
PRODUCER CONSTRUCTION SITE	PC	(Nuclear Density)
PRODUCER QUARRY LABORATORY	PQ	
INDEPENDENT PLANT SITE LABORATORY	IP	
INDEPENDENT NON-PLANT SITE LABORATORY	IL	
INDEPENDENT CONSTRUCTION SITE	IC	(Nuclear Density)
INDEPENDENT QUARRY LABORATORY	IQ	
INDEPENDENT LABORATORY	IN	
IDOT/LOCAL AGENCY PLANT SITE LABORATORY	FP	
IDOT/LOCAL AGENCY CONSTRUCTION SITE	FC	(Nuclear Density)
IDOT/LOCAL AGENCY QUARRY LABORATORY	FQ	
DISTRICT LABORATORY	DI	
DISTRICT SATELLITE LABORATORY	DS	

"TYPE TEST"

Preliminary Test (prior to production, evaluation)	**PRE**
(To be used on start-up nuclear density and core test results that are used for correlation.)	
(use type equipment code N)	
Contractor/Consultant Process Control Test	**PRO**
IDOT Assurance Test	**IND**
Consultant Performing IDOT Assurance Test	**IND**
Special IDOT Investigative Test	**INV**

Resample of failed test same as original (PRO, IND)

DO NOT USE "RES"

"SAMPLED BY"

IDOT: **IDOT personnel use their MISTIC Inspector number**

PRODUCERS: **Contractor, Subcontractor and Producer personnel enter a "9", followed by the District number and seven zeroes (0's).**

Example: 960000000 for District 6

CONSULTANTS: **Consultant personnel enter their company's MISTIC Inspector number**

LOCAL AGENCY: **Local agency personnel enter a "9", followed by the District number, which is repeated until field is filled.**

Example: 966666666 for District 6 local agency

This Page is Reserved

"TYPE EQUIPMENT"

For Density:	**Cores**	**C**
	Nuclear Gauge Determination	**N**
	Adjusted Nuclear Determination	**A**
Marshall/AC:	**Reflux Extraction**	**R**
	Vacuum Extraction	**V**
	Marshall and Nuclear AC or Nuclear AC only	**N**
	Marshall Tests only	**X**

"SAMPLED FROM" CODES (MI-504 Aggregate Gradation Form)

Barge	**BR**	**Road**	**RD**
Belt Stream	**BE**	**Silo/Bin**	**SI**
Cold Feed	**CF**	**Stockpile**	**SP**
Hot Bin	**HB**	**Truck Dump**	**TD**
On Belt (Stopped)	**OB**	**Truck**	**TK**
Production	**PR**	**Weigh Belt**	**WB**
Rail Car	**CR**		

"SAMPLE LOC" CODES (MI-305 HMA Plant Output Form)

Hot Bin	**H**	**Cold Feed**	**C**
Belt	**B**	**Stock Pile**	**S**

HMA Material Codes

Code	Mix	Grad. /Friction	# Gyrations
19502	Binder	IL-19.0L	N30
19503	Surface	IL-9.5L	N30
19512	Binder	IL 19.0	N50
19513	Surface	C	N50
19514	Surface	D	N50
19515	Surface	E	N50
19516	Surface	F	N50
19522	Binder	IL 19.0	N70
19523	Surface	C	N70
19524	Surface	D	N70
19525	Surface	E	N70
19526	Surface	F	N70
19532	Binder	IL 19.0	N90
19533	Surface	C	N90
19534	Surface	D	N90
19535	Surface	E	N90
19536	Surface	F	N90
19510	Surface	IL-4.75	N50

SMA material codes can be found on page 151 of the “Master Material Code Data Base Listing by Material Code” document which can be found on the IDOT website. The code will start with a “1965” value.

Note: For recycled mixes add “R” after 5 digit code: Example: 19534R
For metric mixes add “M” after 5 digit code: Example: 19534M
For Metric-Rec. mix add “MR” after 5 digit code Example: 19534MR

Code number breakdown:

195 indicates a HMA mixture
The 4th digit indicates the number of N_{des} gyrations (1 = 50 gyrations, etc.)
The 5th digit indicates the type of mixture (IL-19.0 or a surface mixture)

Note: The IL-12.5, IL-25.0, N105 and ‘Other’ mixtures, other than SMA mixtures, have been eliminated from the specifications.

Example of HMA Density Requirements

"Mixture Composition	Parameter	Individual Test
IL-4.75	Ndesign = 50	93.0 – 97.4 [1/]
IL-9.5	Ndesign = 90	92.0 – 96.0
IL-9.5, IL-9.5L,	Ndesign < 90	92.5 – 97.4
IL-19.0	Ndesign = 90	93.0 – 96.0
IL-19.0, IL-19.0L	Ndesign < 90	93.0 [2/] – 97.4
SMA	Ndesign = 50 & 80	93.5 – 97.4

The mix code for a 19523 HMA mixture breaks down as:

195 = HMA mixture

2 = _____ gyrations

3 = _______________ mixture

Type of mixture* = _______________ mixture

Number of Gyrations* = _____ gyrations

* See page 10-6 for type of mixture and gyrations

Density requirements = _______________

<u>Class Problem</u>

Determine the mixture, gyrations and the density requirements for a 19532 HMA mixture:

Type of mixture = _______________ mixture

Number of Gyrations = _____ gyrations

Density requirements = _______________

MI 504M Field/Lab Gradation Form (11/20/2012)

Illinois Department of Transportation

Field / Lab Gradations

I.D. Number(1) ______

Inspector No.(2) ______ Inspector Name(3) ______ Date Sampled(4) ______ Seq. No.(5) ______

Mix Plant No.(6) ______ Mix Plant Name(7) ______ *Contract No.(8) ______ *Job No.(9) ______

Responsible Loc.(10) ______ Lab(11) ______ Lab Name(12) ______ Source Name(13) ______

Source(14)	Mat. Code #(15)	Type Test(16)	Orig. I.D. #(17)	Insp. Qty(18).	Spec.(19)	Article(20)	Sampled From(21)	Wash/Dry(22)

(23)

CA FA	75 (3) or 6.3 (1/4)	63 (2.5)	50 (2) 25 (1)	45 (1.75) 9.5 (3/8)	37.5 (1.5) 4.75 (4)	25 (1) 2.36 (8)	19 (3/4) 2 (10)	16 (5/8) 1.18 (16)	12.5 (1/2) 0.6 (30)	9.5 (3/8) 0.425 (40)	4.75 (4) 0.3 (50)	2.36 (8)	1.18 (16) 0.18 (80)	0.6 (30)	0.3 (50) 0.15 (100)	0.15 (100)	.075 (200) .075 (200)

Wash - 0.075(24) ______ PI Ratio(25) ______ Test Results(26) ______ Remarks(27) ______

Sieve CA	Sieve FA	Indiv. Wt. Retained(28)	Cumul. Wt. Retained(29)	Cumul. % Retained(30)	Percent % Passing(31)	Spec. Range % Passing(32)
63 (2.5)						
50 (2)	25 (1)					
45 (1.75)	9.5 (3/8)					
37.5 (1.5)	4.75 (#4)					
25 (1)	2.36 (#8)					
19 (3/4)	2 (#10)					
16 (5/8)	1.18 (#16)					
12.5 (1/2)	0.6 (#30)					
9.5 (3/8)	0.425 (#40)					
6.3 (1/4)						
4.75 (#4)	0.3 (#50)					
2.36 (#8)						
1.18 (#16)	0.18 (#80)					
0.6 (#30)						
0.425 (#40)						
0.3 (#50)	0.15 (#100)					
0.15 (#100)						
0.075 (#200)	0.075 (#200)					
Pan						
Total Dry Wt.(33)						
Total Washed Wt.(34)						
Diff. -0.075(-200)(35)			% Washed - 0.075(36)			

Sampled From Codes			
BR	Barge	RD	Road
BE	Belt Stream	SI	Silo/Bin
CF	Cold Feed	SP	Stockpile
HB	Hot Bin	TD	Truck Dump
OB	On Belt (Stopped)	TK	Truck
PR	Production	WB	Weigh Belt
CR	Rail Car		

0.075 / (37)0.425 ______

(Mix Plant Only)

Lot(38) ______

Bin(39) ______

Copies(40): ______ Tester(41) ______

______ Agency(42) ______

MISTIC INPUT

Date Entered(43) ______

Initials(44) ______

/FOR DTY03504

Printed 12/23/2012

BMPR MI504 (Rev. 11/20/12)

FIELD/LAB GRADATIONS

MI 504M

(Revised 11/20/2012)

1. **I.D. NUMBER:** MISTIC test identification number. Leave blank, because the MISTIC system will generate the test identification number.

2. **INSPECTOR NO.:** Identify the individual who took the sample. For split samples, the same inspector number should be used for both halves of the sample.

   a) IDOT personnel enter their MISTIC inspector number.

   b) Contractor, Subcontractor and Producer personnel, enter a "9" followed by the District number, and seven zeroes (0's).
   Example: (960000000) for District 6.

   c) Consultant personnel enter their company's MISTIC inspector number.

   d) Local agency personnel enter a "9"; followed by the District number, which is repeated until field is filled.
   Example: (966666666) for District 6 local agency.

3. **INSPECTOR NAME:** Enter the name of the inspector who took the sample.

4. **DATE SAMPLED:** Enter the date the sample was taken as month, day, and year in mmddyy format.
   Example: 103112

5. **SEQ. NO.:** Sequence number. Enter any combination of letters and/or numbers up to 6 characters in length. It is used to differentiate multiple samples of the same gradation, taken on the same day. For a split sample, both halves of the split shall have "**SPLIT**" in this field.

6. **MIX PLANT NO.:** Enter the MISTIC code number for the P.C. Concrete or Hot Mix Asphalt Producer. Only one plant may be shown on one report.

7. **MIX PLANT NAME:** Enter the name of mix plant.

8. **CONTRACT NO.:** Leave blank unless the gradation has been sampled at a jobsite for a specific contract. Enter the 5 digit contract number. If it is a local agency contract without a 5 digit number, then enter the 16 or 17 character MFT (Motor Fuel Tax) contract number.

9. **JOB NO.:** Leave blank unless the gradation sampled at the jobsite for a specific contract. Enter the 8 character that corresponds with the 5 digit contract number. If the contract number is not 5 digits, leave this field blank.

10. **RESPONSIBLE LOC.:** Enter the district identification number as a "9" followed by the District number.
    Example: 96 for District 6

11. LAB: Enter the 2 letter MISTIC lab code.

Laboratory Locations	MISTIC Lab Codes
Producer Plant Site Laboratory	PP
Producer NonPlant Site Laboratory	PL
Producer Construction Site	PC
Producer Quarry Laboratory	PQ
Independent Plant Site Laboratory	IP
Independent NonPlant Site Laboratory	IL
Independent Construction Site	IC
Independent Quarry Laboratory	IQ
IDOT/Local Agency Plant Site Laboratory	FP
IDOT/Local Agency Construction Site	FC
IDOT/Local Agency Quarry Laboratory	FQ
District Laboratory	DI
District Satellite Laboratory	DS

NOTE: A Contractor, Subcontractor, and Producer are to use one of the "Produced" lab codes. An IDOT Consultant, Contractor Consultant, Subcontractor Consultant, and Producer Consultant are to use one of the "Independent" lab codes.

12. LAB NAME: Enter the name of company which cannot exceed 20 characters.

13. SOURCE NAME: Enter the name of the aggregate producer.

14. SOURCE: Enter the MISTIC code number of the aggregate producer.
Example: 50912-02

15. MAT. CODE NO.: Material code for the aggregate product. Enter the 8 to 10 character code number of the material being tested.

The following information will help you determine if you have the correct material code number.

- The first space is a "0" to indicate the material is an aggregate.
- The second space indicates the QUALITY LEVEL of the aggregate. Concrete coarse and fine aggregates are always "A" quality. Cement aggregate mixture II coarse aggregate is "D" quality "stabilized," and fine aggregate is "A" quality. Controlled low-strength material fine aggregate is "A" quality, unless alternate fine aggregate materials are used. Hot mix asphalt surface coarse and fine aggregates are generally "B" quality. Hot mix asphalt binder coarse aggregates are generally "C" quality and fine aggregate is "B" quality. (see below).
- The third space indicates the Type of Material (see below).

- The fourth space indicates the Aggregate Type (see below).
- The fifth space indicates the Specification of the aggregate (see below).
- The sixth space may be a "M" to indicate **Metric**.
- The seventh and eighth spaces are the Gradation Number of the aggregate. See Articles 1003.01(c) and 1004.01(c) of the Standard Specifications.
- The ninth and tenth spaces indicate superstructure quality aggregate for concrete use. Always enter "01" if testing superstructure quality aggregate.

QUALITY LEVEL	TYPE OF MATERIAL	AGGREGATE TYPE
0 & 1 Have No Quality	0 = Gravel	C = Coarse Aggregate
2 = A Quality	1 = Crushed Gravel	F = Fine Aggregate
3 = B Quality	2 = Crushed Stone	
4 = C Quality	3 = ACBF Slag	
5 = D Quality	5 = Recycled	
6 = D Quality Stabilized	7 = Natural Sand	
	8 = Stone Sand	
	9 = Special Aggregate	

SPECIFICATION
A = Standard Specification
M = Modified or QC/QA Specification

16. **TYPE INSP:** Type of inspection (see below). For additional information see Attachment 4 in the Project Procedures Guide.

AGENCY	QC/QA	NON QC/QA
Contractor/Producer/ Consultant	PRO	-----
IDOT/Consultant at Aggregate Source	IND (split), INV	PRO
IDOT/Consultant at Mix Plant	IND (split), INV	IND (split-share), INV

17. **ORIG. I.D. #:** Original identification number. Use for resample tests only. Enter the original MISTIC test identification number of the failing test.

18. **INSP. QTY.:** Inspected Quantity. Leave blank. IDOT personnel may enter the quantity that is represented by the gradation test but it is not required.

19. **SPEC.:** Specification. Leave blank. IDOT aggregate personnel should enter the master band ranges under a "PRE" test at the beginning of each production season.
Example: MB2036

20. **ARTICLE:** Leave blank. IDOT aggregate personnel should enter the warning band band ranges under a "PRE" test at the beginning of each production season. Example: MB2234

21. **SAMPLED FROM:** Enter the 2 character designation in the first two spaces. Refer to "Sampled From Codes" box, which is on the form.

22. **WASH/DRY:** Enter a "W" for a washed gradation, or "D" for a dry gradation.

23. **GRADATION RESULTS INPUT TABLE:** Enter the percent passing test results, “percent % passing”, from the calculation table for all sieves. All test results shall be reported to the nearest 1%, except for the 0.075 mm (or 75µm) sieve, which shall be reported to the nearest 0.1%.

24. **WASH - 0.075:** Enter the washed minus .075 mm value from the calculation table to the nearest 0.1%.

25. **PI RATIO:** Plasticity index ratio. Leave blank. IDOT personnel, when appropriate, should enter the PI ratio value.

26. **TEST RESULTS:** Enter “APPR” for results meeting specifications or “FAIL” for failure to meet specifications. Show under “Remarks” action taken for samples not meeting specifications. For example, retest, checked equipment, test method incorrect, will monitor.

27. **REMARKS:** This space should be used to record any comments about the aggregates, or the stockpiling and handling methods uses.

For “IND” inspection, a comparison remark is required, because the assurance test is from a split sample. For an acceptable comparison, enter the following:

- Enter “C” when tests compare within acceptable limits of precision.
- Enter date of comparison.
- Enter initials for “IND” inspector.
- If the sample was witnessed by the “IND” inspector, indicate as “ws.”
- Example: C - 100197 TCS ws.

For an unacceptable comparison, enter the following:

- Enter “X” when tests do not compare within acceptable limits of precision.
- Enter date of comparison.
- Enter initials for “IND” inspector.
- If the sample was witnessed by the “IND” inspector, indicate as “ws.”
- Explain reason for unacceptable comparison.
- Examples are: Producer obtained sample incorrectly; IDOT equipment required repair; Producer performed test method incorrectly; problem was not identified, will investigate further if problem continues.
- Example: X - 100297 TCS ws Producer performed test method incorrectly.

28. **INDIV. WT. RETAINED:** Enter the weight of aggregate on each sieve individually, starting with the largest sieve first. Weigh coarse aggregate to the nearest 1 gram, and fine aggregate to the nearest 0.1 gram. If the sieve was overloaded and split into two or more portions to hand sieve, then write a “S” outside the table on that row (right or left side).

29. **CUMUL. WT. RETAINED:** Cumulative Weight Retained. Add the weight on each sieve, to the weight on any larger sieve(s), and enter that value.

30. **CUMUL. % RETAINED:** Cumulative percent Retained. Divide the cumulative weight retained by the total dry weight, and multiply by 100, for each sieve. Round to the nearest 0.1%, and enter that value.

31. **PERCENT % PASSING:** Subtract the cumulative percent retained, from 100, for each sieve. Record to nearest 0.1%, and enter that value..

28. **SPEC. RANGE % PASSING:** Enter the specification range for all appropriate sieves. These may be Standard Specifications, or modified Standard Specification, or master band limits.

29. **TOTAL DRY WT.:** Enter the weight of the sample after it has been dried to a constant weight. Weigh coarse aggregate to the nearest 1 gram, and fine aggregate to the nearest 0.1 gram.

30. **TOTAL WASHED WT.:** Enter the weight of the sample after it has been washed, and dried back to a constant weight. Weigh coarse aggregate to the nearest 1 gram, and fine aggregate to the nearest 0.1 gram.

31. **DIFF. -0.075 (-200):** Subtract total washed weight from the total dry weight, and enter that value.

32. **% WASHED -0.075:** Divide the “Diff. - 0.075” by the “Total Dry Wt.” and multiply by 100. Round to the nearest 0.1%, and enter that value.

33. **0.075 / 4.25:** Leave blank. IDOT personnel, when appropriate, enter the ratio of the percent passing the .075 mm (#200) sieve and the .425 mm (#40) sieve.

34. **LOT:** Leave blank. IDOT mix plant personnel use if performing individual hot bin “IND” tests. Enter the lot corresponding to the Daily Plant Output (MI 305). Also, enter this in the remarks.

35. **BIN:** Leave blank. IDOT mix plant personnel use if performing individual hot bin “IND” tests. Enter the appropriate hot bin number. Also, enter this in remarks.

36. **COPIES:** Enter the distribution of this report. The normal distribution for mix plant results is the **original** goes to the District Engineer, a copy goes to the Resident Engineer(s), and a copy goes to the QC Manager(s). The distribution for aggregate source tests is the original goes to the District Engineer and a copy goes to the source’s QC manager. Non-QC/QA – Same as above, except that the file copy stays with the tester or the individual who completed the report.

37. **TESTER:** Print the name of the individual who tested the aggregate. The individual’s signature is also required. If the test is run by a Gradation Technician, then the supervisor should sign here also.

38. **AGENCY:** Enter the tester’s employer.

39. **DATE ENTERED:** Leave blank. IDOT will enter the date the results are entered into MISTIC as month, day, and year in mmddyy format.

40. **INITIALS:** Leave blank. IDOT enter initials of the person entering the test results into MISTIC.

MI-305 Daily Plant Output Form

Illinois Department of Transportation

Bituminous Mixture Daily Plant
Output Hot Bin / Cold Feed QC / QA

Sampled by 1 Date Sampled 2 Seq No 3
Mix Plant 4 Name 5 Loc 6
Mix Code 7 Name 8 Desc 9
Type Test 10 Resp Loc 11 Lab 12 Name 13
Lot 14 Start Date: 15 Complete Date: 16

Qnty/Hr.	Batch Wt.	Batches	Loads	Qnty	Dist. Mix No.
17	18	19	20	21	22

	Prod.	Matl.	% Mix		Prod.	Matl.	%
Asphalt	23	24	25	Additive	26	27	28

Temp (C)	Agg. Drier	Agg. Bin	AC	Bit. Mix	Bit. Mix (RE/RT)
Max.	29				
Min.					
Wtd. Avg.					

Mix Time Dry > Wet > Total > 30
Plant Operation Start > 31 Finish > Delays >

Cont.	Job No.	Qnty.	Cont.	Job No.	Qnty.
32	33	34			

Remarks > 35

36 Info. Only (Pro) Marshall & Nuc AC

TSEQ	AJMF
1 ___	1.5 ___
___	1 ___
	3/4 ___
Blow	1/2 ___
___	3/8 ___
___	4 ___
LitD	8 ___
___	16 ___
___	30 ___
	50 ___
BigD	100 ___
___	200 ___
___	BIT ___
% VOID	Nuc AC %
___	___
___	___

TRAN 309
TEST SEQ: 1 38 HOT BIN / COLD FEED/ COMBINED BELT GRADUATION SAMP LOC: 40 WASH: 45 EDIT: Y 37

	RAP	BIN 5	BIN 4	BIN 3	BIN 2	BIN 1	MF	NEW BIT	NEXT PROC 39	
MIX %	41							51		+/-
KG/BT-RV	42								TAR-GET	TOL RANGE
AGG %	43							% PASS		
37.5	44							47	48	49
25										
19										
12.5										
9.5										
4.75										
2.36										
1.18										
600										
300										
150										
75										
Bit	50					BIT TOTAL		52		

Remarks: 53

Authorized By: 57 58

Target Changed ☐
AJMF Changed ☐ 46

Tested By: 55 56

Copies: 54

TRAN 309

Daily Bituminous Plant Report

Page 2 of 2

TEST SEQ: 2

HOT BIN / COLD FEED / COMBINED BELT GRADUATION

SAMP LOC: ____ WASH: ____ EDIT: Y N

	RAP	BIN 5	BIN 4	BIN 3	BIN 2	BIN 1	MF	NEW BIT	NEXT PROC	+/-
MIX %										
KG /BT-RV									TAR-GET	TOL RANGE
AGG %								% PASS		
37.5										
25										
19										
12.5										
9.5										
4.75										
2.36										
1.18										
600										
300										
150										
75										
BIT						BIT TOTAL				

Remarks: ____

Authorized By (Level 2): ____

Tested By (Level 1 or 2): ____

Target Changed ☐

AJMF Changed ☐

INFORMATIONAL ONLY
DO NOT ENTER IN MISTIC

1
Plant Settings

Feeder Settings	
Bin	Settings
1	
2	
3	
4	
5	
Rap	
MF	
AC	

2

Batch Counter	
Final	
Initial	
Total	

3

Accuracy Check	Scale	WGHMN
Gross Weight (1)		
OBS WTS or Theo WTS (2)		
Tare Weight (3)		
Accuracy % [(1-3)-2]÷(1-3)		

4
Scale Checks

Asphalt Scale	
Wt	
0	
50	
100	
150	
200	
250	
300	
350	
400	
450	
500	

5

Scale Check	Date
Aggregate	
Asphalt	
Meter	

6

Aggregate Scale Sensitivity Check	
Weight	
Added Weight	
Total	

Remarks: 8 ____

QC/QA IDOT Bituminous Mixture Daily Plant Output (MI305)
Instructions for Hot Bin/Cold Feeds/Weight Belt

1. **<u>SAMPLED BY</u>:** Enter the identification number of the person taking the sample.

   A. IDOT personnel enter their MISTIC inspector number.

   B. Producers are to use the District designation followed by 0's until the field is filled.
   Example: (960000000) for District 6.

   C. Consultant personnel are to use their tax number. Left justified and right filled with zeros.
   Example: (123450000) for tax number 12345.

   D. Local agency personnel are to use a "9" followed by the District number repeated until field is filled.
   Example: (966666666) for District 6 local agency.

2. **<u>DATE SAMPLED</u>:** Enter as month, day, and year mix was produced.

   Example: 040891 for April 8, 1991

3. **<u>SEQ. NO.</u>:** May be alpha or numerical up to 6 characters in length.

4. **<u>MIX PLANT NO.</u>:** MISTIC Producer/Supplier number.

5. **<u>NAME</u>:** Name of bituminous Producer/Supplier.

6. **<u>LOC</u>:** Show location of the bituminous plant.

7. **<u>MIX CODE</u>:** MISTIC Code number for the bituminous mix being produced.

8. **<u>NAME</u>:** Name of the bituminous mixture.

9. **<u>DESC</u>**: Normally, leave blank for Class I mixtures, except for mixture with rubber added. For **Rubber** mixtures enter ("RUB .5" or "RUB 20"). For BAM Mixtures, use "CA06" or "CA10" to identify aggregate.

10. **<u>TYPE TEST (INSP)</u>:** Enter the correct type test designation from the "MISTIC CODE REFERENCE SHEET" shown in ATTACHMENT A.

    Normally "PRO" for Producer & "IND" for State.

11. **<u>RESP LOC</u>:** Enter District responsible location (e.g. District 9 = 99)

12. **<u>LAB</u>:** Enter the correct lab designation from the "MISTIC CODE REFERENCE SHEET" shown in ATTACHMENT A.

13. **<u>NAME</u>:** Show name if a Consultant or Contractor.

QC/QA IDOT Bituminous Mixture Daily Plant Output (MI305)
Instructions for Hot Bin/Cold Feeds/Weight Belt

14. LOT NO.: Used to identify the days production (format of 999-99). Example: Lot No. 001-01 represents the 1st day of production. Lot No. 002-01 for the 2nd days of production. Please note the Lot Suffix is always "-01". **The TSEQ No. is now used to identify first and second test samples**.

For Start-ups use LOT 000-01 for the sample that represents the material between the Growth Curve Trucks.

For the second set of gradations, a second plant report is required using LOT 000-02.

On Start-ups, Plant Hot Bin/Cold Feed Gradation test must correlate to field density tests taken in the Growth Curves and normal roller pattern area.

15. DATE STARTED: Enter the date the sample began the testing process.

16. DATE COMPLETED: Enter the date that the sample testing was complete.

17. QNTY/HR: Theoretical metric tons, per hour for a continuous mix or drier-drum.

18. BATCH WT: Total batch weight (kg) of aggregate plus AC for a batch plant.

19. BATCHES: Enter the total number of batches for the mix shipped to the job(s) covered by this report. Do not enter wasted batches or batches sent to non-State jobs.

20. LOADS: Enter total number of loads delivered to job(s) for this report.

21. QNTY: Producer is to show the total number of metric tons that were produced of this mixture. Normally only one plant report is required for a day's production. *State's plant report should show a quantity of zero (1).*

22. DIST MIX NO: Enter MISTIC field mixture number for the mix being produced. (e.g. 89BIT0001)

23. AC PROD: Enter MISTIC code for asphalt cement producer.

24. AC MATERIAL: Enter MISTIC code for asphalt cement being used.

25. % MIX: Enter the percentage of AC used in the mixture.

26.* ADD PROD: Enter the MISTIC code for the additive producer.

27.* (ADD) MATERIAL: Enter the MISTIC code for the additive material being used.

QC/QA IDOT Bituminous Mixture Daily Plant Output (MI305)
Instructions for Hot Bin/Cold Feeds/Weight Belt

28.* <u>(ADD) %</u>: Enter the percentage of liquid additive used in relation to the asphalt.

Example: (.75%) Hydrated Lime is expressed as a percentage of aggregate.

*** <u>If no anti-strip additive was used and a rubber additive was used, show the rubber producer, material code and pounds dosage here.</u>**

29. <u>TEMP (C)</u>: Record the temperature obtained at the various locations listed, including the required delivery temperature (Bit Mix RE/RT) as set by the Resident.

30. <u>MIX TIME (Sec)</u>: Record mixing time (in seconds) actually used at the plant.

31. <u>PLANT OPER</u>: List the starting and finishing times (HHMM), and any delays during the days production.

32. <u>CONTRACT</u>: Use Contract Number (usually 5 digits). List all contract quantities covered by this report.

33. <u>JOB NO</u>: Use the Job Number(s) that corresponds with the Contract Number(s).

34. <u>QNTY</u>: Enter total metric tons produced for each contract number (to the nearest tenth of a metric ton), IDOT personnel are to show 0.0 for each contract.

35. <u>REMARKS</u>: List any comments about plant operations or problems. Remarks must be filled out for failed test.

36. <u>MARSHALL & NUC AC</u>: Information copied in from IDOT's computer program if being used. (Otherwise N/A).

37. <u>EDIT</u>: Enter Y (Yes). This will enable MISTIC to compute deviations.

38. <u>TEST SEQ. NO</u>: To be used to identify (a) first, (b) random, (c) resample tests.

TEST SEQ. NO. (TSEQ) format is:

"1R1" where "1" = SAMPLE 1, "R" = resample, and second "1" = first resample.

Normally TSEQ = "1" for first sample and "2" for second sample (ran)

The first resample of "TSEQ = 2" would be identified as "2R1"

If the A.M. sample is a resample of the previous afternoon test, then you must put **"<u>RETEST</u>"** in the remarks area.

39. <u>NEXT</u>: Enter "Y" if there are additional Hot Bin/Cold Feed Tests for the day.

QC/QA IDOT Bituminous Mixture Daily Plant Output (MI305)
Instructions for Hot Bin/Cold Feeds/Weight Belt

40. SAMPLE LOC (H)OT, (C)OLD, (B)ELT, (S)TOCKPILE: Enter the gradation sampling point “H” for hot bin, “C” for cold feed, “B” for a belt sample, or “S” for stockpile.

41. MIX %: Enter the mixture percentages for all the ingredient aggregates in the appropriate slots, and the asphalt % that is “dialed into” the plant control system under NEW BIT.

NOTE: MUST TOTAL 100%

42. KG/BT-REV: Show kilograms per batch of each material used for batch plants, (metric tons per hour for drier-drum, or kilograms per revolution for continuous plants).

43. AGG%: Enter the percentage of aggregate being used from each of the hot bins, weight belt, cold feeds, etc.

44. % PASS: Enter individual bin gradations.

45. WASHED (Y or N): Enter a “Y” for yes if sample was washed or “N” for not washed. If a combination of both enter “Y” and clarify in the REMARKS below in space 53.

46. CHANGE (Y or N): Use “Y” for yes if this data reflects any change from the previous tests data ((MIX FORM, or AC content being added), or “N” for no if data remained the same, list the specific change in the remarks section below.

47. % PASS: Enter the Combined Percent Passing for each sieve fraction to the nearest whole percent (except for the -#200 & AC, which are rounded to the nearest .1%).

The Combined % passing is determined by the summation of all the % Bin on that line.

48. TARGET: Enter the correct TARGETs for the aggregate and asphalt for the material being produced.

49. TOLERANCE RANGE: Enter the applicable tolerance ranges for the aggregate and asphalt for material being produced.

50. RAP BIT: Enter the average % of AC as determined by the series of extraction tests. (However, you must calculate the “prorated RAP asphalt content” based on the percent RAP to determine the **BIT TOTAL %**).

51. NEW BIT: Enter the “new” asphalt content of the mixture (This does not include the residual asphalt contained in the RAP product).

52. BIT TOTAL %: Enter the total percentage of Asphalt being used to the nearest .1%.

QC/QA IDOT Bituminous Mixture Daily Plant Output (MI305)
Instructions for Hot Bin/Cold Feeds/Weight Belt

53. **REMARKS:** Enter any comments pertaining to the above mixture information.

State's IND reports enter "C-mmddyy plus action" or "X-mmddyy plus action" to identify whether producer & State tests compared favorably or failed the comparison.

54. **CC:** Copies to be forwarded to: District, Resident, & Contractor.

55. **TESTER:** Producer and IDOT use signature of person doing the tests.

56. **AGENCY:** Tester's employer (contractor/consultant/IDOT).

57. **INSPECTOR:** Producer use signature of the person responsible for the quality control. IDOT use tester's supervisor signature, or leave blank.

58. **AGENCY:** Producer use Inspector's employer (contractors/consultant name).

IDOT leave blank.

QC/QA PLANT SETTINGS AND SCALE CHECK FORM INSTRUCTIONS
(On reverse side of Daily Plant Output – MI-305)

1. **PLANT FEEDER SETTINGS:** Enter the cold bin feeder setting in inches and the mineral filler and asphalt in points (continuous plants).

2. **BATCH COUNTER:** Record the initial and final batch counter readings.

3. **ACCURACY CHECKS:** Enter SCALE and WEIGHMAN check results.

NOTE: Procedures are discussed in the Plant Operation Section of the Hot Mix Asphalt Level II Manual QC/QA.

4. **ASPAHLT SCALE:** Enter the asphalt scale check information.

5. **SCALE CHECK DATES:** Record the dates that the particular scale checks were made.

6. **AGGREGATE SENSITIVITY CHECK:** Record sensitivity results of the aggregate scales.

7. **ASPHALT TICKETS:** (Optional) Record the Asphalt Producer, material code, and Ticket number for the asphalt received at the plant.

8. **REMARKS:** Make any further comments that may be necessary for clarification. List any scale checks that failed and the corrective action that was taken.

Producer Marshall and Nuclear Asphalt MI-308 Form

Illinois Department of Transportation

Sample Identification

Nuclear Asphalt Content and Marshall

Lab Number 1

Sampled By: 2 Date Sampled: 3 Seq.: 4

Type Insp: 5 Total Samples: ______

Producer #: 6 7 Suffix: ______

Mat Code: 8 9 Desc.: 10

Spec Title: 11 Article: 12 Eff Date: 13

Sampled From: 14 Copy: ______

Resp Location: 15 Lab: 16 Lab Name: 17

Received: 18 Start: 19 Complete: 20 Result: 21

Authorized by: 22 Remarks: ______

Next Screen: ___ Ident: ___ Assign: Y Test: ___ Trans: ______

Contract #:	Job #:	Contract #:	Job #:
23	24		

Trans 308

TSEQ: * Type Equip: 25 Dry Time: 26 Washed: 27 Mix #: 28 Accum: ___

Edit: N QA: ___ Test / Avg: T Lot: 29

WORK AREA ONLY	Sieve	Information Only AJMF	Target	State Only -1- IND	-2- IND	Producer Nuclear Asphalt Tests: Nuclear Asphalt Moisture Correction	-1- Pro	-2- Pro
	37.5							
	25					Pan + Sample Wet >		
	19.5					Pan + Sample Dry >		
	12.5					Diff:		
	9.5					Pan + Sample Wet:		
	4.75					Pan - - - ->		
	2.36					Wet Wt:		
	1.18					% Water:		
	600					Wo =	Nuclear Gauge Data	
	300					Temp =		
	150					Gauge #- - >		
	75					Count - - - ->		
						% Asphalt - - >		
						Water %:		
	BIT					Corrected Asphalt %:		

Marshall Test

			TSEQ*	NUC AC%	AJMF	TOL + -	BLOWS	D (Gmm)	d (Gmb)	% VOIDS
PRO	Producer Input This Data	1		30	31	32		33		
		2								
IND	State Do Not Enter	1								
		2								

IND TSEQ #1 Remark: 40

IND TSEQ #2 Remark: ______

35
Mix Formula Changed ☐ No Change ☐

Tester: 36 Agency: 37 cc: 34

Inspector: 38 Agency: 39

/FOR DTY 03000 MI 308 QC/QA-B

QC/QA
PRODUCER MARSHALL AND NUCLEAR AC REPORT FORM AND IDOT SAMPLE ID SHEET INSTRUCTIONS (MI-308)

1. Lab Number: Leave blank MISTIC system will generate Test ID Number

2. SAMPLED BY: Enter the identification number of the person taking the sample

   A. **IDOT personnel** are to use their Social Security No. (Only applicable when sample taken by IDOT)

   B. **Producers** are to use the District designation followed by 0's until the field is filled.

      EXAMPLE: **District 3** designation is 93; then **"930000000"** would designate a District 3 producer.

   C. **Consultant personnel** are to use their tax number. Left justified and right filled with zeroes. EXAMPLE: (123450000) for tax number 12345.

   D. Local agency personnel: are to use a "9" followed by the District number repeated until the field EXAMPLE: (966666666) for District six.

3. DATE SAMPLED: Enter as month, day, year mix was produced Example: 040891 for April 8,1991

4. SEQ NO: May be alpha or numerical up to 6 characters in length

5. TYPE (INSP) TEST: Enter the correct type test designation from the "MISTIC CODE REFERENCE SHEET" shown in ATTACHMENT A.
   Normally "PRO" for producer & "IND" for State.

6. PRODUCER NO: MISTIC Producer/Supplier number

7. PRODUCER NAME: Name of bituminous Producer/Supplier

8. MATERIAL CODE: MISTIC code number for the bituminous mix being test

9. MATERIAL NAME: Name of the bituminous mixture

10. DESC: Normally, leave blank for Class I mixtures, except for mixture with RUBBER added. For RUBBER mixtures enter ("RUB .5" or "RUB 20"). (Additional information on next page)

QC/QA
PRODUCER MARSHALL AND NUCLEAR AC REPORT FORM
AND IDOT SAMPLE ID SHEET INSTRUCTIONS (MI-308)

For BAM Mixtures, use "CAM06" or "CAM10" to identify Aggregate

11. **SPEC TITLE**: Show specification that applies to material being tested (Standard Specifications, Special Provisions, etc.)

12. **ART**: If applicable, show Article Number of specification

13. **EFF DATE**: Effective date of specification

14. **SAMPLE FR**: Enter source of sample SEE MISTIC CODE REFERENCE SHEET shown in ATTACHMENT "A"

15. **RESP LOC**: Enter District responsible location (e.g. District 9 = 99)

16. **LAB**: Enter the correct lab designation from the "MISTIC CODE REFERENCE SHEET" shown in ATTACHMENT A.

17. **LAB NAME**: Show name if a Consultant's or Contractor's laboratory

18. **DATE REC**: Enter date sample was received (MMDDYY)

19. **START DATE**: Enter the date the sample began the testing process

20. **COMP DATE**: Enter the date that the sample testing was completed

21. **RESULTS**: Enter APPR for approve or FAIL for fail.

22. **AUTH BY**: Level 2 inspector for producer sample report

23. **CONTRACT**: Use Contract Number (usually 5 digits). List all contract quantities covered by this report

24. **JOB NO**: Use Job Number that corresponds with the Contract Number

25. **EQUIP**: Show type of equipment used to performed test SEE MISTIC REFERENCE SHEET shown in ATTACHMENT "A"

QC/QA
PRODUCER MARSHALL AND NUCLEAR AC REPORT FORM AND IDOT SAMPLE ID SHEET INSTRUCTIONS (MI-308)

26. <u>DRY TIME</u>: Enter drying time if reflux is used

27. <u>WASHED</u>: Indicate if extraction sample was washed (Y) yes or (N) no

28. <u>MIX NO</u>: Enter MISTIC bituminous field mixture number for the mix being produced. (e.g. 89BIT0001)

29. <u>LOT NO:</u> Used to identify day's production (format of 999-99) EXAMPLE: Lot number 001-01 represents the 1st day of production. Lot 002-01 for second day's production. Please note the Lot Suffix is always "-01".

    *For **Start-Ups use LOT 000-01 and 000-02** for the Growth Curves.*

    If a second Test Strip is necessary, a second plant report is required using LOT 000-03 and 000-04.

    On Start-Ups, Plant Hot Bin/Cold Feed Gradation test must correlate to field density tests (as much as possible).

30. <u>BIT % PASSING:</u> Show the AC nuclear content to the nearest .1%

31. <u>AC MIX FORMULA:</u> Enter the "adjusted mix formula" for the material being tested

32. <u>AC TOLERANCE:</u> Show allowable asphalt tolerance

33. <u>MARSHALL TESTS:</u> List all Marshall test data ("D" & "d" to the nearest 0.001

34. <u>CC:</u> Copies to be forwarded to District, Resident Engineer, Contract

35. <u>MIX FORMULA CHANGE/NO CHANGE</u>: Indicate whether there has been a change in the mix formula since the last test.

36. <u>TESTER:</u> Producer and IDOT use signature of the person doing the test

37. <u>AGENCY:</u> Tester's employer (contractor/consultant/IDOT).

QC/QA
PRODUCER MARSHALL AND NUCLEAR AC REPORT FORM
AND IDOT SAMPLE ID SHEET INSTRUCTIONS (MI-308)

38. **INSPECTOR:** Producer use signature of the person responsible for quality control.

    IDOT use tester's supervisors signature, or leave blank.

39. **AGENCY:** Producer use inspectors employer (contractors/consultant name)

    IDOT leave blank

40. **REMARKS:** Make any further comments that may be necessary for clarification

    State's IND reports enter "C-mmddyy plus action" or "X-mmddyy plus action" to identify whether producer & state tests compared favorably & action.

    Remarks must be filled out for failed test.

    If the A.M. sample is a resample of the previous afternoon test, you must put **"RETEST"** in the remarks area.

QC/QA IDOT BITUMINOUS NUCLEAR DENSITY TESTING REPORT MI303N FORM

Illinois Department of Transportation

Quality Assurance
Nuclear Density Report QC/QA

I.D. No. ______

Inspector No. ______ Date Sampled ______ Seq. No. ______ County ______

Bit Mix Plant ______ Bit Mix Code ______ Equip. ______ QA ______ Section ______

Contract No. ______ Job No. ______ Target Dens. ______ Route ______

Respons. Loc. ______ Lab ______ Standard Count ______ Project ______

Start Date ______ Complete Date ______

Gauge # ______ Calib. Date ______

Mode ______ Probe Depth ______

Correlation Data
M= ______
B= ______

	Date Laid	Station	Ref	Lift No. (Thick)	Lit d (Gmb)	Big D (Gmm)	% Den	Result	Type Insp	Den Kg/m³	Lot
1											
2											
3											
4											
5											

REMARKS
1 ______
2 ______
3 ______
4 ______
5 ______

Test No.	1			2			3			4			5		
Offset	Count	CR	kg/m³	Count	CR	kg/m³	Count	CR	kg/m³	Count	CR	kg/m³	Count	CR	kg/m³
Average															

CC: ______ Tester ______ Agency ______

______ Inspector ______ Agency ______

MISTIC INPUT
Date Entered ______
Initials ______

'FOR DTY03303'

Printed 11/30/2011

BMPR MI303N (Rev. 07/02/09)
Formerly MI 303N

QC/QA IDOT BITUMINOUS NUCLEAR DENSITY TESTING REPORT FORM INSTRUCTIONS BMPR MI303N FORM

Quality Assurance
Nuclear Density Report QC/QA

I.D. No. 1

Inspector No. 3	Date Sampled 4	Seq. No. 5				County	2
Bit Mix Plant 6	Bit Mix Code 7	Equip. 8	QA Y			Section	
Contract No. 9	Job No. 10	Target Dens. 11				Route	
Responsible Loc. 12	Lab 13	Standard Court 14				Project	

Start Date		Complete Date	
Gauge #	17	Calib. Date	18
Mode	19	Probe Depth	20

Correlation Data
M=
B= 21

	Date Laid	Station	Ref	Lift No. (Thick)	Lit d (Gmb)	Big D (Gmm)	% Den	Result	Type Insp	Den Kg/m^3	Lot
1		23	24	25	26	27	28	29	30	31	32
2											
3											
4											
5											

REMARKS
1 33
2
3
4
5

Test No.	1			2			3			4			5		
34															
Offset	Count	CR	kg/m^3	Count	CR	kg/m^3	Count	CR	kg/m^3	Count	CR	kg/m^3	Count	CR	kg/m^3
Average															

CC: 35

Tester	36	Agency	37
Inspector	38	Agency	39

MISTIC INPUT
Date Entered ____________
Initials ____________

'FOR DTY03303'

BMPR MI303N (Rev. 07/02/09)
Formerly MI 303N

QC/QA IDOT BITUMINOUS NUCLEAR DENSITY TESTING REPORT FORM INSTRUCTIONS BMPR MI303N FORM

1. **ID NO:** Leave blank MISTIC system will generate Test ID Number.

2. **PROJECT IDENTIFICATION:** Job stamp may be used

3. **SAMPLED BY:** Enter the identification number of the person taking the sample.

   A. **IDOT personnel** are to use their Social Security No. or assigned I.D. No.
   (Only applicable when sample taken by IDOT)

   B. **Producers** are to use the District designation followed by 0's until the field is filled.

   EXAMPLE: District 3 designation is 93; then "930000000" would designate a District 3 producer.

   C. **Consultant personnel** are to use their tax number.
   Left justified and right filled with zeroes.
   EXAMPLE: (123450000) for tax number 12345.

   D. **Local agency personnel** are to use a "9" followed by the District number repeated until the field is filled.
   EXAMPLE: (966666666) for District six.

4. **DATE SAMPLED:** Enter date (MMDDYY) mix was produced
   Example: 040891 for April 8, 1991

5. **SEQ NO:** May be numerical or alphabetical up to 6 characters in length.

6. **BIT MIX PLANT:** MISTIC Producer/Supplier number

7. **MIX CODE:** MISTIC code number for the bituminous mix being produced

8. **EQUIP:** Enter type equipment used: "A" for an adjusted nuclear determination, or "N" if the reading was not adjusted (correlated)

9. **CONTRACT NO:** Use Contract Number (usually 5 digits)

10. **JOB NO:** Use Job Number that corresponds with the Contract Number

QC/QA IDOT BITUMINOUS NUCLEAR DENSITY TESTING REPORT FORM INSTRUCTIONS BMPR MI303N FORM

11. **TARGET DENS:** Enter the minimum required density in Kg/Cu m for the mix being tested. This will be based on the minimum % density for type.

    For example, take G_{mm} * 1000 * 0.920 for TYPE I mix.
    For example, take G_{mm} * 1000 * 0.925 for TYPE II mix.

12. **RESPonsible LOC:** Enter District responsible location (e.g.: District 9 = 99

13. **LAB:** Enter the correct lab designation from the "MISTIC CODE REFERENCE SHEET" shown in ATTACHMENT A.

14. **STANDARD COUNT:** Enter the standard count used in the calculations

15. **START DATE:** N/A

16. **COMPLETE DATE:** N/A

17. **GAUGE #:** Enter the number of the gauge being used

18. **CALIB DATE:** Enter the last date the gauge was calibrated

19. **MODE:** Enter the mode of transmission: Direct or Backscatter

20. **DEPTH OF PROBE:** Enter the depth of the probe in inches

21. **CORRELATION DATA:** Enter the nuclear/core correlation data (m & b)used to determine the adjusted nuclear density.

22. **DATE LAID:** Enter the date the material was placed

23. **STATION:** Enter station number where test was taken

24. **REF:** Use direction of pavement (NBP, SBD, EBL, etc.)

    (NBP = North Bound Passing)
    (SBD = South Bound Driving)
    (EBL = East Bound Lane)

QC/QA IDOT BITUMINOUS NUCLEAR DENSITY TESTING REPORT FORM INSTRUCTIONS BMPR MI303N FORM

25. **THICK(Lift number):** Designations in terms of lifts should be denoted from the bottom (including Bam or Poz lifts) in the following format. ".1" would designate 1st (lowest) lift, ".2" then would indicate the next lift (of the same mixture type) placed. Each mixture type will have its own set of lift numbers.

26. **G_{mb} (LIT "d"):** Record G_{mb} (Bulk Specific Gravity) determined during testing to the nearest .001.

27. **G_{mm} (BIG "D"):** Record G_{mm} (Maximum Specific Gravity) used in calculations to the nearest .001

28. **% DENS:** Record the calculated % density (nearest tenth)

29. **RESULTS:** Enter (APPR) for passing test or (FAIL) for failing test (see 34. **REMARKS**)

30. **TYPE TEST:** Enter the correct type test designation from the "MISTIC CODE REFERENCE SHEET" shown in ATTACHMENT A.

31. **DENS Kg/Cu m:** Record the calculated density (Kg/Cu m) to the nearest tenth.

32. **LOT NO:** Used to identify both the day's production (format of 999-99 and the random field density sample location.

    EXAMPLE: Lot number 001-01 represents the 1st day of production & first random sample location. Lot 001-02 identifies the 1st day's production & the second random sample location.

    Retests are identified as follows: The first retest would be designated by using an 8 as the first digit in the suffix (Example: 001-82 would indicate the first retest of the second sample of lot 001.) Subsequent resamples would use descending numbers as indication of additional resamples.
    (Example: The second resample of sample number 2 in lot 001 would be 001-72)

    <u>The field density LOT Prefix correlates with the plant LOT Prefix.</u>

    <u>However, the field density LOT Suffix identifies each random sample while the plant Lot Suffix is always "-01"</u>

    For Start-Ups use LOT 000-01 for the first Growth Curve.

    For the second Growth Curve the Lot Number would be 000-02

    On Start-Ups, Plant Hot Bin/Cold Feed Gradation test must correlate to field density tests (as much as possible).

QC/QA IDOT BITUMINOUS NUCLEAR DENSITY TESTING REPORT FORM INSTRUCTIONS BMPR MI303N FORM (continued)

33. **WORKSHEET:** This sheet may be used to do the required calculations; otherwise, actual calculations must accompany completed form.

34. **REMARKS:** Make any comments regarding test results. State personnel must put a **C-mmddyy** for compared or a **X-mmddyy** for failed comparison. The date must be the date that the data was analyzed. Remarks must be filled out for any failed test.

35. **COPIES:** Distribution of copies: District, Resident Engineer, Contractor

36. **TESTER:** Producer and IDOT use signature of the person doing the testing

37. **AGENCY:** Tester's employer (contractor/consultant/IDOT).

38. **INSPECTOR:** Producer use signature of the person responsible for quality control. IDOT use tester's supervisors signature, or leave blank.

39. **AGENCY:** Producer use inspectors employer (contractors or consultant name)

    IDOT leave blank

This Page is Reserved

Lot Number Examples

001-01 1st day of production for this mix, 1st density test
001-02 1st day of production for this mix, 2nd density test
002-08 2nd day of production for this mix, 8th density test
003-04 3rd day of production for this mix, 4th density test
005-03 5th day of production for this mix, 3rd density test
005-04 5th day of production for this mix, 4th density test

This density test fails, what happens?

005-84 5th day of production, 1st density retest for the 4th test

This density test fails, what happens?

005-74 5th day of production, 2nd density retest for the 4th test

This density test fails, what happens?

Low Density? **High Density?**

Note: Refer to Chapter 1 of this manual, Standard Specifications, Article 1030.05 (d)(7)

Required Density Retest Procedures

Low Density

1st failed test - Move ½ way to the finish roller & immediately retest

2nd failed test - Increase compactive effort

3rd failed test - Shut operation down & investigate low densities

High Density

1st failed test - Move ½ way to the finish roller & retest

2nd failed test - Shut operation down & investigate reason for high densities

Bituminous Core Density Report Form MI-303C

Illinois Department of Transportation

Bituminous Core Density Testing

I.D. No. 1

Inspector No. 3 Date Sampled 4 Seq. No. 5 County 2

Bit Mix Plant 6 Name 7 Section

Bit Mix Code 8 Name 9 Equip: Route

QA: Contract No. 10 Job No. 11 District

Target Dens. (PCF) 12 Project

Resp Loc 13 Lab 14 Lab Name 15 City

Start Date 16 Complete Date 17

*S F X	Core No	Date Laid	Station	Ref	Thick	Lit d (G_{mb})	Big D (G_{mm})	% Den	Result	Type Insp	Den kg/m³	Lot
18	19	20	21	22	23	24	25	26	27	28		29

* (SFX Computer Generated)

REMARKS 31

Core No.								
1. Air Dry Wt								
2. Sat Surf Dry Wt								
3. Sat Sub Wt								
4. Volume (2-3)								
5. Prel % Den ((1÷4)÷10)100								
6. Oven Dry Wt+Pan			30					
7. Pan WT								
8. Oven Dry Wt (6-7)								
9. Bulk SpG(d) (8÷4)								
10. Appar Spg (D)								
11. Final % Den (9÷10)100								
12. Req'd % Den								
13. kg/ m²/ 25 mm Thick								

Copies: DE
32 RE Tester 33 Agency 34
File Inspector 35 Agency 36

MISTIC INPUT
Date Entered
Initials

/FOR DTY03303
MI 303C QC/QA (Rev. 3/96)

QC/QA

IDOT BITUMINOUS CORE TESTING REPORT FORM INSTRUCTIONS (MI 303C)

1. ID NO: Leave blank MISTIC system will generate Test ID Number

2. PROJECT IDENTIFICATION: Job stamp may be used

3. SAMPLED BY: Enter the identification number of the person taking the sample

   A. **IDOT personnel** are to use their Social Security No. (Only applicable when sample taken by IDOT)

   B. **Producers** are to use the District designation followed by 0's until the field is filled.

      EXAMPLE: District 3 designation is 93; then "930000000" would designate a District 3 producer.

   C. **Consultant personnel** are to use their tax number. Left justified and right filled with zeroes. EXAMPLE: (123450000) for tax number 12345.

   D. **Local agency personnel** are to use a "9" followed by the District number repeated until the field is filled.
      EXAMPLE: (966666666) for District six.

4. DATE SAMPLED: Enter Date (MMDDYY) mix was produced Example: 040891 for April 8,1991

5. SEQ NO: May be alpha or numerical up to 6 characters in length.
   Use LOT prefix (e.g. 003) for LOT 003-01.

6. BIT MIX PLANT: MISTIC Producer/Supplier number

7. NAME: Name of bituminous Producer/Supplier

8. MIX CODE: MISTIC code number for the bituminous mix being produced

9. NAME: Name of bituminous mixture

10. CONTRACT NO: Use 5 digit Contract Number

11. JOB NO: Use Job Number that corresponds with the Contract Number

QC/QA

IDOT BITUMINOUS CORE TESTING REPORT FORM INSTRUCTIONS (MI 303C)

12. TARGET DENS: Enter the target density (BIG D, Gmm, in Kg/Cu m) for the mix tested. Should the target density change, start a new report form.

    On shoulders, enter the target density in Kg/Cu m based on the growth curves.

13. RESPonsible LOC: Enter District responsible location (e.g.: District 9 = 99

14. LAB: Enter the correct lab designation from the "MISTIC CODE REFERENCE SHEET" shown in ATTACHMENT A.

15. NAME: Show name if a Consultant or Contractors laboratory

16. START DATE: Enter the date the sample began the testing process

17. COMP DATE: Enter the date that the sample testing was completed

18. SFX: Leave blank, MISTIC system will generate.

19. CORE NO: List core ID number

20. DATE LAID: Enter the date (MMDDYY) the material was placed

21. STATION: Enter station number where core was taken

22. REF: Give reference from centerline RT/LT in meters

23. THICK(Lift number): Record the thickness of the core to the tenth of an inch. Designations in terms of lifts should be denoted from the bottom (including Bam or Poz lifts) in the following format: ".1" would designate the 1st (lowest) lift ".2" would indicate the next lift (of the same mixture type) placed. Each mixture type will have its own set of lift numbers.

24. LIT "d" (Gmb): Record little "d" (Bulk Specific Gravity) determined in test to the nearest .001

25. BIG "D" (Gmm): Record BIG "D" (Maximum Specific Gravity) used in calculations to the nearest .001

QC/QA

IDOT BITUMINOUS CORE TESTING REPORT FORM INSTRUCTIONS (MI 303C)

26. <u>**% DENS**</u>: Record the calculated % density (nearest tenth)

27. <u>**RESULT**</u>: Enter (APPR) for passing test or (FAIL) for failing test. (See 31. <u>**REMARKS**</u>)

28. <u>**TYPE TEST**</u>: Enter the correct type test designation from the "MISTIC CODE REFERENCE SHEET" shown in ATTACHMENT A. <u>**Producer's Core Density Type Test = "PRE" for start-up**</u>.

29. <u>**LOT NO**</u>: Used to identify both the day's production (format of 999-99 and the random field density sample location.

    EXAMPLE: Lot number 001-01 represents the 1st day of production & first random sample location. Lot 001-02 identifies the 1st day's production & the second random sample location.

    The field density LOT Prefix correlates with the plant LOT Prefix. However, the field density LOT Suffix identifies each random sample while the plant Lot Suffix is always "-01"

    *For **Start-Ups use LOT 000-01** for the first Growth Curve.*

    The second Growth Curve if necessary would then be 000-02.

    On Start-Ups, Plant Hot Bin/Cold Feed Gradation test must correlate to field density tests (as much as possible).

30. <u>**CORE WORKSHEET**</u>: This sheet may be used to do the required calculations; otherwise, actual calculation must accompany completed MI-303C.

31. <u>**REMARKS**</u>: Make any comments regarding these test results. <u>Remarks must be filled out for failed tests.</u>

32. <u>**COPIES**</u>: Distribution of copies District, Resident Engineer, & Contractor

33. <u>**TESTER**</u>: Producer and IDOT use signature of the person doing the testing.

34. <u>**AGENCY**</u>: Testers employer (contractor/consultant/IDOT).

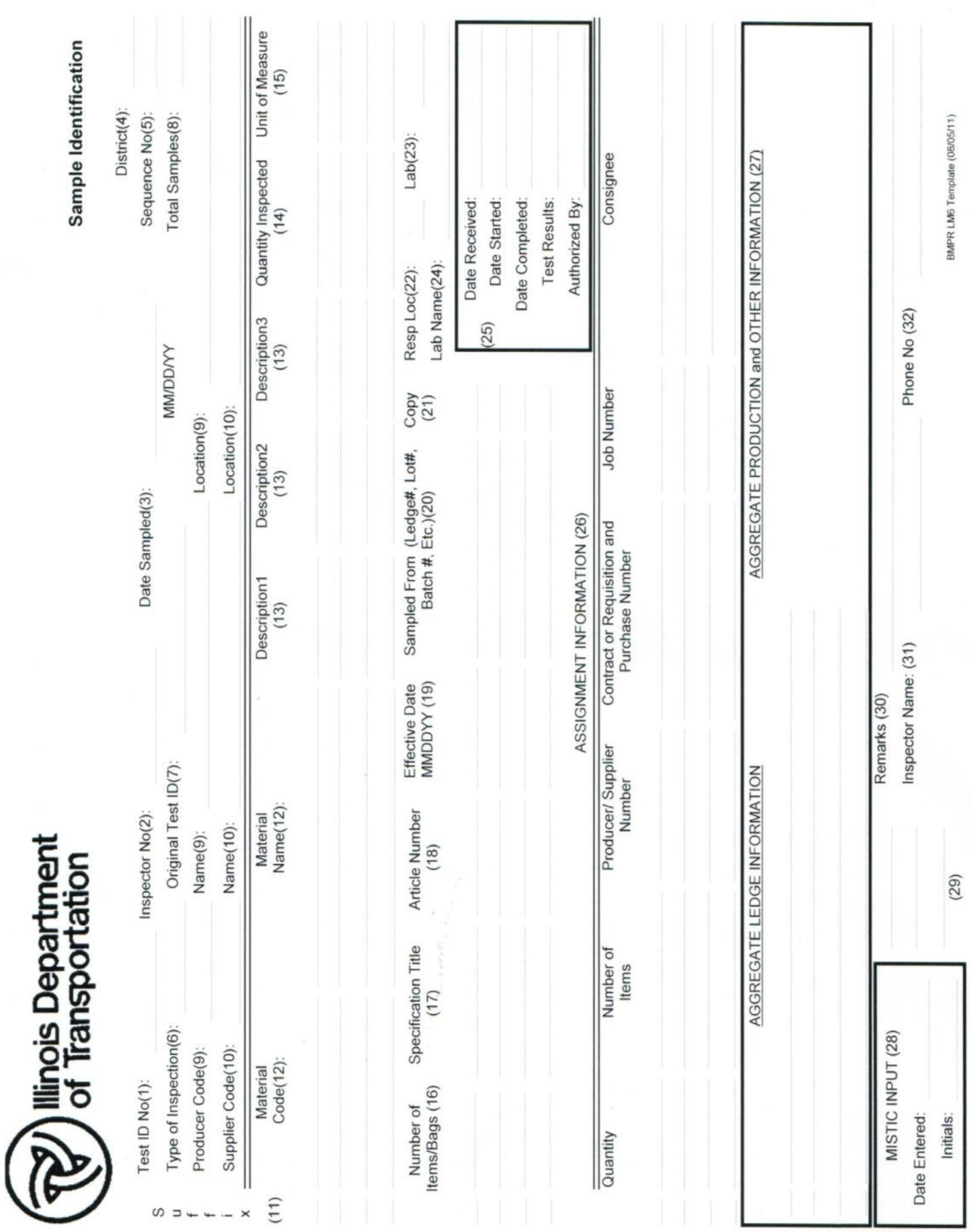
35. <u>**INSPECTOR**</u>: Producer use signature of the person responsible for quality control.

    IDOT use tester's supervisors signature, or leave blank.

36. <u>**AGENCY**</u>: Producer use inspectors employer (contractors/consultant name

    IDOT leave blank

LM-6 Sample Identification Form



Illinois Department of Transportation

Sample Identification

District(4):
Test ID No(1): Inspector No(2): Date Sampled(3): Sequence No(5):
Type of Inspection(6): Original Test ID(7): MM/DD/YY Total Samples(8):
Producer Code(9): Name(9): Location(9):
Supplier Code(10): Name(10): Location(10):

Suffix (11)	Material Code(12):	Material Name(12):	Description1 (13)	Description2 (13)	Description3 (13)	Quantity Inspected (14)	Unit of Measure (15)

Number of Items/Bags (16)	Specification Title (17)	Article Number (18)	Effective Date MMDDYY (19)	Sampled From (Ledge#, Lot#, Batch #, Etc.)(20)	Copy (21)

Resp Loc(22): Lab(23):
Lab Name(24):

(25) Date Received:
Date Started:
Date Completed:
Test Results:
Authorized By:

ASSIGNMENT INFORMATION (26)

Quantity	Number of Items	Producer/ Supplier Number	Contract or Requisition and Purchase Number	Job Number	Consignee

AGGREGATE LEDGE INFORMATION AGGREGATE PRODUCTION and OTHER INFORMATION (27)

MISTIC INPUT (28)
Date Entered:
Initials:

(29)

Remarks (30)
Inspector Name: (31) Phone No (32)

BMPR LM6 Template (08/05/11)

LM-6 Instructions

1.	Test Id No:	Identification number generated by MISTIC that is unique to the sample it represents.
2.	Inspector No:	Identifies the personnel that took the sample (9 spaces).
3.	Date Sampled:	Enter month, day, year in which the sample was taken (6 spaces)
4.	District:	Enter district number (2 spaces)
5.	Sequence No:	Enter alpha, numeric, or both. This field is used to uniquely identify a sample if more than one sample of the same material is taken on the same day. Also use "Split" for split samples (6 spaces). * IDOT personnel are to use their Inspector No. * Producer personnel are to use their designation (91-99) followed by seven zeros. E.g. A producer in District 7 would use "970000000"
6.	Type of Inspection:	Drop down box entry (3 spaces)
7.	Original Test Id:	Currently not used.
8.	Total Samples:	Enter the number of samples being submitted (2 spaces).
9.	Producer Code:	Enter the MISTIC producer/supplier code number where the sample was supplied from (8 spaces).
10.	Supplier Code:	Enter the MISTIC supplier code number where the sample was supplied from (8 spaces).
11.	Suffix:	Enter the alphabetical sequence used when multiple samples are included on one LM6. Relate each sample to the test id number beginning with the letter "A".
12.	Material Code:	Enter the material code that represents the sampled material. Refer to the MISTIC Material Code Book to ensure that both the material code and name correspond with the material being submitted for testing.
13.	Description 1,2 3:	Enter the item no for the 1st, 2nd 3rd description of the material. Refer to the MISTIC Material Code Preface for the list of material descriptions. When used for aggregate information enter ledge number assigned by the BMPR in Description 1.
14.	Quantity Inspected:	Enter the amount of material that the submitted sample represents. This field is used when submitting an acceptance sample for batch or lot approval (8 spaces).

15. Unit of Measure: Enter the unit for the amount of material being submitted for testing. Refer to the MISTIC Code Book to ensure that both the Material code and Unit of measure correspond to one another.

16. Number of items/Bags: Optional, primarily used to convert fasteners items from pieces to lbs. Number of bags automatically generated by material code (aggregate only).

17. Specification Title: Enter the name of the manual or documents that provides the specification that the sampled material is required to meet (10 spaces) E.G. Standard = Standard Specifications for Road Bridge Construction

18. Article Number: Enter the section or article number that provides the specification that the sampled material is required to meet.(10 spaces)

19. Eff. Date: Enter the month, day, and year in which the specification manual or document became effective for providing the specification that the material is required to meet. (6 spaces)

20. Sampled From: Enter the appropriate information to describe where the sample to be tested was taken from. (20 spaces)

21. Copy: Enter a "Y" if the inspector requests a copy of test results when they are complete.

22. Resp. Loc.: Enter district (91-99) or BMPR (50) designation responsible for testing the submitted samples. (3 spaces)

23. Lab: Enter the 2 digit lab designation responsible for testing the submitted samples.

AC	–	Analytic Chemistry	AG	–	Aggregate
BC	–	Bituminous Chemistry	BM	–	Bituminous
CM	–	Cement	CN	–	Concrete
DI	–	District	DS	–	District Satellite
D2	–	2nd District Satellite	D3	–	3rd District Satellite
FC	–	Field Construction	FP	–	Field Plant
FQ	–	Field Quarry	IC	–	Consultant (At job site)
IL	–	Consultant (Central Lab)	IP	–	Consultant (Plant Lab)
IQ	–	Consultant Lab (Quarry)	MT	–	Metal
PC	–	Producer (At job site)	PL	–	Producer (Central Lab)
PP	–	Producer (Plant Lab)	PQ	–	Producer (Quarry Lab)
SL	–	Soil			

24. Lab Name: If an independent lab is used then the name of the laboratory must be entered. (20 spaces)

25. Date Received, Started, Completed, Test Results, and Authorized By: BMPR use only!

26. District: Assignment Information: The following fields are used to automatically assign material to a contract based on test sample approval.

A Quantity - Enter the quality of the tested material being assigned. (8 spaces)

B Number of Items - (Optional) If necessary, enter the number of pieces associated with the quantity being assigned. (6 spaces)

C Producer/Supplier - (Optional) Enter the MISTIC number for the producer/supplier that the material is being assigned to. (8 spaces)

D Contract or Requisition and Purchase No. - Enter the contract number for the contract that the material is being assigned to. (17 spaces)

E Job No. - Enter the job number for the contract number. (10 spaces)

F Consignee - Not used!

27. Aggregate Production and Other Information: If ledge number is entered in DESC1, Information is automatically entered. If no ledge number is entered in DESC1 use this area to provide and additional information about the material being submitted for testing.

28. MISTIC Input: Personnel entering information in MISTIC to obtain Test ID number may date and initial in spaces provided.

29. Copies To: Include where additional copies should be filed or sent.

30. Remarks: The inspector may input information concerning the sample or test information in this field. However, the BMPR may edit or change the information once testing is complete.

31. Inspector Name: Name of the inspector submitting the sample.

32. Phone No: The phone number where the inspector may be reached if a question occurs about the sample once it reaches the responsible Lab.

Big D Field Notification Form

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Mibit_9
Version 10.0 6/1/2000

Report for Illinois Dept of Transportation
Division of Highways
District 91

Lot Prefix: 001 e.g. Density locations will be identified as 001-01,001-02, etc.

Seq. No.: 001

DAILY DENSITY "D" AND PLANT APPROVAL NOTIFICATION

DATE--: 06/07/2016 COPIES

PRODUCER:	1111-01	**Example Company Inc Somewhere 1, IL**
MAT CODE:	19522	**BITCONC BC N70 19.0 TONS**
DISTMIX#:	81BIT1111	
NEW AC%--:	5.5	
DESIGN AC%:	5.5	
BIG D---(Gmm) 4-test average:	2.490	
LITTLE D (Gmb) 4 test average:	2.350	
DESIGN LITTLE D (Gmb)		

THIS PLANT IS CURRENTLY APPROVED FOR THE PRODUCTION OF THE ABOVE MIXTURE.
IF YOU NEED FURTHER INFORMATION, CONTACT THE DISTRICT MATERIALS OFFICE.

IF YOU HAVE ANY QUESTIONS, PLEASE CONTACT THE PLANT TECHNICIAN AT PHONE NO.
333-222-4444

AUTHORIZED BY: **Bob Jones (L2)**

CONTRACT	JOB NUMBER

CONTRACT	JOB NUMBER

REMARKS:

Please use the above LOT Prefix to identify the density tests for this day (e.g. for Lot Prefix 001, your test locations will be identified as Lot 001-01, 001-02, etc.).

Illinois Department of Transportation

Independent Truck Weight Check

District

Instructions: At random, select a loaded truck and obtain a loaded weight on an independent scale. Allow the truck to unload then obtain an empty weight. All information (except * fields) is required. **DO NOT submit forms missing information.** See Construction Manual and the Weight Control Deficiency Deduction Special Provision for additional information.

Ticket Information

Load Ticket Number		Supplier Name	
Loaded Weight (Gross)*		City	
Empty Weight (Tare)*		Supplier Code	
Load Ticket Weight (Net)		Scale Decal No.	
		Decal Date	

Independent Scale Information

Loaded Weight (Gross)		Scale Location	
		Scale Decal No.	
Empty Weight (Tare)		Decal Date	
		Name of Truck	
Calculated Net Weight		Truck Number	

Tolerance %

Ticket Weight – Ind Wt Ck Net Weight / Ind. Wt. Ck. Net Wt. x 100

Tolerance for bituminous should not exceed 0.50%.
Tolerance for aggregates should not exceed 0.70%.

Contracts

List all contracts using material from this supplier this week.

Calculated By ____________ Initials ______ Date ______
Print Name Clearly

Weighs Verified By ____________ Initials ______ Date ______
Print Name Clearly

Hard Copy Submission:

Illinois Department of Transportation, Bureau of Construction, 2300 South Dirksen Parkway, Springfield, IL 62764

Contractor

File

E-Mail:

itwc@dot.il.gov
Contractor
File

BC 2367 (Rev. 7/05)

If the truck is out of tolerance the contractor has two options as spelled out in the Weight Control Deficiency Deduction Special Provision.

1. If requested by the contractor/supplier, the empty truck can be taken to another independent scale to verify the empty weight.

2. If the above request is not made, the contractor/supplier must call a scale company to check or re-calibrate the scales at the plant.

If the contractor/supplier requests a check on the independent scale, please fill out the information below. **Any time the truck is out of tolerance, please note action taken in the Remarks section.**

2nd INDEPENDENT SCALE INFORMATION

Scale Location ______________________________

Scale Decal No. ______________________________

Decal Date ______________________________

Name of Truck ______________________________

Truck Number ______________________________

Empty Weight of Truck ______________________________

Remarks

What-If Problems

This page is reserved

Chapter 2

Problem #1

Problem: While observing plant operations at a batch plant, the plant technician notice that two of the hot bin gate cylinders are in the open position at the same time during the batching operation.

Why is this happening?

What will this do to the mix?

What can/should be done to fix the problem?

This page is reserved

Chapter 2

Problem #2

Problem: During the performance of the 6-minute check at a dryer-drum plant, the following information is generated. If the target value from the weigh-belt calibration is 15.2 accumulated tons and the allowable range is ± 2%, determine if the plant is 'OK' to begin production. If not, what are the possible avenues that the plant technician would take to investigation of the problem? What could be causing the issue?

Print #	Time	Accumulation of Aggregate in TPH	6-Minute Check
Start	5:05:12 am	----------	----------
1st check	5:10:12 am	12.4	
2nd check	5:16:12 am	26.7	
3rd check	5:22:12 am	41.2	

Cause(s):

Solution(s):

This page is reserved

Chapter 2

Problem #3

Problem: While monitoring production at a dryer-drum plant the plant technician noticed that the material exiting the drum into the slat conveyor is not entirely coated with asphalt binder, particularly on the knock-out box side (far end of the drum) of the discharge chute.

What could be the causing this?

What can be done to alleviate the problem?

Cause(s):

Solution(s):

This page is reserved

Chapter 2

Problem #4

Problem: While monitoring operations at a batch plant, the plant technician notices that the plant operator is constantly changing the cold feed rates of the sand bins.

What could possibly be causing this?

How will this affect the plant operations?

How will this affect the mixture performance?

What should be done to correct the situation?

Cause:

Effects on the plant:

Effects on the mixture performance:

Correction:

Chapter 4

Problem #1

Problem: A plant technician, when setting up the initial aggregate percentages at a dryer-drum plant, was using individual stockpile gradations but the projected combined gradations do not match the JMF targets.

What could be causing this?

What should the plant technician do to correct the situation?

The gradations (design & stockpile) in question are on the following page.

Causes:

Solutions:

Chapter 4

Problem #1

Design vs. Field Gradations

Sieve Sizes	Design Gradation			Field Gradation		
	CM11	CM16	FM20	CM11	CM16	FM20
1”	100			100		
3/4”	84			93		
1/2”	**34**	**100**		**45**	**100**	
3/8”	11	95	100	22	98	100
#4	**2**	**24**	**99**	**5**	**41**	**98**
#8	**2**	**4**	**85**	**3**	**13**	**75**
#16	2	2	53	2	8	50
#30	**1**	**2**	**30**	**2**	**7**	**32**
#50	1	2	17	2	6	21
#100	1	2	10	2	5	15
#200	**1**	**1.4**	**7.3**	**1.3**	**4.9**	**11.9**

Chapter 4

Problem #2

Problem: A batch plant hot-bin gradation analysis was performed on a surface mix with the results shown on page 11-13. The combined gradation test results show the #8 sieve is out of specification and the #4 & #200 are close to being out. Corrective action should be taken to bring them back into limits.

Two possible solutions to take are shown on pages 11-14 and 11-15 but have obvious problems themselves.

1. Analyze the given information and determine what corrective actions or adjustments, if any, can be taken to correct the situation.

2. What is possibly causing this situation in the first place?

Hint: Chapter 2, Standard Specifications, Article 1102.01 (b) (10) (last sentence) will give insight to the problem, addressing batch plant sieving efficiency.

Note: **Don't focus on performing calculations for this problem**. They are not needed to determine the possible cause(s). Analyze the given information.

Corrective action(s):

Cause(s):

Chapter 4 What-If Problem #2

Batch Plant Adjustment							Chapter 4 What-if #2			
Material	Rap	Bin 4	Bin 3	Bin 2	Bin 1	MF				
Size		+ 1/2	-1/2 - #4	-#4 - #8	- #8	- #200	New Bit			
Mix %								= 100%		
#'s								Batch Size Tons		3
Agg %			48.0	16.5	34.0	1.5		= 100%		
Sieve	%Pass	%Pass	%Pass	%Pass	%Pass	%Pass	Comb		Control Limits	
Size	%Bin	%Bin	%Bin	%Bin	%Bin	%Bin	Grad	Target	Min	Max
1"										
3/4"										
1/2"			100	100	100	100	100	100		
			48.0	16.5	34.0	1.5				
3/8"			96.4	100	100	100	98	98		
			46.3	16.5	34.0	1.5				
#4			6	75.5	100	100	51	55		
			2.9	12.5	34.0	1.5				
#8			0.8	2.3	70.7	100	26	33		
			0.4	0.4	24.0	1.5				
#16			0.7	0.8	36.3	100	14	17		
			0.3	0.1	12.3	1.5				
#30			0.7	0.7	31.3	100	13	12		
			0.3	0.1	10.6	1.5				
#50			0.6	0.7	13.4	100	7	7		
			0.3	0.1	4.6	1.5				
#100			0.6	0.7	7.5	95	4	5		
			0.3	0.1	2.6	1.4				
#200			0.5	0.6	7.4	85	4.1	3.0		
			0.2	0.1	2.5	1.3				
AC								5.1		

Batch Plant Adjustment — Chapter 4 What-if #2

Material	Rap	Bin 4	Bin 3	Bin 2	Bin 1	MF				
Size		+ 1/2	- 1/2 - #4	- #4 - #8	- #8	- #200	New Bit			
Mix %								= 100%		
#'s								Batch Size Tons		3
Agg %			43.0	20.0	37.0			= 100%		
Sieve	%Pass	%Pass	%Pass	%Pass	%Pass	%Pass	Comb		Control Limits	
Size	%Bin	%Bin	%Bin	%Bin	%Bin	%Bin	Grad	Target	Min	Max
1"										
3/4"										
1/2"			100	100	100	100	100	100		
			43.0	20.0	37.0					
3/8"			96.4	100	100	100	99	98		
			41.5	20.0	37.0					
#4			6	75.5	100	100	55	55		
			2.9	15.1	37.0					
#8			0.8	2.3	70.7	100	27	33		
			0.3	0.5	26.2					
#16			0.7	0.8	36.3	100	14	17		
			0.3	0.2	13.4					
#30			0.7	0.7	31.3	100	12	12		
			0.3	0.1	11.6					
#50			0.6	0.7	13.4	100	5	7		
			0.3	0.1	5.0					
#100			0.6	0.7	7.5	95	3	5		
			0.3	0.1	2.8					
#200			0.5	0.6	7.4	85	3.0	3.0		
			0.2	0.1	2.7					
AC								5.1		

Batch Plant Adjustment — Chapter 4 What-if #2

Material	Rap	+ 1/2	- 1/2 - #4	- #4 - #8	- #8	MF				
Size		Bin 4	Bin 3	Bin 2	Bin 1	- #200	New Bit			
Mix %								= 100%		
#'s								Batch Size Tons		3
Agg %			46.0	8.0	46.0			= 100%		
Sieve	%Pass	%Pass	%Pass	%Pass	%Pass	%Pass	Comb		Control Limits	
Size	%Bin	%Bin	%Bin	%Bin	%Bin	%Bin	Grad	Target	Min	Max
1"										
3/4"										
1/2"			100	100	100	100	100	100		
			46.0	8.0	46.0					
3/8"			96.4	100	100	100	98	98		
			44.3	8.0	46.0					
#4			6	75.5	100	100	55	55		
			2.9	6.0	46.0					
#8			0.8	2.3	70.7	100	33	33		
			0.4	0.2	32.5					
#16			0.7	0.8	36.3	100	17	17		
			0.3	0.1	16.7					
#30			0.7	0.7	31.3	100	15	12		
			0.3	0.1	14.4					
#50			0.6	0.7	13.4	100	7	7		
			0.3	0.1	6.2					
#100			0.6	0.7	7.5	95	4	5		
			0.3	0.1	3.5					
#200			0.5	0.6	7.4	85	3.6	3.0		
			0.2	0.0	3.4					
AC								5.1		

Chapter 6

Problem #1

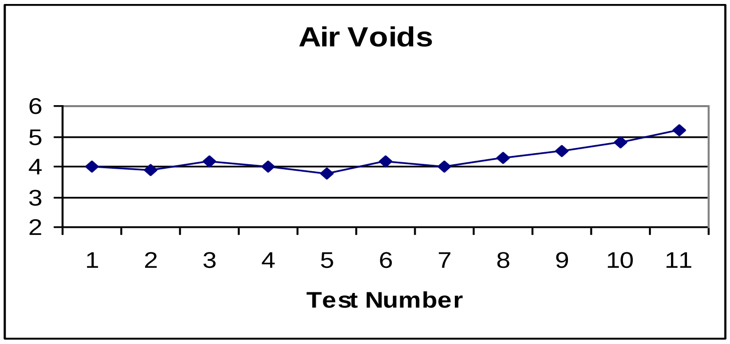
Problem: Using the control charts on page 11-17, determine where or what the problem(s) is/are and what corrective action should be taken?

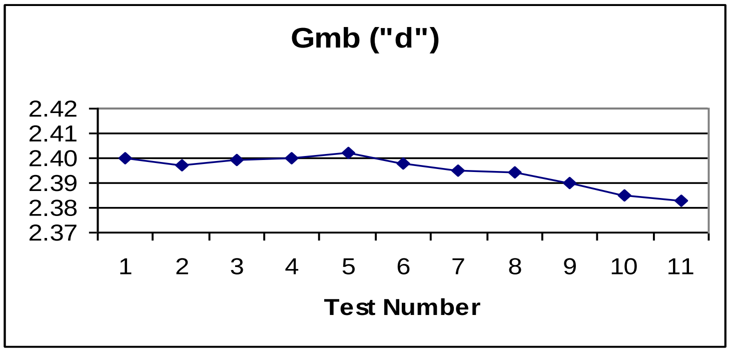
Problems:

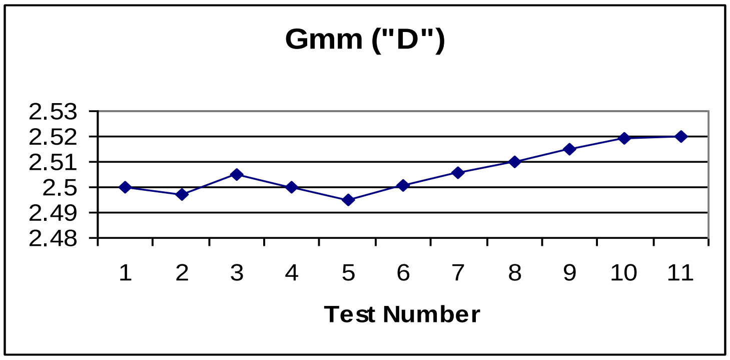
Corrective action:

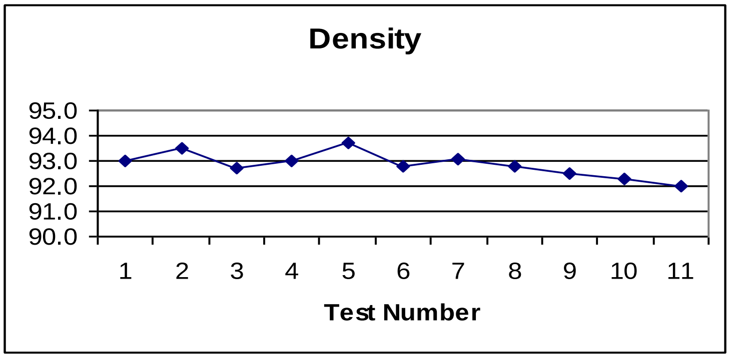
Chapter 6

Problem #1









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Chapter 6

Problem #2

Problem: A dryer-drum plant is producing an IL-19.0 N_{des} 90 binder mixture (19532). The samples taken at the plant is showing high air voids and the density tests from the road is showing high density on the compacted mixture.

What could be causing this problem?

What can be done to correct the problem?

Causes:

Corrective action:

This page is reserved

Chapter 6

Problem #3

Problem: A contractor's technician noticed that the HMA mixture arriving at the job appears to have "**free asphalt**", commonly referred to as **drain-down**, in the bed of <u>some</u> of the trucks. The drain-down is located mostly in the back one third of the truck beds.

The plant producing the HMA mixture is a dryer-drum and the haul time to the job is 40 minutes.

What are some causes for this to happen?

Causes:

This page is reserved

Chapter 6

Problem #4

Problem: A sample of 042CM11 aggregate was taken from a cold feed at a dryer-drum plant utilizing the belt-stream sampling method. The test results show that the percent passing on the critical sieve was 10%-15% coarser than what the corresponding stockpile sample test results were showing.

What could cause this problem?

What will it do to the mix?

What can/should be done to correct the problem?

Cause:

Possible mixture problems:

Corrective action:

This page is reserved

Chapter 12 Contents

MoTP = Manual of Test Procedures
BMPR * = Bureau of Materials and Physical Research* (now Central Bureau of Materials)

*** The Bureau of Materials and Physical Research (BMPR) has officially been renamed as the Central Bureau of Materials (CBM).**

As of the printing of this manual, some documents are still in the process of being updated and will still refer to the Bureau of Materials and Physical Research or BMPR.

Illinois Department of Transportation

Hot-Mix Asphalt QC/QA
QC Personnel Responsibilities and Duties Checklist
Appendix B5

Effective: May 1, 1993
Revised: May 1, 2007

The following checklists detail the required minimum duties of Contractor Quality Control (QC) personnel. The QC Manager has overall responsibility to ensure that the listed duties are performed and documented. The QC Manager shall not perform sampling and/or testing except in emergency situations or in any other situation approved by the Engineer. Additional duties, as necessary, may be required to control the quality of production and placement of the Hot-Mix Asphalt (HMA) mixtures. A Level II Technician may be used to perform any Level I Technician duties.

Note: Testing frequency denoted as "P" = "Prior to Start-up" and as "D" = "Daily".

A. Level I Technician

1. Checklist

a. Perform incoming aggregate gradations before start-up time. (PD) ___

b. Ensure lab equipment is on hand and in working order. (PD) ___

c. Run moisture samples daily (drum only). (PD) ___

d. Determine random sampling times one day in advance and inform the QC Manager and the Engineer of the sampling times. (D) ___

e. Take required samples when required using proper procedures. (D) ___

f. Split required sample and save the Department split; use proper identification. ___

g. Run required tests as soon as possible using proper QC/QA procedures. ___

h. Take resamples as required. ___

i. Plot all random and resample results on control charts as soon as test results are available. ___

j. Take check samples when necessary. (D) ___

k. Contact QC Manager immediately when tests fail or any time problems occur. (D) ___

l. Test cores for Nuclear/Core Correlation (after Start-up). ___

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Hot-Mix Asphalt QC/QA
QC Personnel Responsibilities and Duties Checklist
Appendix B5
(continued)
Effective: May 1, 1993
Revised: May 1, 2007

2. Required Tests. The minimum test frequency shall be according to Section 1030 of the Standard Specifications. However, additional tests may be required by the Engineer.

   a. Stockpiles (washed gradations minimum one per week for each material used) ___

   b. Moisture samples (drum only) ___

   c. Gradations - Belt, Cold-feed, Hot-bin, etc. ___

   d. Nuclear Asphalt Content ___

   e. G_{mb} ___

   f. G_{mm} ___

B. QC Manager and/or Level II Technician Checklist

1. Prior to Mix Production (Preliminary Inspection)

   a. Check for the approved sources of the materials:
      (1) Aggregates — ensure it is from Certified Source ___
      (2) Mineral filler/flyash ___
      (3) Asphalt binder (See d. below.) ___
      (4) Other additives ___

   b. Check the aggregate stockpiling and handling procedures:
      (1) Observe stockpiling procedures to ensure they are built correctly. ___
      (2) Discuss loadout and sampling procedures with endloader operator. ___
      (3) Sample aggregate stockpiles, in conjunction with District inspectors, and submit for Mix Designs. ___

   c. Check the gradation of the aggregates:
      (1) Obtain average gradation of each aggregate (including Master Bands) from the aggregate source. ___

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Hot-Mix Asphalt QC/QA
QC Personnel Responsibilities and Duties Checklist
Appendix B5
(continued)
Effective: May 1, 1993
Revised: May 1, 2007

(2) Compare aggregate source information to stockpile samples at the mix plant and with the design gradation. ___

d. Check asphalt binder:

(1) Source ___

(2) Grade ___

(3) Incoming temperatures ___

(4) Specific Gravity (drum only) ___

e. Verify that the laboratory and laboratory equipment have been inspected and approved by the Department and are in good working order. ___

f. Review Hot-Mix Asphalt Level I and Level II Technician Course manuals.

2. Prior to Production/During Start-Up/During Production

a. Check the mix plant for the following:

(1) Approval and calibration (P) ___

(2) Asphalt binder storage (PD) ___

(3) Stockpiles (PD) ___

(a) correct loadout ___

(b) place in proper cold-feed bins ___

(4) Cold-feed bins or bulkheads and feeders (PD) ___

(5) Dust collecting systems (D) ___

(6) Screens and screening requirements (P) ___

(7) Hot-bin sampler (P) and hot-bin overflow (PD) ___

(8) Weigh belt 6-minute check (drum only) (D) ___

(9) Temperature recorders and thermometers (PD) ___

(10) Mixing timers (batch plant only) and pugmill dam gate (continuous plants) (PD) ___

(11) Surge and storage bins (PD) ___

(12) Platform scales or suspended weigh hopper (PD) ___

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Hot-Mix Asphalt QC/QA
QC Personnel Responsibilities and Duties Checklist
Appendix B5
(continued)
Effective: May 1, 1993
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(13) Anti-strip additive system (when required) (PD) ___

(14) Ticket printer (P) ___

(15) Computer and control systems (PD) ___

b. Check trucks for the following (QC Manager may assign these duties to a Level I Technician):

(1) Truck bed release agents (PD) ___

(2) Insulation (D) ___

(3) Tarps (D) ___

(4) Clean beds (D) ___

c. Coordinate any start-up per Department guidelines (QC Manager only). ___

d. Monitor sampling and testing procedures, density test, and laydown operations; contact man from aggregate producer (QC Manager only). ___

e. Check the mixtures for the following:

(1) Gradation test performed and bin percentages determined before start-up (P) ___

(2) Correct Job Mix Formula is being used (P) ___

(3) Moisture check (drum only) (PD) ___

(4) Temperature (D) ___

(5) Coating and segregation (D) ___

(6) Additives (D) ___

f. Laydown operation (QC Manager only) — Monitor the following field checks:

(1) Check for obvious defects in truck (segregation, uncoated, temperature, etc.) (D) ___

(2) Monitor paver operations (equipment, laydown procedures, etc.) (PD) ___

(3) Rollers and operations (equipment, pattern, procedure, etc.) (PD) ___

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Hot-Mix Asphalt QC/QA
QC Personnel Responsibilities and Duties Checklist
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Effective: May 1, 1993
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(4) Mix characteristics on road (appearance, mat temperature, etc.) (D) ___

(5) Monitor densities as required (D) ___

g. Monitor all test results and make any adjustments necessary (QC Manager only) (D). ___

h. Perform scale checks (minimum one per week per scale). Follow procedure in Construction Manual Documentation Section. ___

i. Prepare and store samples for the District laboratory as required. (D) ___

j. Ensure following records are kept and reports are submitted in a timely manner as required (QC Manager only): (D)

(1) Daily plant output ___

(2) Field gradation ___

(3) Density ___

(4) Marshall (stability and flow when required) ___

(5) Control charts ___

(6) Additives ___

(7) Scale checks ___

(8) Plant diary ___

C. Level I Technician, Level II Technician, and Quality Control Manager Duties

1. Material Source

It is necessary to identify the source of the ingredients to ensure that they have been inspected and the correct quality of aggregate, grade of asphalt binder, and anti-strip additive are being used in the specified mix. Sources shall be verified.

2. Aggregate Quality

The Level II Technician may confirm the quality of the aggregate by requesting current quality information from the District Materials office.

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Hot-Mix Asphalt QC/QA
QC Personnel Responsibilities and Duties Checklist
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3. Stockpiling

Sites for stockpiles shall be grubbed and cleaned prior to storing the aggregates.

Separate stockpiles shall be provided for the various sources and kinds of aggregates. Stockpiles shall be separated to prevent intermingling at the base (width of endloader bucket). If partitions are used, they shall be of sufficient heights to prevent intermingling. Aggregates for HMA mixtures shall be handled, in and out of the stockpiles, in such a manner that will prevent contamination and degradation.

Coarse aggregate stockpiles shall be built in layers not exceeding 1.5 m (5 ft) in height and each layer shall be completely in place before the next layer is started. A stockpile may be expanded by again starting the expansion from the ground and building layers as before. End-dumping over the sides will not be permitted. Use of steel track equipment on Class B Quality, Class C Quality and all blast furnace slag aggregate stockpiles shall not be permitted where degradation is detected. When loading out of stockpiles, vertical faces shall be limited to reasonable heights to eliminate segregation due to tumbling. Segregation or degradation due to improper stockpiling or loading out of stockpiles shall be just cause for rejecting the material.

4. Gradations

The Level II Technician shall obtain the average gradations as well as the Master Bands from the aggregate source. He/She shall run the required gradation's test frequency on incoming aggregate as required in Section 1030 of the Standard Specifications.

5. Asphalt Binder

a. Incoming Asphalt Binder: The Level II Technician shall periodically check the grade and temperature of asphalt binder as received at the plant. If the asphalt binder is shipped by truck, the driver should have in his possession a numbered ticket showing the name and location of the refinery, the name of the material, date shipped, loading temperature, quantity, specific gravity or weight/L (weight/gal), and the number of the tank from which the asphalt was loaded. It is the responsibility of the refinery to load trucks only from tanks that have been tested and approved by the Department. If shipment is made by rail, a tag usually will

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be found on the top of the dome of the tank car indicating that it has been sampled at the refinery.

b. Asphalt Binder Storage: The Level II Technician shall check the temperature of the asphalt binder in storage. The temperatures shall be maintained in accordance with the Standard Specifications. The Level II Technician should be aware of the grade of asphalt binder in each storage tank. Asphalt binders of different sources and grades shall not be intermixed in storage, and the tanks shall be identified.

6. Testing Equipment

Care of the laboratory testing equipment is the responsibility of the Level I Technician. Equipment shall be furnished by the Contractor or Consultant, kept clean, and kept in good working condition. At the start of the project, the technician shall check that all equipment required to be furnished is available and in good condition. Acceptance and, ultimately, performance of a mixture may be dependent on the accuracy of the field tests. Defective equipment could result in erroneous, as well as untimely, results.

7. Asphalt Plant

a. Plant Approval: Plant must be approved and calibrated prior to production each construction season. The QC Manager shall review this information. If it is not available or current, the District Hot-Mix Asphalt Supervisor shall be notified.

b. Cold Aggregate Bins: The cold aggregate bins or bulkheads shall be checked for aggregate intermingling. Each bin or compartment in a bin shall contain only one source and type of aggregate. The bins should be checked each day to ensure the charging of the compartments remains the same as it was for previous operations for the same mix. The QC Manager shall notify the state inspector of changes in aggregate source and gradation and/or gate settings.

c. Dust Collector: The Level II Technician shall check that the dust from the primary collector is returned to the boot of the hot elevator by a metering system as required by Article 1102.01(a)(5) of the Standard Specifications. This metering system should be such as to require a few adjustments in maintaining a uniform rate of collected dust returned to the hot elevator. The primary dust-feed shall occur only when aggregate is being discharged from the drier.

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QC Personnel Responsibilities and Duties Checklist
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Plants having dry secondary collectors shall return this material to a storage silo or the mineral filler bin if it will meet the requirements of the mineral filler specifications (Section 1011 of the Standard Specifications).

d. Screens: Samples from the hot-bins shall be inspected for contamination. An excess of coarse aggregate in the sand bin or sand in the coarse aggregate bins may indicate broken or clogged screens and/or a hole between the bins. The screens shall separate aggregate into sizes to produce a uniform gradation. If fluctuations in gradation occur, a change in screen size and/or aggregate flow rate may be required. Article 1102.01(b)(8) of the Standard Specifications shall be applied.

e. Hot-Bins: The Level II Technician is to ensure that each hot-bin overflow pipe is working to prevent back-up of material into other compartments or bins. An overflow or sudden shortage of material in a bin may indicate a broken or clogged screen, a change in feeding rate, or a change in gradation of the aggregate being used. Overflow pipes shall not be discharged into the hot elevator.

f. Temperature Recording Device: The temperature recording devices shall be checked for compliance with Article 1102.01(a)(7) of the Standard Specifications. A new chart shall be used each day.

g. Timers: The timers used for recycling the wet and dry mixing times for a batch plant shall be checked and set at the required mixing times. On continuous plants, the pugmill dam gate shall be in the raised position. The required times are in the appropriate articles of the Standard Specifications.

h. Batching: The Level II Technician shall observe the batching operation to ensure the approved batch weights are being met. Manually operated batch plants shall have markers on the scales to indicate the approved batch weight of each ingredient material. Automatic batching plants shall have posted near the scales the approved weights per bin. On continuous plants, the gate openings shall be checked for the proper setting. It is recommended that batch counters and/or ton counters be set at "zero" or that initial and final readings be taken and recorded each day.

i. Surge and Storage Bins: When a surge and storage bin are used, approval and scale calibration information should be available. They shall be inspected for compliance with Article 1102.01(a)(6) of the Standard Specifications. Trucks shall be loaded in such a manner as to minimize segregation.

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Hot-Mix Asphalt QC/QA
QC Personnel Responsibilities and Duties Checklist
Appendix B5
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Effective: May 1, 1993
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j. The platform and/or suspended weigh hopper scale shall be checked for proper zero. The scales shall be cleaned off before starting each day.

k. The anti-strip additive system calibration shall be checked and the proper flow rate determined.

l. The weigh ticket printer shall be checked for information required by the specifications.

m. The computer and/or control system shall be checked to see if the correct percentages of materials have been entered. The automatic printer for the computer of the drier drum should be turned on and working.

8. Trucks

A Level I Technician, under the direct supervision of the QC Manager or the Level II Technician, shall inspect the trucks used to transport the HMA mix. The technician shall see that each truck is provided with a cover and is properly insulated, if specified, before it is permitted to be used in the transportation of the mixture from the plant to the job. The truck bed shall be observed for foreign material before the bed is lubricated. He/She shall observe the spraying of the inside of the trucks with a release agent and shall see that no pools of release agent remain in the truck beds before loading.

9. Mixture Inspection

The Level II Technician shall inspect the mixture at the plant, which includes observing the weighing of the materials; checking the temperature of the mixture; and visually inspecting for coating of the aggregates, segregation, and moisture in the mixture. The Level I Technician shall sample and determine the gradation of the hot-bins and/or cold-feeds and the proper amount of asphalt binder being used to ensure conformity to the mix formula. The Level II Technician shall also verify and document the addition rates of the anti-strip additives.

In addition, the Level I Technician shall perform the required core density tests and, when required, extraction tests at the field laboratory.

The QC Manager shall furnish the Contractor with the mixing formulas which have been established for a specific combination of sources of ingredients. The formulas shall state the percentage of aggregate for each sieve fraction and the percentage of asphalt binder. These formulas are to be used in proportioning the ingredient materials for HMA mixtures within the specified tolerances. Changes in the mix formulas are to be made only by the QC Manager.

It is important that the QC Manager observe the laying and compaction of the mixture.

Mixture variations are noticeable in the completed work, and variations that are not apparent in the mixture at the plant sometimes show up as defects in the texture and uniformity of the surface. Flushing of the mixture is a defect that can be detected only on the road.

It is the duty of both the Level I and Level II Technicians to establish and maintain an open line of communications.

Timely and appropriate actions can be instituted by early detection of defects or mixture variations.

10. Scale Checks
When measurement of mixtures is on the basis of weights obtained from batch weights or automatic printers, occasional scale checks shall be made by weighing full truckloads of the mixture on an approved platform scale at the plant site or on a commercial scale approved by the Engineer. The frequency and procedure for the check tests are described in the "Documentation" section of the [Bureau of] *Construction Manual*. The tests will be performed by the Level II Technician and reported on the "Daily Plant Output Report" and/or form BC 2367.

11. Samples

The Level I Technician shall take check samples of the mixture in addition to the required samples. He/She must also store split samples in a dry storage area for the Engineer. Section 1030 of the Standard Specifications discusses sampling procedures and sampling frequency.

12. Reports

The Quality Control Manager is responsible for completion of a "Daily Plant Output Report" (MI 305) for each day of production for each type of mix. Other reports, when required, are "Sample Identification" (LM-6), and Scale Checks.

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Model Annual Quality Control (QC) Plan for Hot-Mix Asphalt (HMA) Production
Appendix B.1

Effective: May 1, 1993
Revised: December 1, 2017

Producer Name: ______________________________
Producer/Supplier No.: ______________________________
Address: ______________________________
City/State/ZIP Code: ______________________________
Phone No.: ______________________________

A. Contractor Responsibilities

This Annual Quality Control (QC) Plan explains how ____________________ proposes to control the equipment, ingredient materials, and production methods to ensure the specified product is obtained. All requirements of section 1030 of the Standard Specifications and this Annual QC Plan will be adhered to. A Quality Control Addendum shall be completed for each contract and submitted prior to the preconstruction conference.

In joint ventures, where one Contractor is producing the mix and another is responsible for the laydown, the Quality Control Manager, from either party, who is ultimately responsible for the Quality Control should be identified in the Quality Control Addendum.

B. Materials

All materials proposed for use are from approved sources. Material sources are identified below for coarse aggregate, fine aggregate, mineral filler, asphalt binder, prime, anti-strip additive, and release agent. This includes the mix type, Producer/Supplier Number, firm name, and firm location.

	Material	Mix Type	Producer/ Supplier No.	Firm Name	Location
(1)					
(2)					
(3)					
(4)					
(5)					
(6)					
(7)					

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Model Annual Quality Control (QC) Plan for Hot-Mix Asphalt (HMA) Production
Appendix B.1
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Effective: May 1, 1993
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	Material	Mix Type	Producer/ Supplier No.	Firm Name	Location
(8)					
(9)					
(10)					

1. Aggregates

The incoming aggregate gradation bands have been developed from the source gradation bands and are attached. Listed below are the contact persons for the aggregate sources furnishing mixture aggregates.

	Name	Firm	Phone Number
Coarse Aggregate			
CA/CM 07/11 (Binder)			
CA/CM 13/16 (Binder)			
CA/CM 13/16 (Surface)			
Fine Aggregate			
FA/FM 01/02			
FA/FM 20/21			

a. Aggregate Stockpile Procedures

All aggregate stockpiles will be built using procedures that will minimize segregation and degradation. All coarse and fine aggregate will be placed in single-layer truck-dumped stockpiles at the mix plant. QC personnel will pay special attention to the loadout, replenishing, and remixing of the aggregate stockpile.

If segregation/degradation becomes a problem, stockpiling procedures will be altered to correct the problem.

b. Incoming Aggregate Gradation Samples

A washed gradation test will be performed for each 500 (tons 450 metric tons) for the first 1,000 tons (900 metric tons) for each aggregate received. Additional gradation tests (every third test will be a washed gradation test) will be run on the frequency of one test per 2,000 tons (1,800 metric tons) for each aggregate received while the stockpiles are being built or aggregate is being shipped in. Gradation correction factors will be developed from washed gradation test results and applied to all dry gradation results. All aggregate (correction factors applied) will meet the mix plant gradation bands as developed according to the current Department policy, "Development of Gradation Bands on Incoming Aggregate at Mix Plants", before being used in mix production at the mix plant. All incoming aggregate gradation results shall be recorded in the plant diary. If a failing sample is encountered, the following resample procedure will be followed:

(1) Immediately resample the aggregate represented by the failing test.

(2) If the first resample passes, the required frequency will be continued.

(3) If the first resample fails, shipment of the aggregate will be halted, and corrective action will be taken. Corrective action may be rejection of the material, remixing or addition of material by feeder/conveyor system, or any other action approved by the Engineer. The aggregate producer will be notified of the problem. A second resample will be taken immediately after corrective action.

(4) If the second resample passes, the aggregate represented will be used, and aggregate shipment into the plant will be resumed.

(5) If the second resample fails, the aggregate represented will not be used in the QC/QA HMA mixture. The material will be removed from the certified aggregate stockpile.

Each contact person listed above has agreed to immediately provide information on aggregate production changes or any significant variations in aggregate characteristics. These include, but are not limited to, changes in production methods, ledge footage, gradation, quality, specific gravity, and absorption. As gradation information is accumulated during stockpile construction, the aggregate gradations will be compared with the mix design gradation. Significant variations from the design gradation but within the acceptable gradation bands will be discussed with the Engineer. A new mix design will be performed when required by the Engineer.

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Model Annual Quality Control (QC) Plan for Hot-Mix Asphalt (HMA) Production
Appendix B.1
(continued)
Effective: May 1, 1993
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c. Required Gradation Sample

After mix production has started, all aggregate stockpiles will be checked with a required washed gradation sample on a weekly basis. This testing will be waived if the mixture is classified as a small tonnage item according to the special provision. The test results shall be compared to the mix plant gradation bands for compliance. These gradation results will be noted in the Plant Diary, and a copy will be provided to the District Engineer.

If a weekly required stockpile sample fails, the following resample procedure will be followed:

(1) Immediately resample and test the new stockpile sample.

(2) If the first resample passes, mix production may continue. Several additional check samples will be taken to monitor the stockpile.

(3) If the first resample fails, mix production will be halted, and corrective action will be taken on the stockpile. Corrective action may include rejection of the material, remixing or addition of material by feeder/conveyor system before use in the plant, or any other action approved by the Engineer. The aggregate contact person will be notified of the problem. A second resample will be obtained immediately after corrective action.

(4) If the second resample passes, mix production will begin. Several additional check samples will be taken to monitor the stockpile.

(5) If the second resample fails, the stockpile will not be used in the QC/QA HMA mixture.

Aggregate not meeting the mix plant gradation bands shall not be used in the QC/QA HMA mixtures.

d. Reclaimed Asphalt Pavement (RAP)

RAP will meet the requirements of Sections 1030 of the Standard Specifications and any Special Provision in the contract.

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Model Annual Quality Control (QC) Plan for Hot-Mix Asphalt (HMA) Production
Appendix B.1
(continued)
Effective: May 1, 1993
Revised: December 1, 2017

C. Mix Design

Mix designs shall be completed according to the Department's Hot-Mix Asphalt Level III Technician Course. All design data and material samples shall be submitted to the Department for verification a minimum of 30 calendar days prior to production.

D. Quality Control Personnel

All requirements of the Standard Specifications Section 1030, and the items listed in the Department's current "QC Personnel Responsibilities and Duties Checklist" will be met by the QC personnel. All personnel being utilized to run the Quality Control sampling and testing shall have taken and passed the appropriate HMA QC/QA level of training. The QC Manager will assign duties in accordance with the "QC Personnel Responsibilities and Duties Checklist". The QC Manager will assure the listed duties are performed and documented. Additional duties, when necessary, will be assigned and monitored by the QC Manager. Sufficient QC personnel will be provided to run the QC Plan. Additional QC personnel will be added when necessary.

E. Quality Control Laboratory/Equipment

A QC laboratory will be provided and maintained in accordance with the Department's current "Hot-Mix Asphalt QC/QA Laboratory Equipment".

Laboratory equipment meeting the requirements of the Department's current "Hot-Mix Asphalt QC/QA Laboratory Equipment" will be provided and properly maintained at the QC laboratory. In the event of equipment failure, ______________________________ will be the source for backup equipment.

All equipment has been calibrated, and the supporting documentation is on file at the QC laboratory. The QC Laboratory was approved by the Department's Central Bureau of Materials and by District __________ on _________________________. The laboratory/equipment will be available for inspection by the Engineer.

Illinois Department of Transportation

Model Annual Quality Control (QC) Plan for Hot-Mix Asphalt (HMA) Production
Appendix B.1
(continued)
Effective: May 1, 1993
Revised: December 1, 2017

F. Mix Plant/Production

Manufacturer ______________________

Model Number ______________________

Serial Number ______________________

Batch Size ______________________

Tons Per Hour ______________________

Approved By ______________________

Approval Date ______________________

It is our intent to run the day following start-up. Production will not begin until the acceptable nuclear/core correlation is complete, all other required tests are acceptable, the targets are established, and the results are reviewed and agreed to by the Department.

The aggregate feeders will be calibrated prior to the start of production using the aggregates and approximate percentages approved in the Job Mix Formula (JMF). At this time aggregate samples will be taken and compared with the JMF.

At the start of mix production or when adjustments are made to the mix, the QC Manager will give the aggregate proportions to the plant operator, and then, periodically throughout the day, checks will be made of the actual proportions used. This will be especially noted and recorded when a nuclear asphalt and/or a mix sample is taken. The results will be immediately reported to the Resident Engineer and/or other designated Department personnel upon completion of the test.

All scale and sensitivity checks will be performed in accordance with the Hot-Mix Asphalt Level II Technician Course manual. Surge bins may be utilized as part of the overall plant operation. The QC Manager shall contact the Department for approval when material will be stored overnight.

G. Sampling and Testing

All sampling and testing, including all required plant tests, resamples, and additional check tests (when necessary), will be performed in accordance with Department test methods in the time frame required in Section 1030 of the Standard Specifications. The "Radioactive Material License" required for nuclear density and asphalt binder content determinations are attached. District Materials or the Central Bureau of Materials personnel are welcome to observe all testing by the QC personnel. Time permitting, split samples will be shared with Department personnel prior to start-up. Coring will be performed using a truck-mounted drill rig or by suitable equipment as approved by the Engineer. An adjustment of 1-1/2% to 2% for minus No. 200 (0.075 mm) material of washed samples vs. dry gradations will be used until a gradation correction factor is established based on preliminary aggregate sampling and testing.

All Department split samples will be stored on site. These samples will be identified with the date and time the material was sampled, Sequence Number, Contract Number, mix plant Producer/Supplier Number, aggregate source Producer/Supplier Number, and the initials of the individual who sampled the material.

H. Placement and Compaction

Only approved equipment will be used in the placement and compaction of the mix in accordance with the Standard Specification requirements.

The QC Manager will verify that all laydown equipment conforms to Department requirements prior to start-up. At the start of laydown, Two Growth Curves will be run on a test strip to determine the suitability of the mix. Mix samples shall be taken and tested from trucks representing material between both Growth Curves. From Growth Curve information, a rolling pattern will be established. Nuclear tests and cores will be taken from the start-up area to verify density and correlation of the nuclear density gauge. Temperatures of the mix will be taken and duly recorded. After the start-up data is approved by the Department and actual production has begun, daily nuclear density tests will be taken at the start of each day's production, along with temperature readings, to verify continued conformance with density requirements. Nuclear density tests according to the Section 1030 will be performed to assure compliance with specified density requirements. Testing will be conducted within the project traffic control, or by use of flaggers, as needed.

Start-up and construction of the test strip is planned to be performed in the morning of the first day. If no problems are encountered, cores for nuclear/core correlation will be taken. The mat will be cooled with ice or dry ice. All tests will be completed for anticipated production the next day.

Should any adverse mix characteristics be observed, the QC Manager shall make mix adjustments as needed to correct the situation.

If segregation should occur, appropriate adjustments will be made in the aggregate stockpiling/loadout, plant production, silo operation, truck loading, or paver operation to alleviate the condition. Only approved truck release agents will be used.

Illinois Department of Transportation

Model Annual Quality Control (QC) Plan for Hot-Mix Asphalt (HMA) Production
Appendix B.1
(continued)
Effective: May 1, 1993
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The QC Manager or his representative will check laydown equipment daily for specification compliance and immediately repair or replace nonconforming equipment.

I. Corrective Action

The QC Manager will initiate corrective action immediately according to Section 1030 of the Standard Specifications. Sufficient tests shall be taken to verify the corrective action has worked. Special care will be taken to assure that mix not complying with specifications is not placed on the road.

J. Reporting of Test Results

All test results will be reported daily to the Resident Engineer and other designated personnel as requested by the Department. The data will be reported on the following forms or on forms generated by the Department's current QC/QA software:

MI 504M	Field/Lab Gradations (stockpile gradations)
MI 305	Bituminous Daily Plant Output (front) Plant Settings and Scale Checks (back)
MI 303C	Bituminous Core Density Testing QC/QA
MI 303N	QC Nuclear Density Report
MI 308	Nuclear Asphalt Content and Volumetric Testing
LM-6	Sample Identification (for liquid asphalt)

The completed forms will be forwarded to the District Engineer within three days of test completion.

K. Control Charts

In addition, control charts will be posted at the laboratory and kept updated for the following test parameters in accordance with the Department's current "Hot-Mix Asphalt QC/QA Control Charts/Rounding Test Values".

Illinois Department of Transportation

Model Annual Quality Control (QC) Plan for Hot-Mix Asphalt (HMA) Production
Appendix B.1
(continued)
Effective: May 1, 1993
Revised: December 1, 2017

1. Gradations

   Hot-Bins/Combined Belt

   Percent Passing 1/2-in. (12.5-mm) Sieve

   Percent Passing No. 4 (4.75-mm) Sieve

   Percent Passing No. 8 (2.36-mm) Sieve

   Percent Passing No. 30 (600-µm) Sieve

   Percent Passing No. 200 (75-µm) Sieve

   Ignition Oven

   Total Dust Content

2. Gravities

   a. Bulk specific gravity

   b. Maximum specific gravity

3. Marshall Air Voids

4. Density

5. Asphalt Binder Content

6. Stockpile Gradations

In the event the Total Dust Content is out of tolerance, measures will be taken to correct the problem, which may include adding Positive Dust Control Equipment.

Contractor's Signature ______________________________ Date ___________________

(Please type or print name) ________________________________ Title _____________

Illinois Department of Transportation

Model Quality Control (QC) Addendum for Hot-Mix Asphalt (HMA) Production
Appendix B2

Effective: July 1, 1995
Revised: May 1, 2007

Contract No.: ______________________
Marked Route: ______________________
Route: ______________________
Section: ______________________
County: ______________________

Contractor: ______________________
Address: ______________________
City/State/ZIP Code: ______________________
Phone No.: ______________________

A. Contractor Responsibilities

This Quality Control Addendum to the Annual Quality Control Plan further explains how ______________________ proposes to control the equipment, ingredient materials, and production methods to ensure the specified product is obtained. All requirements in Section 1030, the Annual QC Plan, and this QC Addendum will be adhered to.

In the case of joint ventures, ______________________ of ______________________ will be the QC Manager and will be ultimately responsible for the Quality Control on this Contract.

B. Reclaimed Asphalt Pavement (RAP)

RAP will meet the requirements of Sections 406, 1030 and 1102 of the Standard Specifications and any Special Provisions in the Contract. ______ percent of RAP is proposed for use in the ______________________ course.

Illinois Department of Transportation

Model Quality Control (QC) Addendum for Hot-Mix Asphalt (HMA) Production
Appendix B2
(continued)
Effective: July 1, 1995
Revised: May 1, 2007

C. Mix Design

Mix designs are attached for Department verification.

D. Quality Control Personnel

The project QC Manager will have overall responsibility and authority for Quality Control at both the plant and on the road and will make the necessary adjustments in the mix production, placement, and compaction to assure conformance with the Standard Specifications and Contract Special Provisions.

The QC personnel and/or consulting firm that will be utilized, as well as the backup QC personnel and/or consulting firm, are as follows:

	Name	Level of Training	Firm	Phone Number
(1)				
(2)				
(3)				
(4)				
(5) (backup)				

E. Mix Plant/Production

The mix for this project will be produced by Producer/Supplier No. ______________.

F. Control Charts

A copy of the Control Charts will be submitted to the Engineer upon completion of the Contract.

Contractor's Signature ______________________________ Title ____________________

(Please type or print name) ________________________________ Date _____________

State of Illinois
Department of Transportation
Division of Highways
Bureau of Materials and Physical Research
Springfield

POLICY MEMORANDUM

Revised: July 9, 2013 This Policy Memorandum supersedes number 4-08.0 dated January 1, 2008	4-08.1

TO: REGIONAL ENGINEERS AND HIGHWAY BUREAU CHIEFS

SUBJECT: APPROVAL OF HOT-MIX ASPHALT PLANTS AND EQUIPMENT

1 SCOPE

This policy governs the approval of hot-mix asphalt (HMA) plants for both Prequalification and production purposes.

2 REFERENCE DOCUMENTS

2.1 *Standard Specifications for Road and Bridge Construction*, edition current at the time of the advertisement for bids, Illinois Department of Transportation.

2.2 *Supplemental Specifications and Recurring Special Provisions*, edition current at the time of the advertisement for bids, Illinois Department of Transportation.

2.3 Prequalification Rules (Manual), Illinois Department of Transportation.

2.4 "The Fundamentals of the Operation and Maintenance of the Exhaust Gas System in a Hot Mix Asphalt Facility", IS-52, National Asphalt Pavement Association.

2.5 "The Uniform Burner Rating Method for Aggregate Dryers", IS-76, National Asphalt Pavement Association.

2.6 Illinois-Modified AASHTO T 11 (Washed Gradations)

2.7 Illinois-Modified AASHTO T 2 (Aggregate Sampling)

2.8 Illinois-Modified AASHTO T 27 (Sieve Analysis)

2.9 Illinois-Modified AASHTO T 30 (Sieve Analysis of Extracted Aggregate)

2.10 Illinois-Modified AASHTO T 164 (Extraction Method)

2.11 Illinois-Modified AASHTO T 308 (Ignition Oven Method)

3 DEFINITIONS

3.1 BUREAU - The Department's Bureau of Materials and Physical Research.

3.2 High ESAL and Low ESAL APPROVAL - A field test administered by the Bureau to determine the capability of an HMA plant to produce mix within the Department's specifications. The test is a prerequisite to production of High ESAL or Low ESAL mixtures for the Department. It may be conducted concurrent with the start of a contract. It is not a prerequisite for initial Prequalification. (Section 7 of this Policy describes the procedure in detail.)

3.3 DEPARTMENT - Illinois Department of Transportation.

3.4 DISTRICT - One of nine of the Department's highway district offices located throughout the state of Illinois.

3.5 EQUIPMENT FACTOR - A Prequalification factor that is a measure of the annual dollar value of production capacity for selected equipment and plant facilities. For HMA plants, the Work Category and Production Rating are used to determine the Equipment Factor.

3.6 HMA PLANT - A plant intended to produce High ESAL, Low ESAL or All Other mixtures for the Department. For the purposes of Prequalification, an HMA plant includes equipment specified in the Department's Prequalification Rules and the *Standard Specifications for Road and Bridge Construction*.

3.7 POSITIVE DUST CONTROL EQUIPMENT (PDCE) - PDCE shall consist of a system that is an integral part of the production process. The system shall accurately weigh all of the secondary dust collected in the baghouse, transfer the material to a storage silo, accurately weigh the required amount of fines to be returned from the storage silo, and transfer them back to the mixture. The positive dust control weighing devices shall have an accuracy of 0.5 percent of the actual weight of material. The system shall be capable of automatically monitoring the dust collection process and adjusting the amount of asphalt cement added to the mixture. The entire system shall be interlocked with the plant controls to respond to production rate changes, start up, and shut down situations. The weighing process shall be displayed and recorded in 0.1 units. The PDCE shall be capable of accurately wasting dust without having any adverse effects on the mixture.

3.8 PREQUALIFICATION APPROVAL STATUS - A rating process established by the Department which requires all prospective bidders to obtain a Certificate of Eligibility prior to being considered for issuance of bidding proposal forms and plans for any contract awarded by the Department, as well as contracts awarded by local agencies requiring approval of award by the Department.

3.9 PREQUALIFICATION SECTION – The section within the Bureau of Construction of the Department responsible for determining responsibility, financial ratings, work ratings and the issuance of bidding proposals.

3.10 PRODUCTION RATING - A nominal production rating for an HMA plant. It is calculated by the Bureau and is one factor used to determine the Prequalification Equipment Factor. It is also the maximum field production rate approved for Department work. (Section 6 of this Policy describes this approval in detail.)

3.11 WORK RATING - A dollar value of work of a particular category of construction that an applicant can perform with his/her organization and equipment in one construction season.

3.12 BITUMINOUS PLANT WORK CATEGORIES – A Prequalification designation determined by the Bureau for an HMA plant based on equipment specification compliance and/or HMA produced.

4 GENERAL

4.1 PREQUALIFICATION

4.1.1 Prior to Prequalification, the Contractor shall complete a plant survey on forms furnished by the Department. The Contractor shall submit the forms to the District in which the plant is located, or the nearest District if the plant is located out-of-state. The District shall forward the submittal to the Bureau.

4.1.2 During the Prequalification process, each HMA plant will be evaluated by the Bureau. The Bureau will determine the Prequalification Work Category and Production Rating used in determining the Contractor's Work Rating.

4.1.3 The Bureau will evaluate the submittal and conduct investigations as necessary.

4.1.4 The Bureau will provide the Work Category to the Prequalification Section. The Work Category will be used by the Prequalification Section to establish a Work Rating for the Contractor according to the Prequalification Rules.

4.1.5 An HMA plant will be evaluated for a single owner only. The pre-qualification rating for a leased plant will apply to a single Contractor only.

4.2 PLANT APPROVAL FOR HIGH ESAL AND LOW ESAL MIXTURES

HMA plants intending to produce High ESAL and/or Low ESAL for the Department shall be evaluated by the Department for High ESAL and Low ESAL Approval as specified herein.

4.3 RE-APPROVAL / PLANT MODIFICATIONS

All plants will be re-surveyed for consideration for continued approval every 5 years. The Department will notify the Contractor to resubmit the survey forms.

4.4 REVOCATION OF PLANT APPROVAL

If the Department determines the HMA plant is unable to consistently produce HMA within the specification tolerances as defined in the contract, the Approval Status may be revoked by the Bureau which would require the Contractor to repeat the plant approval process. The Bureau will notify the Prequalification Section of any and all plant approval revocations.

4.5 REINSTATEMENT PROCESS

If the HMA plant approval is revoked, the Contractor shall provide the Bureau a written plan of corrective action. Once the Bureau reviews and finds the plan acceptable, the plant approval process may begin. If the Bureau requires the installation of the Positive Dust Control Equipment (PDCE), the installation shall comply with section 3.7 above. If PDCE or any other plant modifications are required, the equipment shall be installed and/or modifications made prior to the production of any HMA for the Department. With approval of the Bureau, the installation may be performed prior to the start of the next construction season. The Bureau may stipulate operational conditions or restrictions on the plant until all required modifications are completed.

5 PREQUALIFICATION WORK CATEGORIES

The physical status of the plant determines the Equipment Factor and Work Rating associated with the plant. The Bureau will classify each HMA plant in one of the work categories below. Under each category, the plant shall include the equipment specified in the referenced documents.

5.1 Bituminous Plant Mix – Applicable to a new or used HMA plant that meets the equipment requirements to produce High ESAL and Low ESAL mixtures as stated in the *Standard Specifications for Road and Bridge Construction*. This category is permitted to produce all types of HMA. HMA plants in this category must go through and receive High ESAL and Low ESAL approval, as specified herein, to produce High ESAL and Low ESAL mixtures as described in Section 7.

5.2 Bituminous Aggregate Mixture – Applicable to a new or used HMA plant that meets the equipment requirements to produce All Other mixtures as stated in the *Standard Specifications for Road and Bridge Construction*. This category will be limited to only the production of stabilized sub – base HMA and HMA shoulder.

6 PRODUCTION RATES

All HMA plants will be evaluated by the Bureau and assigned a nominal Production Rating. Production Ratings will be based on this policy and the industry standards, as applicable, in the referenced NAPA publications (NAPA Procedure). Production Ratings will be given in tons (metric tons) of HMA mixture per hour.

6.1 ASSUMED CRITERIA - Ratings will be based on the conventions described in the referenced NAPA publications. Variables included in the NAPA algorithm are assigned the following values:

6.1.1 Assumed gas flow velocity of 1,000 feet (300 meters) per minute for all dryers.

6.1.2 Radius is calculated at the exhaust end chamber of the dryer.

6.1.3 Assume 147 ft^3 ($4.2m^3$) per minute of air required per ton (metric ton) of aggregate.

6.1.4 HMA mixture is assumed to contain 5% asphalt binder.

6.1.5 Combined aggregate contains 5% moisture.

5

6.2 EXCEPTIONS TO NAPA PROCEDURE:

6.2.1 The Contractor may request a temporary increase in Production Rating if the incoming aggregate contains less than 5% moisture. The Contractor shall (1) provide moisture analysis of the aggregate stockpiles, (2) demonstrate to the Engineer that increased production does not affect the quality of the HMA mix, and (3) provide testing requested by the Engineer during the analysis and production.

6.2.2 The Contractor may request a permanent modification to the Production Rating if the design of the plant is not consistent with the schematics and standards contained in the NAPA Procedure. The Contractor shall provide the Manufacturer's certification and all calculations supporting the exception. For plants modified by the Contractor, the Contractor shall provide engineering justification for any request.

6.2.3 For all exceptions, the responsibility for supporting data rests with the Contractor. The Department may reject requests that, in the sole opinion of the Engineer, are not adequately supported.

6.3 OTHER LIMITING FACTORS - The NAPA Procedure may not be applicable in all cases. The plant may include equipment that restricts production capacity below that calculated by the NAPA Procedure. In these instances, the Bureau will calculate the Production Rating based on these restrictions. The Department will provide the Contractor with written notification of any such determination, along with the calculations used to determine the Production Rating. Examples follow:

6.3.1 <u>Sand Screens - Criteria</u>

6.3.1.1 Maximum production rate = R = 1.5 tons per hour per ft^2 of 1/8-inch screen (15 metric tons per hour per m^2 of 3.2mm screen).

6.3.1.2 Sand is 1/3 of aggregate blend.

6.3.1.3 Total aggregate rate = sand screen area x R x 3

6.3.2 <u>Pugmill - Criteria</u>

6.3.2.1 Capacity based on charts supplied by manufacturer, or

6.3.2.2 Alternate formula: Capacity = Net volume below centerline of shaft x 1.15 x 100 lbs/ft^3(1,600 kg/$m^{3)}$.

6.3.2.3 Conversion factor from lbs / batch to tons per hour [TPH] = 0.0325 (kg / batch to metric tons per hour = 0.065). This equation assumes 65 batches per hour.

6.3.3 <u>Aggregate Scale/Hopper Capacities</u>

6

6.3.4 Asphalt Cement Scale/Bucket Capacities

6.3.5 The Contractor may request a recalculation of the Production Rating when plant modifications change the conditions on which the Limiting Factor was calculated.

7 HIGH ESAL AND LOW ESAL APPROVAL

The following will be used to evaluate the consistency of mixtures produced by HMA plants seeking approval to produce High ESAL and Low ESAL mixtures. This includes the sampling, testing, and acceptance requirements for an accelerated gradation and asphalt binder content testing program. It allows for rapid and early determination of reliable target values for gradation and asphalt content.

7.1 The test shall be performed on a High ESAL (Superpave IL-25.0 or IL-19.0) binder mix prior to use of the plant for binder production. It may be conducted concurrent with the start of a contract. It may be carried over into an additional contract only with the approval of the Bureau.

7.2 The Contractor shall proportion the binder mixture to meet the job mix formula (JMF). The Engineer may consent to the use of a High ESAL surface mixture for the test if binder is not included in the initial project. If the evaluation is performed on a surface mixture, a restriction of "Surface Mixture Only" approval will apply. An additional evaluation on a binder mixture will be required in order for full High ESAL and Low ESAL Approval to be granted.

7.3 The Bureau will designate the plant as either Type 1 or Type 2 prior to the start of the High ESAL and Low ESAL Approval process.

7.3.1 Type 1 Plants are defined as those which have a prequalification rating of 250 tons (180 metric tons) per hour or greater of mixture.

7.3.2 Type 2 Plants are defined as those which have a prequalification rating of less than 250 tons (180 metric tons) per hour of mixture.

7.4 PROCEDURE - Test production specifications are as follows:

7.4.1 Lot Sizes

7.4.1.1 Plant Type 1. The quantity shall be 5,000 tons (4,500 metric tons) of approved JMF mixture. The evaluation will include 5 lots of approximately 1,000 tons (900 metric tons) each. Each of the 5 lots will be further divided into 5 sublots (for a total of 25 tests).

7.4.1.2 Plant Type 2. The quantity shall be 3,000 tons (4,500 metric tons) of approved JMF mixture. The evaluation will include 5 lots of approximately 600 tons (545 metric tons) each. Each of the 5 lots will be further divided into 5 sublots (for a total of 25 tests).

7.4.2 The procedure will be run over a period of not less than 3 production days.

7.4.3 No more than 2 lots in any day may be included in the evaluation (to allow for lab testing between days).

7.4.4 One lot may be produced before this evaluation process to determine preliminary target values. With approval of the Engineer, this lot may be used to establish preliminary target values and rolling patterns per the specified start-up procedures.

7.4.5 The Contractor will not be required to cease production between lots. Mixture produced between lots will be evaluated according to the contract specifications.

7.5 SAMPLING - Sampling shall follow the referenced methods:

7.5.1 Aggregate - The Contractor shall take hot-bin or belt samples, with back up splits reserved for the Department's use, for each sublot.

7.5.2 HMA Mixture - The Contractor shall take random samples, with back up splits reserved for the Department's use, from each sublot (25 total) from randomly selected trucks. Approximate sample size shall be ± 2,000g for binder mixtures and ± 1,000g for surface mixtures.

7.6 TESTING

7.6.1 Following the referenced test methods, the Contractor shall perform gradation and asphalt binder content analysis for each sublot. Testing will be performed on each hot-mix asphalt sample. Asphalt binder content (AC) control limits and limits on control sieves will be as follows:

PARAMETER	CONTROL LIMIT (INDIVIDUAL TEST)	CONTROL LIMIT (MOVING AVERAGE OF 4)
% Passing		
12.5 mm (1/2 inch)	± 6%	± 4%
4.75 mm (No. 4)	± 5%	± 4%
2.36 mm (No. 8)	± 5%	± 3%
600 µm (No. 30)	± 4%	± 2.5%
75 µm (No. 200)	± 1.5%	± 1.0%
Asphalt Binder Content	± 0.3%	± 0.2%

7.6.2 Results for each test will be evaluated for conformance with the specified control limits. Note: "Moving average" is the average of the results of the current test and the previous 3 individual tests (4 total).

The Department will test a minimum of one sample per lot for verification purposes.

7.7 ADJUSTMENTS

On the basis of visual analysis and test results, the Contractor may make plant adjustments to improve consistency of the mix. The Engineer will cooperate and assist in this effort when requested.

7.8 ACCEPTANCE

The Bureau may approve the plant for normal production when the evaluation shows that the plant can produce mixture that consistently complies with the project specifications. This will generally be defined as when the moving average of each test (all sieves and asphalt binder content) for a single lot remains within the specified control limits. Each successive lot should also show improving and consistent results. However, the individual test results will also be evaluated for consistency. The final two lots will have no individual test results outside the individual control limits.

7.9 NON-COMPLIANCE

7.9.1 In the case of non-compliance, the Bureau may authorize the production of one or more additional lots for testing. Before any such additional production, the Bureau will require the Contractor to submit a plan of corrective action for approval. The Contractor shall demonstrate contract compliance of all material produced.

7.9.2 The Contractor shall be responsible for performing all additional testing beyond the 25 tests included in this procedure, and providing back up samples for use by the Department. No additional HMA mixture shall be produced for Department contracts until all testing is completed.

7.9.3 The Engineer may direct or carry out any other corrective action available through the QC/QA Special Provision or the Standard Specifications or other contract documents.

7.9.4 Repeating Plant Approval Process:

7.9.4.1 A Contractor failing to produce consistent mixture as defined herein may only continue producing mix if the plant approval process is repeated. A Contractor may repeat the approval process within the same contract with the approval of the Engineer.

7.9.4.2 In order to repeat the approval process on a different contract, the Contractor shall provide a written plan of corrective action to the Bureau. Permission to repeat the plant approval process will only be granted if the Bureau finds the plan of corrective action to be acceptable.

7.9.5 Plant Deficiencies - If the Bureau determines that the plant, as configured, is not capable of meeting the conditions for plant approval, the installation of Positive Dust Control Equipment or other modifications may be required. Approval and scheduling shall proceed per Article 4.5 above.

7.10 COMPENSATION

The Contractor shall be responsible for all costs, including additional laboratory testing due to non-compliance. These costs will be considered as included in the contract unit price for the HMA item involved.

David L. Lippert, P.E.
Engineer of Materials
and Physical Research

JST/dkt

Current PFP & QCP Specifications

PFP = Payment for Performance
QCP = Quality Control for Performance
I-FIT = Illinois Flexibility Index Test

BMPR* = Bureau of Materials and Physical Research
CBM* = Central Bureau of Materials
MoTP = Manual of Test Procedures
BDE = Bureau of Design and Environment

*** The Bureau of Materials and Physical Research has been renamed as the Central Bureau of Materials. As of the printing of this manual, some current documents have not been revised to reflect this change.**

THIS PAGE IS RESERVED

Illinois Department of Transportation

Memorandum

To: Regional Engineers

From: Maureen M. Addis

Subject: Special Provision for Hot-Mix Asphalt – Pay for Performance Using Percent Within Limits – Jobsite Sampling

Date: September 29, 2017

This special provision was developed by the Bureau of Materials and Physical Research to provide a method of constructing hot-mix asphalt pavements utilizing pay adjustments based on percent within limits statistical calculations. This special provision has been revised to require district laboratories to participate in the AASHTO re:source Proficiency Sample Program and remove dispute resolution information now contained in the Department's Manual of Test Procedures for Materials "Pay for Performance Dispute Resolution" document.

This special provision should be inserted into interstate, freeway and expressway resurfacing and full-depth projects having a minimum quantity of 8000 tons (7260 metric tons) per mix. Pay for performance may be considered for smaller projects where a more accurate measure of quality is desired. This special provision should not be used on:

1. Leveling binder
2. Incidental surfacing (e.g. driveways, entrances, minor sideroads)
3. Temporary pavements
4. Shoulders unless they are used as auxiliary lanes
5. Patching
6. Applications where the mixture thickness is less than 3 times the nominal maximum aggregate size.

The districts should include the BDE Check Sheet marked with the applicable special provisions for the January 19, 2018 and subsequent lettings. The Project Development and Implementation Section will include a copy in the contract.

This special provision will be available on the transfer directory September 29, 2017.

80347m

HOT MIX ASPHALT - PAY FOR PERFORMANCE USING PERCENT WITHIN LIMITS - JOBSITE SAMPLING (BDE)

Effective: November 1, 2014
Revised: January 1, 2018

Description. This special provision describes the procedures for production, placement and payment for hot-mix asphalt (HMA) under the pay for performance (PFP) program. This special provision shall apply to the HMA mixtures specified in the plans. This work shall be according to the Standard Specifications except as modified herein.

Delete Articles:	406.06(b)(1), 2nd paragraph	(Temperature requirements)
	406.06(e), 3rd paragraph	(Paver speed requirements)
	406.07(b)	(Rolling)
	406.07(c)	(Density)
	1030.04, last two sentences of first paragraph	(Mix design verification)
	1030.05(a)(4, 5, 7, 8, 9, & 10)	(QC/QA Documents)
	1030.05(d)(2)a.	(Plant Tests)
	1030.05(d)(2)b.	(Dust-to-Asphalt and Moisture Content)
	1030.05(d)(2)d.	(Small Tonnage)
	1030.05(d)(2)f.	(HMA Sampling)
	1030.05(d)(3)	(Required Field Tests)
	1030.05(d)(4)	(Control Limits)
	1030.05(d)(5)	(Control Charts)
	1030.05(d)(6)	(Corrective Action for Required Plant Tests)
	1030.05(d)(7)	(Corrective Action for Field Tests (Density))
	1030.05(e)	(Quality Assurance by the Engineer)
	1030.05(f)	(Acceptance by the Engineer)
	1030.06(a), 2nd paragraph	(Before start-up…)

Definitions.

(a) Quality Control (QC): All production and construction activities by the Contractor required to achieve the required level of quality.

(b) Quality Assurance (QA): All monitoring and testing activities by the Engineer required to assess product quality, level of payment, and acceptability of the product.

(c) Percent Within Limits (PWL): The percentage of material within the quality limits for a given quality characteristic.

(d) Quality Characteristic: The characteristics that are evaluated by the Department for payment using PWL. The quality characteristics for this project are field voids in the mineral aggregate (Field VMA), voids, and density. Field VMA will be calculated using the combined aggregates bulk specific gravity (G_{sb}) from the mix design.

(e) Quality Level Analysis (QLA): QLA is a statistical procedure for estimating the amount of product within specification limits.

(f) Mixture Sublot: A mixture sublot for Field VMA and voids shall be a maximum of 1000 tons (910 metric tons). If the quantity is less than 8000 tons (7260 metric tons), the sublot size will be adjusted to achieve a minimum of 8 tests.

(1) If the remaining quantity is greater than 200 tons (180 metric tons) but less than 1000 tons (910 metric tons), the last mixture sublot will be that quantity.

(2) If the remaining quantity is 200 tons (180 metric tons) or less, the quantity shall be combined with the previous mixture sublot.

(g) Density Interval: Density intervals shall be every 0.2 miles (320 m) for lift thicknesses of 3 in. (75 mm) or less and 0.1 miles (160 m) for lift thicknesses greater than 3 in. (75 mm). If a density interval is less than 200 ft (60 m), it will be combined with the previous density interval.

(h) Lot: A lot consists of ten mixture sublots or 30 density intervals. If seven or less mixture sublots or 19 or less density intervals remain at the end of production of a mixture, the test results for these sublots will be combined with the previous lot for evaluation of percent within limits and pay factors.

Lots for mixture testing are independent of lots for density testing.

(i) Density Test: A density test shall consist of a core taken at a random location within each density interval.

When establishing the target density, the HMA maximum theoretical gravity (G_{mm}) shall be based on the running average of four Department test results including the current day of production. Initial G_{mm} shall be based on the average of the first four test results.

(j) Unconfined Edge Density: The unconfined edge density shall be randomly selected within each 1/2 mile (800 m) section for each unconfined edge.

Pre-Production Meeting. The Engineer will schedule a pre-production meeting prior to the start of production. The HMA QC Plan, test frequencies, and responsibilities of all parties involved in testing and determining the PWL will be addressed. The Engineer will provide the random locations and tonnages in a sealed envelope for the Contractor to sign at the pre-production meeting or prior to paving. The random locations and tonnages may be adjusted due to field conditions according to the Department's Manual of Test Procedures for Materials "PFP and QCP Hot-Mix Asphalt Random Jobsite Sampling" and "PFP and QCP Random Density Procedure". The signed sealed envelope will be given to the Contractor after paving is complete along with documentation of any adjustments. Personnel attending the meetings may include the following:

(a) Resident Engineer

(b) District Mixture Control Representative

(c) QC Manager

(d) Contractor Paving Superintendent

(e) Any consultant involved in any part of the HMA sampling or testing on this project

Quality Control (QC) by the Contractor. The Contractor's QC plan shall include the schedule of testing for both quality characteristics and non-quality characteristics required to control the product such as asphalt binder content and mixture gradation. The schedule shall include sample location. The minimum test frequency shall be according to the following table.

Table 1
Minimum Quality Control Sampling and Testing Requirements

Quality Characteristic	Minimum Test Frequency	Sampling Location
Mixture Gradation	1/day	per QC Plan
Binder Content		
G_{mm}		
G_{mb}		
Density	per QC plan	per QC Plan

The Contractor shall submit QC test results to the Engineer within 48 hours of the time of sampling.

Initial Production Testing. The Contractor shall split and test the first two samples with the Department for comparison purposes. The Contractor shall complete all tests and report all results to the Engineer within two working days of sampling. The Engineer will make Department test results of the initial production testing available to the Contractor within two working days from the receipt of the samples.

Quality Assurance (QA) by the Engineer. The Department's laboratories which conduct PFP testing will participate in the AASHTO re:source's (formerly AMRL) Proficiency Sample Program. The Engineer will test each mixture sublot for Field VMA, voids, and dust/AC ratio; and each density interval for density to determine payment for each lot. A sublot shall begin once an acceptable test-strip has been completed and the AJMF has been determined. All Department testing will be performed in a qualified laboratory by personnel who have successfully completed the Department HMA Level I training.

(a) Voids, Field VMA, and Dust/AC Ratio. For each sublot, the Engineer will determine the random tonnage for the sample and the Contractor shall be responsible for obtaining the sample according to the Department's Manual of Test Procedures for Materials "PFP and QCP Hot-Mix Asphalt Random Jobsite Sampling Procedure". The Engineer will not disclose the random location of the sample until after the truck containing the random tonnage has been loaded and en-route to the project.

(b) Density. The Engineer will not disclose the random location of the sample until after the final rolling.

The Contractor shall cut the 4 in. (100 mm) diameter cores within the same day and prior to opening to traffic unless otherwise approved by the Engineer. All core holes shall be filled immediately upon completion of coring. All water shall be removed from the core holes prior to filling. All core holes shall be filled with a rapid hardening mortar or concrete which shall be mixed in a separate container prior to placement in the hole. Any depressions in the surface of the filled core holes greater than 1/4 in. (6 mm) at the time of final inspection will require removal of the fill material to the depth of the lift thickness and replacement.

The Engineer will witness and secure all mixture and density samples. The Contractor shall transport the secured sample to a location designated by the Engineer.

Test Results. The Department's test results for the first mixture sublot and density interval, of every lot will be available to the Contractor within three working days from the receipt of secured samples. Test results for remaining sublots will be available to the Contractor within ten working days from receipt of the secured sample that was delivered to the Department's testing facility or a location designated by the Engineer.

The Engineer will maintain a complete record of all Department test results. Copies will be furnished upon request. The records will contain, at a minimum, the originals of all Department test results and raw data, random numbers used and resulting calculations for sampling locations, and quality level analysis calculations.

Dispute Resolution. Dispute resolution testing will only be permitted when the Contractor submits their split sample test results prior to receiving Department split sample test results and meets the requirements listed in the Department's Manual of Test Procedures for Materials "Pay for Performance Dispute Resolution". If dispute resolution is necessary, the Contractor shall submit a request in writing within four working days of receipt of the results of the quality index analysis for the lot. The Engineer will document receipt of the request. The request shall specify Method 1 (pay parameter dispute) or Method 2 (individual parameter dispute) as defined in the Department's Manual of Test Procedures for Materials "Pay for Performance Dispute Resolution". The Central Bureau of Materials laboratory will be used for dispute resolution testing.

Acceptance by the Engineer. All of the Department's tests shall be within the acceptable limits listed below:

Table 2

Acceptable Limits	
Parameter	Acceptable Range
Field VMA	-1.0 – +3.0 %[1/]
Voids	2.0 – 6.0 %

Density: IL-19.0, IL-9.5 SMA	 90.0 – 98.0 % 92.0 – 98.0 %
Dust / AC Ratio	0.4 – 1.6 2/

1/ Based on minimum required Field VMA from mix design

2/ Does not apply to SMA

In addition, the PWL for any quality characteristic shall be 50 percent or above for any lot. No visible pavement distress shall be present such as, but not limited to, segregation, excessive coarse aggregate fracturing or flushing.

<u>Basis of Payment</u>. Payment will be based on the calculation of the composite pay factor for each mixture according to the Department's Manual of Test Procedure for Materials "PFP Quality Level Analysis" document. Payment for full depth pavement will be based on the calculation of the Full Depth Pay Factor according to the "PFP Quality Level Analysis" document.

<u>Additional Pay Adjustments</u>. In addition to the composite pay factor for each mix, monetary deductions will be made for dust/AC ratios and unconfined edge densities as shown in Tables 3 and 4 as follows.

Table 3

Dust / AC Pay Adjustment Table 1/	
Range	Deduct / sublot
0.6 ≤ X ≤ 1.2	$0
0.5 ≤ X < 0.6 or 1.2 < X ≤ 1.4	$1000
0.4 ≤ X < 0.5 or 1.4 < X ≤ 1.6	$3000
X < 0.4 or X > 1.6	Shall be removed and replaced

1/ Does not apply to SMA.

Table 4

Unconfined Edge Density Adjustment Table	
Density	Deduct / 0.5 mile (800 m)
≥ 90%	$0
89.0% to 89.9%	$1000
88.0% to 88.9%	$3000
< 88.0%	Outer 1.0 ft (300 mm) will require remedial action acceptable to the Engineer

80347

Illinois Department of Transportation

Memorandum

To:	Regional Engineers
From:	Maureen M. Addis
Subject:	Special Provision for Hot-Mix Asphalt – Quality Control for Performance
Date:	August 4, 2017

This special provision was developed by the Central Bureau of Materials to provide procedures for production, placement and payment of hot-mix asphalt (HMA) under the quality control for performance (QCP) program. It has been revised to secure random number selections, revise the Intelligent Compaction temperature requirements and provide retesting requirements for the Department when precision limits are exceeded.

This special provision should be inserted into HMA contracts utilizing the QCP quality management program. The QCP quality management program is to be used for the following HMA mixtures.

1. Mainline mixture quantities between 1,200 and 8,000 tons (1,016 and 7,620 metric tons).
2. Shoulder applications that are greater than 8 feet (2.4 meters) wide and 1,200 tons (1,016 metric tons) and greater.
3. Leveling binder applications that are 1,200 tons (1,016 metric tons) and greater.

Note to designers: The option of using intelligent compaction should be given to the contractor (i.e. a number of roller passes should be entered in the HMA mix table on the plans) for leveling binder which will be placed at variable depth/thickness (i.e. used to correct cross-slope or rutting).

The districts should include the BDE Check Sheet marked with the applicable special provisions for the November 17, 2017 and subsequent lettings. The Project Development and Implementation Section will include a copy in the contract.

This special provision will be available on the transfer directory August 4, 2017.

80383m

HOT MIX ASPHALT – QUALITY CONTROL FOR PERFORMANCE (BDE)

Effective: April 1, 2017
Revised: November 1, 2017

Description. This special provision describes the procedures for production, placement and payment of hot-mix asphalt (HMA) under the quality control for performance (QCP) program; as well as the requirements for intelligent compaction. This special provision shall apply to the HMA mixtures specified in the plans. This work shall be according to the Standard Specifications except as modified herein.

Delete Articles:	406.06(b)(1), 2nd Paragraph	(Temperature Requirements)
	406.06(b)(2)d.	(Temperature Requirements)
	406.06(b)(3)b.	(Temperature Requirements)
	406.06(e), 3rd Paragraph	(Paver Speed Requirements)
	406.07(b)	(Rolling)
	406.07(c)	(Density)
	1030.05(a)(4, 5, 9,)	(QC/QA Documents)
	1030.05(d)(2)a.	(Plant Tests)
	1030.05(d)(2)b.	(Dust-to-Asphalt and Moisture Content)
	1030.05(d)(2)d.	(Small Tonnage)
	1030.05(d)(2)f.	(HMA Sampling)
	1030.05(d)(3)	(Required Field Tests)
	1030.05(d)(4)	(Control Limits)
	1030.05(d)(5)	(Control Charts)
	1030.05(d)(7)	(Corrective Action for Field Tests (Density))
	1030.05(e)	(Quality Assurance by the Engineer)
	1030.05(f)	(Acceptance by the Engineer)
	1030.06(a), 2nd paragraph	(Before start-up…)

Definitions.

(a) Quality Control (QC). All production and construction activities by the Contractor required to achieve the required level of quality.

(b) Quality Assurance (QA). All monitoring and testing activities by the Engineer required to assess product quality, level of payment, and acceptability of the product.

c) Pay Parameters. Pay parameters shall be field voids in the mineral aggregate (Field VMA), voids, and density. Field VMA will be calculated using the combined aggregates bulk specific gravity (G_{sb}) from the mix design.

(d) Mixture Lot. A mixture lot shall begin once an acceptable test strip has been completed and the adjusted job mix formula has been determined. If the test strip is waived, a mixture lot shall begin with the start of production. A mixture lot shall consist of four sublots unless it is the last or only lot, in which case it may consist of as few as one sublot.

(e) Mixture Sublot. A mixture sublot for Field VMA, voids, and dust/AC shall be a maximum of 1000 tons (910 metric tons).

(1) If the remaining quantity is greater than 200 tons (180 metric tons) but less than 1000 tons (910 metric tons), the last mixture sublot will be that quantity.

(2) If the remaining quantity is 200 tons (180 metric tons) or less, the quantity shall be combined with the previous mixture sublot.

(f) Density Interval. Density intervals shall be every 0.2 miles (320 m) for lift thicknesses of 3 in. (75 mm) or less and 0.1 miles (160 m) for lift thicknesses greater than 3 in. (75 mm). If a density interval is less than 200 ft (60 m), it will be combined with the previous density interval.

(g) Density Sublot. A density sublot shall be the average of five consecutive density intervals.

(1) If less than three density intervals remain outside a density sublot, they shall be included in the previous density sublot.

(2) If three or more density intervals remain, they shall be considered a density sublot.

(h) Density Test. A density test shall consist of a core taken at a random location within each density interval.

When establishing the target density, the HMA maximum theoretical gravity (G_{mm}) shall be based on the running average of four Department test results. Initial G_{mm} shall be based on the average of the first four test results. If less than four G_{mm} results are available, an average of all available Department G_{mm} test results shall be used.

Pre-Production Meeting. The Engineer will schedule a pre-production meeting prior to the start of production. The HMA QC Plan, test frequencies, and responsibilities of all parties involved in testing will be addressed. The Engineer will provide the random locations, tonnages, and sublot selected from each lot in a sealed envelope for the Contractor to sign at the pre-production meeting or prior to paving. The locations, tonnages, and sublot selected from each lot may be adjusted due to field conditions according to the Department's Manual of Test Procedures for Materials "PFP and QCP Hot-Mix Asphalt Random Jobsite Sampling" and "PFP and QCP Random Density Procedure". The signed sealed envelope will be given to the Contractor after paving is complete, along with documentation of any adjustments. Personnel attending the meetings may include the following:

(a) Resident Engineer

(b) District Mixture Control Representative

(c) QC Manager

(d) Contractor Paving Superintendent

(e) Any consultant involved in any part of the HMA sampling or testing on this project

Quality Control (QC) by the Contractor. The Contractor's QC plan shall include the schedule of testing for both pay parameters and non-pay parameters required to control the product such as asphalt binder content and mixture gradation. The minimum test frequency shall be according to Table 1.

Table 1

Minimum Quality Control Sampling and Testing Requirements

Quality Characteristic		Minimum Test Frequency
Mixture Gradation		1 per sublot
Asphalt Binder Content		
Dust/AC Ratio		
Field VMA		
Voids	G_{mb}	
	G_{mm}	

The Contractor's splits in conjunction with other quality control tests shall be used to control production.

The Contractor shall submit split jobsite mix sample test results to the Engineer within 48 hours of the time of sampling. All QC testing shall be performed in a qualified laboratory by personnel who have successfully completed the Department's HMA Level I training.

Intelligent Compaction. When a "Number of Roller Passes" is specified in the HMA Mixture Requirements table on the plans, the Contractor may opt to use intelligent compaction (IC) in lieu of density testing. Coring according to the Department's Manual of Test Procedures for Materials "PFP and QCP Random Density Procedure" is required and will be used for pay adjustments for density sublots that are not in compliance with the contract specifications.

The IC equipment shall be mounted on the breakdown roller(s) and shall record GPS location data, roller pass counts, roller speeds, and HMA mat temperatures. Each day, the accuracy of the GPS and temperature data shall be verified and documented. If the verification fails or is not performed, the IC data will not be used for the affected density sublots.

The IC data for each density sublot shall be analyzed using Veta software to determine the average roller speed, percent roller coverage, and average mat surface temperature for the final roller pass. The Contractor shall submit these summary results, and if requested the raw data from the IC equipment and the data analysis software, to the Engineer within 24 hours of each day of paving using IC.

The required number of roller passes shall be as specified on the plans. The roller speeds shall be according to Article 406.07. The minimum roller coverage shall be 90 percent. The average HMA mat temperature for the initial break down roller pass shall be according to Table 2.

Table 2

Asphalt Mixture Type	Temperature Range (ºF (ºC))
Warm Mix Asphalt	215-275 °F (102-135 °C)
IL-4.75	300-350 °F (155-175 °C)
HMA using SBS PG76-22	300-350 °F (155-175 °C)
HMA using SBS PG76-28	300-350 °F (155-175 °C)
HMA using SBS PG70-22	300-350 °F (155-175 °C)
HMA using SBS PG70-28	300-350 °F (155-175 °C)
Other HMA not listed above	260-325 °F (125-165 °C)

Quality Assurance (QA) by the Engineer. Quality Assurance by the Engineer will be as follows.

(a) Voids, Field VMA, and Dust/AC Ratio. The Engineer will determine the random tonnage and the Contractor shall be responsible for obtaining the sample according to the Department's Manual of Test Procedures for Materials "PFP Hot-Mix Asphalt Random Jobsite Sampling Procedure".

(b) Density: After final rolling, the Engineer will identify the random core locations within each density testing interval according to the Department's Manual of Test Procedures for Materials "PFP and QCP Random Density Procedure".

The Contractor shall cut the 4 in. (100 mm) cores within the same day and prior to opening to traffic unless otherwise approved by the Engineer. All core holes shall be filled immediately upon completion of coring. All water shall be removed from the core holes prior to filling. All core holes shall be filled with a rapid hardening mortar or concrete which shall be mixed in a separate container prior to placement in the hole. Any depressions in the surface of the filled core holes greater than 1/4 in. (6 mm) at the time of final inspection will require removal of the fill material to the depth of the lift thickness and replacement.

The Engineer will witness and secure all mixture and density samples. The Contractor shall transport the secured sample to a location designated by the Engineer.

The Engineer will select at random one split sample from each lot for testing of voids, Field VMA and dust/AC ratio. The Engineer will test a minimum of one sample per project. The Engineer will test all of the pavement cores for density unless intelligent compaction is used. All QA testing will be performed in a qualified laboratory by personnel who have successfully completed the Department's HMA Level I training. QA test results will be available to the

Contractor within ten working days from receipt of secured cores and split mixture samples and after the last sublot from each lot.

The Engineer will maintain a complete record of all Department test results and copies will be provided to the Contractor with each set of sublot results. The records will contain, at a minimum, the originals of all Department test results and raw data, random numbers used and resulting calculations for sampling locations, and quality level analysis calculations.

If QA results do not meet the precision limits listed in Table 3, the Department will verify the results by retesting the retained split sample. The retest will replace the original results.

If the QA results do not meet the 100 percent sublot pay factor limits or still do not compare to QC results within the precision limits in Table 3, after retesting the Engineer will test all split mix samples for the lot.

Table 3

Test Parameter	Limits of Precision
G_{mb}	0.030
G_{mm}	0.026
Field VMA	1.0 %

Acceptance by the Engineer. All of the Department's tests shall be within the acceptable limits listed in Table 4.

Table 4

Parameter		Acceptable Limits
Field VMA		-1.0 – +3.0%[1/]
Voids		2.0 – 6.0%
Density	IL-9.5, IL-19.0, IL-4.75, IL-9.5FG[3/]	90.0 – 98.0%
	SMA	92.0 – 98.0%
Dust / AC Ratio		0.4 – 1.6[2/]

1/ Based on minimum required VMA from mix design

2/ Does not apply to SMA.

3/ Acceptable density limits for IL-9.5FG placed less than 1 1/4 in. (32 mm) shall be 89.0% - 98.0%

In addition, no visible pavement distresses shall be present such as, but not limited to, segregation, excessive coarse aggregate fracturing or flushing.

Basis of Payment. Payment will be based on the calculation of the composite pay factor using QA test results for each mixture according to the Department's Manual of Test Procedures for Materials "QCP Pay Calculation" document.

If intelligent compaction is successfully implemented, the Contractor will receive 100 percent for the density pay factor in Equation 1 of the "QCP Pay Calculation" document for each applicable HMA mixture; otherwise, the density tests and pay adjustments will apply. The pay factor for each density sublot will be based upon either intelligent compaction or density tests and the two will not be mixed.

Dust/AC Ratio. A monetary deduction will be made using the pay adjustment table below for dust/AC ratios that deviate from the 0.6 to 1.2 range. If the tested mixture sublot is outside of this range, the Department will test the remaining sublots for dust/AC pay adjustment.

Table 5

Dust/AC Pay Adjustment Table 1/	
Range	Deduct / sublot
$0.6 \le X \le 1.2$	$0
$0.5 \le X < 0.6$ or $1.2 < X \le 1.4$	$1000
$0.4 \le X < 0.5$ or $1.4 < X \le 1.6$	$3000
$X < 0.4$ or $X > 1.6$	Shall be removed and replaced

1/ Does not apply to SMA.

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Illinois Department of Transportation

PFP Quality Level Analysis
Appendix E.1

Effective: December 12, 2003
Revised: June 28, 2017

This stand-alone document explains the statistical analysis and procedure used to determine the pay factor for a hot-mix asphalt (HMA) mixture on Pay for Performance (PFP) project. HMA materials specified to be sampled and tested for percent within limits payment adjustment (voids, VMA, and in-place density) and dust/AC adjustments will be evaluated for acceptance in accordance with this document.

Pay parameters evaluated using percent within (PWL) limits will be analyzed collectively and statistically by the Quality Level Analysis method using the procedures listed to determine the total estimated percent of the lot that is within specification limits. Quality Level Analysis is a statistical procedure for estimating the percent compliance to a specification and is affected by shifts in the arithmetic mean and the sample standard deviation. Two measures of quality are required to establish the contract unit price adjustment. The first measure is the Acceptable Quality Level (AQL) which is the PWL at which the lot will receive 100 percent pay. The second measure of quality is the Rejectable Quality Level (RQL) at which the Department has determined the material may not perform as desired and may be rejected.

The pay factor on full-depth projects shall be determined by weighting each mixture equally. Material placed at the same gyrations values but with and without polymer will be evaluated as two separate mixtures. For example: one surface mix and one binder mix will be weighted 50/50 regardless of tonnage. Additionally, one surface mix, one polymer binder mix and one non-polymer mix will be evaluated as three equally (1/3) weighted mixtures even if the polymer binder is the only difference between binder lifts.

Pay adjustments for Dust/AC ratio will be applied using the Dust/AC Pay Adjustment Table found in the Hot Mix Asphalt Pay for Performance Using Percent within Limits special provision.

QUALITY LEVEL ANALYSIS

Note: Table 1: Pay Attributes and Price Adjustment Factors contain the UL, LL, and pay factor "f" weights.

Items 1 through 8 of the following procedure will be repeated for each lot of the various pay factor parameters.

(1) Determine the arithmetic mean ($\bar{x}$) of the test results:

$$\bar{x} = \frac{\sum x}{n}$$

Where:

$\sum$ = summation of
x = individual test value
n = total number of test values

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PFP Quality Level Analysis
Appendix E.1
(continued)

Effective: December 12, 2003
Revised: June 28, 2017

(2) Calculate the sample standard deviation (s):

$$s = \sqrt{\frac{n \cdot \Sigma (x)^2 - (\Sigma x)^2}{n(n-1)}}$$

Where:

$\sum(x^2)$ = summation of the squares of individual test values

$(\sum x)^2$ = summation of the individual test values squared

(3) Calculate the upper quality index (Q_U):

$$Q_U = \frac{UL - \bar{x}}{s}$$

Where:

UL = upper specification limit (target value (*TV*) plus allowable deviation)

(4) Calculate the lower quality index (Q_L):

$$Q_L = \frac{\bar{x} - LL}{s}$$

Where:

LL = lower specification limit(target value (*TV*) minus allowable deviation)

(5) Determine P_U (percent within the upper specification limit which corresponds to a given Q_U) from Table 2. (Note: Round up to nearest Q_U in table 2.)

Note: If a *UL* is not specified, P_U will be 100.

(6) Determine P_L (percent within the lower specification limit which corresponds to a given Q_L) from Table 2. (Note: Round up to nearest Q_L in table 2.)

Note: If a *LL* is not specified, P_L will be 100.

(7) Determine the Quality Level or *PWL* (the total percent within specification limits).

$$PWL = (P_U + P_L) - 100$$

(8) To determine the pay factor for each individual parameter lot:

$$\text{Pay Factor (PF)} = 55 + 0.5\,(PWL)$$

Illinois Department of Transportation

PFP Quality Level Analysis
Appendix E.1
(continued)

Effective: December 12, 2003
Revised: June 28, 2017

(9) Once the project is complete determine the Total Pay Factor (*TPF*) for each parameter by using a weighted lot average by tons (mix) or distance (density) of all lots for a given parameter.

TPF = W1PFlot1 + W2PFlot(n+1) + etc.

Where:

W1,W2… = weighted percentage of material evaluated
PF = Pay factor for the various lots
TPF = Total pay factor for the given parameter

(10) Determine the Composite Pay Factor (*CPF*) for each mixture. The *CPF* shall be rounded to 3 decimal places.

$$CPF = \left| f_{VMA}\left(TPF_{VMA}\right) + f_{voids}\left(TPF_{voids}\right) + f_{density}\left(TPF_{density}\right)\right| / 100$$

Substituting from Table 1:

$$CPF = \left|0.3\left(TPF_{VMA}\right) + 0.3\left(TPF_{voids}\right) + 0.4\left(TPF_{density}\right)\right| / 100$$

Where:

f_{VMA}, f_{voids}, *and* $f_{density}$ = Price Adjustment Factor listed in Table 1

TPF_{VMA}, TPF_{voids}, *and* $TPF_{density}$ = *Total Pay Factor for the designated measured attribute from (9)*

(11) Determine the final pay for a given mixture.

*Final Pay = Mixture Unit Price * Quantity * CPF*

Illinois Department of Transportation

PFP Quality Level Analysis
Appendix E.1
(continued)

Effective: December 12, 2003
Revised: June 28, 2017

Table 1: Pay Attributes and Price Adjustment Factors			
Measured Attribute	Factor "*f*"	*UL*	*LL*
VMA	0.3	MDR/1 + 3.0	MDR/1 – 0.7
Plant Voids	0.3	Design Voids + 1.35	Design Voids – 1.35
In-Place Density	0.4	97.0/2	91.5/2
IL 9.5 FG Level Binder3/	0.4	97.0	90.5
IL 19.0	0.4	97.0	92.2
SMA	0.4	98.0	93.0

1. MDR = Minimum Design Requirement
2. Applies to all HMA mixes other than IL-4.75, IL-19.0, SMA and IL 9.5 FG Level Binder placed ≤ 1.25 in. (32 mm) thick
3. Placed at a thickness ≤ 1.25 in. (32 mm)

Illinois Department of Transportation

PFP Quality Level Analysis
Appendix E.1
(continued)

Effective: December 12, 2003
Revised: June 28, 2017

Example:

Determine the Pay factor for the given lot of a N90 HMA surface being placed at 1.5 inches thick as an overlay. The project consists of 10,000 tons over 17 miles.

Note that mix sample and density lots are independent of each other.

In this example the mix sample lot represents 10,000 tons while the density lot represents 6 miles (N=30). The project would have two additional density lots following the same calculations as the first lot. All three lots are combined as per item (9).

Mix sample: Each sublot represents 1000 tons

Lot #	Sublot #	Voids TV = 4.0	VMA Design Min = 14.5
1	1	4.2	14.4
	2	4.5	14.7
	3	3.3	13.9
	4	5.0	15.0
	5	5.4	15.2
	6	2.5	13.5
	7	3.8	14.2
	8	4.1	14.3
	9	4.3	14.4
	10	4.5	14.6
	Average:	4.16	14.42
	Standard Deviation:	0.825	0.498

Density: Each density test interval represents 0.2 mile thus N=30 in which 5 cores are taken per mile would represent 6 miles of paving.

Lot #	Density Test Interval	Density
1	1	91.5
	2	93.0
	3	92.9
	4	93.5
	5	93.0
	6	94.0
	7	92.8
	8	93.5
	9	91.0
	⋮	⋮
	30	92.7
	Average:	92.79
	Standard Deviation:	0.910

Determine the pay factor for each parameter.

Illinois Department of Transportation

PFP Quality Level Analysis
Appendix E.1
(continued)

Effective: December 12, 2003
Revised: June 28, 2017

Voids:

Lot: Average = 4.16
Standard Deviation = 0.825

$$Q_U = \frac{(4.0 + 1.35) - 4.16}{0.825} = 1.44$$

$$Q_L = \frac{4.16 - (4.0 - 1.35)}{0.825} = 1.83$$

N = 10 sublots (from table)

P_U = 94

P_L = 98

PWL = (94 + 98) - 100

PWL = 92

PF = 55 + 0.5 (92)

PF = 101.0

Determine the pay factor for Voids.

PF_{Voids} = 101.0

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(continued)

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VMA:

Lot : Average = 14.42
Standard Deviation = 0.498

$$Q_U = \frac{(14.5 + 3.0) - 14.42}{0.498} = 6.18$$

$$Q_L = \frac{14.42 - (14.5 - 0.7)}{0.498} = 1.24$$

N = 10 sublots (from table)

$P_U = 100$

$P_L = 90$

PWL = (100 + 90) - 100

PWL = 90

PF = 55 + 0.5 (90)

PF = 100.0

Determine the pay factor for VMA.

$PF_{VMA} = 100.0$

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PFP Quality Level Analysis
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(continued)

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Density:

Lot: Average = 92.79
Standard Deviation = 0.910

$$Q_U = \frac{97.0 - 92.79}{0.910} = 4.63$$

$$Q_L = \frac{92.79 - 91.5}{0.910} = 1.42$$

N = 30 Density measurements (from table)

P_U = 100

P_L = 93

PWL = (100 + 93) - 100

PWL = 93

PF = 55 + 0.5 (93)

PF = 100.5

Determine the pay factor for Density.

$PF_{Density}$ = 101.5

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Determine the total pay factors for each parameter. In this example 10,000 tons of mix represents the entire project so only one lot exists for VMA and voids. If more mix lots occurred on a project they would be combined just like density as shown.

Lot #	Mix Tons	Void PF	VMA PF	Density Distance	Density PF
1	10,000	101.0	100.0	31680 ft	101.5
2				31680 ft	101.4
3				24640 ft	97.3
TPF		**101.0**	**100.0**	88000 ft	**100.3**

$TPF_{Density} = W1PF_{lot1} + W2PF_{lot2} + W3PF_{lot3}$

$TPF_{Density} = (31680/88000)(101.5)+(31680/88000)(101.4)+(24640/88000)(97.3)$

$TPF_{Density} = 100.3$

Combine the three Total Pay Factors to determine the Composite Pay Factor for the mix.

$CPF = [0.3(101.0) + 0.3(100.0) + 0.4(100.3)] / 100$

$CPF = 1.004$

Determine the price paid for the given mixture.

Given that the mixture bid price per ton = $65.00 and 10,000 tons were placed.

Plan Unit Pay = $65.00/ton * 10,000 tons = $650,000

Adjusted Pay = $65.00/ ton * 10,000 tons * 1.004 = $652,600

Determine the difference between the adjusted pay and the plan unit pay.

Adjusted pay – Plan Unit Pay = $652,600 – $650,000 = $2,600

If the difference is a positive value this will be the incentive paid. If the difference is a negative value this will be the disincentive paid. In this case a $2,600 incentive would be paid as per policy memorandum 9-4.

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Full Depth Examples:

Given a full-depth project with two mixtures whose combined pay factors were determined to be 101.5% and 99.2%. The full-depth pay factor shall be calculated as follows:

101.5(1/2) + 99.2(1/2) = 100.4%

Determine the adjusted pay for the full-depth pay factor.

Given that the bid price per square yard = $25.00 and 1400 yd^2 were placed.

Plan Unit Pay = $25.00/ yd^2 * 1400 yd^2 = $35,000

Adjusted Pay = $25.00/ yd^2 * 1400 yd^2 * 1.004 = $35,140

Difference = $35,140 – $35,000 = $140 (Positive value = Incentive)

Given a full-depth project with three mixtures whose pay factors were determined to be 98.9%, 101.5% and 99.2%. The full depth pay factor shall be calculated as follows:

98.9(1/3) + 101.5(1/3) + 99.2(1/3) = 99.9%

Determine the adjusted pay for the full-depth pay factor.

Given that the bid price per square yard = $25.00 and 1400 yd^2 were placed.

Plan Unit Pay = $25.00/ yd^2 * 1400 yd^2 = $35,000

Adjusted Pay = $25.00/ yd^2 * 1400 yd^2 * 0.999 = $34,965

Difference = $34,965 – $35,000 = -$35 (Negative = Disincentive)

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TABLE 2: QUALITY LEVELS
QUALITY LEVEL ANALYSIS BY STANDARD DEVIATION METHOD

P_U OR P_L PERCENT WITHIN LIMITS FOR POSITIVE VALUES OF Q_U OR Q_L	UPPER QUALITY INDEX Q_U OR LOWER QUALITY INDEX Q_L														
	n=3	n=4	n=5	n=6	n=7	n=8	n=9	n=10 to n=11	n=12 to n=14	n=15 to n=18	n=19 to n=25	n=26 to n=37	n=38 to n=69	n=70 to n=200	n=201 to infinity
100	1.16	1.50	1.79	2.03	2.23	2.39	2.53	2.65	2.83	3.03	3.20	3.38	3.54	3.70	3.83
99		1.47	1.67	1.80	1.89	1.95	2.00	2.04	2.09	2.14	2.18	2.22	2.26	2.29	2.31
98	1.15	1.44	1.60	1.70	1.76	1.81	1.84	1.86	1.91	1.93	1.96	1.99	2.01	2.03	2.05
97		1.41	1.54	1.62	1.67	1.70	1.72	1.74	1.77	1.79	1.81	1.83	1.85	1.86	1.87
96	1.14	1.38	1.49	1.55	1.59	1.61	1.63	1.65	1.67	1.68	1.70	1.71	1.73	1.74	1.75
95		1.35	1.44	1.49	1.52	1.54	1.55	1.56	1.58	1.59	1.61	1.62	1.63	1.63	1.64
94	1.13	1.32	1.39	1.43	1.46	1.47	1.48	1.49	1.50	1.51	1.52	1.53	1.54	1.55	1.55
93		1.29	1.35	1.38	1.40	1.41	1.42	1.43	1.44	1.44	1.45	1.46	1.46	1.47	1.47
92	1.12	1.26	1.31	1.33	1.35	1.36	1.36	1.37	1.37	1.38	1.39	1.39	1.40	1.40	1.40
91	1.11	1.23	1.27	1.29	1.30	1.30	1.31	1.31	1.32	1.32	1.33	1.33	1.33	1.34	1.34
90	1.10	1.20	1.23	1.24	1.25	1.25	1.26	1.26	1.26	1.27	1.27	1.27	1.28	1.28	1.28
89	1.09	1.17	1.19	1.20	1.20	1.21	1.21	1.21	1.21	1.22	1.22	1.22	1.22	1.22	1.23
88	1.07	1.14	1.15	1.16	1.16	1.16	1.16	1.17	1.17	1.17	1.17	1.17	1.17	1.17	1.17
87	1.06	1.11	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.13	1.13
86	1.04	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08
85	1.03	1.05	1.05	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04
84	1.01	1.02	1.01	1.01	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.99	0.99	0.99
83	1.00	0.99	0.98	0.97	0.97	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.95	0.95	0.95
82	0.97	0.96	0.95	0.94	0.93	0.93	0.93	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
81	0.96	0.93	0.91	0.90	0.90	0.89	0.89	0.89	0.89	0.88	0.88	0.88	0.88	0.88	0.88
80	0.93	0.90	0.88	0.87	0.86	0.86	0.86	0.85	0.85	0.85	0.85	0.84	0.84	0.84	0.84
79	0.91	0.87	0.85	0.84	0.83	0.82	0.82	0.82	0.82	0.81	0.81	0.81	0.81	0.81	0.81
78	0.89	0.84	0.82	0.80	0.80	0.79	0.79	0.79	0.78	0.78	0.78	0.78	0.77	0.77	0.77
77	0.87	0.81	0.78	0.77	0.76	0.76	0.76	0.75	0.75	0.75	0.75	0.74	0.74	0.74	0.74
76	0.84	0.78	0.75	0.74	0.73	0.73	0.72	0.72	0.72	0.71	0.71	0.71	0.71	0.71	0.71
75	0.82	0.75	0.72	0.71	0.70	0.70	0.69	0.69	0.69	0.68	0.68	0.68	0.68	0.68	0.67
74	0.79	0.72	0.69	0.68	0.67	0.66	0.66	0.66	0.66	0.65	0.65	0.65	0.65	0.64	0.64
73	0.76	0.69	0.66	0.65	0.64	0.63	0.63	0.63	0.62	0.62	0.62	0.62	0.62	0.61	0.61
72	0.74	0.66	0.63	0.62	0.61	0.60	0.60	0.60	0.59	0.59	0.59	0.59	0.59	0.58	0.58

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TABLE 2: QUALITY LEVELS
QUALITY LEVEL ANALYSIS BY STANDARD DEVIATION METHOD

P_U OR P_L PERCENT	UPPER QUALITY INDEX Q_U OR LOWER QUALITY INDEX Q_L														
WITHIN LIMITS FOR POSITIVE VALUES OF Q_U OR Q_L	n=3	n=4	n=5	n=6	n=7	n=8	n=9	n=10 to n=11	n=12 to n=14	n=15 to n=18	n=19 to n=25	n=26 to n=37	n=38 to n=69	n=70 to n=200	n=201 to infinity
71	0.71	0.63	0.60	0.59	0.58	0.57	0.57	0.57	0.57	0.56	0.56	0.56	0.56	0.55	0.55
70	0.68	0.60	0.57	0.56	0.55	0.55	0.54	0.54	0.54	0.53	0.53	0.53	0.53	0.53	0.53
69	0.65	0.57	0.54	0.53	0.52	0.52	0.51	0.51	0.51	0.50	0.50	0.50	0.50	0.50	0.50
68	0.62	0.54	0.51	0.50	0.49	0.49	0.48	0.48	0.48	0.48	0.47	0.47	0.47	0.47	0.47
67	0.59	0.51	0.47	0.47	0.46	0.46	0.46	0.45	0.45	0.45	0.45	0.44	0.44	0.44	0.44
66	0.56	0.48	0.45	0.44	0.44	0.43	0.43	0.43	0.42	0.42	0.42	0.42	0.41	0.41	0.41
65	0.52	0.45	0.43	0.41	0.41	0.40	0.40	0.40	0.40	0.39	0.39	0.39	0.39	0.39	0.39
64	0.49	0.42	0.40	0.39	0.38	0.38	0.37	0.37	0.37	0.37	0.36	0.36	0.36	0.36	0.36
63	0.46	0.39	0.37	0.36	0.35	0.35	0.35	0.34	0.34	0.34	0.34	0.34	0.33	0.33	0.33
62	0.43	0.36	0.34	0.33	0.32	0.32	0.32	0.32	0.31	0.31	0.31	0.31	0.31	0.31	0.31
61	0.39	0.33	0.31	0.30	0.30	0.29	0.29	0.29	0.29	0.29	0.28	0.28	0.28	0.28	0.28
60	0.36	0.30	0.28	0.27	0.27	0.27	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.25	0.25
59	0.32	0.27	0.25	0.25	0.24	0.24	0.24	0.24	0.23	0.23	0.23	0.23	0.23	0.23	0.23
58	0.29	0.24	0.23	0.22	0.21	0.21	0.21	0.21	0.21	0.21	0.20	0.20	0.20	0.20	0.20
57	0.25	0.21	0.20	0.19	0.19	0.19	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
56	0.22	0.18	0.17	0.16	0.16	0.16	0.16	0.16	0.16	0.15	0.15	0.15	0.15	0.15	0.15
55	0.18	0.15	0.14	0.14	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
54	0.14	0.12	0.11	0.11	0.11	0.11	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
53	0.11	0.09	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
52	0.07	0.06	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
51	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Note: For negative values of Q_U or Q_L, P_U or P_L is equal to 100 minus the table P_U or P_L. If the value of Q_U or Q_L does not correspond exactly to a figure in the table, use the next higher value.

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PFP Hot-Mix Asphalt Random Plant Samples
Appendix E2

Effective Date: May 1, 2008

Samples shall be obtained at the frequency specified in the Hot Mix Asphalt Pay for Performance Using Percent within Limits special provision.

A. The random plant samples shall be taken at the randomly selected tonnage within a sublot. The random tonnage will be determined by the Engineer using the "Random Numbers" table as specified herein or an approved software program. The tonnage shall be calculated according to the following:

1. Unless otherwise known, determine the random locations for a tonnage in excess of five percent over plan quantity by multiplying the plan quantity tonnage by 1.05 to determine an over-projected final quantity. If the over-projected final quantity is not achieved, disregard the additional random values.

2. Determine the maximum number of sublots needed for the given mixture by dividing the over-projected tonnage calculated above by the sublot size in tons (metric tons). This will determine the maximum number of sublots for the given mixture.

3. Multiply the sublot tonnage by a three-digit random number, expressed as a decimal. The number obtained (rounded to a whole number) shall be the random sampling tonnage within the given sublot.

4. The individual sublot random tonnages shall then be converted to the cumulative random tonnages. This is accomplished by using the following equation for each sublot.

$$CT_n = [(ST) * (n - 1)] + RT_n$$

Where: n = the sublot number
CT = Cumulative tonnage
RT = Random tonnage as determined in #3 above
ST = Sublot tonnage (typically 1000 tons)

B. If the paving is completed for a particular mixture before the specified sampling tonnage for the last sublot is achieved, the partial sublot shall be omitted.

C. Plant truck samples shall be taken of the mixture for testing. Two sampling platforms (one on each side of the truck) shall be provided for sampling of the mix. In order to obtain a representative sample of the entire truck, an equal amount of material shall be taken from each quarter point around the circumference of each pile in the truck to obtain a composite sample weighing approximately 200lbs. (95 kg). All truck samples shall be obtained by using a "D"-handled, square-ended shovel with built-up sides and back (1 to 1-1/2 in. [25 to 38 mm]). The sample shall be taken out of the truck containing the random tonnage as determined by the Engineer following the procedure described herein. The sample

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PFP Hot-Mix Asphalt Random Plant Samples
Appendix E2
(continued)
Effective Date: May 1, 2008

tonnage will be disclosed no more than 30 minutes prior to sampling. Sampling shall be performed by the Contractor under the supervision of the Engineer.

D. The truck sample shall be divided into three approximately equal size (split) samples by the use of an approved mechanical sample splitter. The Engineer will witness all splitting. Two split samples for Department testing shall be placed in Department-approved sample containers provided by the Contractor and identified as per the Engineer's direction. The Engineer will gain immediate possession of both Department split samples. The Contractor may store, discard, or test the remaining split as described in Section 1030 of the Standard Specifications. However, the Contractor must test and provide the sample results in order to initiate the dispute resolution process as described in the Hot Mix Asphalt Pay for Performance Special Provision.

<u>Example:</u>

Given: - Plan quantity = 10,000 tons for a given mixture. - Sublot = 1000 tons (725 metric tons).

1. Determine the over-projected final tonnage.

   10,000 tons * 1.05 = 10,500 tons (Note: Always round up)

2. Determine the maximum number of sublots needed for the project based on the over-projected tonnage.

   10,500 tons/1000 tons = 10.5 (Note: Always round up)
   Therefore, 11 maximum sublots

3. Obtain random numbers from the table and apply a different random number to each sublot.

   1000 * 0.546 = 546
   1000 * 0.123 = 123

   Repeat for **each** sublot.

4. Convert **individual** tonnage to cumulative job tonnage.

   [1000*(1-1)] + 546 = 546
   [1000*(2-1)] + 123 = 1123

   Repeat for each sublot.

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PFP Hot-Mix Asphalt Random Plant Samples
Appendix E2
(continued)
Effective Date: May 1, 2008

The following contains a completed table for the eleven plant random samples:

Lot Number	Sublot Number	Random Number	Tonnage within Sublot		Cumulative Job Tonnage	
1	1	0.546	1000 * 0.546 =	546	[1000 * (1-1)] + 546 =	546
	2	0.123	1000 * 0.123 =	123	[1000 * (2-1)] + 123 =	1123
	3	0.789	1000 * 0.789 =	789	[1000 * (3-1)] + 789 =	2789
	4	0.372	1000 * 0.372 =	372	[1000 * (4-1)] + 372 =	3372
	5	0.865	1000 * 0.865 =	865	[1000 * (5-1)] + 865 =	4865
	6	0.921	1000 * 0.921 =	921	[1000 * (6-1)] + 921 =	5921
	7	0.037	1000 * 0.037 =	37	[1000 * (7-1)] + 37 =	6037
	8	0.405	1000 * 0.405 =	405	[1000 * (8-1)] + 405 =	7405
	9	0.214	1000 * 0.214 =	214	[1000 * (9-1)] + 214 =	8214
	10	0.698	1000 * 0.698 =	698	[1000 * (10-1)] + 698 =	9698
	11	0.711	1000 * 0.711 =	711	[1000 * (11-1)] + 711 =	10711

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PFP Hot-Mix Asphalt Random Plant Samples
Appendix E2
(continued)
Effective Date: May 1, 2008

PFP Hot-Mix Asphalt Random Plant Samples (continued)

RANDOM NUMBERS

0.576	0.730	0.430	0.754	0.271	0.870	0.732	0.721	0.998	0.239
0.892	0.948	0.858	0.025	0.935	0.114	0.153	0.508	0.749	0.291
0.669	0.726	0.501	0.402	0.231	0.505	0.009	0.420	0.517	0.858
0.609	0.482	0.809	0.140	0.396	0.025	0.937	0.301	0.253	0.761
0.971	0.824	0.902	0.470	0.997	0.392	0.892	0.957	0.040	0.463
0.053	0.899	0.554	0.627	0.427	0.760	0.470	0.040	0.904	0.993
0.810	0.159	0.225	0.163	0.549	0.405	0.285	0.542	0.231	0.919
0.081	0.277	0.035	0.039	0.860	0.507	0.081	0.538	0.986	0.501
0.982	0.468	0.334	0.921	0.690	0.806	0.879	0.414	0.106	0.031
0.095	0.801	0.576	0.417	0.251	0.884	0.522	0.235	0.389	0.222
0.509	0.025	0.794	0.850	0.917	0.887	0.751	0.608	0.698	0.683
0.371	0.059	0.164	0.838	0.289	0.169	0.569	0.977	0.796	0.996
0.165	0.996	0.356	0.375	0.654	0.979	0.815	0.592	0.348	0.743
0.477	0.535	0.137	0.155	0.767	0.187	0.579	0.787	0.358	0.595
0.788	0.101	0.434	0.638	0.021	0.894	0.324	0.871	0.698	0.539
0.566	0.815	0.622	0.548	0.947	0.169	0.817	0.472	0.864	0.466
0.901	0.342	0.873	0.964	0.942	0.985	0.123	0.086	0.335	0.212
0.470	0.682	0.412	0.064	0.150	0.962	0.925	0.355	0.909	0.019
0.068	0.242	0.777	0.356	0.195	0.313	0.396	0.460	0.740	0.247
0.874	0.420	0.127	0.284	0.448	0.215	0.833	0.652	0.701	0.326
0.897	0.877	0.209	0.862	0.428	0.117	0.100	0.259	0.425	0.284
0.876	0.969	0.109	0.843	0.759	0.239	0.890	0.317	0.428	0.802
0.190	0.696	0.757	0.283	0.777	0.491	0.523	0.665	0.919	0.146
0.341	0.688	0.587	0.908	0.865	0.333	0.928	0.404	0.892	0.696
0.846	0.355	0.831	0.281	0.945	0.364	0.673	0.305	0.195	0.887
0.882	0.227	0.552	0.077	0.454	0.731	0.716	0.265	0.058	0.075
0.464	0.658	0.629	0.269	0.069	0.998	0.917	0.217	0.220	0.659
0.123	0.791	0.503	0.447	0.659	0.463	0.994	0.307	0.631	0.422
0.116	0.120	0.721	0.137	0.263	0.176	0.798	0.879	0.432	0.391
0.836	0.206	0.914	0.574	0.870	0.390	0.104	0.755	0.082	0.939
0.636	0.195	0.614	0.486	0.629	0.663	0.619	0.007	0.296	0.456
0.630	0.673	0.665	0.666	0.399	0.592	0.441	0.649	0.270	0.612
0.804	0.112	0.331	0.606	0.551	0.928	0.830	0.841	0.702	0.183
0.360	0.193	0.181	0.399	0.564	0.772	0.890	0.062	0.919	0.875
0.183	0.651	0.157	0.150	0.800	0.875	0.205	0.446	0.648	0.685

Note: Always select a new set of numbers in a systematic manner, either horizontally or vertically. Once used, the set should be crossed out.

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PFP and QCP Random Density Procedure
Appendix E.3

Effective: April 1, 2009
Revised: October 1, 2017

Density tests using cores shall be obtained at the frequency specified in the Hot Mix Asphalt Quality Control for Performance (QCP) and Pay for Performance (PFP) Using Percent within Limits special provisions. The random test locations shall be determined as follows:

A) The random core locations shall be taken at the randomly selected test location within each density testing interval. Prior to paving, the random test locations will be determined by the Engineer using the "Random Numbers" table as specified herein or the Department's approved software program. The values are to be considered confidential and are not to be disclosed to anyone outside of the Department until finish rolling is complete. Disclosing the information prior to finish rolling would be in direct violation of federal regulations. Once random test locations are determined by the Engineer, it may be necessary to alter the random test locations due to quantity adjustments, sequencing changes, or other alterations made by the Department or Contractor. The Engineer will document any changes to the random test locations and provide documentation to the Contractor upon completion of the project.

Each core location shall be randomly located both longitudinally and transversely within each density testing interval. Each core location within the density testing interval shall be determined with two random numbers. The first random number is used to determine the longitudinal distance to the nearest 1 ft into the density testing interval. The second random number is used to determine the transverse offset to the nearest 0.1 ft from the left edge of the **paving lane**. In cases where paving is completed over multiple lanes in a single pass of one or more pavers to eliminate unconfined edges between lanes, the **paving lane** is defined as the total combined width of the lanes paved in that single pass. The density intervals shall be every 0.1 mi. (160 m) for lift thicknesses of 3 in. (75 mm) or less and 0.05 mi. (80 m) for lift thicknesses greater than 3 in (75 mm) if the **paving lane** width is greater than 20 ft.

To determine the longitudinal location of a core, multiply the length of the prescribed density interval by the random number selected from the Random Number table. Determine the random transverse offset as follows:

1. PFP. The effective lane width of the pavement shall be used in calculating the transverse offset. The effective lane width is determined by subtracting 1.0 ft for each unconfined edge from the entire paved lane width (i.e. If a 12.0 ft wide paved lane has two unconfined edges, the effective lane width would be 10.0 ft.) Determine the transverse offset by multiplying the effective width by the random number selected from the Random Number table.

   The transverse offset is measured from the left physical edge of the paved lane to locate the core on the pavement. If the left edge was unconfined, it will be omitted by adding 1.0 ft to the calculated transverse offset measurement.

   Random locations that fall within 4.0 inches of a confined edge shall be moved to 4.0 inches off the edge. Areas outside the mainline pavement that are paved concurrently with the mainline pavement (i.e. three-ft wide left shoulders, driveways, etc.) are not considered part of the paved mainline mat. See PFP example calculation herein.

The core density location for the outer 1.0 ft of an unconfined edge will be randomly selected within each 0.5 mile section for each unconfined edge. Longitudinal joint testing shall be located at a distance equal to the lift thickness or a minimum of 4.0 in. (100 mm), from each pavement edge. (i.e. for a 5 in. (125 mm) lift the near edge of the core barrel shall be within 5.0 in. (125 mm) from the edge of pavement.)

2. QCP. The entire width of the pavement shall be used in calculating the transverse offset. No offset movement is to be used for random locations that lie within 1.0 ft from an unconfined edge. Cores taken within 1.0 ft from an unconfined edge will have 2.0% density added for pay adjustment calculation purposes. Random locations that fall within 4.0 in. of an edge shall be moved to 4.0 in. off the edge. See QCP example calculation herein.

B) This process shall be repeated for all density intervals on a given project.

C) Moving Core Locations.

There are two scenarios in which random core locations may be moved longitudinally using the same random transverse offset. The first scenario is to avoid only the obstacles listed under Case 1 below. The second scenario is to avoid pavement defects in the surface being overlaid as described in Case 2 below.

1) Case 1. In the event the random core location will not allow the necessary compactive effort to be applied, the Engineer will adjust the longitudinal location of the core in order to avoid the obstacle. Using the same random transverse offset, the core location will be moved longitudinally, ± 15 feet to avoid the following obstacles only:

   a) Structures or Bridge Decks
   b) Detection loop or other pavement sensors
   c) Manholes or other utility appurtenances

2) Case 2. In the event there are pavement defects in the surface being overlaid, the Contractor may place temporary markings on the shoulder to represent longitudinal locations where a defect is present. These pavement defect locations will be approved by the Engineer. If a random core location lands at the same longitudinal location as the temporary mark, the core will be moved 5 feet in the direction toward the paver at the same transverse offset. In the case of an asphalt scab (i.e. thin layer of less than 0.5 inches of asphalt pavement remaining after milling) the temporary markings shall show the extent or length of the defect. The core location will then be moved to a longitudinal distance 5 feet past the end of the defect toward the paver.

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Effective: April 1, 2009
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D) Example Calculations.

PFP Example.

This **PFP** example illustrates the determination of the core locations within the first mile of a lot.

Given 1.5 in. thickness would require a density testing interval of 0.2 miles. The pavement consists of a 13.0 ft-wide mat with the left edge confined and the right edge unconfined. The random numbers for the longitudinal direction are 0.917, 0.289, 0.654, 0.347, and 0.777. The random numbers for the transverse direction are 0.890, 0.317, 0.428, 0.998, and 0.003.

The individual density test interval distances can be converted to the cumulative random distance using the following equation:

$$CD_n = [D \times (n - 1)] + R_n$$

Where:

n = the density interval number
CD = cumulative distance
D = density testing interval length (typically 1056 ft (0.2 mile))
R = Random distance within the given density testing interval

The longitudinal core locations are determined by multiplying the longitudinal random numbers by 1056 ft (0.2 mile). The transverse core locations are determined by multiplying the transverse random number by the effective width of the paved mat.

Determine the effective lane width by subtracting 1.0 ft, for each unconfined edge, from the entire paved lane width. In this case only the right edge is unconfined, so subtract 1.0 ft from the entire paved lane width of 13.0 ft.

Effective Width = 13.0 ft minus 1.0 ft = 12.0 ft

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The random location for the first mile measured from the beginning of the lot and the left (confined) edge of the paved mat are as follows:

Core #	Longitudinal Location	Cumulative Distance	Transverse Location
1	1056 x 0.917 = 968 ft	1056 x (1-1) + 968 = 968 ft	12.0 x 0.890 = 10.7 ft
2	1056 x 0.289 = 305 ft	1056 x (2-1) + 305 = 1361 ft	12.0 x 0.317 = 3.8 ft
3	1056 x 0.654 = 691 ft	1056 x (3-1) + 691 = 2803 ft	12.0 x 0.428 = 5.1 ft
4	1056 x 0.347 = 366 ft	1056 x (4-1) + 366 = 3534 ft	12.0 x 0.998 = 11.7 ft
5	1056 x 0.777 = 821 ft	1056 x (5-1) + 821 = 5045 ft	12.0 x 0.003 = 0.0 ft = **0.3 ft**[1/]

1/ The 0.0 ft for Core #5 was moved in to 0.3 ft due to the 4 in. minimum from the edge requirement.

QCP Example.

This **QCP** example illustrates the determination of the core locations within the first mile of a project.

Given 1.5" thickness would require a density testing interval of 0.2 miles. The pavement consists of a 13.0 ft-wide mat with the left edge confined and the right edge unconfined. The random numbers for the longitudinal direction are 0.904, 0.231, 0.517, 0.253, and 0.040. The random numbers for the transverse direction are 0.007, 0.059, 0.996, 0.515, and 0.101.

The individual density test interval distances can be converted to the cumulative random distance using the following equation:

$$CD_n = [D \times (n-1)] + R_n$$

Where:

n = the density interval number
CD = cumulative distance
D = density testing interval length (typically 1056 ft (0.2 mile))
R = Random distance within the given density testing interval

The longitudinal core locations are determined by multiplying the longitudinal random numbers by 1056 ft (0.2 mile). The transverse core locations are determined by multiplying the transverse random number by the width of the paved lane (13.0 ft).

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The random location for the first mile measured from the beginning of the lot and the left (confined) edge of the paved mat are as follows:

Core #	Longitudinal Location	Cumulative Distance	Transverse Location
1	1056 x 0.904 = 955 ft	1056 x (1-1) + 955 = 955 ft	13.0 x 0.007 = 0.1 ft = **0.3 ft**[1/]
2	1056 x 0.231 = 244 ft	1056 x (2-1) + 244 = 1300 ft	13.0 x 0.059 = 0.8 ft
3	1056 x 0.517 = 546 ft	1056 x (3-1) + 546 = 2658 ft	13.0 x 0.996 = 13.0 ft = **12.7 ft**[2/]
4	1056 x 0.253 = 267 ft	1056 x (4-1) + 267 = 3435 ft	13.0 x 0.515 = 6.7 ft
5	1056 x 0.040 = 42 ft	1056 x (5-1) + 42 = 4266 ft	13.0 x 0.101 = 1.3 ft

1/ The 0.1 ft offset for Core #1 was moved in to 0.3 ft due to the 4 in. minimum from the edge requirement.
2/ The 13.0 ft offset for Core #3 was move in to 12.7 ft due the 4 in. minimum from the edge requirement. Since this core is within 1 ft from an unconfined edge 2% will be added to the measured core density.

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RANDOM NUMBERS

0.576	0.730	0.430	0.754	0.271	0.870	0.732	0.721	0.998	0.239
0.892	0.948	0.858	0.025	0.935	0.114	0.153	0.508	0.749	0.291
0.669	0.726	0.501	0.402	0.231	0.505	0.009	0.420	0.517	0.858
0.609	0.482	0.809	0.140	0.396	0.025	0.937	0.301	0.253	0.761
0.971	0.824	0.902	0.470	0.997	0.392	0.892	0.957	0.040	0.463
0.053	0.899	0.554	0.627	0.427	0.760	0.470	0.040	0.904	0.993
0.810	0.159	0.225	0.163	0.549	0.405	0.285	0.542	0.231	0.919
0.081	0.277	0.035	0.039	0.860	0.507	0.081	0.538	0.986	0.501
0.982	0.468	0.334	0.921	0.690	0.806	0.879	0.414	0.106	0.031
0.095	0.801	0.576	0.417	0.251	0.884	0.522	0.235	0.389	0.222
0.509	0.025	0.794	0.850	0.917	0.887	0.751	0.608	0.698	0.683
0.371	0.059	0.164	0.838	0.289	0.169	0.569	0.977	0.796	0.996
0.165	0.996	0.356	0.375	0.654	0.979	0.815	0.592	0.348	0.743
0.477	0.535	0.137	0.155	0.767	0.187	0.579	0.787	0.358	0.595
0.788	0.101	0.434	0.638	0.021	0.894	0.324	0.871	0.698	0.539
0.566	0.815	0.622	0.548	0.947	0.169	0.817	0.472	0.864	0.466
0.901	0.342	0.873	0.964	0.942	0.985	0.123	0.086	0.335	0.212
0.470	0.682	0.412	0.064	0.150	0.962	0.925	0.355	0.909	0.019
0.068	0.242	0.777	0.356	0.195	0.313	0.396	0.460	0.740	0.247
0.874	0.420	0.127	0.284	0.448	0.215	0.833	0.652	0.701	0.326
0.897	0.877	0.209	0.862	0.428	0.117	0.100	0.259	0.425	0.284
0.876	0.969	0.109	0.843	0.759	0.239	0.890	0.317	0.428	0.802
0.190	0.696	0.757	0.283	0.777	0.491	0.523	0.665	0.919	0.146
0.341	0.688	0.587	0.908	0.865	0.333	0.928	0.404	0.892	0.696
0.846	0.355	0.831	0.281	0.945	0.364	0.673	0.305	0.195	0.887
0.882	0.227	0.552	0.077	0.454	0.731	0.716	0.265	0.058	0.075
0.464	0.658	0.629	0.269	0.069	0.998	0.917	0.217	0.220	0.659
0.123	0.791	0.503	0.447	0.659	0.463	0.994	0.307	0.631	0.422
0.116	0.120	0.721	0.137	0.263	0.176	0.798	0.879	0.432	0.391
0.836	0.206	0.914	0.574	0.870	0.390	0.104	0.755	0.082	0.939
0.636	0.195	0.614	0.486	0.629	0.663	0.619	0.007	0.296	0.456
0.630	0.673	0.665	0.666	0.399	0.592	0.441	0.649	0.270	0.612
0.804	0.112	0.331	0.606	0.551	0.928	0.830	0.841	0.702	0.183
0.360	0.193	0.181	0.399	0.564	0.772	0.890	0.062	0.919	0.875
0.183	0.651	0.157	0.150	0.800	0.875	0.205	0.446	0.648	0.685

Note: Always select a new set of numbers in a systematic manner, either horizontally or vertically. Once used, the set should be crossed out.

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PFP and QCP Hot Mix Asphalt Random Jobsite Sampling
Appendix E4

Effective: April 1, 2008
Revised: October 1, 2017

Hot-mix asphalt (HMA) samples shall be obtained at the frequency specified in the Hot Mix Asphalt Quality Control for Performance (QCP) and Pay for Performance (PFP) Using Percent within Limits special provisions.

The random jobsite mixture samples shall be taken at the randomly selected test location within a sublot. Prior to paving the random test locations will be determined by the Engineer using the "Random Numbers" table as specified herein or the Department's approved software program. The values are to be considered confidential and are not to be disclosed to anyone outside of the Department prior to the truck containing the random tonnage arriving at the jobsite. Disclosing the information would violate the intent of this procedure and federal regulations.

The sample location shall be determined by calculating the longitudinal distance the truck would travel to produce the random sample tonnage. The starting station for the longitudinal distance measurement is the location of the paver where the truck begins to unload the mixture into the paver or Material Transfer Device (MTD). Computations are made to the nearest foot (see examples in appendix herein). In the event the job site conditions pose a safety risk, the Engineer will adjust the random test location to the nearest safe location. Unsafe conditions include: intersections, narrow or restricted areas such as underpasses, on interchange ramps within 100 feet of an access controlled highway, or any other situation deemed unsafe.

If the paving is completed for a mixture before the specified sampling test location for the last mixture sublot is completed, a test will not be taken and the tonnage will be added to the current lot.

The Contractor may select either sampling behind the paver or sampling from the MTD discharge chute. The Contractor shall provide the necessary equipment and HMA Level I personnel to obtain the required samples, for whatever method is chosen, as specified herein.

A. Behind Paver Sampling.

This method covers the procedures for sampling HMA paving mixtures at the point of delivery immediately behind the paver and before initial compaction. This method is intended to provide a single composite sample that is representative of the mixture as produced (i.e. excludes paver effects).

1. Equipment

   a) IDOT Approved Sampling Shovel (Fig. 1).

   b) Sample Containers (4 each). Metal sample buckets with a minimum capacity of 3.5 gallons (13 liters).

   c) IDOT Approved HMA Sample Splitter.

   d) Plate/Shovel Sampling. The following additional equipment is needed when sampling HMA placed directly over a milled surface, rubblized concrete or an aggregate base.

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Effective: April 1, 2008
Revised: October 1, 2017

1) Sampling Plates (4 each). The sampling plates shall be rectangular and have a minimum size of 14 x 28 inches (360 x 720 mm). Plates shall have a hole approximately 0.25 inches (6 mm) in diameter drilled through each of the four corners.

2) Lifting Handles and Wire Lead. A 24 inch (600 mm) length of wire shall be attached to the two holes on one side of the plate to serve as lifting handle. An additional wire lead shall be attached to one of the lifting handles for locating the buried plate in the pavement. This wire shall extend to the edge of the pavement.

3) Hammer and masonry nails for securing plates and wire lead.

Overall Length = 5 feet
Shovel Width = 10 inches
Shovel Length = 12 inches
Shovel Sides = 4 inches

Figure 1. Aluminum Sampling Shovel & Dimensions

2. Shovel Sample Sampling Procedure (Without Plates). This method shall be used when sampling over smooth HMA and concrete surfaces.

   a) The sampling shovel shall be used at each of the four offsets illustrated in Figure 2. to dig directly downward into pavement until it comes into contact with the previous pavement surface. When in contact, the shovel shall be pushed forward until it is

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full. The shovel shall be lifted up slowly and carefully place the mix into the sample container in order to prevent any loss of HMA.

3. Shovel/Plate Sampling Procedure (With Plates). This method shall be used when sampling HMA directly over aggregate base, stabilized subbase, rubblized concrete, or a milled surface. This method may not be appropriate for 3/4 in. level binder over a milled surface. In the case of IL-4.75 mm or IL-9.5 FG mixtures, if approved by the Engineer, these mixtures may be shovel sampled from the auger area at the designated random location. Intentions of sampling IL-4.75 mm or IL-9.5 FG mixtures in this manner shall be listed in the approved QC Plan.

   a) Each plate with the wire lead attached to handle shall be placed at four locations according for Figure 2. at the designated location ahead of the paver. If conditions on the project require restricting movement of the plate, a nail shall be driven through one of the holes in the plate and into the pavement.

   b) The wire lead shall be extended beyond the edge of the pavement. Trucks, pavers, and/or materials transfer devices will be allowed to cross over the pate and/or wire lead.

   c) After the HMA is placed, the wire lead shall be used to locate the plate. Once located, the wire handles shall be lifted out of the pavement. This will locate the four corners of the plate.

   d) Once the plate edges are defined, the shovel shall be used to dig downward through the thickness of the pavement until it is in contact with the plate. The shovel shall be pushed forward until it is full. The shovel shall be lifted up slowly and carefully place the mix into the sample container in order to prevent any loss of HMA.

   e) Remove sampling plates from pavement.

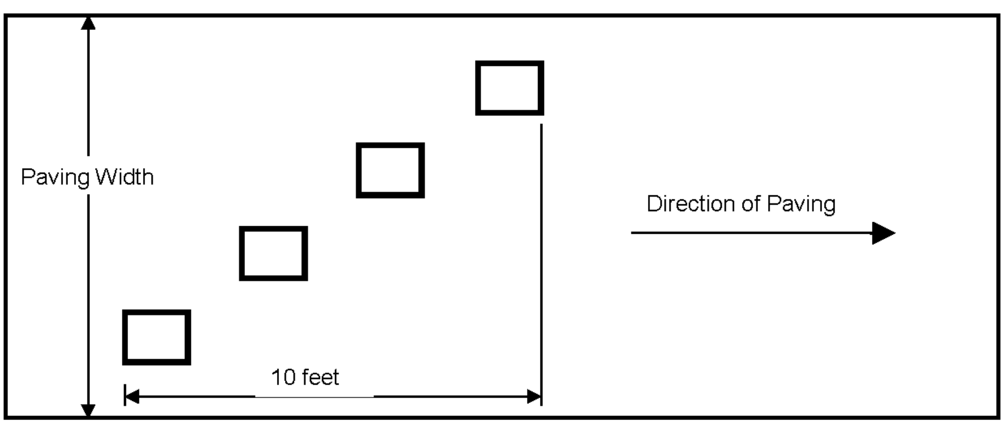

Figure 2. Behind Paver Sampling Layout

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4. Composite/Lab Sample.

   a) HMA samples shall be taken, blended and split, using an IDOT approved HMA splitter, onsite by the Contractor and witnessed by the Engineer. The sample shall be taken immediately behind the paver and before initial roller compaction. One composite sample consists of four increments collected within 10 feet longitudinally and diagonally across the width of the paving operation (Fig. 2). The four increments shall be blended according to HMA Level I procedures to provide a single composite sample.

   b) Composite Sample.

      1) PFP. If the contractor elects to have the option to dispute test results by the Engineer, a composite sample size shall be a minimum of 200 lbs. (90 kg), allowing 50 lbs (23 kg) for District testing, 50 lbs. (23 kg) for Contractor testing, 50 lbs (23 kg) for dispute resolution testing, and 50 lbs. (23 kg backup for Department testing).

      2) QCP. A composite sample size shall be a minimum of 100 lbs. (45 kg), allowing 50 lbs. (23 kg) for District testing, and 50 lbs. (23 kg) for Contractor testing.

   c) Lab Sample.

      1) PFP. The minimum lab sample size of 50 lbs. (23 kg) shall be obtained by splitting the composite samples into four equal lab samples using an IDOT approved HMA splitter. The Engineer will secure three Department lab samples for the Contractor to transport to the District Materials Laboratory.

      2) QCP. The minimum lab sample size of 50 lbs. (23 kg) shall be obtained by splitting the composite samples into two equal lab samples using an IDOT approved HMA splitter. The Engineer will secure the Department lab sample for the Contractor to transport to the District Materials Laboratory.

5. Sample Site Repair

   a) HMA from the paver auger system shall be used to fill the voids left in the pavement from sampling. To reduce segregation and low density in the finished mat, buckets shall be used to fill the voids left by the samples.

      1) HMA from the augers system shall be placed in clean metal buckets just prior to sampling the pavement.

      2) The metal buckets shall be filled with approximately 25% more HMA than will be removed from the void.

   b) The bucket shall be dumped directly over the void.

c) The HMA shall be slightly leveled to provide a gradual hump over the filled void to allow compression of the mix by the roller.

d) Unacceptable site repair shall be removed and replaced at the Contractors expense.

B. MTD Sampling.

This method covers the procedures for sampling HMA paving mixtures at the point of delivery from a material transfer device (MTD).

1. Equipment.

a) MTD Sampling Device. A portable device mounted either in the bed of a pickup truck or on a trailer. The device shall be equipped with a funnel large enough to capture the full stream of HMA from the MTD discharge chute without spillage and shall be capable of capturing a minimum composite HMA sample of 200 lbs (90 kg). See appendix for illustrations of various MTD sampling device configurations.

b) Sample Containers – Metal containers each capable of holding a minimum of 50 lbs. of HMA.

2. MTD Sampling Procedure.

The Engineer will identify the truck containing the sample tonnage immediately prior to sampling. Immediately after the truck containing the random HMA tonnage has finished unloading, the MTD shall pull forward away from the paver far enough to allow the sampling device to be positioned under the MTD discharge chute. The sampling device shall be positioned as level as possible in a safe location readily accessible by the MTD. The MTD shall discharge without spillage a minimum of 200 lbs. (90 kg) of HMA for PFP or 100 lbs. (45 kg) for QCP into the funnel of the sampling device.

3. Composite/Lab Sample.

a) Composite Sample. HMA from all four sample containers of the sampling device shall be blended into one composite sample and split to lab sample size by the Contractor onsite using an IDOT approved HMA splitter. The blending and splitting shall be according to HMA Level I procedures and will be witnessed by the Engineer.

1) PFP. If the contractor elects to have the option to dispute test results by the Engineer, a composite sample size shall be a minimum of 200 lbs. (90 kg), allowing 50 lbs (23 kg) for District testing, 50 lbs. (23 kg) for Contractor testing, 50 lbs (23 kg) for dispute resolution testing, and 50 lbs. (23 kg backup for Department testing).

2) QCP. A composite sample size shall be a minimum of 100 lbs. (45 kg), allowing 50 lbs. (23 kg) for District testing, and 50 lbs. (23 kg) for Contractor testing.

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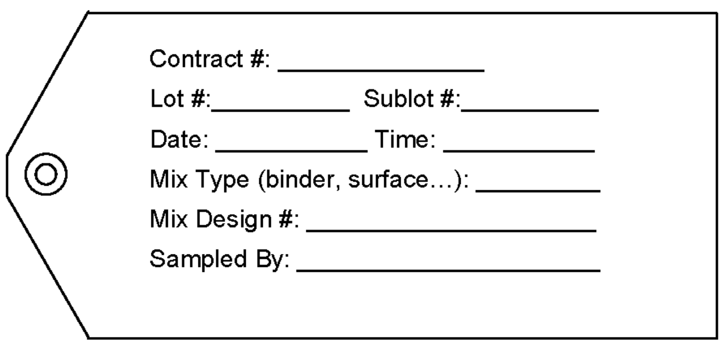
b) Lab Sample.

1) PFP. The minimum lab sample size of 50 lbs. (23 kg) shall be obtained by splitting the composite samples into four equal lab samples using an IDOT approved HMA splitter. The Engineer will secure three Department lab samples for the Contractor to transport to the District Materials Laboratory.

2) QCP. The minimum lab sample size of 50 lbs. (23 kg) shall be obtained by splitting the composite samples into two equal lab samples using an IDOT approved HMA splitter. The Engineer will secure the Department lab sample for the Contractor to transport to the District Materials Laboratory.

C. Documentation – After the sample has been obtained, the following information shall be written on each sample bag or box with a felt tip marker.



D. Sample Security – Each sample bag will be secured by the Engineer using a locking ID tag. Sample boxes will be sealed/taped using a security ID label.

E. Sample Transportation – The Contractor shall deliver the secured sample to the district laboratory, during regular working hours, for testing within two days of sampling.

F. Examples:

1. Behind Paver Sampling. Determination of random sample location for behind paver sampling.

This example illustrates the determination of the random behind the paver test location within a sublot:

Given a surface mix with a design Gmb of 2.400 is being placed 12 feet wide and 1.5 inches thick. The Engineer has elected to determine all the undisclosed random

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tonnages prior to production. The plan quantity on the project was 10,000 tons and enough random values were determined to allow for a 5% overrun assuring enough random tonnages were generated. Ignore any random tonnages beyond what was placed on the project.

Sublot Number	Random Number	Sublot Tonnage	Cummulative Job Tonnage
1	0.1669	167	167
2	0.5202	520	1520
3	0.3000	300	2300
4	0.6952	695	3695
5	0.4472	447	4447
6	0.2697	270	5270
7	0.5367	537	6537
8	0.7356	736	7736
9	0.4045	405	8405
10	0.3356	336	9336
11	0.0899	90	10090

The truck containing the mix representing the 167 tons shall be the first sublot tested. The truck in question contains 160 to 172 cumulative tonnage to be placed on the project. Determine the random location by dividing the value of the selected truck tonnage to determine the random distance value to 3 decimal places.

167 – 160 = 7 (where the random ton falls within the truck)

7/(172-160) = 7/12 = 0.583 (random distance value)

Determine the distance using 58.3% of the distance the truck will pave using the following formula:

$$Longitudinal\ Distance = \frac{384.6 \times Tons \times RD}{Gmb \times width \times thickness}$$

Where:
- Longitudinal Distance = Random distance from starting station (ft)
- Tons = total tons within the sample truck
- RD = random distance value as calculated above
- Gmb = design Gmb for the mix being placed
- Width = width of mat being paved (ft)
- Thickness = thickness of mat being paved (in)

$$Longitudinal\ Distance = \frac{384.6 \times 12 \times .583}{2.400 \times 12 \times 1.5}$$

Longitudinal Distance = 62.3 Ft = 62 Ft.

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PFP and QCP Hot Mix Asphalt Random Jobsite Sampling
Appendix E.4

Effective: April 1, 2008
Revised: October 1, 2017

Measure the calculated longitudinal distance from the starting station where the truck began to unload. Determine and document the random sample station and obtain the random mix sample as outlined herein.

Starting Station = 105 + 00
Random Sample Location = 105 + 00 + 62 = 105 + 62

This process shall be repeated for the subsequent sublots.

2. Examples of MTD Sampling Devices

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RANDOM NUMBERS

0.576	0.730	0.430	0.754	0.271	0.870	0.732	0.721	0.998	0.239
0.892	0.948	0.858	0.025	0.935	0.114	0.153	0.508	0.749	0.291
0.669	0.726	0.501	0.402	0.231	0.505	0.009	0.420	0.517	0.858
0.609	0.482	0.809	0.140	0.396	0.025	0.937	0.301	0.253	0.761
0.971	0.824	0.902	0.470	0.997	0.392	0.892	0.957	0.040	0.463
0.053	0.899	0.554	0.627	0.427	0.760	0.470	0.040	0.904	0.993
0.810	0.159	0.225	0.163	0.549	0.405	0.285	0.542	0.231	0.919
0.081	0.277	0.035	0.039	0.860	0.507	0.081	0.538	0.986	0.501
0.982	0.468	0.334	0.921	0.690	0.806	0.879	0.414	0.106	0.031
0.095	0.801	0.576	0.417	0.251	0.884	0.522	0.235	0.389	0.222
0.509	0.025	0.794	0.850	0.917	0.887	0.751	0.608	0.698	0.683
0.371	0.059	0.164	0.838	0.289	0.169	0.569	0.977	0.796	0.996
0.165	0.996	0.356	0.375	0.654	0.979	0.815	0.592	0.348	0.743
0.477	0.535	0.137	0.155	0.767	0.187	0.579	0.787	0.358	0.595
0.788	0.101	0.434	0.638	0.021	0.894	0.324	0.871	0.698	0.539
0.566	0.815	0.622	0.548	0.947	0.169	0.817	0.472	0.864	0.466
0.901	0.342	0.873	0.964	0.942	0.985	0.123	0.086	0.335	0.212
0.470	0.682	0.412	0.064	0.150	0.962	0.925	0.355	0.909	0.019
0.068	0.242	0.777	0.356	0.195	0.313	0.396	0.460	0.740	0.247
0.874	0.420	0.127	0.284	0.448	0.215	0.833	0.652	0.701	0.326
0.897	0.877	0.209	0.862	0.428	0.117	0.100	0.259	0.425	0.284
0.876	0.969	0.109	0.843	0.759	0.239	0.890	0.317	0.428	0.802
0.190	0.696	0.757	0.283	0.777	0.491	0.523	0.665	0.919	0.146
0.341	0.688	0.587	0.908	0.865	0.333	0.928	0.404	0.892	0.696
0.846	0.355	0.831	0.281	0.945	0.364	0.673	0.305	0.195	0.887
0.882	0.227	0.552	0.077	0.454	0.731	0.716	0.265	0.058	0.075
0.464	0.658	0.629	0.269	0.069	0.998	0.917	0.217	0.220	0.659
0.123	0.791	0.503	0.447	0.659	0.463	0.994	0.307	0.631	0.422
0.116	0.120	0.721	0.137	0.263	0.176	0.798	0.879	0.432	0.391
0.836	0.206	0.914	0.574	0.870	0.390	0.104	0.755	0.082	0.939
0.636	0.195	0.614	0.486	0.629	0.663	0.619	0.007	0.296	0.456
0.630	0.673	0.665	0.666	0.399	0.592	0.441	0.649	0.270	0.612
0.804	0.112	0.331	0.606	0.551	0.928	0.830	0.841	0.702	0.183
0.360	0.193	0.181	0.399	0.564	0.772	0.890	0.062	0.919	0.875
0.183	0.651	0.157	0.150	0.800	0.875	0.205	0.446	0.648	0.685

Note: Always select a new set of numbers in a systematic manner, either horizontally or vertically. Once used, the set should be crossed out.

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PFP and QCP Hot Mix Asphalt Random Jobsite Sampling
Appendix E.4

Effective: April 1, 2008
Revised: October 1, 2017

PFP Jobsite Sampling Location Determination

Date: ______ Contract #: ______ Route: ______

Bit Mix #: ______ Bit Code: ______ Bit Desc.: ______

Design Gmb: ______ Pvt width(w): ______ Pvt thickness(t): ______

Lot #:		Sublot #:		Sampling Tonnage (st):	

Begin Truck Tons (b):		Longitudinal Distance(d): *(d)=[384.6(q)(rd)] / [Gmb(w)(t)]*	
End Truck Tons (e):		Starting Station(ss):	
Tons in Truck (q): *(q)=(e)-(b)*		Random sample location(rl): *(rl)=(ss)+/-(d)* *{add or subtract if up/down sta.}*	
Random Truck distance(rd): *(rd)=[(st)-(b)]/(q)*			

Lot #:		Sublot #:		Sampling Tonnage (st):	

Begin Truck Tons (b):		Longitudinal Distance(d): *(d)=[384.6(q)(rd)] / [Gmb(w)(t)]*	
End Truck Tons (e):		Starting Station(ss):	
Tons in Truck (q): *(q)=(e)-(b)*		Random sample location(rl): *(rl)=(ss)+/-(d)* *{add or subtract if up/down sta.}*	
Random Truck distance(rd): *(rd)=[(st)-(b)]/(q)*			

Lot #:		Sublot #:		Sampling Tonnage (st):	

Begin Truck Tons (b):		Longitudinal Distance(d): *(d)=[384.6(q)(rd)] / [Gmb(w)(t)]*	
End Truck Tons (e):		Starting Station(ss):	
Tons in Truck (q): *(q)=(e)-(b)*		Random sample location(rl): *(rl)=(ss)+/-(d)* *{add or subtract if up/down sta.}*	
Random Truck distance(rd): *(rd)=[(st)-(b)]/(q)*			

Lot #:		Sublot #:		Sampling Tonnage (st):	

Begin Truck Tons (b):		Longitudinal Distance(d): *(d)=[384.6(q)(rd)] / [Gmb(w)(t)]*	
End Truck Tons (e):		Starting Station(ss):	
Tons in Truck (q): *(q)=(e)-(b)*		Random sample location(rl): *(rl)=(ss)+/-(d)* *{add or subtract if up/down sta.}*	
Random Truck distance(rd): *(rd)=[(st)-(b)]/(q)*			

Illinois Department of Transportation

Pay for Performance Dispute Resolution
Appendix E.5

Effective Date: April 1, 2010
Revised: October 1, 2017

A. Scope

This document describes the two methods for disputing PFP test results and the requirements for each. It also provides cost information for dispute testing and instructions for submitting dispute resolution samples to the Central Bureau of Materials.

B. Dispute Resolution

Dispute resolution testing will be permitted when the Contractor submits their split sample test results prior to receiving Department split sample test results. Dispute resolution testing shall be according to Method 1 (pay parameter dispute) or Method 2 (individual parameter dispute). If dispute resolution is necessary, the Contractor shall submit a request in writing within four working days of receipt of the results of the quality index analysis for the lot. The Engineer will document receipt of the request. The request shall specify Method 1 or Method 2. The Central Bureau of Materials (CBM) laboratory will be used for dispute resolution testing.

1. **Method 1:**

Method 1 dispute resolution will be allowed when Contractor and Department split test results exceed the precision limits shown in Table 1. Dispute resolution test results for G_{mm}, G_{mb}, and asphalt binder content will replace the original Department G_{mm}, G_{mb}, and asphalt binder content test results. Method 1 shall be used in cases where Department test results are outside acceptable limits shown in the Special Provision for "Hot Mix Asphalt - Pay For Performance Using Percent Within Limits - Jobsite Sampling (BDE).

Table 1

Test Parameter	Limits of Precision
Voids	1.0 %
Field VMA	1.0 %
Ratio - Dust / Asphalt Binder	0.2
Core Density	1.0 %

2. **Method 2:**

Method 2 dispute resolution will be allowed when: 1) the Contractor participates and complies with the AASHTO re:source Proficiency Sample Program testing protocol as specified herein and 2) the Contractor and Department **adjusted** split test results, as described herein, exceed the precision limits shown in Table 2. The dispute resolution test/s will only be performed for the parameter/s (G_{mm}, G_{mb}, or asphalt content) exceeding precision limits. The dispute resolution test result/s will replace the original Department result/s for the disputed parameters.

Illinois Department of Transportation

Pay for Performance Dispute Resolution
Appendix E.5

Effective Date: April 1, 2010
Revised: October 1, 2017

A. Scope

This document describes the two methods for disputing PFP test results and the requirements for each. It also provides cost information for dispute testing and instructions for submitting dispute resolution samples to the Central Bureau of Materials.

B. Dispute Resolution

Dispute resolution testing will be permitted when the Contractor submits their split sample test results prior to receiving Department split sample test results. Dispute resolution testing shall be according to Method 1 (pay parameter dispute) or Method 2 (individual parameter dispute). If dispute resolution is necessary, the Contractor shall submit a request in writing within four working days of receipt of the results of the quality index analysis for the lot. The Engineer will document receipt of the request. The request shall specify Method 1 or Method 2. The Central Bureau of Materials (CBM) laboratory will be used for dispute resolution testing.

1. **Method 1:**

Method 1 dispute resolution will be allowed when Contractor and Department split test results exceed the precision limits shown in Table 1. Dispute resolution test results for G_{mm}, G_{mb}, and asphalt binder content will replace the original Department G_{mm}, G_{mb}, and asphalt binder content test results. Method 1 shall be used in cases where Department test results are outside acceptable limits shown in the Special Provision for "Hot Mix Asphalt - Pay For Performance Using Percent Within Limits - Jobsite Sampling (BDE).

Table 1

Test Parameter	Limits of Precision
Voids	1.0 %
Field VMA	1.0 %
Ratio - Dust / Asphalt Binder	0.2
Core Density	1.0 %

2. **Method 2:**

Method 2 dispute resolution will be allowed when: 1) the Contractor participates and complies with the AASHTO re:source Proficiency Sample Program testing protocol as specified herein and 2) the Contractor and Department **adjusted** split test results, as described herein, exceed the precision limits shown in Table 2. The dispute resolution test/s will only be performed for the parameter/s (G_{mm}, G_{mb}, or asphalt content) exceeding precision limits. The dispute resolution test result/s will replace the original Department result/s for the disputed parameters.

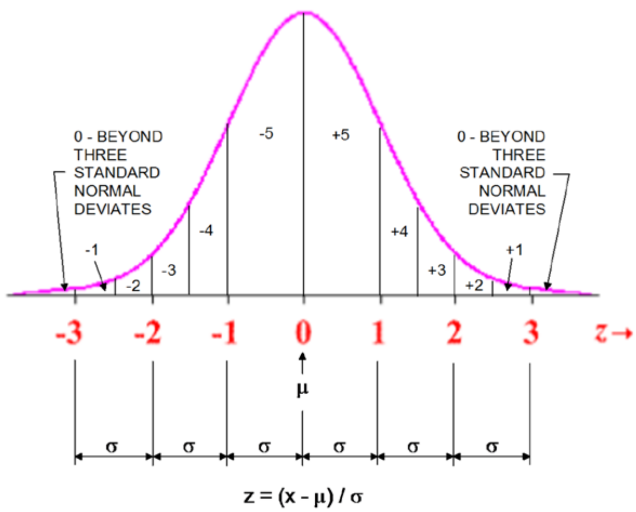
Table 2

Test Parameter	Limits of Precision
G_{mm}	0.008
G_{mb} 1/	0.012
Asphalt Binder	0.2

Note 1/ Both core G_{mb} and gyratory G_{mb}.

a. Proficiency Sample Testing

To qualify to dispute using Method 2, a QC laboratory must participate in the AASHTO re:source's (formerly AMRL) Proficiency Sample Program (PSP). PSP samples are distributed annually to federal, state, independent, commercial, and research testing laboratories. AASHTO re:source scores proficiency test samples by fitting a standard normal distribution to the data from all laboratories (with outliers eliminated). Laboratories whose results fall within one standard normal deviation from the mean are assigned a numerical score of "5." Laboratories whose results fall between 1 and 1½ standard normal deviations from the mean are assigned a score of "4," and the ratings are further decreased one point for each half standard normal deviate thereafter. A positive sign (+) indicates the lab result is above the population mean, and a negative sign (-) indicates the lab result is below the population mean. This system can be depicted graphically, as follows:



For the Contractor to dispute individual test results, G_{mm}, G_{mb}, and/or asphalt content, the following shall be met:

1) The Contractor's laboratory that conducts Quality Control testing shall participate in the appropriate AASHTO re:source PSP;

2) Within 60 calendar days of the date of issuance of a proficiency sample report, the Contractor shall submit each laboratory's proficiency sample report/s to the Department;

3) The Contractor's laboratory that conducts Quality Control testing received a proficiency score of 3 or better on the respective test; and

4) The adjusted split test results for the respective test, G_{mm}, G_{mb}, and asphalt content, exceed the precision limits listed in Table 2. The adjusted split test results account for any offset between

the Department and Contractor test results. The adjusted split test results will be determined for each lot by:

a) For each sublot, subtract the Department's result from the Contractor's result to determine the initial split;

b) For each lot, calculate the average initial split;

c) For each sublot, subtract the average initial split for the lot from the initial split result to determine the adjusted split.

d) Compare the adjusted split precision limits listed in Table 2 to determine whether sample qualifies for dispute testing.

Table 3.

EXAMPLE ADJUSTED SPLIT RESULTS CALCULATION

G_{mm}				
Sublot	Contractor	IDOT	Initial Split	Adjusted Split
1-1	2.456	2.454	0.002	-0.001
1-2	2.458	2.455	0.003	0.000
1-3	2.462	2.466	-0.004	-0.007
1-4	2.471	2.463	0.008	0.005
1-5	2.459	2.461	-0.002	-0.005
1-6	2.474	2.462	0.012	0.009
1-7	2.463	2.465	-0.002	-0.005
1-8	2.463	2.461	0.002	-0.001
1-9	2.472	2.468	0.004	0.001
1-10	2.466	2.464	0.002	-0.001
Average Initial Split			0.003	

If a Contractor laboratory receives a score of 2 or worse on a test, the Contractor shall in order to retain the ability to dispute individual test results, within 60 calendar days of the date of issuance of a proficiency sample report:

1) Conduct a root cause analysis to determine the possible reason(s) for the results;

2) Correct any issues that are uncovered in the investigation;

3) Document investigation and corrective actions; and

4) Submit AASHTO Accreditation Program (AAP) Proficiency Sample Corrective Action Report to the Department.

Consecutive occurrences of a laboratory receiving a score of 2 or worse on a test or nonparticipation in the most recent PSP shall result in the Contractor no longer being able to dispute individual test results until the Contractor receives a satisfactory score on the next regularly scheduled PSP or on an extra proficiency sample. Extra proficiency samples are surplus samples that were produced for a regularly scheduled round of testing and are available for purchase by contacting AASHTO re:source.

The Department will report laboratory scores for all participants for informational purposes.

Density cores for dispute resolution testing shall be taken simultaneously as the random density core. The density core for dispute resolution testing shall be taken within 1 ft (300 mm) longitudinally of the random density core and at the same transverse offset. Density dispute resolution will replace original density test results. For density disputes, the Contractor shall use the Department's running average for G_{mm} when determining compliance with the limits of precision.

If three or more consecutive mixture sublots or G_{mm} results are contested, corresponding density results will be recalculated with the new G_{mm}.

C. Dispute Testing Pay Schedule

The lot pay factor for the lot under dispute resolution will be recalculated. If the recalculated lot pay factor is less than or equal to the original lot pay factor, laboratory costs listed below will be borne by the Contractor.

Table 4

Test	Cost
Method 1 Mix Testing	$1000 / sublot
Core Density	$300 / core
G_{mm}	$200
G_{mb}	$500
Asphalt Content	$500

D. Dispute Submittal Instructions

When submitting HMA mix and/or core samples include the following:

- All District and Contractor split sample test results on attached "PFP Dispute Resolution Form",
- Submit entire dispute resolution HMA mix split sample,
- Cores must be split or sawed to lift testing thickness,
- QC Package template and dailies sent electronically for mix being tested.

Send sample and requested documentation to:

Illinois Department of Transportation
Central Bureau of Materials
Hot Mix Asphalt Laboratory
126 E. Ash Street
Springfield, Illinois 62704-4766
Attention: Joe Rechner Joseph.Rechner@illinois.gov

Any sample sent to CBM without the above listed information will not be processed until all requested information is received.

Illinois Department of Transportation

PFP DISPUTE RESOLUTION

Method 1 ☐ Parameter Disputed: VMA ☐ Voids ☐ D/AC ☐

Method 2 ☐ Parameter Disputed: G_{mb} ☐ G_{mm} ☐ AC ☐

Contract # : ______

Dist. Lab ID # : ______

Mix Design # : ______

Mix Code #: ______

Producer #: ______

CBM Lab #: ______

Wt. for Gmb: ______

Sampled From: Truck ☐ MTD ☐ Road ☐

Sample Date: ______

Date Received: ______

Mix Lot _____ Sublot _____

Sieve Size	District % Passing	Contractor % Passing	CBM % Passing
1 ½ in (37.5 mm)			
1 in (25 mm)			
¾ in (19 mm)			
½ in (12.5 mm)			
3/8 in (9.5 mm)			
#4 (4.75 mm)			
#8 (2.36 mm)			
#16 (1.18 mm)			
#30 (.60 mm)			
#50 (.30 mm)			
#100 (.15 mm)			
#200 (.075 mm)			
Asphalt Binder %			
Dust/Asphalt Binder Ratio			
G_{mm}			
G_{mb}			
% Voids			
G_{sb}			
Field VMA			

CORES

	District	Contractor	CBM
Core #	Gmm†	Gmm	Gmm
Core #	Gmb	Gmb	Gmb
Core #	Density %	Density %	Density %

†This shall be the G_{mm} used for density calculation.

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Illinois Department of Transportation

QCP Pay Calculation
Appendix E.6

Effective: January 1, 2012
Revised: October 1, 2017

This document explains the procedure used to determine the pay adjustment for a hot-mix asphalt (HMA) mixture for Quality Control for Performance (QCP) projects.

The following steps are used to determine the pay deduction for each QCP mixture:

1. Determine sublot deviation from target for each pay parameter.
2. Determine the sublot pay factor for each sublot using the Table 1 and the deviation from target.
3. Determine the average sublot Pay Factor for each pay parameter.
4. Calculate a Combined Pay Factor using the average sublot Pay Factors and Equation 1.
5. Determine the QCP pay deduction for the mixture using Equation 2.
6. The Combined Pay Factor shall not exceed 100%.
7. The 105% column only applies when the district conducts testing of all the sublots within a given lot and all of the tests are within the Acceptable Limits. The 105% column also applies to density sublots where no individual density test is less than 90.0% or greater than 98.0% density. The average sublot Pay Factor for each pay parameter shall be capped at 100.0% prior to calculating the Combined Pay Factor.

Table 1

Parameter	Pay Factor			
	105%	100%	95%	90%
Voids[1/ 3/]	± 0.5%	± 1.2%	± 1.6%	± 2.0%
VMA [3/]	0% to +1.0% above minimum specified	-0.5% to +2.0%	-0.7% to +2.5%	-1.0% to +3.0%
Density[2/4/]	93.5% to 94.5%	92.5% to 96.5%	91.5% to 97.0%	90.0% to 98.0%
SMA	94.0% to 95.0%	93.5% to 96.5%	92.5% to 97.0%	92.0% to 98.0%
IL-9.5FG at < 1.25 in.	93.5% to 94.5%	91.0% to 96.5%	90.0% to 97.0%	89.0% to 98.0%

1/ Ranges based on deviation from the specified design percent Voids.
2/ If no density requirement applies the Contractor will receive 100% for the density pay factor in Equation 1.
3/ If mixture testing is waived for small tonnage, the Contractor will receive 100% for the Voids and VMA pay factors in Equation 1.
4/ A density test where the core thickness is less than 0.75 inch will not be used in the density pay factor calculation.

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QCP Pay Calculation
Appendix E.6

Effective: January 1, 2012
Revised: October 1, 2017

Equation 1: $CPF = 0.30(PF_{Voids}) + 0.30(PF_{VMA}) + 0.40(PF_{Density})$

Where:

CPF = Combined Pay Factor

PF_{Voids}, PF_{VMA}, and $PF_{Density}$ = Average sublot pay factors for the pay parameters

The QCP deduction for a given mixture is calculated by multiplying the Mixture Unit Price by the Quantity and the CPF according to Equation 2 below.

Equation 2: QCP Deduction = (Mixture Unit Price x Mixture Quantity x CPF/100) – (Mixture Unit Price x Mixture Quantity)

Example:

Determine the QCP pay deduction for the given N70 HMA IL-9.5 surface mixture being placed at 1.5 inches thick as an overlay. The project consists of 6,900 tons placed over a distance of 12 lane miles.

Note that mix sample lots and density lots are independent of one another.

In this example the first mix lot represents 4,000 tons while the second lot represents 2,900 tons. There are 12 density sublots representing 12 lane miles (N=12, representing 12 miles x 5 cores/mile = 60 cores).

Mix sample: Each sublot represents 1000 tons except for lot 2, sublot 3 which represents 900 ton.

Lot	Sublot	Contractor	District	Contractor	District
1	1	4.1	***3.2***	14.9	***14.6***
	2	3.9		14.5	
	3	2.5		14.0	
	4	3.0		14.8	
2	1	2.3	***2.5***	14.3	***14.5***
	2	2.1	2.2	14.0	14.1
	3	3.8	3.6	14.7	14.6

Note: Bolded and italicized test results denote the sublot split that was randomly selected by the District for testing.

Density: Since this pavement is < 3 inches thick, cores are taken randomly every 0.2 mile which is 5 cores per mile. Each density sublot represents 1 mile. Therefore with cores taken every 0.2 mile, the density sublot will represent the average of 5 density cores.

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QCP Pay Calculation
Appendix E.6

Effective: January 1, 2012
Revised: October 1, 2017

Density Sublot	Density Intervals (cores)				
	1	2	3	4	5
1	90.4	90.8	91.6	92.4	92.1
2	93.8	94.1	92.3	92.1	92.6
3	91.8	93.5	93.9	92.8	92.5
4	93.7	94.2	93.5	93.3	92.8
5	92.1	94.1	92.6	93.8	92.3
6	94.1	94.3	93.2	94.5	93.9
7	93.6	93.3	92.5	91.9	92.7
8	92.8	93.3	94.2	93.5	93.7
9	91.5	91.2	91.9	91.8	90.9
⋮	⋮	⋮	⋮	⋮	⋮
12	91.5	93.5	92.7	93.8	92.1

Determine the average sublot pay factor for each parameter:

Voids:

Since the District randomly selected and tested the split from sublot 2 in Lot 1, and the void results were 1) within the 100% pay factor tolerance **and** 2) within Precision Limits of the Contractor's results, the District does not need to test the remaining sublots in Lot 1 and the entire Lot receives a Pay Factor of 100%.

For the second Lot the District randomly selected and tested the split from sublot 1. Since the District void results were not within the 100% pay factor tolerance, the District had to test all of the remaining Sublot splits. (see completed table below):

Calculate the void deviation from target for each of the District sublot split results.

Lot 1:
Sublot 2: Deviation = 3.2% - 4.0% = -0.8%

Lot 2:
Sublot 1: Deviation = 2.5% - 4.0% = -1.5%
Sublot 2: Deviation = 2.2% - 4.0% = -1.8%
Sublot 3: Deviation = 3.6% - 4.0% = -0.4%

Using Table 1 and the deviation from Target, determine the corresponding Void sublot Pay Factor for each District test result.

Lot 1:
Sublot 2: Pay Factor associated with -0.8% in Table 1 is 100%

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QCP Pay Calculation
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Effective: January 1, 2012
Revised: October 1, 2017

Lot 2:
Sublot 1: Pay Factor associated with -1.5% in Table 1 is 95%
Sublot 2: Pay Factor associated with -1.8% in Table 1 is 90%
Sublot 3: Pay Factor associated with -0.4% in Table 1 is 105%

Lot	Sublot	Contractor	District	Deviation	Sublot PF
1	1	4.1			
	2	3.9	***3.2***	***-0.8***	***100.0***
	3	2.8			
	4	3.0			
2	1	2.3	***2.5***	***-1.5***	***95***
	2	2.1	2.2	-1.8	90
	3	3.8	3.6	-0.4	105

Note: Bolded and italicized test results denote the sublot split that was randomly selected by the District for testing.

Calculate the average sublot Pay Factor for Voids. (Note: The 100% in Lot 1 represents four sublots and therefore is multiplied by four)

Ave Sublot Pay Factor (PF_{Voids}) = ((100% X 4) + 95% + 90% + 105%) / 7 sublots = **98.6%**

VMA:

Since the District randomly selected and tested the split from Sublot 2 in Lot 1, and the VMA results were 1) within the 100% pay factor tolerance **and** 2) within Precision Limits of the Contractor's results, the District does not need to test the remaining sublots in Lot 1 and the entire Lot receives a Pay Factor of 100%.

For the second Lot the District randomly selected and tested the split from Sublot 1. Since the District results were not within the 100% pay factor tolerance **for Voids**, the District had to test all of the remaining sublot splits. (see completed table below):

Calculate the VMA deviation from target for each of the District sublot split results.

Lot 1:
Sublot 2: Deviation = 14.6% - 15.0% = -0.4%

Lot 2:
Sublot 1: Deviation = 14.5% - 15.0% = -0.5%
Sublot 2: Deviation = 14.1% - 15.0% = -0.9%
Sublot 3: Deviation = 14.6% - 15.0% = -0.4%

Illinois Department of Transportation

QCP Pay Calculation
Appendix E.6

Effective: January 1, 2012
Revised: October 1, 2017

Using Table 1 and the deviation from Target, determine the corresponding VMA sublot pay factor for each District test result.

Lot 1:
Sublot 2: Pay Factor associated with -0.4% in Table 1 is 100%

Lot 2:
Sublot 1: Pay Factor associated with -0.5% in Table 1 is 100%
Sublot 2: Pay Factor associated with -0.9% in Table 1 is 90%
Sublot 3: Pay Factor associated with -0.4% in Table 1 is 100%

Minimum VMA = 15.0%					
Lot	Sublot	Contractor	District	Deviation	Sublot PF
1	1	14.9			
	2	14.5	***14.6***	***-0.4***	***100***
	3	14.4			
	4	14.8			
2	1	14.3	***14.5***	***-0.5***	***100***
	2	14.0	14.1	-0.9	90
	3	14.7	14.6	-0.4	100

Note: Bolded and italicized test results denote the sublot split that was randomly selected by the District for testing.

Calculate the average sublot pay factor for VMA. (Note: The 100% in Lot 1 represents four sublots and therefore is multiplied by four)

Ave Sublot Pay Factor (PF_{VMA}) = ((100% X 4) + 100% + 90% + 100%) / 7 sublots = **98.6%**

Density:

Determine the average density for each sublot.

Determine the sublot pay factor using the average sublot density and Table 1 (see completed table below).

Determine the Density pay factor by averaging the sublot pay factors.

Illinois Department of Transportation

QCP Pay Calculation
Appendix E.6

Effective: January 1, 2012
Revised: October 1, 2017

Density Sublot	Density Intervals (cores) 1	2	3	4	5	Sublot Ave	Sublot PF
1	90.4	90.8	91.6	92.4	92.1	91.5	95
2	93.8	94.1	92.3	92.1	92.6	93.0	100
3	91.8	93.5	93.9	92.8	92.5	92.9	100
4	93.7	94.2	93.5	93.3	92.8	93.5	105
5	92.1	94.1	92.6	93.8	92.3	93.0	100
6	94.1	94.3	93.2	94.5	93.9	94.0	105
7	93.6	93.3	92.5	91.9	92.7	92.8	100
8	92.8	93.3	94.2	93.5	93.7	93.5	105
9	91.5	91.2	91.9	91.8	90.9	91.5	95
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
12	91.5	93.5	92.7	93.8	92.1	92.7	100
						Average Density Sublot PF =	100.5

Combined Pay Factor:

Determine the Combined Pay Factor using Equation 1.

$CPF = 0.30(PF_{Voids}) + 0.30(PF_{VMA}) + 0.40(PF_{Density})$

$= 0.30(98.6) + 0.30(98.6) + 0.4(100.5)$

CPF = 99.4%

QCP Deduction:

Determine the QCP deduction pay for the given mixture using Equation 2.

QCP Deduction = (Mixture Unit Price x Mixture Quantity x CPF/100) – (Mixture Unit Price x Mixture Quantity)

Where: Mixture Unit Price = $65.00

Mixture Quantity = 6,900 tons placed.

QCP Deduction = ($65.00/ton x 6,900 tons x 99.4 / 100) – ($65.00/ton x 6,900 tons)
= - $2691

In this case a $2691 disincentive would be paid as per Construction Memorandum 10-4.

Illinois Department of Transportation

QCP Pay Calculation
Appendix E.6

Effective: January 1, 2012
Revised: October 1, 2017

Full Depth Examples:

Given a full-depth project with two mixtures whose combined pay factors were determined to be 100.0% and 98.2%. The full-depth pay factor shall be calculated as follows:

100.0(1/2) + 98.2(1/2) = 99.1%

Determine the adjusted pay for the full-depth pay factor.

Given that the bid price per square yard = $25.00 and 1400 yd^2 were placed.

Plan Unit Pay = $25.00/ yd^2 * 1400 yd^2 = $35,000

Adjusted Pay = $25.00/ yd^2 * 1400 yd^2 * 0.991 = $34,685

Difference = $34,685 – $35,000 = - $315

Given a full-depth project with three mixtures whose pay factors were determined to be 98.9%, 100.0% and 99.2%. The full depth pay factor shall be calculated as follows:

98.9(1/3) + 100.0(1/3) + 99.2(1/3) = 99.4%

Determine the adjusted pay for the full-depth pay factor.

Given that the bid price per square yard = $25.00 and 1400 yd^2 were placed.

Plan Unit Pay = $25.00/ yd^2 * 1400 yd^2 = $35,000

Adjusted Pay = $25.00/ yd^2 * 1400 yd^2 * 0.994 = $34,790

Difference = $34,790 – $35,000 = - $210

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Illinois Department of Transportation

Best Practices
For
Pay-For-Performance (PFP) and Quality Control for Performance (QCP)
Implementation
Appendix E.7

Effective Date: April 1, 2012
Revised Date: December 1, 2017

Purpose
This document is intended to aid district personnel in successfully preparing for and implementing the Pay-For-Performance (PFP) and Quality Control for Performance (QCP) specifications.

Lab
Since payment on PFP and QCP projects is based on Department test results, attention to laboratory equipment, qualified lab personnel and laboratory efficiency becomes paramount. Review of results from recent "Annual Bituminous Uniformity Studies" (aka Round Robins) and dispute resolutions and addressing any district lab issues resulting in poor comparisons will prove beneficial.

1) Equipment - It is imperative to inspect and calibrate all laboratory testing equipment according to frequencies listed in Policy Memorandum 21-08.0 "Minimum Requirements For Construction Materials Testing Laboratories - Department Operated Laboratories" at a minimum. Inspection and calibration immediately prior to PFP and QCP testing is highly recommended. Always use the same gyratory compactor for a given PFP or QCP contract.

   Assessment of existing and needed equipment should be performed to determine possible benefits of purchasing additional equipment to optimize productivity. Each district should also develop an action plan in the event key equipment breaks down.
2) Personnel – It is also imperative that all laboratory personnel intended to be involved in PFP and QCP testing, be qualified with successful completion of HMA Level I as a minimum. Keep technician assignments as consistent as possible. It is highly recommended to conduct an in-house round robin with the above mentioned laboratory personnel to ensure repeatability.

3) Sample Treatment – Inconsistent treatment of samples prior to testing has been identified as the leading reason for differences in test results between the contractor and the state. It is recommended that samples, for all parties involved, be allowed to cool to room temperature immediately after splitting. The samples should then be reheated and compacted as soon as the samples reach compaction temperature.

4) Efficiency – PFP and QCP are based on Department testing which results in a higher testing frequency for the district laboratory. An internal audit of your district laboratory for efficiency may help identify ways to improve productivity. This activity should be conducted by district materials staff that are not involved in day-to-day testing, or CBM staff if requested.

While the specification allows a 14 working day test turnaround time for PFP and a 10 day turnaround for QCP, the district should attempt to reduce the turnaround time as much as possible. Nationally recognized successful programs have test turnaround results within 5 days.

Project Personnel

Key components of PFP and QCP which provide the necessary compliance with the Code of Federal Regulations are 1) undisclosed random mix and density sample locations, 2) Sample either taken by the Engineer or witnessed by the Engineer, and 3) sample security. The CFR is intended to assure that the sample is under control of the Engineer at all times to verify the quality of the product. Most districts will need to rely on project staff to determine random mix sample and density core locations. It will be important for project personnel to understand their role in witnessing and securing the sample. District Materials and Construction staff should meet prior to the start of a PFP or QCP project to discuss:

1) Responsibilities:
   a) Discuss who will be responsible for sample identifying undisclosed sample location and sample layout
   b) Sample Security; discuss who will transport and / or store samples.
   c) Pay Calculations; discuss who will be responsible for entering data in software and how communication regarding pay factors will occur.
2) Procedures:
   a) Random sample locations
      i) Discuss when to disclose sampling location
      ii) Familiarize Construction personnel with random sample procedures detailed in the Manual of Test Procedures
   b) Sample Layout (utilization of random number table)
      i) Discuss how core densities will be:
         (1) transversely no closer than 1 foot to an unconfined longitudinal joint and 4 inches on a confined longitudinal joint for PFP.
         (2) transversely no closer than 4 inches from an edge for QCP.
      ii) Discuss how to handle coring locations that will need to be opened immediately to traffic

Also, it will be important to make sure Construction personnel have copies of all the necessary supporting documents.

Extra Blank Worksheets

Worksheets **Page**

Homework

NOTE: **Use the given information from Chapter 4 for each homework problem**

In-Class Problems

NOTE: If applicable, all proportioning problems in this section have been adjusted for windage.

Homework Sheets

Dryer-drum plant set-up HW problem #1

Feeder	RAP	#1	#2	#3	#4	MF	-----			
Agg							**New Bit**			
Mix%								**= 100%**		
TPH								**Prod Rate TPH = 700**		
Agg%								**= 100%**		
Sieve Size	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	Comb Grad	Target	Control Limits Min	Max
1										
3/4										
1/2										
3/8										
#4										
#8										
#16										
#30										
#50										
#100										
#200										
AC										

Recycle dryer-drum plant set-up HW problem #2

Recycle Dryer-Drum <u>Set-up</u> Homework Problem #2										
Feeder		**R1**	**#1**	**#3**	**#3**	**MF**	**New Bit**			
Agg		**RAP**	**CM11**	**CM16**	**FM02**	**MF**				
Mix%								**= 100%**		
TPH								**Prod Rate TPH = 500**		
Agg%								**= 100%**		
Sieve	% Pass	% Pass	% Pass	% Pass	% Pass	% Pass	Comb		Control Limits	
Size	% Bin	% Bin	% Bin	% Bin	% Bin	% Bin	Grad	Target	Min	Max
1										
3/4										
1/2										
3/8										
#4										
#8										
#16										
#30										
#50										
#100										
#200										
AC										

Batch plant set-up HW problem #3

Bin #	Bin #4	Bin #3	Bin #2	Bin #1	MF	New Bit			
Size	**+ 1/2**	**-1/2 +#4**	**-4 +#8**	**- #8**	**- #200**				
Mix%							= 100%		
#'s							**Batch Size - Lbs.** =		
Agg%							= 100%		
Sieve Size	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	Comb Grad	Target	Control Limits Min	Max
1									
3/4									
1/2									
3/8									
#4									
#8									
#16									
#30									
#50									
#100									
#200									
AC									

Dryer-drum plant adjustment HW problem #4

Feeder	RAP	#1	#2	#3	MF	------			
Agg		**CM11**	**CM16**	**FM20**	**MF**	**New Bit**			
Mix%							= 100%		
TPH							**Prod Rate - TPH =** 300		
Agg%							= 100%		
Sieve Size	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	Comb Grad	Target	Control Limits Min	Max
1		100	100	100	100		**100**		
3/4		91	100	100	100		**96**		
1/2		34	100	100	100		**74**		
3/8		14	97	100	100		**64**		
#4		3	32	99	100		**43**		
#8		2	9	96	100		**36**		
#16		1	8	56	100		**23**		
#30		1	8	42	100		**17**		
#50		1	7	16	100		**10**		
#100		1	6	6	100		**5**		
#200		1.0	5.5	3.8	85.0		**3.1**		
AC							**4.4**		

Dyer-drum Plant Set-up In-Class Problems

Dryer-Drum Set-up Class Example #1										
Feeder	RAP	#1	#2	#3	#4	------	New Bit			
Size			CM16		FM02	MF01				
Mix%								**= 100%**		
TPH								**Prod Rate TPH = 500**		
Agg%			**67.0**		**31.0**	**2.0**		**= 100%**		
Sieve Size	% Pass	% Pass	% Pass	% Pass	% Pass	% Pass	Comb Grad	Target	Control Limits	
	% Bin	% Bin	% Bin	% Bin	% Bin	% Bin			Min	Max
1										
3/4										
1/2			**100**		**100**	**100**		**100**		
3/8			**96**		**100**	**100**		**98**		
#4			**39**		**100**	**100**		**59**		
#8			**9**		**86**	**100**		**34**		
#16			**7**		**59**	**100**		**24**		
#30			**5**		**35**	**100**		**16**		
#50			**5**		**14**	**100**		**9**		
#100			**5**		**9**	**97**		**7**		
#200			**4.2**		**2.1**	**91.0**		**5.2**		
AC								**5.2**		

Dryer-Drum <u>Set-up</u> Class Example #2

Feeder	RAP	#1	#2	#3	#4	------	-----			
Size			**CM16**	**FM20**		**MF01**	**New Bit**			
Mix%								**= 100%**		
TPH								**Prod Rate TPH = 500**		
Agg%			**66.3**	**31.5**		**2.2**		**= 100%**		
Sieve Size	% Pass	% Pass	% Pass	% Pass	% Pass	% Pass	Comb Grad	Target	Control Limits	
	% Bin	% Bin	% Bin	% Bin	% Bin	% Bin			Min	Max
1										
3/4										
1/2			**100**	**100**		**100**		**100**		
3/8			**95**	**100**		**100**		**97**		
#4			**37**	**99**		**100**		**57**		
#8			**8**	**78**		**100**		**33**		
#16			**6**	**54**		**100**		**23**		
#30			**5**	**32**		**100**		**16**		
#50			**4**	**16**		**100**		**10**		
#100			**3**	**11**		**98**		**8**		
#200			**2.2**	**7.1**		**94.0**		**5.7**		
AC								**6.1**		

Recycle Dyer-drum Plant Set-up In-Class Problems

Recycle Dryer-Drum Set-up Problem #1										
Feeder	RAP	#1	#2	#3	#4	------	-----			
Size	RAP	CM11	CM16	FM20	FM02	MF01	New Bit			
Mix%								= 100%		
TPH								Production Rate 300 TPH		
Agg%			53.5	20.0		1.2		= 100%		
Sieve Size	% Pass	% Pass	% Pass	% Pass	% Pass	% Pass	Comb Grad	Target	Control Limits	
	% Bin	% Bin	% Bin	% Bin	% Bin	% Bin			Min	Max
1										
3/4										
1/2	100		100	100		100		100		
3/8	96		95	100		100		96		
#4	70		37	100		100		60		
#8	46		17	91		100		40		
#16	33		6	64		100		24		
#30	20		5	43		100		17		
#50	15		3	21		100		11		
#100	10		2	5		100		7		
#200	7.9		1.7	4.0		90.0		4.8		
AC	4.5							5.7		

Recycle Dryer-Drum Set-up using RAP & RAS - Problem #2

Feeder	R1	R2	#1	#2	#3	MF	New Bit			
Size	RAS	RAP		CM16	FM20					
Mix%								= 100%		
TPH								Prod Rate - 500 TPH		
Agg%	3.0	15.0		56.0	26.0			= 100%		
Sieve Size	% Pass	% Pass	% Pass	% Pass	% Pass	% Pass	Comb Grad	Target	Control Limits	
	% Bin	% Bin	% Bin	% Bin	% Bin	% Bin			Min	Max
1										
3/4										
1/2	100	100		100	100			100		
3/8	100	93		97	100			98		
#4	100	67		38	100			59		
#8	94	46		9	80			36		
#16	75	34		5	60			25		
#30	48	27		4	38			17		
#50	40	18		4	15			10		
#100	34	12		3	4			6		
#200	27.4	9.4		3.0	3.9			5.0		
AC	27.0	4.5						5.4		

Batch Plant Set-up In-Class Problems

Batch Plant Set-up Example 1							**Surface Mixture**		
Bin # / Size	Bin #4 / + 1/2	Bin #3 / -1/2 +#4	Bin #2 / -4 +#8	Bin #1 / - #8	MF / - #200	New Bit			
Mix%							= 100%		
#'s							**Batch Size - Lbs. =** **2000**		
Agg%							= 100%		
Sieve Size	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	Comb Grad	Target	Control Limits Min	Control Limits Max
1									
3/4									
1/2		100	100	100	100		**100**		
3/8		96	100	100	100		**99**		
#4		6	90	100	100		**57**		
#8		1	6	95	100		**33**		
#16		1	1	70	100		**23**		
#30		1	1	54	100		**19**		
#50		1	1	30	100		**10**		
#100		1	1	18	99		**7**		
#200		1.0	1.0	10.0	88.8		**4.7**		
AC							**6.1**		

Batch Plant Set-up Example 2 — Binder Mixture

Bin # / Size	Bin #4 + 1/2	Bin #3 -1/2 +#4	Bin #2 -4 +#8	Bin #1 - #8	MF - #200	New Bit			
Mix%							= 100%		
#'s							**Batch Size - Lbs.** = **10000**		
Agg%							= 100%		
Sieve Size	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	Comb Grad	Target	Control Limits Min	Control Limits Max
1	100	100	100	100	100		**100**		
3/4	90	100	100	100	100		**95**		
1/2	20	80	100	100	100		**71**		
3/8	18	39	95	100	100		**59**		
#4	1	5	82	100	100		**40**		
#8	1	1	11	93	100		**27**		
#16	1	1	1	50	100		**16**		
#30	1	1	1	35	100		**11**		
#50	1	1	1	17	100		**7**		
#100	1	1	1	11	99		**5**		
#200	0.3	0.3	0.2	6.9	87.7		**3.1**		
AC							**5.9**		

Dryer-drum Adjustment In-Class Problems

Dryer-Drum Adjustment Problem #1 Coarse Example										
Feeder	RAP	#1	#2	#3	#4	------	-----			
Size		CM11	CM16		FM01	MF01	New Bit			
Mix%								= 100%		
TPH								Production Rate 600 TPH		
Agg%		51.3	17.0		29.4	2.3		= 100%		
Sieve Size	% Pass	% Pass	% Pass	% Pass	% Pass	% Pass	Comb Grad	Target	Control Limits	
	% Bin	% Bin	% Bin	% Bin	% Bin	% Bin			Min	Max
1										
3/4										
1/2		41	100		100	100	70	73		
		21.0	17.0		29.4	2.3				
3/8										
#4		3	32		99	100	38	43		
		1.5	5.4		29.1	2.3				
#8		2	8		92	100	32	36		
		1.0	1.4		27.0	2.3				
#16										
#30		2	3		57	100	21	23		
		1.0	0.5		16.8	2.3				
#50										
#100										
#200		1.5	2.4		0.5	90.0	3.4	3.5		
		0.8	0.4		0.1	2.1				
AC								4.0		

Dryer-Drum <u>Adjustment</u> Problem #1 Coarse Example

Feeder	RAP	#1	#2	#3	#4	------	-----			
Size		CM11	CM16		FM01	MF01	New Bit			
Mix%								= 100%		
TPH								Production Rate 600 TPH		
Agg%								= 100%		
Sieve Size	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	Comb Grad	Target	Control Limits Min	Control Limits Max
1										
3/4										
1/2		41	100		100	100		73		
3/8										
#4		3	32		99	100		43		
#8		2	8		92	100		36		
#16										
#30		2	3		57	100		23		
#50										
#100										
#200		1.5	2.4		0.5	90.0		3.5		
AC								4.0		

Dryer-Drum Adjustment Problem #2 Fine Example										
Feeder	RAP	#1	#2	#3	#4	------	-----			
Size		CM11	CM16		FM01	MF01	New Bit			
Mix%								= 100%		
TPH								Production Rate 300 TPH		
Agg%		40.0	18.0		39.0	3.0		= 100%		
Sieve Size	% Pass	% Pass	% Pass	% Pass	% Pass	% Pass	Comb Grad	Target	Control Limits	
	% Bin	% Bin	% Bin	% Bin	% Bin	% Bin			Min	Max
1										
3/4										
1/2		40	100		100	100	76	73		
		16.0	18.0		39.0	3.0				
3/8										
#4		3	32		99	100	49	43		
		1.2	5.8		38.6	3.0				
#8		3	7		92	100	41	36		
		1.2	1.3		35.9	3.0				
#16										
#30		2	3		58	100	27	23		
		0.8	0.5		22.6	3.0				
#50										
#100										
#200		1.5	2.2		0.5	90.0	3.9	3.5		
		0.6	0.4		0.2	2.7				
AC								4.0		

Dryer-Drum Adjustment Problem #2 Fine Example

Feeder	RAP	#1	#2	#3	#4	------	-----			
Size		CM11	CM16		FM01	MF01	New Bit			
Mix%								= 100%		
TPH								Production Rate 300 TPH		
Agg%								= 100%		
Sieve Size	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	Comb Grad	Target	Control Limits Min	Control Limits Max
1										
3/4										
1/2		40	100		100	100		73		
3/8										
#4		3	32		99	100		43		
#8		3	7		92	100		36		
#16										
#30		2	3		58	100		23		
#50										
#100										
#200		1.5	2.2		0.5	90.0		3.5		
AC								4.0		

Dryer-Drum Adjustment Problem #3 Class Example										
Feeder	RAP	#1	#2	#3	#4	------	-----			
Size		CM11	CM16	FM20		MF01	New Bit			
Mix%								= 100%		
TPH								Production Rate 200 TPH		
Agg%		37.0	25.0	38.0				= 100%		
Sieve Size	% Pass	% Pass	% Pass	% Pass	% Pass	% Pass	Comb Grad	Target	Control Limits	
	% Bin	% Bin	% Bin	% Bin	% Bin	% Bin			Min	Max
1										
3/4										
1/2		36	100	100		100	76	80		
		13.3	25.0	38.0						
3/8										
#4		3	49	80		100	44	47		
		1.1	12.3	30.4						
#8		1	16	75		100	33	35		
		0.4	4.0	28.5						
#16										
#30		1	3	30		100	13	13		
		0.4	0.8	11.4						
#50										
#100										
#200		0.5	2.5	7.9		90.0	3.8	4.1		
		0.2	0.6	3.0						
AC								4.7		

Dryer-Drum Adjustment Problem #3 Class Example										
Feeder	RAP	#1	#2	#3	#4	------	-----			
Size		CM11	CM16	FM20		MF01	New Bit			
Mix%								= 100%		
TPH								Production Rate 200 TPH		
Agg%								= 100%		
Sieve Size	% Pass	% Pass	% Pass	% Pass	% Pass	% Pass	Comb Grad	Target	Control Limits	
	% Bin	% Bin	% Bin	% Bin	% Bin	% Bin			Min	Max
1										
3/4										
1/2		36	100	100		100		80		
3/8										
#4		3	49	80		100		47		
#8		1	16	75		100		35		
#16										
#30		1	3	30		100		13		
#50										
#100										
#200		0.5	2.5	7.9		90.0		4.1		
AC								4.7		

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Proportioning Solutions

In-Class proportioning problem solutions

*** The solutions provided for the adjustment problems are shown only for the critical sieves. The test for this class and the real world requires calculations for the entire worksheet to be completed <u>including</u> non-critical sieves.**

NOTE: **<u>Adjustment problems</u> can have more than one solution due to rounding of the combined gradation results (in order to meet the target gradation values). Your solution(s) should be close, normally no more than 1 or 2 percent difference. When working on the adjustment problems, your answer(s) do not have to match these solutions exactly in order to be correct as long as your calculations have been performed correctly. Always check your answers, especially during the written test. The solutions provided here are not considered to be more accurate or more correct, they are just different solutions.**

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Chapter 4 Homework Answers

Dryer-Drum Set-up Homework Problem #1

Dryer-Drum Set-up Homework Problem #1										
Bin #		#1	#2	#3	#4	MF	New Bit			
Size		CM 11	CM 16	FM 20	FM 02	MF 01				
Mix %		**47.0**	**22.6**	**12.5**	**12.5**	**1.4**	**4.0**	= 100%	100.0	
#'s		**329.0**	**158.2**	**87.5**	**87.5**	**9.8**	**28.0**	Batch Size Tons		700
Agg %		**49.0**	**23.5**	**13.0**	**13.0**	**1.5**		= 100%	100.0%	
Sieve	%Pass	%Pass	%Pass	%Pass	%Pass	%Pass	Comb		Control Limits	
Size	%Bin	%Bin	%Bin	%Bin	%Bin	%Bin	Grad	Target	Min	Max
1"		100	100	100	100	100	100	100		
		49.0	23.5	13.0	13.0	1.5				
3/4"		85	100	100	100	100	93	94		
		41.7	23.5	13.0	13.0	1.5				
1/2"		44	100	100	100	100	**73**	**73**		
		21.6	23.5	13.0	13.0	1.5				
3/8"		19	97	100	100	100	60	60		
		9.3	22.8	13.0	13.0	1.5				
#4		10	34	100	100	100	**40**	**39**		
		4.9	8.0	13.0	13.0	1.5				
#8		7	9	75	92	100	**29**	**27**		
		3.4	2.1	9.8	12.0	1.5				
#16		4	6	42	65	100	19	18		
		2.0	1.4	5.5	8.5	1.5				
#30		3	5	29	40	100	**13**	**13**		
		1.5	1.2	3.8	5.2	1.5				
#50		2	4	16	14	100	7	7		
		1.0	0.9	2.1	1.8	1.5				
#100		2	3	8	3	97	5	5		
		1.0	0.7	1.0	0.4	1.5				
#200		1.8	1.9	5.8	1.7	90.0	**3.7**	**3.7**		
		0.9	0.4	0.8	0.2	1.4				
AC								4.0		

Recycle Dryer-Drum Plant Set-up Homework Problem #2

Dryer-Drum Recycle Set-up Homework Example #2										
Feeder		R2	#1	#2	#3	MF	New Bit			
Size		RAP	CM11	CM16	FM02	MF01				
Mix%		25.1	31.7	19.2	20.2	1.0	2.8	= 100%		
TPH		175.7	221.9	134.4	141.4	7.0	19.6	Prod Rate = 700 TPH		
Agg%		25.0	33.0	20.0	21.0	1.0		= 100%		
Sieve Size	% Pass	% Pass	% Pass	% Pass	% Pass	% Pass	Comb Grad	Target	Control Limits	
	% Bin	% Bin	% Bin	% Bin	% Bin	% Bin			Min	Max
1		100	100	100	100	100.0	100	100		
		25.0	33.0	20.0	21.0	1.0				
3/4		94	91	100	100	100	96	96		
		23.5	30.0	20.0	21.0	1.0				
1/2		85	40	100	100	100	77	75		
		21.3	13.2	20.0	21.0	1.0				
3/8		79	15	92	100	100	65	66		
		19.8	5.0	18.4	21.0	1.0				
#4		63	3	40	99	100	47	47		
		15.8	1.0	8.0	20.8	1.0				
#8		46	2	15	92	100	36	36		
		11.5	0.7	3.0	19.3	1.0				
#16		37	2	6	60	100	25	24		
		9.3	0.7	1.2	12.6	1.0				
#30		31	2	4	45	100	20	19		
		7.8	0.7	0.8	9.5	1.0				
#50		23	1	4	14	100	11	10		
		5.8	0.3	0.8	2.9	1.				
#100		13	1	4	3	98	6	6		
		3.3	0.3	0.8	0.6	1.0				
#200		7.6	1.0	4.0	2.2	88.0	4.4	4.3		
		1.9	0.3	0.8	0.5	0.9				
AC		4.5						4.0		

Batch Plant Set-up Homework Problem #3

Batch Plant Set-up Homework Probblem #3										
Bin #	Rap	Bin # 4	Bin # 3	Bin # 2	Bin # 1	MF	New Bit			
Size		+ 1/2	1/2-#4	4-#8	- #8	- #200				
Mix %			**42.7**	**20.8**	**29.5**	**1.7**	**5.3**	= 100%	100.0	
#'s			**3416**	**1664**	**2360**	**136**	**424**	lbs/Batch		8000
Agg %			**45.0**	**22.0**	**31.2**	**1.8**		= 100%	100.0%	
Sieve	%Pass	%Pass	%Pass	%Pass	%Pass	%Pass	Comb		Control Limits	
Size	%Bin	%Bin	%Bin	%Bin	%Bin	%Bin	Grad	Target	Min	Max
1"										
3/4"										
1/2"			100	100	100	100	**100**	**100**		
			45.0	22.0	31.2	1.8				
3/8"			93	100	100	100	**97**	**97**		
			41.9	22.0	31.2	1.8				
#4			4	94	100	100	**56**	**55**		
			1.8	20.7	31.2	1.8				
#8			2	6	92	100	**33**	**33**		
			0.9	1.3	28.7	1.8				
#16			2	1	74	100	**26**	**27**		
			0.9	0.2	23.1	1.8				
#30			1	1	45	100	**17**	**17**		
			0.5	0.2	14.0	1.8				
#50			1	1	23	100	**10**	**10**		
			0.5	0.2	7.2	1.8				
#100			1	1	14	99	**7**	**7**		
			0.5	0.2	4.4	1.8				
#200			0.5	0.4	5.9	88.0	**3.7**	**3.7**		
			0.2	0.1	1.8	1.6				
AC								**5.3**		

Dryer-Drum Adjustment Homework Problem #4

Drier-Drum Adjustment Homework Problem #4									
Feeder		#1	#2	#3	MF	**New**			
Agg		**CM 11**	**CM 16**	**FM 20**	**MF 01**	**Bit**			
Mix%		**38.2**	**24.9**	**32.5**	**0.0**	**4.4**	= 100%		
TPH		**114.6**	**74.7**	**97.5**	**0.0**	**13.2**	**Prod Rate - TPH = 300**		
Agg%		**40.0**	**26.0**	**34.0**	**0.0**		= 100%		
Sieve	% Pass	% Pass	% Pass	% Pass	% Pass	Comb		Control Limits	
Size	% Bin	% Bin	% Bin	% Bin	% Bin	Grad	Target	Min	Max
1		100	100	100	100	**100**	**100**		
		40.0	26.0	34.0	0.0				
3/4		91	100	100	100	**96**	**96**		
		36.4	26.0	34.0	0.0				
1/2		**34**	**100**	**100**	**100**	**74**	**74**		
		13.6	**26.0**	**34.0**	**0.0**				
3/8		14	97	100	100	**65**	**64**		
		5.6	25.2	34.0	0.0				
#4		**3**	**32**	**99**	**100**	**43**	**43**		
		1.2	**8.3**	**33.7**	**0.0**				
#8		**2**	**9**	**96**	**100**	**36**	**36**		
		0.8	**2.3**	**32.6**	**0.0**				
#16		1	8	56	100	**22**	**23**		
		0.4	2.1	19.0	0.0				
#30		**1**	**8**	**42**	**100**	**17**	**17**		
		0.4	**2.1**	**14.3**	**0.0**				
#50		1	7	16	100	**8**	**10**		
		0.4	1.8	5.4	0.0				
#100		1	6	6	100	**4**	**5**		
		0.4	1.6	2.0	0.0				
#200		**1.0**	**5.5**	**3.8**	**85.0**	**3.1**	**3.1**		
		0.4	**1.4**	**1.3**	**0.0**				
AB							**4.4**		

Class Problem Solutions

Dryer-drum Set-up #1

Dryer-Drum Set-up Class Example #1										
Feeder	RAP	#1	#2	#3	#4	------	New Bit			
Size			**CM16**		**FM02**	**MF01**				
Mix%			**63.5**		**29.4**	**1.9**	**5.2**	**= 100%**		
TPH			**317.5**		**147.0**	**9.5**	**26.0**	**Prod Rate TPH = 500**		
Agg%			**67.0**		**31.0**	**2.0**		**= 100%**		
Sieve	% Pass	% Pass	% Pass	% Pass	% Pass	% Pass	Comb		Control Limits	
Size	% Bin	% Bin	% Bin	% Bin	% Bin	% Bin	Grad	Target	Min	Max
1										
3/4										
1/2			**100**		**100**	**100**	**100**	**100**		
			67.0		**31.0**	**2.0**				
3/8			**96**		**100**	**100**	**97**	**98**		
			64.3		**31.0**	**2.0**				
#4			**39**		**100**	**100**	**59**	**59**		
			26.1		**31.0**	**2.0**				
#8			**9**		**86**	**100**	**35**	**34**		
			6.0		**26.7**	**2.0**				
#16			**7**		**59**	**100**	**25**	**24**		
			4.7		**18.3**	**2.0**				
#30			**5**		**35**	**100**	**16**	**16**		
			3.4		**10.9**	**2.0**				
#50			**5**		**14**	**100**	**10**	**9**		
			3.4		**4.3**	**2.0**				
#100			**5**		**9**	**97**	**8**	**7**		
			3.4		**2.8**	**1.9**				
#200			**4.2**		**2.1**	**91.0**	**5.3**	**5.2**		
			2.8		**0.7**	**1.8**				
AC								**5.2**		

Dryer-drum Set-up #2

Drier-Dryer-Drum Set-up Class Example #2

Feeder	RAP	#1	#2	#3	#4	------	-----			
Size			**CM16**	**FM20**		**MF01**	**New Bit**			
Mix%			**62.2**	**29.6**		**2.1**	**6.1**	**= 100%**		
TPH			**311.0**	**148.0**		**10.5**	**30.5**	**Prod Rate TPH = 500**		
Agg%			**66.3**	**31.5**		**2.2**		**= 100%**		
Sieve Size	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	Comb Grad	Target	Control Limits Min	Max
1										
3/4										
1/2			**100**	**100**		**100**	**100**	**100**		
			66.3	**31.5**		**2.2**				
3/8			**95**	**100**		**100**	**97**	**97**		
			63.0	**31.5**		**2.2**				
#4			**37**	**99**		**100**	**58**	**57**		
			24.5	**31.2**		**2.2**				
#8			**8**	**78**		**100**	**32**	**33**		
			5.3	**24.6**		**2.2**				
#16			**6**	**54**		**100**	**23**	**23**		
			4.0	**17.0**		**2.2**				
#30			**5**	**32**		**100**	**16**	**16**		
			3.3	**10.1**		**2.2**				
#50			**4**	**16**		**100**	**10**	**10**		
			2.7	**5.0**		**2.2**				
#100			**3**	**11**		**98**	**8**	**8**		
			2.0	**3.5**		**2.2**				
#200			**2.2**	**7.1**		**94.0**	**5.8**	**5.7**		
			1.5	**2.2**		**2.1**				
AC								**6.1**		

Recycle Dryer-Drum Set-up using RAP Problem #1

Recycle Dryer-Drum Set-up using RAP - Problem #1										
Feeder	RAP	#1	#2	#3	#4	------	-----			
Size	RAP	CM11	CM16	FM20	FM02	MF01	New Bit			
Mix%	24.7		50.0	19.6		1.1	4.6	= 100%		
TPH	74.1		150.0	58.8		3.3	13.8	Prod Rate 300 TPH		
Agg%	25.0		53.0	20.8		1.2		= 100%		
Sieve Size	% Pass	% Pass	% Pass	% Pass	% Pass	% Pass	Comb Grad	Target	Control Limits	
	% Bin	% Bin	% Bin	% Bin	% Bin	% Bin			Min	Max
1										
3/4										
1/2	100		100	100		100	100	100		
	25.0		53.0	20.8		1.2				
3/8	96		95	100		100	96	96		
	24.0		50.4	20.8		1.2				
#4	70		37	100		100	59	60		
	17.5		19.6	20.8		1.2				
#8	46		17	91		100	41	40		
	11.5		9.0	18.9		1.2				
#16	33		6	64		100	26	24		
	8.3		3.2	13.3		1.2				
#30	20		5	43		100	18	17		
	5.0		2.7	8.9		1.2				
#50	15		3	21		100	11	11		
	3.8		1.6	4.4		1.2				
#100	10		2	5		100	6	7		
	2.5		1.1	1.0		1.2				
#200	7.9		1.7	4.0		90.0	4.8	4.8		
	2.0		0.9	0.8		1.1				
AC	4.5							5.7		

Recycle Dryer-Drum Set-up using Rap & RAS Problem #2

Recycle Dryer-Drum Set-up Problem #2										
Feeder	R1	R2	#1	#2	#3	MF	New			
Size	RAS	RAP		CM16	FM20		Bit			
Mix%	3.9	14.9		53.0	24.6		3.6	= 100%		
TPH	19.5	74.5		265.0	123.0		18.0	Prod Rate = 500 TPH		
Agg%	3.0	15.0		56.0	26.0			= 100%		
Sieve	% Pass	% Pass	% Pass	% Pass		% Pass	Comb		Control Limits	
Size	% Bin	% Bin	% Bin	% Bin		% Bin	Grad	Target	Min	Max
1										
3/4										
1/2	100	100		100	100		100	100		
	3.0	15.0		56.0	26.0					
3/8	100	93		97	100		97	98		
	3.0	14.0		54.3	26.0					
#4	100	67		38	100		60	59		
	3.0	10.1		21.3	26.0					
#8	94	46		9	80		36	36		
	2.8	6.9		5.0	20.8					
#16	75	34		5	60		26	25		
	2.3	5.1		2.8	15.6					
#30	48	27		4	38		18	17		
	1.4	4.1		2.2	9.9					
#50	40	18		4	15		10	10		
	1.2	2.7		2.2	3.9					
#100	34	12		3	4		6	6		
	1.0	1.8		1.7	1.0					
#200	27.4	9.4		3.0	3.9		4.9	5.0		
	0.8	1.4		1.7	1.0					
AC	27.0	4.5						5.4		

Batch Plant Set-up #1

Batch Plant Set-up Example #1								**Surface Mixture**		
Bin #		Bin #4	Bin #3	Bin #2	Bin #1	MF	**New Bit**			
Size		**+ 1/2**	**- 1/2 + #4**	**- #4 + #8**	**- #8**	**- #200**				
Mix%			**40.5**	**22.5**	**30.0**	**0.9**	**6.1**	**= 100%**		
#'s			**810**	**450**	**600**	**18**	**122**	**Batch Size = 2000**		
Agg%			**43.0**	**24.0**	**32.0**	**1.0**		**= 100%**		
Sieve Size	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	Comb Grad	Target	Control Limits Min	 Max
1										
3/4										
1/2			**100**	**100**	**100**	**100**	**100**	**100**		
			43.0	**24.0**	**32.0**	**1.0**				
3/8			**96**	**100**	**100**	**100**	**98**	**99**		
			41.3	**24.0**	**32.0**	**1.0**				
#4			**6**	**90**	**100**	**100**	**57**	**57**		
			2.6	**21.6**	**32.0**	**1.0**				
#8			**1**	**6**	**95**	**100**	**33**	**33**		
			0.4	**1.4**	**30.4**	**1.0**				
#16			**1**	**1**	**70**	**100**	**24**	**23**		
			0.4	**0.2**	**22.4**	**1.0**				
#30			**1**	**1**	**54**	**100**	**19**	**19**		
			0.4	**0.2**	**17.3**	**1.0**				
#50			**1**	**1**	**30**	**100**	**11**	**10**		
			0.4	**0.2**	**9.6**	**1.0**				
#100			**1**	**1**	**18**	**99**	**7**	**7**		
			0.4	**0.2**	**5.8**	**1.0**				
#200			**1.0**	**1.0**	**10.0**	**88.8**	**4.7**	**4.7**		
			0.4	**0.2**	**3.2**	**0.9**				
AC								**6.1**		

Batch Plant Set-up #2

Batch Plant Set-up Example 2						Binder Mixture			
Bin #	Bin #4	Bin #3	Bin #2	Bin #1	MF	New			
Size	+ ½	-1/2 +#4	-4 +#8	- #8	- #200	Bit			
Mix%	**27.3**	**29.2**	**12.2**	**24.3**	**1.1**	**5.9**	**= 100%**		
#s	**2730**	**2920**	**1220**	**2430**	**110**	**590**	**Batch Size - Lbs. = 10,000**		
Agg%	**29.0**	**31.0**	**13.0**	**25.8**	**1.2**		= 100%		
Sieve	% Pass	% Pass	% Pass	% Pass	% Pass	Comb		Control Limits	
Size	% Bin	% Bin	% Bin	% Bin	% Bin	Grad	Target	Min	Max
1	100	100	100	100	100	**100**	**100**		
	29.0	31.0	13.0	25.8	1.2				
3/4	90	100	100	100	100	**97**	**95**		
	26.1	31.0	13.0	25.8	1.2				
1/2	20	80	100	100	100	**71**	**71**		
	5.8	24.8	13.0	25.8	1.2				
3/8	18	39	95	100	100	**57**	**59**		
	5.2	12.1	12.4	25.8	1.2				
#4	1	5	82	100	100	**40**	**40**		
	0.3	1.6	10.7	25.8	1.2				
#8	1	1	11	93	100	**27**	**27**		
	0.3	0.3	1.4	24.0	1.2				
#16	1	1	1	50	100	**15**	**16**		
	0.3	0.3	0.1	12.9	1.2				
#30	1	1	1	35	100	**11**	**11**		
	0.3	0.3	0.1	9.0	1.2				
#50	1	1	1	17	100	**6**	**7**		
	0.3	0.3	0.1	4.4	1.2				
#100	1	1	1	11	99	**5**	**5**		
	0.3	0.3	0.1	2.8	1.2				
#200	0.3	0.3	0.2	6.9	87.7	**3.1**	**3.1**		
	0.1	0.1	0.0	1.8	1.1				
AC							**5.9**		

Adjustment #1 - Dryer-drum Plant

<u>Critical Sieves only</u>!

Agg%		46.4	17.5		33.7	2.4		= 100.0%		
Sieve	% Pass	% Pass	% Pass	% Pass	% Pass	% Pass	Comb		Control Limits	
Size	% Bin	% Bin	% Bin	% Bin	% Bin	% Bin	Grad	Target	Min	Max
1										
3/4										
1/2		41	100		100	100	72.6	73		
		19.0	17.5		33.7	2.4				
3/8										
#4		3	32		99	100	42.8	43		
		1.4	5.6		33.4	2.4				
#8		2	8		92	100	35.7	36		
		0.9	1.4		31.0	2.4				
#16										
#30		2	3		57	100	23.0	23		
		0.9	0.5		19.2	2.4				
#50										
#100										
#200		1.5	2.4		0.5	90.0	3.5	3.5		
		0.7	0.4		0.2	2.2				
AC								4.0		

Adjustment #2 - Dryer-drum Plant

<u>Critical Sieves only</u>!

Agg%		45.7	18.8		33.1	2.4		= 100%		
Sieve	% Pass	% Pass	% Pass	% Pass	% Pass	% Pass	Comb		Control Limits	
Size	% Bin	% Bin	% Bin	% Bin	% Bin	% Bin	Grad	Target	Min	Max
1										
3/4										
1/2		40	100		100	100	73	73		
		18.3	18.8		33.1	2.4				
3/8										
#4		3	32		99	100	43	43		
		1.4	6.0		32.8	2.4				
#8		3	7		92	100	36	36		
		1.4	1.3		30.5	2.4				
#16										
#30		2	3		58	100	23	23		
		0.9	0.6		19.2	2.4				
#50										
#100										
#200		1.5	2.2		0.5	90.0	3.5	3.5		
		0.7	0.4		0.2	2.2				
AC								4.0		

Adjustment #3 - Dryer-drum Plant

<u>Critical Sieves only</u>!

Dryer-drum Adjustment Class Problem #3										
Bin #			#1	#2	#3	MF	New Bit			
Size			**CM11**	**CM16**	**FM20**	**MF 01**				
Mix %								= 100%		
#'s								Prod. Rate TPH		200
Agg %			**32.0**	**27.2**	**40.8**			= 100%	100.0%	
Sieve	%Pass	%Pass	%Pass	%Pass	%Pass	%Pass	Comb		Control Limits	
Size	%Bin	%Bin	%Bin	%Bin	%Bin	%Bin	Grad	Target	Min	Max
1"										
3/4"										
1/2"			**36**	**100**	**100**	**100**	**80**	**80**		
			11.5	**27.2**	**40.8**					
3/8"										
#4			**3**	**49**	**80**	**100**	**47**	**47**		
			1.0	**13.3**	**32.6**					
#8			**1**	**16**	**75**	**100**	**35**	**35**		
			0.3	**4.4**	**30.6**					
#16										
#30			**1**	**3**	**28**	**100**	**13**	**13**		
			0.3	**0.8**	**11.4**					
#50										
#100										
#200			**0.5**	**2.3**	**8.2**	**90.0**	**4.1**	**4.1**		
			0.2	**0.6**	**3.3**					
AC								**4.7**		

Adjustment #4 - Batch Plant

Batch Plant Adjustment Example Answer							**Surface Mixture**		
Bin #	Bin #4	Bin #3	Bin #2	Bin #1	MF	New Bit			
Size	+ 1/2	-1/2 +#4	-4 +#8	- #8	- #200				
Mix%		**33.9**	**24.6**	**34.8**	**1.2**	**5.5**	= 100%		
#'s		**3390**	**2460**	**3480**	**120**	**550**	**Batch Size - Lbs.** = **10000**		
Agg%		**35.9**	**26.0**	**36.9**	**1.2**		= 100%		
Sieve Size	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	Comb Grad	Target	Control Limits Min	 Max
1									
3/4									
1/2		100	100	100	100	**100**	**100**		
		35.9	26.0	36.9	1.2				
3/8		88	100	100	100	**96**	**96**		
		31.6	26.0	36.9	1.2				
#4		8	92	100	100	**65**	**65**		
		2.9	23.9	36.9	1.2				
#8		1	2	98	100	**38**	**38**		
		0.4	0.5	36.2	1.2				
#16		1	1	70	100	**28**	**27**		
		0.4	0.3	25.8	1.2				
#30		1	1	49	100	**20**	**20**		
		0.4	0.3	18.1	1.2				
#50		1	1	25	100	**11**	**10**		
		0.4	0.3	9.2	1.2				
#100		1	1	12	100	**6**	**7**		
		0.4	0.3	4.4	1.2				
#200		0.2	0.4	8.9	87.7	**4.6**	**4.6**		
		0.1	0.1	3.3	1.1				
AC							**5.5**		