Approved Asphalt Quality Control Technician

(ODOT Level 2 Asphalt Technician)

This is a course designed for understanding the asphalt testing requirements of Ohio Department of Transportation projects.

Course Manual
Table of Contents

Section 1, Introduction
Section 2, Calculations, Forms and Practice Problems
Section 3, Control Charts
Section 4, Sampling Asphalt Concrete Mix
Section 5, Supplemental Specifications, Specifications and Supplements for Tests
Section 6, AASHTO Standard Test Methods

(see the detailed Table of Contents at the beginning of each Section)
Section 1, Introduction:

Level 2 Prerequisites .................................................................................................................. 1
Pre-testing Information and Central Lab Directions ................................................................. 2
Level 2 Training and Approval ................................................................................................. 3
Supplemental Specification 1041 (1-15-2016), 6 pages
Asphalt Definitions .................................................................................................................... 11-12
Introduction

Level 2 Prerequisite

To be approved as an Asphalt Level 2 Technician for Ohio DoT, you will need the following:

- A Certificate of completion from a recognized Radiation Safety Training Program.
  - Completion of this Radiation training is not required before taking this class or for the Hands-On Practical testing.
  - This class only includes classroom training of the Nuclear AC Gauge
  - The Practical test will only include use of the control panel and the chamber that contains the Nuclear Source.
  - However, Radiation Safety training must be completed and the Certificate must remain on file with the Asphalt Materials Section at the ODOT Central Lab in Columbus before a technician may be Level 2 approved.

- Successful completion of the Level 2 written examination.

- Successful completion of the hands-on practical examination (details to be announced).

- Note:
  - Written and Practical exams will be held a maximum of 2 months pending receipt of the radiation safety certification.
  - Should you not pass the written examination, then it should be retaken within a maximum of 3 weeks.
  - The hands-on practical examination must be completed within 1 month of successfully completing the written exam. Should this time elapse, then the tests will be discarded and the exams will need to be retaken in its entirety.
Asphalt Level 2
Pre-testing Information and Directions

Pre-Test opportunity: Anyone having the appropriate knowledge and experience wishing to schedule to take a Pretest may arrange to do so by contacting Tim Selby at 614-275-1338 or Steve McAvoy (614-275-1379) at the ODOT Central lab. A 90% Score is required to pass the Pretest. If this Level 2 Asphalt Technician pretest is failed, the Level 2 Asphalt Technician School must then be attended before a retest will be given. Written exam results will be e-mailed to you within one week.

Please provide the e-mail address that you would like your test results sent to. There is an area on the front cover of your test booklet ODOT employees' results will be sent to the HT office. Contact your HT coordinator.
If you do not have access to an e-mail address you may contact by phone No sooner than 1:00 pm on the Thursday following the test day. In the event you do not receive an e-mail by 1:00 pm on the Thursday following the test day or you have any questions please contact us at one of the numbers listed below.

Steve McAvoy – 614-275-1379 steven.mcavoy@dot.ohio.gov
Tim Selby – 614-275-1338 tim.selby@dot.ohio.gov

Those who successfully pass the written exam will then be scheduled for the hands on practical (details to be announced).
Those who do not pass the written portion of the exam may schedule a review and retake at the ODOT Central Lab in Columbus, Ohio on a first come basis, depending on the availability of the Test Lab staff.

ODOT Central Test Lab: 1600 W. Broad Street, Columbus, Ohio 43223.

Testing will take place on the second floor of the Lab in room 2015.

Directions to the Lab:

From I-70 Westbound: Exit at #97 W Broad St. Continue straight through the traffic light at the end of the ramp like you are getting back on I-70 West. Veer right into the ODOT complex. At the gate tell the call box attendant who you are there to see (ODOT employee name). Our building (1600) Materials Management is the first building on the right.

From I-70 Eastbound: Exit at #97 W Broad St. Turn left onto W. Broad St and pass under the bridge and turn Left at the first traffic light, like you are getting back on I-70 West. Veer right into the ODOT complex. At the gate tell the call box attendant who you are there to see (ODOT employee name). Our building (1600) Materials Management is the first building on the right.
Level 2 Technician Training and Approval – What is this all about?

The Level 2 training in this class provides the minimum skills and resources needed to get started on the road to becoming an experienced and competent asphalt lab testing technician. The Level 2 Approval enables you to perform QC and QA tests whether you are an asphalt contractor/ producer employee, consultant employee or Ohio DOT employee. The Level 3 Approval allows you to perform and submit asphalt mix designs for Ohio DOT approval.

The Ohio DOT typically uses up to 5 million tons of asphalt concrete mix in a year. The material and placement cost for Ohio asphalt concrete mix is over $350,000,000.00. The vast majority of this material is produced by asphalt concrete mix contractors and producers who design, produce, test and place the asphalt concrete mix. Testing of asphalt concrete mix by the asphalt concrete mix contractor/producer is called QC (quality control).

The Ohio DOT performs testing also. Ohio DOT testing and review that validate the asphalt concrete mix contractor/ producer QC is called monitoring. Ohio DOT tests that are used for payment of the asphalt concrete mix contractor/ producer are called acceptance. Both monitoring and acceptance are called QA (quality assurance). The asphalt concrete mix contractor/producer QC along with Ohio DOT QA, makeup what is called the QC/QA program for asphalt.

All general asphalt concrete mix contractor/ producer QC/QA requirements are found in Ohio DOT C&MS sections 403, 441 and/or 442. General mix and placement requirements are found in Ohio DOT C&MS section 401. Ohio DOT acceptance requirements are found in 403, 448 or 446.

A Level 2 technician should have all the documents needed to fully understand what is expected of the job he/ she is working on. This includes the Ohio DOT C&MS specification book, Ohio DOT supplemental specifications, proposal notes if applicable, copies of all worksheets and forms submitted to the Ohio DOT, and copies of JMF (Job Mix Formula) approval letters. Ohio DOT monitoring checks on the asphalt concrete mix contractor/ producer QC, including the Level 2 technician practices.

The Ohio DOT C&MS specification book, supplemental specifications and proposal notes can be viewed online at:
http://www.dot.state.oh.us/construction/OCA/Specs/default.htm
However, it is in the Level 2 technicians best interest to obtain hard copies for their personal use.

Finally, the Level 2 technician is responsible for maintaining their approval with the Ohio DOT by contacting the Office of Materials Management when their approval is up.

See the latest revision of S 1041 on the following 5 pages.
1041.01 Scope
1041.02 Administration
1041.03 Personnel Approval
1041.04 Laboratory Approval

1041.01 Scope.

A. This supplement outlines the requirements for Contractor and Consultant employees:

1. To perform asphalt concrete quality control testing under the Asphalt Quality Control Technician Level 2 approval program.

2. To perform asphalt concrete mix designs under the Asphalt Concrete Mix Design Level 3 approval program.

3. To perform supervision of asphalt concrete placement under the asphalt Field Quality Control Supervisor (FQCS) approval program.

B. This supplement outlines the requirements for a Contractor's or consultant’s laboratory to be equipped with:

1. The proper equipment to perform asphalt concrete quality control testing in accordance with 403, 441 and 442 (approved Level 2 Laboratory).

2. The proper equipment to perform asphalt concrete mix designs and quality control testing (approved Level 3 Laboratory).

1041.02 Administration.

A. The Division of Construction Management is responsible for the administration of the asphalt approval programs. The Division of Construction Management Control Group will consist of the following Department personnel:

1. Deputy Director, Division of Construction Management
2. Administrator, Office of Construction Administration
3. Administrator, Office of Materials Management

B. The Approval Program Review Group will, when required according to 1041.03.D, conduct reviews of complaints of approved personnel. The Approval Program Review Group consists of the Asphalt Materials Engineer, Office of Materials Management, Pavements Engineer, Office of Construction Administration, one District representative and one industry representative. The Approval Program Review Group will make recommendation to the Division of Construction Management Control Group.

C. The administration of the daily activities of the asphalt approval programs will be performed by the Asphalt Materials Engineer, Office of Materials Management.

1041.03 Personnel Approval.

A. Asphalt Quality Control Technician Level 2

1. The Department will approve quality control personnel upon satisfactory completion of the Level 2 Examination.

2. Eligibility requirements for the examination are the submission of proof of successful completion of a Department approved asphalt concrete quality control course and ‘hands-on’ experience with the equipment.

B. Asphalt Concrete Mix Design Technician Level 3

1. The Department will approve mix design personnel upon satisfactory completion of the Level 3 Examination.

2. Eligibility requirements for the examination are the submission of proof of successful completion of a Department approved asphalt concrete mix design course and submission of proof of successful completion of a Department approved asphalt concrete quality control course.

C. Field Quality Control Supervisor

1. The Department will approve FQCS personnel upon satisfactory completion of a Department approved FQCS course and verified minimum two years’ experience with asphalt placement operations on Department projects.

D. Removal from Work and Removal of Ohio DOT Approval

1. Contractors and their employees are subject to the provisions of C&MS 108.05. Approved personnel may also have their Department Approval removed.
2. The following will apply for possible removal of Department Approval. A complaint submitted by a District of an approved contractor or consultant employee will be reviewed by the District Engineer of Tests and Asphalt Materials Engineer, Office of Materials Management. A criterion for review, will be, but is not limited to, evidence of failure to meaningfully respond to deficiencies as outlined in ODOT C&MS. Lack of meaningful response is defined as a failure to respond to single event items that are major and obvious, or multiple event items that are recurring and minor in nature. Appropriate response is expected even if not directed by Department personnel. The Contractor QC Manager and employee in question will be contacted for information and opportunity for input. This initial review will be documented and a determination of action to be taken will be made. If it is determined a written reprimand is warranted, it will be recommended by the Asphalt Materials Engineer and issued by the Division of Construction Management Control Group. Appeals must be made to the Division of Construction Management Control Group within one month of a decision.

If it is determined action beyond a written reprimand may be required, the Approval Program Review Group will review the complaint and schedule a hearing with the employee. In lieu of a hearing, written statements may be submitted to the Approval Program Review Group by the approved employee. The Approval Program Review Group will make a recommendation to the Division of Construction Management Control Group. All decisions will be made in writing to the employee in question and the Contractor QC Manager. Appeals must be made to the Division of Construction Management Control Group within one month of a decision.

1041.04 Laboratory Approval.

A. Level 2

1. A Level 2 Laboratory will contain the following equipment:

   a. Asphalt Content Nuclear Gauge (AC Gauge). Use a Troxler 3241-C with a 100mCi ± 10 percent Am-241; Be neutron source or an equivalent gauge, approved by OMM, with a 100mCi ± 10 percent source and the capability of transferring its calibration data in accordance with Supplement 1043 to a Troxler gauge meeting the above requirements. Ensure each AC Gauge has its own unique manufacturer-provided ‘reference voltage’ tagged on the gauge or if not tagged a readily available letter from the manufacturer (on the manufacturer’s letterhead) stating the AC Gauge Serial Number and ‘reference voltage’. Locate the AC Gauge in the Level 2 Laboratory at least 10 feet from the nearest variable hydrogen source such as haul roads, asphalt binder or emulsion tanks, water storage tanks, etc.

   b. A minimum 10,000 g digital balance which reads to the nearest 0.1 g.

   c. A minimum of eight (8) AC Gauge pans.

   d. An AC Gauge printer.
e. Mechanical convection oven capable of maintaining a constant temperature of 355 ± 20 °F (180 ± 10 °C) for moisture testing.

f. Mechanical convection oven(s) capable of maintaining 200 - 320 °F (93- 160 °C) and with sufficient space for all required samples and equipment without delaying any testing.

g. Ignition oven meeting Supplement 1054 when required by specification.

h. Muffle furnace capable of maintaining 500 - 600 °C (932-1112 °F) or an ignition oven meeting the requirements of Supplement 1054.

i. Mechanical shaker for 8.00 in (203 mm) or 12.00 in (305 mm) sieves for gradation analysis.

j. Set of 8 inch (200 mm) diameter or 12 inch (300 mm) diameter sieves meeting the requirements of ASTM E11, "Specification for Wire-Cloth and Sieves for Testing Purposes" and of the proper size to ensure conformance to the appropriate gradation specifications.

k. Balances that meet the appropriate specifications.

l. 3000 g electrical centrifuge meeting the requirements of Supplement 1038.

m. Non-corrosive flat pan 12.00 in x 8.00 in (305 mm x 203 mm) and 1.00 in (25 mm) deep.

n. Hot plate.

o. 1000 ml graduate.

p. Crucible suitable for ash determination.

q. Bunsen burner or approved equal.

r. Water bath with clean water meeting the requirements of Supplement 1036 and including a switched suitable heater and switched circulator wired to a properly functioning ground fault interrupt outlet.

s. Metal pycnometer with a 1.06 gal (4000 mL) minimum volume meeting AASHTO T 209. A table top mechanical vibration device designed specifically for the MSG test operating on 120-volts AC and capable of holding the metal pycnometer. Ensure devices are approved by OMM. The residual pressure manometer placed in the vacuum system per AASHTO T 209 may be a digital manometer. Obtain OMM approval of digital manometer models. Provide documentation for NIST traceability. Provide a connection near the vacuum pump for attaching a vacuum gauge as a check when needed.

t. Vacuum pump or water aspirator capable of evacuating air from the container to a residual pressure in accordance with AASHTO T 209.

u. Thermometers will be ASTM Type 17 C meeting the requirements of ASTM E 1 or ASTM Type 63C meeting the requirements of ASTM E 2251.

v. Laboratory style timer with audible warning and visible timing (do not use devices such as watches, cell phones etc.).

w. Automatic, calibrated Marshall specimen compactor and extractor meeting the requirements of AASHTO T 245.

x. When 442 is specified, an automatic, calibrated gyratory specimen compactor meeting the requirements of AASHTO T 312. Include in the calibration internal angle validation per AASHTO T344. At a minimum calibrate the internal angle
annually and when requested by the District due to poor comparison. Measure and record the external angle at each internal angle validation and verify the external angle when a gyratory is moved (if possible for the model in question, otherwise calibrate the internal angle). Place a sticker on the gyratory with the date of internal angle validation and values of internal and external angles measured as appropriate for the model in question. Document internal angle validation per the QCP. Do not use gyratory compactors that cannot meet T 312 and T344 requirements.

y. Miscellaneous equipment as required by the appropriate specification.

Provide a Level 2 Laboratory with a minimum floor area of 250 square feet (18.6 m²). Provide in the lab a desk or similar space for both a technician and monitor to perform paperwork.

2. Maintain the condition of the lab equipment according to the contractor Quality Control Program (403.03). Maintain cleanliness of the lab according to the contractor Quality Control Program (403.03). Maintain the inside temperature of a Level 2 Laboratory at 68 to 86 °F (20 to 30 °C) during working hours.

3. Level 2 Laboratories will be inspected at the time of the asphalt plant inspection by Department personnel. There is no maximum number of times a laboratory may be inspected.

4. Level 2 Laboratories are required to participate in the Department's Reference Testing Program.

B. Level 3

1. A Level 3 Laboratory will meet all the equipment and size requirements of a Level 2 Laboratory and will have the following equipment:

   a. Heated water bath capable of maintaining 140 ± 2 °F (60 ± 1.0 °C).
   b. Marshall test apparatus meeting the requirements of AASHTO T 245 and Gyratory compactor meeting AASHTO T 312.
   c. All apparatus for meeting AASHTO T 283.
   d. Miscellaneous equipment as required by the appropriate specifications.

2. An asphalt ignition oven is not required for a Level 3 Laboratory.

3. A computer with Microsoft Office, internet access and ability to email attachments is required.

4. Level 3 Laboratories will be inspected a minimum of once every two years by Department personnel. There is no maximum number of times a laboratory may be inspected.
5. Level 3 Laboratories are required to participate in the Department's Reference Testing Program.

C. Loss of Approval

1. Failure to maintain required equipment in good condition may result in loss of approval of a laboratory. Loss of approval can be invoked, in written form, by the District Engineer of Tests or the Asphalt Materials Engineer. Re-approval will be granted once the deficiencies have been corrected.

2. Chronic failure to maintain required equipment in good condition may result in loss of approval of a Level 3 approved person to perform work per Section 1041.03.
Definitions

1. **AASHTO** - American Association of State Highway & Transportation Officials

2. **AC Gauge** - Asphalt Content Gauge

3. **Air Voids** - Pockets of air between the coated aggregate particles.

4. **ASTM** - American Society for Testing & Materials

5. **Asphalt or Asphalt Binder** - Liquid asphalt derived from crude oil.

6. **Asphalt Concrete** - A mixture of asphalt binder and aggregate

7. **BSG - Bulk Specific Gravity** - Test performed on compacted asphalt concrete mix.

8. **Density** - The mass of a cubic meter of material at 25° C.

9. **F/A - Fines / Asphalt Ratio** - The value calculated to the nearest (0.1) one-tenth of the fines to asphalt (F/A) ratio, which is the percentage of aggregate passing the No. 200 (75 μm) sieve divided by the percentage of asphalt binder.

10. **F-T : Fifty - Thirty Value** – The value which is calculated to the nearest whole percentage point of the Fifty to Thirty (F-T) value, which is the percent of total aggregate retained between the No.50 (300 μm) and No. 30 (600 μm) sieves, minus the percent of total aggregate retained between the No. 30 (600 μm) and 16 (1.18mm)sieves.

11. **Asphalt Concrete Mix Plants:**
   a) **Batch Plant** - A manufacturing facility for producing asphalt concrete paving mixtures that proportions the aggregate and asphalt binder constituents into the mix by weighed batches, adds asphalt binder material by either weight or volume, and mixes the blend.

   b) **Drum Mix Plant** - A manufacturing facility for producing asphalt concrete paving mixtures that continuously proportions aggregate, heats and dries in a rotating drum and simultaneously mixes them with a controlled amount of asphalt binder material. The same plant may produce cold-mix paving mixtures without heating and drying the aggregate.
12. **J.M.F. – Job Mix Formula** – It is an Asphalt Concrete Mix Design made up of a percentage of Aggregate and a percentage of Asphalt Binder blended to meet a mix types pre-determined design criteria.

13. **MSG - Maximum Specific Gravity** - Test performed on loose asphalt concrete mix, commonly known as RICE test.

14. **Maximum Size Aggregate** - One sieve larger than the nominal maximum size.

15. **Nominal Maximum Size Aggregate** - One sieve size larger than the first sieve to retain more than 10 percent.

16. **PG - Performance Graded Asphalt Binder (eg. PG 64 -22)** - Using the 64 -22 as an example the binder must meet high temperature physical property requirements at least up to a temperature of 64° C and low temperature physical property requirements at least down to -22° C.

17. **QA - Quality Assurance**

18. **QC - Quality Control**

19. **QCP - Quality Control Program**

20. **Specific Gravity** - Ratio of the mass of the given volume of material to the mass of an equal volume of water at the same temperature (25° C or 77° F)

   **NOTE:** Specific Gravity has NO SPECIFIC UNITS.

21. **Optimum Asphalt Content – Design Asphalt Content** – The asphalt content that best fits the blended materials chosen to be utilized in the design asphalt mix. This asphalt content is chosen by utilizing the volumetric properties of a mix design.

22. **D.E.T. –** This abbreviation stands for the District Engineer of Tests. This person is responsible for the quality of the materials being used on ODOT projects in their district. There are twelve (12) districts in the State of Ohio.

23. **D.C.A. -** This abbreviation stands for the District Construction Administrator. This person is responsible for the quality of the construction practices being used on ODOT projects in their district.
Section 2, Calculations, Forms and Practice Problems

Rounding:
Procedure ........................................................................................................................................2
Practice Problem ..........................................................................................................................3

Aggregate Moisture Calculations:
Example ........................................................................................................................................4
Practice Problems .......................................................................................................................5-6

Extraction / Gradation Calculations:
Formulas ........................................................................................................................................7
Extraction / Gradation Composite Worksheet .................................................................................8
F/A ratio and F-T Value Problems ................................................................................................9
Moisture, AC, and F/A Problems ...............................................................................................10
Practice Problems .......................................................................................................................11-12

Effective Asphalt ..........................................................................................................................13

Maximum Specific Gravity Calculations:
Practice Problems .......................................................................................................................14-16

Bulk Specific Gravity and Air Void Calculations:
Temperature Conversion Chart ..................................................................................................17
Formulas for Calculations ........................................................................................................18
Practice Problems .......................................................................................................................19-21

Field Worksheet:
Practice Problem .........................................................................................................................22-23
ODOT Accepted Rounding off Procedure for Level 2 and 3 Asphalt Approval

Note:
If the last number your using to round off is a 5:
You will round up to the next number:

EXAMPLES:

Rounding to the Whole number:

38.5 = 39
38.501 or greater = 39
39.5 = 40
39.501 or greater = 40

**********************************************************

Rounding to the nearest 0.1:

3.85 = 3.9
3.8501 or greater = 3.9
3.95 = 4.0
3.9501 or greater = 4.0

**********************************************************

Rounding to the nearest 0.01:

1.374 = 1.37
1.375 = 1.38
1.385 = 1.39
1.395 = 1.40

**********************************************************

Rounding to the nearest 0.001:

1.3774 = 1.377
1.3785 = 1.379
1.3775 = 1.378
1.37851 = 1.379
ODOT ROUNDING
(Practice Problem)

When the number following the place holder is exactly 5 – **Round Up**

When the place holder is higher than 5 – **Round Up**

When the place holder is less than 5 – **Round Down**

**Examples:**

When rounding to the nearest *whole number*:

4.5000 rounds to 5.0
4.4999 rounds to 4.0
4.5001 rounds to 5.0

Round to nearest whole number (1):

6.4 _____ 6.5 _____ 6.51 _____

5.6 _____ 6.501 _____ 5.5 _____

Round to the nearest tenth (0.1):

7.450 _____ 6.649 _____ 6.651 _____

Round to the nearest thousandth (0.001):

7.9905 _____ 6.7445 _____ 2.6499 _____

2.3354 _____ 7.002500001 _____ 2.999500000 _____
AGGREGATE MOISTURE CALCULATIONS

Used at all Drum Mix Plants and Batch Plants where RAP is introduced at Hot Elevator

Formula:

Aggregate Wet Weight - Aggregate Dry Weight = Aggregate Moisture

$\text{Aggregate Moisture ÷ Aggregate Dry Weight} \times 100 = \% \text{ Moisture}$

Example:

$\text{Agg. Wet Wt. - Agg. Dry Wt. = Wt. of Moisture}$
$1000 \text{ Grams} - 965 \text{ Grams} = 35 \text{ Grams of Moisture}$

$\left(\frac{\text{Agg. Moisture}}{\text{Agg. Dry Wt}}\right) \times 100 = \% \text{ Moisture}$
$\left(\frac{35 \text{ Grams}}{965 \text{ Grams}}\right) \times 100 = 3.6 \% \text{ Moisture}$

Using the formula listed below Calculate the % Moisture for each Aggregate and then combine the answers to obtain the % of Total Moisture.

$\% \text{ Moisture in Agg. # 1} \times \% \text{ Agg. # 1 used in mix (per JMF)} \text{ (made into decimal)}$
$+ \% \text{ Moisture in Agg. # 2} \times \% \text{ Agg. # 2 used in mix (per JMF)} \text{ (made into decimal)}$
$+ \% \text{ Moisture in Agg. # 3} \times \% \text{ Agg. # 3 used in mix (per JMF)} \text{ (made into decimal)}$
$= \text{ Total Moisture of Aggregates for this JMF.}$

Given:

- Agg. # 1 — 40% in JMF
  - Moisture Agg. # 1 = 3.6%
- Agg. # 2 — 20% in JMF
  - Moisture Agg. # 2 = 3.0%
- Agg. # 3 — 40% in JMF
  - Moisture Agg. # 3 = 4.0%

$\text{Agg. # 1 } = 3.6 \times .40 = 1.4 \%$
$\text{Agg. # 2 } = 3.0 \times .20 = + 0.6 \%$
$\text{Agg. # 3 } = 4.0 \times .40 = + 1.6 \%$

----------

Total Moisture = 3.6 %

NOTE: Round off to nearest 0.1 %
Moisture Practice Problem

Given the following information from a JMF:

(1) - Calculate the Moisture Content percentages for each Aggregate Size along with the Rap that is being utilized in this Job Mix Formula composition.

After completion of those calculations:

(2) - Calculate the Total Moisture percentage for the entire Job Mix Formula.

Agg. # 1 — # 57's — 37 % used — Wet Wt. = 1000 grams — Dry Wt. = 965 grams
Agg. # 2 — # 8's — 16 % used — Wet Wt. = 1000 grams — Dry Wt. = 963 grams
Agg. # 3 — SAND — 32 % used — Wet Wt. = 1000 grams — Dry Wt. = 953 grams
Agg. # 4 — RAP — 15 % used — Wet Wt. = 1000 grams — Dry Wt. = 959 grams

Show all Calculations:

\[ \frac{\text{Wet Wt.} - \text{Dry Wt.}}{\text{Wet Wt.}} \times 100 \]

\[ \% \text{ Moisture for Agg. # 1} - \]
\[ + \% \text{ Moisture for Agg. # 2} - \]
\[ + \% \text{ Moisture for Agg. # 3} - \]
\[ + \% \text{ Moisture for Rap # 4} - \]
\[ \% \text{ Total Moisture} = \]
Moisture Practice Problem

(Answer Sheet)

Given the following information from a JMF:

(1) - Calculate the Moisture Content percentages for each Aggregate Size along with the Rap that is being utilized in this Job Mix Formula composition.

After completion of those calculations:

(2) - Calculate the Total Moisture percentage for the entire Job Mix Formula.

Agg. # 1 — # 57's — 37 % used — Wet Wt. = 1000 grams — Dry Wt. = 965 grams
Agg. # 2 — # 8's — 16 % used — Wet Wt. = 1000 grams — Dry Wt. = 963 grams
Agg. # 3 — SAND — 32 % used — Wet Wt. = 1000 grams — Dry Wt. = 953 grams
Agg. # 4 — RAP — 15 % used — Wet Wt. = 1000 grams — Dry Wt. = 959 grams

Show all Calculations:

Agg. # 1  
1000 – 965 = 35 ÷ 965 X 100 = 3.6 % x .37 = 1.3 %

Agg. # 2  
1000 – 963 = 37 ÷ 963 X 100 = 3.8 % x .16 = 0.6 %

Agg. # 3  
1000 – 953 = 47 ÷ 953 X 100 = 4.9 % x .32 = 1.6 %

Agg. # 4  
1000 – 959 = 41 ÷ 959 X 100 = 4.3 % x .15 = 0.6 %

Total = 1.3 % + 0.6 % + 1.6 % + 0.6 % = 4.1 % Total Moisture

% Moisture for Agg. # 1 – 1.3 %
+ % Moisture for Agg. # 2 – 0.6 %
+ % Moisture for Agg. # 3 – 1.6 %
+ % Moisture for Rap # 4 – 0.6 %
% Total Moisture = 4.1 %
Formulas for Extraction / Gradation Worksheet Calculations

**The following information would be obtained through testing:**

** Nuclear Gauge AC — ** Effluent — **Ash per 100 ML

** Sample Gross — ** Extracted Aggregates — **Grams (Sieves)

**Formulas:**

1) Mineral in Effluent (Grams) = Effluent ÷ 100 X Ash per 100 ML (Whole Number)

2) Net Wt. of Agg. (Grams) = Extracted Agg. + Mineral (From Calculation # 1)

3) % Passing (Sieves) = Grams ÷ Net Wt. of Agg. X 100 – 100
   (Round to the Whole Number except the 200 Sieve as it rounds to the 0.1 %)

4) Corrected Bitumen (Grams) = Sample Gross – Net Wt. of Agg. (Whole Number)

5) Corrected Bitumen % = Corrected Bitumen ÷ Sample Gross x 100 (0.1 %)

**To Calculate the Composite: Follow these Steps:**

1) Add the Sample Gross Weights of each Sample Increment.

2) Add the Net Weights of Aggregate of each Sample Increment.

3) Add the Sieve Weights for each sieve size of each Sample Increment.

4) Add the Corrected Asphalt Binder Weights of each sample Increment.

5) To Calculate the % Passing of each Sieve in the Composite – use #3 under Formulas

6) To Calculate the % Asphalt Binder in the Composite – use #5 under Formulas

*** NOTE: Do Not Average The Composite, This can give False Information.***

7) Calculate the F / A Ratio and the F - T Value

** F / A = % Passing the 200 ÷ Nuclear Gauge AC (Report to the tenth)
* F - T = (P30 – P50) – (P16 – P30) (Round to the Whole Number and report as + or - number)
Utilizing the following Data given from this Laboratory Extraction and Gradation analysis along with the Nuclear Asphalt Content Gauge reading:

A. Calculate the corrected gradation percentage and the corrected bitumen content of each sample increment.

B. Combine the increments arithmetically to form the composite sample result.

C. Calculate the Fines / Asphalt Ratio and the Fifty / Thirty Value for the composite.

<table>
<thead>
<tr>
<th>Individual Bowls</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>Composite</th>
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<tbody>
<tr>
<td>Uncorrected Bitumen</td>
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<tr>
<td>Ash in 100 ML</td>
<td>1.06</td>
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<tr>
<td>Mineral in Effluent</td>
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<td>Sample Gross</td>
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<tr>
<td>Retained</td>
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<td>%Pass</td>
<td>GMS</td>
<td>%Pass</td>
<td>GMS</td>
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<tr>
<td>50.00 (2 in)</td>
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<tr>
<td>37.50 (1 ½in)</td>
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<td>25.00 (1 in)</td>
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</tr>
<tr>
<td>19.00 (3/4 in)</td>
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</tr>
<tr>
<td>12.50 (½ in)</td>
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<td>9.50 (3/8 in)</td>
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<td>4.75 (#4)</td>
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<td>2.36 (#8)</td>
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<td>1.18 (#16)</td>
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<td>.600 (#30)</td>
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<td>.075 (#200)</td>
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<td>Pan</td>
<td>2808</td>
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<td>Corrected Bitumen</td>
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</tr>
</tbody>
</table>

F / A Ratio__________   F - T Value__________
F/A & F-T Practice Problem

Given the following Test Results:

Calculate the F/A Ratio and the F-T Value.

% Passing  1/2  72 %
% Passing  3/8  58 %
% Passing  # 4  44 %
% Passing  # 8  36 %
% Passing  # 16  29 %
% Passing  # 30  21 %
% Passing  # 50  8 %
% Passing  # 100  3 %
% Passing  # 200  1.9 %

Extracted AC  5.3 %

Nuclear Gauge AC  5.7 %

Show All Calculations:

F/A__________                    F-T__________
Practice Problem

Given the following Test Results:

(A) Calculate the % Moisture Correction:

(B) Adjust the % PG Binder Content:

(C) Calculate the Fines to Asphalt Ratio:

Nuclear AC 5.9 %

Extracted AC 5.4 %

Mix Wt. Before Dry Back 2500 grams

Mix Wt. After Dry Back 2493 grams

% Passing # 200 Sieve 4.7 %

Moisture %

Adjusted AC %

Fines to Asphalt Ratio
Practice Problem

Utilizing the following Data given from this Laboratory Extraction and Gradation analysis along with the Nuclear Asphalt Content Gauge reading:

A. Calculate the corrected gradation percentage and the corrected bitumen content of each sample increment.

B. Combine the increments arithmetically to form the composite sample result.

C. Calculate the Fines / Asphalt Ratio and the Fifty / Thirty Value for the composite.

<table>
<thead>
<tr>
<th>Individual Bowls</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>Composite</th>
</tr>
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<tbody>
<tr>
<td>Uncorrected Bitumen</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
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<tr>
<td>Ash in 100 ML</td>
<td>1.01</td>
<td>0.86</td>
<td>0.59</td>
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<td>Mineral in Effluent</td>
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<td></td>
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<td>3037</td>
<td>1987</td>
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<td></td>
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<td>1874</td>
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<td>Net Weight of Agg</td>
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</tr>
<tr>
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<td>GMS</td>
</tr>
<tr>
<td>50.00 (2 in)</td>
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<td></td>
</tr>
<tr>
<td>37.50 (1 ½ in)</td>
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<td></td>
</tr>
<tr>
<td>25.00 (1 in)</td>
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<td>0</td>
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<td>9.50 (3/8 in)</td>
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<td>987</td>
<td>660</td>
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<tr>
<td>4.75 (#4)</td>
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<td>1558</td>
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<td>2.36 (#8)</td>
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<td>1755</td>
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<td>2819</td>
<td>2866</td>
<td>1874</td>
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</tbody>
</table>

Corrected Bitumen

F / A Ratio__________  F - T Value__________
Practice Problem  
(Answer Sheet)

Utilizing the following Data given from this Laboratory Extraction and Gradation analysis along with the Nuclear Asphalt Content Gauge reading:

A. Calculate the corrected gradation percentage and the corrected asphalt content of each sample increment.

B. Combine the increments arithmetically to form the composite sample result.

C. Calculate the Fines / Asphalt Ratio and the Fifty / Thirty Value for the composite.

<table>
<thead>
<tr>
<th>Individual Bowls</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>Composite</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uncorrected Bitumen</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reflux</td>
<td></td>
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</tr>
<tr>
<td>Nuclear Gauge</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4.8</td>
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<tr>
<td>Effluent (ML)</td>
<td>4250</td>
<td>4050</td>
<td>2900</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ash in 100 ML</td>
<td>1.01</td>
<td>0.86</td>
<td>0.59</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mineral in Effluent</td>
<td>43</td>
<td>35</td>
<td>17</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sample Gross</td>
<td>3001</td>
<td>3037</td>
<td>1987</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extracted Aggregates</td>
<td>2822</td>
<td>2868</td>
<td>1874</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Net Weight of Agg</td>
<td>2865</td>
<td>2903</td>
<td>1891</td>
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<td>7659</td>
</tr>
</tbody>
</table>

F / A Ratio  1.1  
F - T Value  +4
Effective Asphalt Content and F/A Calculation
Ohio DOT     Ver4/2011

This worksheet is used only when, according to specification, the calculation of the F/A ratio requires the use of the effective asphalt content. The fines portion of the F/A ratio always requires the use of the P200 from a washed gradation (or dry adjusted P200 from correction between previous dry and washed gradation noted on 189).

<table>
<thead>
<tr>
<th>Date</th>
<th>JMF No</th>
<th>Mix sample ID</th>
</tr>
</thead>
</table>

**Step 1  Determine asphalt absorption**

\[ P_{ba} = \text{asphalt absorption, } \% \text{ by mass of aggregate} \]

\[ G_{se} = \text{bulk specific gravity of aggregate (from mix design)} = \] _____________

\[ G_{b} = \text{specific gravity of binder (from mix design)} = \] _____________

\[ G_{se} = \text{effective specific gravity of aggregate (calculated)} = \]

\[ G_{sm} = \frac{P_{mn} - P_{b}}{P_{mn} - G_{b}} \]

\[ P_{mn} = 100 \]

\[ P_{b} = \text{asphalt content (from mix test)} = \] _____________

\[ G_{b} = \text{specific gravity of binder (from mix design)} = \] _____________

Show work:

\[ P_{ba} = 100 \times \frac{G_{sm} - G_{sb}}{G_{sb} G_{se}} \times G_{b} = \] _____________

Show work:

**Note:** \( G_{sb} \) should always be higher than the \( G_{sb} \), if not don’t continue until the problem is corrected.

**Step 2  Determine effective asphalt content**

\[ P_{ba} = \text{effective asphalt content, } \% \text{ by total mass of mix} \]

\[ P_{b} = \text{asphalt content, } \% \text{ by total mass of mix (from mix test)} = \] _____________

\[ P_{ba} = \text{absorbed asphalt, } \% \text{ by mass of aggregate (from above)} = \] _____________

\[ P_{e} = \text{aggregate content, } \% \text{ by total mass of mix (100 - P_{b})} = \] _____________

\[ P_{be} = \frac{P_{b} - P_{ba} \times P_{e}}{100} = \] _____________

Show work:

**Step 3  Determine fines to asphalt ratio (F/A)**

\[ F = \text{washed or corrected dry P200 (attach gradation worksheet)} = \] _____________

\[ A = \text{effective asphalt content (P_{be} from above)} = \] _____________

\[ F/A = \] _____________
Maximum Specific Gravity (Rice)

Practice Problem # 1

Given the following Test Results:

Calculate the Maximum Theoretical Specific Gravity:
NOTE: The sample is from a mix that does not require an SSD weight be obtained.

A = Dry Weight of Mix -------------------------------2669.7 grams

A* = S.S.D. Wt. of Sample -------------------------------2669.7 grams

B = Weight of Container, Mix and Water ----------------------------3343.6 grams

C = Weight of Container and Water (Constant) -----------------------1809.6 grams

D = B – C

E = A* – D

F = A ÷ E

(Show all Calculations)

ANSWER ____________________
Maximum Specific Gravity (Rice)
Practice Problem # 2

Given the following Test Results:

Calculate the Maximum Theoretical Specific Gravity:
NOTE: The sample is from a mix that does not require an SSD weight be obtained.

A = Dry Weight of Mix ----------------------------------------2667.4 grams

A* = S.S.D. Wt. of Sample ----------------------------------------2670.4 grams

B = Weight of Container, Mix and Water -------------------------------3356.7 grams

C = Weight of Container and Water (Constant) -----------------------1809.6 grams

D = B – C

E = A* – D

F = A ÷ E

(Show all Calculations)

ANSWER ____________________
Maximum Specific Gravity (Rice)

Practice Problem # 3
(Test Format)

Given the following information:

Calculate the Maximum Theoretical Specific Gravity:
NOTE: This mix is using the SSD weight of the mix in the calculation procedure.

- Dry Weight of Mix: 1997.3 grams
- S.S.D. Wt. of Sample: 1999.5 grams
- Weight of Container, Mix and Water: 7289.1 grams
- Weight of Container and Water (Constant): 6120.9 grams
- Temperature of Water: 25 Degrees C
- PG Binder %: 5.5%

(Show all Calculations)

ANSWER ____________________
### BULK SPECIFIC GRAVITY

**Example Calculation Worksheet for a Set of (3) Marshall Specimen (s)**

<table>
<thead>
<tr>
<th>Compaction Temperature</th>
<th>Weight in Air (A)</th>
<th>SSD Weight (B)</th>
<th>Weight in Water (C)</th>
<th>Volume, cc (D)</th>
<th>Actual Specific Gravity (E)</th>
<th>Max Theo. Specific Gravity (F)</th>
<th>% Air Voids</th>
</tr>
</thead>
<tbody>
<tr>
<td>290 F</td>
<td>1168.3</td>
<td>1174.6</td>
<td>668.5</td>
<td>506.1</td>
<td>2.308</td>
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<tr>
<td>290 F</td>
<td>1170.1</td>
<td>1172.7</td>
<td>670.5</td>
<td>501.8</td>
<td>2.332</td>
<td></td>
<td></td>
</tr>
<tr>
<td>290 F</td>
<td>1165.9</td>
<td>1167.7</td>
<td>663.9</td>
<td>503.8</td>
<td>2.314</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Water Temp. is 21°C  
Avg. Specific Gravity = 2.318  
Corrected Avg. Specific Gravity = 2.320  
2.425  
4.3

* Formula for Calculating % Air Voids:

\[
\left(\frac{E}{F} \times 100 - 100\right) = \% \text{ AIR VOIDS}
\]

\[
\frac{2.320}{2.425} \times 100 - 100 = 4.3 \%
\]

**Conversion Chart (This chart is also found in S 1036):**  
Absolute Density of Water and Conversion Factor (K) for Various Water Temperatures

<table>
<thead>
<tr>
<th>Temperature C</th>
<th>Correction Factor (K)</th>
<th>Temperature C</th>
<th>Correction Factor (K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>1.002661</td>
<td>21</td>
<td>1.000950</td>
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<td>11</td>
<td>1.002567</td>
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<td>16</td>
<td>1.001903</td>
<td>27</td>
<td>0.999467</td>
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<td>1.001734</td>
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<td>0.999187</td>
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<tr>
<td>20</td>
<td>1.001162</td>
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</tbody>
</table>

**Formula for Correcting Water Bath Temperature:**

\[
\text{Correction Factor (K)} \times \text{Avg. Bulk Specific Gravity} = \text{Corrected Avg. Specific Gravity}
\]

Example for above Test: \(1.000950 \times 2.318 = 2.320\)
Bulk Specific Gravity and % Air Voids

Practice Problem # 1

Given the Following Test Results:

1) Calculate the Bulk Specific Gravity (BSG):

2) Adjust the BSG for Water Bath Temperature:

3) Calculate the % Air Voids:

Dry Weight in Air ------------------------------- 1147.5 Grams

S.S.D. Weight ------------------------------- 1148.9 Grams

Weight in Water ------------------------------- 640.9 Grams

Temperature of Water Bath ------------------------------- 27 Degrees C.

Maximum Theoretical Specific Gravity (MSG) ------ 2.396

(Show all Work)

Answers:

1) Bulk Specific Gravity (BSG) ____________

2) BSG Corrected for Water Bath Temperature ____________

3) % Air Voids _________
Bulk Specific Gravity and % Air Voids

Practice Problem # 2

Given the Following Test Results:

1) Calculate the Bulk Specific Gravity (BSG):

2) Adjust the BSG for Water Bath Temperature:

3) Calculate the % Air Voids:

Dry Weight in Air ----------------------------------- 1151.5 Grams
S.S.D. Weight --------------------------------------- 1152.7 Grams
Weight in Water ------------------------------------- 652.0 Grams

Temperature of Water Bath -------------------------- 21 Degrees C.

Maximum Theoretical Specific Gravity (MSG) --------- 2.396

(Show all Work)

Answers:

1) Bulk Specific Gravity (BSG) ____________

2) BSG Corrected for Water bath Temperature ____________

3) % Air Voids __________
### BULK SPECIFIC GRAVITY and % AIR VOID
(Practice Problem #3)

#### Problem (A)

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<th>Compaction Temperature</th>
<th>Weight in Air (A)</th>
<th>SSD Weight (B)</th>
<th>Weight in Water (C)</th>
<th>Volume cc (D)</th>
<th>Actual Specific Gravity (E)</th>
<th>Max Theo. Specific Gravity (F)</th>
<th>% Air Voids</th>
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</thead>
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Water Temperature is 28 C

Avg. Specific Gravity

Corrected Avg. B.S.G. 2.443

#### Problem (B)

<table>
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<tr>
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<th>Weight in Air (A)</th>
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<th>Weight in Water (C)</th>
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<th>Max Theo. Specific Gravity (F)</th>
<th>% Air Voids</th>
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</tbody>
</table>

Water Temperature is 25 C

Avg. Specific Gravity

Corrected Avg. B.S.G. 2.405

#### Problem (C)

<table>
<thead>
<tr>
<th>Compaction Temperature</th>
<th>Weight in Air (A)</th>
<th>SSD Weight (B)</th>
<th>Weight in Water (C)</th>
<th>Volume cc (D)</th>
<th>Actual Specific Gravity (E)</th>
<th>Max Theo. Specific Gravity (F)</th>
<th>% Air Voids</th>
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</thead>
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<td>1202.2</td>
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<tr>
<td>290</td>
<td>1201.3</td>
<td>1201.9</td>
<td>690.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>290</td>
<td>1205.8</td>
<td>1207.8</td>
<td>685.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Water Temperature is 19 C

Avg. Specific Gravity

Corrected Avg. B.S.G. 2.438
# BULK SPECIFIC GRAVITY and % AIR VOID

(Practice Problem # 3 - Answer Sheet)

## Problem (A)

<table>
<thead>
<tr>
<th>Compaction Temperature</th>
<th>Weight in Air (A)</th>
<th>SSD Weight (B)</th>
<th>Weight in Water (C)</th>
<th>Volume cc (D)</th>
<th>Actual Specific Gravity (E)</th>
<th>Max Theo. Specific Gravity (F)</th>
<th>% Air Voids</th>
</tr>
</thead>
<tbody>
<tr>
<td>290</td>
<td>1318.0</td>
<td>1319.5</td>
<td>755.5</td>
<td>564.0</td>
<td>2.337</td>
<td></td>
<td></td>
</tr>
<tr>
<td>290</td>
<td>1183.9</td>
<td>1184.9</td>
<td>679.5</td>
<td>505.4</td>
<td>2.343</td>
<td></td>
<td></td>
</tr>
<tr>
<td>290</td>
<td>1350.8</td>
<td>1351.7</td>
<td>775.3</td>
<td>576.4</td>
<td>2.344</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Water Temperature – 28°C  
Avg. Specific Gravity: 2.341  
Corrected Avg. B.S.G.: 2.339  
2.443  4.3

## Problem (B)

<table>
<thead>
<tr>
<th>Compaction Temperature</th>
<th>Weight in Air (A)</th>
<th>SSD Weight (B)</th>
<th>Weight in Water (C)</th>
<th>Volume cc (D)</th>
<th>Actual Specific Gravity (E)</th>
<th>Max Theo. Specific Gravity (F)</th>
<th>% Air Voids</th>
</tr>
</thead>
<tbody>
<tr>
<td>290</td>
<td>1232.5</td>
<td>1233.0</td>
<td>702.8</td>
<td>530.2</td>
<td>2.325</td>
<td></td>
<td></td>
</tr>
<tr>
<td>290</td>
<td>1293.8</td>
<td>1294.8</td>
<td>735.6</td>
<td>559.2</td>
<td>2.314</td>
<td></td>
<td></td>
</tr>
<tr>
<td>290</td>
<td>1244.2</td>
<td>1244.8</td>
<td>707.7</td>
<td>537.1</td>
<td>2.317</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Water Temperature – 25°C  
Avg. Specific Gravity: 2.319  
Corrected Avg. B.S.G.: 2.319  
2.405  3.6

## Problem (C)

<table>
<thead>
<tr>
<th>Compaction Temperature</th>
<th>Weight in Air (A)</th>
<th>SSD Weight (B)</th>
<th>Weight in Water (C)</th>
<th>Volume cc (D)</th>
<th>Actual Specific Gravity (E)</th>
<th>Max Theo. Specific Gravity (F)</th>
<th>% Air Voids</th>
</tr>
</thead>
<tbody>
<tr>
<td>290</td>
<td>1202.2</td>
<td>1203.8</td>
<td>693.9</td>
<td>509.9</td>
<td>2.358</td>
<td></td>
<td></td>
</tr>
<tr>
<td>290</td>
<td>1201.3</td>
<td>1201.9</td>
<td>690.8</td>
<td>511.1</td>
<td>2.350</td>
<td></td>
<td></td>
</tr>
<tr>
<td>290</td>
<td>1205.8</td>
<td>1207.8</td>
<td>685.9</td>
<td>521.9</td>
<td>2.310</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Water Temperature – 19°C  
Avg. Specific Gravity: 2.339  
Corrected Avg. B.S.G.: 2.342  
2.438  3.9
## Field Test Worksheet

### Extraction, Dust Correction & Gradation

<table>
<thead>
<tr>
<th>SIEVE #</th>
<th>WEIGHT RETAINED</th>
<th>% PASSING</th>
</tr>
</thead>
<tbody>
<tr>
<td>2&quot;</td>
<td>SOLVENT</td>
<td>3040</td>
</tr>
<tr>
<td>1.5&quot;</td>
<td>DISH &amp; ASH</td>
<td>85.50</td>
</tr>
<tr>
<td>1.0&quot;</td>
<td>DISH</td>
<td>84.62</td>
</tr>
<tr>
<td>3/4&quot;</td>
<td>300</td>
<td></td>
</tr>
<tr>
<td>½&quot;</td>
<td>1220</td>
<td>MIN. in EFF.</td>
</tr>
<tr>
<td>3/8&quot;</td>
<td>1449</td>
<td></td>
</tr>
</tbody>
</table>

| SIEVE WEIGHT | 479.2 |

### Rice Test

| | (A) DRY WT. OF MIX | 1561.1 |
| | (A*) SSD WT. OF MIX | |
| | (B) CONT. OF MIX & WATER | 8428.1 |
| | (C) CONT. OF WATER (CONST) | 7501.1 |
| | (B - C) = (D) | |
| | (A* - D) = (E) | |
| | (A + E) = (F) | |

### Pills

<table>
<thead>
<tr>
<th></th>
<th>DRY WEIGHT (A)</th>
<th>SSD WEIGHT (B)</th>
<th>WT. IN WATER (C)</th>
<th>B - C (D)</th>
<th>A + D (E)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1208.7</td>
<td>1209.7</td>
<td>701.0</td>
<td></td>
<td>MSG (RICE)</td>
</tr>
<tr>
<td>2</td>
<td>1181.2</td>
<td>1182.4</td>
<td>681.9</td>
<td></td>
<td>% AIR VOID</td>
</tr>
<tr>
<td>3</td>
<td>1216.0</td>
<td>1216.7</td>
<td>708.5</td>
<td></td>
<td>AVG. BSG</td>
</tr>
</tbody>
</table>

WATER BATH TEMPERATURE = 26 C

CORR. BSG
# Field Test Worksheets (Answer Sheet)

## SIEVE #
<table>
<thead>
<tr>
<th>WEIGHT RETAINED</th>
<th>% PASSING</th>
<th>(A) DRY WT.. OF MIX</th>
<th>(A*) SSD WT. OF MIX</th>
<th>(B) CONT. OF MIX &amp; WATER</th>
<th>(C) CONT. OF WATER (CONST)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2&quot; SOLVENT</td>
<td>3040</td>
<td>1561.1</td>
<td>1561.9</td>
<td>8428.1</td>
<td>7501.1</td>
</tr>
<tr>
<td>1.5&quot; DISH &amp; ASH</td>
<td>85.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.0&quot; DISH</td>
<td>84.62</td>
<td>(B - C) = (D)</td>
<td>927.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3/4&quot;</td>
<td>300</td>
<td>(A* - D) = (E)</td>
<td>634.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>½&quot;</td>
<td>1220</td>
<td>(A + E) = (F)</td>
<td>2.459</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3/8&quot;</td>
<td>1449</td>
<td>PAN WEIGHT</td>
<td>479.2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## #4, #8, #16, #30, #50, #100, #200

<table>
<thead>
<tr>
<th>ORIG. WT.</th>
<th>EXT. WT.</th>
<th>NET WT.</th>
<th>BIT WT.</th>
<th>% AC</th>
<th>SSD Weight</th>
<th>1561.9</th>
</tr>
</thead>
<tbody>
<tr>
<td>1514</td>
<td>1644</td>
<td>1793</td>
<td>2024</td>
<td>2343</td>
<td>2748</td>
<td>2986</td>
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<td>47</td>
<td>43</td>
<td>38</td>
<td>30</td>
<td>18</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

## Mix & Pan Wt.

<table>
<thead>
<tr>
<th>MIX &amp; PAN WT.</th>
<th>DRY MIX &amp; PAN WT.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2986</td>
<td>2979</td>
</tr>
</tbody>
</table>

## Pan Wt.

<table>
<thead>
<tr>
<th>PAN WT.</th>
<th>% MOISTURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>483</td>
<td>0.3</td>
</tr>
</tbody>
</table>

## F/T Value

<table>
<thead>
<tr>
<th>F/T Value</th>
<th>F/A Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>+4</td>
<td>0.7</td>
</tr>
</tbody>
</table>

## WATER BATH TEMPERATURE = 26 C

<table>
<thead>
<tr>
<th>WATER BATH TEMPERATURE</th>
<th>AVG. BSG</th>
<th>CORR. BSG</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.376</td>
<td>2.375</td>
<td>3.4</td>
</tr>
</tbody>
</table>

## PILLS

<table>
<thead>
<tr>
<th>DRY WEIGHT (A)</th>
<th>SSD WEIGHT (B)</th>
<th>WT. IN WATER (C)</th>
<th>B - C (D)</th>
<th>A ÷ D (E)</th>
<th>MSG (RICE)</th>
<th>% AIR VOID</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 1208.7</td>
<td>1209.7</td>
<td>701.0</td>
<td>508.7</td>
<td>2.376</td>
<td>MSG (RICE)</td>
<td></td>
</tr>
<tr>
<td>2 1181.2</td>
<td>1182.4</td>
<td>681.9</td>
<td>500.5</td>
<td>2.360</td>
<td>2.459</td>
<td></td>
</tr>
<tr>
<td>3 1216.0</td>
<td>1216.7</td>
<td>708.5</td>
<td>508.2</td>
<td>2.393</td>
<td>% AIR VOID</td>
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</table>

## WATER BATH TEMPERATURE = 26 C

<table>
<thead>
<tr>
<th>WATER BATH TEMPERATURE</th>
<th>AVG. BSG</th>
<th>CORR. BSG</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.376</td>
<td>2.375</td>
<td>3.4</td>
</tr>
</tbody>
</table>
Section 3, Control Charts

441.10 ................................................................................................................. 2
441.10-1 Reference Table...................................................................................... 3
Air Void Practice Problem .................................................................................. 4
Asphalt Content Practice Problem ..................................................................... 5
Moving Range Example ....................................................................................... 6
441.10 Control Charts.

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

A. Plot tests showing the percent passing for the 1/2 inch (12.5 mm), No. 4 (4.75 mm), No. 8 (2.36 mm), and No. 200 (75 µm) sieves the percent asphalt binder content, the MSG and the percent air voids. Round all percentages to the nearest whole percent; except, round asphalt binder content, the No. 200 (75 µm) sieve, and air voids to the nearest 0.1 percent.

B. Show the out of specification limits specified in Table 441.10-1 and QCP Warning Band Limits on the control charts.

C. Label each control chart to identify the project, mix type and producer.

D. Record the moving accumulative range for three tests under each test point on the chart for air voids and asphalt binder content. Accumulative range is defined as the positive total of the individual ranges of two consecutive tests in three consecutive tests regardless of the up or down direction tests take. If more than the minimum required testing (i.e. two tests per production day or night, 441.09 first paragraph) is performed do not include the result in accumulative range calculations.

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

A. Any two tests in a row or any two tests in two days are outside OF the specification limits of Table 441.10-1.

B. Any four consecutive moving accumulative ranges greater than specification limits of 2.50 percent for air voids or 0.60 percent for asphalt binder content occur. Any mixture sent to the paving site without stopping production and notifying the Monitoring Team when required by this specification will be considered non-specification material.

Do not restart production until an adequate correction to remedy problems is in place and the Monitoring Team is satisfied. Following a shutdown restart production in a manner acceptable to the DET. When production problems cannot be solved within one day after a plant shut down a Contractor’s representative holding a Level 3 Asphalt Department approval is required to be at the asphalt plant until a full production day is achieved with results satisfactory to the Monitoring Team.
<table>
<thead>
<tr>
<th>Mix Characteristic</th>
<th>Out of Specification Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asphalt Binder Content[1]</td>
<td>-0.3% to 0.3%</td>
</tr>
<tr>
<td>1/2 inch (12.5 mm) sieve[1]</td>
<td>-6.0% to 6.0%</td>
</tr>
<tr>
<td>No. 4 (4.75 mm) sieve[1]</td>
<td>-5.0% to 5.0%</td>
</tr>
<tr>
<td>No. 8 (2.36 mm) sieve[1]</td>
<td>-4.0% to 4.0%</td>
</tr>
<tr>
<td>No. 200 (75 µm) sieve[1]</td>
<td>-2.0% to 2.0%</td>
</tr>
<tr>
<td>Air Voids[2]</td>
<td>2.5 to 4.5</td>
</tr>
<tr>
<td>Air Voids[3]</td>
<td>3.0 to 5.0</td>
</tr>
<tr>
<td>MSG[4]</td>
<td>-0.012 to 0.012</td>
</tr>
</tbody>
</table>

[1] deviation from the JMF
[2] for Design Air Voids of 3.5%
[3] for Design Air Voids of 4.0%
[4] deviation from the MTD
***When producing Asphalt Concrete Mix for an ODOT project which is governed under ODOT’s 441.10, you must plot each Individual Test Result and record the accumulative range (for AV and AC only) on a Control Chart.

Using the Test Results Provided below:
(1) Set up your control chart to include the Specification Band Limit and the QCP Warning Band Limit of (-3.2% to 4.8%) for plotting Air Void test results.

(2) After setting up your Control Chart, Plot each of the Individual Test Results and calculate the accumulative range results for the following Air Void Tests.

This is a 4.0% Air Void Designed Mix:

The First Air Void test result shows a 4.6%

The Second Air Void test result shows a 5.2%

The Third Air Void test result shows a 4.8%

The Fourth Air Void test result shows a 4.1%

The Fifth Air Void test result shows a 6.2%

The Sixth Air Void test result shows a 6.1%
***When producing Asphalt Concrete Mix for an ODOT project which is governed under ODOT’s 441.10, you must plot each Individual Test Result and record the accumulative range (for AV and AC only) on a Control Chart.

Using the Test Results Provided below:

(1)  Set up your control chart to include the Specification Band Limit and the QCP Warning Band Limit of (- 0.2% to 0.2%) for plotting Asphalt Content test results.

(2)  After setting up your Control Chart, Plot each of the Individual Test Results and calculate the accumulative range results for the following Asphalt Content Tests.

*The JMF Asphalt Content is a 5.8%*

The First Asphalt Content test result shows a 6.1%

The Second Asphalt Content test result shows a 6.1%

The Third Asphalt Content test result shows a 5.8%

The Forth Asphalt Content test result shows a 5.6%

The Fifth Asphalt Content test result shows a 5.5%

The Sixth Asphalt Content test result shows a 5.9%
MOVING RANGE EXAMPLE – AC%

<table>
<thead>
<tr>
<th>AC%</th>
<th>6.0</th>
<th>5.4</th>
<th>6.3</th>
<th>6.0</th>
<th>5.8</th>
<th>6.2</th>
<th>6.0</th>
<th>6.1</th>
<th>5.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diff.</td>
<td>-</td>
<td>0.6</td>
<td>0.9</td>
<td>0.3</td>
<td>0.2</td>
<td>0.4</td>
<td>0.2</td>
<td>0.1</td>
<td>0.6</td>
</tr>
<tr>
<td>Range</td>
<td>-</td>
<td>-</td>
<td>1.5</td>
<td>1.2</td>
<td>0.5</td>
<td>0.6</td>
<td>0.6</td>
<td>0.3</td>
<td>0.7</td>
</tr>
</tbody>
</table>

MOVING RANGE LIMITS*

<table>
<thead>
<tr>
<th></th>
<th>2.50%</th>
<th>0.60%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Voids</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AC</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*For four consecutive ranges

Notes:
- Used only for Air Voids and AC Graphs
- Only use the results obtained from the minimum, randomly selected, two QC tests/day

AC = 6.0-5.4=0.6 5.4-6.9=0.9 6.3-6.0=0.3 6.0-5.8=0.2 5.8-6.2=0.4 6.2-6.0=0.2
6.0-6.1=0.1 6.1-5.5=0.6 AC on two test and the difference
Range = 1\(^{st}\) Test=1.5 2\(^{nd}\) Test=1.2 3\(^{rd}\) Test=0.5 4\(^{th}\) Test=0.6 5\(^{th}\) Test=0.6 6\(^{th}\) Test=0.3 7\(^{th}\) Test=0.7
Section 4, Sampling Asphalt Concrete Mix:

Sampling Procedure................................................................. 3-8
Supplement 1035 (1-15-2016), .................................................. (3 pages)
Random Sampling Calculation .................................................. 13
Sampling Asphalt Concrete Mix

A. Sampling – General

1. Importance of Sampling

   a. Sampling helps determine quality of material accepted by ODOT

   b. Sampling helps determine proper payment to the contractor

      (1) Incentive pay above bid price
      (2) Full pay
      (3) Reduced pay

   c. Critical variables in construction

      (1) Materials
      (2) Production process
      (3) Sampling
      (4) Testing
      (5) Construction operations

   d. Deficiency in any of these is detrimental to achieving a quality pavement

2. Importance of Sampling Asphalt Concrete Mix

   a. Proper sampling of asphalt concrete mix is critical to determining specification compliance

   b. Correct procedure at all levels is essential

      (1) Components of the asphalt concrete mix are sampled or certified prior to production of the asphalt concrete mix
      (2) Asphalt concrete mix is sampled at production facility and at project
      (3) Sampling is performed by both contractor and ODOT personnel

The ODOT Sampling and Testing Manual provides guidance on sampling and testing requirements for ODOT personnel
B. Sampling Procedure

1. Concept of Sampling Procedure

   a. For many years, one sample was thought to be sufficient to represent a large quantity of material.

   b. In the late 1970s, ODOT introduced the emerging concept of statistically-oriented specifications, which used the principles of:

      (1) Random sampling
      (2) Using the average of multiple samples
      (3) Sampling from lots and sublots of material

2. Proper Sampling Procedure

   a. A sample is properly taken if it is....

      (1) Representative of the material
      (2) Properly randomized and in conformance with agency procedures

   b. An improperly taken sample can skew the results of the QC and acceptance procedure by indicating that....

      (1) Bad material is acceptable
      (2) Good material is not-approved

3. Value of Proper Sampling

   a. The material represented by a sample of the asphalt concrete mix can have a value of up to $50,000

   b. A sample taken improperly can result in....

      (1) ODOT accepting non-specification material
      (2) The contractor receiving reduced pay for material which meets specifications
      (3) The contractor having to remove and replace material which meets specifications
4. Sampling Before Production

   a. Approvals are responsibility of ODOT Office of Materials Management (Central Lab) in cooperation with District Testing Offices

   b. Coarse and fine aggregates are certified by producer and sampled by District Testing personnel at aggregate plants and asphalt concrete mix facilities

   c. Asphalt binder is certified by producer and check sampled by ODOT Central Lab

5. Sampling During Production at the Asphalt Concrete Mix Plant

   a. Most sampling at the asphalt concrete mix plant is performed by contractor's plant technician as part of quality control function

   b. ODOT personnel (Monitoring Team) observe sampling and testing at the asphalt concrete mix plant and take samples as part of verification acceptance process

6. Sampling at the Project

   a. ODOT personnel participate in acceptance sampling procedure at the project by determining location of random samples for 446 and taking samples of 448 when required

      (1) 446 sample core locations determined by random number calculation
      (2) 448 mix is sampled from road or hopper if construction or plant QC problems occur

C. Sampling Asphalt Concrete Mix Specification Items

1. Sampling 301 and 302

   a. Sampled at the asphalt concrete mix plant from truck selected at random by contractor's QC technician

   b. Monitoring team picks up "split samples" for testing by District Lab

2. Sampling 448

   a. Contractor's QC technician randomly selects truck, takes and tests samples for quality control at the asphalt concrete mix plant
b. Contractor’s QC technician takes and splits sublot acceptance samples from truck selected at random by Monitoring Team

c. Monitoring Team picks up split samples for testing at District Lab

d. If problems arise placing mix at project, such as segregation, or if QC problems persist at the asphalt concrete mix plant, Monitoring Team may require that acceptance samples be taken from paver hopper or from behind paver at locations selected randomly by project personnel

3. Sampling 446

a. Contractor is responsible for cutting cores from completed pavement at random locations determined by ODOT personnel

b. ODOT personnel are responsible for calculating random sampling locations and for making information available to contractor in a timely manner

c. ODOT personnel are responsible for taking immediate possession of and carefully handling cores cut from pavement to prevent damage

d. Cores are to be delivered to District Lab for testing as soon as possible

D. Sampling Materials

1. Sampling Aggregate
   a. Aggregate can be sampled at
      
      (1) Project
      (2) Asphalt Concrete Mix plant
      (3) Aggregate plant

   b. Aggregate can be sampled from
      
      (1) Roadway
      (2) Stockpile
      (3) Bin
      (4) Belt

   c. The proper sampling tools for taking an aggregate sample are:
      
      (1) A shovel with turned-up edges
      (2) A bag, bucket, or other suitable container
(3) Material for identifying the sample and attaching it to the container

2. Sampling Asphalt Binder

   a. Asphalt binder can be sampled from
      (1) Asphalt Concrete Mix plant
      (2) Asphalt terminal

   b. Proper equipment
      (1) Metal quart can
      (2) Gloves
      (3) Identification material

   c. Proper procedure
      (1) Let material flow before filling sample container

3. Sampling Tack and Prime

   a. Liquid asphalt for 407 Tack Coat and 408 Prime Coat shall be certified when delivered to project

   b. One sample per project of each is required unless amount used is a "small quantity"

   c. Sample from distributor or storage tank on project

      (1) One quart in plastic screw top container for tack (asphalt emulsion)

      (2) One quart in metal screw top container for prime (cutback asphalt)

4. Sampling Asphalt Concrete Mix

   a. Asphalt concrete mix is usually sampled from trucks at the asphalt concrete mix plant selected randomly

   b. Proper equipment
      (1) Shovel or scoop with turned-up edges
      (2) Sturdy metal container
      (3) Thermometer
      (4) Identification material
c. Asphalt concrete mix can be sampled at the project from the paver hopper or pavement behind the paver
d. It is sampled at random locations and in accordance with Supplement 1035
e. Proper equipment
   (1) Sampling tube for hopper
   (2) Plate sampler for pavement
   (3) Suitable metal container
   (4) Spatula, trowel, and nails
   (5) Identification material

E. Goal of Sampling

1. The goal of a sampling program is to provide a true representation of the materials used, and in that way contribute to building quality pavements

2. ODOT and contractor personnel can achieve this goal by the following
   a. Familiarity with construction materials
   b. Knowledge of sampling requirements
   c. Adherence to proper sampling methods
   d. Care in taking and processing samples
1035.01 General. Field samples of asphalt concrete will be selected by a random sampling procedure and taken from the mat behind the paver. If the mat thickness is less than 1.25 in (32 mm) the samples will be taken from the paver hopper. A sample form for determining and documenting the location of material in each sublot to be sampled is attached.

1035.02 Equipment. The equipment required for taking samples includes:

A. Spatula or scraping device
B. Clean sample pan
C. Asphalt concrete sampling tube
D. Clean metal plates, Three 10 in x 10 in (250 mm x 250 mm) for mat thickness of 1.25 to 2 in (32 to 50 mm)
E. Nails
F. Trowel or other form of lifting device

1035.03 Random Selection of Sample. Obtain four random samples, taken from within four sublots or partial lots, to represent each specified lot. Determine the particular location of material to be sampled by applying a random percent number, as obtained from a random number table or generator, to the total tonnage in the sublot or partial lot. Anticipate the location of production material selected in its particular truck and in the first, second, or last third fraction of that load. When the approximate location of material is being placed, take the sample.

1035.04 Sampling.

A. Mat - Place the plate in the path of the paver so the sample will be obtained when the desired ton is fed into the spreading screws. Determine where the plate will be located transversely from the edge of pavement by applying a second random percent number to the total width of the mat. If the transverse location selected is in imminent conflict with the paving equipment, the plate shall be moved laterally to the nearest suitable location within the mat width. Nails should be used to prevent the plate from sliding. Mark the location of the plate so
that after the paver has passed, the plate may be found by probing the mat with a trowel. The trowel may then be used to lift the plate and sample from the mat. Place the plate and sample into the sample pan.

B. Paver hopper – For safety samples are to be taken by Contractor personnel only. Samples are taken alternately from over right and left flight feeders when the desired ton is in the hopper. With the loading interrupted and the truck pulled away from the paver, the correct size of sampler is sunk into the mix to collect a proper sample. Material is deposited from the sampler into the sample pan. Fine materials are scraped from inside the sampler, placed in the pan, and the spatula is scraped on the side of the pan. Ensure a sample size not less than 22 lb (10 kg).

1035.05 Identification and Shipment. Complete the sample data card, place in an envelope, and wrap up with the pan. Tag and ship the wrapped sample to District Testing.
<table>
<thead>
<tr>
<th>Sublot</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Initial accumulative total of weight laid</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Sublot size or partial estimate</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Random percentage number from table</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Location in sublot to be sampled (2 X 3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Accumulative weight at sample location (1 + 4)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Initial accumulative total for next sublot (1 + 2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Station where sample taken</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Lane</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>*9. Width of mat</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>*10. Random percentage number from table</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>*11. Distance from edge (right or left) or pavement (9 X 10)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Location of sublot</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. Dates Placed</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Used when taking mat samples.*
Random Sampling Procedure

The Inspector in charge of sampling shall determine four (4), random two (2) digit numbers, from an approved table for each lot. These four (4), two (2) digit numbers shall be entered on the Asphalt Concrete Sampling Sheets. To determine the four (4) random numbers, start at a random point by placing a pencil aimlessly on the approved table of random digits.

**Example 1:** The pencil point picks digit 8, it’s in row 28 column 75. The digit 8 plus the next the next three (3) digits 541 gives row 85, column 41. In row 85 and column 41 find the digit 0 plus the next seven (7) digits to the right, they are 5405472.

These eight (8) digits give the four (4) random numbers 05, 40, 54, and 72.

Using these numbers as percentages, the random ton to be sampled is determined by multiplying the percentage number times the sub-lot or partial sub-lot size. If a lot is not a full lot and consists of maybe 2700 tons, then sublots A, B, & C would be 750 tons and sublot D (partial) would be 450 tons.

**Example Calculation of the Random Ton to be sampled for the Above Lot Size would be:**

- Sublot A = (.05 x 750) = 37.5 tons + 0 tons accumulative = 37.5 tons
- Sublot B = (.40 x 750) = 300 tons + 750 tons accumulative = 1050 tons
- Sublot C = (.54 x 750) = 405 tons + 1500 tons accumulative = 1905 tons
- Sublot D = (.72 x 450) = 324 tons + 2250 tons accumulative = 2574 tons

**If you needed a second set of random numbers for the width of the mat (see below)**

Get these numbers the same way as outlined in Example 1: New Numbers 09, 50, 67, and 75.

- Sublot A = (.09 x 12) = 1.0 foot from edge of mat
- Sublot B = (.50 x 12) = 6.0 feet from edge of mat
- Sublot C = (.67 x 12) = 8.0 feet from edge of mat
- Sublot D = (.75 x 12) = 9.0 feet from edge of mat

**Example 2:** If our pencil point picks the 3 at row 49, column 68, and our next 3 digits are 395. From here we go to row 33 column 95 and find the digit 3. To the right there are less than 7 digits on the table, so we must use the 7 digits to the left. They are 3205497. So the random numbers using this example would be 32, 05, 49, and 73.
Section 5, Supplemental Specifications and Supplements for Tests:

S 1036 – Determination of % Air Voids (10-21-2016) ------------------------ 4 pages
S 1037 – Determination of % Voids in VMA (4-18-2008) ------------------2 pages
S 1038 – Quantitative Extraction VMA (1-15-2016) ..................................4 pages
S 1039 – Mechanical Analysis of Extracted Aggregate (4-18-2008) .............2 pages
S 1043 – Calibration/Test Procedures for Nuclear AC Gauge(1-15-2016) ------- 8 pages
  Formula for Calculation of AC for Mixing ........................................... 1 page
  Nuclear Gauge Offset Example Form ..................................................2 pages
S 1054 – Test Method for Ignition Oven(4-18-2008) ....................................7 pages

SS 800 - REVISIONS TO THE 2016 CONSTRUCTION & MATERIAL SPECIFICATIONS, Asphalt items only (10/21/2016) ------------------ 7 pages

The latest updates of ODOT Supplemental Specifications and testing supplements may be downloaded from the ODOT website at

http://www.dot.state.oh.us/Divisions/ConstructionMgt/OnlineDocs/Pages/ProposalNotesSupplementalSpecificationsandSupplements.aspx

2016 - ODOT Construction and Material Specifications may be downloaded from the ODOT website at

http://www.dot.state.oh.us/Divisions/ConstructionMgt/OnlineDocs/Pages/2016-Online-Spec-Book.aspx

may be downloaded from the ODOT website at

Section 6, AASHTO Standard test methods

T-30 Mechanical Analysis of Extracted Aggregate (2015) __________ 6 pages
T-209 Maximum Specific Gravity (2012), ________________________15 pages
T-245 Mixing and Compacting a Marshall Specimen (2015), ______ 7 pages
T-166 Bulk Specific Gravity Testing (2016), _____________________7 pages
T-269 Air Void Calculation Procedure (2014), ____________________4 pages

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