LabCAT Level A

Colorado Procedures CP's

CP - 30
CP - 41
CP - 44
CP - 75
CP - 81
Cp - 82

Colorado Procedure 30-09

Standard Practice for

Sampling of Aggregates

(This procedure is based upon AASHTO T 2-91. AASHTO T 2-91 or any subsequent revision may not be used in place of this procedure.)

1. SCOPE

1.1 These methods are intended to apply to the sampling of aggregates used in acceptance and quality control from the points of acceptance designated in the Schedule for Minimum Materials Sampling, Testing, and Inspection for the following items:

Item 206 - Structure Backfill, Filter Material, Bed Course Material
Item 304 - Aggregate Base Course
Item 308 - Aggregate for Portland Cement Treated Base
Item 403 - Aggregates for Hot Mix Asphalt
Item 409 - Cover Coat Material
Item 412 - Aggregate for Portland Cement Concrete Pavement
Item 601 - Aggregate for Structural Concrete
Item 608 - Aggregate for Concrete Sidewalk, Bituminous Sidewalk, Concrete Bikeways and Bituminous Bikeways
Item 609 - Aggregate for Concrete Curbing and Bituminous Curbing
Item 610 - Aggregate for Median Cover Material

NOTE 1: Sampling plans and the acceptance and control tests vary with the type of construction in which the material is used.

1.2 The values stated in English units are to be regarded as the standard. The values in parentheses are provided for information purposes only.

1.3 This standard may involve hazardous materials, operations and equipment. This standard does not purport to address all of the safety problems 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 *Colorado Procedure:*
CP 75 Stratified Random Sampling of Materials

3. SIGNIFICANCE AND USE

3.1 Sampling is equally as important as the testing, and the sampler shall use every precaution to obtain samples that will show the nature and condition of the materials which they represent.

3.2 Samples of all aggregates used in HMA and being tested by the Colorado Department of Transportation (CDOT) or its representative shall be taken by the contractor or his representative with an authorized representative of CDOT present during the sampling procedure. Samples of all non-HMA aggregates being tested by CDOT or its representative shall be taken by or, at CDOT's option, witnessed by an authorized representative of CDOT. The CDOT representative present shall take immediate possession of all samples taken. CDOT reserves the right to designate the locations to be sampled and the procedure to be used.

4. SECURING SAMPLES

4.1 *General* · Where practicable, a minimum of one sample per stockpile to be tested for quality shall be obtained from the finished product. Samples from the finished product to be tested for abrasion loss shall not be subject to further crushing or manual reduction in particle size in preparation for the abrasion test, unless the size of the finished product is such that it requires further reduction for testing purposes.

4.2 *Sampling Equipment*. The contractor shall provide suitable equipment needed for proper sampling.

4.3 Procedure:

4.3.1 *Sampling from a Flowing Aggregate Stream* - Samples shall be selected from all of the material produced using CP 75. Use extreme care to avoid segregation when sampling. Sampling the initial discharge or the final few tons from a bin or conveyor belt increases the chances of obtaining segregated material and should be avoided.

4.3.1.1 *Belt Discharge*:

4.3.1.1.1 *Belt Discharge using Hand Tools* - If it is safe and practical to sample directly from the belt discharge, hand tools may be used. Obtain one or more approximately equal increments, selected at random. Combine to form a field sample whose mass equals or exceeds the minimum recommended in Subsection 4.4.2. Take each increment from the entire cross section of the material as it is being discharged using a container at least 12 in. (30 cm) in diameter (or minimum lateral dimension) and having sufficient capacity to hold the sample increment. Make several quick passes through different sections of the material rather than one slow pass. A sampling platform or other means are required to enable the sampler to safely stand within 2 ft. (0.6 meters) of the belt discharge.

4.3.1.1.2 *Belt Discharge using an Automatic Belt Sampler* - Belt discharge samples may be taken using an automatic belt sampler designed to cut the full discharge of the belt without loss of any portion of the material. Take one or more field samples whose combined mass equals or exceeds the minimum recommended in Subsection 4.4.2.

4.3.1.1.3 *Belt Discharge using Power Equipment* - A belt discharge sample may be taken by positioning a front-end loader bucket, truck, or similar equipment beneath the belt discharge. The material obtained shall be placed in a separate, small sampling pile and sampled according to Subsection 4.3.3.2. Obtain a field sample whose mass equals or exceeds the minimum recommended in Subsection 4.4.2.

4.3.1.2 *Bin Discharge* - Test results obtained using bin discharge samples shall not be used for acceptance.

4.3.1.3 *Dry Batch* - When sampling a dry batch, an initial dry batch must be wasted. A second batch may then be sampled as follows. A front-end loader bucket, truck, or similar equipment is positioned under the pugmill to obtain a large sample in one increment. Sample the material according to Subsection 4.3.3.2. Extreme care must be used to avoid segregation and loss of dust sized particles from the sample.

4.3.2 *Sampling from the Stopped Conveyor Belt* Samples shall be selected from all of the material being produced by CP 75 Obtain one or more approximately equal increments and combine to form a field sample whose mass equals or exceeds the minimum recommended in Subsection 4.4.2. Stop the conveyor belt while the sample increments are being obtained. To obtain each increment, insert two templates, the shape of which conforms to the shape of the belt into the aggregate stream on the belt, and space them such that the material contained between them will yield an increment of the required weight. Carefully scoop all material between the templates into a suitable container and collect the fines on the belt with a brush and dustpan and add to the container.

4.3.3 *Sampling from Stockpiles* - When sampling from stockpiles, it may be difficult to obtain representative samples. Sampling from stockpiles should only be done by or under the direction of experienced personnel. When sampling stockpiles of coarse or coarse and fine aggregates, power equipment, when available, should be utilized as described in Subsections 4.3.3.1 and 4.3.3.2. For general guidance in sampling from stockpiles, see Subsections 4.3.3.1 or 4.3.3.3. When sampling Cover Coat Material from the stockpile, the sample shall be taken from the last stockpile prior to delivery to the spreader. The material will be sampled by the random sampling procedure as it is being delivered to the stockpile, or as it is being removed and hauled to the spreader. This will assure that all portions of the material will be sampled.

4.3.3.1. When using power equipment, develop a separate, small sampling pile composed of materials drawn from various levels and locations in the main pile as follows. Remove material from the sides of stockpiles to expose a representative face for sampling. Judgment must be used to determine the number and locations of areas in the big pile to sample in order to represent the stockpile as accurately as possible. The number of portions required will depend on the size of the stockpile, the method of stockpiling, and the visual degree of segregation. Channel the faces thus exposed from bottom to top and sample the material obtained according to Subsection 4.3.3.2.

4.3.3.2 The power equipment should combine the material obtained in a separate small sampling pile. Flatten the pile to form a pad having depth that is not thicker than approximately 1 ft. (0.3

meters). Use a flat, square end shovel and sample the pad from at least three locations, sampling through the full depth of the pad if possible. Several increments shall be combined to compose a field sample whose mass equals or exceeds the minimum recommended in Subsection 4.4.2.

4.3.3.3 Where power equipment is not available, samples from stockpiles should be made up of at least two sets of three increments (180 degrees apart) taken from the top third, at the midpoint, and at the bottom third of the volume of the pile. Place a board or metal shelf vertically into the pile just above the sampling point to prevent loose aggregate from sliding into the sampling area and to aid in preventing segregation. Remove approximately 6 inches (15 cm) of surface material. Use a flat, square end shovel or scoop with sides for sampling. In sampling stockpiles of fine aggregate (3/8 in. (minus 9.5 mm)), the outer layer, which may have become segregated, should be removed and the sample taken from the material beneath. The use of sampling tubes has proven to be satisfactory. Sampling tubes approximately 1 1/4 in. (30 mm) minimum in width by 6 ft. (2 m) in length may be inserted into the pile at random locations to extract a minimum of five increments of material to form the sample. Several increments shall be combined to compose a field sample whose mass equals or exceeds the minimum recommended in Subsection 4.4.2.

4.3.4 *Sampling from Roadway (Bases and Sub-bases)* - Select material to be sampled from all of the material produced (e.g. A station or tonnage) by utilizing CP 75. Obtain at least three approximately equal increments, selected at random from the unit being sampled, and combine to form a field sample whose mass equals or exceeds the minimum recommended in Subsection 4.4.2. Using a flat, square end scoop or shovel, take all sample increments from the roadway for the full depth of the material, wherever possible, taking care to exclude any underlying material.

4.3.5 *Sampling Aggregates from Processed Windrows* - Select material to be sampled from all of the material produced using CP 75. For processed material containing sufficient moisture to maintain a near vertical face, remove material from one side toward the center to the full depth until a representative face is exposed. Channel the face just exposed from bottom to top and obtain a sample whose mass equals or exceeds the minimum recommended in Subsection 4.4.2 by combining portions from at least three equally spaced locations on the exposed face. Use a flat, square end shovel and, exercising care, remove the portions making sure that particles do not roll off the shovel.

4.3.6 *Sampling Aggregates from a Cover Coat Material Spreader* - Samples shall be taken at the last possible location prior to placement on the pavement. With the spreader stopped, samples will be taken from a minimum of three of the individual chip spreader gates as the aggregate is falling from the spreader to the sample container placed on the pavement. These samples will be combined into one sample whose mass equals or exceeds the minimum requirements shown in Subsection 4.4.2. If there is a belt transfer device on the spreader, the Engineer may approve obtaining a representative sample from the belt when the machine is at rest as detailed in Subsection 4.3.2. If neither of these sampling methods are possible, the Engineer may allow random sampling from the stockpile as detailed in Subsection 4.3.3.

4.4 Number and Mass of Field Samples:

4.4.1 The minimum number of field samples required is specified in the CDOT Field Materials Manual under the Schedule for Minimum Materials Sampling, Testing, and Inspection.

4.4.2 The minimum mass for lab samples is given in the CDOT Field Materials Manual in the Schedule for Minimum Materials Sampling, Testing, and Inspection. The minimum mass for field samples is given in Table 30-1. The sample must be large enough to include representative portions of each component of the material. The mass must be predicated on the type and number of tests to which the material is to be subjected and with sufficient material obtained to provide for the proper execution of these tests.

TABLE 30-1: Size of Field Samples

Nominal Maximum Size of Aggregates [A]		Approximate Minimum Mass of Field Samples, lbs. (kg)	
Fine Aggregate:			
No. 8	(2.36 mm)	10	(5)
No.4	(4.75 mm)	10	(5)

Coarse Aggregate:

3/8 in.	(9.5 mm)	15	(7)
1/2 in.	(12.5 mm)	20	(10)
3/4 in.	(19.0 mm)	25	(12)
1 in.	(25.0 mm)	30	(15)
1 1/2 in.	(37.5 mm)	40	(20)
2 in.	(50.0 mm)	45	(22)
2 1/2 in.	(63.0 mm)	50	(25)
3 in.	(75.0 mm)	55	(27)
3 1/2 in.	(90.0 mm)	60	(30)

[A] For processed aggregate, the nominal maximum size is defined in the Appendix to the CDOT Field Materials Manual.

5. SHIPPING SAMPLES

5.1 Transport aggregates in bags or other containers so constructed as to preclude loss or contamination of any part of the sample, or damage to the contents from mishandling during shipment. Do not ship more than 60 lbs. (30 kg) per bag to allow for easier handling of samples. When moisture content is being measured in the aggregate sample, the representative sample must be stored in a sealed container that will prevent any moisture loss.

5.2 Shipping containers for aggregate samples shall have suitable individual identification attached and enclosed so that field reporting, laboratory logging, and test reporting may be facilitated. **Utilization of CDOT Form #633, Sample Tag (for Sacks), is required for all submitted samples.**

Colorado Procedure 41-19

Standard Practice for

Sampling Hot Mix Asphalt

(This procedure is based upon AASHTO T 168-91. AASHTO T 168-91 or any subsequent revisions may not be used in place of this procedure.)

1. SCOPE

1.1 This procedure covers sampling of hot mix asphalt (HMA) at points of manufacture, storage, or delivery.

1.1.1 Samples obtained by this procedure may be used for acceptance and quality control of hot mix asphalt (HMA).

1.2 This Standard may involve hazardous materials, operations, and equipment. This Standard does not purport to address all of the safety problems 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.

1.3 The values stated in acceptable English units are to be regarded as the standard. The values in parentheses are provided for information purposes only.

2. REFERENCED DOCUMENTS

2.1 *Colorado Procedures:*

CP 75 Stratified Random Sampling of Materials

3. SIGNIFICANCE AND USE

3.1 *General:*

3.1.1 Sampling is equally as important as the testing, and the sampler shall use every precaution to obtain samples that will yield an acceptable estimate of the nature and conditions of the materials which they represent.

3.1.2 Care shall be taken in sampling to avoid segregation of the material being sampled. Care shall be taken also to prevent contamination by dust or other foreign matter.

3.1.3 Samples to be used for acceptance or assurance testing shall be taken by the contractor or his representative. An authorized representative of the Colorado Department of Transportation shall be present during the sampling procedure. The CDOT Representative present shall take immediate possession of all samples taken. CDOT reserves the right to designate the method and location of material to be sampled.

4. PROCEDURE, GENERAL

4.1 *Sampling Equipment* - The contractor shall provide equipment needed for safe and appropriate sampling.

4.2 *Sample Handling* - Combine all sample increments. Place sample in a container with 3 to 4 gallon capacity, made of at least 30 gauge non-galvanized metal, having a "bail" type handle and a tight fitting lid.

4.3 *Sampling* - The procedures for selecting samples are described in CP 75. The material shall be sampled using stratified random sampling from all of the material delivered to the job site.

METHOD A - TUBE SAMPLER

5. APPARATUS

5.1 Tube sampler, with a minimum of 2-7/8 in. (73 mm) inside diameter, 16 gauge minimum thickness, and a length and diameter that are variable with desired test specimen size.

5.2 Tube sampler holder with a metal collar into which the sampler fits, with a 3 ft. (1 m) handle or a tube sampler holder with suitable arm arrangement to hold two tube samplers, which can be positioned directly beneath the discharge opening.

5.3 Containers for transporting samples shall have 3 to 4 gallon capacity, be made of at least 30 gauge non-galvanized metal, have a "bail" type handle and a tight fitting lid.

6. PROCEDURE

6.1 Batch Plant and Storage Silos - Insert one or two tube samplers into the sampler holder arm while the arm is swung away from the discharge. Obtain one or more samples from the material being loaded into a single truck using one of the following methods: (1) during discharge of mixture, swing the arm holding the tube(s) through the discharge stream at a rate fast enough to obtain a representative sample filling the tube(s) or (2) prior to the discharge, center the sampling tube(s) directly under the discharge flow. After the mixture has been discharged, return the apparatus to the storage position away from the point of discharge and remove the tube(s). Strike off any material above the top rim of the tube sampler.

METHOD B - POINT OF DELIVERY

7. APPARATUS

7.1 Small flat scoop with vertical sides or square ended shovel.

7.2 Container for transporting samples shall have 3 to 4 gallon capacity, be made of at least 30 gauge non-galvanized metal, have a "bail" type handle and a tight fitting lid.

8. PROCEDURE

8.1 *Sampling from the Windrow Prior to Laydown* - Select three or more locations at random from the windrow. Samples of the windrow shall be secured at each location by removing material from one side of the windrow through the full depth to expose a face. Using the flat scoop, or a square shovel with sides, trench the exposed face from bottom to top, taking care to avoid segregation of particle sizes. Combine the samples from the different locations to obtain the required sample size as specified in Section 11.

8.2 *Sampling from Paving Machine Augers* - While the paver is in motion, observe the operation of the augers, which transport the mixture from the slat feeders to either side of the paver. These augers should be operating eighty percent or more of the time and be at least two-thirds covered with the mixture, if this is not the case, samples taken from the screws may be segregated and this method of sampling should not be used.

8.2.1 If the conditions of Subsection 8.2 are met, obtain at least three approximately equal increments of mixture ahead of the augers which transport the mixture from the slat feeders to either side of the paver as follows: insert the flat scoop or shovel into the mixture and remove the portion with minimal loss of the larger particles.

8.3 *Sampling from a Conveyor Belt* --CDOT does not utilize this sampling technique.

METHOD C - BEHIND PAVER

9. APPARATUS

9.1 Small flat scoop, square ended shovel with vertical sides, or sampling device similar to Figure 41-1.

9.2 Container for transporting samples shall have 3 to 4 gallon capacity, be made of at least 30 gauge non-galvanized metal, have a “bail” type handle and a tight fitting lid.

10. PROCEDURE

10.1 *Sampling from the Roadway Prior to Compaction* - Obtain at least three approximately equal increments, at a longitudinal location selected at random using CP 75, and combine to form a field sample whose quantity equals or exceeds the minimum recommended in Section 11.

10.1.1 Obtain all increments from the roadway immediately behind the machine for the full depth of the material, taking care to exclude any underlying material. Locate the sampling position across the width of the roadway using CP 75. When necessary, place templates on the existing roadway to exclude any underlying material. Clearly mark the specified area from which each increment or sample is to be removed. Templates, which are placed before the mixture is spread, will be a definite aid in securing approximately equal increment weights.

10.2 *Sampling from Roadway after Compaction* - Select the areas to be sampled using CP 75 from the material in place. Obtain at least three approximately equal increments selected from the area being sampled. Take all increments from the roadway through the full depth of the material, taking care to exclude any underlying material. Each increment shall be obtained by coring, sawing, or other methods in such a manner as to ensure a minimum disturbance of the material.

11. SIZE OF SAMPLE

11.1 *Number and Quantities of Field Samples:*

11.1.1 The number of field samples required is specified in the Schedule for Minimum Materials Sampling, Testing, and Inspection contained in the CDOT Field Materials Manual. The CDOT Field Materials Manual specifies the quantities of sample required for testing in the Central Laboratory and the Region Materials Laboratory. Project field tests will require a minimum sample size of 30 lbs (14 kg).

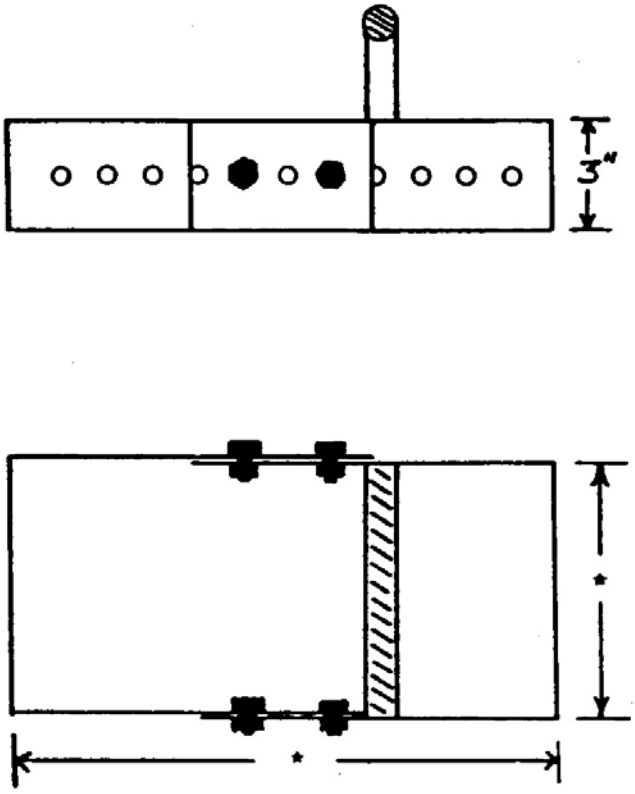
12. SHIPPING SAMPLES

12.1 Transport samples in a container with a 3 to 4 gallon capacity, made of at least 30 gauge non-galvanized metal, having a “bail” type handle and a tight fitting lid so constructed as to preclude loss or contamination of any part of the sample, or damage to the contents from mishandling during shipment.

12.2 Samples shall have individual identification attached providing the information required by the sample user. **Utilization of CDOT Form 633, Sample Tag (for Sacks), is required for all submitted samples.**

13. RECORD

13.1 Document information on CDOT Form 633 or Form 1304.



*Shape and area variable to accomodate sample size required.

Sampler is placed in the uncompacted lift directly behind paver and all material is removed.

FIGURE 41-1

{Page Intentionally Left Blank}

Colorado Procedure 44-19

Standard Method of Test for

Bulk Specific Gravity and Percent Compaction of Compacted Bituminous Mixtures Using Saturated Surface-Dry Specimens

(This procedure is based upon AASHTO T 166-13. AASHTO T 166-13 or any subsequent revisions may not be used in place of this procedure.)

1. SCOPE

1.1 These test methods cover the determination of bulk specific gravity of specimens of compacted bituminous mixtures as defined in ASTM E 1547, Terminology Relating to Industrial and Specialty Chemicals.

1.2 The bulk specific gravity of the compacted bituminous mixtures may be used in calculating the unit weight of the mixture.

2. REFERENCED DOCUMENTS

2.1 *AASHTO Standards*:
M 231 Weighing Devices Used in the Testing of Materials

2.2 *ASTM Standards:*
D 2726 Test Method for Bulk Specific Gravity and Density of Non-Absorptive Compacted Bituminous Mixtures
E 1547 Terminology Relating to Industrial and Specialty Chemicals

2.3 *Colorado Procedures:*
CP 51 Determining the Maximum Specific Gravity of HMA

CP-L 5115 Preparing &Determining the Density of Bituminous Mixture Test Specimens Compacted by the Superpave Gyratory Compactor

3. SIGNIFICANCE AND USE

3.1 This procedure covers and describes two test methods for determining bulk specific gravity in order to calculate the percent relative compaction of Hot Mix Asphalt.

4. TERMINOLOGY

4.1 Definitions:

4.1.1 *Constant Mass* – The mass at which further drying at either temperature as noted in Subsection 10.4 for two hours does not alter the mass.

5. TEST SPECIMENS

5.1 Test specimens may be either laboratory-molded bituminous mixtures or from the bituminous pavements. The mixtures may be surface or wearing course, or leveling course.

5.2 Size of Specimens--It is recommended (1) that the diameter of cylindrically molded or cored specimens, or the length of the sides of sawed specimens, be at least equal to four times the maximum size of the aggregate; and (2) that the thickness of specimens be at least one-and-one-half times the maximum size of the aggregate.

5.3 Pavement specimens shall be taken from pavements with a core drill, a diamond or Carborundum saw, or by other suitable means.

5.4 Care shall be taken to avoid distortion, bending, or cracking of specimens during and after the removal from pavement or mold. Specimens shall be stored in a safe, cool place.

5.5 Specimens shall be free from foreign materials such as seal coat, tack coat, foundation material, soil, paper, or foil.

5.6 If desired, specimens may be separated from other pavement layers by sawing or other suitable means.

6. APPARATUS

6.1 *Balance* – Conforming to the requirements of AASHTO M 231, for the class of balance required for the principle sample weight of the sample being tested. The balance shall be equipped with suitable suspension apparatus and holder to permit weighing the specimen while suspended from the center of scale pan or balance.

6.2 *Suspension Apparatus* -- Wire suspending the container shall be the smallest practical size at the point where it penetrates the water's surface to minimize any possible effects of a variable immersed length. The suspension apparatus shall be constructed to enable the container to be immersed to a depth sufficient to cover it and the test sample during weighing without contacting the bottom of the water bath.

6.3 *Water Bath* -- For immersing the specimen in water while suspended under the balance, equipped with an overflow outlet for maintaining a constant water level.

6.4 *Damp Towel* -- Flannel or terry cloth towel.

6.5 *Oven* – If using Method B (Rapid Test), a forced draft oven capable of maintaining 230°F ± 9° (110°C ± 5°).

6.6 *CoreDry™* – If using Method C (CoreDry™ Test), a CoreDry unit from Instrotek® Inc.

METHOD A

7. PROCEDURE

7.1 Method A shall be used for laboratory compacted specimens only.

7.2 Laboratory compacted specimens, which have not been exposed to moisture, do not require additional drying. Cool the specimen to room temperature at 77°F ± 9° (25°C ± 5°). Samples must not feel warm to the touch. Record the dry mass A. If laboratory compacted specimens are wetted before the dry mass is determined, dry them as specified in Subsection 10.4 once the immersed mass and surface-dry mass have been determined. Immerse each specimen in water at 77°F ± 1.8° (25°C ± 1°) for 4 ± 1 minutes and record the immersed mass, C. Remove the specimen from the water, damp dry the specimen by blotting it as quickly as possible with a flannel cloth or terry cloth towel which has been thoroughly wetted and wrung out, then immediately determine the surface-dry mass, B. The objective of blotting is to remove all of the surface water without losing any water that has been absorbed into the sample. Any water that seeps from the specimen during the weighing operation is considered part of the saturated specimen.

Note 1: If desired, the sequence of testing operations may be changed to expedite the test results. For example, first the immersed mass (C) can be taken, then the surface-dry mass (B) and finally the dry mass (A).

8. CALCULATIONS

8.1.1 Calculate the bulk specific gravity of the specimens as follows (round and report the value to the nearest three decimal places):

$$\text{Bulk Specific Gravity} = \frac{A}{(B - C)}$$

Where:
A = Mass (in grams) of sample in air,
B = Mass (in grams) of surface-dry specimen in air,
C = Mass (in grams) of sample in water.

8.2 Calculate the percent water absorbed by the specimen (on volume basis) as follows:

$$\text{Percent Water Absorbed by Volume} = \frac{(B - A)}{(B - C)} \times 100$$

9. RECORD

9.1 No CDOT Form, record on your own worksheet.

METHOD B (RAPID TEST)

10. PROCEDURE

10.1 Method B shall be used for pavement cores.

10.2 This procedure can be used for testing specimens, which are not required to be saved, and which contain substantial amounts of moisture. Specimens obtained by coring or sawing can be tested the same day by this method. Specimens obtained by coring or sawing shall be tested using Method B or C and shall not be tested using Method A.

10.3 The testing procedure to determine the immersed mass (C) and the surface dry mass (B) shall be the same as given in Section 7. The dry mass (A) of the specimen is determined last, as per Subsection 10.4.

10.4 Determine and record the weight of a large flat bottom drying pan and place the weighed specimen into the pan. For Forced Draft Ovens, place the pan and specimen in a 230°F ± 9° (110°C ± 5°) oven. For 5½ in. (140 mm) diameter or larger cores, or for porous or wet cores, leave the specimen in the oven until it can be easily separated into pieces not larger than 2 in. (50 mm) in diameter. Use extreme caution not to lose any portion of the original specimen while separating it. Replace the separated specimen in the oven. Document the start time. Dry all of the specimen(s) for 3 hours minimum and determine the weight at that time, (record the time). After an additional 2 hours of drying determine the weight at the time, (record the time if needed). The drying of the specimen can be stopped at this minimum of 5 total hours if constant mass is reached. Continue the drying and weighing at 2-hour intervals until constant mass is reached, up to the 24-hour maximum period. Determine the final weight of the heated specimens and use this weight as the dry mass A in the equation in Subsection 8.1.

METHOD C (COREDRY™ TEST)

11. PROCEDURE

11.1 Method C may be used for pavement cores in place of Method B.

11.2 This procedure can be used for testing specimens, which can be saved, and which contain substantial amounts of moisture. Specimens obtained by coring or sawing can be tested the same day by this method. Specimens obtained by coring or sawing shall be tested using Method B or C and shall not be tested using Method A.

11.3 The testing procedure to determine the immersed mass (C) and the surface dry mass (B) shall be the same as given in Section 7. The dry mass (A) of the specimen is determined last, as per Subsection 11.4.

Note 2: If desired, the sequence of testing operations may be changed to expedite the test results. For example, first the dry mass (A) can be taken, then the immersed mass (C), and finally the surface-dry mass (B).

11.4 Turn CoreDry™ to ON position. Allow the CoreDry™ to warm up and go through preparation cycles until the "System Ready" prompt appears. Allow cores to warm to room temperature and towel dry the surface of cores if there is free standing moisture on the surface. Place core on side on wire mesh in the vacuum chamber. Clean any ice or moisture out of moisture trap with a lint free cloth. Place lids on vacuum chamber and moisture trap and press START. CoreDry™ will cycle until drying is complete and chamber will pressurize so lids can be freely removed. If moisture is visible on core surface clean moisture trap and repeat drying process. Determine the final weight of the dried specimens and use this weight as the dry mass A in the equation in Subsection 8.1.

12. CALCULATIONS

12.1 Calculate the bulk specific gravity as shown in Subsection 8.1.

12.2 Calculate percent relative compaction as follows:

$$\text{Percent Relative Compaction} = \frac{\text{Bulk Sp. Gravity}}{\text{Max. Sp. Gravity}} \text{ X } 100$$

Note 3: Max. Sp. Gr. information is in CP 51.

12.3 Calculate the percent air voids as follows:

$$\text{Air Voids} = 100 - \text{Percent Relative Compaction}$$

12.4 Calculate the VMA as follows:

$$VMA = 100 - \frac{G_{mb}P_s}{G_{sb}}$$

Where:
VMA = Voids in mineral aggregate in percent of bulk volume,
G_{sb} = Bulk specific gravity of the aggregate,
G_{mb} = Bulk specific gravity of compacted mix,
P_s = Aggregate, percent by total weight of mix.

13. PRECISION

13.1 Duplicate specific gravity results by the same operator should not be considered suspect unless they differ more than 0.020.

14. RECORD

14.1 CDOT Form 582 is to be used as applicable.

Colorado Procedure 75-08

Standard Practice for

Stratified Random Sampling of Materials

1. SCOPE

1.1 This practice covers the random selection of materials to be sampled and tested.

1.2 This Standard may involve hazardous materials, operations, and equipment. This Standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this Standard to establish appropriate safety and health practices prior to use.

2. REFERENCED DOCUMENTS

2.1 *ASTM Standard:*

D 3665 Standard Practice for Random Sampling of Construction Materials.

3. SIGNIFICANCE AND USE

3.1 The sampling and testing procedures to be followed are specified in the procedures of the tests required.

3.2 The sampling of materials is one of the most critical steps in materials testing. If the material to be tested to determine conformity to specifications is not chosen randomly, the tests will not reflect the true characteristics of the material being evaluated. Most specifications require samples to be taken using a stratified random process. Stratified random requires that one random sample is selected from each sublot or the quantity represented by the minimum sampling frequency. Stratified random sampling ensures that samples are selected uniformly throughout the entire production process.

3.3 Random sampling ensures that all produced material will have an equal chance of being selected for testing. No material is excluded from the chance of being selected unless it is specified in the test specification.

3.4 It is the nature of random testing that some of the samples will represent below average material, just as they will sometimes represent above average material.

3.5 Random number schedules should be predetermined using an established random process. CDOT has developed a random schedule program that can be used for sampling all construction materials. The *Random Schedule* program is included in the Asphalt03 and Voids03 computer programs. Random number schedules used for sampling should not be shared with the supplier before the sample is taken. Contractors can generate their own random number schedules as needed using the computer program. Extra samples may be taken for the contractor's use at the time of sampling.

3.6 Stratified random sampling is called for in most of CDOT's specifications. However, some specifications have a minimum sampling frequency of one per day. Regardless of the quantity produced that day one sample is still required. A predetermined random sampling schedule has no way of knowing what the daily production will be. It is the responsibility of the tester to ensure that the minimum sampling frequency is met in these cases. Other specifications require that a minimum number of samples to be taken regardless of the produced quantity. In these cases the planned quantity is divided by the number of required samples to determine the sampling frequency. A stratified random schedule should be generated using the new sampling frequency.

4. CDOT's RANDOM SCHEDULE PROGRAM

4.1 CDOT's random schedule program is contained in both the Asphalt03 and Voids03 computer programs, found under Tools. It is written in Microsoft Excel and can be used to generate a random sampling schedule for all materials.

5. GENERATING A RANDOM SCHEDULE

5.1 Open the *Random Schedule* program. Enable the macros when asked. Instructions for using the program are included in the Instructions

worksheet. Read through the instructions before using the program. The program requires that Excel's Analysis ToolPak - VBA be installed before the macros will run properly. Follow the instructions on the Instructions worksheet to do this.

5.2 Move to the "Rand Nos" worksheet. Enter the project information into the green shaded cells. Click the "Clear No's" button to clear the worksheet. Click the "Generate Random Numbers" button to generate a set of random numbers. Click the "Print" button to print the random number schedule.

5.2.1 The random schedule program has the option of generating offset random numbers. Offset numbers are used to find a random transverse location. For example, the correct random location for a mat density test is the combination to two random numbers, the longitudinal (along the length of the pavement) and transverse (across the width of the pavement). The generation of transverse numbers can be turned off by changing the cell for generating offset numbers to "No". The "Transverse_Convert" worksheet contains a table that can help you convert the transverse random number into feet and inches based on the width of the pavement.

5.2.2 The random schedule program can only generate up to 70 numbers at one time. To generate numbers in excess of 70 follow the instructions in the "Instructions" worksheet.

5.3 Repeat the steps in Subsection 5.2 to generate a random schedule for all materials and test elements for the project.

6. COMPLETING THE RANDOM SCHEDULE FORM

6.1 On the project, sample as close as possible to the values represented on the sampling schedule. Fill in the "Taken At" column of the random schedule form as samples are being selected. Major deviations from the sampling schedule should be noted and explained on the form or on additional pages as needed.

Colorado Procedure 81-19

Standard Method of Test for

Density and Percent Compaction of HMA Pavement by the Nuclear Method

1. SCOPE

1.1 This method covers the determination of the total density of hot mix asphalt pavement in- place by use of nuclear gauges. The test method used to determine the density of in-place hot mix asphalt pavements is the backscatter method, whereby the source is lowered into near contact with the compacted roadway surface. The direct transmission and air gap methods are not used to test the in-place density of bituminous pavements.

1.2 The nuclear equipment referenced in this method is the Surface Moisture/Density (M/D) Gauge and the Thin Layer Density Gauge. This procedure applies equally to both types of gauges, except as noted.

1.3 The following applies to all specified limits in this standard: For the purposes of determining conformance with these specifications, an observed value or a calculated value shall be rounded off "to the nearest unit" in the last right-hand place of figures used in expressing the limiting value, in accordance with the rounding-off method of AASHTO R 11, Recommended Practice For Indicating Which Places Of Figures Are To Be Considered Significant In Specified Limiting Values.

2. REFERENCED DOCUMENTS

2.1 *Colorado Procedures:*

CP 15 Certification of Consultant Nuclear Moisture / Density Gauges
CP 75 Stratified Random Sampling of Materials
CP 82 Field Correction of the In-Place Measurement of Density of Bituminous Pavement by the Nuclear Method

CP-L 5302 Calibration of CDOT Nuclear Moisture/Density Gauges
CP-L 5304 Calibration of CDOT Nuclear Thin Layer Density Gauges

3. SIGNIFICANCE

3.1 The method described is used for the in-place determination of density of HMA.

3.2 This method is used for acceptance testing of HMA.

3.3 Test results may be affected by chemical composition, sample heterogeneity, and the surface texture of the material being tested. The techniques also exhibit spatial bias in that the apparatus is more sensitive to certain regions of the material under test.

4. APPARATUS

4.1 *Nuclear Moisture/Density (M/D) or Thin Lift Gauge* - The M/D or Thin-Layer gauge shall meet the requirements of CP 15 or CP-L 5302.

5. HAZARDS

5.1 The gauge utilizes radioactive material that may be hazardous to the health of the user unless proper precautions are taken. Users of the gauge must become familiar with applicable safety procedures and government regulations.

6. CALIBRATION/CERTIFICATION

6.1 Calibration/Certification of M/D gauges shall be in accordance with CP-L 5302 or CP 15.

6.2 Calibration/Certification of Thin Layer Density shall be accordance with CP-L 5304 or CP 15.

7. STANDARDIZATION

7.1 All Nuclear Gauges are subject to long-term aging of the radioactive sources, detectors, and electronic systems, which may change the relationship between count rates and the material density and water content. To offset this aging, gauges are calibrated as a ratio of the measurement count rate to a count rate made on a reference standard.

7.2 Standardization of the gauge on the reference standard is required at the start of each day's use, after the gauge has been turned off, or when a gauge's readings are in question. A permanent record of this data shall be retained. The standardization shall be performed with the gauge at least 33 ft away from other nuclear gauges and clear of large masses of water, hydrogenous material, or other items which may affect the reference count rates. Standard counts should be taken in the same environment as the actual measurement counts.

7.3 Turn the gauge on and allow it to stabilize according the manufacturers recommendations.

7.4 Place the gauge on the reference standard as recommended by the gauge manufacturer, and perform a four-minute standard count.

7.5 Compare the standard count obtained in Subsection 7.4 to the average of the previous 4 days' standard counts. If the density standard count is not within 1% of the density 4-day average, rerun the standard count. If the above conditions are not met, contact your On-site Radiation Safety Officer, follow your company's procedures, or contact the gauge manufacturer for further guidance. Record the standard counts on CDOT Form 746 and 428.

8. PROCEDURE

8.1 Using CP 75, select both longitudinal and transverse test locations where the gauge in test position will be at least 6 in. away from any vertical projection. Mark these test locations using a pavement marking pen. The gauge test site shall be an area 8 in. by 13 in. centered over the marked test location. The long axis of the test site must be parallel to the direction of the paver and rollers.

Note 1: When selecting a test location, include all areas 1 foot or more away from confined or unconfined longitudinal joints. Do not include locations closer than 1 foot to longitudinal joints.

8.2 Prepare the gauge test site in the following manner:

8.2.1 Remove all loose and disturbed material from the roadway surface.

8.2.2 Prepare the gauge test site to accommodate the gauge so that the gauge remains level and steady. "Rocking of the gauge may be caused by a non-level surface or by asphaltic aggregate particles becoming cemented to the bottom of the gauge. Obtain maximum contact between the gauge and material being tested. If rocking cannot be corrected, the test site may be moved a few centimeters to level the gauge.

8.2.3 The maximum void beneath the gauge shall not exceed 1/8 in. If necessary, use the minimum possible amount of native fines or fine sand to fill these voids and smooth the surface with a rigid plate or other suitable tool.

Note 2: The placement of the gauge on the surface of the material to be tested is critical to the successful determination of density. The optimum condition is total contact between the bottom surface of the gauge and the surface of the material being tested. This is not possible in all cases and to correct surface irregularities use of sand or similar material as a filler will be necessary. The depth of the filler should not exceed 1/8 in. and the total area filled should not exceed 10 percent of the bottom area of the gauge. Several trial seatings may be required to achieve these conditions.

8.3 Proceed with the test in the following manner:

8.3.1 Place the gauge on the 8 in. by 13 in. gauge test site. Mark two corners of the gauge test site using a pavement marking pen.

8.3.2 Keep all other radioactive sources at least 33 ft. away from the gauge to avoid affecting the measurement.

8.3.3 Tilt the gauge away from the operator slightly. Extend the source rod from the "SAFE" position to the "Backscatter" position, which is the position in which the tip of the source rod attains near contact with the pavement surface. Tilting the gauge will ensure that the index handle trigger of the source rod is securely engaged in the notch on the index rod. Ensure that the source rod is firmly seated against the bottom of the notch, which places the source into near contact with the roadway surface.

8.3.4 Seat the gauge firmly, keeping the base in contact with the prepared gauge test site.

8.3.5 Set the count time to one-minute. Perform two one-minute readings and record the wet density on CDOT Form #428. Turn the gauge 180 degrees and align the gauge over the gauge test site. Perform and record two additional one-minute readings.

Note 3: Most gauges report both wet and dry density. It is important to record the correct reading from the gauge.

8.3.6 If a core sample is required, follow CP 82. Obtain the core or cores for CP 82 from the central longitudinal axis of the gauge test site.

Note 4: If the entire bituminous pavement, that is the old existing asphalt roadway plus the planned overlay, will be less than 4 inches thick, underlying subgrade density variations can cause nuclear gauge test inconsistencies.

9. CALCULATIONS

9.1 Average the four nuclear gauge readings obtained in Subsection 8.3.5.

9.2 Calculate the adjusted wet density value by adding the field density to the correction factor derived through CP 82. Calculate the percent density by dividing the adjusted field density by the laboratory maximum mixture density (i.e. the maximum specific gravity multiplied by 62.4).

10. REPORT

10.1 CDOT Form 746, Nuclear Moisture/Density Gauge Log.

https://www.codot.gov/library/forms/cdot0746.pdf/view

10.2 CDOT Form 428, Nuclear Asphalt-Density Test.

https://www.codot.gov/library/forms/cdot0428.pdf/view

Colorado Procedure 82-08

Standard Method of Test for

Field Correction of the In-Place Measurement of Density of Bituminous Pavement by the Nuclear Method

INTRODUCTION

This method covers the determination of a correction factor which is used to adjust the density readings of in-place bituminous pavement generated by a nuclear surface gauge to core sample densities. A common misconception exists that a calibrated nuclear gauge can and will provide the correct in-place density of a bituminous pavement. However, no two design mixes are identical when placed on a project because the environment and roadway structure are unique; therefore, a standard calibration for bituminous pavements is impossible. Correlating the in-place nuclear density to the in-place core sample density allows for the development of a correction factor that should be valid until the ingredients in the bituminous pavement change or the underlying material changes. Principles of the nuclear test are discussed in the AASHTO T 310 Appendix, as are some of the advantages and disadvantages of the test. Surface nuclear gauges utilize radioactive materials, which may be hazardous to the health of users unless proper precautions are taken.

1. SCOPE

1.1 This method describes the procedures for determining a correction factor to be applied to the in-place measurement, by nuclear methods, of pavement densities. This factor corrects for the varying effects of materials, roadway structure, and environment.

1.2 This procedure should be used on each project as specified in the contract. This procedure may also be used whenever variations in conditions bring the Moisture/Density Gauge or Thin Layer Density Gauge readings into question.

1.3 The values stated in English units are to be regarded as the standard.

2. REFERENCED DOCUMENTS

2.1 *Colorado Procedures*

CP 44	Bulk Specific Gravity and Percent Relative Compaction of Compacted Bituminous Mixtures Using Saturated Surface-Dry Specimens
CP 51	Determining the Maximum Specific Gravity of Bituminous Mixtures
CP 75	Stratified Random Sampling of Materials
CP 81	Density of In-Place Bituminous Pavement by Nuclear Method

3. APPARATUS

3.1 Any tool suitable for removing intact a core of compacted pavement for the full depth of the course or courses. A diamond bit core drill is suitable for this purpose. The core drill must have a diameter of greater than 4 in. (100 mm) and should be equipped to core and retrieve specimens approximately 4 or 6 in. (100 to 150 mm) in diameter.

3.2 A rigid plate or suitable container large enough to hold the sample without distortion after it is removed from the pavement.

3.3 Surface Moisture/Density Gauge or Thin Layer Density Gauge as specified in CP 81.

3.4 Apparatus as specified in CP 51 (Determining the Maximum Specific Gravity of Bituminous Mixtures) and CP 44 (Bulk Specific Gravity of Compacted Bituminous Mixtures Using Saturated Surface-Dry Specimens).

4. PROCEDURE

4.1 Using CP 75, select and record seven longitudinal and transverse test locations where the gauge in test position will be at least 6 in. away from any vertical projection. Mark these test locations using a pavement marking pen. The gauge test site shall be an area 8 in. by 13 in. centered over the marked test location. The long

axis of the test site must be parallel to the direction of the paver and rollers.

NOTE 1: When selecting a test location, include all areas 1 foot or more away from confined or unconfined longitudinal joints. Do not include locations closer than 1 foot to longitudinal joints.

NOTE 2: If the existing pavement depth plus the depth of the planned first lift will be less than 4 in., the nuclear gauge may be affected by variations in the density of the subbase. Thin layer density gauges and cores are not affected by these variations in subbase densities.

NOTE 3: A visual examination of the existing pavement should be conducted before paving begins so that heavily distressed areas may be avoided when selecting test locations in Subsection 4.1. These areas may affect gauge readings, may not be representative of the roadway in general, or may lose their continuity once extracted.

4.2 Obtain nuclear gauge density readings at each test location according to CP 81 for either the nuclear gauge #1 or #2 values.

NOTE 4: CP 81 contains essential details concerning the safety, calibration, and standardization of nuclear gauges.

4.3 Take a core sample from the center of the gauge test site at each test location. This core shall be provided to CDOT for the determination of the nuclear asphalt density correction.

4.3.1 Any additional cores should be taken along the longitudinal axis as close as possible to the original core location.

NOTE 5: The Contractor shall provide cores from each location to CDOT as witnessed by the CDOT tester. If the core is damaged during the coring process, a new gauge test site as close as possible to the original test site along the longitudinal centerline axis of the original test site shall be chosen. The direction of the new test site shall be randomly selected by the CDOT tester. Repeat Subsections 4.1 to 4.3 at the new test site. Once the bulk specific gravity test (CP 44) has been started on a core, the contractor shall no longer have the option of requesting a new test site at that location.

4.4 When the nominal maximum size aggregate in the pavement is 1 in. or less, a 4 in. diameter bit or larger shall be used. When the nominal maximum size aggregate is over 1 in., a 6 inch diameter bit shall be used. When the coring operation has been completed, carefully remove sample by use of the core retriever. Mark each core to allow identification of the test site. Care should be exercised that the sample is not distorted, bent, cracked, or in any way changed from its physical condition as it was before removal from the pavement.

4.5 Separate the core below the layer for which the correction factor is being determined.

4.6 Determine the specific gravity of the core samples in accordance with CP 44.

5. DETERMINATION OF CORRECTION FACTOR

5.1 Calculate the average specific gravity of the seven pavement cores taken from the roadway. Convert the average specific gravity to density by multiplying the specific gravity by 62.4.

5.2 Using CP 81, calculate the average in-place density from the seven sites using the nuclear gauge.

5.3 Calculate the correction factor to be used for measurements of density readings from the same project as follows:

$$A = B - C$$

Where:

A = Correction factor determined for a specific gauge and pavement,
B = Average density of pavement cores,
C = Average density reading from nuclear gauge.

NOTE 6: This correction factor is added to the nuclear gauge density determined on the same pavement using the same nuclear density gauge.

6. REPORT

6.1 The results are reported on the following CDOT forms:

6.1.1 CDOT Form #746 - Nuclear Moisture/ Density Gauge Log (Example in Chapter 800).

6.1.2 CDOT Form #428 - Nuclear Asphalt-Density Test (Example in Chapter 800).

6.1.3 CDOT Form #469 - Nuclear Asphalt-Density Correction (Example in Chapter 800).