ODOT TM 158

Method of Test for

IN-PLACE DENSITY OF EMBANKMENT AND BASE USING DEFLECTION REQUIREMENTS

Scope

This procedure covers the visual determination of density and relative compaction of soil, soil-aggregate mixes and base aggregates.

Definitions:

- **Deflection or Reaction – A movement or deviation of material which returns back to a former or less advanced condition in a localized area directly under the test vehicle tire.**
- **Pumping – Vertical displacement of the top surface of the compacted layer, not directly under the vehicles tires.**
- **Loaded Haul Vehicle – Water truck or Construction material haul unit i.e. belly dump, end dump or similar.**
- **GVW – Gross Vehicle Weight.**

Procedure - General

The compacted layer will be observed for deflection by using a loaded haul vehicle, loaded to the vehicles (GVW). The vehicle will be driven at a speed of 1 – 2 m/s (2 – 4 miles/hour) over the entire compacted layer. There shall be no deflection, reaction, or pumping of the ground surface (as defined above) observed under the moving vehicle's tires. It may be required that testing be performed under the observation of the Engineer.

Report

Results shall be reported on standard form (1793S & 1793B) or other form approved by the agency. Include the following information:

- Location of test & Represented Area, elevation of surface, and thickness of layer tested
- Visual description of material tested
- Description of the equipment used to perform the test
- Name and signature of the technician conducting the test

ODOT TM 223

Method of Test for

Establishing Maximum Dry Density and Optimum Moisture Content of Aggregate Base Materials

Scope

This procedure covers the adjustment of the maximum dry density determined by FOP for AASHTO T 99 Method A, to compensate for coarse particles retained on the 4.75 mm (No. 4) sieve for aggregate base materials only. For Method A of FOP for AASHTO T 99 the adjustment is based on the percent, by mass, of material retained on the 4.75 mm (No. 4) sieve and the bulk specific gravity G_{sb} of the material retained on the 4.75 mm (No. 4) sieve; defined as oversized material.

This procedure will be used in conjunction with FOP for AASHTO T 99 Method A, FOP for AASHTO T-255 / 265 and FOP for AASHTO T 85.

This Process shall be used for Dense Graded Base Aggregate Separated Stockpile sizes of 1" - 0 and smaller. Dense graded Base Aggregate with Separated Stockpile sizes larger than 1" - 0 and Open Graded Base Aggregates are considered non-density testable and should be evaluated according to the appropriate specifications contained in the project contract documents.

Adjustment Equations

1. Use the Maximum Density (D_f) and corresponding Optimum Moisture (MC_f) content values determined by the FOP for AASHTO T 99 Method A, to represent the passing 4.75 mm (No. 4) material.

   For the oversized material use the values determined from FOP for AASHTO T 85. The Bulk Specific Gravity (G_{sb}) (*k*) and the Absorption (MC_c) information are needed.

2. The percentage of oversize material is based on the average percent passing value of the 4.75 mm (No.4) determined by the statistical analysis program (StatSpec) during the crushing operation. See note 1. The percentage of oversize is calculated as follows:

$$P_c = (100 - P_f)$$

   Where:

   P_f = Average (Mean) percent passing the 4.75 mm (No. 4) from StatSpec, rounded to closest whole value.
   P_c = Percent Retained 4.75 mm (No. 4) material

Note 1*: Utilizing the average percentage value of the 4.75 mm (No. 4) during aggregate production is more representative of the material in the stockpile and eliminates bias that can be introduced during sampling and splitting procedures.*

Adjustment Equation Moisture

3. Calculate the corrected moisture content as follows:

$$MC_T = \frac{[(MC_f)\,(P_f) + (MC_c)(P_c)]}{100} \qquad 7.2\% = \frac{[(10.6)\,(60) + (2.1)(40)]}{100}$$

MC_T = corrected moisture content of combined fines and oversized particles, expressed as a % moisture.
MC_f = moisture content of fine particles, as a % moisture (See Note 2).
MC_c = moisture content of oversized particles, as a % moisture (See Note 2).

P_f = percentage of fines

P_c = percentage of oversized material (coarse)

Note 2*: Moisture content of oversize material is based on the Absorption value from FOP for AASHTO T 85. The moisture content of the fines is based on the FOP for AASHTO T 99.*

Adjustment Equation Density

4. Calculate the corrected dry density of the total sample (combined fine and oversized particles) as follows (See Note 3):

$$D_d = \frac{100 D_f k\,(0.9)}{\left[(D_f)(P_c) + (k \times 0.9)(P_f)\right]} \qquad \text{or} \qquad D_d = \frac{100}{\dfrac{P_f}{D_f} + \dfrac{P_c}{(k \times 0.9)}}$$

Where:
D_d = corrected total dry density (combined fine and oversized particles) kg/m^3 (lb/ft^3).
D_f = dry density of the fine particles kg/m^3 (lb/ft^3), determined by T 99 Method A.
P_c = percent of oversize particles, of 4.75 mm (No. 4)
P_f = percent of fine particles, of 4.75 mm (No. 4)

k = Metric: 1,000 * Bulk Specific Gravity (G_{sb}) of coarse particles (kg/m^3).

k = English: 62.4 * Bulk Specific Gravity (G_{sb}) of coarse particles (lb/ft^3).

Note 3*: Tests have shown that granular material can be compacted to 90% of the absolute dry density.*

Calculation

Sample Calculations:

- Metric:

Maximum laboratory dry density (D_f):	2329 kg/m^3
Percent coarse particles (P_c):	40%
Percent fine particles (P_f):	60%
Bulk specific gravity (G_{sb}) of coarse particles (k): (2.697) (1000) =	2697 kg/m^3

$$D_d = \frac{100}{\frac{P_f}{D_f} + \frac{P_c}{(k \times 0.9)}}$$

$$D_d = \frac{100}{\frac{60}{2329} + \frac{40}{(2697 \times 0.9)}}$$

$$D_d = \frac{100}{\frac{60}{2329} + \frac{40}{(2427.3)}}$$

$$D_d = \frac{100}{0.02576 + 0.01648}$$

$$D_d = \frac{100}{0.04224}$$

D_d = 2367.4 - report as - 2367 kg/m^3

- English:

Maximum laboratory dry density (D_f):	140.4 lb/ft^3
Percent coarse particles (P_c):	40%
Percent fine particles (P_f):	60%
Bulk specific gravity (G_{sb}) of coarse particles (k): (2.697) (62.4) =	168.3 lb/ft^3

$$D_d = \frac{100}{\frac{P_f}{D_f} + \frac{P_c}{(k \times 0.9)}}$$

$$D_d = \frac{100}{\frac{60}{140.4} + \frac{40}{(168.3 \times 0.9)}}$$

$$D_d = \frac{100}{\frac{60}{140.4} + \frac{40}{(151.5)}}$$

$$D_d = \frac{100}{0.42735 + 0.26403}$$

$$D_d = \frac{100}{0.69138}$$

D_d = 144.64 - report as - 144.6 lb/ft^3

Report

Results shall be reported on ODOT Form 734-3468 B. Report combined maximum dry density to the closest 1 kg/m^3 (0.1 lb/ft^3) and combined optimum moisture content to the closest 0.1%.

ODOT TM225

Method of Test for

PRESENCE OF WOOD WASTE IN PRODUCED AGGREGATES

1. SCOPE

A. This method of test covers a procedure for determining the presence of wood waste or other deleterious materials, here in known as Contaminate, in produced aggregates.

2. APPARATUS

A. Sample splitter or a canvas suitable for splitting a sample.

B. Balance or scale – Capacity sufficient for the masses listed in Table 1 of AASHTO T 27/ T 11 and accurate to 0.1 percent of the sample mass or to 0.1 g, meeting the requirements of AASHTO M 231.

C. Drying Equipment - Per FOP for AASHTO T255 / T 265.

D. Container and utensils - The container shall be of a size to permit covering the sample with (3" to 4") of water and a spoon.

E. Sieve - (No. 40) meeting the requirements of AASHTO M 92.

F. Optional mechanical aggregate washer.

3. SAMPLE

A. The sample shall be obtained as per FOP for AASHTO T2.

B. The sample shall be split per FOP for AASHTO T248.

C. Size of sample shall conform to Table 1 of the FOP for AASHTO T27 / T11.

4. PREPARATION OF SAMPLE

A. Dry the sample to a constant mass per FOP for AASHTO T255/265. If the sample appears to contain Contaminate materials, use caution during the drying the process. A controlled oven maintained at a temperature of (230 ±9ºF) should be utilized.

5. PROCEDURE

A. Record the sample dry mass to the nearest 0.1 g.

B. Place the dried sample into the container and cover with water to a height of 3" to 4".

C. Agitate the sample with the spoon.

D. Spoon or decant off any floating material over the (No. 40) sieve.

Steps B thru D can be completed during the performance of Method A of the FOP for AASHTO T 27 / T 11 by nesting the #40 sieve over the #200 sieve.

E. Put the contaminate material into a container (suitable for the drying method being used) and dry this material in accordance with FOP for AASHTO T255 / T 265.

F. Determine the Contaminate mass to the nearest 0.1 g, after determining the dry mass of the Contaminate, retain the Contaminate material.

6. CALCULATIONS AND REPORTS

A. $$\text{Wood Waste (nearest 0.01\%)} = \frac{\text{Contaminant mass}}{\text{Sample mass}} \times 100$$

B. Report on **form 734-1792.**

ODOT TM 227

Method of Test for

EVALUATING CLEANNESS OF COVER COAT MATERIAL

SCOPE

The cleanness test indicates the relative amount, fineness, and character of clay-like materials present on aggregate as coatings or otherwise.

APPARATUS

1. Funnel to hold nested 2.36mm (No. 8) (or 2.00mm (No. 10)) and 75 µm (No. 200) sieves at the large end and necked down to rest in a 500 ml graduate at the small end.

2. Plastic wide-mouth 3.8 L (one gallon) jars with lids and rubber gaskets.

3. Sand equivalent cylinder, rubber stopper, and timing device. These items are standard sand equivalent equipment.

4. Graduated glass or plastic cylinders of 10 ml and 500 ml capacities.

5. Sieves. 75 µm (No. 200) and a 2.36mm (No. 8) (or 2.00mm (No. 10)), full height.

6. A balance or scale sensitive to 0.1 g.

7. Sand equivalent stock solution.

8. Splitter. Any device may be used which will divide the sample into representative portions. However, the riffle-type splitter is preferable to hand-quartering.

9. Syringe or spray attachment.

10. Forced draft, ventilated, or convection oven capable of maintaining a temperature of 110±5°C (230±9°F).

CONTROL

1. Temperature of the wash solution shall be maintained within the range of 18°-28° C (64°-82° F) during performance of this test.

2. Use distilled or demineralized water for performance of the cleanness test. This is necessary because the test results are affected by certain minerals dissolved in water.

PREPARATION OF SAMPLE

1. Split a representative portion of the sample large enough to yield 1000 g ±50 g of material (FOP for AASHTO T248).

2. The cover coat material must be tested in oven dry condition (FOP for AASHTO T255). Drying temperature shall not exceed 110°C (230°F). Cool cover coat material to room temperature for testing.

PROCEDURE

1. Place the sand equivalent cylinder on a work table which will not be subjected to vibrations during the sedimentation phase of the test.

2. Pour 7 ml of the STOCK SOLUTION into the sand equivalent cylinder.

3. Nest the two sieves in the large funnel which in turn rests in the 500 ml graduate. The 2.36mm (No. 8) (or 2.00mm (No. 10)) sieve serves only to protect the 75 μm (No. 200) sieve.

4. Place the prepared sample in the 3.8 L (one gallon) jar. Add only enough water to completely cover the aggregate, and cap tightly.

   Note: Do not add too much water at the beginning of the test, as only 500 ml is allowed after the final rinsing.

5. Begin agitation after one minute has elapsed from the introduction of the water. The agitation procedure is described as follows:

5.1 While holding the jar vertically with both hands, the washing shall be done with an arm motion that causes the jar to rotate in a circle with approximately a 150mm (6") radius. The jar may be held either by the sides or by the top and bottom, whichever is more convenient.

Note: The jar itself does not turn on its vertical axis. The jar's vertical axis describes a circle with a 150mm (6") radius, as near as possible.

5.2 Continue this agitation at the rate of two complete rotations per second for one minute.

6. At the end of the agitation period, empty the contents of the jar over the nested 2.36mm (No. 8) (or 2.00mm (No. 10)) and 75 μm (No. 200) sieves.

7. Use the syringe or spray attachment and carefully wash out the jar, pouring the wash water over the nested sieves. Continue to wash the aggregate in the sieves until the graduate is filled to the 500 ml mark.

8. Remove the funnel and nested sieves from the graduate. Bring all solids in the wash water into suspension by capping the graduate with the palm of the hand and turning the cylinder upside down and right side up 10 times through 180°, as rapidly as possible.

9. Immediately pour the thoroughly mixed liquid into the sand equivalent cylinder until the 380mm (15”) mark is reached.

10. Place the stopper in the end of the cylinder, and prepare to mix the contents immediately.

11. Mix the contents of the cylinder by alternately turning the cylinder upside down and right side up, allowing the bubble to completely traverse the length of the cylinder. Repeat this cycle 10 times in approximately 35 seconds. A complete cycle is from right side up to upside down and back to right side up.

11.1 At the completion of the mixing process, place the cylinder on the work table and remove the stopper. Allow the cylinder to stand undisturbed for 20 minutes. Then immediately read and record to the nearest 2.5mm (0.1 inch), the height of the column of sediment.

12. Two unusual conditions may be encountered during this phase of the test.

12.1 A clearly defined line of demarcation may not form in the specified 20 minutes. If this happens, allow the cylinder to stand until one forms, then immediately read and record.

12.2 The liquid immediately above the line of demarcation may still be cloudy at the end of the 20 minutes. The line, although distinct, may appear to be in the sediment column itself. Read and use the line of demarcation after the end of the 20 minute period.

CALCULATIONS

Compute the cleanness value to the nearest whole number by the following formula:

METRIC

$$CV = \frac{81.636 - (0.214H)}{81.636 + (0.786H)} \times 100$$

Where: CV = Cleanness Value
H = Height of sediment in millimeters

Solutions of the above equation are given in Table 1.

ENGLISH

$$CV = \frac{3.214 - (0.214H)}{3.214 + (0.786H)} \times 100$$

Where: CV = Cleanness Value
H = Height of sediment in inches

Solutions to the above equation are given in Table 2.

TABLE 1

Cleanness Values (CV) for 0 to 380 mm Height Reading (Hmm)

Height Reading mm	CV	Height Reading mm	CV	Height Reading mm	CV	Height Reading mm	CV
0	100	97.5	38	195	17	292.5	6
2.5	97	100	38	197.5	17	295	6
5	84	102.5	37	200	16	297.5	6
7.5	91	105	36	202.5	16	300	5
10	89	107.5	35	205	16	302.5	5
12.5	86	110	35	207.5	15	305	5
15	84	112.5	34	210	15	307.5	5
17.5	82	115	33	212.5	15	310	5
20	79	117.5	32	215	14	312.5	5
22.5	77	120	32	217.5	14	315	4
25	75	122.5	31	220	14	317.5	4
27.5	73	125	31	222.5	13	320	4
30	71	127.5	30	225	13	322.5	4
32.5	70	130	29	227.5	13	325	4
35	68	132.5	29	230	12	327.5	3
37.5	66	135	28	232.5	12	330	3
40	65	137.5	28	235	12	332.5	3
42.5	63	140	27	237.5	11	335	3
45	62	142.5	26	240	11	337.5	3
47.5	60	145	26	242.5	11	340	3
50	59	147.5	25	245	11	342.5	2
52.5	57	150	25	247.5	10	345	2
55	56	152.5	24	250	10	347.5	2
57.5	55	155	24	252.5	10	350	2
60	53	157.5	23	255	10	352.5	2
62.5	52	160	23	257.5	9	355	2
65	51	162.5	22	260	9	357.5	1
67.5	50	165	22	262.5	9	360	1
70	49	167.5	21	265	9	362.5	1
72.5	48	170	21	267.5	8	365	1
75	47	172.5	21	270	8	367.5	1
77.5	46	175	20	272.5	8	370	1
80	45	177.5	20	275	8	372.5	1
82.5	44	180	19	277.5	7	375	0
85	43	182.5	19	280	7	377.5	0
87.5	42	185	19	282.5	7	380	0
90	41	187.5	18	285	7		
92.5	40	190	18	287.5	7		
95	39	192.5	17	290	6		

Metric Calculations

8.1 Compute the CV to the nearest whole number by the following formula:

$$CV = \frac{81.636 - (0.214Hmm)}{81.636 + (0.786Hmm)} \times 100$$

Where: CV = Cleanness Value

Hmm= Height of Sediment in millimeters

TABLE 2

Cleanness Values (CV) for 0 to 15.0 inch Height Reading (H)

Height Reading	CV	Height Reading	CV	Height Reading	CV	Height Reading	CV
0	100	4	37	8	16	12	5
0.1	97	4.1	36	8.1	15	12.1	5
0.2	94	4.2	36	8.2	15	12.2	5
0.3	91	4.3	35	8.3	15	12.3	5
0.4	89	4.4	34	8.4	14	12.4	4
0.5	86	4.5	33	8.5	14	12.5	4
0.6	84	4.6	33	8.6	14	12.6	4
0.7	81	4.7	32	8.7	13	12.7	4
0.8	79	4.8	32	8.8	13	12.8	4
0.9	77	4.9	31	8.9	13	12.9	3
1	75	5	30	9	13	13	3
1.1	73	5.1	29	9.1	12	13.1	3
1.2	71	5.2	29	9.2	12	13.2	3
1.3	69	5.3	28	9.3	12	13.3	3
1.4	68	5.4	28	9.4	11	13.4	3
1.5	66	5.5	27	9.5	11	13.5	2
1.6	64	5.6	26	9.6	11	13.6	2
1.7	63	5.7	26	9.7	11	13.7	2
1.8	61	5.8	25	9.8	10	13.8	2
1.9	60	5.9	25	9.9	10	13.9	2
2	58	6	24	10	10	14	2
2.1	57	6.1	24	10.1	9	14.1	1
2.2	56	6.2	23	10.2	9	14.2	1
2.3	54	6.3	23	10.3	9	14.3	1
2.4	53	6.4	22	10.4	9	14.4	1
2.5	52	6.5	22	10.5	8	14.5	1
2.6	51	6.6	21	10.6	8	14.6	1
2.7	49	6.7	21	10.7	8	14.7	0
2.8	48	6.8	21	10.8	8	14.8	0
2.9	47	6.9	20	10.9	7	14.9	0
3	46	7	20	11	7	15	0
3.1	45	7.1	19	11.1	7		
3.2	44	7.2	19	11.2	7		
3.3	43	7.3	18	11.3	7		
3.4	42	7.4	18	11.4	6		
3.5	41	7.5	18	11.5	6		
3.6	40	7.6	17	11.6	6		
3.7	40	7.7	17	11.7	6		
3.8	39	7.8	17	11.8	6		
3.9	38	7.9	16	11.9	5		

ODOT TM 229

Method of Test for

DETERMINATION OF FLAT and ELONGATED MATERIAL IN COARSE AGGREGATES

Scope

This procedure covers the determination of the percentage, by mass, of flat and elongated particles in coarse aggregates for comparison with specification limits.

Flat and elongated particles of aggregates, for some construction applications, may interfere with consolidation and result in harsh, difficult to place materials and a potentially unstable mixture.

For purposes of this test procedure, the term “Elongated Pieces” in applicable specifications shall be taken to be equivalent to the term “Flat and Elongated Particles” used in this test method.

Apparatus

- Balance or scale: Capacity sufficient for the principle sample mass, accurate to 0.1 percent of the sample mass or readable to 0.1 g.
- Sieves, meeting requirements of AASHTO M 92.
- Proportional Caliper Device, meeting the requirements of ASTM D 4791 and approved by the Agency.

Terminology

- Flat and Elongated Particles - Those aggregate particles having a ratio of length to thickness greater than a specified value.

Sampling and Sample Preparation

1. Sample the aggregate in accordance with AASHTO T 2.
2. Dry the sample sufficiently to obtain separation of coarse and fine material and sieve in accordance with AASHTO T 27 over the 4.75 mm (No. 4) sieve. Discard the material passing the specified sieve.
3. Reduce the retained sample according to AASHTO T 248. The minimum sample mass shall meet the requirements listed in Table 1.

Table 1
Required Sample Size

Nominal Maximum Size* mm (in)	**Minimum Sample Mass Retained on 4.75 mm (No. 4) Sieve g (lb)**
37.5 (1-1/2)	2500 (6)
25.0 (1)	1500 (3.5)
19.0 (3/4)	1000 (2.5)
12.5 (1/2)	700 (1.5)
9.5 (3/8)	400 (0.9)
4.75 (No. 4)	200 (0.4)

Note: One sieve larger than the first sieve to cumulatively retain more than 10 percent of the material, using all the sieves listed in Table 1 in AASHTO T 2

4. Determine the dry mass of the reduced portion of the sample to the nearest 0.1 g. This mass is designated **MS** in the calculation.

NOTE: If test is performed in conjunction with AASHTO T 335, recombine material from the fracture test and reduce to the appropriate sample size given in Table 1. The test may also be performed in conjunction with AASHTO T 335 on individual sieves and combined to determine an overall result if material on each individual sieve IS NOT further reduced from the original mass retained on each sieve.

Procedure

1. Set the proportional caliper device to the ratio required in the contract specifications: (2:1, 3:1, or 5:1)

2. Expedite testing through preliminary visual separation of all material which obviously is not flat and elongated.

3. Test each questionable particle by setting the larger opening of the proportional caliper device equal to the maximum dimension of the particle’s length. Determine the dimension which represents the particle thickness (the smallest dimension). Pull the particle horizontally through the smaller opening without rotating, maintaining contact of the particle with the fixed post at all times. If the entire particle thickness can be pulled through the smaller opening, the particle is flat and elongated.

4. Determine the dry mass of the flat and elongated particles to the nearest 0.1 g. This mass is designated as **FE** in the calculation.

Calculation

Calculate the percent of flat and elongated pieces for the sample according to the following equation.

$$\% FE = \frac{FE}{MS} \times 100$$

Where MS = Mass of retained sample
FE = Mass of flat and elongated pieces
%FE = Percent of flat and elongated pieces

Report

Report the percent flat and elongated pieces to the nearest 0.1% on a standard form approved for use by the Agency.

ODOT TM 301

Method of Test For

ESTABLISHING ROLLER PATTERNS FOR THIN LIFTS OF ACP

SCOPE

This method is a procedure which provides a method to establish the roller patterns and number of passes required to achieve a maximum density for the JMF, paving conditions, and equipment on the project. This method is used with the same rollers and materials to be used throughout the project. Changes in materials, rolling equipment or weather conditions may require establishment of new roller patterns. This procedure is used when required by the specifications to determine the optimum rolling pattern for ACP placed in lifts with a nominal thickness less than 2 in.

DEFINITIONS

- **In-Place Density** - the density of a bituminous mixture as it exists in the pavement. The in-place density will be determined using a Nuclear Moisture-Density Gauge according to AASHTO T 355 unless otherwise specified.
- **Evaluation Point** - a testing point selected within the roller pattern and used to determine the increasing in-place densities of the pavement with successive roller passes.
- **Roller Pass** - the passing of a roller over an area (roller width) one time.
- **Roller Coverage** - the rolling of the entire width of pavement one time, including roller overlaps.
- **Breakdown Rolling** - constitutes the first roller coverage on the mixture after it is placed.
- **Intermediate Rolling** - constitutes all rolling following the breakdown rolling, prior to the temperature of the mixture lowering to (180 °F).
- **Optimum Rolling Pattern** – the combination of rollers, temperatures, and roller passes which results in the maximum achievable density for the JMF, paving conditions, and equipment on the project.

- **Finish Rolling** - constitutes the roller coverage, after the intermediate rolling, required to bring the mixture to a smooth, tight surface, while the mixture is warm enough to permit the removal of any roller marks.

APPARATUS

- A nuclear density gauge meeting the apparatus requirements of AASHTO T 355.
- Transport case for properly shipping and housing the gauge and tools.
- Instruction manuals for the specific make and model of the gauge.
- A suitable thermometer for measuring the temperature of the paved surface.

DETERMINING OPTIMUM ROLLING PATTERN

1. An optimum rolling pattern shall be established when required by the specifications.
2. Two evaluation points shall be selected within the section being paved. The evaluation points must be at least 50 feet from a transverse joint; no closer than 2 ft. from the edge of the panel being placed, and in an area that is representative of the overall material and conditions of placement. The two evaluation points shall be located at the same station, but must be at least 3 ft. apart transversely. Make sure the evaluation points are not located where the roller passes overlap.
3. After each roller pass over the evaluation points, the nuclear gauge is used in the backscatter position to determine the in-place density with a 15-second count. Each un-sanded evaluation point is carefully marked so the subsequent tests are made in exactly the same positions and locations.
4. For each roller used and each pass over each evaluation point, record the type of roller, surface temperature, density in-place (15 second reading), direction of travel, and whether in vibratory or static mode. Average the readings from the two evaluation points after each pass.
5. Continue compacting and testing each evaluation point after each roller pass until the average of the readings from the two evaluation points does not increase. (The average of the two readings may decrease or level off to indicate this.)
6. The optimum rolling pattern consists of one less than the number of passes necessary to reach the point at which density does not increase as established in Step 5.

7. Any finish rolling necessary to remove roller marks will be in addition to the required number of passes for the optimum rolling pattern.

REPORT

The report shall be made on the Control Strip Method of Compaction for Thin Lifts of ACP Form 734-2084T.

ODOT TM 304

Method of Test for

NUCLEAR DENSITY/MOISTURE GAUGE CALIBRATION AND AFFECT OF HOT SUBSTRATE

SCOPE

Determination of the accuracy and/ or to calibrate a Nuclear Density/Moisture Gauge and determine the effect of high temperatures, such as that found in Asphalt Concrete Pavements, on the proper functioning of the Nuclear Gauge.

SIGNIFICANCE AND USE

A Nuclear Density/Moisture Gauge calibration check and Hot Substrate Test shall be performed every 12 months or any time the calibration of the gauge is in question.

If a Nuclear Density/Moisture Gauge's accuracy is questioned in the field, a check may be performed per Appendix E of the MFTP. During this check process, Sections 3.A and 3.C maybe modified as deemed necessary by the Region QAC. This is to insure timely results of the Gauge's accuracy. If this check uses modifications and the gauge does not meet the requirements in Section 5, the gauge will require a calibration check per the test procedure without modification.

APPARATUS

1. A Nuclear Gauge capable of making moisture and density determinations. The Gauge shall be so constructed to be licensable in accordance with applicable health and safety standards, established by the State Health Division. A copy of the owner's Radioactive Materials License and a copy of the most current leak test results will accompany the Nuclear Gauge. The Nuclear Gauge shall be in good operating condition.

2. A carrying /transport case.

3. Instruction manual, supplied by the gauge manufacturer, describing the operating procedures for the model of gauge being used.

4. A reference standard block for obtaining standard counts and checking gauge operation.

5. Logbook for recording daily counts obtained on the reference block.

6. Calibration tables, as required, for determining the moisture content and the density from calculated count ratios.

7. Calibration blocks of approximate densities 1717kg/m^3 (107.2 PCF), 2140kg/m^3 (133.6 PCF), and 2631kg/m^3 (164.3 PCF) large enough to represent an infinite below surface volume to the gauge.

8. A High Moisture Calibration Block. Made of suitable material, which will produce a moisture reading of 839kg/m^3 (52.4PCF).

9. Surface temperature measuring device, capable of a range from -10^0 C to 150^0 C (0^0 to 300^0 F) readable to 2^0 C (5^0 F).

10. Hot plate device consisting of an aluminum block, of adequate size, that fits on an electric hot plate mounted on a dolly. The electric hot plate requires a 120 volt, 60 hertz power source.

    Note: ODOT uses an aluminum block 41cm (16in) x 46cm (18in) x 16cm (6.3in).

NUCLEAR DENSITY GAUGE PREPARATION

1. Gauge may be placed in a temperature controlled area for no less than 4 hours, to assure component parts are at a room temperature of 16^{0}C (60^{0}F) to 24^{0}C (75^{0}F).

2. Turn the gauge on and allow it to warm up for a minimum of 10 minutes.

3. Place the Standard count block in the center of the middle calibration block. With the standard count block in this position, perform five standard counts in accordance with the manufacturer's guidelines. Record the standard counts on the Nuclear Density Gauge Calibration Check Sheet and, check that the variances between counts are within the manufacturer’s guidelines. If the variances between counts are within the manufacturer’s guidelines go to No 5.

4. If, the variances between counts are **not** within the manufacturer’s guidelines.

4.1 Continue performing standard counts in accordance with the manufacturer's guidelines. Record and check each standard count for compliance with manufacturer’s guidelines. No more than two additional standard counts should be performed.

4.2 If the manufacturer’s guidelines are met, go to No. 5.

4.3 If the manufacturer’s guidelines **not** are met within two additional standard counts or the additional standard counts continue to show variances outside the manufacturer's guidelines, contact the gauge owner, inform them of the problem and arrange for the return of the gauge.

.

5. Set the gauge to take one-minute counts.

NUCLEAR DENSITY GAUGE HOT SUBSTRATE TEST

1. Plug in or turn on the heating device for the aluminum block. Heat the block to 85^0C $^+$- 2^0C or 185^0F $^+$- 4^0F and check the temperature by using a surface thermometer. (*Heating of the block usually takes 4 to 6 hours*.)

2. With the gauge at room temperature of 16^0C (60^0F) to 24^0C (75^0F) and the block at 85^0C (185^0F). Place the gauge on the block, immediately move the source into the backscatter position and start a one-minute count.

3. Record the first wet density in the "Initial Test" column of the Hot Substrate Test portion of the Nuclear Density Gauge Calibration Check Sheet and immediately start a second one-minute count. Continue taking one-minute counts and recording wet densities until there are a total of four.

4. Leave the gauge on the block for 10 minutes.

5. At the conclusion of the 10-minute waiting period, immediately start a one-minute count. Record the wet density in the "Final Test" column of the Hot Substrate Test portion of the Nuclear Calibration Check Sheet and immediately start a second one-minute count. Continue taking one-minute counts and recording wet densities until there is a total of four. Remove the gauge from the block to cool.

6. If, at anytime during the test, the gauge display fogs or becomes unreadable due to moisture, the gauge fails this test. Input no data on the Nuclear Density Gauge Calibration Check Sheet and put an explanation of why the gauge failed in the "Remarks" section, then sign and date the sheet. Contact the gauge owner and arrange for it's return. A copy of the Nuclear Density Gauge Calibration Check Sheet shall be made available to the gauge owner.

7. Average the "Initial test" column and average the "Final test" column. Compare the Initial test average to the Final test average. If the averaged densities are within 16 kg/m^3 (1.0 lbs/ft^3) the gauge passes this test. If the averaged densities are not within 16 kg/m^3 (1.0 lbs/ft^3) the gauge fails.

8. If the results "Pass", indicate the result on the Nuclear Density Gauge Calibration Check Sheet under "Hot Substrate Results". Allow the gauge to cool to room temperature and then proceed with the calibration check.

9. If the results “Fail”, indicate the result on the Nuclear Density Gauge Calibration Check Sheet under “Hot Substrate Results”, then sign and date it. If an ODOT Quality Assurance Program Inspection Tag is currently on the gage, remove it from the gage and place it with Nuclear Density Gauge Calibration Check Sheet in your records. Inform the owner of the failure and arrange for the return of the gauge. A copy of the Nuclear Density Gauge Calibration Check Sheet shall be made available to the gauge owner.

NUCLEAR DENSITY/MOISTURE GAUGE ANNUAL CHECK OF ACCURACY FOR GAUGES WITH INTERNAL COMPUTERS

1. The calibration blocks shall be located in accordance with the manufacturer's recommendations, and no other unshielded Nuclear gauge shall be within 15 meters (50 feet) during annual check of accuracy or calibration. An example of a the Nuclear Density Gauge Calibration Check sheet is enclosed with this procedure

2. Block Values used by ODOT.

	Back Scatter	**Direct Transmission**
Low Density	1735 kg/m^3(108.3 PCF)	1717 kg/m^3 (107.2PCF)
Medium Density	2161 kg/m^3 (134.9PCF)	2140 kg/m^3(133.6PCF)
High Density	2657 kg/m^3 (165.9PCF)	2632 kg/m^3 (164.3PCF)

3. With the gauge at room temperature 16^{0}C (60^{0}F) to 24^{0}C (75^{0}F). Locate the gauge on the Low-Density block so the edge of the gauge closes to the probe is 2.5cm (1 inch) from the edge of the transmission hole and the gauge is in the center of the block. The gauge shall not be placed on the block in such a manner so that it covers the transmission hole during backscatter reading. Move the handle into the backscatter position. Perform two one-minute counts and record the wet density results.

4. Repeat this process on the Medium and High Density blocks.

5. Locate the source rod in the 50mm(two inch) direct transmission position and seat in the transmission hole of the Low density block. Perform two one-minute counts and record the wet densities.

6. Repeat the counting and recording procedures for all depth increments to the maximum depth on the Low, Medium, and High Density Blocks.

7. Average each individual depth’s results and compare the averaged result with the respective block densities listed above. If this is an annual check then the averaged results must be within ± 16kg/m3 (1.0 lbs/ft3) on the low and Medium Density blocks and ± 24kg/m3 (1.5 lbs/ft3) on the High Density Block of the values given in No. 2 or the gauge fails and must be recalibrated, go to the Nuclear Density/Moisture Gauge Calibration Procedure section later in this chapter. If this is a check of a gauge

recalibrated in accordance with the Nuclear Density/Moisture Gauge Calibration Procedure section then the results are all to be within the within ± 16kg/m3 (1.0 lbs/ft3) of the values given in No. 2 above. If the above parameters are met, continue to No. 8 below. If the above parameters are not met the gauge must be recalibrated in accordance with the Nuclear Density/Moisture Gauge Calibration Procedure section.

8. Place the gauge on the Low Density Block so as not to be influenced by the transmission hole. Move the handle into the backscatter position. Perform one four-minute count and record the moisture density. The moisture density must be within ± 8 kg/m3 (0.5 lbs/ft3) of 0 kg/m3 (0.0 lbs/ft3), if it is not the gauge must be recalibrated according to the Nuclear Density/Moisture Gauge Calibration Procedure section below.

9. Place the High Moisture Block on the High Density Block. Place the gauge on the High Moisture Block. Move the handle into the backscatter position. Perform one four-minute count and record the moisture density. The moisture density must be within ± 16 kg/m3 (1.0 lbs/ft3) of 839 kg/m3 (52.4 lbs/ft3), if is not the gauge must be recalibrated according to the Nuclear Density/Moisture Gauge Calibration Procedure section below.

NUCLEAR DENSITY/MOISTURE GAUGE CALIBRATION AND CHECK FOR GAUGES THAT DO NOT HAVE INTERNAL CALIBRATION CAPABILITY

The use of this type of gauge is rare, Contact ODOT for the appropriate procedure if required.

NUCLEAR DENSITY/MOISTURE GAUGE CALIBRATION PROCEDURE

1. Gauges must have a new calibration performed if any of the parameters in section 5 are not met. An example of a recording sheet is enclosed with this procedure.

2. With the gauge at room temperature 16^0C (60^0F) to 24^0C (75^0F). Locate the gauge on the Low-Density block so as not to be influenced by the transmission hole. Move the handle into the backscatter position. Set the gauge to take four-minute counts and if applicable set to read in counts. Perform two four-minute counts and record the Density counts.

3. Repeat this process on the Medium and High Density blocks. Average the two counts for each individual block.

4. Locate the source rod in the 50mm (two inch) direct transmission position on the Low density block and seat in the transmission hole. Perform one four-minute count and record the depth and Density count for that depth.

5. Repeat the counting and recording procedures for all depth increments to the gauge's maximum depth on all three blocks.

6. Input the data into NCAL or other calibration program in accordance with the programmer's guidelines.

   Note: must use the averaged backscatter counts that have been rounded to the nearest whole number when entering into NCAL.

   Note: when counts are to large to enter into NCAL, all counts, including standard counts must be divided by ten.

7. Print out the new constants.

8. Before the new constants are entered into the gauge, record the constants currently being used by the gauge.

9. Input the new constants in the gauge in accordance with the manufacturer's recommendations.

10. With the new constants in the gauge, the gauge must be checked for accuracy. Perform the accuracy check in accordance with the Nuclear Density/Moisture Gauge Annual Check of Accuracy for Gauges with Internal Computers section above.

11. For gauges calibrated by ODOT:

11.1 Upon successful completion of the accuracy check, record in a log the manufacturer and model of the gauge, the serial number, and the owner of the gauge.

11.2 Complete the Nuclear Density Gauge Calibration Check Sheet. Make a copy of the Check Sheet, which is to be kept with the gauge.

11.3 Contact the owner and arrange for the return of the gauge.

GAUGES CALIBRATED BY OTHERS

1. All gages must be verified by ODOT in accordance with the Nuclear Density/Moisture Gauge Annual Check of Accuracy for Gauges with Internal Computers section above.

2. Upon successful verification by ODOT, record in a log the manufacturer and model of the gauge, the serial number, and the owner of the gauge.

3. A copy of the calibration and ODOT verification is to be kept with the gauge.

4. Arrange for the return of the gauge.

REPORT

Each work sheet shall include:

- Manufacturer and model number of gauge
- Serial number of gauge
- Gauge owner
- Date of calibration check
- Name of technician performing calibration check
- Block densities to the nearest 1 Kg/m^3 or 0.1 lbs/ft^3
- Moisture Block densities to the nearest 0.1 Kg/m^3 or 0.1 lbs/ft^3
- Gauge, wet density readings to the nearest 1 Kg/m^3 or 0.1 lbs/ft^3
- Moisture reading check to the nearest 0.1 Kg/m^3 or 0.1 lbs/ft^3
- Signature of technician performing calibration check

FILE

A file should be generated (electronic or paper) for each gauge checked. This file should at a minimum contain the following information:

- Initial check documentation report
  Worksheet from the Report section above.

- If calibration was performed:
  Initial check documentation report
  Generated Constants
  Check documentation report Worksheet from the Report section above

The work sheets included with this test method are available in an Excel format. Contact the closes Quality Assurance Coordinator to your location.

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Nuclear Density Gauge Calibration Check ODOT TM304

MAKE: ____________ MODEL: ____________ DATE: ________

SERIAL NO: ____________ GAUGE OWNER: ____________

Standard Block has been verified: to have the same SN as the gauge being checked and that it is not cracked, split, delaminated or otherwise damaged.

	1st	2nd	3rd	4th	Average	5th	% Diff
DENSITY STANDARD:							
MOISTURE STANDARD:							

HOT SUBSTRATE TEST @ 185° F ± 4° F

BS	INITIAL TEST	Lb/cu.Ft	Wait Ten Minutes	FINAL TEST	Lb/cu.Ft
Four one-minute counts	1			1	
	2			2	
	3			3	
	4			4	
	AVE			AVE	

RESULTS:

CALIBRATION CHECK

Probe Depth	BS	2	4	6	8	10	12
	108.3	**107.2**					
LOW BLOCK READINGS							
Average Readings							
	134.9	**133.6**					
MEDIUM BLOCK READINGS							
Average Readings							
	165.9	**164.3**					
HIGH BLOCK READINGS							
Average Readings							

LO BLOCK MOIST **0.0 Lb**

FOUR-MINUTE COUNT	H2O (Lb)

RESULTS:

HI BLOCK MOIST **52.4 Lb**

FOUR-MINUTE COUNT	H2O (Lb)

RESULTS:

New Calibration by ODOT? YES ☐ NO ☐

NOTES:

SIGNATURE: ____________ DATE: ________

STATE OF OREGON 1859

Nuclear Density Gauge Calibration Check ODOT TM304

MAKE: **Troxler** MODEL: **3430** DATE: **10/14/2010**

SERIAL NO: **12345** GAUGE OWNER: **Nuke Guage Testers inc**

Standard Block has been verified: to have the same SN as the gauge being checked and that it is not cracked, split, delaminated or otherwise damaged.

	1st	2nd	3rd	4th	Average	5th	% Diff
DENSITY STANDARD:	3000.0	3050.0	3050.0	3000.0	3025.0	3055.0	1.0
MOISTURE STANDARD:	430.0	430.0	420.0	420.0	425.0	420.0	-1.2

HOT SUBSTRATE TEST

@ 185° F ± 4° F

BS	INITIAL TEST	Lb/cu.Ft	Wait Ten Minutes	FINAL TEST	Lb/cu.Ft
Four one-minute counts	1	165.5		1	165.5
	2	165.5		2	165.5
	3	165.5		3	165.5
	4	165.5		4	165.5
	AVE	165.5		AVE	165.5

RESULTS:

PASS

CALIBRATION CHECK

Probe Depth	**BS**	**2**	**4**	**6**	**8**	**10**	**12**
	108.3	**107.2**					
LOW BLOCK READINGS	108.3	107.2	107.2	107.2	107.2	107.2	107.2
	108.3	107.2	107.2	107.2	107.2	107.2	107.2
Average Readings	108.3	107.2	107.2	107.2	107.2	107.2	107.2
	PASS	**PASS**	**PASS**	**PASS**	**PASS**	**PASS**	**PASS**
	134.9	**133.6**					
MEDIUM BLOCK READINGS	134.9	133.6	133.6	133.6	133.6	133.6	133.6
	134.9	133.6	133.6	133.6	133.6	133.6	133.6
Average Readings	134.9	133.6	133.6	133.6	133.6	133.6	133.6
	PASS	**PASS**	**PASS**	**PASS**	**PASS**	**PASS**	**PASS**
	165.9	**164.3**					
HIGH BLOCK READINGS	165.9	164.3	164.3	164.3	164.3	164.3	164.3
	165.9	164.3	164.3	164.3	164.3	164.3	164.3
Average Readings	165.9	164.3	164.3	164.3	164.3	164.3	164.3
	PASS	**PASS**	**PASS**	**PASS**	**PASS**	**PASS**	**PASS**

LO BLOCK MOIST **0.0 Lb**

FOUR-MINUTE COUNT	H2O (Lb)
	0.0

RESULTS: **PASS**

HI BLOCK MOIST **52.4 Lb**

FOUR-MINUTE COUNT	H2O (Lb)
	52.4

RESULTS: **PASS**

New Calibration by ODOT? YES [X] NO [ ]

NOTES:

SIGNATURE: ____________________ DATE: 10/14/2010

OREGON DEPARTMENT OF TRANSPORTATION
CALIBRATION DATA SHEET

MAKE:

CALIB. DATE:

MODEL:

TECHNICIAN:

SERIAL NUMBER:

OWNER OF GAUGE:

DENSITY STANDARD:	

MOISTURE STANDARD:	

		Count	**Kg/m3**	**Count**	**Kg/m3**	**Count**	**Kg/m3**
BLOCK WT.			**1734**		**2161**		**2658**
BS	1						
	2						
4 Min	A						

BLOCK WT.			**1717**		**2140**		**2632**
50	4Min						
100	4Min						
150	4Min						
200	4Min						
250	4Min						
300	4Min						

LO BLOCK MOISTURE

FOUR-MINUTE COUNT:	

HI BLOCK MOISTURE

FOUR-MINUTE COUNT:	

☐ **CAL. CHANGE** RECALIBRATE GAUGE DATA

SIGNATURE \ DATE:________________________________

Recalibrate

MAKE: CALIB. DATE:

MODEL: TECHNICIAN:

SERIAL NUMBER:

OWNER OF GAUGE:

DENSITY STANDARD:	2829

MOISTURE STANDARD:	689

		Count	**Kg/m3**	**Count**	**Kg/m3**	**Count**	**Kg/m3**
BLOCK WT.			**1734**		**2161**		**2658**
BS	1	8721		6547		4847	
	2	8670		6545		4817	
4 Min	A	8696		6546		4832	

BLOCK WT.			**1717**		**2140**		**2632**
50	4Min	52609		35916		23503	
100	4Min	46386		29489		17719	
150	4Min	32499		19261		10657	
200	4Min	20580		11205		5933	
250	4Min						
300	4Min						

LO BLOCK MOISTURE

FOUR-MINUTE COUNT:	744.0

HI BLOCK MOISTURE

FOUR-MINUTE COUNT:	12601.0

x **CAL. CHANGE** RECALIBRATE GAUGE DATA

SIGNATURE \ DATE:________________________________

Recalibrate

Nuclear Density Gauge Calibration Check ODOT TM304

MAKE: MODEL: DATE:

SERIAL NO: GAUGE OWNER:

HOT SUBSTRATE TEST @ 185 F + or - 4 F

BS	INITIAL TEST	Lb/cu.Ft	Wait Ten Minutes	FINAL TEST	Lb/cu.Ft
Four one-minute counts	1			1	
	2			2	
	3			3	
	4			4	
	AVE			AVE	

RESULTS:

DENSITY STANDARD:					
MOISTURE STANDARD:					

CALIBRATION CHECK

Probe Depth	**BS**	**2**	**4**	**6**	**8**	**10**	**12**

	108.3	**107.2**					
LOW BLOCK READINGS							
Average Readings							

	134.9	**133.6**					
MEDIUM BLOCK READINGS							
Average Readings							

	165.9	**164.3**					
HIGH BLOCK READINGS							
Average Readings							

LO BLOCK MOIST **0.0 Lb**

FOUR-MINUTE COUNT	H2O (Lb)

RESULTS:

HI BLOCK MOIST **52.4 Lb**

FOUR-MINUTE COUNT	H2O (Lb)

RESULTS:

New Calibration by ODOT? YES ☐ NO ☐

NOTES:

SIGNATURE: ____________________ DATE: __________

Nuclear Density Gauge Calibration Check ODOT TM304

MAKE: MODEL: DATE:

SERIAL NO: GAUGE OWNER:

HOT SUBSTRATE TEST @ 185 F + or - 4 F

BS	INITIAL TEST	Lb/cu.Ft	Wait Ten Minutes	FINAL TEST	Lb/cu.Ft
Four one-minute counts	1	165.4		1	166.9
	2	165.3		2	165.8
	3	166.7		3	165.9
	4	168.8		4	165.9
	AVE	166.6		AVE	166.1

RESULTS:

PASS

DENSITY STANDARD:	2826.0	2831.0	2820.0	2829.0	2829.0
MOISTURE STANDARD:	693	682.0	685.0	690.0	689.0

CALIBRATION CHECK

Probe Depth	**BS**	**2**	**4**	**6**	**8**	**10**	**12**
	108.3	**107.2**					
LOW BLOCK READINGS	108.9	107.6	107.8	107.4	107.0	107.1	107.0
	109.2	107.7	106.8	107.3	107.1	108.0	107.3
Average Readings	109.1	107.7	107.3	107.4	107.1	107.6	107.2
	PASS	**PASS**	**PASS**	**PASS**	**PASS**	**PASS**	**PASS**
	134.9	**133.6**					
MEDIUM BLOCK READINGS	134.5	132.8	132.8	133.3	134.1	133.5	133.7
	134.4	133.3	132.9	133.1	134.0	133.9	133.8
Average Readings	134.5	133.1	132.9	133.2	134.1	133.7	133.8
	PASS	**PASS**	**PASS**	**PASS**	**PASS**	**PASS**	**PASS**
	165.9	**164.3**					
HIGH BLOCK READINGS	165.1	165.1	164.7	164.4	165.0	164.4	165.8
	165.0	164.1	164.4	164.7	165.1	165.5	165.7
Average Readings	165.1	164.6	164.6	164.6	165.1	165.0	165.8
	PASS	**PASS**	**PASS**	**PASS**	**PASS**	**PASS**	**FAIL**

LO BLOCK MOIST **0.0 Lb**

FOUR-MINUTE COUNT	H2O (Lb)
	0.3

RESULTS: **PASS**

HI BLOCK MOIST **52.4 Lb**

FOUR-MINUTE COUNT	H2O (Lb)
	51.4

RESULTS: **PASS**

New Calibration by ODOT? YES [X] NO [ ]

NOTES:

SIGNATURE: ____________________ DATE: __________

MAKE: CALIB. DATE:

MODEL: TECHNICIAN:

SERIAL NUMBER:

OWNER OF GAUGE:

DENSITY STANDARD:	

MOISTURE STANDARD:	

		Count	**Lb/Ft3**	**Count**	**Lb/Ft3**	**Count**	**Lb/Ft3**
BLOCK WT.			**108.3**		**134.9**		**165.9**
BS 4 Min	1						
	2						
	A						

BLOCK WT.			**107.2**		**133.6**		**164.3**
2	4Min						
4	4Min						
6	4Min						
8	4Min						
10	4Min						
12	4Min						

LO BLOCK MOISTURE

FOUR-MINUTE COUNT:	

HI BLOCK MOISTURE

FOUR-MINUTE COUNT:	

☐ **CAL. CHANGE** Calibration Data

SIGNATURE \ DATE:________________________________

Recalibrate

MAKE: CALIB. DATE:

MODEL: TECHNICIAN:

SERIAL NUMBER:

OWNER OF GAUGE:

DENSITY STANDARD:	2829	**MOISTURE STANDARD:**	689

		Count	**Lb/Ft3**	**Count**	**Lb/Ft3**	**Count**	**Lb/Ft3**
BLOCK WT.			**108.3**		**134.9**		**165.9**
BS	1	8721		6547		4847	
	2	8670		6545		4817	
4 Min	A	8696		6546		4832	

BLOCK WT.			**107.2**		**133.6**		**164.3**
2	4Min	52609		35916		23503	
4	4Min	46386		29489		17719	
6	4Min	32499		19261		10657	
8	4Min	20580		11205		5933	
10	4Min						
12	4Min						

LO BLOCK MOISTURE

FOUR-MINUTE COUNT:	744.0

HI BLOCK MOISTURE

FOUR-MINUTE COUNT:	12601.0

X **CAL. CHANGE** Calibration Data

SIGNATURE \ DATE:________________________________

Recalibrate

ODOT TM 305

Method of Test For

CALCULATING THE MOVING AVERAGE MAXIMUM DENSITY (MAMD)

SCOPE

This method establishes the procedure for calculating the Moving Average Maximum Density (MAMD). The MAMD is the reference density used in conjunction with density readings from a nuclear gauge to determine the percent compaction for comparing with required specification limits.

DEFINITIONS

Gmm - Maximum theoretical or “rice” specific gravity determined according to AASHTO T 209. If the “dryback” procedure in AASHTO T 209 is required or specified for determining the rice values for a JMF, then the “dryback” rice shall be used for MAMD calculation.

Maximum Density Test (MDT) - Maximum density for the mixture calculated according to the following:

$$\text{MDT (Metric)} = \text{Gmm} \times 1000 \text{ kg/m}^3$$

$$\text{MDT (English)} = \text{Gmm} \times 62.4 \text{ lb/ft}^3$$

PROCEDURE

1. Determine the MDT for the first sublot produced each day. A minimum of one MDT is required each day of production, even if no random sublot sample is obtained. For production days when the first random sublot sample will not occur until late in the shift, a separate sample for MDT may be obtained early in the shift. Note the purpose of the sample on project documentation. All provisions of this procedure and AASHTO T 209 still apply to a non-sublot sample MDT.

2. AASHTO T 209 is required for each sublot, however, for purposes of calculating the MAMD, use only the MDT from the first sublot produced each day.

3. If a MDT result varies more than 20 kg/m^3 (1.3 lb/ft^3) from the previous MAMD, obtain another sample and determine a new Gmm. Calculate the MDT. If the second MDT is closer to the previous MAMD than the first MDT, use it. If not, use the first MDT.

4. Any MDT representing rejected materials will not be included in the MAMD calculation. Obtain a sample representing nonrejected material to determine the daily MDT.

5. Calculate the MAMD as follows:

5.1 The initial MAMD is the MDT for the first production day.

5.2 The next MAMD is the average of the MDT's from the first two production days.

5.3 The next MAMD is the average of the MDT's from the first three production days.

5.4 The next MAMD is the average of the MDT's from the first four production days.

5.5 For the fifth day, the MAMD is the average of the MDT's for the first 5 production days.

5.6 For future production days, the MAMD is the average of the MDT for that day and the MDT's from the previous 4 production days.

6. A new MAMD must be started when a new JMF is used. A JMF adjustment is not considered a new JMF.

7. A change in Lots due to a change in the minimum required compaction or due to a change in the test procedure used to determine asphalt content does not require a new MAMD calculation to be started.

REPORT

Report MAMD to the nearest whole kg/m^3 (nearest 0.1 lb/ft^3). Document MAMD calculations on Form 734-2050

EXAMPLE

METRIC

MDT Date	MDT	MAMD
8/1/02	2696	2696
8/2/02	2676	2686
8/3/02	2668	2680
8/4/02	2652* 2665**	2676
8/5/02	2662	2673
8/8/02	2660	2666

* MDT is more than 20 kg/ m^3 (2680-2652=28) from the last MAMD. Another MDT test is required.
** 2665 is closer to the previous MAMD(2680) than 2652, therefore 2665 is used to calculate the MAMD.

ENGLISH

MDT Date	MDT	MAMD
8/1/02	168.3	168.3
8/2/02	167.0	167.7
8/3/02	166.5	167.3
8/4/02	165.5* 166.4**	167.1
8/5/02	166.2	166.9
8/8/02	166.0	166.4

* MDT is more than 1.3 lb/ft^3 (167.3-165.5 = 1.8) from the last MAMD. Another MDT test is required.
** 166.4 is closer to the previous MAMD(167.3) than 165.5, therefore 166.4 is used to calculate the MAMD.

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ODOT TM 306

Method of Test For
PERFORMING A CONTROL STRIP FOR ACP PAVEMENT

SCOPE

A control strip is a field procedure, which provides data to establish roller patterns, which will achieve a maximum density. The method is designed to use the same compaction equipment and materials throughout the project. Changes in materials, compaction equipment, or weather conditions, may require a new roller pattern or verification of the adequacy of the roller pattern being used.

SIGNIFICANCE AND USE

This procedure is used to determine the optimum rolling pattern for ACP and evaluate the JMF for in-place properties that could impact overall performance of the placed material. This evaluation can determine whether the ACP in place void content is too low or high and is an indicator of potential problems with the JMF proportions.

GENERAL PROCEDURE

The procedure is performed in two separate phases using an initial site to collect the roller information and confirming the rolling pattern is consistent and uniform.

1. An initial point is used to establish the maximum density that can be achieved with a JMF and the compaction equipment used.

2. Using the roller information collected during the initial point evaluation, the optimum rolling pattern is applied to a test strip section and tested to ensure that the optimum roller pattern achieved specified density and uniformity.

DEFINITIONS

- **In-Place Density -** The density of the compacted bituminous mixture as it exists in the pavement. The in-place density will be determined, in accordance with AASHTO T 355, using a Nuclear Moisture-Density Gauge unless otherwise specified.

- **Control Strip Length –** This is equal to the length of the rolling pattern being used for compaction of a section of pavement that has been placed to the specified width and thickness. **Maximum length shall not exceed 500 ft.**

- **Initial Point -** A testing point selected and used to determine the increasing in-place densities of the pavement with successive roller passes.

- **Roller Pass -** The passing of a roller over an area (roller width) one time.

- **Roller Coverage -** The rolling of the entire width of pavement one time, including roller overlaps.

- **Breakdown Rolling -** The first roller coverage~~'s~~ on the mixture after it is placed.

- **Intermediate Rolling -** All rolling following the breakdown rolling, until the temperature of the mixture cools to a temperature at which it can be finish rolled.

- **Finish Rolling -** All rolling after the intermediate rolling that is required to bring the mixture to a smooth surface and remove any roller marks.

APPARATUS

- A nuclear density gauge meeting the apparatus requirements of AASHTO T 355.

- transport case for properly shipping and housing the gauge and tools

- instruction manuals for the specific make and model of the gauge

- filler material and tools to process the filler material

- a suitable thermometer for measuring the temperature of the paved surface

PERFORMING CONTROL STRIP

Initial Point Evaluation

1. A control strip shall be constructed when required by the specifications. The initial point shall be established within the first 200 ton of production unless otherwise approved by the Engineer. If a uniform rolling pattern cannot be established in a reasonable manner to complete a control strip the first day of placing ACP, contact the Engineer.

2. The control strip shall meet the following conditions:

   A. Match the length of the rolling pattern with a maximum length of 500 ft.
   B. Part of the roadway
   C. Placed to the specified width and thickness of roadway design
   D. Composed of the same materials as the rest of the lift
   E. Compacted with the same equipment as the rest of the lift

3. An **Initial Point** is selected. The initial point must be at least 50 ft. from the beginning of the mat placement and no closer than 2 ft. from the edge of the mat and in an area that is representative of the overall material being placed.

4. After each roller pass over the initial point the nuclear gauge is used in the backscatter position to determine the in-place density, with a 15 second count. The un-sanded initial point is carefully marked so that subsequent tests are made in exactly the same position and location.

5. For each roller used and each pass over the initial point record the type of roller, surface temperature, density in-place (15 second reading), direction of travel, and whether vibratory or static mode. The information is recorded on the Control Strip Method of Compaction Testing, Form 734-2084.

6. Continue compaction and testing after each roller pass, until the density readings taken at the initial point do not increase. (The density readings may decrease or level off to indicate this.) Note: A time delay in roller passes might occur during this process, due to ACP showing signs of tenderness or movement. (Often associated with moisture and/or oil related properties).

7. The density of the initial point is then tested according to AASHTO T 355. The density readings are recorded.

    - If the density of the initial point meets the minimum specified density continue with step 1, Test Strip Evaluation. For Control Strips constructed at the beginning of production of a JMF, use the MDT from the JMF until the first MDT from produced mix is available. Use the first MDT from produced mix as the MAMD (per ODOT TM 305) after it is available. Control Strips constructed at all other times, use the current MAMD.

    - If the initial point does not meet minimum specified density, adjustments to the rolling pattern or compaction equipment must be made. After the adjustments have been made, a new control strip area is selected and tested starting with step 1.

Test Strip Evaluation

The optimum roller pattern determined in the Initial point evaluation process shall be applied to a test strip location.

1. A new test strip section shall be constructed and meet the following conditions:

    A. Match the length of the rolling pattern with a maximum length of 500 ft.
    B. Part of the roadway
    C. Placed to the specified width and thickness of roadway design
    D. Composed of the same materials as the rest of the lift
    E. Compacted with the same equipment as the rest of the lift

2. After the optimum rolling pattern has been applied select five test locations at random stations within the test strip section (Random Stations per Form 734-1972 or other approved method). The transverse locations shall be at:

    1. 1 ft. from left edge of panel
    2. Midpoint of left half of panel
    3. Center of panel
    4. Midpoint of right half of panel
    5. 1 ft. from right edge of panel

    Test the five random locations according to AASHTO T 355. The results of the density tests are recorded to the nearest 0.1 #/cf.

Control Strip Evaluation

3. The Control Strip is valid only if the following conditions are met:

   A. The initial point meets the minimum specified compaction required.

   B. The individual densities of the five random test locations from Test Strip Evaluation Step 2 are within ± 1.5% of the average compaction of the five random tests.

   C. The average density of the five Test Strip Evaluation random test locations is no less than the minimum specified compaction required.

4. Immediately inform the CAT II of the results of the control strip. If any of the density test locations are over 95% compaction (based on MAMD) inform the Project Manager or designated representative and the paving contractor's representative.

5. **Any points used to develop the control strip are not allowed to be used as sublot quality control/acceptance tests.**

REPORT

The report shall be made on the Control Strip Method of Compaction Testing, Form 734-2084.

ODOT TM 321

Method of Test for

Asphalt Content of Bituminous Mixtures by Plant Recordation

1. SCOPE

This method contains the procedures for determining the asphalt content, RAM or RAS content, lime content, mineral filler content, fiber content, and liquid additive content of ACP and EAC mixtures produced by batch, drum, or other acceptable mixing plants. Use of this method is contingent on consistent agreement between the plant recording equipment (meters and/or scales) and a physical inventory of the materials used. If the agreement between the inventory and plant recording equipment does not exist, the inventory data will be used to adjust the recordation data for acceptance.

2. SIGNIFICANCE AND USE

This method can be used to determine the asphalt content of a mixture at any point in time for determining the acceptance of a product and to determine partial payment for the product. It can be applied to batch, drum, or other acceptable plants and for all asphalt mixture constituents, including percent of RAM or RAS, percent of Lime, percent of mineral filler, percent of fiber, percent of liquid additive, and any other additives.

3. TERMINOLOGY

3.1 ***Reclaimed Asphalt Pavement (RAP)*** – removed and/or processed pavement materials containing asphalt binder and aggregate.

3.2 ***Recycled Asphalt Shingles (RAS)*** – tear-off or manufacturer waste shingle product materials containing asphalt and fine aggregate and fiberglass material.

3.3 ***Recycled Asphalt Material (RAM)*** – recycled asphaltic materials containing asphalt binder and aggregate. RAM may be RAP only or a combination of RAP and RAS for purposes of this test procedure. (*Currently limited to RAP and RAS*).

4. PROCEDURES – ACP WITHOUT RAM or RAS - DRUM PLANTS

4.1 General

The quantity of dry aggregate (after adding lime, if appropriate) as measured by the belt scale and the amount of asphalt as measured by the plant meter system for a predetermined period of time are used to determine the percentage of asphalt being added to the mixture.

The quantity of lime, mineral filler, fibers, liquid additive, or any other additive as measured by an appropriate meter for a predetermined period of time are used to determine the percentage of the appropriate constituent in the mixture.

For Commercial ACP Plants where the procedures described herein are deemed impractical the following process shall be used:

a) The ACP supplier will submit, in writing, a plan for verifying and documenting calibration of all appropriate meters on a daily basis.

b) The Engineer and Region Quality Assurance Coordinator shall review, work with the supplier to modify if necessary, and approve the proposed plan.

c) The supplier will perform the agreed upon process for ODOT contracts.

4.2 Plant Calibration

4.2.1 Standard Drum Plants

Calibrate the plant aggregate belt scales, asphalt meter, and any other scales or meters according to ODOT TM 322 prior to the beginning of paving. Make the results of the calibration available at the asphalt plant for review by the Engineer. Recalibrate the plant when the comparison of the recordation data and plant inventory is outside the limits established in this procedure.

4.2.2 Drum Plants Equipped with Calibration Tank on Load Cells

Plants that have the capability of producing for short periods of time from a calibration tank which can be weighed using load cells or a scale are not required to conduct the meter calibration in ODOT TM 322. Calibrate the weighing device using the standard required for plant scale calibration.

4.2.3 Storage of Mixture in Silo's

Develop a system to determine the quantity of mixture in the silos at the beginning and end of the day if any. This value will be used to adjust the total weight of mixture produced in a day.

4.3 Daily Total Requirements

4.3.1 Belt Scale and Meter Totalizers: Record the asphalt, aggregate, lime (if appropriate), mineral filler (if appropriate), fiber (if appropriate), liquid additive (if appropriate), or any other additive totalizer readings at the beginning and the end of each days production. Record the plant setting for aggregate moisture used throughout the day. This data will be used to determine the total quantity of material produced for comparison with the plant inventory data.

4.3.2 Waste: Weigh and record the material measured by the plant belt scales and meters that did not get weighed by the plant truck scales (wasted) (this could include materials sent to the road and material generated from the production facility). All waste shall be itemized as to type and associated weight, i.e. start-up and shut-down, dust rejection, spilled material etc. An alternative means of determining the weight of wasted materials may be proposed to the Engineer, in writing, when daily weighing of waste is determined to be impractical.

4.3.2.1 For purposes of determining waste for comparison of meters with physical inventory at the end of each day, material wasted due to plant start-ups, shut-downs, or other operations shall be evaluated as follows: 50% of the total wasted weight will be considered "uncoated aggregate waste" with no asphalt coating and 50% will be considered "mix waste" which is coated with the average asphalt content calculated for the day based on physical inventory. Enter these weights in the appropriate locations on form 734-2401.

4.3.2.2 For purposes of determining waste for comparison of meters with physical inventory at the end of each day, material wasted due to rejection on the grade or elsewhere will be considered "mix waste" which is coated with the average asphalt content calculated for the day based on physical inventory. Combine this value with the "mix waste" determined in 4.3.2.1 and enter the new value in the appropriate location on form 734-2401.

4.3.2.3 If asphalt cement payment is based on tank sticks and invoices, calculate the amount of waste liquid asphalt using the "mix waste" weights from 4.3.2.1 and 4.3.2.2, the average asphalt content calculated for the day from the "BY TANK % Pb" box on form 734-2401, and the "DAILY AVERAGE MIX MOISTURE" box on Form 734-2401. The "mix waste" will need to be converted to "dry mix waste" before calculating the waste liquid asphalt. Convert "mix waste" to "dry mix waste" with the following formula:

$$\frac{\textit{(wet "mix waste")}}{\textit{1 + (Average Mix Moisture Content, Percent/100)}}$$

Calculate waste liquid asphalt according to the following:

$$Dry\text{"}mixwaste\text{"}\times\left[\frac{AverageAsphaltContent, percent}{100}\right]$$

Enter the waste liquid asphalt in the "deductions after beginning inventory" box on form 734-2043. Document in the "Waste Deduction Calculation" portion of form 734-2043.

4.3.3 Asphalt Content by Meters: Calculate the percent asphalt by meters for the day's production according to the following formula:

$$\frac{\textit{(Weight of Asphalt) x 100}}{\textit{(Wt. of Asphalt) + ("Actual Dry" Weight of Aggregate) – "Uncoated Aggr Waste"}}$$

Calculate the “Actual Dry” weight of aggregate using the daily totalizer reading for the aggregate, plant aggregate moisture setting, and average of the sublot cold feed moisture tests for the day using the process described in Section 4.4.3. “Uncoated Agg Waste” is waste generated from start ups and shut downs.

4.3.4 Total “Dry” Material Weighed by Meters: Determine the total weight of “dry” material weighed by the meters for the day’s production using the following formula:

(Wt. of Asphalt) + (“Actual Dry” Wt of Aggregate) – (Uncoated Aggregate Waste)

NOTE: *When materials such as mineral filler or fibers are added to the plant but not weighed by the final aggregate belt scale, the above formula will need to be modified as necessary to account for the additional materials.*

4.4 Sublot Requirements

4.4.1 Determine the moisture content of the combined aggregate from the cold feeds according to AASHTO T 255 for each sublot.

4.4.2 For each sublot as required by the acceptance program random number sampling schedule, record the asphalt, aggregate, lime(if appropriate), mineral filler(if appropriate), fiber(if appropriate), liquid additive(if appropriate), or any other additive used for a period of 15 ± 2 minutes. This is accomplished by recording the totalizer readings at the beginning and end of the selected time period and subtracting, or by obtaining the results of the plant printout over the required period. Record the plant setting for aggregate moisture used during the selected time period.

4.4.3 Determine the “actual dry” weight of aggregate according to the following:

4.4.3.1 Convert “dry” weight of aggregate as measured by the plant to “actual wet” weight using the following formula:

$$Plant\text{"}Dry\text{"}Weight \times \left[1 + \frac{PlantMoistureSetting, percent}{100}\right]$$

Example:

Plant “Dry” Weight of Aggregate = *163.4 tons*
Plant Moisture Setting, % = *3.2*

“Actual Wet” Weight of Aggregate = $163.4 \times \left[1 + \frac{3.2}{100}\right] = 168.6$ *tons*

4.4.3.2 Convert "Actual Wet" weight of aggregate to "Actual Dry" weight of aggregate using the following formula:

$$\frac{\textit{("Actual Wet" Weight of Aggregate)}}{\textit{1 + (Sublot Aggregate Moisture Content, Percent/100)}}$$

Example:

"Actual Wet" Weight of Aggregate = 168.6 tons
Sublot Aggregate Moisture Content, % = 3.6

"Actual Dry" Weight of Aggregate = $\frac{168.6}{1+(3.6/100)} = \frac{168.6}{1.036} = 162.7$ *tons*

4.4.4 Determine the volume of asphalt used for a base temperature of 60°F by multiplying the gallons from the meter by the appropriate temperature correction factor from column A in the attached table 2.03.

Example:

Gallons of Asphalt = 2734.8
Temperature, F = 309
Correction Factor = 0.9158

Gallons of Asphalt at 60°F = 2734.8 x 0.9158 = 2504.5

NOTE: *Some plant meters measure the quantity of asphalt directly in weight. If this is the case, skip Sections 4.4.4 and 4.4.5 and proceed directly to Section 4.4.6.*

4.4.5 Convert gallons of asphalt at 60°F to weight (tons) using the following formula:

$$\frac{\textbf{(gallons of Asphalt at 60°F) x (Asphalt Specific Gravity at 60°F)}}{\textbf{239.9 gallons/ton}}$$

Example:

Volume of Asphalt at 60°F = 2503.5 gallons
Asphalt Specific Gravity at 60°F = 1.027

Weight of Asphalt = $\frac{2503.5 x 1.027}{239.9}$ *= 10.72 tons*

4.4.6 Calculate the percent asphalt content using the following formula:

$$\frac{\textit{(Weight of Asphalt) x 100}}{\textit{(Wt. of Asphalt) + ("Actual Dry" Weight of Aggregate)}}$$

Example:

Weight of Asphalt = 10.72 tons
"Actual Dry" Weight of Aggregate = 162.7 tons

Asphalt Content, % $= \frac{10.72 x 100}{10.72 + 162.7}$ *= 6.18*

NOTE: *When materials such as mineral filler or fibers are added to the plant but not weighed by the final aggregate belt scale, the above formula will need to be modified as necessary to account for the additional materials.*

4.4.7 If appropriate, calculate the percent lime using the following formula:

(Weight of Lime) x 100
("Actual Dry" Weight of Aggregate) - (Weight of Lime)

NOTE: *The percent of lime is based on dry weight of virgin aggregate only. The "Actual Dry" Weight of Aggregate in the above equation would not include any mineral filler or fibers.*

4.4.8 When applicable, calculate the percent mineral filler, percent fibers, and/or percent liquid additive using the particular plant configuration and meter set up as necessary to compare the appropriate percentages with the job mix formula requirements.

4.5 Asphalt Content Determination for Drum Plants Equipped with Calibration Tank on Load Cells or scale

Follow the procedures given above in Section 4.4 except items 4.4.4 and 4.4.5 are deleted and the direct readout of the tons of asphalt used from the calibrated tank is entered into Section 4.4.6.

4.6 Asphalt Content by Inventory

4.6.1 Liquid Asphalt on Hand

Determine the gallons of asphalt on hand in the tanks prior to the start of production. Convert the gallons at tank temperature to weight (tons) at 60°F using the formulas in Section 4.4.4 and 4.4.5.

4.6.2 Liquid Asphalt Delivered

Total the weight of liquid asphalt delivered to the asphalt plant for the production day. It is recommended that each transport be weighed prior to and after unloading to verify the actual delivered weight.

4.6.3 Liquid Asphalt Used

Add the weight of liquid asphalt on hand at the beginning of the day to the weight of liquid asphalt delivered and subtract the weight of liquid asphalt on hand at the end of the day. The answer gives the quantity of liquid asphalt used that day based on inventory. Reduce this amount by the quantity of liquid asphalt that was removed from the tank and did not enter the plant. This could include liquid asphalt removed for tack or other purposes.

Example:

Weight of Asphalt on Hand at Start of Production =	*96.40 tons*
Weight of Asphalt Delivered During Day =	*124.80 tons*
Weight of Asphalt on Hand at End of Production =	*61.40 tons*

Weight of Asphalt Used = 96.4 + 124.8 - 61.4 = 159.80 tons

4.6.4 Total Mixture Produced by Inventory

4.6.4.1 Total "Wet" Mixture Produced

Determine the total weight of "wet" mixture produced during the day from the truck invoices. Add to this the total "mix waste" determined from sections 4.3.2.1 and 4.3.2.2. Calculate the total "wet" mixture produced using the following formula:

Total "Wet" Mixture = Weight from Invoices + "Mix Waste"

4.6.4.2 Total "Dry" Mixture Produced

Determine the total weight of "dry" mixture produced during the day using the following formula:

$$\frac{\text{(Total "Wet" Weight of Mixture)}}{1 + \text{(Average Mixture Moisture, Percent/100)}}$$

Example:

Total "Wet" Weight of Mixture =	*2675.00 tons*
Average Mixture Moisture Content, % =	*0.42*

Total "Dry" Weight of Mixture = $\frac{2675.0}{1+(0.42/100)}$ *= 2663.81 tons*

4.6.4.3 Asphalt Content by Inventory

Determine the percent asphalt content by inventory of the mixture by the following formula:

$$\frac{\text{(Liquid Asphalt Used) x 100}}{\text{(Total "Dry" Weight of Mixture)}}$$

Example:

Liquid Asphalt Used = *159.80 tons*
Total "Dry" Weight of Mixture = *2663.81 tons*

Asphalt Content by Inventory, % = $\frac{159.80x100}{2663.80}$ *= 6.00*

4.6.4.4 Total "Wet" Mixture Produced

Determine the total weight of "wet" mixture produced during the day from the truck invoices. Add to this the total "mix waste" and "uncoated aggregate waste" determined from sections 4.3.2.1 and 4.3.2.2. Calculate the total "wet" mixture produced using the following formula:

Total "Wet" Mixture = Wt from Invoices + "Mix Waste" + "Uncoated Aggregate Waste"

4.6.4.5 Total "Dry" Mixture Produced

Determine the total weight of dry mixture produced during the day using the following formula:

$$\frac{\text{(Total "Wet" Mixture)}}{\text{1 + (Average Mixture Moisture, Percent/100)}}$$

Example:

Total "Wet" Weight of Mixture = *2675.00 tons*
Average Mixture Moisture Content, % = *0.42*
Total "Dry" Weight of Mixture = $\frac{2675.0}{1+(0.42/100)}$ *= 2663.81 tons*

4.7 ACP Recordation System Verification

On a daily basis compare the percent asphalt content from the daily total meter data from Section 4.3.3 to the percent asphalt content determined by the inventory method from Section 4.6.4.3. If the difference exceeds ±0.20 percent, recalibrate the plant. For those production days when the above tolerance is exceeded, the asphalt content for each sublot used for acceptance as determined from the meter method will be adjusted by the difference determined in this verification process for that day.

Calculate the asphalt content correction value (difference) from the following formula:

Asphalt Content Correction, % =

Asphalt Content by Inventory, % - Asphalt Content by Meter, %

If Asphalt Content Correction Difference (%) ≤ ±0.20%, then Correction = 0.0%

If Asphalt Content Correction Difference (%) > ±0.20%, then adjust sublot asphalt content values according to:

Adjusted Asphalt Content for Sublot n, % =

Asphalt Content for Sublot n by meter, % + Asphalt Content Correction, %

Example:

Asphalt Content by Daily Inventory, % = 6.00
Asphalt Content by Daily Meter, % = 6.22

Asphalt Content by Sublots for the Daily Production:

Sublot 1-11	*6.10%*
Sublot 1-12	*6.18%*
Sublot 1-13	*6.21%*

Asphalt Content Correction, % = 6.00 - 6.22 = -0.22
Difference -0.22% > ±0.20%, therefore apply correction to daily sublots

Adjusted Sublot Asphalt Contents:

Sublot 1-11	*6.10% + (- 0.22%) = 5.88%*
Sublot 1-12	*6.18% - 0.22% = 5.96%*
Sublot 1-13	*6.21% - 0.22% = 5.99%*

In addition, on a daily basis compare the total “dry weight” of materials measured by the plant meters from Section 4.3.4 with the total “dry” weight of mixture from Section 4.6.4.5 according to the equation below. If the difference exceeds ±1.0 percent, recalibrate the plant. The Engineer may waive this requirement for small production days where less than 1000 tons is produced.

$$\frac{(\text{Total Dry Weight of Materials from Meters} - \text{Total “Dry” Mixture}) \times 100}{\text{Total “Dry” Mixture}}$$

Perform a second calculation comparing weight of asphalt as measured by the asphalt meter to the weight of asphalt used by inventory according to the equation below (%ERROR ASPHALT METER vs TANK MEASURE on Form 2401). If the difference is less than or equal to ±0.5%, then the asphalt meter is in calibration and only the belt scales need to be recalibrated. If the difference exceeds ±0.5%, then all meters and scales need recalibration.

$$\frac{\text{(Total Weight of Asphalt from Meters – Total Weight of Asphalt by Inventory)} \times 100}{\text{Total Weight of Asphalt by Inventory}}$$

5. PROCEDURES – ACP WITH RAM and/or RAS - DRUM PLANTS

5.1 General

The quantity of dry aggregate (after adding lime, if appropriate) and dry RAM as measured by the belt scales, the amount of asphalt as measured by the plant meter system, and the quantity of dry RAS, lime, mineral filler, fibers, liquid additive, or any other additive as measured by an appropriate meter for a predetermined period of time are used to determine the percentage of the appropriate constituent in the mixture.

The intent of the procedure presented in this section is to verify calibration of the RAM, RAS, lime, mineral filler, or fiber meters on a daily basis.

For Commercial ACP Plants where the procedures described herein are deemed impractical the following process shall be used:

a) The ACP supplier will submit, in writing, a plan for verifying and documenting calibration of all appropriate meters on a daily basis.

b) The Engineer and Region Quality Assurance Coordinator shall review, work with the supplier to modify if necessary, and approve the proposed plan.

c) The supplier will perform the agreed upon process for ODOT contracts.

5.2 Plant Calibration

5.2.1 Standard Drum Plants

Calibrate the plant aggregate belt scales, RAM belt scale, RAS belt scale, asphalt meter, and any other meters according to ODOT TM 322 prior to the beginning of paving. Make the results of the calibration available at the asphalt plant for review by the Engineer.

5.2.2 Drum Plants Equipped with Calibration Tank on Load Cells

Plants which have the capability of producing for short periods of time from a calibration tank which can be weighed using load cells or a scale are not required to conduct the meter calibration in ODOT TM 322. Calibrate the weighing device using the standard required for plant scale calibration.

5.2.3 Storage of Mixture in Silo's

Develop a system to determine the quantity of mixture in the silos at the beginning and end of the day if any. This value will be used to adjust the total weight of mixture produced in a day.

5.3 Daily Total Requirements

5.3.1 Belt Scale and Meter Totalizers: Record the asphalt, aggregate, RAM, RAS (if appropriate), lime (if appropriate), mineral filler (if appropriate), fiber (if appropriate), liquid additive (if appropriate), or any other additive totalizer readings at the beginning and the end of each days production. For commercial plants making multiple runs during a day, this data shall be recorded for each run and summed up at the end of the day.

Record the plant settings for aggregate moisture, RAM moisture, and RAS moisture (if appropriate) used throughout the day. Document this information on form 734-2401.

5.3.2 Waste: Weigh and record the material measured by the plant belt scales and meters that did not get weighed by the plant truck scales (wasted) (this could include materials sent to the road and material generated from the production facility). All waste shall be itemized as to type and associated weight, i.e. start-up and shut-down, dust rejection, spilled material etc. An alternative means of determining the weight of wasted materials may be proposed to the Engineer, in writing, when daily weighing of waste is determined to be impractical.

5.3.2.1 For purposes of determining waste for comparison of meters with physical inventory at the end of each day, material wasted due to plant start-ups, shut-downs, or other operations shall be evaluated as follows: 50% of the total wasted weight will be considered "uncoated aggregate waste" with no asphalt coating and 50% will be considered "mix waste" which is coated with the average asphalt content calculated for the day based on physical inventory. Enter these weights in the appropriate locations on form 734-2401.

5.3.2.2 For purposes of determining waste for comparison of meters with physical inventory at the end of each day, material wasted due to rejection on the grade or elsewhere will be considered "mix waste" which is coated with the average asphalt content calculated for the day based on physical inventory. Combine this value with the "mix waste" determined in 5.3.2.1 and enter the new value in the appropriate location on form 734-2401.

5.3.2.3 If asphalt cement payment is based on tank sticks and invoices , calculate the amount of waste liquid asphalt using the "mix waste" masses from 5.3.2.1 and 5.3.2.2, the average asphalt content calculated for the day from the "BY TANK % Pb" box on form 734-2401, and the "DAILY AVERAGE MIX MOISTURE" box on Form 734-2401.

The "mix waste" will need to be converted to "dry mix waste" before calculating the waste liquid asphalt. Convert "mix waste" to "dry mix waste" with the following formula:

$$\frac{\textbf{(wet "mix waste")}}{\textbf{1 + (Average Mix Moisture Content, Percent/100)}}$$

Calculate waste liquid asphalt according to the following:

$$Dry"mixwaste"\times\left[\frac{AverageAsphaltContent, percent}{100}\right]$$

Enter the waste liquid asphalt in the “deductions after beginning inventory box” on form 734-2043. Document calculations in the “Waste Deduction Calculation” portion of form 734-2043.

5.3.3 Total “Dry” Material Weighed by Meters: Determine the total weight of “dry” material weighed by the meters for the day’s production using the following formula:

(Wt. of Asphalt) + (“Actual Dry” Wt of Aggregate) + (“Actual Dry” Wt of RAM) + (“Actual Dry” Wt of RAS) – (Uncoated Aggregate Waste)

NOTE: *When materials such as mineral filler, fibers, or RAS are added to the plant but not weighed by a belt scale, the above formula will need to be modified as necessary to account for the additional materials.*

5.4 Sublot Requirements

5.4.1 Determine the moisture content of the combined aggregate from the cold feeds according to AASHTO T 255 and the moisture content from the RAM cold feed according to AASHTO T 329 for each sublot. RAS feed on an independent metered cold feed; determine the moisture content for the RAS according to AASHTO T 329.

5.4.2 For each sublot as required by the acceptance program random number sampling schedule, record the asphalt, aggregate, RAM, RAS (if appropriate), lime (if appropriate), mineral filler (if appropriate), fiber (if appropriate), liquid additive (if appropriate), or any other additive used for a period of 15 ± 2 minutes. This is accomplished by recording the totalizer readings at the beginning and end of the selected time period and subtracting, or by obtaining the results of the plant printout over the required period. Record the moisture plant settings of all the materials used by the plant for the selected time period.

5.4.3 Determine the actual dry weight of aggregate according to the formulas given in Sections 4.4.3.1 and 4.4.3.2.

5.4.4 Determine the actual dry weight of RAM and/or RAS (if appropriate), according to the formulas given in Sections 4.4.3.1 and 4.4.3.2 using weights of RAM and/or RAS in place of the weights of aggregate.

5.4.5 Determine the weight of asphalt used according to Sections 4.4.4 and 4.4.5.

5.4.6 Calculate the percent RAM using the following formula:

(“Actual Dry” Weight of RAM) x 100
(“Actual Dry” Weight of RAM) + (“Actual Dry” Weight of Aggregate)

5.4.7 If appropriate, calculate the percent RAS using the following formula:

(“Actual Dry” Weight of RAS) x 100
(“Actual Dry” Weight of RAS) + (“Actual Dry” Weight of RAP) + (“Actual Dry” Weight of Aggregate)

5.4.8 If appropriate, calculate the percent lime using the following formula:

(Weight of Lime) x 100
(“Actual Dry” Weight of Aggregate) - (Weight of Lime)

5.4.9 When applicable, calculate the percent mineral filler, percent fibers, and/or percent liquid additive using the particular plant configuration and meter set up as necessary to compare the appropriate percentages with the job mix formula requirements.

5.4.10 Determine the percent binder replacement as follows:

5.4.10.1 Calculate the percent virgin asphalt content using the following formula:

(Weight of Asphalt) x 100
(Weight of Asphalt) + (“Actual Dry” Weight of RAS) + (“Actual Dry” Weight of RAP/RAM) + (“Actual Dry” Weight of Aggregate)

5.4.10.2 Determine the total percent asphalt content according to AASHTO T 308.

5.4.10.3 Calcuate the percent binder replacement using the following formula:

((Total Percent Asphalt) – (Percent Virgin Asphalt)) x 100
(Total Percent Asphalt)

5.5 Total Mixture Produced by Inventory

5.5.1 Total “Wet” Mixture Produced

Determine the total weight of “wet” mixture produced during the day from the truck invoices. Add to this the total “mix waste” and “uncoated aggregate waste’ determined from sections 5.3.2.1 and 5.3.2.2. Calculate the total “wet” mixture produced using the following formula:

Total “Wet” Mixture = Wt from Invoices + “Mix Waste” + “Other Mixture”

5.5.2 Total "Dry" Mixture Produced

Determine the total weight of dry mixture produced during the day using the following formula:

$$\frac{\textit{(Total "Wet" Weight of Mixture)}}{\textit{1 + (Average Mixture Moisture, Percent/100)}}$$

Example:

Total "Wet" Weight of Mixture = 2675.00 tons
Average Mixture Moisture Content, % = 0.42

$$\textit{Total "Dry" Weight of Mixture} = \frac{2675.0}{1+(0.42/100)} = 2663.81 \textit{ tons}$$

5.6 ACP Recordation System Verification

On a daily basis compare the total "dry weight" of materials measured by the plant meters from Section 5.3.3 with the total "dry" weight of mixture from Section 5.5.2 according to the equation below. If the difference exceeds ±1.0 percent, recalibrate the plant. The Engineer may waive this requirement for small production days where less than 1000 tons is produced.

$$\frac{\textit{(Total Dry Weight of Materials from Meters – Total "Dry" Weight of Mixture)} \times 100}{\textit{Total "Dry" Weight of Mixture}}$$

Perform a second calculation comparing weight of asphalt as measured by the asphalt meter to the weight of asphalt used by inventory according to the equation below (%ERROR ASPHALT METER vs TANK MEASURE on Form 2401). If the difference is less than or equal to ±0.5%, then the asphalt meter is in calibration and only the belt scales need to be recalibrated. If the difference exceeds ±0.5%, then all meters and scales need recalibration.

$$\frac{\textit{(Total Weight of Asphalt from Meters – Total Weight of Asphalt by Inventory)} \times 100}{\textit{Total Weight of Asphalt by Inventory}}$$

6. PROCEDURES - ACP BATCH PLANTS

6.1 General

The weights of aggregate and asphalt from a series of batches are used to determine the percentage of asphalt being added to the mixture. The weights of RAM, RAS, lime, mineral filler, fibers, or other additives from a series of batches are used to determine the respective percentages added to the mixture, if appropriate.

6.2 Plant Calibration

6.2.1 Plant Scales

Calibrate the plant scales according to procedures approved by the Engineer. Recalibrate the scales as necessary and when the recordation verification system requires.

6.2.2 Storage of Mixture in Silo's

Develop a system to determine the quantity of mixture in the silos at the beginning and end of the day if any. This value will be used to adjust the total weight of mixture produced in a day.

6.3 Asphalt Content Determination for Batch Plants

6.3.1 Determine the total weight of asphalt, aggregate, RAM (if appropriate), RAS (if appropriate), mineral filler (if appropriate), fibers (if appropriate), and lime (if appropriate) used in the mixture by accumulating the batch weights for the production day. This data will be used to determine the total quantity of material produced for comparison with the plant inventory data. Reduce the quantity of asphalt, aggregate, RAM, RAS, and lime as appropriate by the quantity of material which was measured by the plant and did not get weighed by the plant truck scales (wasted) (this could include materials sent to the road).

6.3.2 For each asphalt content determination as required by the acceptance program random number sampling schedule, accumulate the total quantity of asphalt, aggregate, RAM(if appropriate), RAS (if appropriate), and lime(if appropriate) used for 15 ± 2 consecutive batches.

6.3.3 Determine the weight of dry aggregate, dry RAM (if appropriate), dry RAS (if appropriate) by using the following formula:

$$\frac{\textit{(Total Weight of Aggregate)}}{\textit{1 + (Mixture Moisture Content, Percent/100)}}$$

Example:

Weight of Wet Aggregate = 151.6 tons
Mix Moisture Content, % = 0.42

$$\textit{Weight of Dry Aggregate} = \frac{151.6}{1+(0.42/100)} = \frac{151.6}{1.0042} = 150.97\ \textit{tons}$$

6.3.4 Calculate the percent asphalt content using the formula in Section 4.4.6. Calculate the percent RAM, RAS, and percent lime, if appropriate, using the formulas in Sections 5.4.6, 5.4.7, and 5.4.8 respectively.

6.4 ACP Recordation System Verification

On a daily basis compare the total "dry weight" of materials measured by the plant scales from Section 6.3.3 with the total "dry" weight of mixture from Section 5.5.2 according to the equation below. If the difference exceeds ±1.0 percent, recalibrate the plant. The Engineer may waive this requirement for small production days where less than 1000 tons is produced..

$$\frac{(\text{Total Dry Weight of Materials from Meters} - \text{Total "Dry" Weight of Mixture}) \times 100}{\text{Total "Dry" Weight of Mixture}}$$

If the ±1.0% tolerance is exceeded, perform a second calculation comparing weight of asphalt as measured by the asphalt meter to the weight of asphalt used by inventory according to the equation below (%ERROR ASPHALT METER vs TANK MEASURE on Form 2401). If the difference is less than or equal to ±0.5%, then the asphalt meter is in calibration and only the belt scales need to be recalibrated. If the difference exceeds ±0.5%, then all meters and scales need recalibration.

$$\frac{(\text{Total Weight of Asphalt from Meters} - \text{Total Weight of Asphalt by Inventory}) \times 100}{\text{Total Weight of Asphalt by Inventory}}$$

7. PROCEDURES – EAC PLANTS

7.1 General

The quantity of dry aggregate, as measured by the belt scale, and the amount of emulsified asphalt measured by the plant metering system for a predetermined period of time are used to determine the percentage of emulsified asphalt being added to the dry aggregates. Minor variations will be allowed in this method for a particular type of plant operation as appropriate with the approval of the Engineer.

7.2 Plant Calibration

Calibrate the plant aggregate belt scales and asphalt meter according to ODOT TM 322 prior to the beginning of paving. Make the results of the calibration available at the EAC plant for review by the Engineer. Recalibrate the plant when the comparison of the recordation data and plant inventory is outside the limits established in this procedure.

7.3 Daily Total Requirements

7.3.1 Belt Scale and Meter Totalizers: Record the asphalt and aggregate totalizer readings at the beginning and the end of each day's production. Record the plant setting for aggregate moisture used throughout the day. This data will be used to determine the total quantity of material produced for comparison with the plant inventory data.

7.3.2 Waste: Weigh and record the mass of material measured by the plant belt scales and meters that did not get weighed by the plant truck scales (wasted) (this could include materials sent to the road and material generated from the production facility). All waste shall be itemized as to type and associated weight, i.e. start-up and shut-down, dust rejection, spilled material etc. An alternative means of determining the mass of wasted materials may be proposed to the Engineer, in writing, when daily weighing of waste is determined to be impractical.

7.3.2.1 For purposes of determining waste for comparison of meters with physical inventory at the end of each day, material wasted due to plant start-ups, shut-downs, or other operations shall be evaluated as follows: 50% of the total wasted mass will be considered "uncoated aggregate waste" with no asphalt coating and 50% will be considered "mix waste" which is coated with the average asphalt content calculated for the day based on physical inventory. Enter these weights in the appropriate locations on form 734-2401.

7.3.2.2 For purposes of determining waste for comparison of meters with physical inventory at the end of each day, material wasted due to rejection on the grade or elsewhere will be considered "mix waste" which is coated with the average asphalt content calculated for the day based on physical inventory. Combine this value with the "mix waste" determined in 7.3.2.1 and enter the new value in the appropriate location on form 734-2401.

7.3.2.3 Calculate the amount of waste liquid asphalt using the "mix waste" masses from Sections 7.3.2.1 and 7.3.2.2 and the average asphalt content calculated for the day from the "BY TANK %Pb" box on form 734-2401. Enter the waste emulsified asphalt in of the "deductions after beginning inventory" box on form 734-2043. Document calculations in the "Waste Deduction Calculations" portion of form 734-2043.

7.3.3 Asphalt Content by Meters: Calculate the percent emulsified asphalt by meters for the day's production according to the following formula:

$$\frac{\text{(Weight of Asphalt) x 100}}{\text{("Actual Dry" Weight of Aggregate) – "Uncoated Agg Waste"}}$$

Calculate the "Actual Dry" weight of aggregate using the daily totalizer readings for the aggregate, plant aggregate moisture setting, and average of the sublot aggregate cold feed moisture tests for the day using the process described in Section 7.4.3.

7.4 Sublot Requirements

7.4.1 Determine the moisture content of the combined aggregate from the cold feeds according to AASHTO T 255 for each sublot.

7.4.2 For each sublot as required by the acceptance program random number sampling schedule, record the asphalt and aggregate used for a period of 15 ± 2 minutes. This is accomplished by recording the totalizer readings at the beginning and end of the selected time period and subtracting, or by obtaining the results of the plant printout over the required period. Record the plant setting for aggregate moisture used for the selected time period.

7.4.3 Determine the "actual dry" weight of aggregate according to the following:

7.4.3.1 Convert "dry" weight of aggregate as measured by the plant to "actual wet" weight using the following formula:

$$Plant"Dry"Weight \times \left[1 + \frac{PlantMoistureSetting, percent}{100}\right]$$

Example:

Plant "Dry" Weight of Aggregate = 163.4 tons
Plant Moisture Setting, % = 3.2

"Actual Wet" Weight of Aggregate = $163.4 \times \left[1 + \frac{3.2}{100}\right] = 168.6$ *tons*

7.4.3.2 Convert "Actual Wet" weight of aggregate to "Actual Dry" weight of aggregate using the following formula:

$$\frac{(\text{"Actual Wet" Weight of Aggregate})}{1 + (\text{Sublot Aggregate Moisture Content, Percent}/100)}$$

Example:

"Actual Wet" Weight of Aggregate = 168.6 tons
Sublot Aggregate Moisture Content, % = 3.6

"Actual Dry" Weight of Aggregate = $\frac{168.6}{1 + (3.6/100)} = \frac{168.6}{1.036} = 162.7$ *tons*

Determine the volume of emulsified asphalt used for a base temperature of 60°F by multiplying the gallons from the meter by the appropriate temperature correction factor from attached Table B.1.

Example:

Gallons of Asphalt = 2560.4
Temperature, F = 149
Correction Factor = 0.97775

Gallons of Asphalt at 60°F = 2560.4 x 0.97775 = 2503.4

NOTE: *Some plant meters measure the quantity of asphalt directly in mass. If this is the case, skip Sections 7.4.5 and 7.4.6 and proceed directly to Section 7.4.7.*

7.4.5 Convert gallons of emulsified asphalt at 60°F to tons using the following formula:

$$\frac{\textbf{(gallons of Asphalt at 60°F) x (Asphalt Specific Gravity at 60°F)}}{\textbf{239.9 gallons/ton}}$$

Example:

Volume of Asphalt at 60°F = 2503.4 gallons
Asphalt Specific Gravity at 60°F = 1.027

Weight of Asphalt = $\frac{2503.4x1.027}{239.9}$ *= 10.72 tons*

7.4.6 Calculate the percent asphalt content using the following formula:

$$\frac{\textit{(Weight of Asphalt) x 100}}{\textit{(“Actual Dry” Wt. Of Aggregate)}}$$

Example:
Weight of Asphalt = 10.72 tons
“Actual Dry” Weight of Aggregate = 158.33 tons

Asphalt Content, % = $\frac{10.72x100}{158.33}$ *= 6.77*

7.5 Asphalt Content by Inventory

7.5.1 Emulsified Asphalt on Hand

Determine the gallons of asphalt on hand in the tanks prior to the start of production. Convert the gallons at tank temperature to weight (tons) at 60°F using the formulas in Section 7.4.4 and 7.4.5.

7.5.2 Emulsified Asphalt Delivered

Total the weight of liquid asphalt delivered to the asphalt plant for the production day. It is recommended that each transport be weighed prior to and after unloading to verify the actual delivered weight.

7.5.3 Emulsified Asphalt Used

Add the weight of emulsified asphalt on hand at the beginning of the day to the weight of emulsified asphalt delivered and subtract the weight of emulsified asphalt on hand at the end of the day. The answer gives the quantity of emulsified asphalt used that day based on inventory.

Reduce this amount by the quantity of emulsified asphalt that was removed from the tank and did not enter the plant. This could include liquid asphalt removed for tack or other purposes.

Example:

Weight of Asphalt on Hand at Start of Production =	*96.40 tons*
Weight of Asphalt Delivered During Day =	*124.80 tons*
Weight of Asphalt on Hand at End of Production =	*61.40 tons*

Weight of Asphalt Used = 96.4 + 124.8 - 61.4 = 159.80 tons

7.5.4 Total Mixture Produced by Inventory

7.5.4.1 Total "Wet" Mixture Produced

Determine the total weight of "wet" mixture produced during the day from the truck invoices. Add to this the total "mix waste" determined from Sections 7.3.2.1 and 7.3.2.2. Calculate the total "wet" mixture produced using the following formula:

Total "Wet" Mixture = Weight from Invoices + "Mix Waste"

7.5.4.2 Total "Dry Aggregate" from Mixture Produced

Determine the total "Dry Aggregate" from the mixture produced for the day from the following formula:

$$\frac{\text{(Total "Wet" Mixture – Emulsified Asphalt Used)}}{\text{1 + (Average Aggregate Moisture Content, Percent/100)}}$$

7.5.4.3 Asphalt Content by Inventory

Determine the percent asphalt content by inventory of the mixture by the following formula:

$$\frac{\text{(Emulsified Asphalt Used) x 100}}{\text{Total "Dry Aggregate" from Mixture Produced}}$$

Example:

Emulsified Asphalt Used =	*159.80 tons*
Total "Dry Aggregate" from Mixture Produced =	*2663.80 tons*

Asphalt Content by Inventory, % = $\frac{159.80x100}{2663.80 - 159.80}$ = *6.38*

7.6 EAC Recordation System Verification

On a daily basis compare the percent asphalt content from the meter data from Section 7.3.3 to the percent asphalt content determined by the inventory method from Section 7.5.4.3. If the difference exceeds ±0.20 percent, recalibrate the plant. For those production days when the above tolerance is exceeded, the asphalt content for each sublot used for acceptance as determined from the meter method will be adjusted by the difference determined in this verification process for that day.

Calculate the asphalt content correction value (difference) from the following formula:

Asphalt Content Correction, % =

Asphalt Content by Inventory, % - Asphalt Content by Meter, %

If Asphalt Content Correction Difference (%) ≤ ±0.20%, then Correction = 0.0%

If Asphalt Content Correction Difference (%) > ±0.20%, then adjust sublot asphalt content values according to:

Adjusted Asphalt Content for Sublot n, % =

Asphalt Content for Sublot n by meter, % + Asphalt Content Correction, %

Example:

Asphalt Content by Daily Inventory, % = 6.38
Asphalt Content by Daily Meter, % = 6.65

Asphalt Content by Sublots for the Daily Production:

Sublot 1-4	*6.77%*
Sublot 1-5	*6.62%*
Sublot 1-6	*6.61%*

Asphalt Content Correction, % = 6.38 - 6.65 = -0.27
Difference -0.27% > ±0.20%, therefore apply correction to daily sublots

Adjusted Sublot Asphalt Contents:

Sublot 1-4	*6.77% + (- 0.27%) = 6.50%*
Sublot 1-5	*6.62% - 0.27% = 6.35%*
Sublot 1-6	*6.61% - 0.27% = 6.34%*

Table 2.03 Temperature-Volume Corrections for Asphalt (continued)

Observed Tempera-ture, °F	Volume Correction Factor to 60° F [1]		Observed Tempera-ture, °F	Volume Correction Factor to 60° F [1]		Observed Tempera-ture, °F	Volume Correction Factor to 60° F [1]		Observed Tempera-ture, °F	Volume Correction Factor to 60° F [1]	
	A	B		A	B		A	B		A	B
0	1.0211	1.0241	70	0.9965	0.9950	140	0.9723	0.9686	210	0.9486	0.9418
1	1.0208	1.0237	71	0.9962	0.9956	141	0.9720	0.9682	211	0.9483	0.9414
2	1.0204	1.0233	72	0.9958	0.9952	142	0.9716	0.9678	212	0.9479	0.9410
3	1.0201	1.0229	73	0.9955	0.9948	143	0.9713	0.9674	213	0.9476	0.9407
4	1.0197	1.0225	74	0.9951	0.9944	144	0.9710	0.9670	214	0.9472	0.9403
5	1.0194	1.0221	75	0.9948	0.9940	145	0.9706	0.9666	215	0.9469	0.9399
6	1.0190	1.0217	76	0.9944	0.9936	146	0.9703	0.9662	216	0.9466	0.9395
7	1.0186	1.0213	77	0.9941	0.9932	147	0.9699	0.9659	217	0.9462	0.9391
8	1.0183	1.0209	78	0.9937	0.9929	148	0.9696	0.9655	218	0.9459	0.9388
9	1.0179	1.0205	79	0.9934	0.9925	149	0.9693	0.9651	219	0.9456	0.9386
10	1.0176	1.0201	80	0.9930	0.9921	150	0.9689	0.9647	220	0.9452	0.9380
11	1.0172	1.0197	81	0.9927	0.9917	151	0.9686	0.9643	221	0.9449	0.9376
12	1.0169	1.0193	82	0.9923	0.9913	152	0.9682	0.9639	222	0.9446	0.9373
13	1.0165	1.0189	83	0.9920	0.9909	153	0.9679	0.9635	223	0.9442	0.9369
14	1.0162	1.0185	84	0.9916	0.9905	154	0.9675	0.9632	224	0.9439	0.9365
15	1.0158	1.0181	85	0.9913	0.9901	155	0.9672	0.9628	225	0.9436	0.9361
16	1.0155	1.0177	86	0.9909	0.9897	156	0.9669	0.9624	226	0.9432	0.9358
17	1.0151	1.0173	87	0.9909	0.9893	157	0.9665	0.9620	227	0.9429	0.9354
18	1.0148	1.0168	88	0.9902	0.9889	158	0.9662	0.9616	228	0.9426	0.9350
19	1.0144	1.0164	89	0.9899	0.9885	159	0.9658	0.9612	229	0.9422	0.9346
20	1.0141	1.0160	90	0.9896	0.9881	160	0.9655	0.9609	230	0.9419	0.9343
21	1.0137	1.0156	91	0.9892	0.9877	161	0.9652	0.9605	231	0.9416	0.9339
22	1.0133	1.0152	92	0.9889	0.9873	162	0.9648	0.9601	232	0.9412	0.9335
23	1.0130	1.0148	93	0.9885	0.9869	163	0.9645	0.9597	233	0.9409	0.9331
24	1.0126	1.0144	94	0.9882	0.9865	164	0.9641	0.9593	234	0.9405	0.9328
25	1.0123	1.0140	95	0.9878	0.9861	165	0.9638	0.9589	235	0.9402	0.9324
26	1.0119	1.0136	96	0.9875	0.9857	166	0.9835	0.9585	236	0.9399	0.9320
27	1.0116	1.0132	97	0.9871	0.9854	167	0.9631	0.9582	237	0.9395	0.9316
28	1.0112	1.0128	98	0.9868	0.9850	168	0.9628	0.9578	238	0.9392	0.9313
29	1.0109	1.0124	99	0.9864	0.9846	169	0.9624	0.9574	239	0.9389	0.9309
30	1.0105	1.0120	100	0.9861	0.9842	170	0.9621	0.9570	240	0.9385	0.9305
31	1.0102	1.0116	101	0.9857	0.9838	171	0.9618	0.9566	241	0.9382	0.9301
32	1.0098	1.0112	102	0.9854	0.9834	172	0.9614	0.9562	242	0.9379	0.9298
33	1.0095	1.0108	103	0.9851	0.9830	173	0.9611	0.9559	243	0.9375	0.9294
34	1.0091	1.0104	104	0.9847	0.9826	174	0.9607	0.9555	244	0.9372	0.9290
35	1.0088	1.0100	105	0.9844	0.9822	175	0.9604	0.9551	245	0.9369	0.9286
36	1.0084	1.0096	106	0.9840	0.9818	176	0.9601	0.9547	246	0.9365	0.9283
37	1.0081	1.0092	107	0.9887	0.9814	177	0.9597	0.9543	247	0.9362	0.9279
38	1.0077	1.0088	108	0.9833	0.9810	178	0.9594	0.9539	248	0.9359	0.9275
39	1.0074	1.0084	109	0.9830	0.9806	179	0.9590	0.9536	249	0.9356	0.9272
40	1.0070	1.0080	110	0.9826	0.9803	180	0.9587	0.9532	250	0.9352	0.9268
41	1.0067	1.0076	111	0.9823	0.9799	181	0.9584	0.9528	251	0.9349	0.9264
42	1.0063	1.0072	112	0.9819	0.9795	182	0.9580	0.9524	252	0.9346	0.9260
43	1.0060	1.0068	113	0.9816	0.9791	183	0.9577	0.9520	253	0.9342	0.9257
44	1.0056	1.0064	114	0.9813	0.9787	184	0.9574	0.9517	254	0.9339	0.9253
45	1.0053	1.0060	115	0.9809	0.9783	185	0.9570	0.9513	255	0.9336	0.9249
46	1.0049	1.0056	116	0.9806	0.9779	186	0.9567	0.9509	256	0.9332	0.9245
47	1.0046	1.0052	117	0.9802	0.9775	187	0.9563	0.9505	257	0.9329	0.9242
48	1.0042	1.0048	118	0.9799	0.9771	188	0.9560	0.9501	258	0.9326	0.9238
49	1.0038	1.0044	119	0.9795	0.9767	189	0.9557	0.9498	259	0.9322	0.9234
50	1.0035	1.0040	120	0.9792	0.9763	190	0.9553	0.9494	260	0.9319	0.9231
51	1.0031	1.0036	121	0.9788	0.9760	191	0.9550	0.9490	261	0.9316	0.9227
52	1.0028	1.0032	122	0.9785	0.9756	192	0.9547	0.9486	262	0.9312	0.9223
53	1.0024	1.0028	123	0.9782	0.9752	193	0.9543	0.9482	263	0.9309	0.9219
54	1.0021	1.0024	124	0.9778	0.9748	194	0.9540	0.9478	264	0.9306	0.9216
55	1.0017	1.0020	125	0.9775	0.9744	195	0.9536	0.9475	265	0.9302	0.9212
56	1.0014	1.0016	126	0.9771	0.9740	196	0.9533	0.9471	266	0.9299	0.9208
57	1.0010	1.0012	127	0.9768	0.9736	197	0.9530	0.9467	267	0.9296	0.9205
58	1.0007	1.0008	128	0.9764	0.9732	198	0.9526	0.9463	268	0.9293	0.9201
59	1.0003	1.0004	129	0.9761	0.9728	199	0.9523	0.9460	269	0.9289	0.9197
60	1.0000	1.0000	130	0.9758	0.9725	200	0.9520	0.9456	270	0.9286	0.9194
61	0.9997	0.9996	131	0.9754	0.9721	201	0.9516	0.9452	271	0.9196	0.9190
62	0.9993	0.9992	132	0.9751	0.9717	202	0.9513	0.9448	272	0.9279	0.9186
63	0.9990	0.9988	133	0.9747	0.9713	203	0.9509	0.9444	273	0.9276	0.9182
64	0.9986	0.9984	134	0.9744	0.9709	204	0.9506	0.9441	274	0.9273	0.9179
65	0.9983	0.9980	135	0.9740	0.9705	205	0.9503	0.9437	275	0.9269	0.9175
66	0.9979	0.9976	136	0.9737	0.9701	206	0.9499	0.9433	276	0.9266	0.9171
67	0.9976	0.9972	137	0.9734	0.9697	207	0.9496	0.9429	277	0.9263	0.9168
68	0.9972	0.9968	138	0.9730	0.9693	208	0.9493	0.9425	278	0.9259	0.9164
69	0.9969	0.9964	139	0.9727	0.9690	209	0.9489	0.9422	279	0.9256	0.9160

Table 2.03 Temperature-Volume Corrections for Asphalt (continued)

Observed Temperature, °F	Volume Correction Factor to 60° F[1]		Observed Temperature, °F	Volume Correction Factor to 60° F[1]		Observed Temperature, °F	Volume Correction Factor to 60° F[1]		Observed Temperature, °F	Volume Correction Factor to 60° F[1]	
	A	B		A	B		A	B		A	B
280	0.9253	0.9157	335	0.9073	0.8956	390	0.8896	0.8760	445	0.8721	0.8567
281	0.9250	0.9153	336	0.9070	0.8952	391	0.8892	0.8756	446	0.8718	0.8564
282	0.9246	0.9149	337	0.9066	0.8949	392	0.8889	0.8753	447	0.8715	0.8560
283	0.9243	0.9146	338	0.9063	0.8945	393	0.8886	0.8749	448	0.8714	0.8557
284	0.9240	0.9142	339	0.9060	0.8942	394	0.8883	0.8746	449	0.8709	0.8554
285	0.9236	0.9138	340	0.9057	0.8938	395	0.8880	0.8742	450	0.8705	0.8550
286	0.9233	0.9135	341	0.9053	0.8934	396	0.8876	0.8738	451	0.8702	0.8547
287	0.9230	0.9131	342	0.9050	0.8931	397	0.8873	0.8735	452	0.8699	0.8543
288	0.9227	0.9127	343	0.9047	0.8927	398	0.8870	0.8731	453	0.8696	0.8540
289	0.9223	0.9124	344	0.9044	0.8924	399	0.8867	0.8728	454	0.8693	0.8536
290	0.9220	0.9120	345	0.9040	0.8920	400	0.8864	0.8724	455	0.8690	0.8533
291	0.9217	0.9116	346	0.9037	0.8917	401	0.8861	0.8721	456	0.8687	0.8529
292	0.9213	0.9-113	347	0.9034	0.8913	402	0.8857	0.8717	457	0.8683	0.8526
293	0.9210	0.9109	348	0.9031	0.8909	403	0.8854	0.8717	458	0.8680	0.8522
294	0.9207	0.9105	349	0.9028	0.8906	404	0.8851	0.8710	459	0.8677	0.8519
295	0.9204	0.9102	350	0.9024	0.8902	405	0.8848	0.8707	460	0.8674	0.8516
296	0.9200	0.9098	351	0.9021	0.8899	406	0.8845	0.8703	461	0.8671	0.8512
297	0.9197	0.9094	352	0.9018	0.8895	407	0.8841	0.8700	462	0.8668	0.8509
298	0.9194	0.9097	353	0.9015	0.8891	408	0.8838	0.8696	463	0.8665	0.8505
299	0.9190	0.9087	354	0.9011	0.8888	409	0.8835	0.8693	464	0.8661	0.8502
300	0.9187	0.9083	355	0.9008	0.8884	410	0.8832	0.8689	465	0.8658	0.8498
301	0.9186	0.9080	356	0.9005	0.8881	411	0.8829	0.8686	466	0.8655	0.8495
302	0.9181	0.9076	357	0.9002	0.8877	412	0.8826	0.8682	467	0.8652	0.8492
303	0.9177	0.9072	358	0.8998	0.8873	413	0.8822	0.8679	468	0.8649	0.8488
304	0.9174	0.9069	359	0.8995	0.8870	414	0.8819	0.8675	469	0.8646	0.8485
305	0.9171	0.9065	360	0.8992	0.8866	415	0.8816	0.8672	470	0.8643	0.8481
306	0.9167	0.9061	361	0.8989	0.8863	416	0.8813	0.8668	471	0.8640	0.8478
307	0.9164	0.9058	362	0.8986	0.8859	417	0.8810	0.8665	472	0.8636	0.8474
308	0.9161	0.9054	363	0.8982	0.8856	418	0.8806	0.8661	473	0.8633	0.8471
309	0.9158	0.9050	364	0.8979	0.8852	419	0.8803	0.8658	474	0.8630	0.8468
310	0.9154	0.9047	365	0.8976	0.8848	420	0.8800	0.8654	475	0.8627	0.8464
311	0.9151	0.9043	366	0.8973	0.8845	421	0.8797	0.8651	476	0.8624	0.8461
312	0.9148	0.9039	367	0.8949	0.8841	422	0.8794	0.8647	477	0.8621	0.8457
313	0.9145	0.9036	389	0.8966	0.8838	423	0.8791	0.8644	478	0.8618	0.8454
314	0.9141	0.9032	369	0.8963	0.8834	424	0.8787	0.8640	479	0.8615	0.8451
315	0.9138	0.9028	370	0.8960	0.8831	425	0.8784	0.8637	480	0.8611	0.8447
316	0.9135	0.9025	371	0.8957	0.8827	426	0.8781	0.8633	481	0.8608	0.8444
317	0.9132	0.9021	372	0.8953	0.8823	427	0.8778	0.8630	482	0.8605	0.8440
318	0.9128	0.9018	373	0.8950	0.8820	428	0.8775	0.8626	483	0.8602	0.8437
319	0.9125	0.9014	374	0.8947	0.8816	429	0.8772	0.8623	484	0.8599	0.8433
320	0.9122	0.9010	375	0.8944	0.8813	430	0.8768	0.8619	485	0.8596	0.8430
321	0.9118	0.9007	376	0.8941	0.8809	431	0.8765	0.8616	486	0.8593	0.8427
322	0.9115	0.9003	377	0.8937	0.8806	432	0.8762	0.8612	487	0.8590	0.8423
323	0.9112	0.9000	378	0.8934	0.8802	433	0.8759	0.8609	488	0.8587	0.8420
324	0.9109	0.8996	379	0.8931	0.8799	434	0.8756	0.8605	489	0.8583	0.8416
325	0.9105	0.8992	380	0.8928	0.8795	435	0.8753	0.8602	490	0.8580	0.8413
326	0.9102	0.8989	381	0.8924	0.8792	436	0.8749	0.8599	491	0.8577	0.8410
327	0.9099	0.8985	382	0.8921	[illegible]	437	0.8746	0.8595	492	0.8574	0.8406
328	0.9096	0.8981	383	0.8918	0.8784	438	0.8743	0.8592	493	0.8571	0.8403
329	0.9092	0.8978	384	0.8915	0.8781	439	0.8740	0.8588	494	0.8568	0.8399
330	0.9089	0.8974	385	0.8912	0.8777	440	0.8737	0.8585	495	0.8565	0.8396
331	0.9086	0.8971	386	0.8908	0.8774	441	0.8734	0.8581	496	0.8562	0.8383
332	0.9083	0.8967	387	0.8905	0.8770	442	0.8731	0.8578	497	0.8559	0.8389
333	0.9079	0.8963	388	0.8902	0.8767	443	0.8727	0.8574	498	0.8556	0.8386
334	0.9076	0.8960	389	0.8899	0.9763	444	0.8724	0.8571	499	0.8558	0.8383
									500	0.8549	0.8379

[1] Use column A for factors asphalts with API gravity at 60°F of 14.9° or less or with specific gravity 60/60°F of 0.967 or higher. Use column B factors for asphalts with API gravity at 60°F from 15.0° to 34.9° or with specific gravity 60/60°F from 0.850 to 0.966.

ODOT TM 322

Method of Test for

ASPHALT CONCRETE PLANT CALIBRATION PROCEDURE FOR:

Hot Mix Asphalt Concrete (ACP)
and
Emulsified Asphalt Concrete (EAC)

SCOPE:

This test method is established to specify procedures for calibrating the weighing and measuring devices used in the asphalt materials processing plant.

Plant calibration is required in order to accept asphalt content, RAP content, RAS content, or RAM content, liquid additives content, hydrated lime content, mineral filler content, or fiber content by meter reading as allowed or required in the specifications, special provisions, or by Contract Change Order.

TERMINOLOGY:

Reclaimed Asphalt Pavement (RAP) – removed and/or processed pavement materials containing asphalt binder and aggregate.

***Recycled Asphalt Shingles (RAS)* –** tear-off or manufacturer waste shingle product materials containing asphalt and fine aggregate and fiberglass material.

Recycled Asphalt Material (RAM) – agency approved recycled asphaltic materials containing asphalt binder and aggregate. RAM may be RAP only or a combination of RAP and RAS for purposes of this test procedure. (Currently limited to RAP and RAS).

CALIBRATION PROCEDURE:

1. General:

Perform the plant calibration procedures described herein for each weighing or measuring device used to proportion each size of aggregate, asphalt cement, RAM, RAS, and any other liquid or dry additives used in the asphalt plant.

Submit copies of appropriate forms fully documenting all readings, measurements, and calculations to the Engineer for review and approval prior to starting production.

In lieu of using the ODOT TM 322 procedures described herein, the Contractor may submit in writing prior to start of production, accompanied by appropriate forms, an alternative procedure for plant calibration. If approved by the Engineer, the alternative plant calibration procedures may be used.

2 **Scale Specifications:**

Provide scales meeting the requirements of applicable specifications.

3. **Asphalt Meter Calibration:**

The asphalt meter can be checked by two methods:

Alternate I:

a. Weigh the delivery truck or trailer on the platform scales.

b. Record the asphalt meter reading.

c. Off-load the truck or trailer through the asphalt meter into the storage tank.

d. Record the meter reading and determine quantity using the meter calibration factor previously established by the contractor.

e. Weigh the empty truck or trailer.

f. Record the temperature of the delivered asphalt.

g. Use the appropriate conversion factor to convert the delivered asphalt to gallons if the meter measurement is in volume.

h. Determine percent of error between weighed material and measured material through meter.

i. The asphalt meter result shall be within 0.5 percent for ACP plants and 1.0 percent for EAC plants of the known gallons or tons. If not, recalibrate the meter.

Alternate II:

a. Weigh a container or tank truck such as an asphalt distributor truck capable of holding a minimum of 1000 gallons.

b. Record the plant asphalt meter reading.

c. Pump a minimum of 1000 gallons through the meter into the container or truck.

d. Record the plant asphalt meter reading (weight or volume). If the plant meters measure volume, calculate the gallons delivered to the truck using the meter calibration factor previously established by the contractor.

e. Weigh the container or truck.

f. Record the asphalt temperature.

g. Convert the gross weight of the asphalt to gallons if the meter measurement is in volume.

h. Compare the weighed material to the quantity delivered through the asphalt meter.

i. The asphalt meter result shall be within 0.5 percent for ACP plants and 1.0 percent for EAC plants of the known gallons or tons. If not, recalibrate the meter.

4. **Virgin Aggregate Belt Scale Calibration:**

Warm up the conveyor belt scale by operating for at least 30 minutes. Make a zero-load check run of empty belt while operating.

Alternate I:

a. Empty all aggregate bins and conveyors.

b. Weigh a **minimum** of 8 tons of aggregate.

c. Pass the weighed material over the recorded belt scale.

d. Repeat this process twice:

For ACP plants, perform the process once with the plant set at low tons per hour production and once with the plant set at high tons per hour production.

For EAC plants, set the plant at the planned production rate for both cycles.

e. Depending on the type of belt scale totalizer used, time the passage of the material and multiply by the belt scale factor tons/hr., or record the belt totalizer before and after passage of the material.

f. Compare the belt scale reading to the weight of material.

g. The belt scale results shall be within 0.5 percent for ACP plant and 1.0 percent for EAC plants of the known amount. If not, recalibrate the belt scale.

Alternate II:

a. Record the belt scale totalizer reading. If there is no totalizer, begin timing belt passage.

b. For ACP plants, operate the conveyor with aggregates:

1. 4 minutes at low tons per hour production
2. 2 minutes at high tons per hour production

c. For EAC plants, operate the conveyor with aggregates for 2 to 6 minutes at the planned production rate (time is determined by how long it takes to fill one or more haul vehicles).

d. Divert this material into a truck or portable container.

e. Determine gross weight of material on the platform scale.

f. Depending on the type of belt scale totalizer used, stop timing the passage of the material and multiply by the belt scale factor tons/hr, or record the belt totalizer after passage of the material.

g. Compare the belt scale quantity to weighed quantity. The belt scale results shall be within 0.5 percent for ACP plants and 1.0 percent for EAC plants of the known amount. If not, recalibrate the belt scale.

5. **RAM Belt Scale Calibration:**

Follow the procedure for the virgin aggregate belt scale calibration (Section 4). **Compare the RAM belt scale quantity to weighed quantity. The belt scale results shall be within 0.5 percent of the known amount. If not, recalibrate the RAP belt scale.**

6. **Liquid Additives Calibration:**

Follow the procedure for asphalt meter calibration (Section 3); only substitute an appropriate sized container or gallons of additive for testing.

The plant device results shall be within 0.5 percent of the known amount. If not, recalibrate the meter.

7. **RAS, Mineral Filler or Hydrated Lime Additive:**

Follow the procedure for virgin aggregate belt scale calibration (Section 4), except apply the procedure to the vane feeder, belt scale, or other metering device as appropriate, and weigh out a minimum of 100 lb of RAS, mineral filler or lime into an appropriate sized container .

The plant device results shall be within 0.5 percent of the known amount. If not, recalibrate the device.

8. **Fiber Additives:**

Calibrate the metering system for fiber additives according to the fiber additive equipment manufacturer's recommendation. Provide documentation of the procedure to the Engineer.

ODOT TM 323
DETERMINATION OF CALIBRATION FACTORS
For
DETERMINING THE ASPHALT CEMENT CONTENT OF ASPHALT CONCRETE PAVEMENT
BY THE
IGNITION METHOD

1. SCOPE

1.1 This test method covers the determination of a Calibration Factor (CF) used in determining asphalt cement content of ACP paving mixtures with or without reclaimed asphalt pavement (RAP) or recycled asphalt shingles (RAS) by the ignition method according to AASHTO T308. This test method also includes determination of gradation correction factors.

1.2 The values stated in metric units are to be regarded as the standard.

1.3 This method may involve hazardous materials, operations, and equipment. This method does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this method to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. REFERENCED DOCUMENTS

AASHTO T308	Determining the Asphalt Binder Content of Hot Mix Asphalt (HMA) by the Ignition Method.
AASHTO T30	Mechanical Analysis of Extracted Aggregate

ODOT Contractor Mix Design Guidelines for Asphalt Concrete

3. Terminology

Calibration Factor (C_F) - The average difference between the known (batched) asphalt binder content and calculated asphalt cement content from incineration results.

ACP - Asphalt Concrete Pavement

Reclaimed Asphalt Pavement (RAP) – removed and/or processed pavement materials containing asphalt binder and aggregate.

Recycled Asphalt Shingles (RAS) – tear-off or manufacturer waste shingle product materials containing asphalt and fine aggregate and fiberglass material.

Recycled Asphalt Material (RAM) – agency approved recycled asphaltic materials containing asphalt binder and aggregate. RAM may be RAP only or a combination of RAP and RAS for purposes of this test procedure. (Currently limited to RAP and RAS).

4. SUMMARY OF TEST METHOD

Four samples of ACP with a known asphalt content and gradation are batched. The asphalt cement in two, possibly four of the samples is incinerated according to AASHTO T308 and the asphalt binder content is calculated. The difference between the known (batched) asphalt binder content and calculated asphalt cement content (from incineration results) is determined for each sample. The average of the difference is the Calibration Factor (C_F) applied to production tests according to AASHTO T308. The gradations of the incinerated samples are determined and compared with a “blank” sample that has not been incinerated.

Establish a Calibration Factor (C_F) for each JMF. This procedure must be performed for every ignition furnace on a project for each JMF before any acceptance or verification testing is completed.

The CMDT, who develops the JMF for a project will provide properly batched samples to each of the field QC and QA laboratories and to the ODOT Central Laboratory for the CAT1 to use in calculating a Calibration Factor (C_F) and gradation correction factors. An alternate CMDT may provide the required calibration samples, if approved by the Engineer.

A new calibration factor is required if the source or grade of the asphalt cement changes, if the source of RAP or RAS changes, if a different ignition furnace is used, or for a new JMF. A new calibration factor shall be determined for each JMF prior to its first use every calendar year. Calibration factors for a JMF shall be “transferred” from project to project during a calendar year, unless one of the above conditions applies.

5. APPARATUS

Supply apparatus as required by AASHTO T308. Use the same ignition furnace for the calibration that will be used for production testing.

6. CALIBRATION SAMPLE PREPARATION – MIXTURES WITHOUT RAM or RAS

6.1 Sample the aggregate, mineral filler, lime, fibers, and other appropriate additives to be used for the calibration specimens from material designated for use on the project. Use the brand and grade of asphalt cement designated for the JMF.

6.2 Prepare six calibration mixture samples at the JMF asphalt cement content and gradation and with the appropriate proportions of mineral filler, lime, fibers or other additive included in the JMF.

Batch the specimens according to standard industry procedures, modified as follows:

- Batch each sample separately and according to the tolerances in Section 6.4.
- Before adding asphalt cement randomly select one sample and set it aside as the "blank" sample. See Section 6.3.
- Provide sample sizes meeting the requirements of AASHTO T308
- Mix and discard one of the remaining five samples. The purpose of this sample is to "butter" the mixing bowl.
- For the remaining four (or more) samples, tare the mixing bowl and weigh the mixing bowl again after the mixture is removed from the bowl. The empty bowl must be within ±1 gram of the previous tare weight.
- Individually identify each calibration sample and supply documentation showing the actual weights of aggregate, asphalt cement, mineral filler, lime, fibers or any other additive for each sample and resultant actual calculated asphalt cement content for each sample. Also provide documentation for each sample verifying that the empty bowl weight after mixing is within ±1 gram of the empty bowl weight prior to mixing. An example batch form (2327CB) is available under Section 3 of the MFTP.

NOTE: Errors in batching or failure to take great care in ensuring that all sample material is removed from the mixing bowl can result in significant errors in the Calibration Factor.

These errors can affect the statistical pay factor for the Contractor and the quantity of asphalt cement the Agency pays for. Every effort should be taken to ensure that batching and mixing errors are minimized. The amount of lime in a calibration sample can substantially affect the calibration factor, so extra care shall be taken to ensure the proper amount is batched.

6.3 The "blank" sample as selected in 6.2 shall have the same gradation, but no asphalt cement shall be added. This "blank" sample will be used to establish correction factors for the aggregate gradations. The "blank" sample is not burned.

6.4 Batch each sample according to the JMF target values within the following tolerances:

Batching Tolerances "Virgin Aggregate and Add Asphalt Cement"

Sieve Size	**Allowable Difference**
Larger than (No. 8)	±3.0%
Size (No. 8)	±2.0%
Larger than (No. 200) and smaller than (No. 8)	±1.0%
Size (No. 200) and smaller	±0.5%
Asphalt Cement	±0.10%

7. CALIBRATION SAMPLE PREPARATION - MIXTURES WITH RAM or RAS

If allowed by the Engineer, the percentage of asphalt cement in RAM or RAS (P_{br}) and the gradation of the residual aggregate from the recycled material(s) may be determined by an alternative method. If an alternative method is allowed, skip to Section 7.7.

7.1 Sample the aggregate, reclaimed material (RAP, RAM & RAS), mineral filler, lime, fibers, and other appropriate additives to be used for the calibration specimens from material designated for use on the project. Use the brand and grade of virgin asphalt cement designated for the JMF.

7.2 Batch a minimum of five samples of each reclaimed material, as appropriate, according to the gradation of the reclaimed material in the JMF. Batch each sample so that it consists of 100% reclaimed material. Follow the table below for required number of samples:

Material Type	Number of RAP samples	Number of RAS samples	Number of RAM samples
RAP	5	0	0
RAS	0	5	0
RAM	0	0	5
Unblended RAM (RAP and RAS to be blended during production)	5	5	0

Batch the RAM samples according to standard industry practices with a sample size appropriate for AASHTO T308. Note that for infrared furnaces, the higher set temperature "burn profile" may be necessary to provide complete combustion of the sample.

For RAS Only samples the sample size shall be between 500 and 750 grams.

7.3 Test each sample of 100% RAM according to AASHTO T308 Method A or Method B (with a 60 minute burn time) to determine the cement content of each.

For RAS samples, the incineration time will be determined using AASHTO T 308, including steps 10-14 of Method B. Method A may also be used utilizing the internal scale to indicate a mass loss per Step 10. For both Method A & B, an ending mass loss percentage of 0.03 percent will be utilized to indicate the completion of the burn.

7.4 Determine the average total percent loss of the five samples. Subtract 0.5% from the average total percent loss. By definition, a Calibration Factor of 0.5% shall be the standard for 100% reclaimed materials, since it is difficult and time consuming to determine the Calibration Factor for mixtures comprised of 100% reclaimed materials. ***See Section 9 for example calculations.***

7.5 The value(s) determined in Section 7.4 will be considered the percentage of asphalt cement in the reclaimed material(s) **(P_{br})**.

7.6 Perform sieve analysis on the incinerated five reclaimed material samples according to AASHTO T30. Average the five gradations for each reclaimed material type. The average gradation will be considered the gradation for the individual material type. Each gradation shall be provided with the calibration samples.

7.7 Prepare six calibration mixture samples at the JMF asphalt cement content and gradation with the appropriate proportions of reclaimed material, mineral filler, lime, fibers or any other additive. Batch the specimens according to standard industry procedures, modified as given below. The actual asphalt cement content used to calculate the Calibration Factor will be a combination of **P_{br}** for each reclaimed material and the virgin asphalt cement added.

- Batch each sample separately. The batching of the virgin aggregate shall meet the tolerances outlined in Section 6.4.
- Provide sample sizes meeting the requirements of AASHTO T308.
- Before adding reclaimed materials or asphalt cement randomly select one sample and set it aside as the "blank" sample. See Section 7.8.
- Mix and discard one of the remaining five samples. The purpose of this sample is to "butter" the mixing bowl.

NOTE: For each sample, combine and thoroughly dry-mix the virgin aggregate and reclaimed material(s) before adding virgin asphalt cement.

- For the remaining four (or more) samples, tare the mixing bowl and weigh the mixing bowl again after the mixture is removed from the bowl. The empty bowl must be within ±1 gram of the previous tare weight.
- Individually identify each calibration sample and supply documentation showing the actual weights of aggregate, reclaimed material(s), virgin asphalt cement, mineral filler, lime, fibers or any other additive for each sample and resultant actual (calculated) asphalt cement content for each sample. Also provide documentation for each sample verifying that the empty bowl weight after mixing was within ±1 gram of the empty bowl weight prior to mixing. An example batch form (2327CB) is available under Section 3 of the MFTP.

NOTE: Errors in batching or failure to take great care in ensuring that all sample material is removed from the mixing bowl can result in significant errors in the Calibration Factor. These errors can affect the statistical pay factor for the Contractor and the quantity of asphalt cement the Agency pays for. Every effort should be taken to ensure that batching and mixing errors are minimized.

The amount of lime in a calibration sample can substantially affect the calibration factor, so extra care shall be taken to ensure the proper amount is batched.

7.8 For the “blank” sample, virgin aggregate (including mineral filler, lime, fibers or any other additive) and reclaimed material(s) in the proper proportions will be provided separately. The virgin aggregate shall be batched within the tolerances of section 6.4. Incinerate the reclaimed material(s) provided for the “blank” sample according to AASHTO T308 Method A or Method B (with a 60-minute burn time). Gradations for the residual aggregate from the reclaimed material(s) and the virgin aggregate (including mineral filler, lime, fibers or any other additive) shall be determined separately according to AASHTO T 30 and AASHTO T27/11.

Mathematically combine the results of the residual aggregate from the reclaimed material(s) and the virgin aggregate (including mineral filler, lime, fibers or any other additive) to determine the overall gradation result. Provide separate sieve analysis results for the residual aggregate from the reclaimed material(s), the virgin aggregate component, and the overall computed gradation.

NOTE: Reporting of the separate gradations provides a check of the batching process and ensures the virgin aggregate component, in a JMF containing RAP, has been accurately accounted for according to the JMF percentages.

8. CALIBRATION PROCEDURE (MIXTURES WITH OR WITHOUT RECLAIMED MATERIALS)

8.1 Freshly mixed samples may be tested immediately. Cooled calibration samples must be preheated to (340±9°F) for 120±5 minutes to remove moisture.

8.2 Test two of the samples according to AASHTO T308 Method A or Method B (with a 60 minute burn time) to determine the cement content of each. **The method used for calibration must be used for production testing**. The incinerator shall be kept at 1000°F even if the correction factor exceeds 0.5%.

8.3 If the difference between the cement contents of the two samples exceeds 0.15 percent, perform two additional tests and, from the four tests, discard the high and low result. Determine the Calibration Factor from the two original or remaining results, as appropriate. Calculate the difference between the actual and measured cement contents for each sample.

The Calibration Factor (C_F) is the average of the differences expressed in percent by mass of the ACP mix. ***See Section 8 for example calculations***

8.4 Perform sieve analysis on the residual aggregates from the incinerated samples used to calculate the Calibration Factor according to AASHTO T30. Average the two results. Perform sieve analysis on the “blank” sample according to AASHTO T30.

8.5 Determine the difference in gradation between the “blank” sample and the average of the two incinerated calibration samples. The gradation correction factor for each sieve size is the difference between the result from the “blank” sample and the average of the two incinerated calibration samples to the nearest 0.1%. ***See Section 8 for example calculations.***

If the correction factor for any single sieve size exceeds the allowable difference for that sieve established in the following table, contact the Engineer. The Engineer will determine whether or not to apply the gradation correction factors for all sieves.

Gradation Difference Tolerances

Sieve	Allowable Difference
Sizes larger than (No. 8)	±5.0%
Size (No. 8)	±4.0%
Sizes larger than (No. 200) and smaller than (No. 8)	±2.0%
Size (No. 200) and smaller	±1.0%

9. CALCULATIONS

CALIBRATION FACTOR *(Section 7.3)*

$$C_F = \frac{[\,(D1 - P1) + (D2 - P2)\,]}{2}$$

D1, D2 = Total sample loss in percent in calibration samples 1 and 2.
P1, P2 = Actual asphalt cement (%) added in calibration samples 1 and 2.
C_F = Calibration Factor

IF: D1 = 6.52 %
D2 = 6.62 %
P1 and P2 = 6.20 %

THEN: C_F = 0.37 %

GRADATION CORRECTION FACTORS *(Section 7.5)*

Sieve Size	Blank Gradation %	Average of two Incinerated samples %	Correction Factor %
(3/4″)	**97.0**	**94.0**	**+3.0**
(1/2″)	**86.3**	**85.9**	**+0.4**
(3/8″)	**77.3**	**75.8**	**+1.5**
(No. 4)	**46.5**	**47.3**	**-0.8**
(No. 8)	**31.2**	**32.0**	**-0.8**
(No. 30)	**12.4**	**14.2**	**-1.8**
(No. 200)	**6.0**	**7.2**	**-1.2**

FINAL GRADATION CALCULATION *(Section 7.5)*

Sieve Size	Incinerated Washed Gradation %	Correction Factor %	Final Gradation
(3/4″)	**94.6**	**+3.0**	**98**
(1/2″)	**86.9**	**+0.4**	**87**
(3/8″)	**54.3**	**+1.5**	**56**
(No. 4)	**47.8**	**-0.8**	**47**
(No. 8)	**32.5**	**-0.8**	**32**
(No. 30)	**15.3**	**-1.8**	**14**
(No. 200)	**8.6**	**-1.2**	**7.4**

PERCENT ASPHALT CEMENT IN 100% RECLAIMED MATERIAL (*Section 6.4)*

P_{br} = (D1 + D2 + D3 + D4) / 4 - 0.5%

D1, D2, D3, D4 = Total loss in the ignition furnace (from Section 6.3)

0.5% = standard mix calibration factor for all reclaimed materials

P_{br} = [(6.6 + 6.1 + 5.9 + 6.2) / 4] - 0.5%

P_{br} = 5.7%

ODOT TM 326

Method of Test for

Preparation of Field Compacted Gyratory Specimens
Determination of Average G_{mb} for ACP Volumetric Calculations

1. SCOPE

This method covers preparation of field compacted specimens using the Superpave™ gyratory compactor. This method conforms, in general, to AASHTO T 312 supplemented herein to conform to Oregon Quality Assurance program standard practices.

AASHTO T 312 is presented in Annex A of this procedure.

2. SIGNIFICANCE AND USE

Gyratory specimens are used to measure the Bulk Specific Gravity (**G_{mb}**) of a compacted ACP mixture. The **G_{mb}** is used to calculate the volumetric properties of a compacted ACP mixture.

3. APPARATUS

Provide apparatus meeting the requirements of Section 4 of AASHTO T 312.
In addition, provide the following:

3.1 Containers – Provide shallow, flat, rigid metal pans large enough to accommodate a 5,000 gram sample spread to a depth of 1” to 2”, for uniform heating/conditioning of the ACP mixture.

3.2 Thermometers – Digital or dial-type thermometers with metal stems or probes for determining temperature of aggregates, binder and HMA between 50˚ F and 450˚ F. **Non-contact thermometers are not acceptable.**

3.3 Funnel - A funnel or other device for transferring AC mixture from containers into molds is suggested. The device must not cause segregated specimens.

3.4 Oven – Forced air, ventilated, or convection oven capable of maintaining the temperature surrounding the sample at 325 ± 9°F.

4. STANDARDIZATION

Standardize the gyratory compactor according to Section 6 of AASHTO T 312.

Verify calibration of the ram pressure, angle of gyration, gyration frequency, and specimen height measurement system using procedures and at frequencies recommended by the manufacturer. Provide a log book with each compactor documenting calibrations and calibration checks performed and make it available for review by Agency representatives. The log book shall contain the brand, model, and serial number of the compactor. As a minimum, the log book shall also include the types of calibration checks performed, results of the checks, actions taken to correct problems, date performed, and the name of the technician performing the procedures.

The load cell provided by the manufacturer for standardization must be checked on an annual basis with a traceable device according to the ODOT Laboratory Certification Program. The angle of gyration shall be based on internal measurements per AASHTO T 344 and the calibration verified according to the manufacturer's recommendations.

5. PREPARATION OF APPARATUS

Prepare apparatus for use according to Section 7 of AASHTO T 312 modified as necessary per the manufacturer's recommendations. Specimen height must be recorded according to the requirements of Section 4.1.1 of AASHTO T 312.

The number of gyrations required (N_{design}) will be provided on the Job Mix Formula (JMF).

6. TEST PROCEDURE

6.1 At least one hour prior to compacting specimens, place all specimen mold assemblies, sample container, scoop/spoons, etc. in an oven and heat to within the placement temperature range given on the JMF.

6.2 Two gyratory specimens are required per Mix Design Verification test. Obtain a sample of ACP mixture per AASHTO T 168 (typically this requires a weight of 10,000 gram or more). **(Note: This sample is <u>in addition to</u> mix required for other quality control testing).**

The sample size for each specimen must be sufficient to produce compacted specimens with a final height of 115 ± 5 mm. Specimens with heights outside this range will be discarded and not used for volumetric calculations. Immediately re-sample the ACP mixture per AASHTO T 168 (typically this requires a weight of 10,000 gram or more). The sample size may be given on the JMF.

If not, the sample size may be estimated by the following:

$$Sample\ Size\ (grams) = \frac{\boldsymbol{G_{mb}} \times 2026}{1.03}$$

Where: $\boldsymbol{G_{mb}}$ = Bulk Specific Gravity at the target given on the JMF

Or

$$Sample\ Size\ (grams) = \boldsymbol{G_{mm}} \times \boldsymbol{N}$$

N Factor	
3/4" =	**1853.4**
1/2" =	**1872.9**
3/8" =	**1892.4**

Where: $\boldsymbol{G_{mm}}$= Maximum Specific Gravity at the target given on the JMF.
N Factor = Based on Nominal Maximum size of ACP.

6.3 Reduce the sample according to AASHTO R 47 to obtain the desired specimen sample sizes.

6.4 Weigh the appropriate sample size into a container meeting the requirements of Section 3.1, spread to a depth of 1" to 2" and place in oven. Repeat for the second specimen.

6.4.1 *Oven Temperature* - The temperature of the oven should be set such that the samples, when compacted, reach a temperature within the "Placement Temperature" range given on the project JMF. The temperature of the oven shall at no time exceed the maximum "Mixing Temperature" on the JMF.

NOTE: Maintaining required temperatures is of critical importance in preparing gyratory specimens. Every effort should be made during the procedure to minimize heat loss to the sample and to maintain the required minimum temperature. Loss of heat may result in significant additional time required to heat the sample to proper temperature. Variability in compaction temperatures between specimens can result in unacceptable variability in $\mathbf{G_{mb}}$ test results.

6.4.2 *Mixture Aging (to allow for asphalt absorption and to heat to compaction temperature)* – Bring the two samples to the “Placement Temperature” range by uniform heating in an oven. The samples should be conditioned for a time period of 1 hour minimum to 1 hour 30 minutes maximum from the time they are sampled. A sample to be tested for maximum specific gravity ($\mathbf{G_{mm}}$) according to AASHTO T 209 should be conditioned for the same period of time, unless altered per the yellow sheet provisions of AASHTO T 209. The aging time may be increased or decreased to better reflect the actual ACP storage time and haul time if approved by the Engineer.

6.5 After the conditioning time in Section 6.4.2 has expired, check the temperature of the material at several locations in the container. If it is within the “Placement Temperature” range, proceed with remaining steps. If it is too cool, continue heating to get the required temperature. Samples must be compacted within 3 hours of sampling or they will be discarded.

NOTE: Temperature differences within a sample can cause variable results. Select containers that meet the requirements of Section 3.1 and that will evenly heat the material to minimize temperature variability within a sample.

6.6 Load each sample into a mold and recheck the temperature of the mix, with a thermometer meeting Section 3.2 criteria, in the center of the mold to ensure that is in the proper range. Take care not to segregate the samples when loading material into the mold. Compact with N_{design} gyrations according to Section 9 of AASHTO T 312. Take care not to deform the specimen when extruding the sample and removing it from the compactor.

NOTE: It may be necessary to partially extrude the specimen from the mold and allow it to cool for a few minutes prior to final removal. Some mixes may deform or fall apart, especially at lower gyrations, if removed too hot resulting in erroneous measurements.

6.7 Place flat side down on a smooth and level surface, properly identify, and cool until the specimen reaches room temperature.

6.8 Determine the bulk specific gravity of each specimen according to AASHTO T166.

7. REPORTING

For each MDV test performed with a gyratory compactor, provide the following to the Agency:

- The specimen height for each compacted specimen.
- Temperature of each specimen at time of compaction.
- The time at which each sample was obtained and compacted.
- Provide G_{mb} calculations for each sample.
- Calculate the average of the two sample $G_{mb's}$. The average will be used for volumetric calculations.
- Report volumetric calculations on a form approved by the Agency.

8. PROCEDURE FOR PRODUCTION VERIFICATION (QA) SAMPLES

This section covers procedures required for gyratory compaction of verification samples split and performed by the Contractor QC lab and Agency QA lab. The Contractor and Agency will perform ODOT TM 326 and the process described in this section for all verification samples obtained during the time Mix Design Verification (MDV) testing is being performed.

8.1 Perform applicable portions of Sections 4, 5, and 6 of this procedure, supplemented as follows:

8.1.1 Obtain sufficient material such that each laboratory can compact two specimens.

8.1.2 Reduce samples to the appropriate mass and place in containers immediately after sampling.

8.1.3 Allow each sample to cool to ambient temperature for a minimum of 12 hours. An alternative procedure for conditioning and compacting the samples will be allowed if agreed upon by the Contractor and the Region Quality Assurance Coordinator.

8.1.4 Heat the specimens to the JMF compaction range. Not to exceed the "Mixing Temperature" upper range on the JMF. Condition the AASHTO T 209 specimen according to T 209 criteria. Each specimen shall be in the oven no longer than 4 hours (3 hours if not reheated).

8.2 Provide documentation to the Agency according to Section 7 of this procedure.

<u>**ANNEX A**</u>

AASHTO T 312

Preparing and Determining the Density of Asphalt Mixture Specimens by Means of the Superpave Gyratory Compactor

AASHTO Designation: T 312/T 312-15

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ODOT TM 327

Method of Test for

Correlation of Nuclear Gauge Readings
and
Determination of ACP Density Using Pavement Cores

1. SCOPE

This test method describes the test procedures for the correlation of the nuclear gauge readings, and the density of cores removed from the roadway. Cores removed from the roadway for the purpose of a correlation of a nuclear gauge, or for density testing shall represent a single JMF for each correlation.

2. APPARATUS

2.1. Nuclear Density Gauge Equipment - See AASHTO T 355, Apparatus

2.2. Coring Equipment – See AASHTO R 67, Apparatus

3. PROCEDURE CORE CORRELATION TO NUCLEAR GAUGE

When comparing the density of the core, determined by the Bulk Specific Gravity (**G_{mb}**) performed in accordance with AASHTO T-166, to the corresponding site of a nuclear density gauge reading, taken in accordance with AASHTO T 355, a correlation can be established. With the correlation, all gauge readings will be adjusted to match the in-place density based on the cores. The core correlation is gauge specific and must be obtained with no traffic allowed on the pavement between gauge readings and extraction of the core. All gauges that will be used on the project for testing the JMF represented by this process should be correlated to the core locations prior to removal of the core.

3.1 Site Location:

3.1.1. If traffic is allowed on the pavement before the gauge density measurements are completed, measurements shall be completed within 48 hours of paving or as allowed by the Engineer.

3.1.2. Traffic shall not be allowed in the test locations between the time gauge measurements are completed and cores are removed and holes back filled.

3.1.3. The site locations shall meet the “Test Site Location” requirements above and be representative of the entire cross-section of the travel lane being paved. Representatives of the both the Contractor and the Quality Assurance unit shall agree on the core locations.

3.2. Randomly identify 10 core locations on the proposed pavement to be tested in accordance with ODOT TM 400 Stratified Random Sampling.

3.3. Perform Nuclear Gauge Testing in accordance with AASHTO T 355.

3.4. Core the location according to AASHTO R 67. Remove the core to a minimum depth of the lift being placed. The relative position of the core to the nuclear gauge readings for each test location shall be as illustrated in Figure 1. Extreme care shall be taken when extracting the cores, avoid such tools as pry-bars and screwdrivers as they will cause damage.

3.5. Separate the layer of ACP to be tested from the remainder of each core according to AASHTO R 67. In the event the tested layer is damaged the number of cores must meet the following conditions:

3.5.1. If 8 to 10 cores are in good condition proceed with step 3.6.

3.5.2. If less than 8 cores are in good condition, additional cores and gauge readings will need to be obtained such that an even number of cores are tested for both QC and QA; to achieve a minimum of 10 cores to be analyzed.

3.6. Once the cores have been separated the contractor will deliver half of the cores to the Quality Assurance unit and both parties will determine the Bulk Specific Gravity of the provided set according to AASHTO T-166.

3.7. Prior to the bulking operation measure and record each specimen's thickness to the nearest 1/8". Once the bulking process is completed both parties will provide nuclear gauge readings and bulk specific gravity test results to the Project Manager for determination of the correlation factor.

3.8. Calculate a correlation factor for the nuclear gauge reading as follows:

3.8.1. Determine the density of the cores by multiplying the bulk specific gravity obtained from AASHTO T 166 by 62.4 lb/ft^3. Round this result to the nearest 0.1 lb/ft^3.

3.8.2. Calculate the difference between the core density and the average nuclear gauge density at each test site to the nearest 0.1 lb/ft^3. Calculate the average difference and standard deviation of the differences for the entire data set to the nearest 0.1 lb/ft^3.

3.8.3. If the standard deviation of the differences is equal to or less than 2.5 lb/ft^3, the correlation factor applied to the nuclear density gauge reading shall be the average difference calculated in 3.8.2.

3.8.4. If the standard deviation of the differences is greater than 2.5 lb/ft^3, the test site with the greatest variation from the average difference shall be eliminated from the data set. Then the data set properties and correlation factor recalculated following 3.8.2 and 3.8.3.

3.8.5. If the modified data set meets the allowable and the number of cores remaining in the data set and if less than 8 cores remain additional cores and gauge readings will need to be obtained such that an equivalent number of cores are obtained for testing, for both QC and QA and to achieve a minimum of 10 cores to be analyzed. The minimum number of cores used to determine the correlation shall be 8.

3.9. **Core Correlation Example:**

	Core results from T 166:	Average Gauge reading:	Difference:	X	X^2
1	144.9 lb/ft^3	142.1 lb/ft^3	2.8 lb/ft^3	-0.7	0.49
2	142.8 lb/ft^3	140.9 lb/ft^3	1.9 lb/ft^3	0.2	0.04
3	143.1 lb/ft^3	140.7 lb/ft^3	2.4 lb/ft^3	-0.3	0.09
4	140.7 lb/ft^3	138.9 lb/ft^3	1.8 lb/ft^3	0.3	0.09
5	145.1 lb/ft^3	143.6 lb/ft^3	1.5 lb/ft^3	0.6	0.36
6	144.2 lb/ft^3	142.4 lb/ft^3	1.8 lb/ft^3	0.3	0.09
7	143.8 lb/ft^3	141.3 lb/ft^3	2.5 lb/ft^3	-0.4	0.16
8	142.8 lb/ft^3	139.8lb/ft^3	3.0 lb/ft^3	0.9	0.81
9	144.8 lb/ft^3	143.3 lb/ft^3	1.5 lb/ft^3	-0.6	0.36
10	143.0 lb/ft^3	141.0 lb/ft^3	2.0 lb/ft^3	-0.1	0.01
		Average Difference:	+2.1 lb/ft^3		

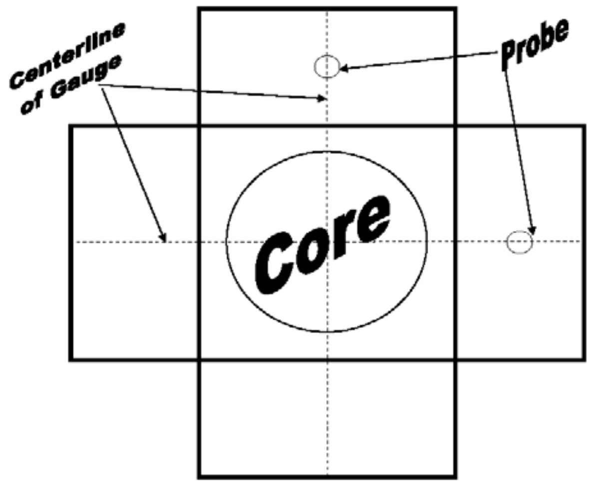
$$\text{Standard Deviation} = \sqrt{\frac{\sum X^2}{\text{n-1}}}$$

Where:
∑ = Sum
x = Difference from the average Difference
n-1 = number of data sets minus 1
Example: 10 – 1 = 9

$$\text{Standard Deviation} = \sqrt{\frac{2.50}{9}} = 0.53$$

The Sum of X^2 = 2.5 and the number of data sets = 9 for a computed standard deviation of 0.53. This is within the allowable 2.5 therefore no cores are eliminated, use the average difference from all ten cores.

Figure 1



3.10. **Applying Correlation Example:**

Reading #1: 141.5 lb/ft^3

Reading #2: 140.1 lb/ft^3 Two readings within tolerance? (YES)

Reading average: 140.8 lb/ft^3

Core Correlation : +2.1 lb/ft^3

Corrected reading: 142.9 lb/ft^3

G_{mm} and maximum density from the FOP for AASHTO T 209:

G_{mm} = 2.466 =>2.466 X 62.4 => 153.9 lb/ft^3

$$\frac{\text{Corrected Reading}}{\text{Maximum Density}} X 100 = \%\text{ compaction} \qquad \frac{142.9}{153.9} \boldsymbol{X} 100 = 92.9\%$$

4. PROCEDURE DENSITY CORES

This procedure is used to determent the locations, density, and compaction of cores removed from the roadway. It is employed for third party resolution and for confirmation of failing verification of density.

4.1. Test Site location shall meet the 3.1 requirements listed above. Randomly identify 5 core locations representing the proposed pavement to be tested in accordance with ODOT TM 400 Stratified Random Sampling.

4.2. Core each location according to AASHTO R 67; remove the core to a minimum depth of the lift being evaluated. Extreme care shall be taken when extracting the cores, avoid such tools as pry-bars and screwdrivers as they will cause damage.

4.3. Separate the layer of ACP to be tested from the remainder of each core According to AASHTO R 67.

4.4. Determine the density of the cores by the AASHTO T 166, Bulk Specific Gravity of Compacted Bituminous Mixtures Using Saturated Surface Dry Specimens.

4.5. Determine the percent compaction for each core density using the MAMD done in accordance with ODOT TM 305 for the pavement being evaluated. Determine the sublot compaction by averaging the percent compaction of the 5 test locations per sublot.

5. REPORTING

5.1. Compaction by Nuclear Gauge

- Project Name and Number
- Project Manager and Contractor
- Bid Item for mix being placed
- Type of ACP being evaluated
- Mix Design Lab Number
- Design thickness of lift
- Nuclear Gauge Serial Number, Make & Model
- Panel width
- Rollers being used and Position in train
- Assigned Test Number for each location tested
- The date each location was tested
- The location of each test station and offset
- The lift of ACP location was tested
- The individual Nuclear Density reading at each test location
- Average Nuclear Density reading at each test location
- MAMD used for each test location

- The required Percent Compaction
- The Sublot Average Percent Compaction
- The Represented area i.e. Station to Station and Offset to Offset
- Technician's Name, Cert. number and signature

5.2. **Core Correlation, provide the following information to the Agency:**

- Project Name and Number
- Project Manager and Contractor
- Bid Item for mix being placed
- The date the cores were obtained
- The lift of ACP being evaluated
- Type of ACP being evaluated
- Mix Design Lab Number
- Nuclear Gauge Serial Number, Make & Model
- The individual Nuclear Density reading at each test location
- Average Nuclear Density reading at each core location
- Average thickness of each core to the nearest 1/8"
- Core density value and the following T-166 information:
    - Mass of core in air,
    - Mass of core in water
    - SSD mass of core
- Calculated Bulk Specific Gravity and Density
- Individual differences between average gauge densities and core densities
- Standard Deviation of the differences
- Indicate any data sets eliminated from use in the Correlation Factor
- Correlation Factor
- Document who performed the CDT, CAT-1 and QCCS work, name, cert number and signatures.
- ODOT form 2327-15 is available to perform the correlation calculations.

5.3. **Density of Cores**

- Project Name and Number
- Project Manager and Contractor
- Bid Item for mix being placed
- The date each core location was sampled
- The lift of ACP location was sampled
- Type of ACP being evaluated
- Mix Design Lab Number
- Design thickness of lift
- Core density value and the following T-166 information:
    - Mass of core in air,
    - Mass of core in water
    - SSD mass of core
- Core thickness
- MAMD used for each test location

- The individual Core percent compaction at each test location
- The average percent compaction per sublot
- Document the CDT, and CAT-1 full names and cert. numbers.

ODOT TM 335

PRESENCE OF HARMFUL MATERIALS IN RECYCLED ASPHALT SHINGLES

1. Scope.

This method covers the procedure to be used for the determination of harmful materials (e.g. nails, glass, rubber, soil, brick, tars, paper, plastic, wood chips, metal flashing, and other material not used in the manufacturing of asphalt shingles) in a sample of recycled asphalt shingles (RAS).

2. Apparatus

2.1. Balance or scale accurate to within 0.1 percent of the sample mass or readable to 0.1 g and meeting the requirements of AASHTO M 231.
2.2. Forced draft (preferred), ventilated or convection oven
2.3. Magnet rated with a minimum rating of 10 lbs of pull.

3. Sample Preparation

3.1. Sample per AASHTO T 2
3.2. Reduce to testing size per AASHTO T 248.
3.3. The minimum mass shall conform to Table 1 of AASHTO T 27/11.

4. Procedure - General.

4.1. Prepare a companion moisture sample and dry the sample following AASHTO T 255/T 265, Directions for Drying Aggregate, under the Controlled section.

4.2. Determine and record the wet mass of the entire test sample to the nearest 0.1 gram, designate as W_{wt} for calculation in 5.1.

4.3. Spread the sample to a depth of a ½-inch or less on a clean non-magnetic surface.

4.4. Pass the magnet over the entire sample between 1/8 and ½ inch above the sample.

4.5. Determine and record the weight of the remaining sample not retained by the magnet. Designate as “A” for calculation in 5.1.

4.6. Calculate the weight of the metal fragments according to section 5.1.

4.7. Sieve the remaining material over the 3/8 inch, the No. 4, the No. 8, and the No. 30 sieves. Sieve the material for 10 ±2 min.

4.8. Discard the portion of material passing the No. 30 sieve.

4.9. Check the material retained on each sieve for all deleterious content including but not limited to wood, paper, plastic and other material not used in the manufacturing of asphalt shingles:

4.9.1. Spread the portion of the sample retained on each sieve individually, out in a pan large enough to examine the individual particles carefully.

4.9.2. Separate and remove the deleterious matter from the sample by visual inspection.

4.9.3. Weigh all deleterious matter removed from the RAS sample retained on each sieve to the nearest 0.1 g and record each weight as $N_{3/8}$, N_4, N_8, and N_{30} respectively for use in calculation in Section 5.2.

5. Calculations

5.1. Calculate total dry weight of sample, W_t as follows:

$$W_t = W_{wt} - \left(W_{wt} \times \frac{M_i - M_f}{M_f} \right)$$

Where:

M_i = initial weight of companion moisture sample, g
M_f = final weight of companion moisture sample, g
W_{wt} = total weight of wet sample, g

5.2. Calculate the weight of metal fragments to the nearest 0.1 grams as follows:

$$M = W_T - A$$

Where:

M = weight of material retained by the magnet, g
W_T = total dry weight of sample, g
A = weight of material not retained by the magnet, g

5.3. Calculate the percent by weight of deleterious material in the sample:

$$P = \frac{M + N_{3/8} + N_4 + N_8 + N_{30}}{W_T} x100$$

Where:

P = percent of deleterious matter by weight
M = weight of material retained by magnet, g
$N_{3/8}$ = weight of deleterious substance retained on the 3/8 inch sieve, g
N_4 = weight of deleterious substance retained on the No. 4 sieve, g

N_8 = weight of deleterious substance retained on the No. 8 sieve, g
N_{30} = weight of deleterious substance retained on the No. 30 sieve, g
W_T = total dry weight of sample, g

6. Report

6.1. Mass of sample
6.2. Mass harmful material
6.3. Percentage of harmful materials (0.1%)

ODOT TM 400

Method of Test for

Determining Random Sampling and Testing locations

Significance

This procedure is used to determine random sampling and test location for various field tested materials used in highway construction. Use of accepted random sampling techniques is intended to minimize any bias on the part of the person taking the sample. Testing and sampling locations and procedures are just as important as testing. For test results or measurements to be meaningful, it is necessary that the sampling locations be selected at random, typically by use of a table of random numbers. Other approved techniques yielding a system of randomly selected locations may also be allowed.

Scope

This method is intended for use during Quality Control and Quality Assurance sampling and testing during the manufacturing of aggregates, during the production of mixtures, and/or during the placement of materials in their final location on the grade. This method is also intended for post construction use in identifying in-place materials for sampling and testing when production results are called into question.

This method covers determining random samples by tonnage or by geometric stations. The method also covers a methodology for converting a predetermined random tonnage to an equivalent random station when stationing is more advantageous for use by the technician.

Definitions

Lots and Sublots

A lot is a pre-selected quantity representing a sample of the whole or the entire quantity being sampled or measured can be defined as a lot. A lot may be comprised of several portions that are called sublots. Each sublot can then be analyzed to better represent the whole or “lot”.

Straight Random Sampling vs. Stratified Random Sampling

Straight random sampling considers an entire lot as a single unit and determines each sample location based on the entire lot size. Stratified random sampling divides the lot into a specified number of sublots or units and then determines each sample location within the distinct sublot or unit. Both methods result in random distribution of samples to be tested for compliance and are normally outlined in the agency’s specification.

Procedure

Straight Random Sampling

1. Determine the size of the lot and number of tests required. If statistical means are to be used for acceptance use a minimum of three random tests.

2. Obtain the random numbers to be utilized either by the use of a random number table or other approved method. I.e. Calculator, computer, etc.

   Form 1792 R 9-06, is available to assist with the random number management. (A Random Number Table is included in this procedure).

3. Normally, a five digit value is used to determine the random sample location. The entire five digit number can be utilized or portions there of. Multiply the lot by the random number**.** This will yield the test location within the lot to perform the testing.

Stratified Random Sampling

1. Determine the number of sublots in the lot by dividing the lot quantity by the defined sublot size and round up to the nearest whole number. If statistical means are to be used for acceptance use a minimum of three sublots. If the lot generates less than three defined sublots, divide the lot quantity by three and redefine the sublots to this new smaller size..

2. Divide the sublot size by the number of tests required. i.e. 5 tests per 1000 ton sublot, equals 1 test per 200 ton sublot segment.

3. Obtain the random numbers to be utilized either by the use of a random number table or other approved method. I.e. Calculator, computer, etc.

   Form 1792 R 9-06, is available to assist with the random number management. (A Random Number Table is included in this procedure).

4. Multiply the sublot segment size by the random number and add the beginning tonnage or station to determine the sampling or testing locations. This will yield the test location within the sublot segment to perform the testing.

Converting Predetermined Random Tonnages to Equivalent Random Stations by use of Yield Calculations (In-Place Testing)

1. Designation of a random sample location can be based on either a tonnage or station. Station application is for in-place field work such as density on ACP or sampling of aggregates or soils. Because the required sublot size is typically in a tonnage it is necessary to convert that tonnage into a length per ton to find the corresponding station in the field.

Note: All measurements must be expressed in Feet and % density is in decimal form.

English Example (computing feet per ton):

Given:

- MAMD is 151.9 lbs/ft^3
- Density Requirement is 92% (0.92) or the average density determined in the field can be utilized.
- Panel thickness is 2” (2”/12”) = (0.167 ft)
- Panel Width 16ft.
- Random Tonnage = 714 tons
- Beginning Station = 183+50

Step 1: Compute the Average Volume per ton.

$$Average\ Volume = \frac{2000_{lbs\ /\ ton}}{151.9_{lbs\ /\ ft^3} \times 0.92}$$

$$Average\ Volume = \frac{2000_{\not{lbs}\ /\ ton}}{151.9_{\not{lbs}\ /\ ft^3} \times 0.92} = 14.31_{ft^3\ /\ ton}$$

Step 2: Calculate the cross-sectional area.

$$Cross-Sectional\ \ Area = 0.167_{ft} \times 16_{ft} = 2.67_{ft^2}$$

Step 3: Calculate the yield in feet per ton of paving by dividing the average volume by the cross-sectional area.

$$Yield = \frac{14.31_{ft^3}\ /\ _{ton}}{2.67_{ft^2}}$$

$$Yield = \frac{14.31\,\cancel{ft^3}\ / ton}{2.67\,\cancel{ft^2}} = 5.36\,ft\ /\ ton$$

Step 4: Calculate the number of feet required to pave 714 tons of ACP (714 tons is the random generated value).

$$Feet\ of\ Paving = 714_{tons} \times 5.36\,ft\ /\ ton$$

$$Feet\ of\ Paving = 714\,\cancel{tons} \times 5.36\,ft\ /\ \cancel{ton} = 3827\,ft$$

Step 5: Calculate the random location based on stationing by adding the distance in feet to the reference station.

- First convert the distance to a station reference by dividing the value by 100. 3827 / 100 = 38.27 or 38+27.
- Starting reference station is 183+50.
- 183+50 plus 38+27 = 221+77 random location longitudinally.
- Then measure the random distance from desired edge of panel for test site offset.

Note: *Taking the inverse or reciprocal of the yield factor, based on a length / weight relationship, a weight to length factor can be determined. Either convention can be utilized to determine a distance of coverage based on a known quantity.*

Example:

$$\frac{1}{5.36} = 0.18657\,tons\ /\ ft$$

$$\frac{714\,tons}{0.18657\,tons\ /\ ft} =$$

$$\frac{714\,\cancel{tons}}{0.18657\,\cancel{tons}\ /\ ft} = 3827\,ft$$

Report

All random numbers shall be submitted on standard forms approved by the agency.

Random Number Table

Line/Col.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1	16897	16881	22931	30360	86899	51400	15815	41234	81861	82040	35678
2	16066	03723	89146	22426	63867	63506	17781	49403	04287	20424	07348
3	85075	44878	72033	58248	77069	18971	39182	30082	56504	46566	42681
4	92639	30948	57302	81544	63775	52944	80353	63289	86249	75673	09155
5	35721	37005	49818	86207	62735	44649	23672	06383	04114	28132	05908
6	40489	59044	89605	35282	26421	01022	61386	92737	87214	45817	91765
7	44342	01656	85330	48692	24303	00857	37624	26026	24111	11525	09849
8	48339	55094	00436	05613	45626	16491	78652	60998	80789	51080	74835
9	78149	23513	40239	08012	07515	30771	22169	42811	65528	69258	08210
10	53975	05987	19104	37420	24813	05085	57626	68003	81529	15681	28910
11	47291	70452	34590	31785	85351	54591	59692	55567	45079	45751	40201
12	34542	53478	24010	23177	47320	47810	63102	42071	01144	52342	74604
13	07353	34902	98261	40943	21138	20089	18299	39147	87712	40470	72981
14	70361	33031	17937	83411	03889	16309	94376	88326	69494	20471	67255
15	33361	61660	86771	02004	01567	06219	97827	75885	90188	56494	52163
16	12998	73394	24693	34225	42333	69609	53915	18304	82164	56042	12097
17	29623	44833	25355	29022	41902	42322	67751	04941	42039	86077	87066
18	94859	35317	68957	47114	24840	73777	87089	17554	15613	59887	68990
19	68417	40318	85951	46929	07799	11666	94557	69499	73074	78549	50198
20	11826	65897	95213	07860	14082	23312	72457	17117	27707	33332	76374
21	85532	33390	48065	62862	93745	87022	68944	18825	96608	12332	31279
22	09588	86051	27474	46612	94954	66084	28031	11486	26895	56861	49260
23	99396	93908	91658	93214	79134	00272	89581	92129	23926	01510	55723
24	78462	91590	31144	91250	85550	11080	97373	63397	39601	43019	09742
25	98696	01557	06498	39892	02702	52858	36984	45515	21716	92369	81682

ODOT TM 769-13

Method of Test for

Certification of Inertial Profiler Equipment

1. SIGNIFICANCE

1.1 This test method describes the procedure for measuring the vertical and horizontal accuracy of an Inertial Profiler for purposes of certification under Oregon Department of Transportation (ODOT) Quality Assurance Program. The profiler will be tested on a calibration course of known International Roughness Index (IRI) for accuracy and repeatability.

2. SCOPE

2.1 This test method covers Inertial Profilers employing automated data collection of pavement profile for the purpose of determining IRI. Measurements are made using non-contact sensing systems from a moving platform meeting the requirements of Section 4, equipment and AASHTO M 328.

3. REFERENCED DOCUMENTS

3.1 AASHTO M 328
3.2 AASHTO R56
3.3 AASHTO R 57
3.4 ProVAL User Manual

4. EQUIPMENT

4.1 An Inertial Profiler, triggering equipment, and calibration equipment meeting the requirements of AASHTO M 328 and AASHTO R 57. Note: Submit documentation detailing the specifications of the equipment to be used and the manufacturer's recommended calibration and calibration check procedures.
4.2 The device must be capable of reporting elevations with a resolution of 0.001 inches or finer at a sampling interval of 2 inches or less within the operating speed of the profiler. The device must provide a means to field calibrate and measure the horizontal distance traveled.
4.3 The device must be equipped with software capable of generating, displaying, storing, and reporting IRI at 0.10 mile intervals. The profiler software will be capable of generating an ERD file that contains the profile data in ERD format and a PPF file that contains the data in PPF format.
4.4 The Inertial Profiler must be equipped with auto triggering equipment and a printer for hard copies of data output.
4.5 Lateral laser spacing of 69 to 71.5 inches is required.
4.6 Maintain the low pass filter at 0.000 feet and the High Pass filter at 200.000 feet for all calibration and certification testing.

5. OPERATOR REQUIREMENTS

5.1 The operator shall be proficient in the calibration and operation of the profiler per the manufacturers' recommended procedures. The certification of the profiling system is tied to the operator. All prospective operators must go through the certification procedure with the equipment with acceptable results to be certified. Certification documentation will show which operators are approved for each profiler.

6. CERTIFICATION REFERENCE SITE

6.1 The certification reference site will be designated by the ODOT, Pavement Services Unit. The reference site will include a Distance Measurement Instrument (DMI) verification section and a section for determining the accuracy and the repeatability of the profiler.

7. REFERENCE VALUE DETERMINATION

7.1 The profile of the reference site will be determined by the ODOT, Pavement Services Unit using an accepted reference device. The IRI will be computed from the collected data.

7.2 The section for DMI Verification will be established by the ODOT, Pavement Services Unit. The start and the end locations of the section will be marked.

8. EQUIPMENT CALIBRATION VERIFICATION

8.1 *Distance Measurement Instrument (DMI) Verification:* The DMI of the profiler shall be set to report distance in feet. The operator will guide the profiler over the DMI section length as laid out by ODOT. The DMI must be triggered by the auto triggering equipment at the start and at the end of the DMI section, and the DMI readout recorded. The operator shall make two additional runs following the same procedure. Each run and distance readout will be observed by an ODOT representative. The average of the three absolute differences (between the DMI readout and actual length of section) must be less than 0.10% of the known distance.

8.2 If the profiler's DMI does not pass the above requirement, then the operator shall calibrate the DMI to the known distance specified by ODOT, and repeat the three runs as stated above.

Note: The DMI reading is affected by the tire pressure. Hence, operators should make sure that the tire pressure is set to the manufacturers' recommended value and the tires are sufficiently warmed-up before calibrating the profiler and performing the required runs.

8.3 *Bounce test:* Perform according to the manufacturer's recommendations. If the profiler manufacturer does not have a procedure, then perform the following:

Position the vehicle on a flat and level surface. Place a smooth, flat, non-glossy material plate under each sensor (the base plate used for the block check can be used). Using the equipment's normal data collection software, initiate a data collection run using a simulated travel speed at the midpoint of the manufacturer's recommended data collection speed range.

(The only difference between a bounce test and a normal data collection run is that there is an artificial longitudinal travel signal supplied and the vehicle is not actually travelling along the road. The bounce test utilizes the same data collection software and routines used during normal data collection).

Allow the profiler to collect a minimum of 528 ft of static profile with the host vehicle as motionless as possible. Next, the sensor(s) should be moved vertically for a total displacement of approximately 1-2 in. (a yardstick may be helpful until the operator gets used to the procedure). This movement must continue until a minimum of 528 ft of simulated longitudinal distance has been covered. The typical method for full size high speed host vehicles is to push the mounting system (bumper) down an inch or so and let the vehicle suspension rebound to create the total vertical travel of 1-2 in. The typical method for light-weight, slow-speed host vehicles is to stand toward the center of the vehicle platform and hop up and down such that all four corners of the vehicle suspension travel approximately 1-2 in. vertically. Stop the test after a minimum of 528 ft of bounce profile is collected.

The IRI during the static portion of the test must be less than 3 in/mile and the IRI during the bounce portion must be less than 10.0 in/mile or the manufacturer's recommended maximum, whichever is less. This requirement shall be met for each sensor. If the IRI value is greater than the stated values, provide documentation explaining why to the ODOT's Pavement Services Unit. The Pavement Services Unit will determine either acceptance or failure of this test based on the documentation provided. An ODOT representative will observe and record the IRI value from the bounce test.

Note: Some profiling systems require a warm-up period before use. The system should be turned on for a minimum of fifteen minutes prior to calibration verification, or per the manufacturer's recommendations.

8.4 *Vertical height test:* The height sensor will be checked with blocks of a known thickness of 0.25-in, 0.50-in and 1.00-in. A smooth base plate will be placed under the height sensor height measurements will be taken, or the vertical height will be zeroed. A 0.25-in block will be placed on top of the base plate under the height sensor and height measurements will be taken. The 0.25-in block will be removed and replaced with the 0.50-in block on top of the base plate and height measurements will be taken. The 0.50-in block will be removed and replaced with the 1.00-in block on top of the base plate and height measurements will be taken.

The average height of the base plate will be calculated for those systems that cannot be zeroed. This height will be subtracted from the measured height readings for the 0.25-in block, the 0.50-in block and the 1.00-in block to calculate the measured thickness of each block. The error in calculated thickness will be determined from the average of the absolute values of the difference between the calculated thickness and the known thickness for the measurements. To pass the height test, the average of the absolute differences must be less than or equal to 0.01-in for each block.

An ODOT representative will observe the measured height values of the base plate and blocks.

8.5 *Calibration Verification Log:* Maintain a log book which records the inertial profiler's history of all calibrations and equipment repairs or replacement. This log shall be made available to ODOT employees at any time on ODOT projects.

9. EQUIPMENT CERTIFICATION PROCEDURE

9.1 *Dynamic Test:* After meeting the requirements of Section 8, the Operator will use the Inertial Profiler to collect profile data on the designated certification reference track. The certification reference track will be a minimum of 528 feet in length.

The Operator will make a minimum series of five runs over the certification reference track. Set the horizontal measurement interval and the reporting interval on the Inertial Profiler to not greater than 2.00 inches. The data collection must be triggered by the automated triggering equipment. Terminate data collection at the end of the designated section. A minimum of five repeat runs of the profiler will be made on each section, and the IRI values computed for each run. The profiler will be operated at the speed that will be used for normal data collection, within the speed range recommended by the manufacturer of the profiler and typical of the data collection speed for contract smoothness measurement.

(Note: Make sure that the tires on the profiler are warmed up before doing the Dynamic test. If they are not warmed up, that can affect the DMI between runs and can significantly affect the Repeatability and Accuracy Scores that are computed in Section 9.3).

9.2 *Data Format:* Profile data will be collected, stored, and reported in a format recognized by the latest version of ProVAL (FHWA smoothness software available at www.roadprofile.com), and given to the ODOT representative for evaluation as described in Section 9.3.

9.3 *Repeatability and Accuracy:* The latest version of the ProVAL Profiler Certification Module will be used for cross correlation, to evaluate the five runs. For these computations, the following settings will be used in the In ProVAL Profiler Certification Module: (1) basis or comparison filter will be set to IRI without the 250 mm filter applied and (2) the comparison runs filter will be set to IRI with the 250 mm filter applied. A Repeatability score of 90% and an Accuracy score of 88% will be required for both wheel paths for certification.

10. EQUIPMENT REQUIREMENTS

10.1 All of the following conditions must be met for certification of the Inertial Profiler:

- Pass all Equipment Calibration Verifications -- Section 8.
- Meet Repeatability requirement-- Section 9.3.
- Meet Accuracy requirement-- Section 9.3.

11. CERTIFICATION OF OPERATORS AND EQUIPMENT

11.1 The ODOT Pavement Quality Engineer will make the final determination as to the acceptability of the Equipment for purposes of certification. The certification is good for 365 days, provided the there are no software updates, equipment is not damaged or reconfigured and no significant changes are made to the profiling equipment or the host vehicle per the judgment of the Engineer.

Notice of Certification: Upon successful completion of this test method, written notice of certification will be issued by ODOT and include the following:

- Identification of the profiler certified (make, model, serial number, software version, and owner)
- Identification of the operator(s)
- Date of certification
- Low & High Pass filter settings at the time of the certification runs
- Repeatability results
- Verification of IRI using cross correlation results.
- Acceptable operation speed

ODOT TM 770

Method of Test for

DETERMINING THE GRAPHIC PROFILE INDEX WITH A CALIFORNIA TYPE PROFILOGRAPH OR AN INERTIAL LASER PROFILOMETER

SCOPE

This test method describes the procedure for checking the horizontal and vertical accuracy of the plotter and for determining the profile index from profilograms of pavement made with the California Type Profilograph. A procedure used to locate individual deviations is also included.

Profilograms generated from Profilometers employing an accelerometer established inertial profiling reference and a laser height sensing instrument may also be evaluated using the procedures described herein.

The profilogram is recorded on a horizontal scale of 1:300 and vertical scale of 1:1. The determination of the Profile Index involves measuring “scallops” that appear outside a “blanking” band. The determination of individual high areas involves the use of a special template. An alternative horizontal scale may be used when the calculations are performed by analysis software.

EQUIPMENT

1 California Profilograph

1.1 The profilograph shall be the California Type, computerized or not computerized, complete with recorder for determining the profile index of highway pavements.

1.2 The equipment consists of a steer able metal frame 25 ft (7.62 m) in length supported at both ends by wheel assemblies consisting of six wheels each.

1.3 A rubber tired profile wheel approximately 1.5 ft (0.5 m) in diameter and which may be retracted when not in use is attached at mid-frame. The profile wheel is connected to a mid-frame mounted strip-chart recorder containing rollers for chart paper, recording pen and events marker. The recorder will record the profile of the pavement surface on a horizontal scale of 1:300 and a vertical scale of 1:1. A storage case for the recorder shall be provided.

2 Profilometers

2.1 The profilometer shall employ an accelerometer established inertial profiling reference and a laser height sensing instrument to produce a true profile of the pavement surface.

2.2 The device must be capable of reporting elevations with a resolution of 0.004 in (0.1 mm) or finer at an interval of 6 in (150 mm) or less. The device must provide a means to calibrate and measure the horizontal distance traveled.

2.3 The device must be equipped with software capable of generating the equivalent California Type Profilograph plot (profilogram) and values as well as the locations of bumps and dips.

CALIBRATION TESTS

Perform all calibrations and calibration verifications in the presence of a representative of the Agency. Provide documentation to the Agency that the calibration tests have been successfully completed. The Contractor will submit what equipment will be used, the make model and the Manufacturer's recommended calibration procedure, 10 days before smoothness measurements are to begin.

1 Calibration Frequency

1.1 California Profilograph

The profilograph shall be calibrated at the beginning of each day's use, each time the profilograph is disassembled and reassembled or whenever the accuracy of the profilograph run is in question. Both the vertical and horizontal accuracy of the profilogram shall be checked.

1.2 Profilometer

Perform horizontal and vertical calibration of the profilometer at the frequency recommended by the manufacturer or at any time test results are questionable. It is recommended that the horizontal calibration be checked once per day.

2 Vertical Calibration

2.1 California Profilograph

2.1.1 Set the profilograph in a stationary position on a reasonably smooth and level surface.

2.1.2 Check the tire pressure of the profile wheel if an inflatable tire is used. It should be 25 psi (172 kPa).

2.1.3 Place a 24 in X 36 in X $^1/_8$ in (600 mm x 900 mm x 3 mm) steel or aluminum plate or ¼ in (6 mm) plywood underneath the recording wheel. This will eliminate the unevenness of the surface under the wheel.

2.1.4 Mark where the recording pen is located on the vertical scale. For computerized profilographs, follow the manufacturer's instructions.

2.1.5 Slide the ½ in (12.5 mm) thick calibration block, as detailed below, underneath the recording wheel in a manner that will result in an accurate motion of the recording pen.

2.1.6 Mark the new position of the recording pen and measure the distance between the two marks. For computerized profilographs, follow the manufacturer's instructions.

2.1.7 The distance should be 1/2 in ± 1/16 in (12.5 mm ± 1.5 mm).

2.1.8 If the distance is not within these limits, adjust the plotter to the required vertical accuracy prior to use. Follow the manufacturer's recommendation for vertical adjustment.

2.2 Profilometer

Perform vertical calibration of profilometers according to the manufacturer's recommendations.

3 Horizontal Calibration

3.1 California Profilograph

3.1.1 Measure and mark off a straight distance of 0.1 mile (200 m) on a reasonably level and smooth paved surface.

3.1.2 Place the center of the profile wheel on the zero mark. Mark the location where the recording pen is positioned on the horizontal scale. For computerized profilographs, follow the manufacturer's instructions. Operate the profilograph over the marked distance to the 0.1 mile (200 m) mark. Stop with the center of the profile wheel on the 0.1 mile (200 m) mark.

3.1.3 The horizontal graph line should be 21.12 in ± 0.16 in (667 mm long ± 4 mm).

3.1.4 If the horizontal graph line is not within these limits, adjust the plotter to the required horizontal accuracy prior to use. Follow the manufacturer's recommendation for horizontal adjustment.

Note: Air moisture and tension on the paper roll can affect the horizontal distance.

3.2 Profilometer

3.2.1 Measure and mark off a straight distance of 0.1 mile (200 m) on a reasonably level paved surface.

3.2.2 Perform horizontal measurement calibration according to the manufacturer's recommendations.

Note the air pressures in the tires on the vehicle when the horizontal calibration is performed. Check the pressures as necessary during the day to ensure the tire pressure is maintained. If the tire pressure changes, adjust the pressure or recalibrate the horizontal measurement. Tire pressure will influence the horizontal distance measured by the profilometer.

4 Calibration Verification

Before performing smoothness measurements on the project, verify the calibration of the California-type profilograph or Laser Profilometer by running the machine twice over a 200 m (0.1 mile) section of pavement with repeating results. The calibration shall be considered acceptable when the difference in Profile Index between consecutive test runs is 5 mm/km (0.3 in/mile) or less. Provide documentation to the Engineer verifying that the calibration and test runs have been successfully completed.

A fog line or other straight line on a relatively smooth pavement surface is suggested for performing this check.

TESTING

1 Operate the profiling device to provide complete graphic profiles at all locations required by the contract specification.

2 Operate the profiling device either in the direction of vehicle travel or the direction of placement as determined by the Engineer.

3 Operate the California Profilograph along the specified wheel paths and other locations at a speed not greater than three miles per hour. Do not tow the profilograph. Operate the Profilometer along the specified wheel paths and other locations at speeds recommended by the manufacturer. Take care to keep the device as parallel as possible to centerline.

4 Mark on the profile chart the appropriate identification and project stationing, matching the project plans, for each profile. For example: northbound, outside travel lane, right wheel path could be identified as N-OL-R. Include project identification and project stations on the outside of the rolls.

5 Mark and identify the project stationing on the profiles and identify the location of milepost markers. Initial and date the beginning and ending project stations of each day's run on the profilogram.

6 Identify by project stationing on the profiles any areas excluded by specifications.

7 The **project** stationing is referenced on the profile chart by marking a line on the chart at a known project station and writing the project station on the chart and, reference the location of milepost markers. The beginning and ending project stations of each day's run is initialed on the profilogram. The project stationing is checked every mile and the chart paper or horizontal location is reset. (If out of tolerance, 1% or 53 feet /mile).

DETERMINATION OF THE PROFILE INDEX

1 General

Before beginning the profile index counts, profiles are divided into 0.1 mile (200 m) segments and into partial segments as required by the contract specifications.

Profilometers and Computerized Profilographs automatically perform the calculations presented below. It will not be necessary to recompute the Profile Index from these devices unless the results are in question.

2 Profile Index Equipment – Manual Trace

The only special equipment needed to determine the profile index is a plastic scale 1.70 in (45 m) wide and 21.12 in (667 mm) long representing a pavement length of 0.1 mile (200 m) at a scale of 1:300. Near the center of the scale is an opaque blanking band 0.2 in (5 mm) wide extending the entire length of the plastic scale. On either side of this blanking band are parallel scribed lines 0.1 in (1 mm) apart. These lines serve as a convenient scale to measure deviations called “scallops” of the profile above and below the blanking band.

3 Method of Counting for Profile Index

3.1 Place the plastic scale over the profile in such a way as to “blank out” as much of the profile as possible. When this is done, scallops above and below the blanking band will be approximately balanced.

3.2 For short radius super elevated curves it is necessary to shift the scale to blank out the central portion of the trace. When such conditions occur, the profile is broken into short sections and the blanking band repositioned on each section while counting.

3.3 Beginning at the right end of the scale, measure and total the height of all the scallops appearing both above and below the blanking band, measuring each scallop to the nearest 1 mm (0.05 in). Write this total on the profile sheet near the left end of the scale together with a small mark to align the scale when moving to the next section. Short portions of the profile line may be visible outside the blanking band, but unless they project 0.05 in (1 mm) or more and extend longitudinally for 2 ft (0.6 m) (0.1 in (2 mm) on the profilogram) or more, they are not included in the count.

3.4 When scallops occurring in the first 0.1 mile (200 m) section are totaled, slide the scale to the left, aligning the right end of the scale with the small mark previously made and proceed with the counting in the same manner.

4 Calculation of the Profile Index

The profile index is the inches per mile in excess of the 0.2 in (5 mm) blanking band. The formulas for converting counts to profile index is as follows:

METRIC

$$\text{Profile Index} = \frac{\text{Total Count (mm)} \times 1000\ \text{m/km}}{\text{Length (m) of Full 200 m Segment or of Partial \_\_\_\_\_* m Segment}}$$

* Report to nearest whole meter

ENGLISH

$$\text{Profile Index} = \frac{\text{Total Count (in)}}{\text{Length of Full 0.1 mile Segment or of Partial \_\_\_\_\_* mile Segment}}$$

* Report to nearest 0.01 mile

DETERMINATION OF INDIVIDUAL DEVIATIONS IN EXCESS OF 0.36 in (9 mm)

Profilometers and Computerized Profilographs automatically perform the calculations presented below. It will not be necessary to re-compute the individual deviations from these devices unless the results are in question.

1 Equipment – Manual Trace

The only special equipment needed is a plastic template having a line 1 in (25 mm) long scribed on one face with a small hole or scribed mark at either end and a slot 0.36 in (9 mm) from and parallel to the scribed line. (1 in (25 mm) line corresponds to a horizontal distance of 25 ft (7.5 m) on the horizontal scale of the profilogram.)

2 Procedure

2.1 At each prominent peak or high point on the profile trace, place the template so that the small holes or scribe marks at each end of the scribed line intersect the profile trace to form a chord across the base of the peak or indicated bump. The line on the template does not need to be horizontal. With a sharp pencil draw a line using the narrow slot in the template as a guide. Any portion of the trace extending above this line will indicate the approximate length and height of the deviation in excess of 0.36 in (9 mm).

2.2 There may be instances where the distance between easily recognizable low points is less than (1 in (25 ft)) (25 mm (7.5 m)). In such cases a shorter chord length shall be used in making the scribed line on the template tangent to the trace at the low points. It is the intent, however, that the baseline for measuring the height of bumps will be as nearly 25 ft (1 in) (7.5 m (25 mm)) as possible, but in no case to exceed this value. When the distance between prominent low points is greater than 25 ft (1 in) (7.5 m (25 mm)), make the ends of the scribed line intersect the profile trace when the template is in a nearly horizontal position.

ODOT TM 772-13

Method of Test for

DETERMINING THE INTERNATIONAL ROUGHNESS INDEX WITH AN INERTIAL LASER PROFILER

1. SCOPE

1.1 This test method describes the procedure for operating a profiler, checking the calibration (horizontal and vertical accuracy) of the profiler, and determining the International Roughness Index (IRI) and areas of Localized Roughness from pavement profiles obtained by an inertial profiler. A procedure for Quality Control and Quality Assurance smoothness measurements on paving projects is also included.

2. REFERENCED DOCUMENTS

2.1 AASHTO M 328
2.2 AASHTO R 54
2.3 AASHTO R 56
2.4 AASHTO R 57
2.5 ProVAL User Manual

3. EQUIPMENT

3.1 Profilers

3.1.1 The profilers shall employ an accelerometer established inertial profiling reference and a laser height sensing instrument to produce a true profile of the pavement surface, as described in AASHTO M 328.

3.1.2 The device must be capable of reporting elevations with a resolution of 0.001 inches or finer at a sampling interval of 2 inches or less within the operating speed of the profiler. The device must provide a means to field calibrate and measure the horizontal distance traveled.

3.1.3 The device must be equipped with software capable of generating, displaying, storing, and reporting IRI at 0.10 mile intervals. The profiler software is required to generate ERD files that contain the profile data in the ERD format and a .PPF files that contain the data in .PPF format

3.1.4 Maintain the low pass filter setting at 0.00 feet.

3.1.5 Maintain the high pass filter setting at 200.00 feet

4. CALIBRATION VERIFICATION

Submit to the Project Manager for approval at least 10 days before smoothness measurements are to begin, the following:

- Documentation detailing equipment to be used and the manufacturer's recommended calibration and calibration check procedures;
- The ODOT Pavement Services Unit Certification documentation, showing certification of the operator and profiling equipment.

Perform all calibration verifications in the presence of the designated representative of the Project Manager.

4.1 Calibration Frequency

At a minimum, perform calibration once per calendar year per the manufacturer's recommendations and procedures.

4.2 Profiler Calibration Check

Perform horizontal and vertical calibration check at the frequency recommended by the manufacturer or at any time during testing if the test results are questionable. At a minimum, check vertical and horizontal calibration daily and at any time a configuration change is made to the profiler.

4.2.1 Vertical Calibration Check

Perform a vertical calibration check on each height sensor in the profiler according to the manufacturer's recommendations. At a minimum, (1) obtain a reading on a smooth base plate, then place a 0.25-in thick block on the base plate, and obtain a reading, and from these two readings compute the thickness of the block as measured by the profiling system, (2) obtain a reading on a smooth base plate, then place a 0.50-in thick block on the base plate and obtain a reading, and from these two readings compute the thickness of the block as measured by the profiling system, (3) obtain a reading on a smooth base plate, then place a 1.00-in thick block on the base plate and obtain a reading, and from these two readings compute the thickness of the block as measured by the profiling system. The thickness of the blocks used for this test shall meet the requirements of AASHTO R 57. The thickness of the blocks as determined by the profiling system should be within 0.01 inches of the actual thickness of the block.

4.2.2 Horizontal Calibration Check

This check is performed to verify the accuracy of the Distance Measurement Instrument (DMI). As a minimum, measure and mark off (to within 0.05%) a straight distance of 528 feet on a reasonably level, paved surface. Test the section 3 times.

The average of the three runs should be less than 1 foot absolute difference from the known 528 feet. If the profiler fails to meet this requirement, calibrate the DMI according to the manufacturer's recommendations and repeat the horizontal calibration and adjustments until the required average is achieved.

Note: Check the air pressure in the tires on the vehicle as necessary during horizontal calibration process to ensure the tire pressure is maintained. If the tire pressure changes, adjust the pressure or recalibrate the horizontal measurement until acceptable, repeatable horizontal calibration check is accomplished. Tire pressure will influence the horizontal distance measured by the profiler.

4.3 Bounce Test

Perform the Bounce test according to the manufacturer's recommendations. As a minimum, place the profiler on a flat level smooth pavement with the electronics on and the vehicle stationary. The IRI corresponding to each sensor should be less than 3.0 inches/mile, for the time period that it would take the profiler to travel 528 feet. Next, move the vehicle ("bounce") vertically with 2 inches minimum of vertical travel, for the time period that it would take the profiler to travel 0.10 mile. The IRI corresponding to each sensor should be under 10.0 inch/mile or under the manufacturer's recommended maximum, whichever is less.

4.4 Calibration Verification

Before performing smoothness measurements on the project for each shift (day or night) of testing, verify the calibration of the Profiler by operating the machine twice over a 528 foot section of pavement with repeating test results. The calibration shall be considered acceptable when the difference in IRI between 2 consecutive test runs is 4.0 in/mile or less. If a single laser is used, then one wheel path will be tested. If two lasers are used (right and left) the average of the two IRI will be used. Provide documentation to the Project Manager verifying that the calibration and test runs have been successfully completed for each shift of testing.

A fog line or other straight line on a relatively smooth pavement surface is suggested for performing this check.

Maintain a log to be kept with the profiler, to provide a record of calibration history.

5. QUALITY CONTROL PROFILE TESTING AND REPORTING

5.1 Operate the profiling device to provide data for complete graphic profiles at all locations required by the contract specification.

5.2 Locate and mark all excluded areas by specification. ***Do not profile excluded areas noted in the specifications.*** Test excluded areas according to the applicable specification.

5.3 Operate the profiling device in the direction of travel.

5.4 Set the reporting interval to 2.0 inches or less.

5.5 Operate the profiler in order to collect data along the specified wheel paths at a constant speed, which is within the operating speed range as recommended by the manufacturer (see Section 5.9 for the location of the wheel paths). Take care to keep the device as parallel as possible to centerline. Bring the profiler to the desired speed and alignment prior to the beginning of the test section. Maintain the profiler speed at as constant a rate as possible throughout the test section. Use the manufacturer's recommended lead-in and lead-out distances, or a minimum of 200 feet. Profiler speed will be maintained through the end of the test section.

5.6 Label Profile reports and data files with the appropriate identification and project stationing, matching the project plans, for each profile. For example: northbound, outside travel lane, right wheel path could be identified as N-OL-R. Include project identification and project stations on the report that contains the table outlined in section 5.11.

5.7 Mark and identify the project stationing on the profiles. Initial and date the beginning and ending project stations of each day's test runs on the profile reports.

5.8 A horizontal distance tolerance of a maximum of 1.0% or 53 feet/mile is required. Reference the project stationing on the profile at a known project station at the beginning and ending of each run and excluded area. Write the project station on the chart or use event markers to reference the locations of verified project stationing. Check the project stationing every mile at a minimum.

5.9 Measure both the right and left wheel path. Measure the left wheel path at 3 feet from the lane divider (center line). Measure the right wheel path at 9 feet from the lane divider (center line). When using an inertial profiler that collects a single wheel path per pass, make sure that each wheel path starts and stops at the same longitudinal location.

5.10 Do not mix travel lanes in the same data file. Submit profile data (hard copies and data files – in the .ERD, .PPF and manufacturer specific file formats) for all travel lanes and wheel paths for the entire project except for excluded areas, per specification (do not profile excluded areas).

5.11 Submit to the Project Manager a table that identifies the lanes, wheel paths, and distance locations (Stations and/or Mile Posts) tested for each data file, representing all profiles on the project. (Most profile manufacturers have a reporting format that is acceptable.)

5.12 The Project Manager will evaluate the profile reports generated from .ERD, or .PPF raw data files through the most current version of the ProVAL software (available at www.roadprofile.com) for payment according to 00745.96. IRI values are evaluated to the nearest 0.1 inches/mile.

6. DETERMINATION OF THE INTERNATIONAL ROUGHNESS INDEX

Calculate the left wheel path IRI, right wheel path IRI, and the mean IRI (average of left and right wheel path IRI) for each 0.10 mile and partial section. The mean IRI will be used for incentive/disincentive determination according to 00745.96.

7. DETERMINATION OF LOCALIZED ROUGHNESS

Use the most current version of ProVAL software to evaluate profiles for areas of Localized Roughness per the Specification minimum. Determine areas of localized roughness by computing the IRI over a continuous 25-ft length. Determine areas of localized roughness for each wheel path. Generate a report and submit it to the Project Manager for review. Stake or mark areas identified as exceeding the minimum specified Localized Roughness in a method acceptable to the Engineer for the ride test per specification.

8. QUALITY ASSURANCE

At the discretion of the Project Manager, the Agency will perform Quality Assurance of profiles on the projects according to the following:

The Agency profiler or a third party profiler will run a minimum of 50% completed wearing course included areas under the IRI specification for the contract or season of paving. The contractor run profile will be considered acceptable if the mean IRI of both wheelpaths averaged over all profiled lanes and a minimum of 90.0% of all measured 0.1 mile segments deviate by less than ±6.0 in/mile IRI. The Project Manager will resolve any discrepancies; this could include re-certification of the profilers, or third party testing of smoothness on the project.

ODOT TM 775

Method of Test for

NON-DESTRUCTIVE DEPTH MEASUREMENT OF PORTLAND CEMENT CONCRETE PAVEMENT

SCOPE

This method uses a probe and ring device to measure the thickness of freshly placed portland cement concrete pavement.

APPARATUS

1. Probe – A 6 mm (1/4 in) rod graduated in 2 mm (0.1 in) increments capable of measuring depths from 200 mm (8 in) to 350 mm (14 in).

2. Ring Device - A 150 mm (6 in) diameter sliding ring that is capable of being locked to the probe.

PROCEDURE

1. Determine random sample locations according to current Agency procedures

2. While holding onto the ring device, insert the probe into the freshly placed concrete pavement. Adjust the rod slightly as necessary to ensure that the probe makes contact with the underlying base material.

3. Slowly release the ring device until it comes to rest against the pavement surface. The ring must be uniformly seated for its entire circumference on the surface or the probe is not perpendicular to the surface.

4. Lock the ring device to the probe in this position.

5. Remove the apparatus and read the depth at the top of the ring device.

6. Document results according to Agency procedures.

REPORTING

Results shall be reported on standard forms approved for use by the agency. Provide the following information:

- Date and Time
- Project information
- Location (stationing) of thickness determination (longitudinal and offset reference)
- Note random method used
- Thickness of measurement to nearest 1mm (0.1inch)
- Signature of individual performing measurement

ODOT TM 777

Method of Test for

EVALUATION OF RETROREFLECTIVITY OF DURABLE & HIGH PERFORMANCE PAVEMENT MARKINGS USING PORTABLE HAND-OPERATED INSTRUMENT

1. SCOPE

1.1 This method covers the testing of retroreflectivity of durable and high performance pavement markings using portable hand-operated instruments. It is intended to provide a standard method for evaluating as-constructed retroreflectivity of longitudinal and transverse pavement markings in a contract to assure minimum retroreflectivity standards are met as per standard specifications.

1.2 For the purpose of this test procedure, the term "retroreflectivity" refers to dry retroreflectivity.

2. REFERENCED DOCUMENTS

2.1 ASTM E 1710-05, "Standard Test Method for Measurement of Retroreflective Pavement Marking Materials with CEN-Prescribed Geometry Using a Portable Retroreflectometer."

3. DEFINITIONS

Lot: The portion of a street or highway where new pavement markings are installed. If a street or highway includes two or more separate roadways (e.g. divided highway), lot may refer to each roadway separately.

Sublot: Each lot is divided into a number of sublots based on the total length of the lot.

4. APPARATUS

4.1 Use a 30-meter geometry hand-operated retroreflectometer meeting ASTM E 1710-05 with the following capabilities:

- Built-in printer
- Date and Time stamp
- ID labeling

5. CALIBRATION OF APPARATUS

5.1 Calibrate and service the apparatus by the manufacturer every two years per manufacturer's recommendation. Carry the certification of calibration at all times.

5.2 Zero and calibrate the apparatus in the field per the manufacturer's instructions. Perform calibrations at the beginning of each day of use and as frequently as recommended by the manufacturer.

6. PROCEDURE

6.1 Measure retroreflectivity of durable and high performance pavement markings within 48 hours of application of markings.

6.2 When taking Measurements:

- If a valid measurement is not attainable at a location due to a pothole, grass, obvious tracking, a profiled bump, etc., move forward to the first available location for a valid reading.
- Take measurements on a dry and clean surface. Ambient temperature shall be more than 40 degrees Fahrenheit. Do not take measurements if there is fog or surface condensation.

6.3 For yellow lines and crosswalk bars, take measurements in alternate directions. For all other markings, take measurements in the direction of traffic.

6.4 If a project contains multiple material types (e.g.: thermoplastic edge lines and tape broken lines), evaluate each material type separately for acceptance.

7. SAMPLING FREQUENCY

7.1 General:

If a lot length is one mile or less, the entire lot is a sublot.

For lots longer than one mile, divide the lot into sublots, where each sublot is one mile long. If the last sublot is less than 1/2 mile long, combine this sublot with the previous sublot. If the length of the last sublot is 1/2 mile or more, treat this sublot as a separate sublot.

7.2 Measurement of Retroreflectivity

7.2.1 Longitudinal Markings:

- For sublots that are one mile long or longer, take measurements at 300 ft intervals for each line.
- For sublots that are less than one mile long, take measurements at 300 ft intervals for each line. If the total number of readings for a color is less than 10, take at least 10 readings at equal intervals for that color.

7.2.2 Transverse Markings:

- The Engineer will randomly select 25 percent of the bars within each sublot for retroreflectivity testing. Round fractions up to the next whole number.
  - Each stop bar and crosswalk bar is a separate marking.
  - Measurement will be based on the area of each selected bar. Take one random measurement in every three sq. ft. of each selected bar.
- The Engineer will randomly select 25 percent of the legends from each sublot for retroreflectivity testing. Round fractions up to the next whole number.
  - Each legend is a separate marking. For legends with more than one element (i.e. bicycle and railroad crossing), each element counts as a separate legend for testing purposes.
  - For legends that are eight ft or more in height or width, take five random measurements per legend.
  - For legends that are less than eight ft in height or width, take three random measurements per legend.

8. REPORTING

8.1 Record all data on ODOT forms 734-4101 thru 734-4105 as required.

8.2 Attach field print-outs from the retroreflectometer for each zero and calibration reading performed.

8.3 Attach field print-outs from the retroreflectometer with the following information contained on the print-out for each measurement:

- Date and time
- Location ID