Shingles in Paving Demonstration

Specifications for recycled asphalt shingles (RAS) derived from tear-off roofing scrap

Recycled asphalt shingles (RAS)
to be used in hot mix asphalt (HMA) pavement on a
King County Department of Transportation overlay paving project
to be constructed in 2009

King County Solid Waste Division (KCSWD)

1. Overview

For purposes of this specification, the following definitions apply.

- "Asphalt shingle recycling operator" (or "Operator") shall be defined as the company, or companies, that receive tear-off asphalt shingle scrap and transform it into a finished recycled asphalt shingles (RAS) product.
- "Asphalt shingle recycling facility" (or "Facility") shall be defined as the physical plant (or plants) where tear-off asphalt shingles are received, processed, tested and stockpiled. This may include separate transfer locations.
- "Asbestos containing material" (or "ACM") means any material containing more than 1% asbestos as defined by WAC 296-62-07703.
- "Tear-off roofing scrap," or "tear-off asphalt shingle scrap," is defined as asphalt roofing shingles that have been generated during demolition or replacement of existing roofs.

For purposes of the *LinkUp* Shingles in Paving Demonstration project, the specification requires that the Operator, under contract to supply the RAS, and its Facility:

- Secure a supply of tear-off asphalt shingle scrap and stockpile it, process/grind the scrap, test and stockpile the RAS product;
- Be compliant with their jurisdictions comprehensive solid waste management plan, Chapter 173-350 WAC Solid Waste Handling Standards, and any additional local solid waste handling regulations or requirements;
- Be permitted as a solid waste handling facility or has properly notified both the Department of Ecology and local health department of the intent to operate under the exemption option;
- Have the necessary plans in place for protecting worker health/safety and the environment;
- Perform testing on the finished RAS product and provide verification that the RAS product does not include asbestos containing material (ACM) as per local, state and federal regulations;
- Meet RAS material quality standards specified herein prescribed to help ensure optimum performance when used in hot mix asphalt (HMA); and
- Meet other stockpiling, sampling and testing requirements specified herein.

The above material quality specifications and supplier qualifications are described in greater detail in the remainder of this document.

2. Material Quality Specifications

The material quality specifications are designed to ensure that the Operator and its Facility produces a RAS product that meets these specifications in the necessary quality and quantity to supply to King County Roads Services Division as part of King County's *LinkUp* Shingles in Paving Demonstration project. In addition, the Operator and Facility must meet the following sourcing, inspecting, sampling, testing, and stockpiling standards to ensure that the project is free of asbestos-containing material (ACM).

1. Only asphalt shingles are admissible for the project. Other asphalt roofing products (e.g., built up roofing, rolled or sheet roofing, etc.) are not eligible.
2. Incidental amounts of other roofing materials (e.g., wood, plastic, metal, etc.) are allowed in the incoming loads to the Operator.
3. Each incoming load of tear-off shingles for the demonstration project must be inspected by an AHERA-accredited inspector at the time of unloading at the Operator's Facility. If suspect ACM material is found in incoming loads, the load should be rejected or tested for ACM. If material is determined to contain ACM, then the facility must follow the rules of Puget Sound Clean Air Agency for handling asbestos and this material can not be used in the demonstration project.
4. The finished RAS product must be randomly sampled and tested to ensure that it is free of ACM according to procedures specified in Section 4: RAS Sampling and Testing Requirements.
5. The final RAS product shall be processed so that 100 percent passes the 12.5-mm (1/2 inch) sieve and a minimum of 95 percent passes the 9.5-mm (3/8 inch) sieve when tested in accordance with the test method in Washington State Department of Transportation's (WSDOT) *Materials Manual* "FOP for WAQTC/AASHTO for Sieve Analysis of Fine and Coarse Aggregates." (See Attachment 1.)
6. The Operator shall determine the asphalt content of the final RAS product in accordance with either or both of the following test methods:
   - "FOP for AASHTO Determining the Asphalt Binder Content of Hot Mix Asphalt (HMA) by the Ignition Method." (See Attachment 1.)
   - AASHTO T – 164, "Quantified Extraction of Asphalt Binder for Hot Mix Asphalt". (Also in ASTM D2172-05. "Standard Test Methods for Quantitative Extraction of Bitumen from Bituminous Paving Mixtures." See http://www.astm.org/Standards/D2172.htm for ordering information.)

   The Operator shall provide the original lab data reports that include a description of the method used to determine asphalt content of the final RAS product.
7. The final RAS product shall be substantially free of extraneous waste materials and entirely free of whole, intact nails. Extraneous materials such as metals, glass, rubber, nails, soil, brick, tars, paper, wood and plastic shall not exceed 3.0 percent by mass as determined on material retained on the 4.75-mm (No. 4) sieve. Lighter material such as paper, wood and plastic shall not exceed 1.5 percent by mass as determined on material retained on the 4.75-mm (No. 4) sieve. The method of sampling and testing shall be in accordance with "FOP for AASHTO Standard Practice for Sampling Aggregates" and "FOP for WAQTC/AASHTO Sieve Analysis of Fine and Coarse Aggregates." (See Attachment 1.)
8. The final RAS product shall not contain more than 5.0 percent moisture when tested in accordance with "FOP for AASHTO Total Evaporable Moisture Content of Aggregate by Drying." (See Attachment 1.) The Operator shall take necessary steps to ensure excessive moisture is not retained in the RAS stockpiles.

3. Operator and Facility Qualifications

In addition to producing a RAS product that meets the material quality specifications outlined above, the Operator must certify that the contractor and Facility meet all relevant safety, health

and environmental regulations and standards, including, but not limited to, the following requirements:

1. Be compliant with their jurisdiction's comprehensive solid waste management plan, Chapter 173-350 WAC Solid Waste Handling Standards, and any additional local solid waste handling regulations or requirements;
2. Be permitted as a solid waste handling facility or has properly notified both the Department of Ecology and local health department of the intent to operate under the exemption option;
3. Have in place a workplace accident prevention program that addresses workplace hazards in accordance with WAC 296-800-140. The plan must address asbestos hazards; and
4. The Operator must submit a complete and signed form that certifies that the Operator and its Facility meet the above requirements and standards. (See Material Verification Form.)

4. RAS Sampling and Testing Requirements

The Shingle Recycling Operator shall collect and test samples of the finished RAS product. The Operator shall document sampling methods and maintain adequate records of all testing results.

Asbestos Testing

1. Asbestos testing shall occur on the finished RAS product after grinding, screening or other finishing processes are complete. For purposes of asbestos testing, the Operator shall collect one (1) random sample from the finished RAS product stockpile for every 10 tons of RAS produced.
2. The Operator shall collect a minimum of one (1) pound samples. These samples shall be split in half and clearly labeled. The first set of samples shall be transmitted to an accredited asbestos testing laboratory. The second set of samples shall be retained, stored by the Operator, and made available to KCSWD upon request.
3. Samples shall be analyzed by polarized light microscopy as specified in EPA regulations 40 CFR Part 763, Subpart E by an accredited laboratory.
4. The Operator shall provide copies of the original asbestos laboratory reports.
5. The Operator shall allow KCSWD and WSDOT access to its Facility to observe the shingles recycling operations.
6. The Operator shall allow KCSWD and WSDOT to arrange for their own collection of samples directly from the finished RAS product pile upon request.
7. If ACM is found in the RAS product stockpile, the entire pile is not admissible for the project."

Construction Material Quality Control and Verification Testing

Quality control and verification testing should be conducted on the finished RAS product after screening or other finishing processes are complete. Testing should be completed using the following procedures.

1. The Operator shall collect six (6) random material samples of the finished RAS product. Three (3) of these samples shall be retained by the Operator and three (3) of these samples shall be shipped to WSDOT as replicates.
2. Each sample shall be a minimum of 25 pounds.
3. The Operator shall use standard procedures for RAS product sampling from the stockpile as per "FOP for AASHTO Standard Practice for Sampling Aggregates." (See Attachment 1.) [Note: Alternative or additional sampling collection procedures may be proposed by the Operator but first must be approved by KCSWD.]
4. The Operator must test the samples for compliance with the "Material Quality Specifications" as specified herein (Section 2)
5. All test results, including copies of original lab reports, must be provided to KCSWD and WSDOT.

Attachment 1: Select Test Methods from WSDOT's Materials Manual

KCSWD has compiled a summary of relevant test methods from WSDOT's Materials Manual (January 2008), which reflects the continual policy of adopting consensus standards across AASHTO, ASTM, WAQTC, and WSDOT test methods wherever possible.[1]

The full Materials Manual can be accessed online at http://www.wsdot.wa.gov/publications/manuals/fulltext/M46-01/Materials.pdf. However, this attachment provides excerpts from the January 2008 version edition of the WSDOT Materials Manual for the tests most relevant for the King County *LinkUp* Shingles in Paving Demonstration Project.

LinkUp, working with WSDOT, will provide technical assistance on how to successfully follow these procedures to the Operator selected to supply the RAS materials for this project.

Procedure	Number	Owner	Test Method (January 2008)
T	27/11 *	WSDOT	FOP for WAQTC/AASHTO for Sieve Analysis of Fine and Coarse Aggregates
T	308 *	WSDOT	FOP for AASHTO for Determining the Asphalt Binder Content of Hot Mix Asphalt (HMA) by the Ignition Method
T	2	WSDOT	FOP for AASHTO for Standard Practice for Sampling Aggregates
T	255	WSDOT	FOP for AASHTO for Total Evaporable Moisture Content of Aggregate by Drying

*Note: WSDOT intends to update these two test methods with the next edition of its Materials Manual to be published in January 2009.

[1] WSDOT annually publishes an updated version of its Materials Manual every January.

WSDOT FOP FOR WAQTC/AASHTO T 27/T 11[1]

Sieve Analysis of Fine and Coarse Aggregates

Significance

Sieve analyses are performed on aggregates used in roadway bases and in portland cement and asphalt cement concretes. Sieve analyses reveal the size makeup of aggregate particles – from the largest to the smallest. A gradation curve or chart showing how evenly or unevenly the sizes are distributed between largest and smallest is created in this test. How an aggregate is graded has a major impact on the strength of the base or on the properties and performance of concrete. In portland cement concrete (PCC), for example, gradation influences shrinkage and shrinkage cracking, pumpability, finishability, permeability, and other characteristics.

Scope

This procedure covers sieve analysis in accordance with AASHTO T 27 and materials finer than No. 200 (75 µm) in accordance with AASHTO T 11. The procedure combines the two test methods.

Sieve analyses determines the gradation or distribution of aggregate particles within a given sample in order to determine compliance with design and production standards.

Accurate determination of material smaller than No. 200 (75 µm) cannot be made with AASHTO T 27 alone. If quantifying this material is required, it is recommended that AASHTO T 27 be used in conjunction with AASHTO T 11. Following AASHTO T 11, the sample is washed through a No. 200 (75 µm) sieve. The amount of material passing this sieve is determined by comparing dry sample masses before and after the washing process.

This procedure covers sieve analysis in accordance with AASHTO T 27 and materials finer than No. 200 (75 µm) in accordance with AASHTO T 11. The procedure includes two method choices, A, and B.

Apparatus

- Balance or scale: Capacity sufficient for the masses shown in Table 1, accurate to 0.1 percent of the sample mass or better and conform to the requirements of AASHTO M 231.
- Sieves – Meeting the requirements of AASHTO M 92.
- Mechanical sieve shaker – Meeting the requirements of AASHTO T 27.
- Suitable drying equipment (see FOP for AASHTO T 255)
- Containers and utensils: A pan or vessel of a size sufficient to contain the sample covered with water and to permit vigorous agitation without loss of any part of the sample or water
- Optional Mechanical washing device

[1] This FOP is based on T 27/T 11-07 and has been modified per WSDOT standards.
To View the redline modifications, contact WSDOT Quality Systems Manager (360) 709-5412.

Sample Sieving

In all procedures it is required to shake the sample over nested sieves. Sieves are selected to furnish information required by specification. The sieves are nested in order of decreasing size from the top to the bottom and the sample, or a portion of the sample, is placed on the top sieve. The sample may also be sieved in increments.

Sieves are shaken in a mechanical shaker for the minimum time determined to provide complete separation for the sieve shaker being used.

Time Evaluation

WSDOT has deleted this section.

Overload Determination

Additional sieves may be necessary to provide other information, such as fineness modulus, or to keep from overloading sieves. The sample may also be sieved in increments.

Additionl sieves may be necessary to provide other information, such as fineness modulus, or to keep from overloading sieves. The sample may also be sieved in increments. For sieves with openings smaller than No. 4 (4.75 mm), the mass retained on any sieve shall not exceed 4 g/in^2 (7 kg/m^2) of sieving surface. For sieves with openings No. 4 (4.75 mm) and larger, the mass, in grams shall not exceed the product of 2.5 x (sieve opening in mm) x (effective sieving area). See Table 1.

Sieve Size US inches (mm)	8 φ (203)	12 φ (305)	12 x 12 (305 x 305)	14 x 14 (350 x 350)	16 x 24 (372 x 580)
	Sieving Area m^2				
	0.0285	0.0670	0.0929	0.1225	0.2158
3½ (90)	*	15.1	20.9	27.6	48.5
3 (75)	*	12.6	17.4	23.0	40.5
2½ (63)	*	10.6	14.6	19.3	34.0
2 (50)	3.6	8.4	11.6	15.3	27.0
1½ (37.5)	2.7	6.3	8.7	11.5	20.2
1 (25.0)	1.8	4.2	5.8	7.7	13.5
¾ (19.0)	1.4	3.2	4.4	5.8	10.2
⅝ (16.0)	1.1	2.7	3.7	4.9	8.6
½ (12.5)	0.89	2.1	2.9	3.8	6.7
⅜ (9.5)	0.67	1.6	2.2	2.9	5.1
¼ (6.3)	0.44	1.1	1.5	1.9	3.4
No. 4 (4.75)	0.33	0.80	1.1	1.5	2.6
Less than (No. 4)	0.20	0.47	0.65	1.2	1.3

Note: Sample sizes above are in kilograms to covert: to grams multiple by 1,000. To convert to pounds multiple by 2.2.

Maximum Allowable Mass of Material Retained on a Sieve, kg
TABLE 1

Sample Preparation

Obtain samples in accordance with the FOP for AASHTO T 2 and reduce to the size shown in Table 1 in accordance with the FOP for AASHTO T 248.

If the gradation sample is obtained from FOP for AASHTO T-308, the Ignition Furnace, proceed to Procedure Step 1 of procedure method A.

Nominal Maximum Size* in.	(mm)	Minimum Dry Mass lb	kg
US No. 4	(4.75)	1	0.5
¼	(6.3)	2	1
⅜	(9.5)	2	1
½	(12.5)	5	2
⅝	(16.0)	5	2
¾	(19.0)	7	3
1	(25.0)	13	6
1¼	(31.5)	17	7.5
1½	(37.5)	20	9
2	(50)	22	10
2½	(63)	27	12
3	(75)	33	15
3½	(90)	44	20

Sample Sizes for Aggregate Gradation Test
TABLE 2

* For aggregate, the nominal maximum size, (NMS) is the largest standard sieve opening listed in the applicable specification, upon which any material is permitted to be retained. For concrete aggregate, NMS is the smallest standard sieve opening through which the entire amount of aggregate is permitted to pass.

Note: For an aggregate specification having a generally unrestrictive gradation (i. e. wide range of permissible upper sizes), where the source consistently fully passes a screen substantially smaller than the maximum specified size, the nominal maximum size, for the purpose of defining sampling and test specimen size requirements may be adjusted to the screen, found by experience to retain no more than 5% of the materials.

WSDOT Note 1: These sample sizes are standard for aggregate testing but, due to equipment restraints, samples may need to be partitioned into several “subsamples.” See method A.

Overview

Method A - This method is the preferred method of sieve analysis for HMA aggregate.

- Determine dry mass of original sample
- Wash through a No. 200 (75 µm) sieve
- Determine dry mass of washed sample
- Sieve material

Method B

- Determine dry mass of original sample
- Wash through a No. 200 (75 µm) sieve
- Determine dry mass of washed sample
- Sieve coarse material
- Determine mass of fine material
- Reduce fine portion
- Determine mass of reduced portion
- Sieve fine portion

Procedure Method A

1. Dry the sample in accordance with the FOP for AASHTO T 255, and record to the nearest 0.1 percent of total mass or better.
2. When the specification requires that the amount of material finer than No. 200 (75 µm) be determined, do Step 3 through Step 9 – otherwise, skip to Step 10.

   WSDOT Note 3: If the applicable specification requires that the amount passing the No. 200 (75 µm) sieve be determined on a portion of the sample passing a sieve smaller than the nominal maximum size of the aggregate, separate the sample on the designated sieve and determine the mass of the material passing that sieve to 0.1 percent of the mass of this portion of the test sample. Use the mass as the original dry mass of the test sample.
3. Nest a sieve, such as a No. 10 (2 mm), above the No. 200 (75 µm) sieve.
4. Place the test sample in a container and add sufficient water to cover it.

   WSDOT requires the use of a detergent, dispersing agent, or other wetting solution when washing a sample from FOP for AASHTO T 308, an ignition furnace sample.

   WSDOT Note 4: A detergent, dispensing agent, or other wetting solution may be added to the water to assure a thorough separation of the material finer than the No. 200 (75 µm) sieve from the coarser particles. There should be enough wetting agent to produce a small amount of suds when the sample is agitated. Excessive suds may overflow the sieves and carry material away with them.
5. Agitate vigorously to ensure complete separation of the material finer than No. 200 (75 µm) from coarser particles and bring the fine material into suspension above the coarser material. When using a mechanical washing device, exercise caution to not degrade the sample.
6. Immediately pour the wash water containing the suspended and dissolved solids over the nested sieves, being careful not to pour out the coarser particles.
7. Add a second change of water to the sample remaining in the container, agitate, and repeat Step 6. Repeat the operation until the wash water is reasonably clear.
8. Return all material retained on the nested sieves to the container by flushing into the washed sample.
9. Dry the washed aggregate in accordance with the FOP for AASHTO T 255, and then cool prior to sieving. Record the dry mass.

10. Select sieves to furnish information required by the specifications. Nest the sieves in order of decreasing size from top to bottom and place the sample, or a portion of the sample, on the top sieve.
11. Place sieves in mechanical shaker and shake for a minimum of 10 minutes, or the minimum time determined to provide complete separation if this time is greater than 10 minutes for the sieve shaker being used.
12. Determine the individual or cumulative mass retained on each sieve and the pan to the nearest 0.1 percent or 0.1 g.

    WSDOT Note 5: Use coarse wire brushes to clean the No. 40 600 µm (No. 30) and larger sieves, and soft bristle brushes for smaller sieves.

Calculations

The total mass of material after sieving should be verified with the mass before sieving. If performing T 11 with T 27 this would be the dry mass after wash. If performing just T 27 this would be the original dry mass. When the masses before and after sieving differ by more than 0.3 percent do not use the results for acceptance purposes. When performing the gradation from HMA using T 308, the masses before and after sieving shall not differ by more than 0.2%.

Calculate the total percentages passing, individual or cumulative percentages retained, or percentages in various size fractions to the nearest 0.1 percent by dividing the masses for method A, or adjusted masses for methods B and C, on the individual sieves by the total mass of the initial dry sample. If the same test sample was first tested by T 11, use the total dry sample mass prior to washing in T 11 as the basis for calculating all percentages. Report percent passing as indicated in the "Report" section at the end of this FOP.

Percent Retained:

Where:

IPR = Individual Percent Retained
CPR = Cumulative Percent Retained
M = Total Dry Sample mass before washing
IMR = Individual Mass Retained OR Adjusted Individual mass from Methods B or C
CMR = Cumulative Mass Retained OR Adjusted Individual mass From Methods B or C

$$IPR = \frac{IMR}{M} \times 100 \text{ OR } CPR = \frac{CMR}{M} \times 100$$

OR

Percent Passing (Calculated):

Where:

PP = Percent Passing
PPP = Previous Percent Passing
PP = PPP-IPR OR PP = 100-CPR

Calculate cumulative percent retained on and passing each sieve on the basis of the dry mass of total sample, before washing. This will include any material finer than No. 200 (75 µm) that was washed out.

Divide the cumulative masses, or the corrected masses, on the individual sieves by the total mass of the initial dry sample (prior to washing) to determine the percent retained on and passing each sieve. Calculate the percent retained on and passing each sieve. Report percent passing as indicated in the "Report" section at the end of this FOP.

Example

Dry mass of total sample, before washing: 3214.0 g

Dry mass of sample, after washing out the No. 200 (75 µm) minus: 3085.1 g

For the ½ sieve:

Cumulative Mass retained on ½" sieve = 161.0 g

Cumulative % retained = $\frac{161.0}{3214.0} \times 100 = 5.0\%$ retained

% passing = 100-5.0 = 95% passing ½" sieve

Sieve Size in. (mm)		Cumulative Mass Retained g	Cumulative Percent Retained	Reported Percent Passing*
¾	(19.0)	0	0	100
½	(12.5)	161.0	5.0	95
⅜	(9.5)	642.0	20.0	80
No. 4	(4.75)	1118.3	34.8	65
**No. 6	(3.35)	1515.2		
No. 10	(2.0)	1914.7	59.6	40
No. 40	(0.425)	2631.6	81.9	18
No. 80	(0.210)	2862.7	89.1	11
No. 200	(0.075)	3051.1	94.9	5.1
Pan		3086.4		

Gradation on All Screens

Test Validation: 3086.4 – 3085.1/3085.1 x 100 = 0.04 % which is within the 0.3 percent requirement and the results can be used for acceptance purposes.

* Report No. 200 (75 µm) sieve to 0.1 percent. Report all others to 1 percent.

** Intermediate sieve used to prevent overloading the U. S. No. 10 sieve.

Procedure Method B

1. Perform steps 1 thru 9 from the "Procedure Method A" then continue as follows:
2. Select sieves to furnish information required by the specifications. Nest the sieves in order of decreasing size from top to bottom through the No. 4 (4.75 mm) with a pan at the bottom to retain the minus No. 4 (4.75 mm).

   See WSDOT Note 2 above.
3. Place sieves in mechanical shaker and shake for a minimum of 10 minutes, or the minimum time determined to provide complete separation if this time is greater than 10 minutes for the sieve shaker being used.
4. Determine the individual or cumulative mass retained on each sieve and the pan to the nearest 0.1 percent or 0.1 g. Ensure that all material trapped in the openings of the sieve are cleaned out and included in the mass retained.

   Note 4: Use coarse wire brushes to clean the No. 40 and larger sieves, and soft bristle brushes for smaller sieves.

   Determine the mass retained on each sieve to the nearest 0.1 percent of the total mass or better.
5. Determine the mass retained on each sieve to the nearest 0.1 percent of the total mass or better.
6. Determine the mass of the material in the pan [minus No. 4 (4.75 mm)].
7. Reduce the minus No. 4 (4.75 mm) using a mechanical splitter in accordance with the FOP for AASHTO T 248 to produce a sample with a mass of 500 g minimum. Determine and record the mass of the minus No. 4 (4.75 mm) split.
8. Select sieves to furnish information required by the specifications. Nest the sieves in order of decreasing size from top to bottom through the No. 200 (75 µm) with a pan at the bottom to retain the minus No. 200 (75 µm).
9. Place sieves in mechanical shaker and shake for a minimum of 10 minutes, or the minimum time determined to provide complete separation if this time is greater than 10 minutes for the sieve shaker being used.
10. Determine the individual or cumulative mass retained on each sieve and the pan to the nearest 0.1 percent or 0.1 g. Ensure that all material trapped in the openings of the sieve are cleaned out and included in the mass retained.

    Note 4: Use coarse wire brushes to clean the No. 40 and larger sieves, and soft bristle brushes for smaller sieves.

Calculations

Compute the "Adjusted Cumulative Mass Retained" of the size increment of the original sample as follows when determining "Cumulative Mass Retained":

Divide the cumulative masses, or the corrected masses, on the individual sieves by the total mass of the initial dry sample (prior to washing) to determine the percent retained on and passing each sieve. Calculate the percent retained on and passing each sieve. Report percent passing as indicated in the "Report" section at the end of this FOP.

When material passing the No. 4 (4.75 mm) sieve is split and only a portion of that is tested, the proportionate share of the amount passing the No. 200 (75 µm) sieve must be added to the sample mass to obtain a corrected test mass. This corrected test mass is used to calculate the gradation of the material passing the No. 4 (4.75 mm) sieve.

$$C = \left(\frac{M_1}{M_2} \times B \right) + D$$

where:

C = Total cumulative mass retained of the size increment based on a total sample
M_1 = mass of fraction finer than No. 4 (4.75 mm) sieve in total sample
M_2 = mass of reduced portion of material finer than No. 4 (4.75 mm) sieve actually sieved
B = cumulative mass of the size increment in the reduced portion sieved.
D = cumulative mass of plus No. 4 (4.75 mm) portion of sample.

Example:

Dry mass of total sample, before washing: 3214.0 g

Dry mass of sample, after washing out the No. 200 (75 µm) minus: 3085.1 g

Gradation on Coarse Screens

Sieve Size in. (mm)	Cumulative Mass Retained g	Cumulative Percent Retained	Reported Percent Passing*
¾ (19.0)	0	0	100
½ (12.5)	161.0	5.0	95
⅜ (9.50)	642.0	20.0	80
No. 4 (4.75)	1118.3	34.8	65

Pan = 1968.0

Test Validation : 1118.3 + 1968.0 – 3085.1/3085.1 x 100 = 0.04% which is within the 0.3 percent requirement and the results can be used for acceptance purposes.

The actual mass of material passing the No. 4 (4.75 mm) sieve and retained in the pan is 1968.0 g. This is M_1.

The pan (1968.0 grams) was reduced in accordance with the FOP for AASHTO T 248, so that at least 500 g are available. In this case, the mass determined was 512.8 g. This is M_2.

Sieve Size in. (mm)	Cumulative Mass Retained (g)
No. 4 (4.75)	0
No. 10 (2.00)	207.5
No. 40 (0.425)	394.3
No. 80 (0.210)	454.5
No. 200 (0.075)	503.6
Pan	512.8

Gradation on Fine Screens

Test Validation: 512.8 - 512.8/512.8 = 0.0 % which is within the 0.3 percent requirement and the results can be used for acceptance purposes.

For the No. 10 sieve:

$M_1 = 1968.0g$

$M_2 = 512.8g$

$B = 207.5g$

$D = 1118.3g$

$$C = \left(\frac{M_1}{M_2} \times B\right) + D = \left(\frac{1968.0g}{512.8g} \times 207.5g\right) + 1118.3g = 1914.7g$$

% retained $\frac{1914.7g}{3214.0g} = 59.6\%$

% passing = 100-59.6=40.4% reported as 40%

Sieve Size in. (mm)	Cumulative Mass Retained g	Adjusted Cumulative Mass Retained g	Cum. Percent Retained	Reported Percent Passing*
¾ (19.0)	0	0	0	100.0
½ (12.5)	161.1	161.1	5.0	95
⅜ (9.5)	642.5	642.5	20.0	80
No. 4 (4.75)	1118.3	1118.3	34.8	65
No. 10 (2.0)	207.5 x 3.838 + 1118.3	1914.7	59.6	40
No. 40 (0.425)	394.3 x 3.838 + 1118.3	2631.6	81.6	18
No. 80 (0.210)	454.5 x 3.838 + 1118.3	2862.7	89.1	11
No. 200 (0.075)	503.6 x 3.838 + 1118.3	3051.1	94.9	5.1
Pan	512.8 x 3.838 + 1118.3	3086.4		

Final Gradation on All Screens

- Report No. 200 (75 µm) sieve to 0.1 percent. Report all others to 1 percent.

Alternative Method B

As an alternate method to account for the fact that only a portion of the minus No. 4 (4.75 mm) material was sieved, multiply the fine screen "Percent Passing" values by the percent passing the No. 4 (4.75 mm) sieve obtained in the coarse screen procedure, 65 percent in this case.

The mass retained in the pan must be corrected to include the proper percent of No. 200 (.075 mm) minus material washed out.

Divide the cumulative masses, or the corrected masses, on the individual sieves by the corrected pan mass of the initial dry sample (prior to washing) to determine the percent retained on and passing each sieve. Calculate the percent retained on and passing each sieve. Report percent passing as indicated in the "Report" section at the end of this FOP.

Dry mass of total sample, before washing: 3214.0 g

Dry mass of sample, after washing out the No. 200 (75 µm) minus: 3085.1 g

Amount of No. 200 (75 µm) minus washed out: 3214.0 g – 3085.1 g = 128.9 g

Gradation on Coarse Screens

Sieve Size in. (mm)	Cumulative Mass Retained g	Cumulative Percent Retained	Reported Percent Passing*
¾ (19.0)	0	0	100
½ (12.5)	161.0	5.0	95
⅜ (9.50)	642.0	20.0	80
No. 4 (4.75)	1118.3	34.8	65

Pan = 1968.0

Test Validation : $\frac{1118.3 + 1968.0 - 3085.1}{3085.1 \times 100} = 0.04\%$
which is within the 0.3 percent requirement and the results can be used for acceptance purposes.

The actual mass of material passing the No. 4 (4.75 mm) sieve and retained in the pan is 1968.0 g. This is M_3.

The pan (1968.0 grams) was reduced in accordance with the FOP for AASHTO T 248, so that at least 500 g are available. In this case, the mass determined was 512.8 g. This is M_4.

Corrected pan mass = $M_4 \frac{(M_4)(C_1)}{M_3}$

Where:

M_4 = mass retained in the pan from the split of the No. 4 (4.75 mm) minus.
M_3 = mass of the No. 4 (4.75 mm) minus of entire sample, not including No. 200 (.075 mm) minus washed out.
C_1 = mass of No. 200 (.075 mm) minus washed out.

Sieve Size in. (mm)	Cumulative Mass Retained (g)	Cumulative Percent Retained	Percent Passing
No. 4 (4.75)	0	0	100.0
No. 10 (2.00)	207.5	38.0	62.0
No. 40 (0.425)	394.3	72.2	27.8
No. 80 (0.210)	454.5	83.2	16.8
No. 200 (0.075)	503.6	92.2	7.8
Pan	512.8		

The corrected pan mass is the mass used to calculate the percent retained for the fine grading.

Example:

M_4 = 512.8g

M_3 = 1968.0g

C_1 = 128.9g

Corrected pan mass $= 512.8g + \frac{(512.8g)(128.9g)}{1968.0g} = 546.4g$

For the No. 10 sieve:

Mass of No. 10 sieve = 207.5g

Corrected Pan Mas = 546.4g

Cumulative % retained = $\frac{207.5g}{546.4g} = 38.0\%$

% passing = 100-38.0 = 62.0%

Adjusted % passing No. 10 = % passing No. 10 x % No. 4 = 62.0 x 0.65 = 40%

Sieve Size in. (mm)	Adjustment	Reported Percent Passing*
¾ (19.0)		100
½ (12.5)		95
⅜ (9.5)		80
No. 4 (4.75)	100 x .65 =	65
No. 10 (2.00)	62.0 x .65 =	40
No. 40 (0.425)	27.8 x .65 =	18
No. 80 (0.210)	16.8 x .65 =	11
No. 200 (0.075)	7.8 x .65 =	5.1
Final Gradation on All Screens		

- Report No. 200 (75 µm) sieve to 0.1 percent. Report all others to 1 percent.
- **SAMPLE CALCULATION FOR FINENESS MODULUS**

  Fineness Modulus (FM) is used in determining the degree of uniformity of aggregate gradation in PCC mix designs. It is an empirical number relating to the fineness of the aggregate. The higher the FM, the coarser the aggregate. Values of 2.40 to 3.00 are common for FA in PCC.

  The FM is the sum of the percentages retained on specified sieves 150 mm (6”), 75 mm (3”), 37.5 mm (1½), 19.0 mm (¾), 9.5 mm (⅜), No. 4 (4.75 mm), 2.36 mm (No. 8), 1.18 mm (No. 16), 0.60 mm (No. 30), 0.30 mm (No. 50), and 0.15 mm (No. 100) divided by 100 gives the FM.

The following example is for WSDOT Class 2 Sand:

WSDOT Class 2 Sand				
Sieve	**Size**	**% Passing**	**% Retained**	**% Retained on Specified Sieves**
6 in.	150 mm	100	0	0
3 in.	75 mm	100	0	0
2½ in.	62.5 mm	100	0	0
2 in.	50 mm	100	0	0
1½ in.	37.5 mm	100	0	0
1 in.	25 mm	100	0	0
¾ in.	19 mm	100	0	0
½ in.	12.5 mm	100	0	0
⅜ in.	9.5 mm	100	0	0
No. 4	4.75 mm	100	0	0
No. 8	2.36 mm	87	13	13
No. 16	1.18 mm	69	31	31
No. 30	0.60 mm	44	56	56
No. 50	0.30 mm	18	82	82
No. 100	0.15 mm	4	96	96
				= 278
				FM = 2.78

Report

Results shall be reported on standard forms approved for use by the agency. Depending on the agency, this may include:

- Cumulative mass retained on each sieve*
- Cumulative percent retained on each sieve*
- Percent passing and retained on each sieve shall be reported to the nearest 1 percent except for the percent passing the U.S. No. 200 (75 µm) sieve, which shall be reported to the nearest 0.1 percent
- FM to the nearest 0.01 percent for WSDOT Class 2 Sand

Report results using WSDOT Form 422-020, or other report approved by the State Materials Engineer.

Performance Exam Checklist

WAQTC FOP FOR AASHTO T 27/T 11
SIEVE ANALYSIS OF FINE AND COARSE AGGREGATES

Participant Name _____ Exam Date _____

Procedure Element	Yes	No
1. The tester has a copy of the current procedure on hand?	❒	❒
2. All equipment is functioning according to the test procedure, and if required, has the current calibration/verification tags present?	❒	❒
3. Minimum sample mass meets requirement of Table 1 or from FOP for AASHTO T308?	❒	❒
4. Test sample dried to a constant mass by FOP for AASHTO T 255?	❒	❒
5. Test sample cooled and mass determined to nearest 0.1 percent of mass?	❒	❒
6. Sample placed in container and covered with water? (If specification requires that the amount of material finer than the No. 200 sieve is to be determined.)	❒	❒
7. Dispersing Agent used for HMA?	❒	❒
8. Contents of the container vigorously agitated?	❒	❒
9. Complete separation of coarse and fine particles achieved?	❒	❒
10. Wash water poured through nested sieves such as No. 10 and No. 200?	❒	❒
11. Operation continued until wash water is reasonably clear?	❒	❒
12. Material retained on sieves returned to washed sample?	❒	❒
13. Washed aggregate dried to a constant mass by FOP for AASHTO T 255?	❒	❒
14. Washed aggregate cooled and mass determined to nearest 0.1 percent of mass?	❒	❒
15. Sample placed in nest of sieves specified? (Additional sieves may be used to prevent overloading as allowed in FOP.)	❒	❒
16. Material sieved in verified mechanical shaker for minimum of 10 minutes or for the minimum verified time whichever is longer?	❒	❒
17. Mass of residue on each sieve determined to 0.1 percent of mass?	❒	❒
18. Total mass of material after sieving agrees with mass before sieving to within 0.3 percent, or 0.2 percent for HMA (per FOP for AASHTO T308)?	❒	❒
19. Percentages calculated to the nearest 0.1 percent and reported to the nearest whole number, except No. 200 - reported to the nearest 0.1 percent?	❒	❒
20. Percentage calculations based on original dry sample mass?	❒	❒
21. Calculations performed properly? If material passing No. 4 sieve is split and only a portion is tested, calculation as noted in FOP performed properly?	❒	❒

First attempt: Pass ❒ Fail ❒ Second attempt: Pass ❒ Fail ❒

Signature of Examiner _____

Comments:

Washington State
Department of Transportation

WSDOT FOP for AASHTO T 308[1]

Determining the Asphalt Binder Content of Hot Mix Asphalt (HMA) by the Ignition Method 1

1. SCOPE

1.1 This test method covers the determination of asphalt binder content of HMA mixtures by ignition at temperatures that reach the flashpoint of the binder in a furnace. The means of sample heating may be the convection method or the direct infrared (IR) irradiation method. The aggregate remaining after burning can be used for sieve analysis using FOP for AASHTO T 27/T11.

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

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

2. REFERENCED DOCUMENTS

2.1 *AASHTO Standards*

M 231	Weighing Devices Used in the Testing of Materials
T 2	Sampling of Aggregates
T 30	Mechanical Analysis of Extracted Aggregate
T 40	Sampling Bituminous Materials
T 110	Moisture or Volatile Distillates in Hot-Mix Asphalt (HMA)
T 168	Sampling Bituminous Paving Mixtures
T 248	Reducing Samples of Aggregate to Testing Size

2.2 *Manufacturer's Instruction Manual*

2.3 *WSDOT Standards*

FOP for AASHTO T 329	*Moisture Content of Asphalt (HMA) by Oven Method*
FOP for WAQTC T27/11	Sieve Analysis of Fine and Coarse Aggregates
FOP for AASHTO T 168	Sampling Bituminous Paving Materials
WSDOT 712	Reducing Samples of Hot Mix Asphalt to Testing Size
SOP 728	Method for Determining Ignition Furnace Calibration Factor

[1] This FOP is based on AASHTO T 308-05 and has been modified per WSDOT standards. To view the redline modifications, contact WSDOT Quality Systems Manager at (360) 709-5412.

3. SUMMARY OF TEST METHOD

3.1 The asphalt binder in the paving mixture is ignited using the furnace equipment applicable to the particular method. The asphalt binder content is calculated as the difference between the initial mass of the asphalt mixture and the mass of the HMA residual aggregate, with adjustments for the calibration factor, and the moisture content. The asphalt content is expressed as mass percent of moisture-free mixture.

4. SIGNIFICANCE AND USE

4.1 This method can be used for quantitative determinations of asphalt binder content and gradation in HMA mixtures and pavement samples for quality control, specification acceptance, and mixture evaluation studies. This method does not require the use of solvents. Aggregate obtained by this test method may be used for gradation analysis according to T 27/11.

5. SAMPLING

5.3 Obtain samples of freshly produced hot-mix asphalt in accordance with WAQTC FOP for AASHTO T 168.

5.4 The test specimen for asphalt content determination shall be the end result of a larger sample taken in accordance with FOP for AASHTO T 168.

5.5 If the mixture is not sufficiently soft to separate for testing, carefully heat the mixture in an oven until sufficiently soft, not to exceed 350 F or the recommended mixing temperature from the mix design verification report. Do not leave the sample in the oven for an extended period of time.

5.6 The size of the test sample shall be governed by the nominal maximum aggregate size of the mixture and shall conform to the mass requirement shown in Table 1. Specimen sizes shall not be more than 500 g greater than the minimum recommended specimen mass. The maximum sample size including basket shall not exceed the capacity of the balance.

Note 1: Large samples of fine mixes tend to result in incomplete ignition of asphalt binder.

Nominal Max. Agg. * Size	Class of HMA		Minimum Mass of Specimen, g	Maximum Mass of Specimen, g
	Superpave	Other		
US No. 4			1200	1700
⅜ in.	⅜ In.	Class G & D	1200	1700
½ in.	½ In.	Class A, B, & ATB	1500	2000
¾ in.	¾ In.		2000	2500
1 in.	1 in.	Class E	3000	3500
1½ in.			4000	4500

* For aggregate, the nominal maximum size, (NMS) is the largest standard sieve opening listed in the applicable specification, upon which any material is permitted to be retained. For concrete aggregate, NMS is the smallest standard sieve opening through which the entire amount of aggregate is permitted to pass.

Note: For an aggregate specification having a generally unrestrictive gradation (i.e. wide range of permissible upper sizes), where the source consistently fully passes a screen substantially smaller than the maximum specified size, the nominal maximum size, for the purpose of defining sampling and test specimen size requirements may be adjusted to the screen, found by experience to retain no more than 5% of the materials.

6. CALIBRATION

6.1 Note 2 and this section have been replaced with the following:

The Calibration is to be performed according to WSDOT Standard Operating Procedure SOP 728.

Test Method A

7. APPARATUS

7.1 Ignition Furnace — A forced air ignition furnace that heats the samples by either convection method or direct IR direct irradiation method. The convection-type furnace must be capable of maintaining the temperature at 1072°F (578°C). The furnace shall have an internal balance thermally isolated from the furnace chamber accurate to 0.1 g. The balance shall be capable of weighing a 3500 gram sample in addition to the sample baskets. A data collection system will be included so that the weight can be automatically determined and displayed during the test. The furnace shall have a built in computer program to calculate change in mass of the sample baskets and provide for the input of a correction factor for aggregate loss. The furnace shall provide a printed ticket with the initial specimen mass, specimen mass loss, temperature compensation, correction factor, corrected asphalt content (percent), test time, and test temperature. The furnace chamber dimensions shall be adequate to accommodate a sample size of 3500 grams. The furnace shall provide an audible alarm and indicator light when the sample mass loss does not exceed 0.01 percent of the total sample mass for three consecutive minutes. The furnace door shall be equipped so that the door cannot be opened during the ignition test. A method for reducing furnace emissions shall be provided. The furnace shall be vented into a hood or to the outside and, when set up properly, shall have no noticeable odors escaping into the laboratory. The furnace shall have a fan with capability to pull air through the furnace to expedite the test and to reduce the escape of smoke into the laboratory.

Note 3: The furnace shall also allow the operator to change the ending mass loss percentage to 0.02 percent, WSDOT uses 0.01%.

7.2 Sample Basket(s) — of appropriate size that allows the sample(s) to be thinly spread and allows air to flow through and around the sample particles. Sets with two or more baskets shall be nested. The sample shall be completely enclosed with screen mesh, ¬perforated stainless steel plate, or other suitable material.

7.2.1 Sample Basket Assembly — consisting of sample basket(s) (7.2), catch pan (7.3), and an assembly guard to secure sample basket(s) to catch pan.

Note 4: Screen mesh or other suitable material with maximum and minimum opening of No. 8 (2.36 mm) and No. 30 (600 microns) respectively has been found to perform well.

7.3 Catch Pan — of sufficient size to hold the sample basket(s) so that aggregate particles and melting asphalt binder falling through the screen mesh are caught.

7.4 Oven or suitable devise — Capable of maintaining 325 ± 25°F (163 ± 14°C).

7.5 Balance — of sufficient capacity and conforming to the requirements of M231, Class G2, for weighting specimen in basket(s).

7.6 Safety Equipment — safety glasses or face shield, high temperature gloves, long sleeve jacket, a heat resistant surface capable of withstanding 1202°F (650°C) and a protective cage capable of surrounding the sample baskets during the cooling period.

7.7 Miscellaneous Equipment — a pan larger than the sample basket(s) for transferring sample after ignition, spatulas, bowls, and wire brushes.

8. TEST PROCEDURES

8.1 Test Initiation

8.1.1 Preheat the ignition furnace to 1000°F (538°C). Manually record the furnace temperature (set point) prior to the initiation of the test if the furnace does not record automatically.

8.2 Determine the moisture content of the samples according to FOP for AASHTO T 329 *Moisture Content of Asphalt (HMA) by Oven Method*.

8.3 Enter the calibration factor for the specific mix to be tested.

8.4 Weigh and record the mass of the sample basket(s) and catch pan (with guards in place).

8.5 Prepare the sample as described in Section 5. Evenly distribute this sample in the sample basket(s) that have been placed in the catch pan, taking care to keep the material away from the edges of the basket. Use a spatula or trowel to level the specimen.

8.6 Weigh and record the total mass of the sample, basket(s), catch pan, and basket guards. Calculate and record the initial mass of the specimen (total mass minus the mass of the specimen basket assembly).

8.7 Input the initial mass of the specimen in whole grams into the ignition furnace controller. Verify that the correct mass has been entered.

8.8 Tare or zero furnace balance, open the chamber door, and gently set the sample baskets in the furnace. Close the chamber door, and verify that the sample mass (including the basket(s)) displayed on the furnace scale equals the total mass recorded in Section 8.6 within ± 6 g. Differences greater than 6 g or failure of the furnace scale to stabilize may indicate that the sample basket(s) are contacting the furnace wall. Initiate the test by pressing the start/stop button. This will lock the sample chamber and start the combustion blower.

Note 5: The furnace temperature will drop below the setpoint when the door is opened, but will recover with the door closed and when ignition occurs. Sample ignition typically increases the temperature well above the setpoint, depending on sample size and asphalt content.

WSDOT Note: Operator should wear safety equipment – high temperature gloves, face shield, fire-retardant shop coat – when opening the door to load or unload the sample.

WSDOT Safety Note: Do not attempt to open the furnace door until the binder has been completed burned off.

8.9 Allow the test to continue until the stable light and audible stable indicator indicate the test is complete (the change in mass does not exceed 0.01 percent for three consecutive minutes). Press the start/stop button. This will unlock the sample chamber and cause the printer to print out the test results.

8.10 Use the corrected asphalt binder content (0.01 percent) from the printed ticket. If a moisture content (0.01 percent) has been determined, subtract the percent moisture from the printed ticket corrected asphalt content, and report the resultant value as the corrected asphalt binder content to 0.1 percent.

8.11 Open the chamber door, remove the sample basket assembly and place on heat resistance surface and cover with the protective cage. Allow sample to cool to room temperature (approximately 30 minutes).

Test Method B

WSDOT does not use Method B and has deleted it from the procedure.

11. GRADATION

11.1 Allow the specimen to cool to room temperature in the sample baskets.

11.2 Empty the contents of the baskets into a flat pan. Use a small wire sieve brush to ensure that any residual fines are removed from the baskets.

11.3 Perform the gradation analysis according to FOP for WAQTC T 27/T11.

12. REPORT

12.1 Report the test method (A), corrected asphalt binder content, calibration factor, temperature compensation factor (if applicable), total percent loss, sample mass, moisture content (if determined) and the test temperature. Attach the original printed tickets to the report for units with internal balances.

12.2 The asphalt percentage and aggregate gradation shall be reported on WSDOT Form 350 560 or other report approved by the State Materials Engineer.

13. PRECISION AND BIAS

13.1 Precision — Precision was determined in an NCAT round-robin study for surface mixes using Test Method A. Precision has not yet been determined for Test Method B.

Asphalt Content	Acceptable Range of Standard Deviation, Percent	Two Test Results, Percent
Single Operator Precision	0.04	0.11
Multi Lab Precision	0.06	0.17

Precision
Table 2

Note 10: The precision estimates are based on 4 aggregate type, 4 replicates, and 12 laboratories participating with 0 laboratory results deleted as outlying observations. All 4 aggregates were tested in surface mixes and had relatively low absorption values.

13.2 Bias — The bias for Test Methods A and B has not been determined.

Performance Exam Checklist

Determining the Asphalt Cement Content of Hot Mix Asphalt (HMA) by the Ignition Method for AASHTO T 308

Participant Name _____ Exam Date _____

Procedure Element	**Yes**	**No**
1. The tester has a copy of the current procedure on hand?	❒	❒
2. All equipment is functioning according to the test procedure, and if required, has the current calibration/verification tags present?	❒	❒
Procedure		
1. Oven at correct temperature 538 C?	❒	❒
2. Mass of sample baskets and catch pan recorded?	❒	❒
3. Samples evenly distributed in basket?	❒	❒
4. Mass of sample recorded?	❒	❒
Method A		
5. Enter calibration factor for specific mix design?	❒	❒
6. Initial mass entered into furnace controller?	❒	❒
7. Sample correctly placed into furnace?	❒	❒
8. Test continued until stable indicator signals?	❒	❒
9. Binder content obtained on printed ticket?	❒	❒
10. Binder content corrected for moisture?	❒	❒
11. All calculations performed correctly?	❒	❒

First attempt: Pass ❒ Fail ❒ Second attempt: Pass ❒ Fail ❒

Signature of Examiner _____

Comments:

WSDOT FOP for AASHTO T 2[1]

Standard Practice for Sampling Aggregates

1. Scope

   1.1 This practice covers sampling of coarse and fine aggregates for the following purposes:

   1.1.1 Preliminary investigation of the potential source of supply,

   1.1.2 Control of the product at the source of supply,

   1.1.3 Control of the operations at the site of use, and

   1.1.4 Acceptance or rejection of the materials.

   ~~***Note 1:*** Sampling plans and acceptance and control tests vary with the type of construction in which the material is used. Attention is directed to Practices E 105 and D 3665.~~

   1.2 The values stated in English ~~inch-pounds~~ units are to be regarded as the standard.

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

2. Referenced Documents

   2.1 AASHTO Standards:

   T 248 Reducing Samples of Aggregate to Testing Size

   2.2 ASTM Standards:

   C 702 Practice for Reducing Field Samples of Aggregate to Testing Size
   D 2234 Test Method for Collection of a Gross Sample of Coal
   D 3665 Practice for Random Sampling of Construction Materials
   E 105 Practice for Probability Sampling of Materials
   E 122 Practice for Choice of Sample Size to Estimate the Average Quality of a Lot or Process
   E 141 Practice for Acceptance of Evidence Based on the Results of Probability Sampling

3. Significance and Use

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

   3.2 When sampling of aggregate sources for preliminary testing, the sampling must be witnessed or taken by a designated representative of the Regional Materials Engineer. The Acceptance samples will be taken by a qualified tester employed by the contracting agency or their designated qualified representative.

   ~~Samples for preliminary investigation tests are obtained by the agency guidelines (Note 2). Samples of materials for control of the production at the source or control of the work at the site of use are obtained by the manufacturer, contractor, or other parties responsible for accomplishing the work. Samples for tests to be used in acceptance or rejection decisions by the purchaser are obtained by the purchaser or his authorized representative.~~

This Procedure is based on AASHTO T 2-91 (2000).

Note 2: The preliminary investigation and sampling of potential aggregate sources and types occupies a very important place in determining the availability and suitability of the largest single constituent entering into the construction. It influences the type of construction from the standpoint of economics and governs the necessary material control to ensure durability of the resulting structure, from the aggregate standpoint. This investigation should be done only by agency guidelines ~~a responsible trained and experienced person~~. For more comprehensive guidance, see the Appendix.

4. SECURING SAMPLES

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

Native soils within the contract limits to be used for embankment construction and/or backfill material do not require the sampling by a qualified tester. For material that requires gradation testing such as but not limited to manufactured aggregates and Gravel Borrow, a qualified tester shall be required for sampling.

4.2 Inspection — The material shall be inspected to determine discernible variations. The seller shall provide suitable equipment needed for proper inspection and sampling.

4.3 Procedure

4.3.1 Sampling from a Flowing Aggregate Stream (Bins or Belt Discharge) — Select units to be sampled by a random method, ~~such as Practice D3665~~, from the production. ~~Obtain at least three approximately equal increments, selected at random from the unit being sampled, and combine to form~~ Obtain a field sample whose mass equals or exceeds the minimum recommended in 4.4.2. Take the sample ~~each increment~~ from the entire cross section of the material as it is being discharged. The Standard Specifications require an mechanical, automatic or semi-automatic sampling device be used for processed materials. ~~It is usually necessary to have a special device constructed for use at each plant. This device consists of a pan of sufficient size to intercept the entire cross section of the discharge stream and hold the required quantity of material without overflowing. A set of rails may be necessary to support the pan as it is passed under the discharge stream. Insofar as is possible, keep bins continuously full or nearly full to reduce segregation.~~

Note 3: Sampling the initial discharge or the final few tons from a bin or conveyor belt increases the chances of obtaining segregated material and should be avoided.

4.3.2 Sampling from the Conveyor Belt (Stopped)— Select units to be sampled by a random method, ~~such as Practice D 3665~~, from the production. Obtain a field sample ~~at least three approximately equal increments~~, selected at random, from the unit being sampled and combine to form a field sample whose mass equals or exceeds the minimum recommended in 4.4.2. Stop the conveyor belt while the sample increments are being obtained. Insert two templates, the shape of which conforms to the shape of the belt in the aggregate stream on the belt, and space them such that the material contained between them will yield an increment of the required weight. Carefully scoop all material between the templates into a suitable container and collect the fines on the belt with a brush and dust pan and add to the container.

4.3.3 Sampling from Stockpiles or Transportation Units — Avoid sampling coarse aggregate or mixed coarse and fine aggregate from stockpiles or transportation units whenever possible, particularly when the sampling is done for the purpose of determining aggregate properties that may be dependent upon the grading of the sample. If circumstances make it necessary to obtain samples from a stockpile of coarse aggregate or a stockpile of combined coarse and fine aggregate, design a sampling plan for the specific case under consideration. ~~This approach will allow the sampling agency to use a sampling plan that will give a confidence in results obtained there from that is agreed upon by all parties concerned to be acceptable for the particular situation.~~ The sampling plan shall define the number of samples necessary to represent lots and sublots of specific sizes. General principles for sampling from stockpiles are applicable to sampling from trucks, rail cars, barges or other transportation units. For general guidance in sampling from stockpiles, see the Appendix.

4.3.4 Sampling from Roadway (Bases and Subbases) — WSDOT has deleted this section.

4.4 Number and Masses of Field Samples

4.4.1 The number of field samples (obtained by one of the methods described in 4.3) required depends on the criticality of, and variation in, the properties to be measured. Designate each unit from which a field sample is to be obtained prior to sampling. The number of field samples from the production should be sufficient to give the desired confidence in test results.

Note 4: Guidance for determining the number of samples required to obtain the desired level of confidence in test results may be found in Test Method D 2234, Practice E 105, Practice E 122, and Practice E 141.

4.4.2 The field sample masses cited are tentative. The masses must be predicated on the type and number of tests to which the material is to be subjected and sufficient material obtained to provide for the proper execution of these tests. Standard acceptance and control tests are covered by ASTM standards and specify the portion of the field sample required for each specific test. Generally speaking, the amounts specified in Table 1 will provide adequate material for routine grading and quality analysis. Extract test portions from the field sample according to T 248 or as required by other applicable test methods.

5. SHIPPING SAMPLES

5.1 Transport aggregates in bags or other containers so constructed as to preclude loss or contamination of any part of the sample, or damage to the contents from mishandling during shipment. The weight limit for each bag of aggregate is 30 pounds maximum.

5.2 Shipping containers for aggregate samples shall have suitable individual identification attached and enclosed so that field reporting, laboratory logging, and test reporting may be facilitated.

All samples submitted for testing to the Region or State Materials Laboratories shall be accompanied by completed sample transmittal (WSDOT Form 350-056) or equivalent.

Table 1
Size of Samples

~~Maximum Nominal Size of Aggregates[A]~~	~~Approximate Minimum Mass of Field Samples, kg[B]~~
~~Fine Aggregate~~	
~~2.36 mm~~	~~10~~
~~4.75 mm~~	~~10~~
~~Coarse Aggregate~~	
~~9.5 mm~~	~~10~~
~~12.5 mm~~	~~15~~
~~19.0 mm~~	~~25~~
~~25.0 mm~~	~~50~~
~~37.5 mm~~	~~75~~
~~50 mm~~	~~100~~
~~63 mm~~	~~125~~
~~75 mm~~	~~150~~
~~90 mm~~	~~175~~

Nominal Maximum Size [A]* in (mm)		**Minimum Mass[B] lb (kg)**	
US No. 4	(4.75)	5	(2)
1/4	(6.3)	10	(4)
3/8	(9.5)	10	(4)
1/2	(12.5)	20	(8)
5/8	(16.0)	20	(8)
3/4	(19.0)	30	(12)
1	(25.0)	55	(25)
1 1/4	(31.5)	70	(30)
1 1/2	(37.5)	80	(36)
2	(50)	90	(40)
2 1/2	(63)	110	(50)
3	(75)	140	(60)
3 1/2	(90)	180	(80)

A*For aggregate, the nominal maximum size, (NMS) is the largest standard sieve opening listed in the applicable specification, upon which any material is permitted to be retained. For concrete aggregate, NMS is the smallest standard sieve opening through which the entire amount of aggregate is permitted to pass.

~~AFor processed aggregate the nominal maximum size of particles is the largest sieve size listed in the applicable specification, upon which any material is permitted to be retained.~~

~~BFor combined coarse and fine aggregates (for example, base or subbase) minimum weight shall be coarse aggregate minimum plus 10 kg.~~

Note 5: For an aggregate specification having a generally unrestrictive gradation (i. e. wide range of permissible upper sizes), where the source consistently fully passes a screen substantially smaller than the maximum specified size, the nominal maximum size, for the purpose of defining sampling and test specimen size requirements may be adjusted to the screen, found by experience to retain no more than 5% of the materials.

APPENDIXES

Xl. SAMPLING AGGREGATE FROM STOCKPILES OR TRANSPORTATION UNITS

X1.1 Scope

X1.1.1 In some situations it is mandatory to sample aggregates that have been stored in stockpiles or loaded into rail cars, barges, or trucks. In such cases the procedure should ensure that segregation does not introduce a serious bias in the results.

Xl.2 Sampling From Stockpiles

X1.2.1 In sampling material from stockpiles it is very difficult to ensure unbiased samples, due to the segregation which often occurs when material is stockpiles, with coarser particles rolling to the outside base of the pile. For coarse or mixed coarse and fine aggregate, every effort should be made to enlist the services of power equipment, such as a front end loader, to develop a separate, small sampling pile composed of materials drawn from various levels and locations in the main pile after which several increments may be combined to compose the field sample. If necessary to indicate the degree of variability existing within the main pile, separate samples should be drawn from separate areas of the pile.

X1.2.2 Where power equipment is not available, samples from stockpiles should be made up of at least three increments taken from the top third, at the mid-point, and at the bottom third of the volume of the pile. A board shoved vertically into the pile just above the sampling point aids in preventing further segregation. In sampling stockpiles of fine aggregate the outer layer, which may have become segregated, should be removed and the sample taken from the material beneath. Sampling tubes approximately 1 ½ in. (30-mm) min by 6 ft. (2-m) min in length may be inserted into the pile at random locations to extract a minimum of five increments of material to form the sample.

Xl.3 Sampling From Transportation Units

X 1.3.1 In sampling coarse aggregates from railroad cars or barges, effort should be made to enlist the services of power equipment capable of exposing the material at various levels and random locations. Where power equipment is not available, a common procedure requires excavation of three or more trenches across the unit at points that will, from visual appearance, give a reasonable estimate of the characteristics of the load. The trench bottom should be approximately level, at least 1 ft. (0.3 m) in width and in depth below the surface. A minimum of three increments from approximately equally spaced points along each trench should be taken by pushing a shovel downward into the material. Coarse aggregate in trucks should be sampled in essentially the same manner as for rail car or barges, except for adjusting the number of increments according to the size of the truck. For fine aggregate in transportation units, sampling tubes as described in Xl.2 may be used to extract an appropriate number of increments to form the sample.

X2. EXPLORATION OF POTENTIAL AGGREGATE SOURCES

X2.1 Scope

X2.1.1 Sampling for evaluation of potential aggregate sources should be performed by a responsible trained and experienced person. Because of the wide variety of conditions under which sampling may have to be done it is not possible to describe detailed procedures applicable to all circumstances. This appendix is intended to provide general guidance and list more comprehensive references.

X2.2 Sampling Stone from Quarries of Ledges

X2.2.1 Inspection — The ledge or quarry face should be inspected to determine discernible variations or strata. Differences in color and structure should be recorded.

X2.2.2 Sampling and Size of Sample — Separate samples having a mass of at least 55 lbs (25 kg) should be obtained from each discernible stratum. The sample should not include material weathered to such an extent that it is no longer suitable for the purpose intended. One or more pieces in each sample should be at least 6 X 6 X 4 inch (150 by 150 by 100 mm) in size with the bedding plane plainly marked, and this piece should be free of seams or fractures.

X2.2.3 Record — In addition to the general information accompanying all samples the following information should accompany samples taken from ledges or quarry faces:

X2.2.3.1 Approximate quantity available. (If quantities is very large this may be recorded as practically unlimited.)

X2.2.3.2 Quantity and character of overburden.

X2.2.3.3 A detailed record showing boundaries and location of material represented by each sample.

Note X2.1: A sketch, plan, and elevation, showing the thickness and location of the different layers is recommended for this purpose.

X2.3 Sampling Roadside or Bank Run Sand and Gravel Deposits

X2.3.1 Inspection — Potential sources of bank run sand and gravel may include previously worked pits from which there is an exposed face or potential deposits discovered through air-photo interpretation, geophysical exploration, or other types of terrain investigation.

X2.3.2 Sampling — Samples should be so chosen from each different stratum in the deposit discernible to the sampler. An estimate of the quantity of the different materials should be made. If the deposit is worked as an open-face bank or pit, samples should be taken by channeling the face vertically, bottom to top, so as to represent the materials proposed for use. Overburdened or disturbed material should not be included in the sample. Test holes should be excavated or drilled at numerous locations in the deposit to determine the quality of the material and the extent of the deposit beyond the exposed face, if any. The number and depth of test holes will depend upon the quantity of the material needed, topography of the area, nature of the deposit, character of the material, and potential value of the material in the deposit. If visual inspection indicates that there is considerable variation in the material, individual samples should be selected from the material in each well defined stratum. Each sample should be thoroughly mixed and quartered if necessary so that the field sample thus obtained will be at least 25 lb (12 kg) for sand and 75 lb (35 kg) if the deposit contains an appreciable amount of coarse aggregate.

X2.3.3 Record — In addition to the general information accompanying all samples the following information should accompany samples of bank run sand and gravel:

X2.3.3.1 Location of supply.

X2.3.3.2 Estimate of approximate quantity available.

X2.3.3.3 Quantity and character of overburden.

X2.3.3.4 Length of haul to proposed site of work.

X2.3.3.5 Character of haul (kind of road, maximum grades, etc.)

X2.3.3.6 Details as to extent and location of material represented by each sample.

Performance Exam Checklist

Sampling of Aggregates
FOP for AASHTO T 2

Participant Name _____ Exam Date _____

Procedure Element	**Yes**	**No**
1. The tester has a copy of the current procedure on hand?	☐	☐
Conveyor Belts –Stopped		
2. Belt stopped?	☐	☐
3. Sampling device set on belt, avoiding intrusion of adjacent material?	☐	☐
4. Sample, including all fines, scooped off?	☐	☐
Flowing Aggregate Sampler		
5. Container passed through full stream of material as it runs off end of belt? (Mechanical, Automatic or Semi Automatic Sampler Only)	☐	☐
Transport Units		
6. Three or more trenches cut across the unit?	☐	☐
7. Trench bottom level and approximate 1 foot wide and 1 foot below surface of material in unit?	☐	☐
8. Three samples taken at equal spacing along each trench?	☐	☐
Stockpiles		
9. Create vertical face, if one does not exist, or use mechanical equipment to build a small sampling pile?	☐	☐
10. At least three increments taken, at various locations?	☐	☐
Procedure Element		
11. If vertical face cannot be created, increment taken from at least three locations from top, middle, and bottom?	☐	☐
12. When sampling sand, outer layer removed and increments taken from a least five locations?	☐	☐

First attempt: Pass ☐ Fail ☐ Second attempt: Pass ☐ Fail ☐

Signature of Examiner _____

Comments:

Washington State
Department of Transportation

WSDOT FOP for AASHTO T 255[1]

Total Evaporable Moisture Content of Aggregate by Drying

1. SCOPE

1.1 This test method covers the determination of the percentage of evaporable moisture in a sample of aggregate by drying, both surface moisture and moisture in the pores of the aggregate. Some aggregate may contain water that is chemically combined with the minerals in the aggregate. Such water is not evaporable and is not included in the percentage determined by this test method.

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

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For specific precautionary statements, see 5.3.1, 7.2.1, and 7.3.1.

2. REFERENCED DOCUMENTS

2.1 *AASHTO Standards:*

M 92	Wire-Cloth Sieves for Testing Purposes
M 231	Weighing Devices Used in Testing Materials
R 16	Regulatory Information for Chemicals Used in AASHTO Tests
T 2	Sampling of Aggregate
T 19/T 19M	Bulk Density ("Unit Weight") and Voids in Aggregate
T 84	Specific Gravity and Absorption of Coarse Aggregate
T 85	Specific Gravity and Absorption of Fine Aggregate

2.2 *ASTM Standards:*

C 125	Terminology Relating to Concrete and Concrete Aggregates
C 670	Practice for Preparing Precision Statements for Test Methods for Construction Materials

3. TERMINOLOGY

3.1 *Definitions:*

3.1.1 For definitions of terms used in this test method, refer to ASTM C 125.

[1] This FOP is based on AASHTO T 255-00 and has been modified per WSDOT standards. To view the redline modifications, contact WSDOT Quality Systems Manager at (360) 709-5412.

4. Significance and Use

4.1 This test method is sufficiently accurate for usual purposes, such as adjusting batch quantities of ingredients for concrete. It will generally measure the moisture in the test sample more reliably than the sample can be made to represent the aggregate supply. In rare cases where the aggregate itself is altered by heat, or where more refined measurement is required, the test should be conducted using a ventilated, controlled temperature oven.

4.2 Large particles of coarse aggregate, especially those larger than 2 in. (50 mm), will require greater time for the moisture to travel from the interior of the particle to the surface. The user of this test method should determine by trial if rapid drying methods provide sufficient accuracy for the intended use when drying large size particles.

5. APPARATUS

5.1 Balance — The balances shall have sufficient capacity, be readable to 0.1 percent of the sample mass, or better, and conform to the requirements of M 231.

5.2 Source of Heat — A ventilated oven capable of maintaining the temperature surrounding the sample at 110 ± 5°C (230 ± 9°F). Where close control of the temperature is not required (see Section 4.1), other suitable sources of heat may be used, such as an electric or gas hot plate, electric heat lamps, or a ventilated microwave oven.

5.3 Sample Container — A container not affected by the heat, and of sufficient volume to contain the sample without danger of spilling, and of such shape that the depth of sample will not exceed one fifth of the least lateral dimension.

5.3.1 Precaution — When a microwave oven is used, the container shall be nonmetallic.

Note 1: Except for testing large samples, an ordinary frying pan is suitable for use with a hot plate, or any shallow flat-bottomed metal pan is suitable with heat lamps or oven. Note Precaution in Section 5.3.1.

5.4 Stirrer — A metal spoon or spatula of convenient size.

6. SAMPLING

6.1 Sampling shall generally be accomplished in accordance with FOP for AASHTO T 2, except for the sample size may be as stated in Table 1.

6.2 Secure a sample of the aggregate representative of the moisture content in the supply being tested and having a mass not less than the amount listed in Table 1. Protect the sample against loss of moisture prior to determining the mass.

Nominal Maximum [A]		Minimum Mass [B]	
Size* in.	(mm)	lb	kg
US No. 4	(4.75)	1	0.5
¼	(6.3)	2	1
⅜	(9.5)	2	1
½	(12.5)	5	2
⅝	(16.0)	5	2
¾	(19.0)	7	3
1	(25.0)	13	6
1¼	(31.5)	17	7.5
1½	(37.5)	20	9
2	(50)	22	10
2½	(63)	27	12
3	(75)	33	15
3½	(90)	44	20
4	(100)	55	25
6	(150)	110	50

* For aggregate, the nominal maximum size, (NMS) is the largest standard sieve opening listed in the applicable specification, upon which any material is permitted to be retained. For concrete aggregate, NMS is the smallest standard sieve opening through which the entire amount of aggregate is permitted to pass.

Note: For an aggregate specification having a generally unrestrictive gradation (i. e. wide range of permissible upper sizes), where the source consistently fully passes a screen substantially smaller than the maximum specified size, the nominal maximum size, for the purpose of defining sampling and test specimen size requirements may be adjusted to the screen, found by experience to retain no more than 5% of the materials.

Note: When determining moisture content for T 99 samples, use approximately 100 grams, and approximately 500 grams for T 180 samples.

[A]Based on sieves with square openings.

[B]Determine the minimum sample mass for lightweight aggregate by multiplying the value listed by the dry-loose unit mass of the aggregate in kg/m3 (determined using T 19M/T 19) and dividing by 1600.

Sample Size for Aggregate
Table 1

7. PROCEDURE

7.1 Determine the mass of the sample to the nearest 0.1 percent or better of the total sample mass.

7.2 Dry the sample thoroughly in the sample container by means of the selected source of heat, exercising care to avoid loss of any particles. Very rapid heating may cause some particles to explode, resulting in loss of particles. Use a controlled temperature oven when excessive heat may alter the character of the aggregate, or where more precise measurement is required. If a source of heat other than the controlled temperature oven is used, stir the sample during drying to accelerate the operation and avoid localized overheating. When using a microwave oven, stirring of the sample is optional.

7.2.1 Caution — When using a microwave oven, occasionally minerals are present in aggregates that may cause the material to overheat and explode. If this occurs it can damage the microwave oven.

7.3 When a hot plate is used, drying can be expedited by the following procedure. Add sufficient anhydrous denatured alcohol to cover the moist sample. Stir and allow suspended material to settle. Decant as much of the alcohol as possible without losing any of the sample. Ignite the remaining alcohol and allow it to burn off during drying over the hot plate.

7.3.1 Warning — Exercise care to control the ignition operation to prevent injury or damage from the burning alcohol.

7.4 The sample is thoroughly dry when further heating causes, or would cause, less than 0.1 percent additional loss in mass.

WSDOT NOTE: When weighing hot samples, use a heat sink to protect the balance.

7.5 Determine the mass of the dried sample to the nearest 0.1 percent or better of the total sample mass after it has cooled to room temperature.

8. CALCULATION

8.1 Calculate total evaporable moisture content as follows:

$$p = \frac{100\,(W - D)}{D}$$

where:

p = total evaporable moisture content of sample, percent;
W = mass of original sample, g; and
D = mass of dried sample, g

8.2 Surface moisture content is equal to the difference between the total evaporated moisture content and the absorption, with all values based on the mass of a dry sample. Absorption may be determined in accordance with T 85, Test for Specific Gravity and Absorption of Coarse Aggregates, or T 84, Test for Specific Gravity and Absorption of Fine Aggregates

9. PRECISION AND BIAS

See AASHTO T 255 for Precision and Bias

10. REPORT

Report results using WSDOT Form 422-020 , or other report approved by the State Materials Engineer.

Performance Exam Checklist

Total Moisture Content of Aggregate by Drying
FOP for AASHTO T 255

Participant Name _____ Exam Date _____

Procedure Element	Yes	No
1. The tester has a copy of the current procedure on hand?	❐	❐
2. All equipment is functioning according to the test procedure, and if required, has the current calibration/verification tags present?	❐	❐
3. Representative sample of appropriate mass obtained?	❐	❐
4. Mass of clean, dry container determined?	❐	❐
5. Sample placed in container and mass determined?	❐	❐
6. Test sample mass conforms to the required mass?	❐	❐
7. Sample mass determined to 0.1 percent?	❐	❐
8. Loss of moisture avoided prior to mass determination?	❐	❐
9. Sample dried by a suitable heat source?	❐	❐
10. Sample cooled prior to mass determination?	❐	❐
11. If aggregate heated by means other than a controlled oven, is sample stirred to avoid localized overheating?	❐	❐
12. Mass determined and compared to previous mass – showing less than 0.1 percent loss?	❐	❐
13. Calculations performed properly and results reported to the nearest 0.1 percent?	❐	❐

First attempt: Pass ❐ Fail ❐ Second attempt: Pass ❐ Fail ❐

Signature of Examiner _____

Comments: