2024 Edition

AGGREGATE TECHNICIAN

PART ONE

MoDOT

Aggregate Technician

2024 – Updates

- **New: Aggregate is now divided into two parts, see the COURSE CONTENT PAGE for the division.**
    - **NOTE: Must have both parts to receive certification in Aggregate Technician.**
- No major changes in the methods.

2023 – Updates

- **AASHTO T11:**
    - **T11 Oven**: The thermometer for measuring the oven temperature shall meet the requirements of M339M/M339 with a range of at least 90 to 130°C (194 to 266°F) and an accuracy of ± 1.25°C (± 2.25°F) (see note 1),
        - NOTE 1: Thermometer types to use include:
            - ASTM E1 Mercury Thermometer
            - ASTM 2877 digital metal stem thermometer
            - ASTM E230/E230M thermocouple thermometer, Type J or K, Special Class, Type T any Class
            - IEC 60584 thermocouple thermometer, Type J or K, Class 1, Type T any Class
            - Dial gauge metal stem (bi-metal) thermometer

    - **T255 Oven**: The thermometer for measuring the oven temperature shall meet the requirements of M339M/M339 with a range of at least 90 to 130°C (194 to 266°F) and an accuracy of ± 1.25°C (± 2.25°F) (see note 1),
        - NOTE 1: Thermometer types to use include:
            - ASTM E1 Mercury Thermometer
            - ASTM 2877 digital metal stem thermometer
            - ASTM E230/E230M thermocouple thermometer, Type J or K, Special Class, Type T any Class
            - 60584 thermocouple thermometer, Type J or K, Special class 1, Type T any Class
            - Dial gauge metal stem (Bi-metal) thermometer

- **AASHTO T27**:
  - **T27 Oven**: The thermometer for measuring the oven temperature shall meet the requirements of M339M/M339 with a range of at least 90 to 130°C (194 to 266°F) and an accuracy of ± 1.25°C (± 2.25°F) (see note 3),
    - NOTE 3: Thermometer types to use include:
      - ASTM E1 Mercury Thermometer
      - ASTM 2877 digital metal stem thermometer
      - ASTM E230/E230M thermocouple thermometer, Type J or K, Special Class, Type T any Class
      - IEC 60584 thermocouple thermometer, Type J or K, Class 1, Type T any Class
      - Dial gauge metal stem (Bi-metal) thermometer

2022 – Updates

- **No updates**

2021 – Updates

- **AASHTO T11** - Mechanical Washing: Do not wash the sample in a mechanical washer for more than 10 min.

2020 – Updates

- **AUDIT NOTIFICATION SLIDE ADDED TO ALL MANUALS:** To all material testers, who work on Missouri Highways, this includes Consultants, Contractors, City, County, and MoDOT workers; you will be audited by **MoDOT IAS Inspectors** and sometimes **FHWA** personnel.
- **No Method Changes for 2020.**

COURSE CONTENT

AGGREGATE TECHNICIAN

PART ONE

AASHTO R 90	Sampling of Aggregate Products
AASHTO R 76 ASTM C702	Reducing Samples of Aggregate to Testing Size
AASHTO T 255 ASTM C566	Total Evaporable Moisture Content of Aggregate by Drying
AASHTO T 11 ASTM C117	Materials Finer Than No. 200 Sieve in Mineral Aggregates by Washing
AASHTO T 27 ASTM C136	Sieve Analysis of Fine and Coarse Aggregates
Appendix	
Glossary	

Aggregate Technician

PART ONE

AASHTO R 90

Sampling Aggregate Products

Required Audits

All testers on Federal-Aid Projects (MoDOT or Off-System) are required by the FHWA to be audited at least once per year.

Reasons:

- To ensure proper test procedures are being utilized.
- To ensure testing equipment is calibrated and operating properly.

- **Types of Audits;** procedure or comparison.
- **Be Proactive;** schedule your audit as early as possible with MoDOT Materials in district offices, do NOT wait till the end of the year.
- **Provide Proof;** when audited, present a MoDOT Certification Card, or a MoDOT Letter.

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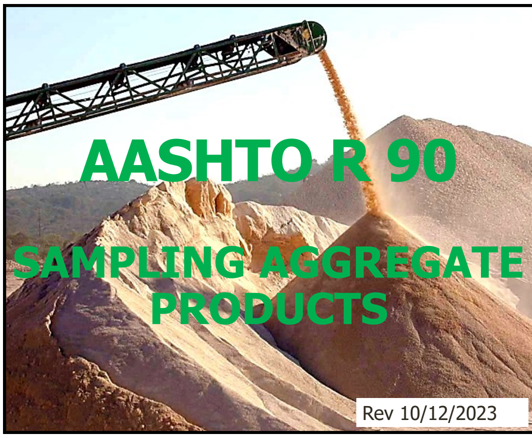

AASHTO R 90

SAMPLING AGGREGATE PRODUCTS

Rev 10/12/2023

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SAFETY GEAR

Personal Protective Equipment (PPE)

- Goggles or Safety Glasses
- Ear Plugs or Earmuffs
- Steel-Toed Boots
- Hardhat
- Safety Vest
- Dust Mask

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SCOPE

- This practice covers the procedures for obtaining representative samples of Coarse Aggregate (CA), Fine Aggregate (FA), or combinations of Coarse and Fine Aggregate (CA/FA) products to determine compliance with requirements of the specifications under which the aggregate is furnished.
- This method includes sampling from conveyor belts, transport units, roadways, and stockpiles.

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SIGNIFICANCE AND USE

- Sampling is a critical step in determining the quality of the material being evaluated. Care shall be exercised to ensure that samples are representative of the material being evaluated.
- This practice is intended to provide standard requirements and procedures for sampling coarse, fine, and combination of coarse and fine aggregate products.

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SECURING SAMPLES

(All Methods)

- *General*: Where practicable, samples to be tested for quality shall be obtained from the finished product.
- *Inspection*: The material to be sampled shall be visually inspected to determine discernible variations, corrective action shall be taken to establish *homogeneity* in the material prior to sampling.

Examples of variations: *Segregation, clay pockets, varying seams, boulders.*

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TERMINOLOGY

- **Coarse Aggregate (CA)**
  - All the material retained on the #4 (4.75mm) sieve and above.
- **Fine Aggregate (FA)**
  - All the material passing the #4 (4.75mm) sieve.
- **Special Note**
  - MoDOT – Specific sample sizes are on the following chart. **These sizes are different from AASHTO/ASTM specifications.**

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MoDOT AGGREGATE SAMPLE SIZES

Maximum size Aggregate	Minimum Weight/Mass of Sample
2″ (50 mm)	80 lb. (36kg)
1-½″ (37.5 mm)	54 lb. (25kg)
1″ (25.0 mm)	36 lb. (16kg)
¾″ (19.0 mm)	22 lb. (10kg)
½″ (12.5 mm)	14 lb. (6kg)
⅜″ (9.5 mm)	10 lb. (5kg)
Fines and Natural Sands	500g

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AGGREGATE SAMPLEING PROCEDURES:

- **Conveyor Belt**
  1. Using a sampling device (belt discharge)
  2. Using a template
- **Stockpiles**
  1. Using a loader
  2. Using a flat board
  3. Using a sampling tube (fine aggregate)
- **Transport Units**
  Not recommended.
  If approved by MoDOT, use a safety rail, sample with a shovel.
- **Roadway**
  1. In place **(preferred)**
  2. Berm or windrow **Not recommended, therefore not covered.**

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CONVEYOR BELT SAMPLING

Sampling Device Procedure

Coarse Aggregate (CA) & Combined (CA/FA)

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EQUIPMENT

- Safety Gear; PPE
- Sampling Device
- Proper Containers

Conveyor Belt - Sampling Device

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PROCEDURE

1. Plant is operating at the usual rate.
2. Select a random sample from a conveyor belt discharge during production.
   - If sampling for quality control or acceptance, record the sampling time, date, and location.
   - Avoid the initial or end of an aggregate run.

Conveyor Belt - Sampling Device

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3. Pass the sampling device at a constant speed through the entire cross-section of the stream flow once in each direction without overflowing the sampling device.

4. Include all material from the sampling device when empting into the container.

5. Obtain one or more equal increments as required for testing, and combine to form a field sample.

Conveyor Belt - Sampling Device

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CONVEYOR BELT SAMPLING

Template Procedure

Coarse Aggregate (CA) & Combined (CA/FA)

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EQUIPMENT

- Safety gear; PPE
- Template
- Scoop or trowel
- Brush or broom
- Proper containers
- Tag out items

Conveyor Belt - Template

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PROCEDURE

NOTE: Record sampling time or location, or both.

1. **STOP** the conveyor belt.
   Lock and Tag Out !

2. Select a random sample area from production.
   Note: Avoid sampling at the beginning or end of an aggregate run.
3. Insert the sampling template on the belt to yield one increment.

Conveyor Belt - Template

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4. Remove all material including the fines from inside the template with a scoop and a brush into a clean dry container.
5. Obtain one or more equal increments to supply enough material for the required test(s).
6. Combine the increments to form a field sample.

Conveyor Belt - Template

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Conveyor Belt Automatic Sampling Device

- The Automatic Sampling Device is a permanently attached device that allows a sample container to pass perpendicularly through the entire stream of material or diverts the entire stream of material into the container by manual, hydraulic, or pneumatic operation.
- May be used if properly maintained and inspected.

Conveyor Belt - Automatic

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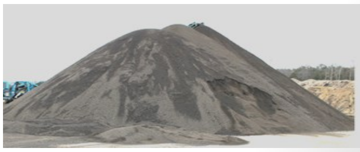
STOCKPILES

Re-blend a segregated stockpile before sampling.



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Show Stockpile Videohttps://youtu.be/JXXSssLHrAc

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STOCKPILE SAMPLING

Loader Procedure

Coarse Aggregate (CA) & Combined (CA/FA)

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EQUIPMENT

Stockpile - Loader

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Stockpile – Loader Procedure

(Sampling from a flat surface created by a loader)

NOTE: Record sampling time or location, or both.

1. Re-blend segregated material with the loader.
2. Direct the loader operator to enter the stockpile with the bucket at least **1 foot** above the ground level to avoid contaminating the stockpile.
3. Discard the first bucket-full.

Stockpile - Loader

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4. Have the loader re-enter the stockpile to obtain a full loader bucket of the material.
5. Tilt the bucket just high enough to permit free flow of the material to create a small pile to the side.

(Repeat as necessary)

6. Create a flat surface by having the loader back drag the small pile.

Stockpile - Loader

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Stockpile - Loader

7. Collect a minimum of **three random** locations from the flat surface that are at least **one foot** from the sample pile edge.
8. Fully insert the shovel, exclude the underlying material, roll back the shovel, and without losing material place it in a clean dry container.
9. Combine the increments to form a field sample.

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STOCKPILE SAMPLING

Flat Board & Shovel Procedure

Coarse Aggregate (CA) & Combined (CA/FA)

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EQUIPMENT

Stockpiles – Flat Board

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PROCEDURE

(Sampling from a horizontal surface on a stockpile face)

NOTE: Record sampling time or location, or both.

1. With a shovel, create a horizontal surface with a vertical face.
2. Insert a flat board against a vertical face behind sampling location to prevent sloughing.
3. Do not use sloughed material.
4. Obtain a sample from the horizontal surface near vertical face.

Stockpiles – Flat Board

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5. Obtain at least one increment of equal size from the **top** third, **middle** third, and **bottom** third of the pile.
6. Combine the increments to form a field sample.

Stockpiles – Flat Board

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STOCKPILE SAMPLING

Sampling Tube Procedure

Fine Aggregate (FA) Only

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EQUIPMENT

- Sampling tube with the dimensions:
  - 1¼″ diameter x 6 feet in length, tip cut at a 45° angle

Stockpiles – Sampling Tube

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PROCEDURE

NOTE: Record sampling time or location, or both.

1. Remove the outer layer of the stockpile.
2. Using a sampling tube obtain a minimum of **5** samples from random locations on the stockpile.
3. Combine the increments in a clean dry sample container to form a field sample.

Stockpiles – Sampling Tube

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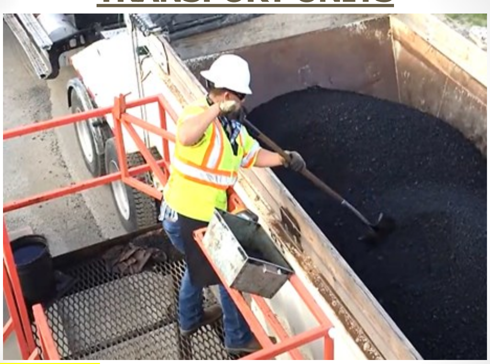
TRANSPORT UNITS



(Updated Slide)

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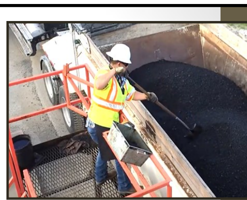
Transport Units

NOT RECOMMENDED,

However, for some samples MoDOT may approve sampling from transport Units.



Procedure:

- Use a platform with safety railing.
- Use a shovel.
- Remove 1 foot from the top surface.
- Visually divide an area into 4 quadrants.
- Obtain an increment from a quadrant and another increment from the opposite quadrant, repeat if needed, combine for a sample.

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(New Slide)

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ROADWAY BASE IN-PLACE SAMPLING

Coarse Aggregate (CA) & Combined (CA/FA)

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EQUIPMENT

Roadway Base -In-Place

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PROCEDURE

NOTE: Record sampling time or location, or both.

1. Obtain a representative sample after spreading and before compaction using a random number set for a QC/QA sample.
2. If **not** a QC/QA sample, obtain at least **1** or more random increments before compaction for a field sample.
3. Clearly mark the specific area from which materials will be removed with the template or square nosed shovel.

Roadway Base -In-Place

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4. With a shovel, remove the full depth of material from inside the marked area; exclude any underlying material.
5. Combine the increments to form a field sample.

Roadway Base -In-Place

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STOCKPILES

Roadway Base Sampling

- Sampling from a berm or windrow
  - MoDOT does not sample from berms or windrows.

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SHIPPING SAMPLES

Proper Container

- Bags made for shipping aggregates, or other suitable containers that prevent contamination or loss during shipment.
- NOTE: MoDOT prefers bags

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Proper Identification:

Shipping Samples

- Shipping containers for aggregate samples shall have suitable individual identification that is clearly marked on the outside and enclosed.
- Include ID, location, date & time, material type, and quantity of material represented by the sample, if applicable.

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Common Errors (All methods):

- Using an improper sampling device.
- Sampling in segregated areas.
- Not obtaining enough increments.
- Not labeling the bags inside and out with proper identification.
- Allowing overflowing of a stream flow device.
- Not being safe. (example; Not performing lock out/tag out on a stopped conveyer belt.)

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AASHTO R 90: Sampling of Aggregates
PROFICIENCY CHECKLIST

Applicant ______________________________

Employer ______________________________

NOTE: For all QC/QA or Acceptance sampling, record the time or location or both.

Conveyor Belt Sampling – Sampling Device – Coarse/Combined Aggregate NOTE: Automatic belt samplers may be used if properly maintained and inspected.	Trial 1	Trial 2
1. Plant was operating at the usual rate.		
2. Random samples taken from a conveyor belt discharge taken from production.		
- Avoided sampling the beginning or end of a run.		
3. Sample taken from the entire cross-section of material once in each direction without overflowing the device.		
4. Included all material from the sampling device into a clean empty container.		
5. Obtained 1 or more increments to form a field sample.		
Conveyor Belt Sampling – Template - Coarse/Combined Aggregate		
1. Conveyor belt stopped, locked and tagged out.		
2. Random samples taken from production.		
- Avoided sampling at the beginning or end of a run.		
3. Template placed on the belt to yield one increment.		
4. All material inside the template scooped into a proper container including fines.		
5. Obtained 1 or more increments to combine for a field sample.		
Stockpile Sampling – Flat Board – Coarse/Combined Aggregate		
1. Created a horizontal surface with a vertical face.		
2. Inserted board vertically against a vertical face to prevent sloughing.		
3. Discarded sloughed material.		
4. Obtained a sample from the horizontal surface close to the vertical face.		
5. Obtained at least one increment from; the top third, the middle third, and the bottom third of the stockpile.		
6. Combined to form a field sample.		
Stockpile Sampling - Sampling Tube - Fine Aggregate Only		
1. Outer layer of the stockpile removed.		
2. Obtained a minimum of 5 random tube insertions on the stockpile.		
3. Combined to form a field sample.		
Stockpile Sampling – Loader – Coarse/Combined Aggregate		
1. Segregation avoided by re-blending the pile.		
2. Loader entered the pile with bucket at least 1 foot above the ground.		
3. Discarded first bucket-full.		
4. Loader re-entered stockpile to obtain a full loader bucket of material		
5. Bucket tilted just enough to free flow material creating a small sampling pile. (Can go back for more).		
6. Back-dragged the small pile to form a sampling pad.		
7. Randomly collected a minimum of 3 increments with a shovel at least 1 foot from sample pile edge.		
8. Fully Inserted the shovel, excluding underlying material, placed in a clean dry container.		
9. Combined increments to form a field sample.		
Roadway Base Sampling – In-Place – Coarse/Combined Aggregate		
1. Obtained a representative sample after spreading and before compaction using a random number set for a QC/QA sample.		
2. If not a QC/QA sample, obtained at least 1 or more random increments before compaction for a field sample.		
3. Clearly marked the specific area with a template or square nosed shovel.		
4. Used a square nose shovel and or a metal template to mark the area.		
5. With a shovel, removed the full depth of material from inside the marked area excluding underlying material.		
6. Combined increments to form a field sample.		
	PASS FAIL	PASS FAIL

Examiner: ______________________________ Date: ______________

AASHTO R 76

ASTM C702

Reducing Samples of Aggregate

To Testing Size

AASHTO R 76

REDUCING SAMPLES OF AGGREGATE TO TESTING SIZE

Rev 10/11/2023

1

SIGNIFICANCE AND USE

- The significance for AASHTO R 76, is to reduce a large sample obtained in the field or produced in the laboratory to the proper size for conducting a number of tests to describe the material and measure its quality. These methods are conducted in such a manner that the smaller test sample portion will be representative of the larger sample and therefore the total supply.

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SAMPLING

- The samples of aggregate obtained in the field shall be taken in accordance with AASHTO R 90 (ASTM D75), or as required by individual test methods and shall be reduced by AASHTO R 76 (ASTM C702).

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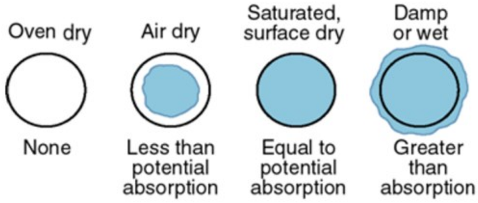
The moisture content of aggregate is defined in four states:



Total Moisture = Free (surface) Moisture + Absorbed Moisture

NOTE: The Damp or Wet State #4 has free moisture on the particle surface.

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METHODS

- **Method A**: Mechanical Splitter
  - Riffle Splitter
- **Method B**: Quartering
  - Canvas
  - Hard, Clean, Level Surface
- **Method C**: Miniature Stockpile

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Method Selection

METHOD A **Mechanical Splitter** "Air Dry"	**METHOD B** **Quartering** "Free Moisture"	**METHOD C** **Miniature Stockpile** "Free Moisture"
Fine Aggregate	Fine Aggregates	Fine Aggregates
Coarse Aggregates	Coarse Aggregates	
Combined/Mixed Aggregates	Combined/Mixed Aggregates	

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Things to know before you begin:

- Minimize the chance of variability during handling.
- The reduction method used depends upon the maximum aggregate size, the moisture condition, and the equipment available.
- A sample collected in two or more increments shall be thoroughly mixed before reducing.
- The mechanical splitter is the preferred method for reducing coarse aggregate.

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METHOD A

MECHANICAL SPLITTER

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APPARATUS

Method A - Mechanical Splitter

- Shall have an even number of equal width chutes.
- At least **8 chutes** for coarse aggregate.
- At least **12 chutes** for fine aggregate.
- Must discharge alternately to each side of the splitter.
- Equipped with 2 receptacles to hold the two halves of the sample following splitting.

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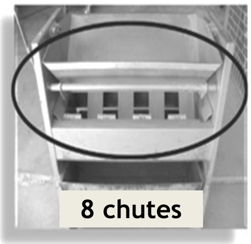
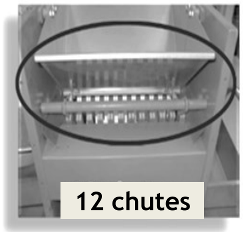


Coarse Aggregate



Fine Aggregate

Apparatus 10

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- Equipped with a hopper or straightedge pan, which has a width equal to or slightly less than the overall width of the assembly of chutes.
- Designed for smooth flow without restriction or loss of material.
- For coarse aggregate and mixed aggregate, the minimum width of the individual chutes shall be approximately 50% larger than the largest particles in the sample to be split.

Apparatus 11

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- For dry fine aggregate in which the entire sample will pass the ⅜″ (9.5mm) sieve, the minimum width of the individual chutes shall be at least 50% larger than the largest particles in the sample and the maximum width shall be ¾″ (19mm).
- **NOTE:** A preliminary split may be made using a mechanical splitter to reduce a fine aggregate sample that is very large. Set the chute openings to 1½ inch or more to reduce the sample to not less than 5,000g. Dry the obtained portion and reduced it to testing sample size using Method A.

Apparatus 12

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SAMPLE PREPARATION

Method A - Mechanical Splitter

- Sample should be air-dry.
- Clean the chutes before splitting and between splits.
- Large samples should be representative of the material.
  (Blending may be necessary)

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PROCEDURE

Method A - Mechanical Splitter

1. Material is in an air-dry condition.
2. Adjust the openings for the correct chute size.
3. Load the hopper uniformly, distributing the sample from edge to edge, avoiding segregation.
4. The rate at which the sample is introduced shall allow free flowing through the chutes into the receptacles below.

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5. Reintroduce the portion of the sample in one of the receptacles into the splitter as many times as necessary to reduce the sample to the size specified for the intended test.

NOTE: The portion of the material collected in the other receptacle may be reserved for reduction in size for the other tests.

Procedure

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Procedure

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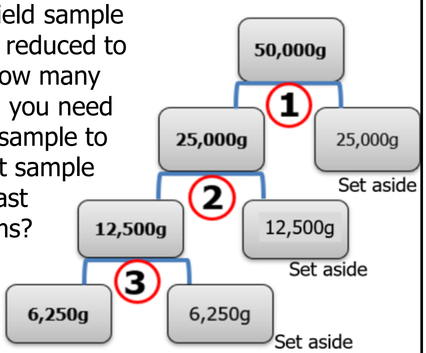
Sample Size Question…

A 50,000g field sample needs to be reduced to 10,000g. How many times would you need to split this sample to obtain a test sample size of at least 10,000 grams?



Ans: 2

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METHOD B

QUARTERING

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EQUIPMENT

Method B - Quartering

- Straight-edged scoop
- Square-nosed shovel or trowel
- Broom or brush
- Canvas or Tarp for alternate method approximately 6′ x 8′
- Long stick or pipe

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SAMPLE PREPARATION

Method B - Quartering

- Fine, coarse, or combined aggregates must be in a moist condition.
- For fine aggregates, the sample should be wet enough to stand in a vertical face. If the sample does not have free moisture on the surfaces, the sample may be moistened to achieve this condition.

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PROCEDURE

Method B - Quartering

1. Place the sample on a clean, hard, level surface where there will be neither loss of material nor the accidental addition of foreign material.
2. Mix by turning the material over completely at least **THREE** times until thoroughly mixed.
3. Form a conical pile.

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4. Flatten evenly so the diameter is 4-8 times the thickness.
5. Divide this into 4 equal quarters with a shovel or trowel.
6. Remove two diagonally opposite quarters, including all fine material, brush the spaces clean and set the other two quarters aside for later use.

Procedure 21

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7. Take the remaining 2 quarters, mix and quarter until the sample is reduced to the desired size.

NOTE: Save the unused portion until testing is completed.

Procedure 22

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Method B - Quartering

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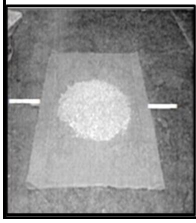
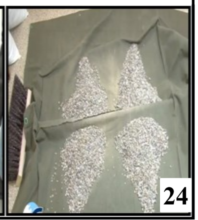
Method B - Alternate Quartering Method Using a Canvas and Broom Stick

1. Place a canvas blanket on a clean, level surface.
2. Mix by lifting opposite corners towards each other causing the material to be rolled a minimum of four times.
3. Use a stick to quarter as shown below.





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4. Take opposite quarters to test or to further reduce.

Method B – Alternate Quartering

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METHOD C

MINIATURE STOCKPILE

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EQUIPMENT
Method C - Miniature Stockpile

- Shovel or trowel (For mixing the aggregate)
- Straight-edged scoop
- Small sampling thief, small scoop, or spoon

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PROCEDURE
Method C - Miniature Stockpile

1. Place the original sample of damp fine aggregate on a hard clean, level surface.
2. Mix the material thoroughly by turning the entire sample over at least three times.
3. With the last turning, shovel the entire sample into a conical pile by depositing each shovel full on top of the preceding one.

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Optional step: The conical pile may be flattened to a uniform thickness and diameter by pressing the apex with a shovel or trowel so that each quarter sector of the resulting pile will contain the material originally in it.

4. Obtain a sample by selecting at least **FIVE** increments of material at random locations from the pile and combine them to attain the appropriate sample size.

Procedure

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Common Errors:

- Improper method for reduction based on moisture condition.
- Using wrong size chute openings.
- Failure to introduce sample to chutes evenly.
- Failure to use proper flow rate while splitting.

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AASHTO R 76: Reducing Field Samples of Aggregate to Testing Size
PROFICIENCY CHECKLIST

Applicant____

Employer____

Trial #	1	2
Method A – Splitting		
8 chutes for Coarse (CA), 12 chutes for Fine (FA)		
1. Material in an air-dry condition.		
2. Adjusted the openings to be 50% larger than the largest particle.		
3. Material spread uniformly on feeder from edge to edge.		
4. Rate of feed slow enough so that sample flows freely through chutes.		
5. Material in one receptacle re-split until desired weight was obtained.		

Method B - Quartering		
1. Moist sample placed on clean, hard, level surface.		
2. Mixed by turning over completely at least 3 times with shovel.		
3. Conical pile formed.		
4. Pile flattened to uniform thickness and diameter of 4-8 times thickness.		
5. Divided into 4 equal portions with shovel or trowel.		
6. Removed two diagonally opposite quarters, including all fines.		
7. Remaining quarters, mixed and quartered until reduced to desired sample size.		
NOTE: The sample may be placed upon a canvas quartering cloth and a stick or pipe may be placed under the tarp to divide the pile into quarters.		

Method C – Miniature Stockpile (Damp Fine Aggregate Only)		
1. Moist fine aggregate sample placed on clean, hard, level surface.		
2. Material thoroughly mixed by turning over completely three times.		
3. Small stockpile formed.		
4. Obtain at least 5 samples taken at random with sampling thief, small scoop, or spoon, combined to attain appropriate sample size.		

Pass Pass

Fail Fail

Examiner:______________________________Date:______________________

AASHTO T 255

ASTM C566

Total Evaporable Moisture Content

of
Aggregate by Drying

AASHTO T 255

Total Evaporable Moisture Content of Aggregate by Drying

Rev. 10/15/2020

1

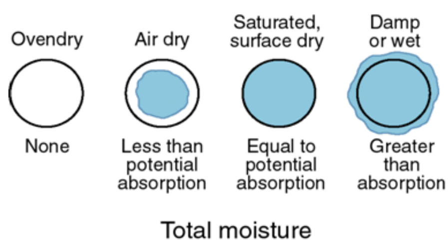
SCOPE

- 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 method.

2

2

The moisture content of aggregate is defined in four states:



Total Moisture = Free (surface) Moisture + Absorbed Moisture

NOTE: The Damp or Wet State #4 has FREE moisture on the particle surface.

3

3

SIGNIFICANCE AND USE

- Used for adjusting batch quantities of ingredients for concrete.
- Measures the moisture in a test sample.
- Calculates the free moisture of aggregates to adjust for water-cement ratio.
- Affects the concrete plant report calculations.
- Affects the asphalt plant production rate and asphalt-cement content.
- NOTE: Larger particles will require greater time for the moisture to travel from the interior to the surface.

4

4

EQUIPMENT

- Scale
  - Readable to 0.1 percent of the sample mass, or better
- Source of Heat
  - Ventilated oven 230 ± 9˚F (110 ± 5°C)
  - Hot plate
  - Ventilated microwave oven
  - Electric heat lamps

5

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- Sample Container
  - Air tight cans
    - Not affected by heat
    - Sufficient volume size
- Other Items
  - Gloves
  - Metal Spoon
  - Brush
  - Pans
- Shovel or Scoop
  - for sampling

Equipment

6

6

SAMPLING

- Obtain a sample In accordance with AASHTO R90/ASTM D75.
- 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 using the *Nominal Maximum Size of Aggregate*. (See Glossary for definition)
- Protect the sample against moisture loss prior to determining the mass.

7

7

AASHTO Sample Size (TABLE 1)

Nominal Maximum Size of Aggregate in. (mm)	Minimum Sample Mass Lbs. (g.)
#4 (4.75)	1.1 (500)
⅜" (9.5)	3.3 (1,500)
½" (12.5)	4.4 (2,000)
¾" (19.0)	6.6 (3,000)
1" (25.0)	8.8 (4,000)
1 ½" (37.5)	13.2 (6,000)

8

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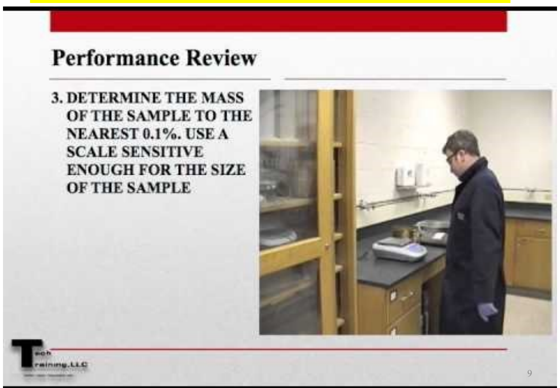
Moisture Content- Video https://youtu.be/YXfpniVawc0



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PROCEDURE

1. **Obtain representative sample** in an air tight container.
   - It is advised to retrieve sample from interior of aggregate stockpile.
   - Cover immediately to prevent any moisture loss.
   - Protect the sample against moisture loss when transporting to a testing facility and prior to determining the mass.
2. **Weigh and record the wet sample** to the nearest 0.1% of the total mass, typically 0.1g.

(From this point on do not lose material or overheat the sample.)

10

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3. **Dry the sample using one of the following; oven, hot plate, or microwave oven.**
   - Ventilated Oven: (Preferred)
     - Easily regulated at 230 ± 9˚F (110 ± 5°C).
     - Good for sensitive aggregates.
   - Hot Plate: (Fast) Exercise caution!
     - Periodically stir to avoid overheating causing aggregate to fracture.
     - If aggregate cannot be heated without fracture, use a ventilated oven.

Procedure 11

11

– Ventilated Microwave Oven: Use a non-metal container, stirring is optional.

(If the material explodes you can not use the microwave, go to another method of drying.)

NOTE: Material used in the microwave cannot be used for any other test method.

Procedure 12

12

4. **Remove the sample from the heat source** when the sample is thoroughly dried to a *constant mass*.

<u>The sample is thoroughly dried to a constant mass when further heating causes, or would cause, less than 0.1 % additional loss in mass</u>.

5. **Allow to cool**.

6. **Weigh and record** the mass of the dried sample to the nearest **0.1** % of the total mass.

Procedure

13

13

CALCULATIONS

- Determine the total evaporable moisture content

$$p = \frac{W - D}{D} \times 100$$

- p = percent total evaporable moisture content
- W = mass of original sample, (g)
- D = mass of dried sample, (g)

14

14

Class Practice

Calculate the total evaporable moisture content:

- Mass of original sample = 3,523.0 g
- Mass of dried sample = 3,501.0 g
- Report your answer to the nearest 0.1%

15

15

Answer

$$p = \frac{W - D}{D} \times 100$$

$$\frac{3523.0 - 3501.0}{3501.0} \times 100 = \mathbf{0.6\%\ \textit{Moisture}}$$

16

16

REPORTING RESULTS

- Record results in the bound field book to the nearest **0.1 %** total moisture.
- Notify plant operator of results.

17

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Common Errors:

- Overheating
- Insufficient sample size
- Loss of material when stirring
- Loss of moisture prior to testing
- Sample not dried to a constant mass

18

18

AASHTO T 255: Total Evaporable Moisture Content of Aggregate by Drying
PROFICIENCY CHECKLIST

Applicant____

Employer____

Trial #	1	2
1. Representative test sample secured		
2. Test sample mass conforms to following from the AASHTO T 255 Table:		
3. Mass determined to the nearest 0.1% of the total mass		
4. Loss of moisture avoided prior to determining the mass		
5. Sample dried by a suitable heat source		
6. If heated by means other than a controlled temperature oven, is sample stirred to avoid localized overheating		
7. Sample dried to constant mass and mass determined to nearest 0.1% of the total mass		
8. Moisture content calculated by: % moisture = $\frac{\text{wet sample mass - dried sample mass}}{\text{dried sample mass}}$ x 100		

Nominal Maximum Size of Aggregate in. (mm)	Minimum Sample Mass Lbs. (g.)
#4 (4.75)	1.1 (500)
⅜" (9.5)	3.3 (1,500)
½" (12.5)	4.4 (2,000)
¾" (19.0)	6.6 (3,000)
1" (25.0)	8.8 (4,000)
1 ½" (37.5)	13.2 (6,000)

PASS PASS

FAIL FAIL

Examiner:______________________________________ Date:________________

AASHTO T 11

ASTM C117

Materials Finer Than

No. 200 Sieve in Mineral Aggregates

by Washing

MoDOT

AASHTO T11

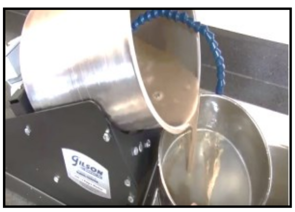
MATERIALS FINER THAN
No. 200 (75 µm) SIEVE IN
MINERAL AGGREGATES BY WASHING

Rev 10/14/2020

1

SCOPE

- This test washes the fine particles through the #200 (75 µm) sieve to give an accurate determination of the minus #200 portion in a sample.



2

2

SIGNIFICANCE AND USE

- Material finer than the # 200 (75-ųm) sieve can be separated from larger particles much more efficiently and completely by wet sieving than through the use of dry sieving. Therefore, when accurate determinations of material finer than #200 in fine or coarse aggregate is desired, this test method should be used on the sample prior to dry sieving in accordance with AASHTO T 27.

3

3

EQUIPMENT

- Oven capable of 230 ± 9°F (110 ± 5°C)
- Scale, reads to 0.1% of the sample mass or better
- Sieve **#200**
  Plus a
  #8 sieve or a
  #16 sieve
- Suitable container
- Wetting agent
  for "Method B"
- Water
- Spoon

4

4

SAMPLING

- Sample the aggregate in accordance with AASHTO R 90 (ASTM D75).
- Thoroughly mix the sample of aggregate to be tested and reduce the quantity to an amount suitable for testing using the methods described in AASHTO R 76.
- The test specimen shall be a representative sample based on **AASHTO Table 1**.

5

5

AASHTO Table 1 – Sample Mass Requirements

Nominal Maximum Size (NMAS), in.(mm)	Minimum Weight of Sample, grams
#4 (4.75)	300
3/8" (9.5)	1000
3/4" (19.0)	2500
1 ½" (37.5) or larger	5000

- Nominal Maximum Aggregate Size; (NMAS) is defined as the smallest sieve which 100% of sample passes.
- **Note:** If the aggregate size is an in-between size just go to the next size on the chart for the amount ex: ½" you would go to 2500 grams.

6

6

SAMPLE PREPARATION

Method A

- Dry the test sample to a constant mass at 230 ± 9°F (110 ± 5°C) and determine the mass to the nearest 0.1 % of the mass of the test sample.
- Check the #200 sieve for damage before testing. (if damaged replace the sieve)

NOTE: Take care not to overload the #200 sieve during washing.

7

7

PROCEDURE

Method A

1. Place the sample into a washing pan/vessel suitable for heating in the oven.
2. Add water to cover the aggregate.

Optional Method B:
Add a small amount of wetting agent only once per sample during agitation.

3. Agitate the sample.
(Use a spoon or similar tool to agitate the sample.)

8

8

4. Immediately pour the wash water through the nest of sieves avoiding the decantation of the coarser particles.

Nest of sieves: Is the use of two or more sieves stacked together. In this case the stack consist of two sieves. Use either a sieve size #8 or #16 placed on top of a #200 sieve. This will protect the delicate #200 sieve from damage while washing.

5. Add another charge of water to the sample in the pan, agitate, decant the wash water through the nest of sieves as before. Repeat several times until the wash water is clear.

Procedure

9

9

6. Material on sieves returned to washed sample.

- Do not decant any water from the pan except through a # 200 sieve to avoid loss of material.

- **MECHANICAL WASHING** *(Optional)***:**
  If mechanical washing equipment is used, the charging of water, agitating, and decanting will be a continuous operation.

Mechanical Washers: Maximum wash time is **<u>10 minutes</u>**.

10 MINUTES MAX

Procedure

10

7. Oven dry the sample to a constant mass at a temperature of 230 ± 9°F (110 ± 5°C), weigh to the nearest 0.1 % of the original mass of the sample. **(Typically 1 gram)**

8. Calculate the loss and report the results.

Procedure 11

11

CALCULATIONS

- Calculate the amount of material passing a # 200 sieve by washing as follows:

$$A = \frac{(B - C)}{B} \times 100$$

A = Total % passing #200 (75 µm) sieve
B = Original dry mass of sample (grams)
C = Dry mass of sample after washing and drying to constant mass (grams)

12

12

REPORTING

Report the percentage of material finer than the #200 sieve by washing to the nearest **0.1 % if the loss is less than 10%.**

Report the result to the nearest **whole number if the loss is 10% or more.**

13

13

Sample Calculations

$$A = \frac{(B - C)}{B} \times 100$$

B = 532 grams

C = 521 grams

$$A = \frac{(532 - 521)}{532} \times 100$$

A = 2.1%

14

14

Classroom Exercise and Reporting Results

Determine the percent of minus #200 material and report the answer to the nearest 0.1% if less than 10%, to the nearest 1% if 10% or more:

Original dry weight (B) = 3171 g

Washed dry weight (C) = 2729 g

15

15

ANSWER

$$A = \frac{(B - C)}{B} \times 100$$

$$A = \frac{3171 - 2729}{3171} \times 100$$

Answer: A = 13.94
Reported: A = **14%**

16

16

Common Errors:

- Overloading #200 sieve
- Losing sample when transferring or washing
- Using a damaged #200 sieve

17

17

AASHTO T 11: Materials Finer Than No. 200 Sieve in Mineral Aggregates by Washing

PROFICIENCY CHECKLIST

Applicant ___________________________________

Employer ___________________________________

Trial #	1	2
1. Test sample dried to constant mass at 230 ± 9°F (110 ± 5°C).		
2. Test sample allowed to cool and mass determined to 0.1%.		
3. #200 sieve checked for damage. Cover the #200 with a #8 or #16 sieve.		
4. Sample placed in a container and covered with water.		
5. Wetting agent added. (optional)		
6. Sample and contents of container vigorously agitated. Note: Mechanical washers maximum time 10min of washing.		
7. Wash water poured through the sieve nest.		
8. Wash water free of coarse particles.		
9. Operation continued until wash water is clear.		
10. Material on sieves returned to washed sample.		
11. Excess water decanted from washed sample only through the #200 sieve.		
12. Washed aggregate dried to constant mass at 230 ± 9°F (110 ± 5°C).		
13. Washed aggregate mass cooled and determined to 0.1%.		
14. Calculation: % less than #200 = $\frac{\text{Orig. dry mass} - \text{Final dry mass}}{\text{Orig. dry mass}} \times 100$		

PASS PASS

FAIL FAIL

Examiner:____________________ Date:____________________

AASHTO T 27

ASTM C136

Sieve Analysis of Fine and Coarse Aggregates

AASHTO T 27

ASTM C136

Rev 10/11/2023

1

SCOPE

- Sieve analysis of aggregate is used to determine compliance with design, production control requirements, and verification of specifications.
- According to AASHTO, either Cumulative or Non-Cumulative methods may be used.
- Analysis of aggregate extracted from asphalt mixtures is conducted in accordance with AASHTO T30 (Mechanical Analysis of Extracted Aggregate).

2

2

SIGNIFICANCE AND USE

- This method is used primarily to determine the grading of materials proposed for use as aggregates or being used as aggregates. The results are used to determine compliance of the particle size distribution with applicable specification requirements and to provide necessary data for control of the production of various aggregate products. The data may also be useful in developing relationships concerning porosity and packing.
- Accurate determination of material finer than the #200 sieve cannot be achieved by use of this method alone. Therefore, AASHTO T 11 for material finer than the #200 sieve by washing should be used.

3

3

EQUIPMENT

- **Scale** – readable to 0.1% of the sample mass or better
- **Sieves**
- **Brushes** – soft and stiff brushes
- **Pans**
- **Oven**– Capable of maintaining 230 ± 9°F (110 ± 5°C)
  – A **Hot Plate** may be used

4

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- **Mechanical Shaker**
  – Check sieving thoroughness every **12 months** or **as needed** throughout the year.
    - The timer will be calibrated/verified during this process.
  – A Record of this verification will be kept in the lab's Quality Manual System (QMS).
  – See appendix for **AASHTO R 18** calibrating/verification process of mechanical sieve shakers.

Equipment 5

5

- **Brushes**
  – Varity to clean out sieves
    $\geq$ #30 sieve use a wire brush or stiff brush
    < #30 sieve use a soft bristle brush

Equipment 6

6

DEFINITIONS AND LANGUAGE

- **Nominal Maximum Aggregate Size (NMAS)**
  - For AASHTO T 27 this is defined as the smallest sieve that the specification for the material being tested allows for 100% of the material to pass.

7

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Interchangeable Words

- **Sieve Analysis** and **Gradation**
- **Weight** and **Mass**
- **Minus *(sieve #)* Material** and **Material Passing through a *(sieve #)***
  - Example: **-4 Material** = Material Passing through **#4 sieve**
- **Plus *(sieve #)* Material** and **Material Retained on a *(sieve #)***
  - Example: **+4 Material** = Material retained on a **#4 sieve**

Definitions and Language

8

8

THREE THINGS TO KNOW BEFORE SIEVE ANALYSIS

1. Sieve Condition
2. Check Sieving Thoroughness
3. Sieve Overloading

9

9

1. SIEVE CONDITION

- Check sieves for the following conditions prior to use.
  - Large Holes
  - Tears
  - Unevenly spaced wires
  - Cracks around rim
  - Bowed screens
  - Cleanliness
  - Periodically examine finer mesh sieves against a backlight or white background for damaged openings or perimeter separations; use magnified viewing if needed.

- Wash finer sieves periodically per manufacturers instructions.
- **Replace or repair any damaged sieves.**

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2. CHECK SIEVING THOROUGHNESS

- Use a snug fitting pan and cover to prevent sample loss.
- Strike side of sieve with heel of hand at a rate of **150 times per minute**, turning about **1/6 turn** every **25 strokes**.

11

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- There should not be more than **0.5 %** by mass of the total sample pass any sieve during **1 minute** of continuous hand sieving.
  - If **>0.5%** increase the time for sieving.
  - For more information see the Annex in this chapter section <u>A2 TIME EVALUATION</u>.

Sieving Thoroughness

12

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3. SIEVE OVERLOADING

- For sieves with openings **smaller than #4**, the quantity retained on any sieve at the completion of the sieving operation shall not exceed **(4g/in²)** of sieving surface area.
- For sieves with openings **#4 and greater**, the quantity retained in kg shall not exceed the product of:

  2.5 X [sieve opening, mm x (effective sieving area, m²)]

  (This quantity is shown in AASHTO T27 Table 1)

See **Table 1** on the next slide for an example of allowable amounts on an 8"diameter sieve, and 14" square sieve.

See ANNEX A1 at the end of this chapter for more information.

13

13

AASHTO TABLE 1

Maximum Allowable Quantity Of Material Retained*

Sieve Opening Size	8" Diameter Sieve	12" Diameter Sieve
2" (50 mm)	7.9 lbs (3.6 kg)	18.5 lbs. (8.4 kg)
1½" (37.5 mm)	6.0 lbs (2.7 kg)	13.75 lbs. (6.3 kg)
1" (25.0 mm)	4.0 lbs (1.8 kg)	9.25 lbs. (4.2 kg)
3/4" (19.0 mm)	3.1 lbs (1.4 kg)	7.5 lbs. (3.2 kg)
1/2" (12.5 mm)	2.0 lbs (0.89 kg)	4.7 lbs. (2.1 kg)
3/8" (9.5 mm)	1.5 lbs (0.67 kg)	3.5 lbs. (1.6 kg)
No. 4 (4.75 mm)	0.7 lbs (0.33 kg)	1.75 lbs. (0.8 kg)

**Table 1 of the current AASHTO T 27 standard shows a complete table of different size sieves of the maximum allowable quantities of material retained on a sieve.*

Sieve Overloading 14

14

- To **prevent** sieve overloading on an individual sieve, use one or more of the following methods:
  - Insert additional sieves.
  - Split sample into two or more portions, sieve each portion individually and combine the portions retained on the sieve before calculating the percentage of the sample on the sieve.
  - Use sieves having a larger frame size that provides a greater sieving area.

Sieve Overloading 15

15

SAMPLING

- Sample the aggregate in accordance with AASHTO R 90/ASTM D75.
- Thoroughly mix the sample and reduce to sample size using AASHTO R76.
- Use the Nominal Maximum Aggregate Size of the sample to determine the amount needed for testing from the MoDOT-EPG Chart on the next slide.

Note: The MoDOT-EPG Chart required amounts are different than that of AASHTO T 27.

16

16

MoDOT-EPG CHART

MoDOT Sample Sizes for Aggregate Gradation Test

Nominal Maximum Agg. Size in. (mm)	Minimum Mass of Test Sample lb. (g)
3/8" (9.5)	2.5 (1,000)
1/2" (12.5)	3.5 (1,500)
3/4" (19.0)	5.5 (2,500)
1" (25.0)	9 (4,000)
1 ½" (37.5)	13.5 (6,000)

Dried Fine Aggregate, Minimum **500** grams.

Found in the MoDOT EPG Section 1001 **17**

17

SAMPLE PREPARATION

- Dry the reduced sample to a constant mass in an oven at 230 ± 9°F (110 ± 5^0 C). A hot plate can be used – fracturing of aggregates should be avoided.

18

18

PROCEDURE
Sieve Analysis

19

19

- Weigh the dried sample and record the weight to the nearest gram. (Original Dry Mass)

Procedure – Original Dry Mass

20

20

PERFORM AASHTO T 11 (Optional)

NOTE: Test T 11 is an **option** but is generally used with T 27.

- Perform **AASHTO T 11** (Washing out the minus #200 fines from the sample).
- Dry the **washed aggregate** to a constant mass at 230 ± 9°F (110 ± 5°C).
- Allow to cool.
- Weigh the **washed dried sample** and record the weight to the nearest gram.

Note: This weight will be called the “Washed Dry Mass” on your sieve analysis worksheet.

Procedure – AASHTO T 11

21

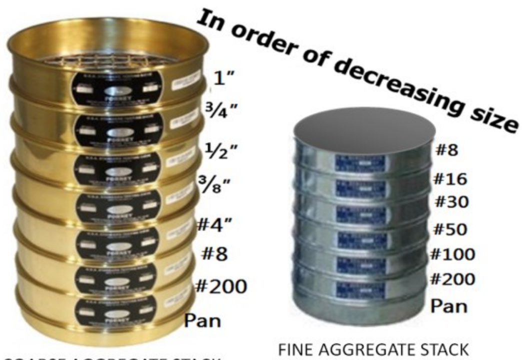
21

- Stack the sieves by assembling the required sieves in order of decreasing size.
- **NOTE:** Use of additional sieves may be added to prevent the required sieves from being overloaded.

- **NOTE:** For particles that are 3 inches and larger, use a Mechanical Screen-Shaker or Hand Sieve particles.

Procedure – Stacking Sieves **22**

22



COARSE AGGREGATE STACK

FINE AGGREGATE STACK

Procedure – Stacking Sieves **23**

23

- Carefully load the sieves by taking the dried, pre-weighed sample and pour it into the top of the sieve stack.
- Do not lose any material.
- Put the lid on top.

Note: Always include the #200 sieve, even if T11 was performed.

Procedure – Loading Sieves **24**

24

- Agitate and shake each sieve **mechanically** or **by hand** for a sufficient period, established by trial or checked by measurement on the actual test sample, to meet the criterion for adequacy of sieving.
- **Sieving Criterion**
  - Shake until **≤ 0.5%** by mass of the total sample passes during **1 minute** of continuous hand sieving.

Procedure - Agitation 25

25

- **Mechanical Sieving**: Place the stack of sieves in a Mechanical Shaker set at the calibrated/verified time. (Approximately 7-10 min)

- If the timer was not calibrated/verified,

Hand Sieve after agitation.

Procedure – Mechanical Agitation 26

26

Sieving by HAND: Shake until ≤ 0.5% by mass of the total sample passes during 1 minute of continuous hand sieving

NOTE: Do NOT force particles or manipulate them to go through the sieve openings.

Procedure – Manual Agitation 27

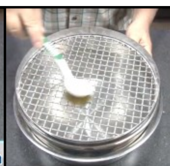
27

- **Method used to <u>check</u> mechanical shakers and hand sieving:**
  - Tap side of sieve sharply with heel of hand 150 strokes/minute, rotating 1/6 turn every 25 strokes.
  - Shake until ≤ 0.5% by mass of the total sample passes during 1 minute of continuous hand sieving.

Procedure – Check for Sieving Thoroughness **28**

28

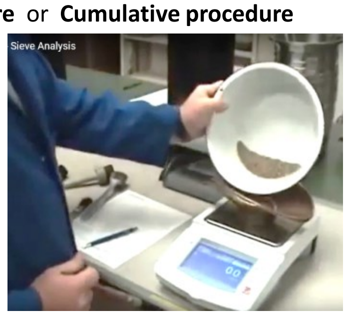
- After agitating the sample, unload and weigh the retained material on each sieve.
- Start with the largest sieve from the top of the stack and unload the retained aggregates using the appropriate BRUSH to clean out the sieves.



Procedure – Unloading and Weighing **29**

29

- Weigh and record the retained aggregates from each sieve using either the **Non-Cumulative procedure** or **Cumulative procedure**



Procedure – Unloading and Weighing **30**

30

WEIGHING - Non - Cumulative Process

- Unload each sieve fraction separately into its own individual (tared) pan.
- Weigh each pan separately and write the weight next to the corresponding sieve size on the report.
- Record to nearest 0.1 % by total mass, typically 1 gram.

For The Minus #200

- Tare out a different pan and unload the minus #200 material from the pan from the sieve nest and record the weight.

31

31

WEIGHING - Cumulative Process

- Unload the material retained on the largest sieve into a tared pan and record the weight to the nearest 0.1% of the total mass, typically 1 gram.
- ***Do not tare (zero) scale***, add material from next sieve into the same pan, record the combined weight.
- Repeat unloading and recording the combined weight until all sieves have been unloaded from the sieve stack into the same pan.

For The Minus #200

- Tare out a different pan and unload the minus #200 material from the pan from the sieve nest and record the weight.

32

32

CALCULATE AND REPORT

Depending upon the form, the material tested and the specification, the report shall include one of the following:

- Total percentage of material passing each sieve.
- Total percentage of material retained on each sieve.
- Percentage of material retained between consecutive sieves.

✓ All values for the percent passing are reported to the nearest whole number for all sieves including material passing the (No. #200) sieve for values ≥ 10%.

✓ Material passing the (No. # 200) sieve for values less than 10% , reported to the nearest tenth (0.1)%.

33

33

SIEVING ACCURACY

- **MoDOT** sieving accuracy: Sieving accuracy tolerance for sieve analysis is ±1 gram per sieve used. This can be found in the MoDOT EPG.

We will use MODOT sieving accuracy for this certification.

- **AASHTO T 27** sieving accuracy: The total mass of the material after sieving should check closely with the total original dry mass of the sample placed on the sieves. If the two amounts differ by more than **0.3%**, based on the total original dry sample mass, the results should not be used for acceptance purposes.

34

34

CALCULATIONS -NON-CUMULATIVE

Equation for all sieves:

$$\%Passing = \frac{total\ weight\ passing}{original\ dry\ weight}\ x\ 100$$

Equation for the pan (Minus #200):

$$\%\ \text{passing}\ \#200 = \frac{(T11\ loss + pan\ weight)}{original\ dry\ weight}\ x\ 100$$

Equation for T11 loss:

A = Total % passing #200
B = Original dry mass of sample
C = Dry mass of sample after washing & drying to constant mass.

$$A = \frac{(B-C)}{B}\ x\ 100$$

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CALCULATIONS - CUMULATIVE

Equation for all sieves:

$$\%Passing = 1 - \left(\frac{cumulative\ weight}{original\ dry\ weight}\right) x\ 100$$

Equation for the pan (Minus #200):

$$\%\ \text{passing}\ \#200 = \frac{(T11\ loss + pan\ weight)}{original\ dry\ weight}\ x\ 100$$

Equation for T11 loss:

A = Total % passing #200
B = Original dry mass of sample
C = Dry mass of sample after washing & drying to constant mass

$$A = \frac{(B-C)}{B}\ x\ 100$$

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Calculation of the Fineness Modulus
"FOR INFORMATION ONLY"

- Calculate the fineness modulus, **when required**, by adding the total percentages of material in the sample that are coarser than each of the following sieves (cumulative percentages retained), and dividing the sum by 100; Sieves: #100, #50, #30, #16, #8, #4, # ⅜, # ¾, # 1 ½, and larger, increasing the ratio of 2 to 1.
- Report the fineness modulus to the nearest 0.01%.

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COMMON ERRORS

- Insufficient sample size.
- Overloading sieves.
- Loss of material when transferring from sieve to weighing pan.
- Insufficient cleaning of sieves.
- Using worn or cracked sieves.
- Sieving not thorough.
- Losing material performing AASHTO T 11. (washing minus #200) prior to gradation.

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SIEVE ANALYSIS PRACTICE PROBLEMS

***We will use Mo-DOT EPG sieving accuracy for this certification.**

NOTE: At the end of the module you will find enlarged copies of the slides and blank practice sheets.

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Class Problem **1A**

Instruction and Practice

For Cumulative and Non-cumulative Sieve Analysis

Class Problem	1A
	Weighed Amounts, g
Dry Original Mass (g):	5226
(T11) Dry Washed Mass (g):	5195
37.5mm **(1½")**	
25mm **(1")**	0
19mm **(¾")**	464
12.5mm **(½")**	2304
9.5mm **(⅜")**	1162
4.75mm **(#4)**	1182
2.36mm **(# 8)**	53
1.18mm **(#16)**	
600μm **(#30)**	
300μm **(#50)**	
150μm **(#100)**	
75μm **(#200)**	26
Pan	2

40

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Non – Cumulative Process - Class Problem 1A

Enlarged

Original Dry Mass:	(A) 5226	g
(AASHTO T11) Dry Mass Washed:	5195	g
Washing Loss (Minus #200)	31	g

Sieve Size	Indiv. Sieve Weight Retd. (g)		Weight Passing (g)			Reported % Passing
25mm (1")	0	A - 0 =	5226	$\frac{5226}{5226}$	x 100 =	100
19mm (¾")	464	5226 - 464 =	4762	$\frac{4762}{5226}$	x 100 =	91
12.5mm (½")	2304	4762 - 2304 =	2458	$\frac{2458}{5226}$	x 100 =	47
9.5mm (⅜")	1162	2458 - 1162 =	1296	$\frac{1296}{5226}$	x 100 =	25
4.75mm (#4)	1182	1296 - 1182 =	114	$\frac{114}{5226}$	x 100 =	2
2.36mm (#8)	53	114 - 53 =	61	$\frac{61}{5226}$	x 100 =	1
1.18mm (#16)						
600μm (#30)						
300μm (#50)						
300μm (#50)						
150μm (#100)						
75μm (#200)	26	61 - 26 =	35			x
Pan (Minus #200)	2					x
Washing Loss (Minus #200)	31					x
Total (Minus #200)	33	= 2 + 31		$\frac{33}{5226}$	x 100 =	0.6
Total Weight Retained :	(B) 5224					
Accuracy Check = (A-B) = Less than 1/sieve?	Yes	(5226-5224) = 2 < 7				

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Non – Cumulative Process – Class Problem 1A

Enlarged

Original Dry Mass:	(A) 5226	g
(AASHTO T11) Dry Mass Washed:	5195	g
Washing Loss:	31	g

Sieve Size	Indiv. Sieve Weight Retd. (g)	Weight Passing (g)		Reported % Passing
25mm (1")	0	5226		100%
19mm (¾")	464	4762		91
12.5mm (½")	2304	2458		47
9.5mm (⅜")	1162	1296		25
4.75mm (#4)	1182	114		2
2.36mm (#8)	53	61		1
1.18mm (#16)				
600μm (#30)				
300μm (#50)				
300μm (#50)				
150μm (#100)				
75μm (#200)	26	35	x	x
Pan (Minus #200)	2			x
Washing Loss (Minus #200)	31			x
Total (Minus #200)	33	→		0.6
Total Weight Retained :	(B) 5224			
Accuracy Check = (A-B) = Less than 1/sieve?	Yes			

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Cumulative Process – Class Problem 1A

Enlarged

Original Dry Mass:	(A) 5226	g
(AASHTO T11) Dry Mass Washed:	5195	g
Washing Loss (Minus #200)	31	g

Sieve Size	Indiv. Sieve Weight Retd. (g)		Total Retained (g)		% Retained		Reported % Passing
25mm (1")	0		0		0		100
19mm (¾")	464	0 + 464 =	464	$\frac{464}{5226}$ x 100 =	9	100 – 9 =	91
12.5mm (½")	2304	464 + 2304 =	2768	$\frac{2768}{5226}$ x 100 =	53	100 – 53 =	47
9.5mm (⅜")	1162	2768 + 1162 =	3930	$\frac{3930}{5226}$ x 100 =	75	100 – 75 =	25
4.75mm (#4)	1182	3930 + 1182 =	5112	$\frac{5112}{5226}$ x 100 =	98	100 – 98 =	2
2.36mm (#8)	53	5112 + 53 =	5165	$\frac{5165}{5226}$ x 100 =	99	100 – 99 =	1
1.18mm (#16)							
600µm (#30)							
300µm (#50)							
300µm (#50)							
150µm (#100)							
75µm (#200)	26	5165 + 26 =	5191		x		x
Pan (Minus #200)	2						x
Washing Loss (Minus #200)	31						x
Total (Minus #200)	33	= 2 + 31		$\frac{33}{5226}$ x 100 =	→		0.6
Total Weight Retained :	(B) 5224	= 33 + 5191					
Accuracy Check = (A-B) = Less than 1/sieve?	Yes	(5226-5224) = 2 < 7					

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Cumulative Process – Class Problem 1A

Enlarged

Original Dry Mass:	(A) 5226	g
(AASHTO T11) Dry Mass Washed:	5195	g
Washing Loss:	31	g

Sieve Size	Indiv. Sieve Weight Retd. (g)	Total Retained (g)	% Retained	Reported % Passing
25mm (1")	0	0	0	100
19mm (¾")	464	464	9	91
12.5mm (½")	2304	2768	53	47
9.5mm (⅜")	1162	3930	75	25
4.75mm (#4)	1182	5112	98	2
2.36mm (#8)	53	5165	99	1
1.18mm (#16)			0	100
600µm (#30)			0	100
300µm (#50)			0	100
300µm (#50)			0	100
150µm (#100)			0	100
75µm (#200)	26	5191	x	x
Pan (Minus #200)	2			x
Washing Loss (Minus #200)	31			x
Total (Minus #20)	33	→		0.6
Total Weight Retained :	(B) 5224			
Accuracy Check = (A-B) = Less than 1/sieve?	Yes			

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Class Problem **2B**

Work this Gradation Out **Cumulative** And Then **Non-cumulative**

Class Problem	2B
	Weighed Amounts, g
Dry Original Mass (g):	5040
(T11) Dry Washed Mass (g):	4571

37.5mm **(1½")**	
25mm **(1")**	
19mm **(¾")**	0
12.5mm **(½")**	1150
9.5mm **(⅜")**	
4.75mm **(#4)**	1700
2.36mm **(# 8)**	1275
1.18mm **(#16)**	
600µm **(#30)**	
300µm **(#50)**	
150µm **(#100)**	
75µm **(#200)**	398
Pan	44

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Non – Cumulative Class Problem 2B — **2B**

Dry Original Mass (g): 5040 (A)
(T11) Dry Washed Mass (g): 4571
Washing Loss (g): 469

Enlarged copy at the end of module

Sieve Size	Indiv. Sieve Wt. Retained (g)	Weight Passing (g)	Reported % Passing
37.5mm (1½")			
25mm (1")			
19mm (¾")	0	5040	100
12.5mm (½")	1150	3890	77
9.5mm (⅜")			
4.75mm (#4)	1700	2190	43
2.36mm (# 8)	1275	915	18
1.18mm (#16)			
600µm (#30)			
300µm (#50)			
150µm (#100)			
75µm (#200)	398		
Pan	44		
Washing Loss (g):	469		% Passing -200
Total Minus #200	513		10
Total Weight Retained:	5036 (B)		

Modot Accuracy Check = (A-B) = Less than 1/sieve? 5040 - 5036 = 4 4 < 5 = yes **46**

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CUMULATIVE CLASS PROBLEM – 2B — **2B**

Dry Original Mass (g): 5040 (A)
(T11) Dry Washed Mass (g): 4571
Washing Loss (g): 469

Enlarged copy at the end of module

Sieve Size	Cumulative wt. Retained (g)	% Retained	Reported % Passing
37.5mm (1½")			
25mm (1")			
19mm (¾")	0	0	100
12.5mm (½")	1150	23	77
9.5mm (⅜")			
4.75mm (#4)	2850	57	43
2.36mm (# 8)	4125	82	18
1.18mm (#16)			
600µm (#30)			
300µm (#50)			
150µm (#100)			
75µm (#200)	4523		
Pan	44		
Washing Loss (g):	469		% Passing -200
=**Total Minus #200**	513		10
Total Weight Retained:	5036 (B)		

Modot Accuracy Check = (A-B) = Less than 1/sieve? 5040 - 5036 = 4 4 < 5 = yes **47**

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Fine Gradation
Class Problem 3A

Complete the sieve analysis on the blank worksheet provided using the weights listed here.
You may choose either Cumulative or Non-cumulative method.
When you are finished the instructor will check it.

CLASS PROBLEM:	**3A**
	FINE Agg Weighed Amounts, g
Dry Original Mass (g):	526
(T11) Dry Washed Mass (g):	520
37.5mm **(1½")**	
25mm **(1")**	
19mm **(¾")**	
12.5mm **(½")**	
9.5mm **(⅜")**	0
4.75mm **(#4)**	25
2.36mm **(# 8)**	60
1.18mm **(#16)**	209
600µm **(#30)**	168
300µm **(#50)**	40
150µm **(#100)**	13
75µm **(#200)**	2
Pan	1

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CUMULATIVE - Problem 1A

Updated 10/14/2020

Dry Original Mass (g): **5226** (A)

(T11) Dry Washed Mass (g): **5195**

Washing Loss (g): 31

Sieve Size	Cumulative wt. Retained (g)	% Retained	% Passing
37.5mm (1½")			
25mm (1")	**0**	**0**	**100**
19mm (¾")	0+**464** = **464**	(**464**/**5226**) x 100 = **9**	100-**9** = **91**
12.5mm (½")	464+**2304** = **2768**	(**2768**/**5226**) x 100=**53**	100-**53** = **47**
9.5mm (⅜")	2768+**1162** = **3930**	(**3930**/**5226**) x 100 = **75**	100-**75** =**25**
4.75mm (#4)	**5112**	**98**	100 - **98** = **2**
2.36mm (# 8)	**5165**	**99**	**1**
1.18mm (#16)			
600µm (#30)			
300µm (#50)			
150µm (#100)			
75µm (#200)	5165 + **26** = **5191**		
Pan (#200):	2		
+ Washing Loss (#200):	31		% Passing -200
=**Total Minus** (#200):	**33**		(**33**/A)*100=0.6
Total Weight Retained:	5224 (B)	Also add Total -200	**0.6**

NON-CUMULATIVE - Problem 1A

Dry Original Mass (g): **5226** (A)

(T11) Dry Washed Mass (g): **5195**

Washing Loss (g): 31

Sieve Size	Indiv. Sieve Wt. Retained (g)		% Passing
37.5mm (1½")			
25mm (1")	0	A - 0 = 5226	(5226/**5226**) x 100 =**100**
19mm (¾")	464	5226-464=**4762**	(**4762**/**5226**) x 100 = **91**
12.5mm (½")	2304	**4762**-2304 =**2458**	(**2458**/**5226**) x 100 = **47**
9.5mm (⅜")	1162	**2458**-1162= **1296**	(**1296**/**5226**) x 100 = **25**
4.75mm (#4)	1182	114	**2**
2.36mm (# 8)	53	61	**1**
1.18mm (#16)			
600µm (#30)			
300µm (#50)			
150µm (#100)			
75µm (#200)	26		
Pan (#200):	2		
+ Washing Loss (#200):	31		% Passing -200
=**Total Minus** (#200):	33		(**33**/A)*100=0.6
Total Weight Retained:	5224 (B)	Also add Total -200	**0.6**

Non – Cumulative Process - Class Problem 1A

Enlarged

Original Dry Mass:	(A) 5226	g				
(AASHTO T11) Dry Mass Washed:	5195	g				
Washing Loss (Minus #200)	31	g				
Sieve Size	**Indiv. Sieve Weight Retd. (g)**		**Weight Passing (g)**			**Reported % Passing**
25mm (1")	0	A - 0 =	5226	$\frac{5226}{5226}$	x 100 =	100
19mm (¾")	464	5226 - 464 =	4762	$\frac{4762}{5226}$	x 100 =	91
12.5mm (½")	2304	4762 - 2304 =	2458	$\frac{2458}{5226}$	x 100 =	47
9.5mm (⅜")	1162	2458 - 1162 =	1296	$\frac{1296}{5226}$	x 100 =	25
4.75mm (#4)	1182	1296 - 1182 =	114	$\frac{114}{5226}$	x 100 =	2
2.36mm (#8)	53	114 - 53 =	61	$\frac{61}{5226}$	x 100 =	1
1.18mm (#16)						
600µm (#30)						
300µm (#50)						
300µm (#50)						
150µm (#100)						
75µm (#200)	26	61 - 26 =	35			x
Pan (Minus #200)	2					x
Washing Loss (Minus #200)	31					x
Total (Minus #200)	33	= 2 + 31		$\frac{33}{5226}$	x 100 =	0.6
Total Weight Retained :	(B) 5224					
Accuracy Check = (A-B) = Less than 1/sieve?	Yes	(5226-5224) = 2 < 7				

Non – Cumulative Process – Class Problem 1A

Enlarged

Original Dry Mass:	(A) 5226	g		
(AASHTO T11) Dry Mass Washed:	5195	g		
Washing Loss:	31	g		
Sieve Size	**Indiv. Sieve Weight Retd. (g)**	**Weight Passing (g)**		**Reported % Passing**
25mm (1")	0	5226		100%
19mm (¾")	464	4762		91
12.5mm (½")	2304	2458		47
9.5mm (⅜")	1162	1296		25
4.75mm (#4)	1182	114		2
2.36mm (#8)	53	61		1
1.18mm (#16)				
600µm (#30)				
300µm (#50)				
300µm (#50)				
150µm (#100)				
75µm (#200)	26	35	x	x
Pan (Minus #200)	2			x
Washing Loss (Minus #200)	31			x
Total (Minus #200)	33		→	0.6
Total Weight Retained :	(B) 5224			
Accuracy Check = (A-B) = Less than 1/sieve?	Yes			

Cumulative Process – Class Problem 1A

Enlarged

Original Dry Mass:	(A) 5226	g
(AASHTO T11) Dry Mass Washed:	5195	g
Washing Loss (Minus #200)	31	g

Sieve Size	Indiv. Sieve Weight Retd. (g)		Total Retained (g)			% Retained		Reported % Passing
25mm (1")	0		0			0		100
19mm (¾")	464	0 + 464 =	464	$\frac{464}{5226}$	x 100 =	9	100 – 9 =	91
12.5mm (½")	2304	464 + 2304 =	2768	$\frac{2768}{5226}$	x 100 =	53	100 – 53 =	47
9.5mm (⅜")	1162	2768 + 1162 =	3930	$\frac{3930}{5226}$	x 100 =	75	100 – 75 =	25
4.75mm (#4)	1182	3930 + 1182 =	5112	$\frac{5112}{5226}$	x 100 =	98	100 – 98 =	2
2.36mm (#8)	53	5112 + 53 =	5165	$\frac{5165}{5226}$	x 100 =	99	100 – 99 =	1
1.18mm (#16)								
600µm (#30)								
300µm (#50)								
300µm (#50)								
150µm (#100)								
75µm (#200)	26	5165 + 26 =	5191			x		x
Pan (Minus #200)	2							x
Washing Loss (Minus #200)	31							x
Total (Minus #200)	33	= 2 + 31		$\frac{33}{5226}$	x 100 =	→		0.6
Total Weight Retained :	(B) 5224	= 33 + 5191						
Accuracy Check = (A-B) = Less than 1/sieve?	Yes	(5226-5224) = 2 < 7						

Cumulative Process – Class Problem 1A

Enlarged

Original Dry Mass:	(A) 5226	g
(AASHTO T11) Dry Mass Washed:	5195	g
Washing Loss:	31	g

Sieve Size	Indiv. Sieve Weight Retd. (g)	Total Retained (g)	% Retained	Reported % Passing
25mm (1")	0	0	0	100
19mm (¾")	464	464	9	91
12.5mm (½")	2304	2768	53	47
9.5mm (⅜")	1162	3930	75	25
4.75mm (#4)	1182	5112	98	2
2.36mm (#8)	53	5165	99	1
1.18mm (#16)			0	100
600µm (#30)			0	100
300µm (#50)			0	100
300µm (#50)			0	100
150µm (#100)			0	100
75µm (#200)	26	5191	x	x
Pan (Minus #200)	2			x
Washing Loss (Minus #200)	31			x
Total (Minus #20)	33	→		0.6
Total Weight Retained :	(B) 5224			
Accuracy Check = (A-B) = Less than 1/sieve?	Yes			

Non – Cumulative Process - Class Problem 1A

Enlarged

Original Dry Mass:	(A) 5226	g
(AASHTO T11) Dry Mass Washed:	5195	g
Washing Loss (Minus #200)	31	g

Sieve Size	Indiv. Sieve Weight Retd. (g)		Weight Passing (g)		Reported % Passing
25mm (1")	0	A - 0 =	5226	$\frac{5226}{5226}$ x 100 =	100
19mm (¾")	464	5226 - 464 =	4762	$\frac{4762}{5226}$ x 100 =	91
12.5mm (½")	2304	4762 - 2304 =	2458	$\frac{2458}{5226}$ x 100 =	47
9.5mm (⅜")	1162	2458 - 1162 =	1296	$\frac{1296}{5226}$ x 100 =	25
4.75mm (#4)	1182	1296 - 1182 =	114	$\frac{114}{5226}$ x 100 =	2
2.36mm (#8)	53	114 - 53 =	61	$\frac{61}{5226}$ x 100 =	1
1.18mm (#16)					
600µm (#30)					
300µm (#50)					
300µm (#50)					
150µm (#100)					
75µm (#200)	26	61 - 26 =	35		x
Pan (Minus #200)	2				x
Washing Loss (Minus #200)	31				x
Total (Minus #200)	33	= 2 + 31		$\frac{33}{5226}$ x 100 =	0.6
Total Weight Retained :	(B) 5224				
Accuracy Check = (A-B) = Less than 1/sieve?	Yes	(5226-5224) = 2 < 7			

Non – Cumulative Process – Class Problem 1A

Enlarged

Original Dry Mass:	(A) 5226	g
(AASHTO T11) Dry Mass Washed:	5195	g
Washing Loss:	31	g

Sieve Size	Indiv. Sieve Weight Retd. (g)	Weight Passing (g)		Reported % Passing
25mm (1")	0	5226		100%
19mm (¾")	464	4762		91
12.5mm (½")	2304	2458		47
9.5mm (⅜")	1162	1296		25
4.75mm (#4)	1182	114		2
2.36mm (#8)	53	61		1
1.18mm (#16)				
600µm (#30)				
300µm (#50)				
300µm (#50)				
150µm (#100)				
75µm (#200)	26	35	x	x
Pan (Minus #200)	2			x
Washing Loss (Minus #200)	31			x
Total (Minus #200)	33		→	0.6
Total Weight Retained :	(B) 5224			
Accuracy Check = (A-B) = Less than 1/sieve?	Yes			

Cumulative Process – Class Problem 1A

Enlarged

Original Dry Mass:	(A) 5226	g
(AASHTO T11) Dry Mass Washed:	5195	g
Washing Loss (Minus #200)	31	g

Sieve Size	Indiv. Sieve Weight Retd. (g)		Total Retained (g)		% Retained		Reported % Passing
25mm (1")	0		0		0		100
19mm (¾")	464	0 + 464 =	464	$\frac{464}{5226}$ x 100 =	8.9	100 - 8.9 =	91
12.5mm (½")	2304	464 + 2304 =	2768	$\frac{2768}{5226}$ x 100 =	53.0	100 - 53.0 =	47
9.5mm (⅜")	1162	2768 + 1162 =	3930	$\frac{3930}{5226}$ x 100 =	75.2	100 - 75.2 =	25
4.75mm (#4)	1182	3930 + 1182 =	5112	$\frac{5112}{5226}$ x 100 =	97.8	100 - 97.8 =	2
2.36mm (#8)	53	5112 + 53 =	5165	$\frac{5165}{5226}$ x 100 =	98.8	100 - 98.8 =	1
1.18mm (#16)							
600µm (#30)							
300µm (#50)							
300µm (#50)							
150µm (#100)							
75µm (#200)	26	5165 + 26 =	5191		x		x
Pan (Minus #200)	2						x
Washing Loss (Minus #200)	31						x
Total (Minus #200)	33	= 2 + 31		$\frac{33}{5226}$ x 100 =		→	0.6
Total Weight Retained :	(B) 5224	= 33 + 5191					
Accuracy Check = (A-B) = Less than 1/sieve?	Yes	(5226-5224) = 2 < 7					

Cumulative Process – Class Problem 1A

Enlarged

Original Dry Mass:	(A) 5226	g
(AASHTO T11) Dry Mass Washed:	5195	g
Washing Loss:	31	g

Sieve Size	Indiv. Sieve Weight Retd. (g)	Total Retained (g)	% Retained	Reported % Passing
25mm (1")	0	0	0	100
19mm (¾")	464	464	8.9	91
12.5mm (½")	2304	2768	53.0	47
9.5mm (⅜")	1162	3930	75.2	25
4.75mm (#4)	1182	5112	97.8	2
2.36mm (#8)	53	5165	98.8	1
1.18mm (#16)			0.0	100
600µm (#30)			0.0	100
300µm (#50)			0.0	100
300µm (#50)			0.0	100
150µm (#100)			0.0	100
75µm (#200)	26	5191	x	x
Pan (Minus #200)	2			x
Washing Loss (Minus #200)	31			x
Total (Minus #20)	33	→		0.6
Total Weight Retained :	(B) 5224			
Accuracy Check = (A-B) = Less than 1/sieve?	Yes			

CUMULATIVE Class Problem 2B

ANSWERS – 2B

Dry Original Mass (g): 5040 **(A)**

(T11) Dry Washed Mass (g): 4571

Washing Loss (g): 469

Sieve Size	Cumulative wt. Retained (g)	% Retained	% Passing
37.5mm (1½")			
25mm (1")			
19mm (¾")	0	0	100
12.5mm (½")	1150	23	77
9.5mm (⅜")			
4.75mm (#4)	2850	57	43
2.36mm (# 8)	4125	82	18
1.18mm (#16)			
600ɥm (#30)			
300ɥm (#50)			
150ɥm (#100)			
75ɥm (#200)	4523		
Pan	44		
Washing Loss (g)	469		
Total Minus #200	513		
Total Weight Retained:	5036	**(B)**	% Passing -200
			10

MoDOT Accuracy Check = (A-B) = Less than 1/sieve? 5040 - 5036 = 4 4 < 5 = YES

Non - CUMULATIVE Class Problem 2B

Dry Original Mass (g): 5040 **(A)**

(T11) Dry Washed Mass (g): 4571

Washing Loss (g): 469

Sieve Size	Individual Sieve wt. Retained (g)	Wt. passing	% Passing
37.5mm (1½")			
25mm (1")			
19mm (¾")	0	5040	100
12.5mm (½")	1150	3890	77
9.5mm (⅜")			
4.75mm (#4)	1700	2190	43
2.36mm (# 8)	1275	915	18
1.18mm (#16)			
600ɥm (#30)			
300ɥm (#50)			
150ɥm (#100)			
75ɥm (#200)	398		
Pan	44		
Washing Loss (g)	469		
Total Minus #200	513		
Total Weight Retained:	5036	**(B)**	% Passing -200
			10

8.2. Select sieves with suitable openings to furnish the information required by the specifications covering the material to be tested. Use additional sieves as desired or necessary to provide other information, such as fineness modulus, or to regulate the amount of material on a sieve to meet the requirements of Annex A1. Nest the sieves in order of decreasing size of opening from top to bottom and place the sample, or portion of the sample if it is to be sieved in more than one increment, on the top sieve. Agitate the sieves by hand or by mechanical apparatus for a sufficient period, established by trial or checked by measurement on the actual test sample, to meet the criterion for adequacy of sieving described in Annex A2.

8.3. Limit the quantity of material on a given sieve so that all particles have opportunity to reach sieve openings a number of times during the sieving operation.

8.3.1. *Prevent an overload of material on an individual sieve as described in Table A1 by one or a combination of the following methods:*

8.4. Unless a mechanical sieve shaker is used, hand sieve particles retained on the 75 mm (3 in.) by determining the smallest sieve opening through which each particle will pass by rotating the particles, if necessary, in order to determine whether they will pass through a particular opening; however, do not force particles to pass through an opening.

8.5. Determine the mass of each size increment on a scale or balance conforming to the requirements specified in Section 6.1 to the nearest 0.1 percent of the total original dry sample mass. The total mass of the material after sieving should check closely with the total original dry mass of the sample placed on the sieves. If the two amounts differ by more than 0.3 percent, based on the total original dry sample mass, the results should not be used for acceptance purposes.

ANNEX A

(Mandatory Information)

A1. OVERLOAD DETERMINATION

A1.1. Do not exceed a mass of 7 kg/m^2 (4 g/in^2) of sieving surface for sieves with openings smaller than 4.75 mm (No. 4) at the completion of the sieving operation.

A1.2. Do not exceed a mass in kilograms of the product of 2.5 × (sieve opening in mm) × (effective sieving area) for sieves with openings 4.75 mm (No. 4) and larger. This mass is shown in Table A1.1 for five sieve-frame dimensions in common use. Do not cause permanent deformation of the sieve cloth due to overloading.

Note A1—The 7 kg/m^2 (4 g/in.^{2}) amounts to 200 g for the usual 203-mm (8-in.) diameter sieve [with effective or clear sieving surface diameter of 190.5 mm (7 $^1/_2$ in.)] or 450 g for a 305-mm (12-in.) diameter sieve [with effective or clear sieving surface diameter of 292.1 mm (11 $^1/_2$ in.)]. The amount of material retained on a sieve may be regulated by: (1) the introduction of a sieve with larger openings immediately above the given sieve, (2) testing the sample in multiple increments, or (3) testing the sample over a nest of sieves with a larger sieve-frame dimension.

Table A3.1—Maximum Allowable Mass of Material Retained on a Sieve, kg

Sieve Opening Size	Nominal Dimensions of Sieve[a]				
	203.2 mm, dia[b]	254 mm, dia[b]	304.8 mm, dia[b]	350 by 350, mm	372 by 580, mm
	Sieving Area, m^2				
	0.0285	0.0457	0.0670	0.1225	0.2158
125 mm (5 in.)	c	c	c	c	67.4
100 mm (4 in.)	c	c	c	30.6	53.9
90 mm ($3^1/_2$ in.)	c	c	15.1	27.6	48.5
75 mm (3 in.)	c	8.6	12.6	23.0	40.5
63 mm ($2^1/_2$ in.)	c	7.2	10.6	19.3	34.0
50 mm (2 in.)	3.6	5.7	8.4	15.3	27.0
37.5 mm ($1^1/_2$ in.)	2.7	4.3	6.3	11.5	20.2
25.0 mm (1 in.)	1.8	2.9	4.2	7.7	13.5
19.0 mm ($^3/_4$ in.)	1.4	2.2	3.2	5.8	10.2
12.5 mm ($^1/_2$ in.)	0.89	1.4	2.1	3.8	6.7
9.5 mm ($^3/_8$ in.)	0.67	1.1	1.6	2.9	5.1
4.75 mm (No. 4)	0.33	0.54	0.80	1.5	2.6

[a] Sieve-frame dimensions in inch units: 8.0-in. diameter; 10.0-in. diameter; 12.0-in. diameter; 13.8 by 13.8 in. (14 by 14 in. nominal); 14.6 by 22.8 in. (16 by 24 in. nominal).

[b] The sieve area for round sieves is based on an effective or clear diameter of 12.7 mm ($^1/_2$ in.) less than the nominal frame diameter because ASTM E11 permits the sealer between the sieve cloth and the frame to extend 6.35 mm ($^1/_4$ in.) over the sieve cloth. Thus, the effective or clear sieving diameter for a 203.2-mm (8.0-in.) diameter sieve frame is 190.5 mm ($7^1/_2$ in.). Sieves produced by some manufacturers do not infringe on the sieve cloth by the full 6.35 mm ($^1/_4$ in.).

[c] Sieves indicated have less than five full openings and should not be used for sieve testing.

A2. TIME EVALUATION

A2.1. The minimum time requirement shall be evaluated for each shaker at least annually by the following method:

A2.1.1. Shake the sample over nested sieves for approximately 10 min.

Note A2—If the sample material may be prone to degradation, reduce the initial shaking time in Section A2.1.1 to 5 min, and begin each recheck with a new sample.

A2.1.2. Provide a snug-fitting pan and cover for each sieve and hold the items in a slightly inclined position in one hand.

A2.1.3. Hand-shake each sieve continuously for 60 s by striking the side of the sieve sharply and with an upward motion against the heel of the other hand at the rate of about 150 times per min, turning the sieve about one sixth of a revolution at intervals of about 25 strokes.

A2.2. If more than 0.5 percent by mass of the total sample before sieving passes any sieve after one minute of continuous hand sieving, adjust the shaker time and repeat Section A2.1.

A2.3. In determining sieving time for sieve sizes larger than 4.75 mm (No. 4), limit the material on the sieve to a single layer of particles.

A2.4. If the size of the mounted testing sieves makes the described sieving motion impractical, use 203-mm (8-in.) diameter sieves to verify the adequacy of sieving.

A2.5. If the mass retained on any sieve exceeds the maximum allowable mass per Table A1.1, select a different sample and repeat Section A2.

---

[1] Similar but not identical to ASTM C136-06.

Equipment Checked: **MECHANICAL SHAKERS**

Purpose:

This method provides instructions for checking the sieving thoroughness and time required to sieve a sample.

Equipment Required:

1. Stopwatch readable to 0.1s
2. Balance, readable to 0.1g
3. Appropriate sieves, pans, lids

Tolerance:

Equipment shall meet the sieving thoroughness specified in the applicable test method(s).

Procedure:

1. Obtain a well graded sample that covers the range of sieves to be used in the mechanical shaker.
2. Starting at the lower end of the estimated sieving time, run the mechanical shaker.
3. Conduct a hand check on each sieve in the stack for sieving sufficiency as follows:
   a. Hold the individual sieve, provided with a snug-fitting pan and cover, in a slightly inclined position in one hand.
   b. Strike the side of the sieve sharply and, with an upward motion against the heel of the other hand at the rate of about 150 times per minute, turn the sieve about one-sixth of a revolution at intervals of about 25 strokes.
   c. In determining the sufficiency of sieving for sizes larger than the No 4. sieve, limit the material on the sieve to a single layer of particles. If the size of the mounted testing sieves makes the described motion impractical, use 8-inch diameter sieves to verify the sufficiency of sieving.
4. Determine the sieving sufficiency according the applicable test method(s).
5. Repeat the sieving and sufficiency check procedure for at least two more sieving times.
6. The first sieving time the sufficiency check meets the tolerance should be noted as the standard sieving time for your mechanic shaker.

Considerations:

1. Certain test methods note that excessive sieve time (more than 10 minutes) to adequate sieving can result in degradation of the sample.
2. Different aggregate hardness or aggregate angularity may require different sieving times with a mechanical shaker to avoid sample degradation. Additional checks may be required using the different types encountered by the laboratory. (required if complying with C1077)
3. Overloading individual sieves with too much material during the check will result in erroneous results.

Dry Original Mass (g): ______________ **(A)**

(T11) Dry Washed Mass (g): ______________

Washing Loss (g): ______________

Sieve Size		Individual Sieve Weight Retd. (g)			% Passing
37.5mm	(1½")				
25mm	(1")				
19mm	(¾")				
12.5mm	(½")				
9.5mm	(⅜")				
4.75mm	(#4)				
2.36mm	(# 8)				
1.18mm	(#16)				
600ųm	(#30)				
300ųm	(#50)				
150ųm	(#100)				
75ųm	(#200)				
	Pan				
	Washing Loss (g)				'% Passing -200
	Total Minus #200				
	Total Weight Retained:		**(B)**		

MoDOT Accuracy Check = (A-B) = Less than 1/sieve? ________

Dry Original Mass (g): ______________ **(A)**

(T11) Dry Washed Mass (g): ______________

Washing Loss (g): ______________

Sieve Size		Individual Sieve Weight Retd. (g)			% Passing
37.5mm	(1½")				
25mm	(1")				
19mm	(¾")				
12.5mm	(½")				
9.5mm	(⅜")				
4.75mm	(#4)				
2.36mm	(# 8)				
1.18mm	(#16)				
600ųm	(#30)				
300ųm	(#50)				
150ųm	(#100)				
75ųm	(#200)				
Pan					
Washing Loss (g)					
Total Minus #200					
Total Weight Retained:			**(B)**		

'% Passing -200

MoDOT Accuracy Check = (A-B) = Less than 1/sieve? ________

Dry Original Mass (g): ______________ **(A)**

(T11) Dry Washed Mass (g): ______________

Washing Loss (g): ______________

Sieve Size	Individual Sieve Weight Retd. (g)			% Passing
37.5mm (1½")				
25mm (1")				
19mm (¾")				
12.5mm (½")				
9.5mm (⅜")				
4.75mm (#4)				
2.36mm (# 8)				
1.18mm (#16)				
600ɥm (#30)				
300ɥm (#50)				
150ɥm (#100)				
75ɥm (#200)				
Pan				
Washing Loss (g)				'% Passing -200
Total Minus #200				
Total Weight Retained:		**(B)**		

MoDOT Accuracy Check = (A-B) = Less than 1/sieve? __________

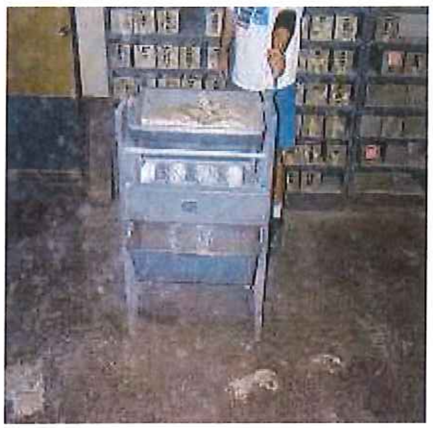
Category: 1001 General Requirements for Material – Engineering Policy Guide

1001.5 Field Testing Procedures

1001.5.1 Sieve Analysis

The frequency of aggregate Quality Assurance tests shall be in accordance with the specifications. This includes retained samples from quality control tests and independent samples. Sieve analysis of mineral filler shall be in accordance with AASHTO T37. Sieve analysis for the determination of particle size distribution of coarse and fine aggregate shall be performed in accordance with AASHTO T27 and T11, with the following exceptions.

1001.5.1.1 Apparatus



Sample being split

(a) Stove - Electric, natural gas, propane, or other suitable burner capable of maintaining a controlled temperature, may be used in lieu of an oven.

(b) Pans - Pans of sufficient size and quantity for washing and drying samples and for holding separated fractions of material.

(c) Brass sieve brush.

(d) Large spoon or trowel.

(e) Sample splitter.

1001.5.1.2 Sample Preparation

Samples of aggregate for sieve analysis shall be taken in accordance with EPG 1001.3 Sampling Procedures and reduced to the proper size for testing in accordance with ~~AASHTO T248~~ AASHTO R76. The sample for testing shall be approximately the size shown below and shall be the end result of the sampling method. The selection of samples of an exact predetermined weight (mass) shall not be attempted.

Table 1001.5.1.2 Size of Testing

Coarse Aggregate	
Maximum Size of Particle[1]	**Minimum Weight (Mass) of Sample lb. (kg)**
2" (50 mm)	20 (9)
1-1/2" (37.5 mm)	13.5 (6)
1" (25.0 mm)	9 (4)
3/4" (19.0 mm)	5.5 (2.5)
1/2" (12.5 mm)	3.5 (1.5)
3/8" (9.5 mm)	2.5 (1)
[1] Maximum size of particle is defined as the smallest sieve through which 100 percent of material will pass.	
Fine Aggregate	
Manufactured Fines and Natural Sand	500 grams

1001.5.1.3 Procedure

The sieve analysis shall be performed in accordance AASHTO T27. When determination of the minus 200 material is required, this shall be performed in accordance with AASHTO T11. A dry gradation may be run on any material where the accuracy of the sieve analysis does not require washing. The district Construction and Materials Engineer should be consulted when there is a question as to whether a dry or washed gradation should be run.

1001.5.1.4 Worksheet Form T-630R and Calculations, Passing Basis

One method for calculating gradation on a passing basis is as follows: The material that has been separated by the sieving operation shall be weighed starting with the largest size retained. This weight (mass) shall be recorded in the plant inspector's workbook on the line corresponding to the sieve on which the material is retained. Examples are given in Fig 1001.10.2 Form T-630R Example 1, page 1 and

page 2. The second largest sized material is then added to the largest size in the weigh pan and the accumulated total is recorded on the line corresponding to the sieve on which the material is retained. This operation is continued with the accumulated total being recorded on the line corresponding to the sieve on which the material is retained down to the smallest sieve, in this example, the No. 200 (75 μm) size sieve. The final quantity of material remaining in the pan (in this instance, minus No. 200 (75 μm) material) should be recorded on the line designated as "PAN." The "PAN + LOSS" is the sum of the "LOSS" from washing over a No. 200 (75 μm) sieve plus the amount retained in the "PAN". The quantity retained on the smallest sieve is then added to the quantity in the "PAN + LOSS" and is to be recorded on the line designated as "TOTAL". The "TOTAL" should equal the original dry weight (mass) within a tolerance of one gram for each sieve that the material passed through. The difference between the "TOTAL" and the "ORIGINAL DRY WEIGHT (MASS) is recorded on the line designated "DIFFERENCE". Tolerance for the sieving is plus or minus 1 gram per sieve. In the examples above, the tolerance should be equal to or less than plus or minus 5 grams (five sieves were used, beginning with the smallest sieve through which 100 percent passed). This tolerance is to be recorded on the line designated as "SIEVE ACCURACY".

The total amount of material finer than the smallest sieve shall be determined by adding the weight (mass) of material passing the smallest sieve obtained by dry sieving to that lost by washing. In the example, the amount lost by washing as recorded on the "LOSS" line was found to be 442 grams. The 7 on the "PAN" line shows that 7 additional grams were obtained in the dry sieving operation. This total quantity, 449 grams, is recorded on the "PAN + LOSS" line.

Except for the smallest sieve used, the percent passing is determined by dividing the quantity shown for each sieve by the original dry weight (mass) and subtracting the percentage from 100. The percentage passing the smallest sieve is found by dividing the quantity shown on the "PAN + LOSS" line by the original dry weight (mass). The percentage for the smallest sieve is shown on the line for that sieve.

Enter the SM Sample ID in the column next to “RECORD NO,” then enter information from Form T-630R in SM.

The following shows Form T-630R being used to record the gradation of a material produced to meet Section 1003 specifications.

FORM T-630R

PLANT INSPECTION AGGREGATE WORKSHEET

MATERIAL ______ PRODUCT OR SPEC. NO ______

FACILITY CODE ______ PRODUCER ______

PURCHASE ORDER NO. ______ PLANT LOCATION ______

CONSIGNED TO ______ LEDGE ______

DESGINATION ______

MECHANICAL SIEVE ANALYSIS

RECORD NO.											
DATE											
INSPECTOR											
ORIG/WET WT.		%		%		%		%		%	
ORIG.DRY WT.											
WASHED DRY WT.											
LOSS											
FIELD MOIST.											SPEC LIMIT
37.5 mm (1 ½")											
25 mm (1")											
19 mm (3/4")											
12.5 mm (1/2")											
9.5 mm (3/8")											
4.75 mm (# 4)											
2.36 mm (# 8)											
2.0 mm (#10)											
1.18 mm (#16)											
850 µm (# 20)											
600 µm (# 30)											
425 µm (# 40)											
300 µm (# 50)											
150 µm (#100)											
75 µm (#200)											
PAN											
PAN + LOSS											
TOTAL											
DIFFERENCE											
SIEVE ACCURACY											
TONS ACC/REJ.											
QUALITY DETERMINATION											
ORIG.WT.											
DELT											
SHALE											
CHERT											
OTHER											
TOTAL DELT											
PLASTICITY INDEX											
IN COMPUTER		☐		☐		☐		☐		☐	

REPORT DATA AND REMARKS

______

______

______

______

AASHTO T 27: Sieve Analysis of Fine and Coarse Aggregate
PROFICIENCY CHECKLIST

Applicant____

Employer____

Trial#	1	2
Fine Aggregate		
1. Reduced per AASHTO R76		
2. Minimum sample mass 500 g		
Coarse Aggregate		
1. Reduced per AASHTO R76 used sample size determined from nominal maximum aggregate size, and MoDOT' s EPG chart		
2. Sample dried to constant mass at 230 ± 9°F (110 ± 5°C), weighed to nearest 0.1% by mass (typically, 1 gram) and recorded		
- AASHTO T 11 may be performed at this point, Washing Material Finer Than No. 200 Sieve, dried to a constant mass at 230 ± 9°F (110 ± 5°C), weight recorded, and weight loss calculated to nearest whole number		
3. Stacked appropriate sieves in descending order		
4. Poured sample in the top sieve without losing material		
5. Agitated **Manually** or **Mechanically**		
- **Manual Sieving** continued until not more than 0.5% by mass of the total sample passes a given sieve during 1 minute of continuous hand sieving		
- **Mechanical Sieving** Verified annually - Timer verified/calibrated for sieving thoroughness. (Established by trial or checked by measurement on the actual test sample to meet the 0.5% criteria as in hand sieving above. (Records kept in the lab) - Set at verified/calibrated time approximately 7-10 min. - Or if timer not verified/calibrated, hand sieved afterwards for sieving accuracy		
6. Precautions taken to not overload sieves		
7. Weighed material in each sieve either by **Non-Cumulative** or **Cumulative** method		
8. Total mass of material after sieving agrees with mass before sieving to within 1 gram per sieve used (If not, do not use for acceptance testing)		
9. Percentages calculated to nearest 0.1% and reported to nearest whole number		
10. Percentage calculations based on original dry sample mass, including the passing No. 200 fraction if T 11 was used		

PASS PASS

FAIL FAIL

Examiner: ________________________________ Date: ___________

Appendix

Aggregate Technician

AT - Appendix

2023 – Thermometer List for Aggregate Technician Methods

- **<u>AASHTO T11</u>:**
    - **T11 Oven**: The thermometer for measuring the oven temperature shall meet the requirements of M339M/M339 with a range of at least 90 to 130°C (194 to 266°F) and an accuracy of ± 1.25°C (± 2.25°F) (see note 1),
        - NOTE 1: Thermometer types to use include:
            - ASTM E1 Mercury Thermometer
            - ASTM 2877 digital metal stem thermometer
            - ASTM E230/E230M thermocouple thermometer, Type J or K, Special Class, Type T any Class
            - IEC 60584 thermocouple thermometer, Type J or K, Class 1, Type T any Class
            - Dial gauge metal stem (bi-metal) thermometer

            - IEC 60584: thermocouple thermometer, Type T, Class 1

- **<u>AASHTO T27</u>:**
    - **T27 Oven**: The thermometer for measuring the oven temperature shall meet the requirements of M339M/M339 with a range of at least 90 to 130°C (194 to 266°F) and an accuracy of ± 1.25°C (± 2.25°F) (see note 3),
        - NOTE 3: Thermometer types to use include:
            - ASTM E1 Mercury Thermometer
            - ASTM 2877 digital metal stem thermometer
            - ASTM E230/E230M thermocouple thermometer, Type J or K, Special Class, Type T any Class
            - IEC 60584 thermocouple thermometer, Type J or K, Class 1, Type T any Class
            - Dial gauge metal stem (Bi-metal) thermometer

2023 – AT - Thermometer list continued . . .

- **T255 Oven**: The thermometer for measuring the oven temperature shall meet the requirements of M339M/M339 with a range of at least 90 to 130°C (194 to 266°F) and an accuracy of ± 1.25°C (± 2.25°F) (see note 1),
  - NOTE 1: Thermometer types to use include:
    - ASTM E1 Mercury Thermometer
    - ASTM 2877 digital metal stem thermometer
    - ASTM E230/E230M thermocouple thermometer, Type J or K, Special Class, Type T any Class
    - 60584 thermocouple thermometer, Type J or K, Special class 1, Type T any Class
    - Dial gauge metal stem (Bi-metal) thermometer

Glossary

Revised: 09/17/2019

Aggregate Glossary of Terms

Absorption – The increase in mass (weight) due to water contained in the pores of the material.

Air Dry Aggregate – Aggregate that is dry at the particle surface but containing some internal moisture.

Coarse Aggregate – Aggregate which is predominately larger than the #4 (4.75mm) sieve.

Combined Aggregate – Aggregate that is a blend of both coarse and fine particles.

Field Sample – A quantity of the material of sufficient size to provide an acceptable estimate of the average quality of a unit.

Fine Aggregate – Aggregate which has a nominal maximum size of the #4 (4.75mm) sieve or smaller.

Lot- A sizable isolated quantity of bulk material from a single source, assumed to have been produced by the same process (for example, a day's production or a specific mass or volume).

Maximum Aggregate Size-(*Superpave*) One size larger than the nominal maximum aggregate size.

Maximum size of Aggregate/particle – *(in specifications for aggregate)* the smallest sieve opening through which the entire amount of aggregate is required to pass.

Nominal Maximum Size – Nominal Maximum is defined as the smallest sieve which 100% of sample passes.

Oven Dry Aggregate – Aggregate that has no internal or external moisture.

Saturated Surface Dry – An ideal condition in which the aggregate can neither absorb nor contribute water. In this condition, the interior has absorbed all the moisture it can hold, but the surface is dry = No Free Moisture.

Sieve Analysis – Determination of particle size distribution (gradation) using a series of progressively finer sieves.

Test Portion - A quantity of the material to be tested of sufficient size extracted from the larger field sample by a procedure designed to ensure accurate representation of the field sample, and thus of the unit sampled.

Sieving to Completion – Having no more than 0.5 % of aggregate particles retained on any sieve after shaking which should have passed through that sieve. Percent is calculated by mass of material retained divided by the original mass.

Tare – The mass (weight) of a pan or container. Normally the balance is adjusted to a "zero" reading by moving the scale counterbalance, or in the case of electronic scales, by tapping the tare button after the pan is placed on the scale to get a zero reading.

Unit- A batch or finite subdivision of a lot of bulk material (for example, a truck load or a specific area covered).

Wet Aggregate – Aggregate containing moisture on the particle surface.

Absorption: The increase in the mass of aggregate due to water in the pores of the material, but not including water adhering to the outside surface of the particles, expressed as a percentage of the dry mass. The aggregate is considered "dry" when it has been maintained at a temperature of 110 ± 5ºC for sufficient time to remove all uncombined water by reaching a constant mass.

Bulk Specific Gravity (also known as Bulk Dry Specific Gravity): The ratio of the weight in air of a unit volume of aggregate (including the permeable and impermeable voids in the particles, but not including the voids between particles) at a stated temperature to the weight in air of an equal volume of gas-free distilled water at a stated temperature.

Bulk Specific Gravity (SSD): The ratio of the mass in air of a unit volume of aggregate, including the mass of water within the voids filled to the extent achieved by submerging in water for 15 to 19 hours (but not including the voids between particles) at a stated temperature, compared to the weight in air of an equal volume of gas-free distilled water at a stated temperature.

Apparent Specific Gravity: The ratio of the weight in air of a unit volume of the impermeable portion of aggregate at a stated temperature to the weight in air of an equal volume of gas-free distilled water at a stated temperature.

SSD – Saturated Surface Dry: The condition in which the aggregate has been soaked in water and has absorbed water into its pore spaces. The excess, free surface moisture has been removed so that the particles are still saturated, but the surface of the particle is essentially dry.

Specific Gravity – The ratio of the mass (or weight in air) of a unit volume of a material to the mass of the same volume of gas-free distilled water at stated temperatures. Values are dimensionless.