Behind the Screens: Determining the Sufficiency of Mechanical Sieving Devices

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Although it's not rocket science when it comes to shaking rocks, there is some "rock-it" science involved. Hence, there are some basic requirements you should understand when using a mechanical shaker to test aggregates according to the following standards:

- *AASHTO T 27, Standard Method of Test for Sieve Analysis of Fine and Coarse Aggregates*
- *ASTM C136, Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates*
- *AASHTO T 30, Standard Method of Test for Mechanical Analysis of Extracted Aggregate*
- *ASTM D5444, Standard Test Method for Mechanical Size Analysis of Extracted Aggregate*

How does it Work?
The shaking motion of the shaker needs to cause the aggregate particles to bounce so that all of the various faces of the individual particles will fall towards the screen at some point. The best way to accomplish this is to shake the aggregate both in a vertical and lateral motion.

Shake it, Don't Break it
Mechanical shakers can prove their worth by passing a sieving sufficiency/thoroughness check in a reasonable period of time. But what's "reasonable?" *AASHTO T 27* and *AASHTO T 30* and *ASTM C136* both state the shake time should be kept under 10 minutes. *ASTM D5444* just states that the shake time needs to be "reasonable." To be clear, an hour is not reasonable, and AASHTO re:source recommends following the 10 minute guideline of the other three methods in most cases. The methods also warn that shaking for longer lengths of time could lead to degradation of the aggregate.

Calculating and Satisfying Sufficiency Requirements
There's only one way to check for shaking sufficiency (and we'll come back to this later), but there are two different criteria for determining a satisfactory endpoint. The satisfactory endpoint for *AASHTO T 27*, *AASHTO T 30*, and*ASTM D5444* has been reached when "not more than 0.5 percent by mass of the total sample passes any sieve during one minute of continuous hand sieving." The endpoint for *ASTM C136* has been reached when "not more than one percent by mass of the material retained on any individual sieve will pass that sieve during one minute of continuous hand sieving."

Please note that you must divide by the **original total** sample mass in the calculation for the 0.5% requirement stated in *AASHTO T 27*, *AASHTO T 30*, and *ASTM D5444*. However, you must divide by the sample mass retained **on the respective sieve after mechanical shaking** in the calculation for the 1% requirement stated in *ASTM C136*. Two different equations! These calculations usually result in the *ASTM C136* requirement being the tighter requirement to meet, but this is not always the case. If you have a large amount of material retained on one particular sieve and a total sample mass that is not at least double that amount, then the 0.5% requirement of the other methods becomes the tighter requirement to meet.

Now what about this 1% requirement? Is this an absolute value or a rounded value? Do you fail this requirement if you have 1.00001% passing during the hand sieving operation, or is an actual value of 1.49% okay since it rounds down to 1%? We recommend that you evaluate the results when the next decimal place is added, i.e. the nearest 0.1% for the 1% requirement, and the nearest 0.01% for the 0.5% requirement. Thus, the 1.00001% example is acceptable (it rounds to 1.0%), but the 1.49% example is over the acceptable limit (because it rounds to 1.5%).

Hand-Shake Confirmation
And now we return to the one and only way to check for sufficiency. All four test methods tell you that you will be checking the mechanical sieving sufficiency by using a one-minute hand shake. Please keep in mind this hand shake is to be performed in sequence after the mechanical shake. It is not a parallel operation that is run on split samples. It is a single sample that is first shaken mechanically, the individual masses of material determined, and the material then being shaken manually to see how much additional material passes during the manual shake. The best way to go about doing this is to determine the masses of your sieves so you'll be able to determine the amount of material retained on those sieves by

calculation. Anything that will keep you from having to remove the material from the sieves in between the mechanical and manual shakes is preferable.

All four standards tell you to hand shake the material in the same way. Here is the language as it is found in Section 8.4 of *AASHTO T 27*:

> Hold the individual sieve, provided with a snug-fitting pan and cover, in a slightly inclined position in one hand. 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. In determining sufficiency of sieving for sizes larger than the 4.75-mm (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 sieving motion impractical, use 203-mm (8 in.) diameter sieves to verify the sufficiency of sieving.

This description of how to perform the hand shake should be included in your shaker sufficiency check procedure. There's the saying "different strokes for different folks," but for moving aggregates, you should use only use one.

Types of Aggregate in *ASTM C1077*

Laboratories that need to conform to the requirements of *ASTM C1077, Standard Practice for Agencies Testing Concrete and Concrete Aggregates for Use In Construction and Criteria for Testing Agency Evaluation*, have an additional concern. *ASTM C1077* requires these labs to establish a shake time "for each different type of aggregate tested." Although shake times need to be established for both coarse and fine aggregates, "type" here refers to material shape and composition. Here is the wording of *ASTM C1077* in Note 3:

> Different types of aggregate refer to shape and composition, not supplier. For example, agitation periods for elongated materials may need to be extended, while softer materials that break down easily may require a shorter period to minimize alteration of the particle size distribution.

This requirement includes two components: (1) labs that test more than one type of aggregate will need to perform multiple sufficiency checks; and (2) the type of aggregate being tested needs to be identified on the sieving sufficiency check records. If you have two types of material being tested in your lab, and both types are shaken on two different mechanical shakers, you should be performing four sufficiency checks each year.

Additional Considerations

Don't overload the sieves. The overload requirements for *AASHTO T 30* and *ASTM D5444* are tighter than those for*AASHTO T 27* and *ASTM C136*, so pay attention to these differences. You can look to Table 1 of *AASHTO T 27*and *ASTM C136* for their specified load limits. For *AASHTO T 30* and *ASTM D5444*, here is a convenient table for their load limits for 8-in and 12-in diameter sieves:

Sieve	Opening Size in mm	Mass in grams for 8-in Diameter	Mass in Grams for 12-in Diameter
< #4	< 4.75	200	438
#4	4.75	385	867
1/4 in.	6.3	510	1149
3/8 in.	9.5	770	1734
1/2 in.	12.5	1013	2281
3/4 in.	19.0	1539	3468

Make sure the initial total sample mass agrees with the post-mechanical-shake cumulative mass. Once again, we have two different requirements. *AASHTO T 27* and *ASTM C136* require that the two masses agree with each other to within 0.3% of the initial total sample mass, and *AASHTO T 30* and *ASTM D5444* require that the two agree to within 0.2% of the initial total sample mass. If the post-shake cumulative mass is larger, you might have used sieves that weren't cleaned out well enough. If the post-shake mass is smaller, your sieve shaker might be losing material. This is a sign that the shaker requires some maintenance —bring a wrench! In either case, you'll want to start over. We recommend treating these percentages as absolute values for the same reason mentioned when discussing the sieving sufficiency requirements.

What about a Wash?

Occasionally, we have seen some laboratories that believe it is necessary to hand wash the aggregate before performing a mechanical shaker sufficiency check. We're not convinced that washing the aggregate prior to performing a mechanical shaker sufficiency check is necessary. Including a wash will certainly have the effect of allowing more to pass each sieve before a "failure" is noted for *AASHTO T 30* or *ASTM D5444*. But if you pass the sufficiency test without performing a wash, you are most likely conforming to a stricter requirement. So feel free to skip

the wash as part of your annual check of the shaker sufficiency unless experience with your materials and equipment, or if other standards and/or specifications dictate otherwise.

Check Procedure and Check Records

Does your written procedure for checking the sieving sufficiency for your mechanical shakers cover all of these concerns? Take a look at it! Does it include the equipment needed to perform this check? Does it have enough detail so that two different people can read the procedure and perform the check in the same way?

What about your completed records? Do they include all of the relevant information? Are all the requirements noted in Section 6.1.5 of *AASHTO R 18, Establishing and Implementing a Quality Management System for Construction Materials Testing Laboratories*, included?

If you think your procedure and records may be incomplete, feel free to compare them to the example documents we created (see links below). Keep in mind that AASHTO re:source is not in the business of creating spreadsheets for laboratories to use as part of their QMS – so please make sure that you have your own form and only use this for comparisons and problem-solving purposes.

Example Documents:

Note: The check record provided below includes a place for wash results. If you will not be performing a wash as part of your check, but you would like to use this form for comparisons, just make sure both sample masses in Row 20 are the same. The form is protected so you don't accidentally erase a formula.

Mechanical Sieve Shaker Check Procedure
Mechanical Sieve Shaker Check Record

References

- AASHTO, "AASHTO R 18, Standard Practice for Establishing and Implementing a Quality Management System for Construction Materials Testing Laboratories," *Standard Specifications for Transportation Materials and Methods of Sampling and Testing*, Part 1B: Specifications, 2013.
- AASHTO, "AASHTO T 27, Standard Method of Test for Sieve Analysis of Fine and Coarse Aggregates,"*Standard Specifications for Transportation Materials and Methods of Sampling and Testing*, Part 2A: Tests, 2013.
- AASHTO, "AASHTO T 30, Standard Method of Test for Mechanical Analysis of Extracted Aggregate,"*Standard Specifications for Transportation Materials and Methods of Sampling and Testing*, Part 2A: Tests, 2013.
- ASTM International, "ASTM C136, Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates,"*Book of Standards*, Volume 04.02, 2006.
- ASTM International, "ASTM D5444, Standard Test Method for Mechanical Size Analysis of Extracted Aggregate," *Book of Standards*, Volume 04.03, 2008.
- ASTM International, "ASTM C1077, Standard Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation," *Book of Standards*, Volume 04.02, 2013(b).