

MECHANICAL SHAKER TIME AND SIEVING EFFICIENCY DETERMINATIONS

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Over agitation and improper testing techniques for aggregate can lead to degraded aggregate samples and improper test results. To many technicians disbelief, ASTM C136 and AASHTO T27 do not specify how long a mechanical shaker's timer should be set in order to accomplish proper agitation. In order to understand the proper use of mechanical shakers, we must first explain the reasons for using this equipment.

Mechanical shakers are not mandatory equipment for performing particle size analyses. The use of mechanical shakers is primarily for the benefit of the individual testing the material and not the results. Gradation specifications state the required limits for determining when a sample is properly separated. In ASTM the material must not have more than 1.0% passing any sieve in 1 minute of continual hand sieving. In AASHTO the material must not have more than 0.5% passing in 1 minute of continual hand sieving. Hand sieving is defined as follows:

The sieve in question should be placed over an unused pan and covered. The side of the sieve shall be struck with an upward motion using the palm of the hand. The sieve is struck at a rate of 150 blows per minute. Each 25 blows the sieve is rotated 1/6th of a turn.

Therefore, the limitations for gradation are base upon hand sieving specifications and not equipment. These limits are often referred to as refusal conditions.

Mechanical shakers are utilized to minimize the amount of physical labor that the technician must perform in order to meet the refusal requirements. By using a mechanical shaker, the technician is not required to hand sieve for the entire period necessary for all of the material to reach the refusal condition. This can be a great time saver for laboratories performing many gradations each day. However, utilizing mechanical equipment in lieu of hand sieving can also have detrimental effects such as degradation.

Performing a gradation by hand differs from performing a gradation using a mechanical shaker in that, when hand sieving you can stop the agitation process as soon as the refusal conditions are met. Mechanical shakers are controlled with a timer and will continue to agitate the material even after the refusal conditions are met. The only comment that both the ASTM and the AASHTO specifications make in reference to agitation times for mechanical shakers is that longer than 10 minutes may result in degradation of the material. When you consider that these are National specifications, you begin to realize that this may or may not be a conservative value. For example, if this time is based on a National average for aggregate durability, then in some areas of the country with harder materials it may be well beyond 10 minutes before degradation would take place. Conversely, in some areas of the country with softer materials, such as Florida, it will be less than 10 minutes before degradation will take place. In fact, based upon test data analyzed over the last 4 years, 10 minutes is too long an agitation time for some Florida limestone aggregates.

So how long do you run your mechanical shaker? This is not an easily answered question. The amount of time that you run your shaker is directly linked to the refusal requirements for gradations. One of the primary reasons for using a mechanical shaker is so you don't have to hand sieve each sample. However, in order to be able to bypass the hand sieving requirements, you must prove that the mechanical shaker is performing to the refusal specifications. The mechanical shaker must agitate the material until it meets the 1.0% or 0.5% passing specification when compared to a hand sieved sample. The hazard is that if the mechanical shaker is allowed to run for that time period, it may exceed the amount of time it takes for degradation to begin.

The first test that must be performed is to determine the time required for degradation to begin, if at all. In order to obtain data for this test it will be necessary to have a sample of aggregate. Since the result obtained should be a conservative value, the aggregate that you select for this test should be the softest material available in your area. Note it is always possible to test even softer material than was selected for this determination. Be aware that this determination may have to be repeated for significantly different type of materials.

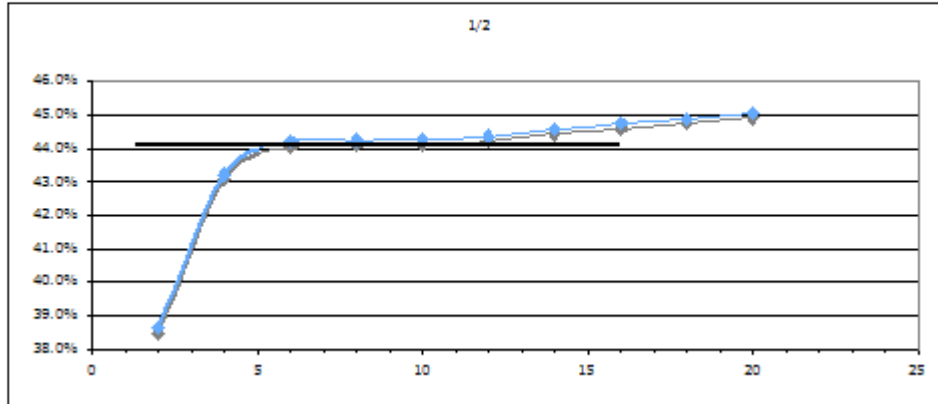
Place the material in the stack of sieves and set the timer on the mechanical shaker for a specified time interval (t). For example 2 minutes. Run the mechanical shaker for the timed interval. Remove the material from each sieve without hand sieving and weigh individually. Return the material to the stack of nested sieves and set the timer on the mechanical shaker for 2t. For example 4 minutes. Repeat the weighing operation. Repeat the agitation operation for 3t, 4t, 5t, 6t, 7t, 8t, 9t, and 10t. Graph the weight retained for a selected sieve containing the most material.

Time Period (min)	2	4	6	8	10	12	14	16	18	20
Sieve	Weight Retained									
1	1000	990	989	989	987	987	980	975	970	965
3/4	3500	3400	3395	3394	3393	3393	3380	3360	3340	3320
1/2	9000	8100	7890	7880	7879	7879	7870	7850	7820	7790
3/8	3700	4400	4610	4615	4616	4616	4610	4620	4630	4640
4	2300	2550	2551	2551	2552	2552	2560	2570	2580	2590
8	1500	1530	1531	1532	1532	1532	1550	1560	1570	1580
pan	1000	1030	1034	1039	1041	1041	1050	1065	1090	1115

As can be seen from the graph, there is not much benefit gained from agitating the material beyond 6 minutes. In an analysis of the data below, inspect the amount of material passing each sieve. As can be determined, the amount of material retained on each sieve stabilizes at 6 minutes.

Time Period (min)	2	4	6	8	10	12	14	16	18	20
Sieve	% Passing									
1	95.5%	95.5%	95.5%	95.5%	95.5%	95.5%	95.5%	95.6%	95.6%	95.6%
3/4	79.5%	80.0%	80.1%	80.1%	80.1%	80.1%	80.1%	80.2%	80.2%	80.3%
1/2	38.6%	43.2%	44.2%	44.3%	44.3%	44.4%	44.6%	44.8%	44.9%	45.1%
3/8	21.8%	23.2%	23.3%	23.3%	23.3%	23.4%	23.6%	23.8%	24.0%	24.2%
4	11.4%	11.6%	11.7%	11.7%	11.7%	11.8%	12.0%	12.2%	12.3%	12.5%
8	4.5%	4.7%	4.7%	4.7%	4.7%	4.8%	5.0%	5.1%	5.2%	5.3%
pan	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Based on this example, the timer on the mechanical shaker can be set anywhere from 6 minutes until about 12 minutes. Degradation is the point at which further agitation changes the result by more than 0.5%. As can be seen from the % passing table, degradation effects the result by 0.5% at about 15 minutes.



Now that the agitation time has been identified, the sieving efficiency at that time must be verified. There are a number of ways to verify sieving efficiency. I feel the most simplistic is by verifying the efficiency by hand sieving the sample after agitation to verify the refusal requirements have been met.

Place a sample of known mass in the stack of sieves and agitate for the determined time period. After the shaker has completed the time, hand sieve each individual sieve to verify that the amount passing in 1 minute of hand sieving is not greater than the specified 1% or 0.5%.

If the results differ by more than the refusal requirements, increase the agitation time and repeat the verification. The agitation time may be increased up to the point of degradation as determined by the previous procedure.

Once the appropriate agitation time has been selected, it must be verified annually by performing this sieving efficiency determination at the selected time.