Sieves: Making the Grade, Part I

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Sieves come in many shapes and sizes and are used for a variety of materials. The purpose of putting a sieve to good use is always the same; separating particles into size fractions. You are probably familiar with sieving in some capacity – we use the process every day, sometimes without even realizing it! Whether you are sifting flour for a cake, panning for gold, drying your laundry, making coffee, or even checking to see if your carry-on luggage will fit in an overhead storage bin, you are sieving. Congratulations. Even your fingers can act as a sieve! Have you ever filtered through a handful of sand to find a sea shell or a lost piece of jewelry? Your fingers act as particle barriers, letting the smaller pieces of sand pass through, leaving the precious shells in your hand.

Okay, okay, *technically* you are not sieving (using a wire cloth mounted in a frame), but you *are* performing a size fractionation. That's the whole point, right?

While I could write a book about the importance of sieving your baking ingredients, the main focus of this article is construction materials testing sieves. Depending on the type of work you do, you are probably familiar with a certain suite of sieving equipment. In an asphalt cement testing lab, you might encounter a few 3-inch diameter fine mesh sieves. If you work at a quarry, you might be responsible for a screen that is nearly twenty feet long! Regardless of the equipment varietal you employ, sieve use can open a Pandora's Box of issues.

This article will focus on some introductory terminology, usage of ASTM test methods versus in-house procedures, physical requirements of sieves, and tips on maintaining your sieves in good working condition.

Terminology

To understand the requirements of sieves themselves - calibration, maintenance, and usage - we have to get on the same page with vocabulary. The following terms are definitions adapted from discussions in the three testing standards listed in the "Literature" portion of this article.

compliance test sieve– a test sieve manufactured using sieve cloth which has been inspected prior to being mounted in the sieve frame. The standard deviation of the measurements of the required number of measured openings (*ASTM E11*, Table 1, Column 7) cannot exceed the requirements listed Column 8. The confidence level is 66%. Compliance sieves are commonly used in construction materials testing. [To learn more about confidence levels, read "Measurement Uncertainty for Hillbillies."]

inspection test sieve– a test sieve manufactured using sieve cloth which has been inspected after being mounted in the sieve frame. The standard deviation of the measurements of the required number of measured openings cannot exceed the requirements listed in *ASTM E11*, Table 1, Column 10 to a confidence level of 99 %.

calibration test sieve– a test sieve manufactured using sieve cloth which has been inspected after being mounted in the sieve frame. The standard deviation of the measurements of the required number of measured openings cannot exceed the requirements listed in E11 Table 1, Column 12 to a confidence level of 99.73 %.

aperture size– the dimension defining an opening in a screening surface (Figure 1).

margin or border– an unperforated area located along the perimeter of a plate.

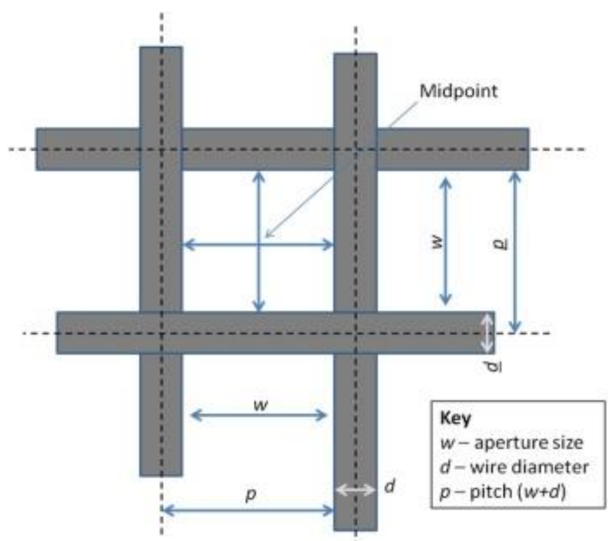

Figure 1

mesh– the number of wires or openings per linear inch (25.4 mm) counted from the center of any wire to a point exactly 1 in. (25.4 mm) distant, including the fractional distance between either thereof.

> *Example*: We call a sieve with 75 µm openings a "No. 200 mesh" because it has 200 openings per inch.

maximum size– The smallest sieve through which 100 percent of the aggregate sample particles pass. Superpave defines the maximum aggregate size as "one sieve larger than the nominal maximum size."

nominal maximum size– The largest sieve that retains some of the aggregate particles but generally not more than 10 percent by weight. Superpave defines nominal maximum aggregate size as "one sieve size larger than the first sieve to retain more than 10 percent of the material."

warp wires– wires running the long way of the cloth as woven.

shute wires– wires running the short way of, or across the cloth, as woven. (These are also known as shoot, fill, or weft wires.)

plain weave– sieve cloth in which the warp wires and shute wires pass over one and under one in both directions.

twill weave– sieve cloth in which the warp wires and shute wires pass over two and under two wires in both directions.

Literature

Whether you are part of a big or small laboratory, public or private, you need to have a way to check and standardize your sieves. While Part 2 of this article will cover specific requirements, I will try to familiarize you with some of the documents and resources you might find useful in the interim.

ASTM E11

Many test methods requiring sieves often reference *ASTM E11*. There is a reason for that. *ASTM E11, Standard Specification for Woven Wire Test Sieve Cloth and Test Sieves* contains diagrams, useful charts, and requirements for different kinds of sieves. This standard is often referenced by laboratories in their quality system as their procedure to check sieves. It is important to note the requirements of *ASTM E11* Table 1, columns 9 and 11. These columns state how many openings must be measured on inspection and calibration sieves in order to be in compliance. For most construction materials applications, checking this number of openings on an annual basis is excessive. In actuality, the requirements of this standard are intended for manufacturers, and not necessarily the end-user. For this reason, many labs prefer to write their own check procedure that includes the measurement and recording of fewer openings, as well as a visual inspection. This practice is acceptable by the requirements of *AASHTO R 18, Establishing and Implementing a Quality Management System for Construction Materials Testing Laboratories*. Just be careful; AASHTO re:source and CCRL assessors will compare your procedures to your records to ensure you are following the steps outlined in the procedure that is in *your* quality manual!

Table 1 of *ASTM E11* contains a lot of information. Perhaps some of the most relevant information is in columns 4 and 5. Column 4 lists the maximum average deviation from the opening. This means that the average of each aperture opening must fall between column 1 ± column 4. Column 5 contains the absolute maximum variation for any individual opening, resulting in column 6, which is the value of the maximum allowable individual opening. If any one aperture opening exceeds the value in column 6, your sieve is no longer in compliance.
Tip: Use the values in column 4 in your own check procedure, rather than referencing ASTM E11.

ASTM E2427

Another, less ubiquitous test standard is *ASTM E2427, Standard Test Method for Acceptance by Performance Testing for Sieves*. You are probably more familiar with the contents of this test method than you think. This is the test method that outlines how to determine the percent difference between a reference sieve and a testing sieve using reference material. Using this test method is an excellent way to check the sufficiency of your mechanical shaker, call attention to a poorly performing sieve, and to standardize multiple sets of sieves against a master set.

ASTM E1638

Are you confused by all of this new language yet? Check out *ASTM E1638, Standard Terminology Relating to Sieves, Sieving Methods, and Screening Media*. This standard is a list of definitions covering terms used in other standards and procedures. *ASTM E1638* is useful for getting everyone on the same page and avoiding confusing slang when communicating with people in other industries.

What to Look for

So you're in the market for some sieves, eh? Buying sieves is sort of like buying a car. Will you use it for hauling heavy loads or just zipping around? What kinds of features do you need? How much can you afford? Here are a few questions to consider:

What materials are you working with?

Do you process a lot of aggregate on a daily basis or do you mostly deal with soils? What about asphalt binder? If you're using a variety of materials, it's likely that you will have to buy multiple sets of sieves. Coarse aggregate processing will beat up fine sieves, so invest in a large box mechanical shaker to separate large samples. If you're mostly processing soils with particle sizes smaller than a No. 4 sieve for physical tests, 12-inch or 8-inch should do the trick. If you're sieving asphalt binder or emulsions, a 3-inch screen will work just fine. In addition, decide if you want shallow or deep sieves. Deeper sieves can be useful if you use your sieves as part of a wet-sieving procedure. Shorter sieves can allow more sieves to be used in a single stack while still fitting into a mechanical shaker properly.

What kind of work are you doing?
Does it require a high degree of precision? What about cross-contamination? For most construction materials testing applications, compliance sieves are perfectly acceptable. If you're doing highly sensitive testing, an inspection or calibration sieve that has a lower degree of uncertainty may be more appropriate for your application. What about the material? Most round sieves are either brass or stainless steel. Brass has a tendency to oxidize and hold on to particles, and is a bit more malleable than stainless steel. Stainless steel is a more robust metal and will stay cleaner longer than brass. Stainless steel sounds like a no-brainer, but…

How much money do you have to spend?
Due to the rough nature of most construction materials (compared to food particles, for example), sieves have a relatively short life-span. This means you will either need to take *really* good care of your sieves, or not invest so heavily that you can't afford to buy a new sieve here and there. Inspection and calibration sieves are vastly more expensive than compliance sieves, and a set of stainless steel sieves can cost 50 – 70% more than brass sieves. If you have a lot of money to invest, it might be worth it to have one master set of high-precision, stainless steel sieves that you use to standardize other sieves sets.

In the end, it's all up to you what kind of investment you want to make. There's no one right answer to what kind of sieves you should buy, as long as you are maintaining your sieves and keeping up with required documentation.

Are your sieves making the grade?
Compliance sieves are most commonly used by testing laboratories to grade and prepare materials. These sieves shall be verified using either an inspection sieve or compliance sieve. According to *ASTM E11*, each compliance test sieve shall include the following information:

1. "Test Sieve"
2. "ASTM E11"
3. Name of the manufacturer or distributor
4. Test sieve designation (from Table 1, column 1 of *ASTM E11*)
5. Unique serial number permanently marked on the sieve frame, sieve skirt, or nameplate
6. Grade designation (optional)
7. Alternative test sieve designation (From Table 1, column 2 of *ASTM E11*) (optional)

In addition to these requirements, it is important to make sure that your sieves are in good working order. Some things to keep an eye out for are clogged screens, dry-rotting mounting resin, and abused walls.

Clogged Screens
To check for a clogged screen, hold one sieve up to the light. Can you see through it pretty clearly? Good! You're doing a fine job of removing particles after each gradation. Having trouble seeing through your screen? This means that your screen is clogged with material from a lifetime of sieving and not thoroughly removing all of the particles. This can impact the effectiveness of your sieves, since each newly introduced particle won't necessarily have access to all of the screen openings. Additionally, it is possible that you might get a higher percent retained for a sieve if some of the stuck particles come loose while you are extracting your intended material.

Dry-Rotting Resin
Dry-rotting resin used to hold mesh in place in some sieves can get particles stuck in it. Depending on the extent of the rot, you may even have particles pass through a crack into the sieve below. One way to avoid this is to keep your sieves at room temperature, and replace or repair any sieve or resin as soon as the resin begins to deteriorate.

Abused Walls
How often have you had to get a screw driver and really pry your sieves apart? Too often? Me too. In addition to maintaining proper screens, you have to make sure the brass or stainless steel walls are in good condition. Over a lifetime of gradations the walls get banged, deformed, and oxidized, resulting in difficulty combining and separating sieve stacks. Material can be lost through a gaping deformation in a sieve skirt, or accidentally be flung out while

trying to separate one sieve from another. Make sure you are gentle with the malleable metal frames and get them repaired or replaced when they become deformed. This also applies to pans and lids.

You can look forward to my next post, "Sieves: Making the Grade, Part 2." This article will focus on sieve calibration (requirements for *AASHTO R 18* and AASHTO re:source, where opening dimensions come from, go no-go gauges) and use with a mechanical shaker.

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