TECHNICAL NOTE

Understanding Porometer versus AOS Testing of a Geotextile

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This technical note focuses on the use of ASTM D6767 - *Test Method for Pore Size Characteristics of Geotextiles by Capillary Flow Test* versus ASTM D4751 - *Test Method for Determining Apparent Opening Size of a Geotextile*.

ASTM D6767 - *Test Method for Pore Size Characteristics of Geotextiles by Capillary Flow Test* was first adopted as an ASTM Standard in 2002. The standard has gone through revision and updates in 2008, 2011, 2014 and most recently in 2016 (ASTM D6767-16). ASTM D4751 - *Test Method for Determining Apparent Opening Size of a Geotextile* was first adopted as an ASTM Standard in 1999, the standard has also gone through several revisions and updates in 2004, 2012 and 2016 (ASTM D4751-16).

As an original manufacturer of geosynthetic products, TenCate Geosynthetics takes quality control (QC) very seriously. This includes GAI-LAP Accredited laboratories at our manufacturing facilities for QC testing. TenCate Geosynthetics QC department continually looks to use the most efficient, accurate and precise test methods for quality control testing of geosynthetic products. This includes testing for determining the opening size of geotextiles. To such end, TenCate Geosynthetics now tests the opening size of geotextiles using ASTM D6767. This test method provides geotextile properties used to select the correct geotextile to meet the filtration requirements relative to the project soil properties using porometer testing. An authoritative examination of the test methods used to determine the filtration capacity of geotextiles and the accuracy of their test data is presented in White Paper #31 from the Geosynthetic Institute (Koerner, 2014)

White Paper #31

How do the tests differ?

ASTM D4751 Test Method for Determining Apparent Opening Size (AOS) measures the largest apparent pore diameter in a geotextile. The test method allows for two test methods to determine this value, Method A – Glass Bead Dry Sieving and Method B – Capillary Porometer. The summery of these test methods as written in the standard is as follows:

4.1 Glass Bead Dry-Sieving Method A – *A geotextile specimen is placed in a sieve frame and specifically sized glass beads are placed on the geotextile surface. The geotextile and frame are shaken laterally so that the jarring motion will induce the beads to pass through the test specimen. The procedure is repeated on the same specimen with various size glass beads until its apparent opening size has been determined.*

4.2 Capillary Porometer, Method B - *is performed by subjecting a geotextile specimen to an air flow test where air flow and pressure are measured. The same specimen is then wetted with a mineral oil and subjected to an increasing air pressure while measuring the resulting flow rate. The opening sizes are calculated from this data using standard capillary theory and the specific algorithm defined in these test methods.*

This AOS test method provides only one opening size value called the 0_{95} of the material; a pore size distribution is not outlined in this test method.

While this test is not completely destructive, setting the fabric in the sieve can lead to inaccurate results due to distortion of the sample from over handling, particularly with some woven geotextiles. The test does not have the ability to distinguish between material defects such as a single larger hole that does not necessarily reflect the properties of the material or the product characteristics.

Using the glass bead sieving of Method A has some limitations of testing. The most obvious issue encountered in the AOS test is the high probability of smaller sized test beads passing through larger sized openings in the fabric, rather than passing through the openings that are the same size as the specific test bead diameter. Additionally, the bead sizes are stepped so the opening size can only be reported in increments following the bead sizes (Standard US Sieve sizes). Other AOS testing problems with dry sieving glass beads include: fracturing of glass beads; electrostatic effects that cause testing beads to stick together (causing smaller beads to behave like larger beads); and beads becoming trapped in the material from friction (this is particularly true with the smaller diameter glass beads). With so many potential challenges with the Method A test method, TenCate Geosynthetics has decided to use Method B for determining the pore size of geotextiles. Method B accurately and precisely provides the geotextile opening size information. It also allows for the flexibility of determining the range of pore size characteristics as outlined in ASTM D6767.

ASTM D6767 Test Method for Pore Size Characteristics of Geotextiles by Capillary Flow Test is a test method in which a wetting fluid is used to saturate the pores of the geotextile test sample, followed by a non-reacting gas that displaces the fluid from the geotextile pores. To perform the test, a geotextile sample is cut and placed into the chamber of the test device. The porometer forces air through the dry sample, taking measurements at different valve position increments (cc/min or l/min) and at varying pressures (psi, kPa). When the maximum predetermined pressure or flow rate is reached, the testing device resets, readying for the second phase of the test. Next, the geotextile sample is saturated with a wetting fluid with a known surface tension and subjected to another series of pressure and flow rate measurements. The raw data from these measurements are run through a series of calculations to determine the minimum, maximum and mean pore size, filter flow percentage (comparable to permeability, and can be used to calculate retention values such as O_{95}), and pore size distribution.

What does Porometer testing provide?

The Porometer test method is not limited to a single opening size and will measure opening values between O_5 and O_{98}. Each test has a range of opening sizes which are reported as an average for a sample. One would have to run countless AOS tests to provide the same amount of information provided from one porometer test, but the test comparison is impractical because the AOS test only measures O_{95}. Using the values obtained for the Porometer testing of the geotextile, one can accurately predict the way the material will perform during both AOS testing and water flow testing (ASTM D4491).

Porometer test method defines a material's drainage and filtration characteristics (information not provided by AOS method). The Porometer test method is also more accurate.

To highlight the improved information that the porometer testing can provide, we have compared the data of several geotextiles (in Table 1, below). Utilizing porometer test data generated in 2010/2011 for Mirafi® HP370, HP570 and RS580i, the AOS and Water Flow for these products could be predicted. Table 1 indicates RS580i has larger pore openings and that there are fewer large pore openings compared to HP370 and HP570. RS580i also has a more uniform pore distribution within the 30μm - 250μm range which attributes to RS580i having a higher hydraulic flow rate.

Table 1

	Pore Size O50 ASTM D6767 microns	Pore Size O95 ASTM D6767 microns	Water Flow ASTM D4491 gpm/ft²	AOS ASTM D4751 US Sieve	Pore Distribution ASTM D6767 30 μm - 250 μm
RS580I	185	350	100	50	2.96
HP370	165	325	55	40	6.86
HP570	185	355	50	40	12.6

All values are typical

The ability for the Porometer test to predict a geotextile's test results from AOS and Water Flow testing is an indication of the Porometer test's ability to predict a geotextile's soil retention ability and permeability requirements in the field. While the AOS does have an application for use in geotextile manufacturing QC/QA testing, Porometer testing provides much more in-depth information about a geotextile without suffering from the limited information and testing problems encountered using the AOS test.

A graphical representation of the data obtained from both Porometer testing and AOS testing on Mirafi® RS580i is shown in Figure 1. The typical pore size distribution curve for RS580i can be related to its filtration capacity for a candidate soil much more accurately than a single AOS value. TenCate Geosynthetics is currently developing soil filtration guidance that will utilize the pore size distributions of our geotextiles determined from Porometer testing.

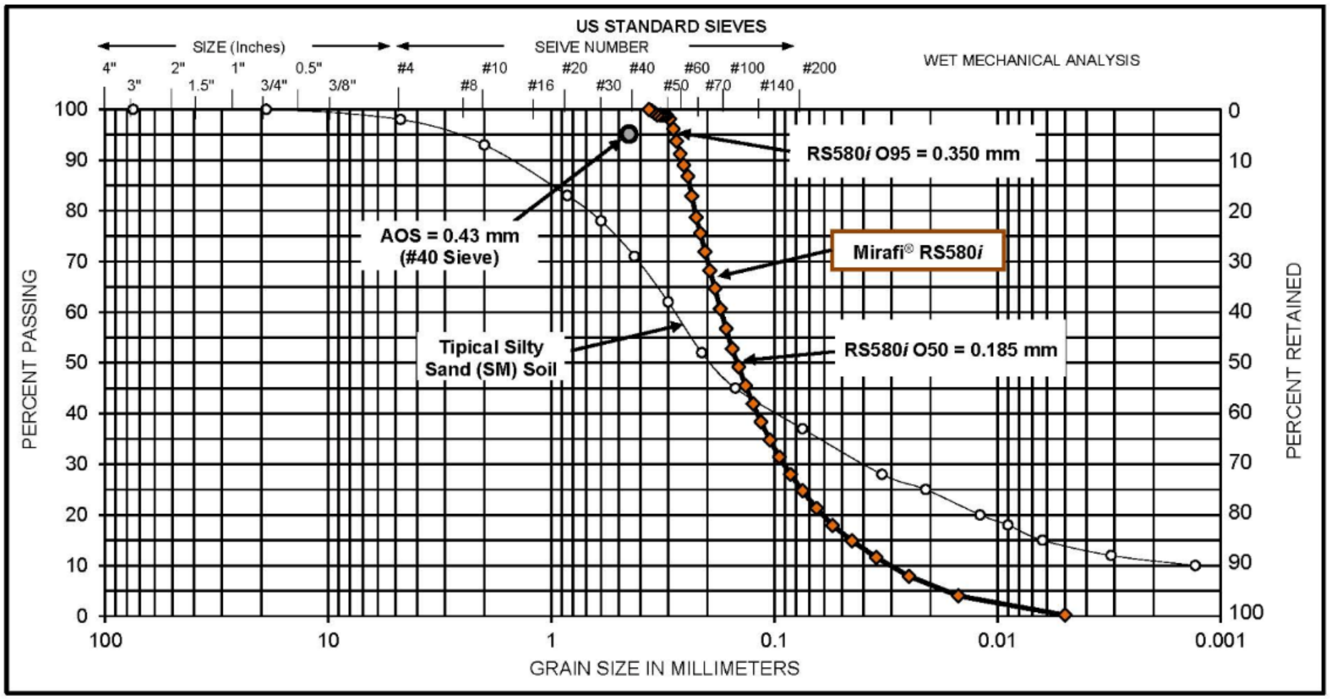

Figure 1. Pore size distribution and AOS value of Mirafi® RS580i compared to a silty sand (SM) soil grain size distribution.

Appendix A
ASTM D4751Test Method for Determining Apparent Opening Size of a Geotextile versus ASTM D6767 Test Method for Pore Size Characteristics of Geotextiles by Capillary Flow Test

Apparent Opening Size of a Geotextile	Pore Size Characteristics of Geotextiles by Capillary Flow Test
Test method: ASTM D4751	**Test method**: ASTM D6767
Summary of Procedure: • Material to be tested is cut to size (*approximately 10" in diameter*) to fit into a sieve pan. • Sample is then securely mounted inside the sieve pan. 50 grams of glass beads of a known size are placed on top of the sample. • Sieve pan is then covered and placed in sieve shaker and shaken for 10 minutes. • The glass beads that pass through the fabric are then collected from below the fabric and weighed. • For a material to obtain a "pass" result for a given bead size, no more than 5% of the original 50 grams of beads may pass through the fabric. • Each bead size must be tested individually on a given material. For example, if a material allows 20% of 70 sieve beads pass, then it should be tested for a 60 sieve. It would pass for a 60 sieve, if less than 5% of the 60 sieve beads pass. • Sieve bead sizes/diameter cross reference **Sieve number** — **Diameter (mm)** 20 — 0.85 30 — 0.60 40 — 0.425 50 — 0.30 70 — 0.212 100 — 0.15	**Summary of Procedure:** • Test conducted using a device called a *capillary flow porometer.* • Material to be tested is cut to size (about 1" in diameter) and saturated with a liquid of known surface tension. • It is placed into a sealed chamber in the promoter so that air only flows *through* the material and not escape around the edges. • Air is forced toward the sample at increasing pressure until the largest pore opens under the pressure. This is also called the *bubble point opening size* because when the largest pore opens, the first bubble of saturation liquid from the sample is formed. • Test continues by incrementally increasing the pressure until *all* pores in the sample are opened. • Each pressure is recorded by the porometer. From this pressure data and surface tension of the liquid, each opening size is calculated using Darcy's law and this calculation assumes spherical shape pore. • The test results provide graphical distribution of all pore sizes i.e., illustrates if there are many small pores/few large pores, etc. • Also provides numerical values for largest pore (bubble point pore) diameter and mean pore diameter.
Comments: AOS test essentially determines the largest single opening size in a fabric; if there is one very large hole, relative to the "normal" holes found in the fabric, then the results could be skewed as all the glass beads will pass through this one large hole. AOS test is subject to testing inconsistencies; i.e., operator error in sample preparation, etc., distortion of yarns/fibers in sample to be tested.	**Comments:** Pore size test determines size of all pores within a sample. From that data, the mean and largest pore size diameter are calculated, along with a distribution chart of pore sizes, illustrating the range of pore sizes and relative number. Pore size test is less susceptible to operator error, and is much more repeatable from test to test. Data is presented in graphical and tabular form as computer generated documents.

References:

ASTM D6767 (2016), “Standard Test Method for Pore Size Characteristics of Geotextiles by Capillary Flow Testing,” ASTM, West Conshohocken, PA.

ASTM D4751 (2016), “Standard Test Method for Determining Apparent Opening Size of a Geotextile,” ASTM, West Conshohocken, PA.

Koerner, R. M., Koerner, G. R, “On the Need for a Better Test Method Than Dry or Wet Sieving to Obtain the Characteristic Opening Size for Geotextile Filter Design Purposes,” Geosynthetic Institute’s White Paper #31, September 18, 2014.