Designation: E2814 – 18

Standard Specification for Industrial Woven Wire Filter Cloth[1]

This standard is issued under the fixed designation E2814; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

INTRODUCTION

Industrial metal filter cloth is a special type of woven wire cloth that can be produced in many specifications, often proprietary in nature. Sometimes referred to as Dutch weave or Hollander weave, filter cloth can be woven in a variety of metals and is woven with a greater number of wires in one direction than the other, and utilizing two different wire diameters. This specification covers woven wire filter cloth for industrial use, which is commonly rated by its micron retention capability. Its purpose is to introduce standard terms and definitions, to observe common technical considerations that a user should be aware of, and to present alternative acceptance criteria based on a desired pore size, or micron retention filtration rating. It should be noted this specification excludes standard industrial woven wire cloth and sieve cloth from its scope, since these are covered under Specifications E2016 and E11, respectively, as well as excludes plastic and synthetic filter cloth.

1. Scope*

1.1 This specification covers the special grade of industrial woven wire cloth, referred to as filter cloth, for general filtration including the separation of solids from fluids (liquids or gases), based on a desired particle size retention. Filter cloth can be made of any primary metal or metal alloy wire that is suitable for weaving.

1.2 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A478 Specification for Chromium-Nickel Stainless Steel Weaving and Knitting Wire

A555 Specification for General Requirements for Stainless Steel Wire and Wire Rods

E11 Specification for Woven Wire Test Sieve Cloth and Test Sieves

E1638 Terminology Relating to Sieves, Sieving Methods, and Screening Media

E2016 Specification for Industrial Woven Wire Cloth

2.2 *SAE Standards:*[3]

ARP-901 Bubble-Point Test Method

3. Terminology

3.1 *Definitions:*

3.1.1 For additional terminology, refer to Terminology E1638.

3.1.2 *bubble point test, n*—a capillary flow test method that measures the pressure required to force an air bubble through a filter cloth sample wetted under a test liquid of known surface tension.

3.1.2.1 *Discussion*—The pressure is inversely proportional to the pore size, should be standardized, and the pressure

[1] This specification is under the jurisdiction of ASTM Committee E29 on Particle and Spray Characterization and is the direct responsibility of Subcommittee E29.01 on Sieves, Sieving Methods, and Screening Media.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from SAE International (SAE), 400 Commonwealth Dr., Warrendale, PA 15096, http://www.sae.org.

*A Summary of Changes section appears at the end of this standard observed at the first bubble point location is considered the absolute rating. The test result pressure can be converted to a calculated pore size or micron retention by applying a selected tortuosity factor.

3.1.3 *cloth thickness, n*—the cross sectional height of the filter cloth, nominally estimated by adding the warp wire diameter plus two times the shute wire diameter.

3.1.4 *crimp, n*—corrugation in the warp and shute wires.

3.1.4.1 *Discussion*—The crimp in the wires is formed during the weaving process, and the tension existing between the warp and shute wires fundamentally determines the respective amount or depth of crimp, which in part establishes the firmness of the filter cloth. In standard filter cloth the warp wire is tensioned such that it only crimps minimally if at all, and the shute wire crimps predominately around the warp wire. In reverse filter cloth the warp wire is held under reduced tension as it does crimp around the shute wire, but the shute wire remains predominately straight.

3.1.5 *cut point, n*—the particle size above which 97 % of the particles are trapped by the filter.

3.1.6 *filter cake (surface cake), n*—material that is retained on the filter cloth during processing.

3.1.6.1 *Discussion*—The filter cake forms and builds up as particulate is retained, until the increased flow resistance of the filter cake requires it be removed from the filter cloth, typically by back flushing. The deposition of material forming the filter cake can aid in filtration by providing depth filtration, which results in a lower micron retention.

3.1.7 *filter cloth, n*—a special type of woven wire cloth, also referred to as Dutch weave, with a greater number of wires in one direction than the other, and utilizing two different wire diameters.

3.1.8 *glass bead test, n*—method for determining the filtration rating of filter cloth using a set of presorted, precisely sized spherical glass beads, passing them through the filter cloth, and examining the beads passed or captured.

3.1.8.1 *Discussion*—The largest bead passed is considered the absolute micron retention rating.

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

3.1.10 *micron, n*—common filtration reference to a particle size, properly defined as a micrometre.

3.1.11 *micron retention, n*—separation particle size of the filter cloth expressed as a diameter in micrometres.

3.1.12 *micron retention, absolute, n*—diameter of the largest spherical particle that will pass through the filter cloth under laboratory conditions representing the maximum pore size.

3.1.13 *micron retention, nominal, n*—subject to user definition, an indication of the average pore size of the filter cloth.

3.1.13.1 *Discussion*—The nominal rating may refer to: *(1)* the glass bead or particle size the filter cloth will retain 90 % of by weight; *(2)* the bubble point pore size when the tenth bubble location appears; or *(3)* the degree of filtration achieved under specific process conditions such as operating pressure, concentration of contaminant, and the buildup of filter cake, such that 94 % to 98 % of all particles of the nominal value will be retained after a given working period.

3.1.14 *percent open area, n*—not applicable; because of the irregular triangular-shaped opening formed at an angle to the plane of the filter cloth surface, the percent open area is generally not a specified parameter.

3.1.15 *shute wires, n*—wires running the short way of, or across the cloth, as woven (also referred to as the shoot, fill, or weft wires).

3.1.16 *types of weaves, n:*

3.1.16.1 *double warp, adj*—filter cloth (either plain or twill) in which two warp wires are used instead of one for each warp pitch thus reducing the micron retention of a similar regular single-warp wire specification (see Fig. 1).

3.1.16.2 *plain, adj*—filter cloth in which the shute wires pass over one and under one warp wire (see Fig. 2).

3.1.16.3 *reverse weave, adj*—filter cloth in which the warp and shute wires are woven in a reverse configuration (see Fig. 3).

3.1.16.4 *twill, adj*—filter cloth in which the shute wires pass over two and under two wires (see Fig. 4).

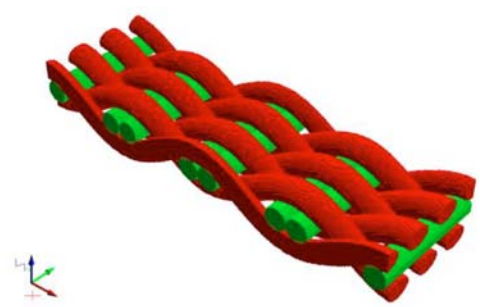


FIG. 1 Double Warp Plain

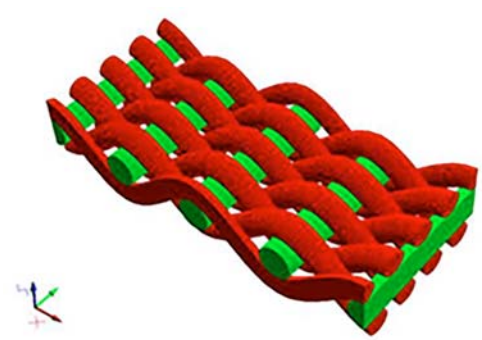


FIG. 2 Plain Weave

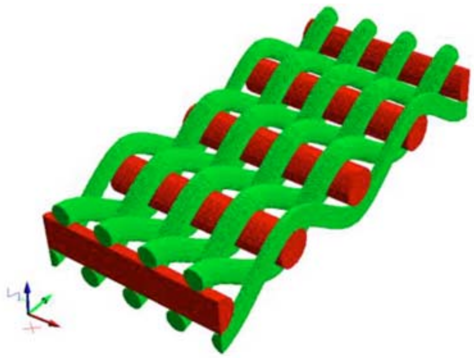


FIG. 3 Reverse Plain Weave

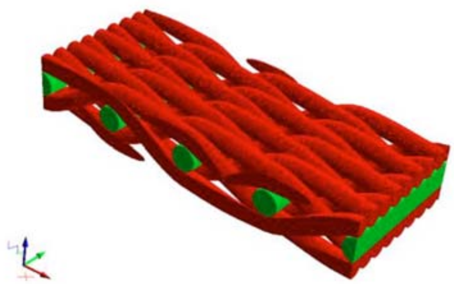


FIG. 4 Twill Weave

3.1.17 *warp wires, n*—the wires running the long way of the cloth as woven.

3.1.18 *weight per unit area, n*—weight per square foot for filter cloth can be approximated (without consideration for the significant crimp of the shute wire) by the following equation:

$$Wt/ft^2 = \left[12 M_w \left(12\pi \left(D_w{}^2/4\right) \rho\right)\right] + \left[12 M_s \left(12\pi \left(D_s{}^2/4\right) \rho\right)\right] \quad (1)$$

where:

Wt/ft^2 = weight (lb) per square foot,
M_w = mesh warp,
M_s = mesh shute,
D_w = diameter warp wire,
D_s = diameter shute wire,
ρ = density of material ($lb/in.^3$) (0.2836 for stainless steel 304), and
π = constant 3.1416.

3.1.18.1 *Discussion*—The theoretical mass per unit area can be similarly calculated with SI units or an approximate multiplier factor of 4.8824 can be used to obtain kilograms per square metre.

3.1.19 *wire diameter, n*—the cross sectional size of the wire expressed in decimal parts of an inch or the metric equivalent.

4. Significance and Use

4.1 Industrial filter cloth is a specialized product that can be manufactured in many specifications. The purpose of this specification is to *(1)* introduce standard terms and definitions associated with wire filter cloth, *(2)* observe common technical considerations that a user should be aware of, and *(3)* present normal tolerances as well as alternative acceptance criteria based on a desired pore size, or micron retention filtration rating. As often numerous specifications may be developed to result in a common micron retention by varying the weave type, mesh count, and wire diameters, it is recommended that the user consult with their filter cloth supplier regarding specific filter cloth specifications of interest and include in their discussions durability, pressure drop, and cleaning capability requirements. The purpose of this specification is not to suggest a limited selection of specifications.

5. Filter Cloth Specifications

5.1 Filter cloth is woven in a variation of sometimes proprietary parameters based on often common nominal mesh count specifications. This is due to minor variations in mesh count and wire diameters used to affect micron retention, porosity, and other factors related to specific operating conditions, as well as possibly for manufacturing convenience. Therefore, it is not appropriate to provide a comprehensive table of common filter specifications stating construction requirements and resulting parameters.

5.2 Industrial filter cloth can be woven from a great variety of metals and alloys. For the purposes of tolerances as woven, the following metals are applicable: brass, nickel & high nickel alloys (including Monel,[4] Inconel,[4] and Hastelloy[5]), phosphor bronze, stainless steel alloys (300 and 400 series), and commercially pure titanium.

5.2.1 Woven wire filter cloth tolerances for other metals may or may not be applicable depending on the particular specification and should be discussed with the supplier. Note that the physical properties of the wire to be woven may have an impact on overall filter cloth quality (for example, uniformity of mesh, surface roughness, etc.).

5.3 A selection of typical woven wire filter cloth specifications are presented with their particle size retentions as determined by bubble point testing, glass bead testing, the Tittel and Berndt with Blackmore model, and the GeoDict[6] computer model, for comparison of these results. Due to various factors that will affect the result of each method, exact correlation cannot be expected (see 6.3). These specifications are only for example, as countless others may be considered for weaving, see Table 1.

6. Technical Requirements

6.1 *Filter Cloth Acceptance Criteria*—Filter cloth may be manufactured and supplied based on acceptance criteria as agreed with the supplier. While the normal acceptance criteria should be based on mesh count and wire diameter tolerances, other possibilities include pore size as predicted by bubble point test method, glass bead challenge test method, the Tittel and Berndt with Blackmore geometric math model, or geometric computer models.

[4] A trademark of Huntington Alloy Corp., Catlettsburg, KY.

[5] A trademark of Haynes International, Inc., Kokomo, IN.

[6] GeoDict is registered as a trademark of Math2Market GmbH, Kaiserslautern, Germany. The sole source of supply of this simulation program known to the committee at this time is the GeoDict by Math2Market GmbH, Kaiserslautern, Germany. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

TABLE 1 Separation Particle Size for Typical Filter Cloth

Mesh	Wire Diameters		Weave	Pore Size in micrometres			
	Warp	Shute		Bubble Point	Computer GeoDict	Glass Bead	Title & Berndt
12 × 64	0.023	0.0165	standard plain	258	300	325	283
24 × 110	0.015	0.010	standard plain	111	150	138	137
30 × 150	0.009	0.007	standard plain	93	119	113	113
30 × 160	0.009	0.007	standard plain	88	114	112	113
50 × 250	0.0055	0.0045	standard plain	53	69	67	68
50(2) × 250	0.0045	0.0045	double plain	41	48	55	50
20 × 200	0.0135	0.011	standard twill	122	138	166	155
30 × 250	0.011	0.0082	standard twill	88	111	118	112
120 × 500	0.004	0.0028	standard twill	39	43	50	23
80 × 700	0.004	0.003	standard twill	35	38	47	42
200 × 900	0.0023	0.0018	standard twill	21	21	20	14
200 × 1400	0.0023	0.0016	standard twill	15	15	20	14
128 × 36	0.008	0.0157	reverse plain	84	74	111	n/a
130 × 30	0.008	0.016	reverse plain	125	110	136	n/a
171 × 46	0.0059	0.0118	reverse plain	71	64	82	n/a
630 × 130	0.0016	0.005	reverse plain	20	15	22	n/a
132 × 16	0.0142	0.0181	reverse twill	219	221	293	n/a
325 × 39	0.0059	0.0118	reverse twill	85	90	105	n/a

6.2 *Normal Manufacturing Tolerance Criteria*—The mesh count and wire diameters shall be specified and acceptance determined by verification of the tolerances thereon, as these are the controlled parameters during the weaving process.

6.2.1 *Wire*—The diameter tolerance for wire before weaving commonly should be in accordance with industrial standards as in accordance with Table 2 (for further information, see Specification A478). It is recognized that mechanical deformation of at least one of the wires occurs during weaving. Therefore, the diameter measured after weaving can only be used as a guide to the original nominal diameter.

6.2.2 *Mesh Count*—Tolerances in mesh count shall be applied separately for warp and shute, in accordance with Table 3.

6.3 *Alternative Testing and Prediction Criteria*—The following four testing and pore size prediction methods are offered as optional alternatives to the primary filter cloth acceptance criteria in accordance with 6.2, Normal Manufacturing Tolerance. Accordingly, if any of these alternatives are to be invoked, the method and specifics must be explicitly agreed to by the user and supplier.

6.3.1 *Bubble Point Testing*—The use of this characterization technique shall specify either a minimum pressure or pore size, along with the nominal mesh designation, and acceptance shall be based on the test result of a sample(s) as agreed.

TABLE 2 Tolerances for Stainless Steel Wire in accordance with Specification A555

Wire Diameter		Tolerance	
in.	mm	in.	mm
Under 0.0330 to 0.0240, incl	Under 0.84 to 0.61, incl	±0.0005	±0.013
Under 0.0240 to 0.0120, incl	Under 0.61 to 0.30, incl	±0.0004	±0.010
Under 0.0120 to 0.0080, incl	Under 0.30 to 0.20, incl	±0.0003	±0.008
Under 0.0080 to 0.0048, incl	Under 0.20 to 0.12, incl	±0.0002	±0.005
Under 0.0048	Under 0.12	±0.0001	±0.003

TABLE 3 Tolerance in Mesh Count Tolerance in Mesh ± %

Type Filter Cloth	Warp	Shute
Standard Weave	2	6
Reverse Weave	2	4

6.3.1.1 Properly called capillary flow porometry, bubble point testing is based on the fact that the pressure required to force an air bubble through filter cloth wetted under a test liquid of known surface tension is inversely proportional to the pore size. The test is conducted by mounting the filter cloth sample in a special test fixture, immersed in a test fluid, air pressure is slowly applied to the fluid, and a manometer is used to determine the pressure when the first air bubble is observed on the surface. This location indicates the largest pore size or absolute filtration rating of the sample. SAE Standard ARP-901 offers a comprehensive review of bubble point testing physics and details the application of correcting for test fluid surface tension, immersion depth, and temperature in order to standardize the test result pressure. The sample size is dependent on the test fixture to be used (for example, 1 in. diameter, 3 in. × 3 in.) (see Fig. 5).

6.3.1.2 It is important to note that the test fundamentally determines a pressure, and a minimum pressure (typically in psi or inches of water) may be specified as the acceptance criteria. However, as filter cloth is normally rated by the size particle it will retain, the resulting pressure is often converted to a pore size diameter, commonly expressed in micrometres. A geometric correction or tortuosity factor is used, defined as the ratio of the tortuous pore path length a particle must follow to the actual filter cloth thickness. While other factors are sometimes referenced, ARP-901 suggests a tortuosity factor of 1.65 (constant 342/207) be applied to the pressure to calculate the pore diameter (see Appendix X1). Accordingly, if a pore size is to be the acceptance criteria, a tortuosity factor shall be specified and agreed for use with the supplier (for example, some industry literature suggests 342/236 = 1.45 is more appropriate).

FIG. 5 Test Fixture

6.3.1.3 Geometric computer models (see 6.3.4) support the logic that this geometric tortuosity factor should be different not only for plain vs. twill vs. reverse weave specifications, but may vary for individual mesh specifications within each of these mesh types. Hence it has been observed that using a single factor for all mesh specifications can lead to large variation in calculated pore size results; again why a minimum pressure is the optimum specification vs. calculated pore size.

6.3.1.4 Further, it should be noted that the same mesh specification can result in different bubble point pressures but not necessarily due to different pore size (in accordance with ARP-901 this can be due to wire roughness, metal chemical characteristics, and a hysteresis effect). Conversely, the different geometry of different mesh specifications with similar pore size can yield different bubble point pressures due to different test fluid contact angles.

6.3.2 *Glass Bead Testing*[7]—The use of this characterization technique shall specify a cut point (not to be confused with pore size distribution) along with the nominal mesh designation, and acceptance shall be based on conducting a glass bead test on a sample(s) as agreed.

6.3.2.1 Properly called gravimetric challenge testing, narrow size distribution glass microspheres are used to determine the largest size microspheres that will pass thru the filter cloth (hence challenging the sample). The process of gravimetric analysis uses a sample of microspheres that have been prepared and made traceable using National Institute of Standards and Technology (NIST) certified electroformed sieves, and image analysis to check that there is a smooth Gaussian distribution without peaks or discontinuity of the glass bead sizes. The filter cloth sample is mounted in a sieve frame, weighed, the filter cloth surface covered typically ~80 % with a weighed sample of the calibrated microspheres, shaken using a mechanical, air-jet, or sonic sieve shaker to end point (typically 1 minute), and re-weighed with the retained material. The percentage of the microspheres passing is then used to determine the cut point from the microsphere sample calibration graph (a cumulative graph of weights vs. bead diameters).

6.3.2.2 This characterization technique can be highly accurate based on using properly prepared microspheres, and can accordingly then provide a NIST traceable certification (see example Appendix X2). In the absence of a formal test method standard for gravimetric challenge testing, the user and supplier shall develop agreement for the exact test methodology to be utilized. For less than 20 micrometre gravimetric challenge testing, a wet solution of microspheres should be used vs. the standard dry test method.

6.3.3 *Geometric Math Model*[8]—The filter cloth acceptance shall be based on manufacturing specific mesh counts and wire diameters within tolerances agreed with the supplier, that have been used in the Tittel and Berndt with Blackmore geometric math model to predict the pore size. This model can be used to predict the micron retention or separation particle size of any filter cloth specification a user and supplier wish to develop, and for comparative purposes.

6.3.3.1 This mathematical model assumes rigid, spherical particles that pass through various planes or cross sections of the filter cloth, created by the shute wires stretched around the warp wires and positioned geometrically adjacent to one another. The separation particle size is determined for the applicable geometric plane based on the weave type and specification ratios.

6.3.3.2 While five geometric planes of the filter cloth are considered (three of interest as the outer two are symmetrical), Plane 3, designated the geometric middle plane of the filter cloth, is the primary plane of interest. Accordingly, the separation particle size (dTr_3) is determined for plain weave with warp wire to shute wire diameter ratios within the range 1.00 to 1.50 (see Annex A1). For twill weave with warp pitch to warp wire diameter ratios greater than 3.22, Plane 2 is considered and the separation particle size (dTr_2) is determined (see Annex A2). The geometric math model is not applicable for reverse weave filter cloth.

6.3.4 *Geometric Computer Model*—The filter cloth acceptance shall be based on specific mesh counts and wire diameters within tolerances agreed with the supplier. These values are based upon the results generated in a computer simulation, which the criteria may be to target flow, pore size, or some other mesh characteristic.

6.3.4.1 An example of a suitable simulation program is the software GeoDict. This solution allows multi-scale 3D image processing, visualization and simulation of filter cloth. With their MatDict and PoroDict modules, characterization of pore size by geometrically fitting spheres into the pore volume is achieved, as well as the "percolation path" of selected sphere diameters, surface area, and bubble point pressure on the basis of the largest pore and the Young-Laplace equation.

6.3.4.2 This acceptance characterization technique can accurately predict the maximum pore size of a filter cloth specification based on analysis of the minimum mesh count tolerance in conjunction with the minimum wire diameter

[7] As in accordance with: Rideal, G., *A New High Precision Method of Calibrating Test Sieves*, Whitehouse Scientific Ltd., 2005.

[8] Derivation outlined in E2814 – 11, Appendix X1.

tolerance. The advantage of the computer modeling technique is that it not only can determine a maximum particle size that can pass through the mesh, but it can also provide the particle size distribution. This method is particularly useful for comparative analysis.

6.3.4.3 The model results are based on user input of appropriate and accurate parameters. Most parameters of the filter cloth models define the basic thread and weaving patterns; however the user must additionally define some parameters about the shape details, including the amount of thread overlap, wire broadening due to wire bending, and lateral deformations. If necessary, parameters can be fine-tuned by comparing micro-tomography scans of a real filter cloth with a digital model. Particular caution should be used when generating the PoreDict module Bubble Point pressure, as this requires the input of a contact angle which is very subjective and can result in great variation in results. Examples of plain and twill weave specifications with their typical input parameters are given in Appendix X3.

6.4 *Workmanship, Finish, and Appearance:*

6.4.1 The shute wires should be stretched around the warp wires and positioned adjacent to one another in standard weave and the opposite for reverse weave.

6.4.2 Filter cloth may exhibit some blemishes or defects that are inherent to the weaving process. Irregular gaps between the shute wires may indicate irregular pore size. Any irregular opening in an area of filter cloth, as a result of any various cause, shall be considered a defect if the agreed to micron retention is exceeded. The permissible number of major blemishes or defects should be discussed with the supplier, particularly with regard to the dimensions of the pieces to be used.

6.4.3 The flatness of woven filter cloth with regard to both curl and waviness should be discussed with the supplier.

6.4.4 Some filter cloth specifications may exhibit frayed edges.

6.4.5 Firmness is a subjective term referring to the planar rigidity of filter cloth established by the tensile strength of the material, the relationship of the mesh to wire diameters, the type of weave, the amount of crimp in the wires, and the tension on the warp wires during the weaving. The absence of firmness in woven wire filter cloth is termed sleaziness. Woven wire filter cloth should normally exhibit satisfactory firmness; that may be discussed with the supplier.

6.4.6 Woven filter cloth may be covered with a film of oil or other lubricant as a result of the manufacturing process. The wire may show traces of products used in, or markings caused by, the wire drawing process.

6.4.7 The tolerances that can be held on cut-to-size pieces of filter cloth can be dependent on the piece size, the mesh, wire diameters, type of weave, and firmness of the weave. These factors should be considered in the discussion of tolerances with the supplier.

6.4.8 The thickness of the filter cloth may affect the performance depending on the application (for example, airflow); accordingly if appropriate, a cloth thickness tolerance should be discussed with the supplier.

6.5 *Delivery:*

6.5.1 Except when specifically agreed to otherwise, the total quantity of filter cloth furnished should be within ±10 % of the quantity ordered. The invoice should be based on the actual quantity furnished.

6.5.2 A standard roll is 100 linear feet (30.5 m) ± 10 linear feet (3 m), but each specification should be discussed with the supplier.

6.5.3 The nominal width of the roll should be specified, as well as the permissible tolerance if applicable, and whether the roll may be delivered with or without selvage edges.

6.5.4 The percentage of yield of the filter cloth shall be agreed on with the customer and will vary according to the specification and size of the product.

7. Testing Procedure

7.1 Filter cloth is best inspected using a backlight to observe irregular and defective openings.

7.2 The mesh count of filter cloth may be checked using a counting glass compatible with the degree of fineness or suitable optical analysis methods (see Fig. 6). All test apparatus should be calibrated against standards traceable to the National Institute of Standards and Technology.

7.3 The mesh of each 100 foot roll of filter cloth shall be counted in accordance with Table 4, and shall be within the mesh count tolerance in accordance with Table 3.

8. Packaging and Labeling

8.1 *Packaging*—Depending on the specification, woven filter cloth may be rolled on a wooden or cardboard roll or more durable specifications without a center roll, but in any case, the method of packaging should take into account the likelihood of it being damaged. Any special packaging should be specified and agreed to with the supplier.

FIG. 6 Counting Glass

TABLE 4 Mesh Count Sampling

	per 100 foot roll Number of Random Samples		Count Length	
Standard Weave Shute Mesh	Warp	Shute	in.	mm
Coarser than 160 mesh, incl	1	10	0.500	12.7
Over 160 to 250 mesh, incl	1	15	0.500	12.7
Over 250 to 700 mesh, incl	1	15	0.250	6.35
Finer than 700 mesh	1	20	0.250	6.35
Reverse Weave Shute Mesh	Warp	Shute	in.	mm
Coarser than 30 mesh, incl	1	10	1.000	25.4
Over 30 to 100 mesh, incl	1	10	0.500	12.7
Finer than 100 mesh	1	15	0.250	6.35

8.2 *Labeling:*

8.2.1 Filter cloth should be labeled with the following information:

8.2.1.1 The name of the manufacturer or distributor;

8.2.1.2 The material of the wire;

8.2.1.3 The mesh designation of the specification;

8.2.1.4 The type of weave; and

8.2.1.5 The quantity, that is, length and width, or the size and number of pieces.

8.2.2 Other labeling requirements may be subject to agreement between the customer and the supplier.

9. Certification

9.1 At the time of ordering, customers may request a test certificate containing the following information or parts thereof:

9.1.1 *Chemical Analysis of the Weaving Wires*—For the chemical analysis of the material, the wire manufacturer's batch, lot, heat, or melt number analysis is applicable.

9.1.2 Mesh count or additional tests as agreed between the customer and the supplier.

10. Keywords

10.1 bubble point testing; Dutch weave; filter cloth; filter cloth geometric modeling; GeoDict; glass bead testing; gravimetric challenge testing; micron retention; tortuosity factor; wire cloth

ANNEXES

(Mandatory Information)

A1. CALCULATION OF dTr_3 FOR SEPARATION PARTICLE SIZE IN ACCORDANCE WITH TITTEL AND BERNDT (1973)[9]

A1.1 For 24 × 110 mesh plain:

A1.1.1 Pitch warp wires (t_1):

$$t_1 = 1/24 = 0.0417\text{ in.} = 1.0583\text{ mm}$$

A1.1.2 Warp wire diameter (d_k):

$$d_k = 0.015\text{ in.} = 0.381\text{ mm}$$

A1.1.3 Shute wire diameter (d_s):

$$d_s = 0.010\text{ in.} = 0.254\text{ mm}$$

A1.1.4 Ratio of warp to shute wire diameters (b):

$$b = d_k/d_s = 1.50$$

A1.2 For the "Plane 3" pore triangle:

A1.2.1 Base of triangle (g):

$$g = d_s*\left(\frac{1+(1+b)^2*0.66*(1-b*d_s/t_1)}{[1+(1+b)^2*0.436]^{0.5}} - 1\right)$$

$$g = 0.2250$$

A1.2.2 Height of triangle (h_t):

$$h_t = t_1*0.5*\left(1+\frac{1-[1+(1+b)^2*0.436]^{0.5}}{(1+b)^2*0.66} - (b*d_s/t_1)\right)$$

$$h_t = 0.2194$$

A1.2.3 Particle size (dTr_3):

$$dTr_3 = g*\{[(g/(2*h_t))^2+1]^{0.5} - g/(2*h_t)\}$$

$$dTr_3 = 0.137\text{ mm} = 137\ \mu\text{m}$$

[9] Tittel, R. and Berndt, R., "Zur bestimmung der trennteilchengr ße von filtergeweben," *Faserforschung und Textiltechnik*, Vol 24, 1973, pp. 505–510.

A2. CALCULATION OF dTr_2 FOR SEPARATION PARTICLE SIZE IN ACCORDANCE WITH TITTEL AND BERNDT (1973)[9] WITH BLACKMORE (2009)

A2.1 For 20 × 250 mesh twill:

A2.1.1 Pitch warp wires (t_1):

$$t_1 = 1/20 = 0.050\text{ in.} = 1.270\text{ mm}$$

A2.1.2 Warp wire diameter (d_k):

$$d_k = 0.010\text{ in.} = 0.254\text{ mm}$$

A2.1.3 Shute wire diameter (d_s):

$$d_s = 0.0085\text{ in.} = 0.216\text{ mm}$$

A2.1.4 Ratio of warp to shute wire diameters (b):

$$b = d_k/d_s = 1.1765$$

A2.1.5 Ratio of warp pitch to warp wire diameter:

$$t_1/d_k = 5.00$$

A2.2 For the "Plane 2" pore triangle:

A2.2.1 Coordinate origin ratio (t/t_1):

$$t/t_1 = [(1+b)^2+3]/[2*((1+b)^2+1)]$$

$$t/t_1 = 0.6743$$

A2.2.2 Geometric dimension (x):

$$x = d_s*\left(\frac{[(1+b)^6+7*(1+b)^4+7*(1+b)^2+1]^{0.5}}{2*((1+b)^2+1)} - 1\right)$$

$$x = 0.1087$$

A2.2.3 Particle size (d_0):

$$d_0 = d_s*(\{(x/d_s+1)^2/[(x/d_s+1)^2 - 0.25]^{0.5}\} - 1)$$

$$d_0 = 0.1283$$

A2.2.4 Correction factor (Z):

$$Z = t_1/[t_1^2 - d_s^2*(1+b)^2]^{0.5}$$

$$Z = 1.0764$$

A2.2.5 Particle size (dTr_2):

$$dTr_2 = d_0 - [0.4*d_s*(Z-1)]$$

$$dTr_2 = 0.122\text{ mm} = 122\ \mu\text{m}$$

APPENDIXES

(Nonmandatory Information)

X1. BUBBLE POINT TEST RESULT STANDARDIZATION IN ACCORDANCE WITH SAE ARP-901

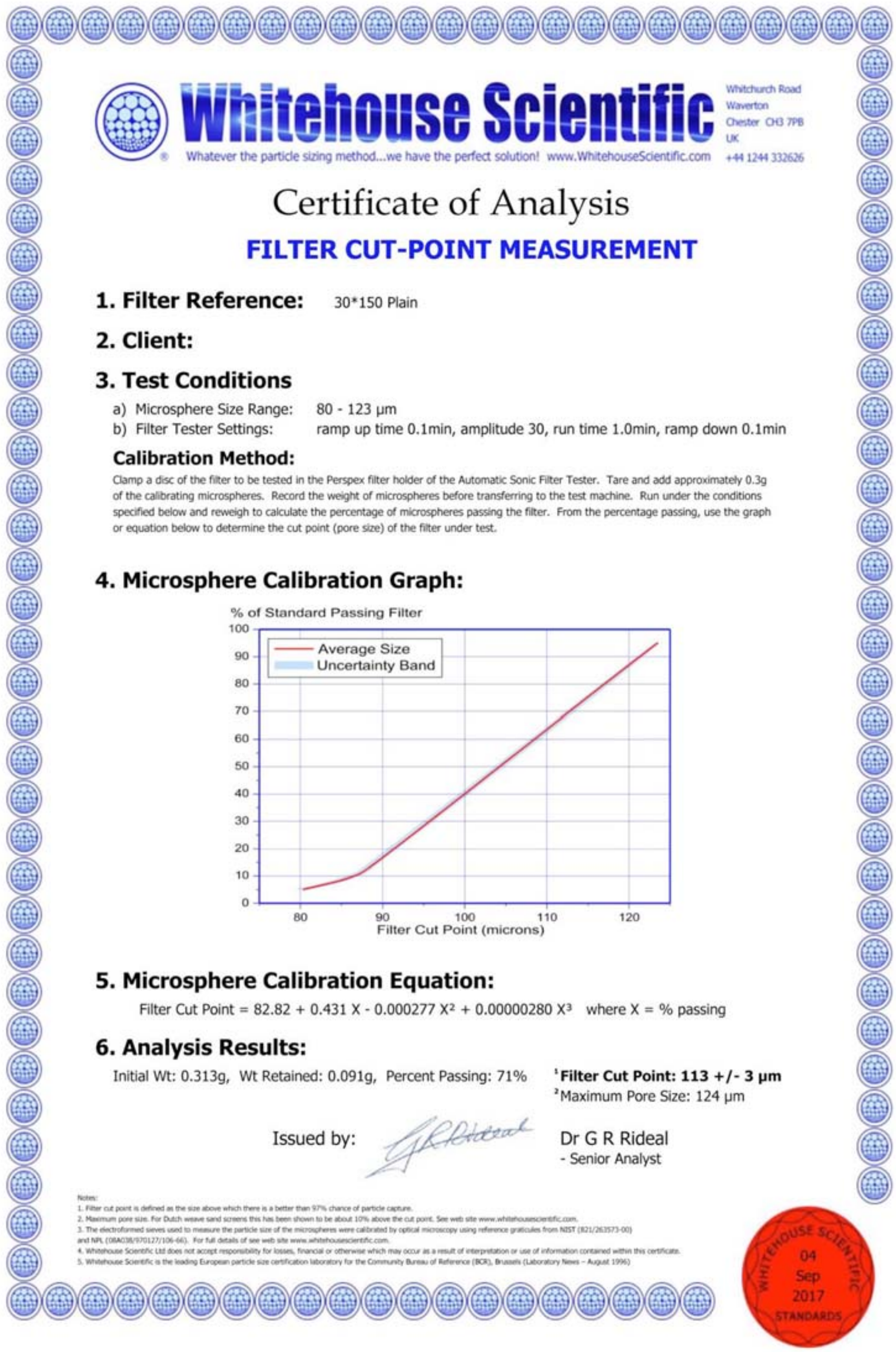
X1.1 See Table X1.1.

TABLE X1.1 Bubble Point Test Result Standardization in accordance with SAE ARP-901

Test liquid	IPA (reagent grade isopropyl alcohol)
77 deg. F, standard surface tension	21.15 dynes / cm
Specific gravity	0.782 grams / cm^3
Test liquid temperature	79.0 deg. F
Actual liquid surface tension	21.0 dynes / cm
Sample immersion depth	0.15 inches
1st bubble point pressure	10.40 inches H_2O
Standardized pressure formula	$P = (21.15 / S) (p - d \cdot h)$
where	S = actual liquid surface tension
	p = bubble point pressure
	d = test liquid specific gravity
	h = sample immersion depth
Standardized pressure P	10.36 inches H_2O
ARP-901 tortuosity factor	207
Calculated largest pore	D = tortuosity factor / P
Pore size D	20.0 microns

X2. CERTIFICATE OF ANALYSIS

X2.1 See Fig. X2.1.



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Certificate of Analysis

FILTER CUT-POINT MEASUREMENT

1. Filter Reference: 30*150 Plain

2. Client:

3. Test Conditions

a) Microsphere Size Range: 80 - 123 µm

b) Filter Tester Settings: ramp up time 0.1min, amplitude 30, run time 1.0min, ramp down 0.1min

Calibration Method:

Clamp a disc of the filter to be tested in the Perspex filter holder of the Automatic Sonic Filter Tester. Tare and add approximately 0.3g of the calibrating microspheres. Record the weight of microspheres before transferring to the test machine. Run under the conditions specified below and reweigh to calculate the percentage of microspheres passing the filter. From the percentage passing, use the graph or equation below to determine the cut point (pore size) of the filter under test.

4. Microsphere Calibration Graph:

5. Microsphere Calibration Equation:

Filter Cut Point = 82.82 + 0.431 X - 0.000277 X^2 + 0.00000280 X^3 where X = % passing

6. Analysis Results:

Initial Wt: 0.313g, Wt Retained: 0.091g, Percent Passing: 71%

[1] **Filter Cut Point: 113 +/- 3 µm**

[2] Maximum Pore Size: 124 µm

Issued by: Dr G R Rideal - Senior Analyst

Notes:
1. Filter cut point is defined as the size above which there is a better than 97% chance of particle capture.
2. Maximum pore size. For Dutch weave sand screens this has been shown to be about 10% above the cut point. See web site www.whitehousescientific.com.
3. The electroformed sieves used to measure the particle size of the microspheres were calibrated by optical microscopy using reference graticules from NIST (821/263573-00) and NPL (08A038/970127/106-66). For full details of see web site www.whitehousescientific.com.
4. Whitehouse Scientific Ltd does not accept responsibility for losses, financial or otherwise which may occur as a result of interpretation or use of information contained within this certificate.
5. Whitehouse Scientific is the leading European particle size certification laboratory for the Community Bureau of Reference (BCR), Brussels (Laboratory News – August 1996)

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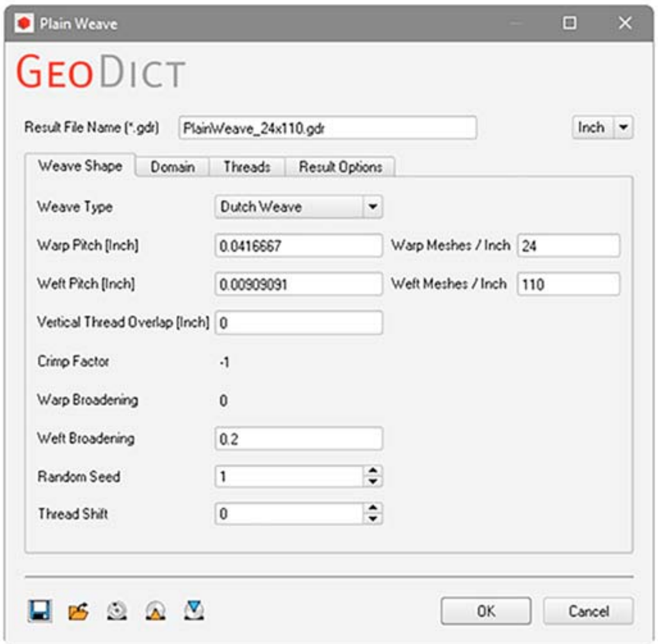
FIG. X2.1 Certificate of Analysis

X3. EXAMPLE MODELS

X3.1 *Example Model 1*—24 × 110 mesh plain (dutch weave).

X3.1.1 *Input Parameters*—See Tables X3.1-X3.3.

TABLE X3.1



Weave Type: Dutch Weave. Predefines crimp factor –1 and warp broadening to 0.

Warp Meshes / Inch: 24

Weft Meshes / Inch: 110

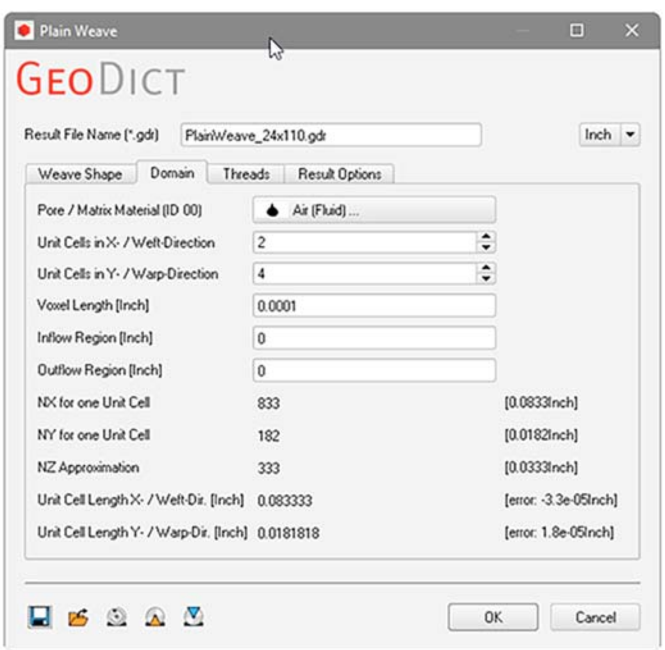
Vertical Thread Overlap: 0 in. No overlap of warp and weft wires.

Weft broadening: 0.2. weft wires are getting broader by 20 % due to bending.

Random seed: 1. In this model, nothing is random and will be ignored.

Thread Shift: 0. Additional shift of weft threads between two warp threads.

TABLE X3.2

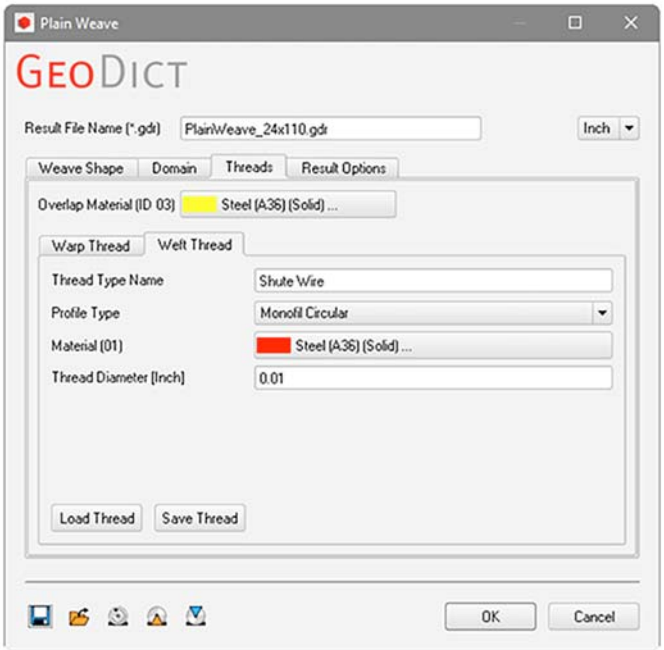


Unit Cells in Weft-Direction / Warp-Direction: 2⁄4 . Number of repetitions to be generated. For symmetric models increased for visual aspects only.

Voxel Length: 0.0001 in. Resolution of discretized model. Influences later simulations, for example, percolation path resolution. Smaller voxel length requires more computation time and amount of memory.

Inflow / Outflow region: 0 in. Additional free space on top/bottom side of model.

TABLE X3.3



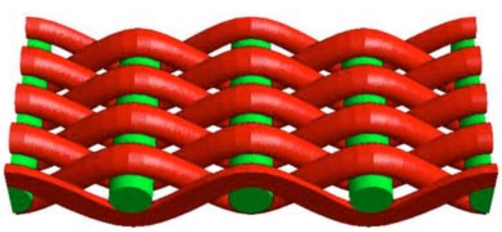
Warp/Weft Profile Type: circular. Shape of initial threads.

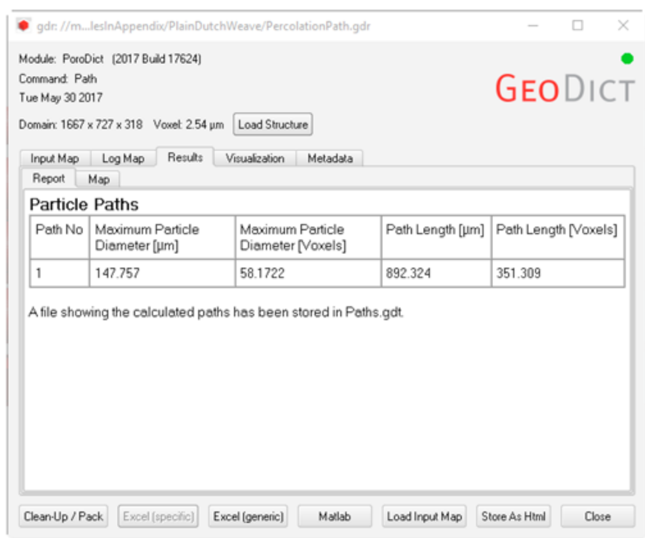
Warp/Weft Material: here steel. Required only for some further simulations, for example, electrical conductivity or deformations.

Warp/Weft Diameter: for circular threads only diameter is required. In this example, the weft thread diameter is set to 0.01 in, the warp thread diameter is set to 0.015 in.

X3.1.2 *Image of Resulting Model and Percolation Path Analysis for Largest Spherical Particle Diameter*—See Table X3.4.

TABLE X3.4



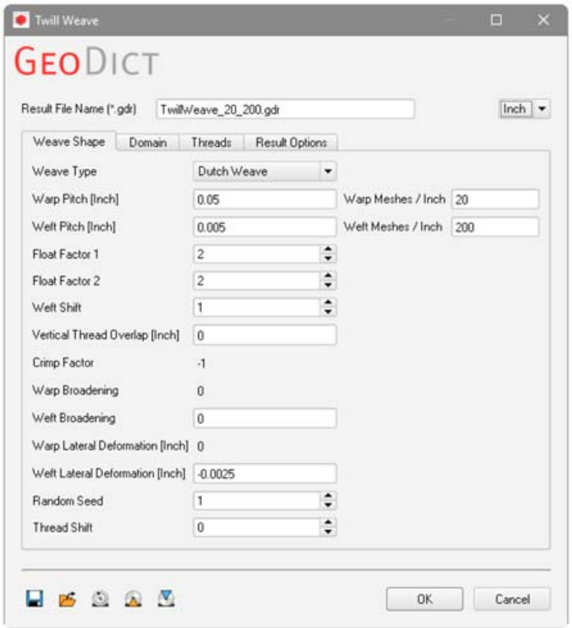


X3.1.3 *Result Accuracy*—The voxel length determines the accuracy of the percolation path results. Here, with a voxel length of 2.54 µm (0.0001 in.) and computed path length of 147.8 µm, the resulting accuracy is 1.7 %.

X3.2 *Example Model 2*—20 × 200 mesh twill (dutch weave).

X3.2.1 *Input Parameters*—See Tables X3.5-X3.7.

TABLE X3.5



Weave Type: Dutch Weave. Predefines crimp factor –1 and warp broadening to 0.

Warp Meshes / Inch: 20

Weft Meshes / Inch: 200

Float Factor: 2. Number of threads to span before changing sides.

Vertical Thread Overlap: 0 in. No overlap of warp and weft wires.

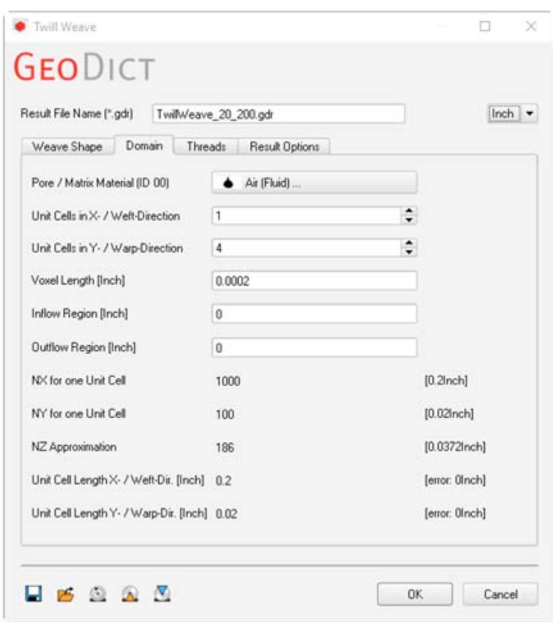
Weft broadening: 0. Assumed no or only little broadening.

Lateral Deformation: –0.0025 in. Movement of threads in lateral directions. Is dependent on thread diameters and thread pitches. Here, chosen to be half the weft pitch to make weft threads to pass each other and minimize weft thread overlap. Be aware that for twill dutch meshes this number is negative.

Random seed: 1. In this model, nothing is random and will be ignored.

Thread Shift: 0. Additional shift of weft threads between two warp threads.

TABLE X3.6

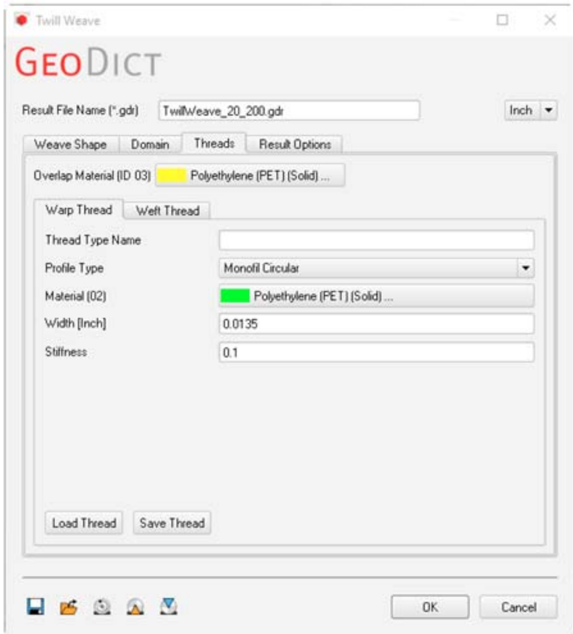


Unit Cells in Weft-Direction / Warp-Direction: ¼ . Number of repetitions to be generated. For symmetric models increased for visual aspects only.

Voxel Length: 0.0002 in. Resolution of discretized model. Influences later simulations, for example, percolation path resolution. Smaller voxel length requires more computation time and amount of memory.

Inflow / Outflow region: 0 in. Additional free space on top/bottom side of model.

TABLE X3.7



Warp/Weft Profile Type: circular. Shape of initial threads.

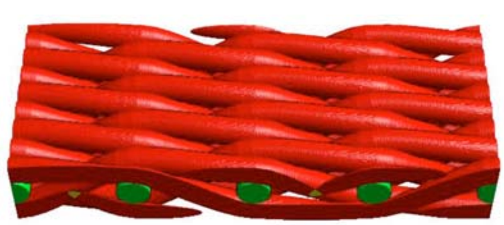
Warp/Weft Material: here steel. Required only for some further simulations, for example, electrical conductivity or deformations.

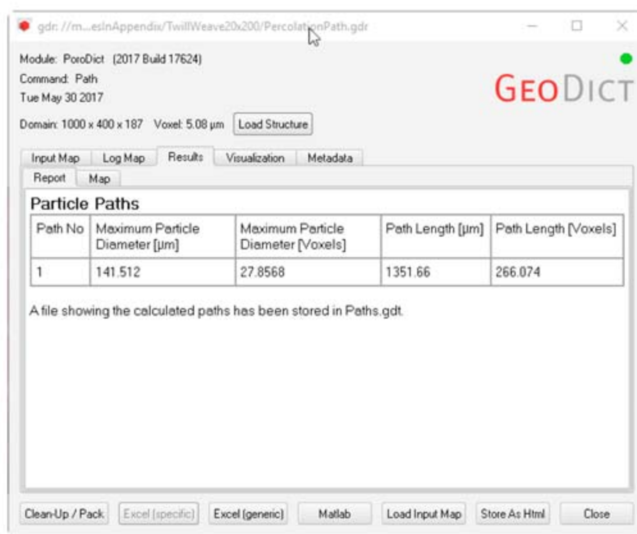
Warp/Weft Diameter: for circular threads only diameter is required. In this example, the weft thread diameter is set to 0.011 in., the warp thread diameter is set to 0.0135 in.

Stiffness: 0.1. Amount how straight threads follow contact points. Stiffness 0: no bending, straight line between contact points. Stiffness 1: Threads touch contact points tangentially.

X3.2.2 *Image of Resulting Model and Percolation Path Analysis for Largest Spherical Particle Diameter*—See Table X3.8.

TABLE X3.8





X3.2.3 *Result Accuracy*—The voxel length determines the accuracy of the percolation path results. Here, with a voxel length of 5.08 µm (0.0002 in.) and computed path length of 141.5 µm, the resulting accuracy is 3.6 %.

SUMMARY OF CHANGES

Committee E29 has identified the location of selected changes to this standard since the last issue (E2814 – 11) that may impact the use of this standard. (Approved April 1, 2018.)

(1) Standard E2814 was changed from a Guide to a Specification, which as well as other ancillary revisions, required a major revision of Section 6 from Technical Considerations to Technical Requirements, accordingly adding tolerances and acceptance criteria.