Geosynthetics - 7th ICG - Delmas, Gourc & Girard (eds) © 2002 Swets & Zeitlinger, Lisse ISBN 90 5809 523 1

Maturing of an industry: the need and development of generic specifications

R. M. KOERNER & G. Y. HSUAN, Geosynthetic Research Institute, Drexel University, Philadelphia, PA USA
G. R. KOERNER, Geosynthetic Institute, Folsom, PA USA

ABSTRACT: The past 25-years of geosynthetics development have seen the identification of distinct categories of products, e.g., geotextiles, geomembranes, etc. Within each category there are variations, yet the common characteristics are so great that many feel generic specifications can (and should) be developed. Such specifications are greatly desired by the user community consisting of regulators, owners, designers and their respective specifying personnel. Some manufacturers are also supportive of such efforts so as to reduce the number of required variations within a specific product. This would help to reduce inventory and aide in just-in-time delivery. Specifications developed to date include four related to geomembranes, two to geotextiles and one to geonets. The paper presents the process that has been used to develop the above mentioned generic specifications. Selected example specifications are commented upon and three are presented. As with any maturing industry, the authors feel that the time has come for the development of generic specifications on certain geosynthetic materials which are used in common applications.

1 INTRODUCTION

Since the time of the first international conference (Paris 1977), the geosynthetics industry has grown enormously. What was then a "filter fabric" and "pond liner" industry centered in Europe and North America, has grown into a full family of geosynthetic products known throughout the world. Parallel to this growth in the use of geosynthetics has been similar progress in the development of design techniques and test methods, as well as major improvements in the manufacturing process. The geosynthetics industry, with respect to its beginnings, has clearly matured. In so doing, many designs, test methods and manufacturing processes have become relatively common and capable of being standardized. In particular, numerous test methods can be embodied in the development of generic specifications, the topic to which this paper is directed.

At the outset, however, it must be emphatically noted that all geosynthetics cannot, and should not, be standardized in the form of generic specifications. Clearly, application areas which still have a wide variety of different products to choose from and products for completely new applications are not ready for standardization and perhaps never will be. That being said, geosynthetics (as with most other engineering materials) can be divided into two broad classifications; conventional and specialty products. In this paper, it is the conventional products which are focused upon. They are the type of products which can be approached via a generic specification.

It is suggested that such generic specifications are both good and necessary for conventional geosynthetic materials. "Good" because specifications bring a common (albeit minimum) set of test methods, limiting properties and test frequencies to candidate materials for a particular application. "Necessary" because a generic specification is an excellent vehicle for broadening the use of products to a wide range of potential users (who are not geosynthetics experts) for the particular application under consideration.

This paper presents the methodology the authors have used to develop seven such generic specifications. An additional three specifications are in the development process as of this writing.

2 THE DEVELOPMENT PROCESS

To state that the development of a widely "acceptable" generic specification is difficult, is a vast understatement. The main stakeholders in this regard are resin/additive producers and the geosynthetic manufacturers. In this regard, the pressures that are exerted in crafting a specification are often toward noncritical test methods, minimum property values, and minimum testing frequencies. Yet, noncritical test methods, minimum values and minimum testing frequencies are often not acceptable to the user community consisting of regulators, owners, designers, specifiers and testing laboratories. Among this group of users, the pressures exerted in crafting a specification are toward critical tests, maximum property values, and upper-end values of testing frequencies. Thus, a balance is necessary between the following conflicting perspectives;

- selection of only critical and typically essential test methods,
- negotiating between minimum and maximum test values, and
- etting acceptable testing frequencies to assure proper quality control.

With the above constraints in mind, the following process has been used to establish generic specifications within the Geosynthetic Research Institute. When promulgated, these specifications are available for unlimited use by whoever so desires and can be adopted by significantly larger standards institutes such the International Standards Organization (ISO) and/or the American Society for Testing and Materials (ASTM).

Step 1. Assess the Need for the Specification

It is important that the need for a generic specification on a particular application is shared by the majority of manufacturers which market such a product. It is equally important that such a document would be of use to the user community. Both are necessary since after crafting the specification it must have a good likelihood of being used in practice. The more relevant the final specification, the less modifications that are made to it, and the more use it has to the entire community. Furthermore, the product can be produced for just-in-time delivery or inventoried for maximum efficiency on the part of the manufacturer resulting in an optimal situation for all groups involved.

Step 2: Develop the Essential Table(s)

Together with the resin/additive producers and manufacturers of the specific product under discussion, a table(s) is developed which consists of (i) appropriate test methods, (ii) the ASTM, ISO, or GRI test designations, the (iii) minimum values (sometimes a maximum value or range of values is more appropriate), and (iv) the minimum testing frequency for proper quality control purposes. This is the most difficult part of the entire process. It is this table which is eventually used as a single item in most procurement situations. Insofar as possible, the table should be a self standing document describing the product with respect to its required physical, mechanical, hydraulic and endurance properties. Based on the history of our existing specifications, this step has required at least three and sometimes as many as twelve iterations. Often, a special testing program is required to obtain particular values. This was the case with stress crack resistance of HDPE geomembranes, oxidative induction time of a number of polyolefin products, molecular weight and carboxyl end group of polyester products, and various puncture values for thick nonwoven protection geotextiles. These tests are conducted on all available products attempting to meet the specification. Generally, the mean minus two or three standard deviations is used for the specification value. Such testing is felt to be critical since it gives a base-line reference to the values in the specification thereby adding to its credibility.

Step 3: The Addition of Text to the Table(s)

The adding of text, built around the tentatively approved table(s), is relatively straightforward. The ASTM/ISO style is generally followed due to the familiarization of users to this type of document. When the text is drafted, the resin/additive and relevant manufacturers groups review it along with the table(s) and make recommendations. At this point it should be noted that GRI specifications are not consensus documents. While they are approved majority documents, complete agreement among all involved is not always obtained. Clearly, a large majority of the member organizations is required to move the draft specification on to the next step, but sometimes a few producers or manufacturers feel that the timing is not right or have a different marketing strategy for their product in this particular application.

Step 4: Review by Entire Membership

Since the institute has regulators, facility owners, designers, testing laboratories and installers (in addition to resin/additive producers and manufacturers), the next step is to circulate the document to all of the current organizations. Their critique is most important. Without tacit approval, the specification will simply not be used in practice. To date, the most contentious specification has been the geomembrane seam specification. The magnitude of strength values, shear elongation, and peel separation (i.e., separation-in-plane) all have had strenuous challenges. Nevertheless, approval by a large majority of members has been achieved after some adjustment of values.

Step 5: Publication of the Specification

The GRI specifications (as with its test methods and guides) are available to everyone (members and nonmembers) for a nominal fee. They can be ordered directly or obtained over the Internet. Comments and critique by members and nonmembers is always welcomed. Such comments are very valuable as indicated in the next step of the process.

Step 6: Ongoing Review and Modification of the Specification

Every specification that is developed and promulgated by GRI is considered to be "living document". The specifications are always available for modification, if so warranted. Suggestions can be made by anyone who uses or produces product within the scope of the particular application area. The resin/additive producers and product manufacturers focus groups meet approximately twice per year to discuss the status of their respective specifications. Modifications are made when and where appropriate. For editorial or minor technical issues that are obvious oversights, the document is revised immediately. As such, the latest modification is always the applicable specification.

3 EXAMPLES OF GRI GENERIC SPECIFICATIONS

Due to space limitations the full text and tables of the existing and draft GRI specifications cannot be presented. However, the essence of three specifications are presented; (i) HDPE geomembranes, (ii) nonwoven protection geotextiles, and (iii) draft biplanar geonet composites.

3.1 GRI-13 HDPE Geomembrane Specification

Our first effort in generating generic specifications was for HDPE geomembranes, smooth and textured, in thicknesses of 0.75 to 3.00 mm, see Table 1 for the smooth surfaced material. Particularly contentious issues were as follows:

- minimum thickness, particularly textured
- minimum stress crack resistance
- carbon black dispersion categories
- initial oxidation induction time (OIT)
- OIT after oven aging
- OIT after ultraviolet exposure
- frequency of testing

This specification has had five (relatively minor) modifications to date.

3.2 GRI-GT12 Nonwoven Geotextile Specification

This specification focuses on nonwoven geotextiles used as protection (or cushioning) materials to protect geomembranes. It applies to all types of polymer fibers and covers the mass per unit area range from 340 to 2160 g/m^2, see Table 2. Particularly contentious issues were the choice of preferred puncture method (where pin, CBR and pyramid probes are all allowed), the requirement that all values (except UV resistance) are minimum average roll values (MARV) and the elimination of minimum testing frequencies. This latter item was justified on the basis that requiring MARV necessitates the manufacturer to perform adequate testing to establish the statistical data base of their particular products.

3.3 GRI-GN2 Specification for Biplanar Geonets and Geonet Composites (currently draft)

GRI-GN2 is for drainage geonets and geonet composites formed by lamination of geotextiles on one or both of their surfaces. It is subdivided according to the geonet (by itself), the geotextiles (by themselves), and the geonet composite (as a bonded unit), see Table 3. Particularly contentious issues were the minimum thickness and transmissivity values. After much discussion, these values were omitted and left to the parties involved to be decided on a site-specific and product-specific basis. The geotextile specifications were taken directly from a widely used specification promulgated by the American Association of State Highway and Transportation Officials, AASHTO M288. The geotextile values are MARV and, as such, there is no minimum frequency of testing values listed. The geonet and composite tests, however, do have minimum testing frequency listed. The specification is not yet finalized and, as such, is identified as draft.

4 CONCLUSIONS

In every technology there is a beginning, maturing, and long-term sustainable growth time frame. This paper suggests that some geosynthetics have entered into the maturing stage, at least for some applications. Where appropriate, the development of generic specifications is both good and necessary. The Geosynthetic Research Institute has been very active over the past 3-years in this regard. Seven product specifications are currently available. They are continuously maintained and updated on a regular basis. In addition there are four specifications in various stages of development.

Such generic specifications can be used on a worldwide basis for the particular application that they are focused upon. They can be adopted freely be federal and state agencies as well as owners, engineers, specifiers, manufacturers and other interested parties. It is important, however, that the latest modification be cited. Feedback from the user community is very desirable and we hereby solicit such commentary and critique of our ongoing efforts in this regard.

5 ACKNOWLEDGEMENTS

The financial assistance of the member organizations of the Geosynthetic Institute and its related institutes for research, information, education, accreditation and certification is sincerely appreciated. Their identification and contact member information is available on the institute's web site at <<geosynthetic-institute.org>>.

Rev. 4: 13 December 2000

Table 1. GRI GM13 High Density Polyethylene (HDPE) Geomembrane Specification - (Smooth Surfaces)

Properties	Test Method ASTM	Test Value							Testing Frequency (minimum)
		0.75 mm	1.00 mm	1.25 mm	1.50 mm	2.00 mm	2.50 mm	3.00 mm	
Thickness, mm (min. ave.)	D5199	nom.	nom.	nom.	nom.	nom.	nom.	nom.	per roll
• lowest individual of 10 values		-10%	-10%	-10%	-10%	-10%	-10%	-10%	
Density (min.), gm/cm3	D 1505/D 792	0.940	0.940	0.940	0.940	0.940	0.940	0.940	90,000 kg
Tensile Properties *(1)* (min. ave.)	D 638 Type IV								9,000 kg
• yield strength, kN/m		11	15	18	22	29	37	44	
• break strength, kN/m		20	27	33	40	53	67	80	
• yield elongation, %		12	12	12	12	12	12	12	
• break elongation, %		700	700	700	700	700	700	700	
Tear Resistance, N (min. ave.)	D 1004	93	125	156	187	249	311	374	20,000 kg
Puncture Resistance, N (min. ave.)	D 4833	240	320	400	480	640	800	960	20,000 kg
Stress Crack Resistance, hr. *(2)*	D 5397 (App.)	200	200	200	200	200	200	200	per GRI GM-10
Carbon Black Content - %	D 1603 *(3)*	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	9,000 kg
Carbon Black Dispersion	D 5596	note *(4)*	note *(4)*	note *(4)*	note *(4)*	note *(4)*	note *(4)*	note *(4)*	20,000 kg
Oxidative Induction Time (OIT), min. (min. ave.) *(5)*									90,000 kg
(a) Standard OIT	D 3895	100	100	100	100	100	100	100	
— or —									
(b) High Pressure OIT, min.	D 5885	400	400	400	400	400	400	400	
Oven Aging at 85°C *(5), (6)*	D 5721								
(a) Standard OIT (min. ave.) - % retained after 90 days	D 3895	55	55	55	55	55	55	55	per each formulation
— or —									
(b) High Pressure OIT (min. ave.) - % retained after 90 days	D 5885	80	80	80	80	80	80	80	
UV Resistance *(7)*									
(a) Standard OIT (min. ave.)	D 3895	N. R. *(8)*	N.R. *(8)*	N.R. *(8)*	N.R. *(8)*	N.R. *(8)*	N.R. *(8)*	N.R. *(8)*	per each formulation
— or —									
(b) High Pressure OIT (min. ave.) - % retained after 1600 hrs *(9)*	D 5885	50	50	50	50	50	50	50	

(1) Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction
Yield elongation is calculated using a gage length of 33 mm
Break elongation is calculated using a gage length of 50 mm
(2) The yield stress used to calculate the applied load for the SP-NCTL test should be the manufacturer's mean value via MQC testing.
(3) Other methods such as D 4218 (muffle furnace) or microwave methods are acceptable if an appropriate correlation to D 1603 (tube furnace) can be established.
(4) Carbon black dispersion (only near spherical agglomerates) for 10 different views: 9 in Categories 1 or 2 and 1 in Category 3
(5) The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.
(6) It is also recommended to evaluate samples at 30 and 60 days to compare with the 90 day response.
(7) The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.
(8) Not recommended since the high temperature of the Std-OIT test produces an unrealistic result for some of the antioxidants in the UV exposed samples.
UV resistance is based on percent retained value regardless of the original HP-OIT value.

References

D5199 Measuring Nominal Thickness of Geosynthetics
D1505 Density of Plastics by the Density-Gradient Technique
D792 Density and Specific Gravity of Plastics by Displacement
D638 Tensile Properties of Plastics
D1004 Initial Tear Resistance of Plastic Film and Sheeting
D4833 Index Puncture of Geosynthetics
D5397 Stress Crack Resistance of Geomembranes Using Notched Constant Tensile Load Test
D1603 Measuring Carbon Black in Olefin Plastics
D5596 Microscopic Evaluation of Dispersion of Carbon Black in Geosynthetics
D3895 Oxidative Induction Time of Polyolefins by Differential Scanning Calorimetry
D5885 Oxidative Inductive Time by High Pressure Differential Scanning Calorimetry
D5721 Air-Oven Aging of Polyolefin Geomembranes

Table 2(a). GRI GT12 Specification for Geotextiles Used as Geomembrane Protection (i.e.,Cushioning) Materials   Original: 18 February 2002

Property[(1)]	Test Method ASTM	Unit	Mass/Unit Area (g/m^2)					
Mass per unit area	D5261	g/m^2	340	406	542	812	1080	2160
Grab tensile strength	D4632	kN	1.02	1.33	1.64	2.00	2.25	2.90
Grab tensile elongation	D4632	%	50	50	50	50	50	50
Trap. tear strength	D4533	kN	0.42	0.51	0.64	0.89	0.96	1.33
Puncture (pin) strength	D4833	kN	0.53	0.62	0.75	1.11	1.33	1.78
UV resistance[(2)]	D4355	%	70	70	70	70	70	70

Note:

(1) All values are MARV except UV resistance. It is a minimum value.

(2) Evaluation to be on 50 mm strip tensile specimens after 500 hours exposure.

Table 2(b). Alternative Puncture Test Methods to be Considered in Place of Pin Puncture, ASTM D4833, in Table 2(a)

Property[(1)]	Test Method ASTM or GRI	Unit	Mass/Unit Area (g/m^2)					
Mass per unit area	D5261	g/m^2	340	406	542	812	1080	2160
Puncture (pyramid) strength	D5494	kN	1.33	1.42	1.82	1.96	2.27	3.56
Puncture (CBR) strength	D6241	kN	3.11	3.56	4.00	4.90	7.56	11.12
Puncture (CBR) elongation	D6241	mm	38	38	38	38	38	38

(1) All values are MARV

References

D5261 Measuring Mass per Unit Area of Geotextiles
D4632 Grab Breaking Load and Elongation of Geotextiles
D4533 Trapezoidal Tearing Strength of Geotextiles
D4355 Deterioration of Geotextiles to UV Light and Water
D5494 Pyramid Puncture Resistance of Geomembranes
D6241 Static Puncture of Geosynthetics Using a 50-mm Probe

Table 3. "Draft" Specification for Biplanar Geonets and Biplanar Geonet Composites

Property	Test Method (ASTM or GRI)	Test Value		Testing Frequency (minimum)
(a) Geonet (before lamination)				
Density, g/cc (min. ave.)	D1505/D792	0.940		per 4,500 m^2
Thickness, mm (min. ave.)[(1)]	D5199	(5)		per 4,500 m^2
Carbon Black Content, %	D4218	1.0-3.0		per 9,000 m^2
Transmissivity (min. ave.)[(2)]	D4716	(5)		per 18,000 m^2
(b) Geotextile (before lamination)[(3)]		Class 1	Class 2	
Mass/Unit Area, g/m^2 (MARV)	D5261	270	200	Note (6)
Grab Strength, N (MARV)	D4632	900	700	
Tear Strength, N (MARV)	D4533	350	250	
Puncture Strength, N (MARV)	D4833	350	250	
Permittivity, sec^{-1} (MARV)	D4491	0.2	0.2	
AOS, mm (MaxARV)	D4751	0.25	0.25	
UV Stability, % ret. (500 hr.)	D4355	50	50	
(c) Geonet Composite (after lamination)				
Transmissivity (min. ave.)	D4716	(5)		per 18,000 m^2
Ply Adhesion, N/m (min. ave.)[(4)]	D6636	87		per 9,000 m^2

(1) The diameter of the presser foot shall be 56 mm and the pressure shall be 2.0 kPa.

(2) The test shall be performed between rigid end platens at a hydraulic gradient of 1.0; a pressure of 480 kPa; and a seating dwell time of 15 min.

(3) These values are Class 1 and Class 2 of the AASHTO M288-00 specification for drainage (filtration) requirements of 15 to 50% fines passing the #200 sieve. Generally, one or the other will be used.

(4) This is the average of five equally spaced tests across the roll width

(5) This is the product specific test conditions and value

(6) Since these geotextile values are MARV, the statistics needed to obtain such values dictate the frequency of testing.

References

D4218 Carbon Black Content by the Muffle-Furnace Technique
D4716 Determining the In-Plane Flow Rate and Transmissivity of a Geosynthetic
D5261 Mass per Unit Area of Geotextiles
D4491 Water Permeability of Geotextiles by Permittivity
D4751 Determining Apparent Opening Size of a Geotextile
D6636 Ply Adhesion Strength of Reinforced Geomembranes