



MANUFACTURING QUALITY CONTROL GEOMEMBRANES AND DRAINAGE PRODUCTS

AGRU AMERICA, INC.

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AGRU AMERICA, INC. - QA/QC

Manufacturing – Quality Assurance/Quality Control

AGRU AMERICA, Inc. extrudes high density polyethylene (HDPE) and linear low density polyethylene (LLDPE) geomembrane, HDPE Geonet, Geocomposite, geotextile and GCL products at its three production plants located at 500 Garrison Road, Georgetown, South Carolina, 29440, 2000 East Newlands Drive, Fernley, Nevada, 89408 and 181 Hwy 521, Andrews SC 29510.

Our USA Manufacturing Quality Assurance Program is dependent on the utilization of in-house laboratories in each plant which are, when necessary, complemented with testing performed by certified outside laboratories such as:

- TRI/Environmental California; Anaheim, CA
Telephone (714) 520-9631; Fax (714) 520-9637
- TRI/Environmental, Inc.; Austin, Texas
Telephone (512) 263-2101; Fax (512) 263-2558

And other GRI-LAP accredited laboratories.

Raw Material – Manufacturer's Certificate of Conformity

HDPE and LLDPE resin is supplied to our plants in bulk and subjected to the following procedures:

- Prior to shipment, our resin supplier submits a certificate of analysis. Once approved, the resin is released for shipment to our plant.
- One sample is taken from each rail car after arrival and tested as follows:
Melt Index ASTM D1238 190°C, 2.16kg, and Density ASTM D792 Method B.
- Once the tests have been completed and results found to be in compliance with our requirements, the resin is then unloaded into our silo system.
- At this stage, our supplier has performed one battery of tests and Agru America has performed one to verify the manufacturer's certificate of analysis.
- Off specification resin is returned to the supplier.
- The Manufacturer's MFI Test Data is reported on the Geomembrane Quality Certificate (Agru America's MFI Testing is done to verify the resin manufacturer's reported data).



GEOMEMBRANE

The Extrusion Process

The resin is conveyed through a vacuum pump system and flexible hoses to a dryer hopper, feeding the resin by gravity into an 8-inch barrel. This barrel is divided into five heating zones, each heating zone being computer controlled and constantly monitored.

A screw in the barrel turns at a prescribed and monitored speed. It conveys the resin slowly to full plastication, and then the plasticated resin is fed through a manifold into a coat hanger die having a width of approximately 24 feet. The die lips are open to a prescribed distance governed by the thickness of the geomembrane to be extruded.

Exiting the die, the plasticated resin forms a controlled and monitored bead, which feeds into a chrome three-roll stack in a prescribed pattern. Each chrome roll is set at a prescribed temperature, controlled by water circulation.

Exiting the controlled cooling of the roll stack, the geomembrane travels down the take off haulers towards the winder. On the way to the take off, the liner is trimmed to bring the finished width to the applicable standard. Trimmings are granulated.

The trimmed edge of one side of the geomembrane is marked every meter (3.28 ft) with thickness, resin type (HDPE or LLDPE), Agru America name, and year of manufacture. This marking also serves as product identification.

The geomembrane is visually inspected for surface defects as it travels down the take off by both the extruder and the winder operators.

The geomembrane is wound on a recycled HDPE core having 6" ID (150mm), 7" OD (175mm) and 22'8" (6.8m) length.

Each standard length roll weighs approximately 3,900 pounds (1770 kg.). Rolls are fitted with two nylon slings when shipped.

Post Extrusion Quality Control

Once start-up conditions are over and commercial extrusion is initiated, post-production quality control comes into operation. A series of test procedures are performed based upon either our standard frequency of testing (attached), or frequencies required by customer specifications.

A sample approximately 11" by the full width of the geomembrane is taken from every roll. Based on the specified test frequencies, certain specimens are die cut, tested, and the results summarized on the Quality Certificate issued by our Quality Control Department. The certificate is signed electronically by the Quality Control Manager.

Rolls failing to comply with either customer project specifications and/or our own latest revision to our published data sheets are set aside and re-classified as off-spec (Class B rolls).



Quality Certificates are provided for all rolls of geomembrane with the exception of off-spec (Class B rolls).

Sometimes a third party quality assurance representative is mandated by the owner of a project to oversee our manufacturing QA. We gladly subscribe to this procedure and make all our records available 24 hours a day for the duration of the mandate. The following roll identification items are reported in our Quality Certificate:

(example) **GTA00XXXXYYYY**

GT	A	XXXX	YYYY
PLANT ID	MACHINE ID	PRODUCTION ID	COUNTER

First and second digit
Third digit
Fourth-Seventh digits
Last four digits

Plant (GT=Georgetown / FN=Fernley)
Machine ID
Unique Production ID
Sequential counter



Product Description (liner type: Smooth, Microspike[®], Drain[®], Super Gripnet[®], etc.)

Roll Length & Width in feet / meters, thickness in mils / mm.

Raw material lot and/or batch number and supplier/product identification (from resin manufacturer's Certificate of Analysis – sample attached)

All geomembrane rolls are labeled as follows:

- roll stickers on the cores for each roll
- roll stickers on the outside of the finished roll



The following test results are reported in the Geomembrane Quality Certificate, derived from our standard test frequency (attached) and/or supplied raw material manufacturer Certificates of Analysis. Tests performed are the latest revisions of the standards listed. At a minimum this meets or exceeds GRI GM 13/17 requirements:

Test / Method	Results Reported & Modifications to Standard (if any)
Thickness †ASTM D5199(Smooth) †ASTM D5994(Textured) (Both Modified)	Minimum, Maximum, and Average Sheet Thickness in mm and mils. Modification from Standard = Measurements are taken upon sample reaching Lab Temperature Equilibrium.
Asperity Height †ASTM D7466 (Modified) Textured liner only	Asperity height in mils Modifications from Standard = Edge samples are collected from the smooth/textured junction, <u>not</u> 1 foot from edge. ASTM D5994 specimens are used for this test, <u>not</u> direct placement.
Density †ASTM D792 method B	Density in g/cc
Melt Flow Index †ASTM D1238	g/10minutes (Conditions =190°C, 2.16kg). NOTE: Resin Manufacturer's <u>Certificate of Analysis result</u> is reported. Our testing
Carbon Black Content †ASTM D4218	% Carbon Black by weight
Carbon Black Dispersion †ASTM D5596	Category (Only near spherical agglomerates per GRI GM 13 & 17)
Tensile Strength †ASTM D6693 Type IV, 2 inches / minute (Modified)	Average Strength @ Yield & Break in psi, ppi, & N/mm Average Elongation @ Yield & Break in % Modification from Standard = Average of MD & TD results are reported NOTE 1: The D6693 results equate to the following NOTE 2: Yield data not reported for LLDPE
Tear Resistance †ASTM D1004 (Modified)	Tear Resistance in Lbs & N. Modifications from Standard = Test is run upon sample reaching Lab Temperature Equilibrium. Average Tear Resistance of MD & TD is reported.
Puncture Resistance †ASTM D4833 (Both Modified)	Puncture Resistance in Lbs & N. Modification from Standard = Test is run upon sample reaching Lab Temperature Equilibrium.
Notched Constant Tensile Load †ASTM D5397 (Single Point, Appx.)	Pass / Fail at 500 hours (or as required by customer specifications). First roll of new resin lot tested. Tested in the weaker principal direction. This test is run on HDPE only, and on smooth edge of textured liners.
Oxidative Induction Time (OIT) †ASTM D3895 Standard, 200°C, 1atm.	OIT Time in minutes. Modification from Standard = One run only – if result is below 140 minutes, a second run is done to verify the first.



The following test methods are now certified by Agru America based on historical results, as they are not required by the GRI GM13 / 17, and are not considered typical MQC tests.

Test / Method	Results Certified
Low Temperature Brittleness ASTM D746	Pass / Fail for each specimen (5 specimens in both MD & TD), 100 % of samples passing. Results Certified to -80°C (-112°F)
ESCR †ASTM D1693	Pass / Fail for each specimen (5 specimens in both MD & TD), 100 % of samples passing. Results Certified to 2,000 hours
Dimensional Stability †ASTM D1204 (Modified)	15 minutes or 1 hour at 100°C Results Certified to ± 2% for all geomembranes

†GRI-LAP Accredited for this method (Including Modifications)

In addition to the testing described above, an in-house procedure is performed within the smooth edges of Textured (Microspike DS & SS) and Structured (Supergrip, Grip, Drain, MicroDrain) liner by the QC Lab in both plants.

Summarized, the procedure is a modified Graves Tear test (ASTM D1004), testing 2 specimens taken in the cross machine direction, and 2 specimens from the machine direction from within the smooth edges. Both the individual specimen results and the specimens themselves are checked. This test is currently being performed on each test roll (each time a tensile test is performed) produced in both plants.

The average result will be reported on the geomembrane roll Quality Certificates.

In addition to our MQC testing, Agru America will continually strive to produce superior products with isotropic characteristics.



Drainage Net (Geonet)

AGRU America drainage net is made from a blend of high quality HDPE resin and a carbon black masterbatch. The purpose of the carbon black is to protect the plastic from UV damage in the field application.

All raw materials as well as the finished products are consistently monitored by specially trained lab technicians. Raw materials are tested as above for Geomembrane.

The blend of raw materials is plasticized by an extruder, which presses the melt through a screen changer to filter out impurities. The plastic is then fed into a rotating die which creates the net. The cooling of the net takes place in a water tank at a tightly controlled temperature. A series of nip rollers pull the net out of the tank and through the downstream equipment to the winders. The net is cut to length automatically and wound onto a 4" OD cardboard core.

Before the finished rolls are taken out of the winder frame, the quality control technician either releases the material into stock or classifies the material as scrap.

When approved by QC, the rolls are transferred to the storage yard.

Geocomposite

In addition to the drainage net, AGRU America offers geocomposites which consist of geotextiles laminated to one or both sides of the net.

All geotextiles used for this lamination process are being inspected to meet AGRU America's (or project) specifications.

The lamination process takes place just before the net reaches the winders at the end of the extrusion line. After melting the surface of the HDPE drainage net, a geotextile is pressed into the net by means of a calender. The outer 6 inches of net are not laminated and the geotextile overlaps the net by an additional 6 inches on both sides of the product.

Before the finished rolls are taken out of the winder frame, the quality control technician either releases the material into stock or classifies the material as scrap.

When approved by QC, the rolls are stretch wrapped and transferred to the storage yard. All drainage net and geocomposite rolls are labeled as follows:

- one label on each face of the roll
- one label on the laboratory sample
- numbering system is as above for geomembrane



The following test results are reported in the Geonet/Composite Quality Certificate, derived from our test results and/or supplied raw material manufacturer Certificates of Analysis. Tests performed are the latest revisions of the Standards listed:

Test / Method	Results Reported & Modifications to Standard (if any)
Thickness (Geonet) †ASTM D5199	Minimum, Maximum, and Average Geonet Thickness in mm and mils. Modification from Standard = Measurements are taken upon sample reaching Lab Temperature Equilibrium. English Units reported
Density (Geonet) †ASTM D792	Geonet Density in g/cc
Melt Flow Index (Geonet) †ASTM D1238	g/10minutes (Conditions =190°C, 2.16kg). NOTE: <u>Resin Manufacturer's Certificate of Analysis result</u> is reported. Our testing verifies this result.
Carbon Black Content (Geonet) †ASTM D4218	% Carbon Black by weight
Peak Tensile Strength (Geonet) †ASTM D5035 or †ASTM D7179 (Both Modified)	MD Only tested, TD upon request only. Peak Strength @ Break in ppi Modification from Standard = English Units reported
Mass Per Unit Area (Geonet) †ASTM D5261	Average Mass per Unit Area in lb/ft ² Modification from Standard = English Units reported
Transmissivity (Geonet) †ASTM D4716	Transmissivity, m ² / sec Plate to Plate , 21°C, gradient = 0.1, load = 10,000psf, seat time = 15 minutes is Agru America's Standard Geonet MQC Transmissivity test (may be changed per project MQC specs)
Transmissivity (Geocomposite) †ASTM D4716	Transmissivity, m ² / sec Plate to Plate , 21°C, gradient = 0.1, load = 10,000psf, seat time = 15 minutes is Agru America's Standard Geocomposite MQC Transmissivity test (may be changed per project MQC specs)
Ply Adhesion (Geocomposite) †ASTM D7005	Peel Strength, lbs/in, min. ave.

†GRI-LAP Accredited for this method (Including Modifications)

Geomembrane

Standard Frequency of Testing



Product Data

Property	Test Method	Frequency of testing (minimum)*
Thickness (min. ave.), mil	ASTM D5994/D5199	per roll
Asperity Height (min. ave.), mil	ASTM D7466	per roll, for textured liner
Density, g/cc, minimum	ASTM D792, Method B	200,000 lbs (railcar) on finished liner & incoming resin
Tensile Properties (ave. both directions)	ASTM D6693, Type IV	
Strength @ Yield (min. ave.), lb/in width	2 in/minute	20,000 lbs
Elongation @ Yield (min. ave.), % (GL=1.3in)	5 specimens in each direction	20,000 lbs
Strength @ Break (min. ave.), lb/in width		20,000 lbs
Elongation @ Break (min. ave.), % (GL=2.0in)		20,000 lbs
Tear Resistance, lbs. (min. ave.)	ASTM D1004	45,000 lbs
Puncture Resistance, lbs. (min. ave.)	ASTM D4833	45,000 lbs
Carbon Black Content (range in %)	ASTM D4218	20,000 lbs
Carbon Black Dispersion (Category)	ASTM D5596	45,000 lbs
Stress Crack Resistance (NCTL), hours	ASTM D5397, Appendix	200,000 lbs (railcar)
Oxidative Induction Time, minutes	ASTM D3895, 200°C, 1 atm O ₂	200,000 lbs (railcar) on finished liner
Melt Flow Index, g/10 minutes	ASTM D1238, 190°C, 2.16kg	200,000 lbs (railcar) on incoming resin
Oven Aging	ASTM D5721	
with HP OIT, (% retained after 90 days)	ASTM D5885, 150°C, 500psi O ₂	per resin formulation
UV Resistance	ASTM D7238	
with HP OIT, (% retained after 1600 hours)	ASTM D5885, 150°C, 500psi O ₂	per resin formulation
2% Secant Modulus, lb/in. (max.)	ASTM D5323	per resin formulation- for LLDPE liner only
Axi-Symmetric Break Resistance Strain, % (min.)	ASTM D5617	per resin formulation- for LLDPE liner only

These test frequencies meet or exceed GRI's GM13 and GM17.

*These test frequencies may be changed based on project specifications, and represent the minimum MQC testing performed.
Additional costs may be incurred if required testing is greater than listed above

All information, recommendations and suggestions appearing in this literature concerning the use of our products are based upon tests and data believed to be reliable; however, it is the users responsibility to determine the suitability for their own use of the products described herein. Since the actual use by others is beyond our control, no guarantee or warranty of any kind, expressed or implied, is made by Agru America as to the effects of such use or the results to be obtained, nor does Agru America assume any liability in connection herewith. Any statement made herein may not be absolutely complete since additional information may be necessary or desirable when particular or exceptional conditions or circumstances exist or because of applicable laws or government regulations. Nothing herein is to be construed as permission or as a recommendation to infringe any patent.

Geonet, Geotextile and Geocomposite Standard Frequency of Testing



Geonet Component⁽⁴⁾

Property	Test Method	Frequency of Testing (min.)*
Thickness, (mm)	ASTM D5199	per 50,000 ft ²
Peak Tensile Strength, lbs./in. (MD)	ASTM D5035/ASTM D7179	per 50,000 ft ²
Density, g/cm ³	ASTM D792, Method B	per 50,000 ft ²
Carbon Black Content	ASTM D4218	per 50,000 ft ²
Transmissivity ⁽¹⁾ , m ² /sec.	ASTM D4716	per 500,000 ft ²

Geotextile Component⁽⁴⁾

Property	Test Method	Frequency of Testing (min.)*
Mass per Unit Area, oz./sq. yd.	ASTM D5261	per 100,000 ft ²
Grab Tensile Strength, lbs.	ASTM D4632	per 100,000 ft ²
Grab Elongation, %	ASTM D4632	per 100,000 ft ²
Trapezoidal Tear, lbs.	ASTM D4533	per 100,000 ft ²
Puncture, lbs.	ASTM D6241	per 540,000 ft ²
Permittivity ⁽²⁾ , sec. ⁻¹	ASTM D4491	per 540,000 ft ²
Water Flow ⁽²⁾ , gpm./ft ²	ASTM D4491	per 540,000 ft ²
Apparent Opening Size, ⁽²⁾ U.S. Std Sieve Size (max.)	ASTM D4751	per 540,000 ft ²
UV Resistance after 500 hours, % Strength Retained	ASTM D4355	per resin formulation

Geocomposite

Property	Test Method	Frequency of Testing (min.)*
Laminated Strength (Ply Adhesion), lbs./in.	ASTM D7005	per 50,000 ft ²
Transmissivity ⁽³⁾ , m ² /sec.	ASTM D4716	per 500,000 ft ²

*These test frequencies may be changed based on project specifications, and represent the minimum MQC testing performed. Additional costs may be incurred if required testing is greater than listed above.

- Notes: 1. Geonet Transmissivity at a temp. of 21°C, gradient of 0.1 and a load of 10,000psf: seating time 15 min. between steel plates.
 2. At time of manufacture. Handling may change these properties.
 3. Geocomposite Transmissivity at a temp. of 21°C, gradient of 0.1 and a load of 10,000psf: seating time 15 min. between steel plates.
 4. Component Properties are prior to Lamination

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Certificate of Analysis

Shipped To: AGRU AMERICA INC:GEORGETOWN
500 GARRISON RD
GEORGETOWN SC 29440-9688
USA

Recipient: PALMER
Fax:

Delivery #: 88834459
PO #: 8206
Weight: 185400 LB
Ship Date: 04/11/2014
Package: BULK
Mode: Hopper Car
Car #: PSPX002181
Seal No: 322565

Product:
MARLEX POLYETHYLENE K307 BULK

Lot Number: H7240417

Property	Test Method	Value	Unit
Melt Index	ASTM D1238	0.22	g/10mi
HLMI Flow Rate	ASTM D1238	21	g/10mi
Density	D1505 or D4883	0.938	g/cm3
Pellet Count	P02.08.03	27	pel/g
Production Date		03/29/2014	

The data set forth herein have been carefully compiled by Chevron Phillips Chemical Company LP (CPChem).
However, there is no warranty of any kind, either expressed or implied, applicable to its use, and the user assumes all risk and liability in connection therewith.



Troy Griffin
Quality Systems Coordinator

For CoA questions contact Customer Service Representative at +1-832-813-4806