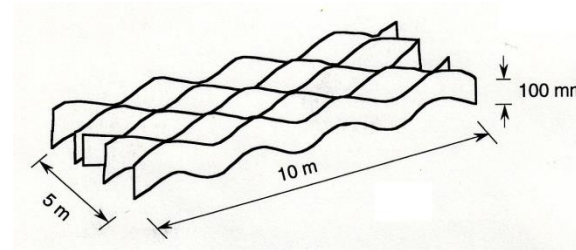
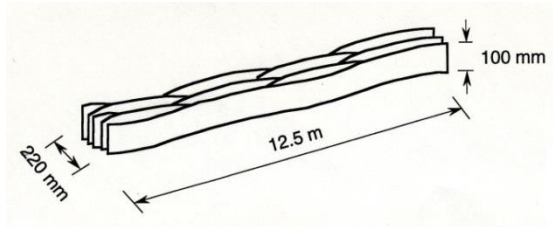
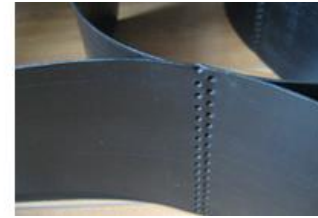


GTI-GS15 Specification

- for -

Geocells Made from HDPE Strips

- strips are generally from 3 to 8 in. (75 to 100 mm) height
- welded together into a 3-D cellular structure
- opened and then filled with soil (or other) in field



Diagrams and photographs of three-dimensional geocells used for civil engineering applications.
(Compliments of In-Line Plastics/GeoProducts, Syntec Corp. and InterGeo/Golder)

Commentary

- other polymers have also been used
- even larger cells made from geotextiles
- strips are usually embossed (textured) for enhanced friction from infilled soil
- strips can be perforated for drainage
- strips can also be joined by steel wire for stability on steep slopes
- twelve test results are required in specification

Required Tests Used for Specification

Physical Tests

1. wall thickness
2. density

Endurance Properties

8. carbon black content
9. carbon black dispersion
10. oxidative induction time
11. oven aging
12. ultraviolet resistance

Mechanical Tests

3. seam efficiency
4. tensile properties
5. tear resistance
6. puncture resistance
7. direct shear friction angle

1. Wall Thickness

- tapered micrometer via ASTM D5199 is not recommended due to double texturing
- values are invariably too high or too low
- recommended is GRI-GS14 standard
- requires area, density and mass of specimen
- formula calculated wall thickness

Procedure

- cut ten specimens ca. 50 mm (2.0 in.) diameter
- determine weight and area of specimen
- determine density via D792 and D1505
- calculate thickness as follows
$$t = M / A\rho$$
- repeat for each specimen
- min. ave. ≥ 1.25 mm (50 mils)
- also individual min. ≥ 1.13 mm (45 mils)
- testing frequency is one per bundle

2. Density

- uses ASTM D1505 (gradient column) or ASTM D792 (displacement)
- min. ave. of 3 tests for D1505
- min. ave. of 2 tests for D792
- D1505 is the more accurate test
- value ≥ 0.940 g/cc (resin is lower)
- test each railcar: 90,000 kg or 200,000 lb



Gradient Column
(D1505)



Displacement
(D792)

3. Seam Efficiency

- follows GRI-GS13 standard which is based on “perforated and textured sheet”
- compares seam strength to actual sheet strength (as a percentage)
- use full height for gauge length
- five specimens to establish “min. ave.”
- 100% efficiency required
- frequency is 9,000 kg (20,000 lb)



Geocell seam and sheet specimens before and after testing.

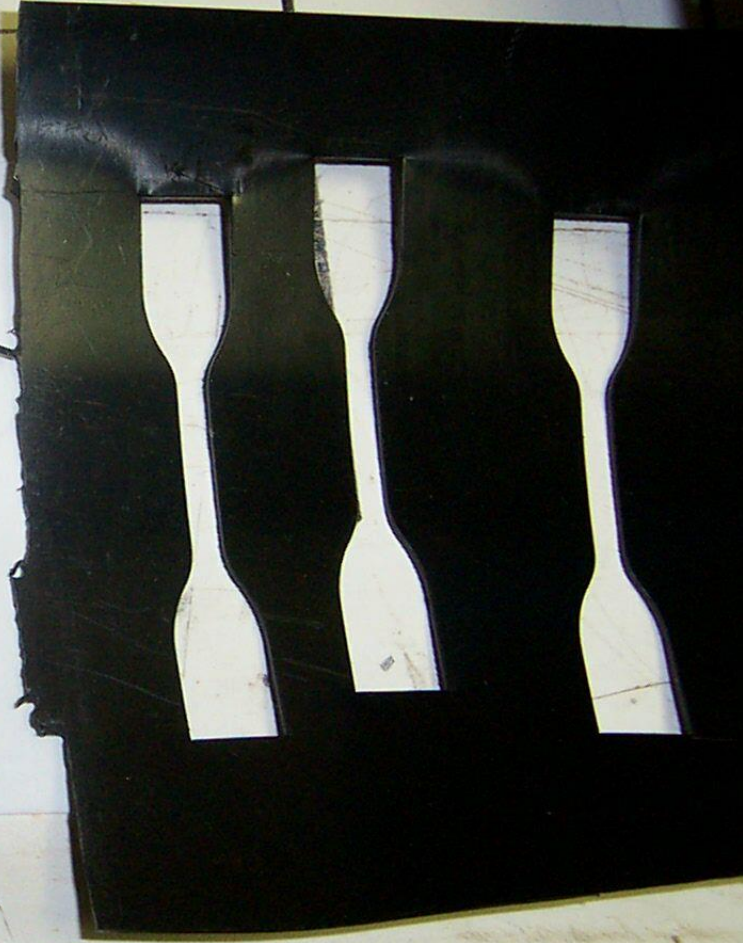
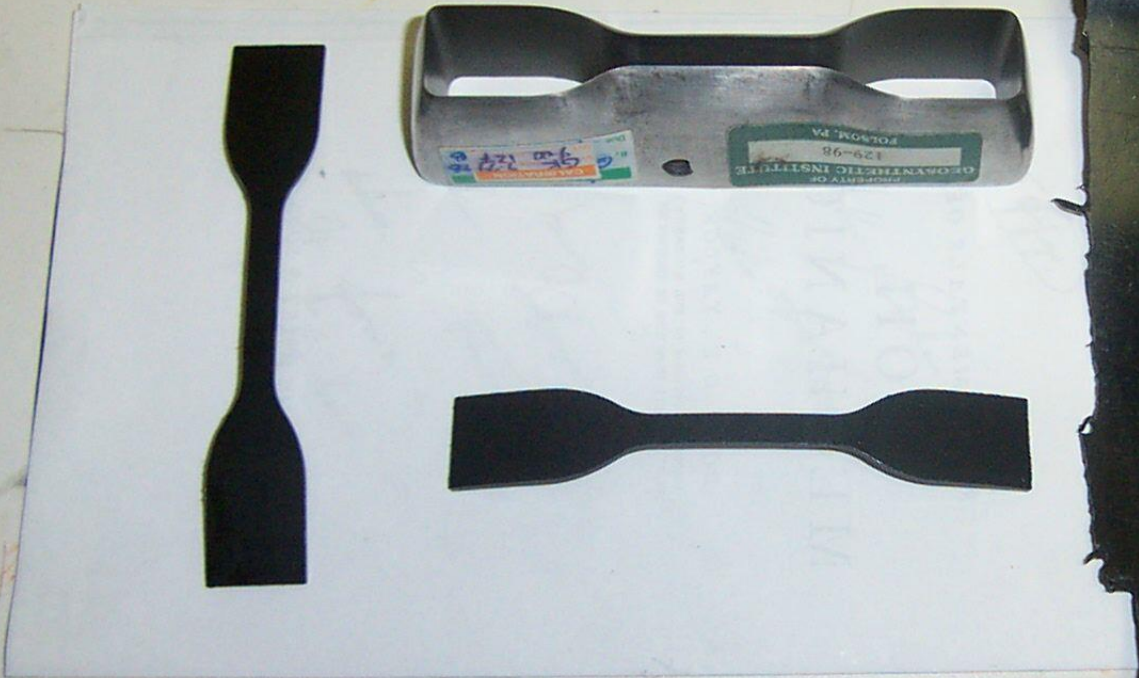
4. Tensile Properties

- follows ASTM D6693 Type IV
- min. ave. of five longitudinal samples

Property	S.I. –values	American-values
yield strength	18 kN/m	105 lb/in.
break strength	13 kN/m	75 lb/in.
yield elongation	12%	12%
break elongation	100%	100%

- frequency is 9,000 kg (20,000 lb)

ASTM D6693
Test Specimens



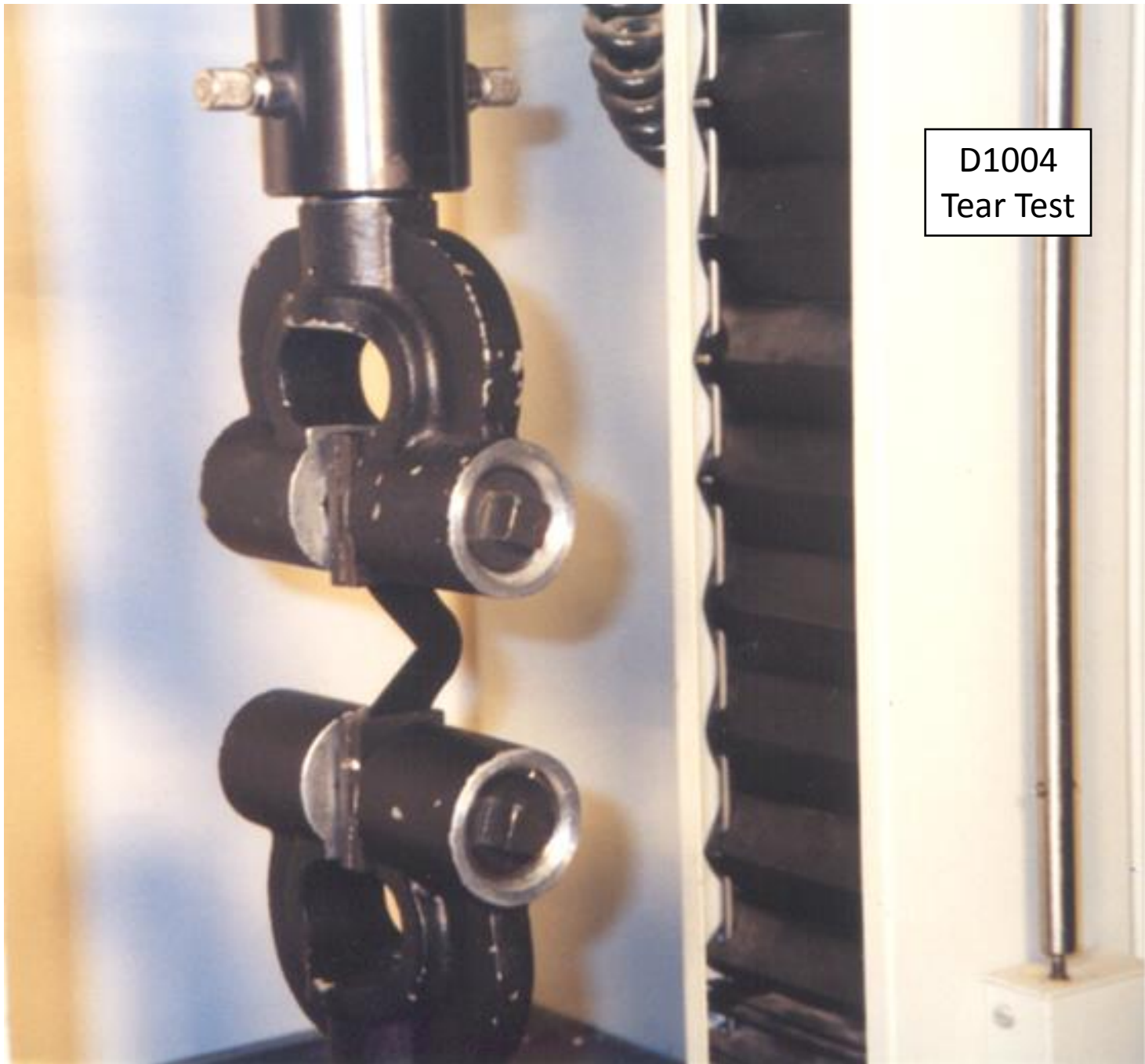


D6693
"Dogbone"
Test in Progress



5. Tear Resistance

- follows ASTM D1004
- called the 90° tear test
- min. ave. of 10 longitudinal samples
- required is 155 N (35 lb)
- frequency is 20,000 kg (45,000 lb)

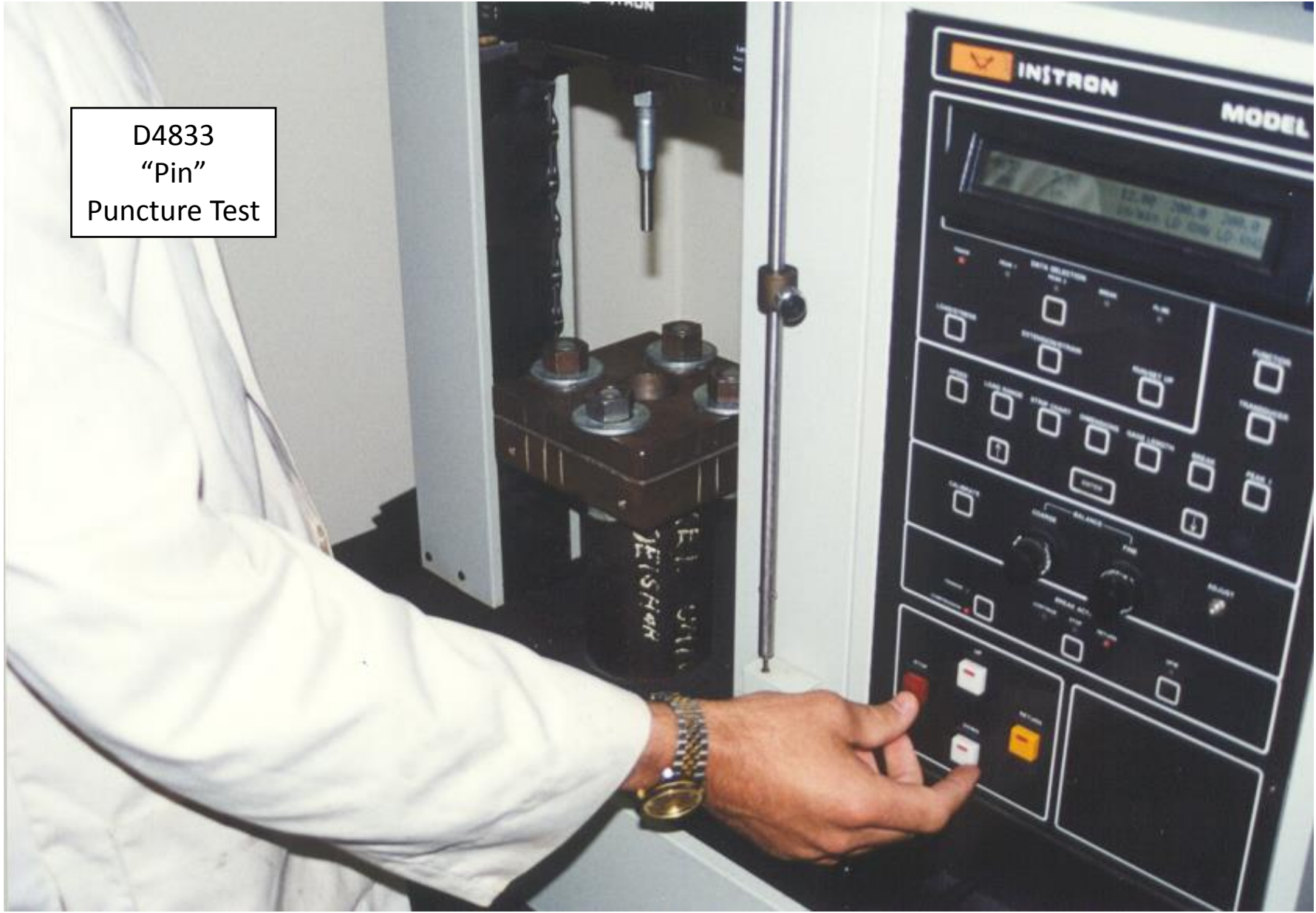


D1004
Tear Test

6. Puncture Resistance

- follows ASTM D4833
- called “pin” puncture
- CBR puncture is an alternative (5x pin)
- min. ave. of 10 longitudinal specimens
- required is 330 N (75 lb)
- frequency is 20,000 kg (45,000 lb)

D4833
"Pin"
Puncture Test



7. Direct Shear Friction Angle

- follows ASTM D5321
- shear box adapted to cell strip height
- lower half uses well graded sand
- details based on site-specific issues
- minimum friction angle is 30°
- frequency is 20,000 kg (45,000 lb)



(a) Small shear box

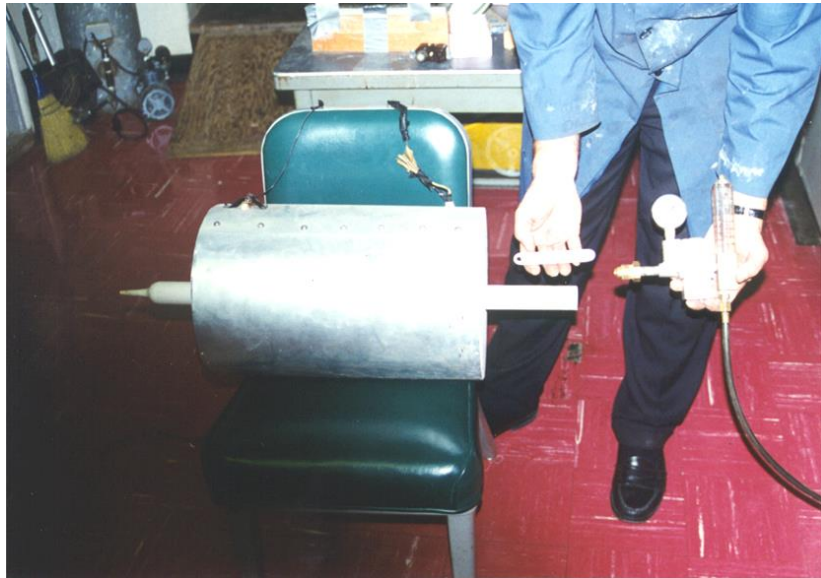


(b) Large shear box

Various shear boxes for different strip heights

8. Carbon Black Content

- follows ASTM D1603 (combustion boat placed in tube furnace), or
- muffle furnace (D4218) or microwave is okay if correlation is established
- ave. of two tests in 2.0 to 3.0% range
- frequency is every 9000 kg (20,000 lb)



Combustion Boat in Tube Furnace
D1603

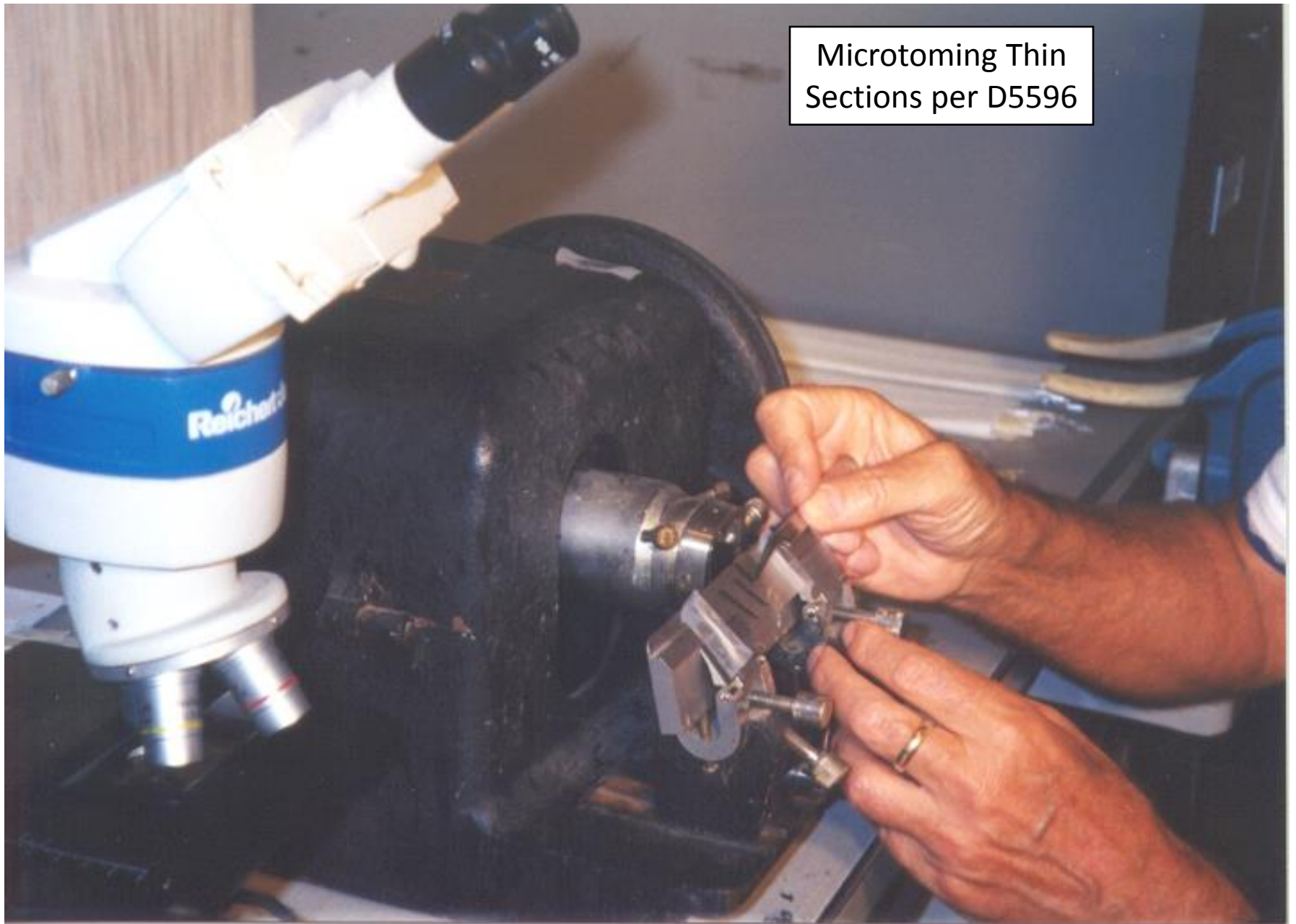


Muffle Furnace
D4218

9. Carbon Black Dispersion

- follows ASTM D5596
- microtome section (8-15 mm thick)
- view under microscope at 100X
- 10 views are compared to chart
- 9 in Cat. 1 or 2; 1 in Cat. 3
- only considers “near spherical” shapes (this is not CB distribution)
- frequency every 20,000 kg (45,000 lb)

Microtoming Thin
Sections per D5596



RATING

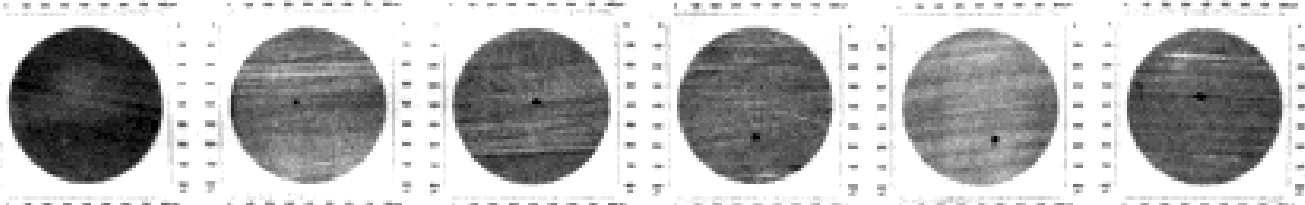
AGGLOMERATE SIZE RANGE

CARBON DISPERSION CLASSIFICATION CHART FOR GEOSYNTHETICS



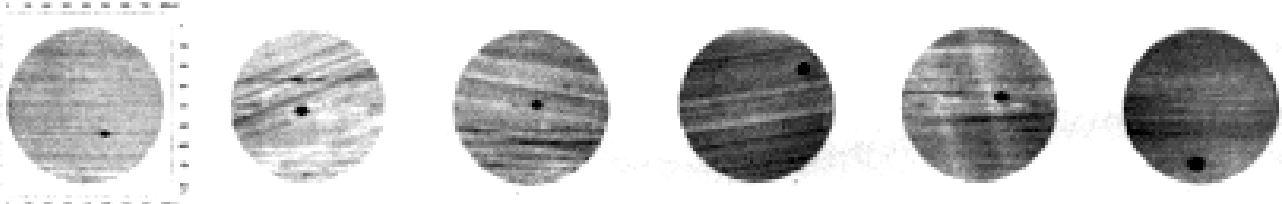
CATEGORY 1

< 500 μm^2
(Diameter < 25 μm)



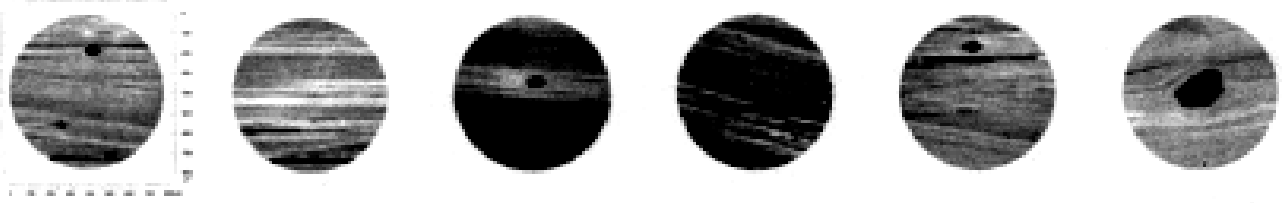
CATEGORY 2

< 1000 μm^2 - < 4000 μm^2
(Diameter 25 μm - 75 μm)



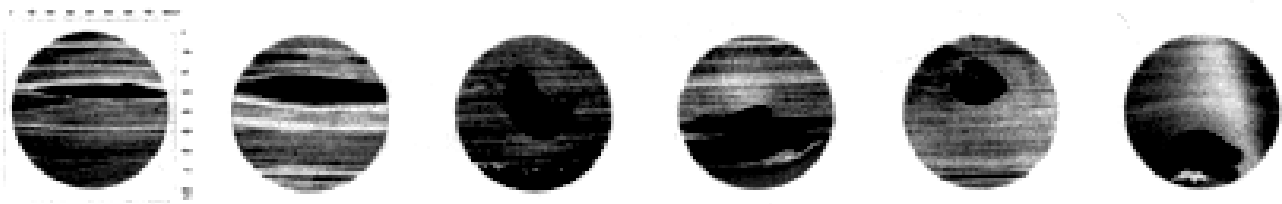
CATEGORY 3

< 4000 μm^2 - 24 - 100 μm^2
(Diameter 75 μm - 175 μm)



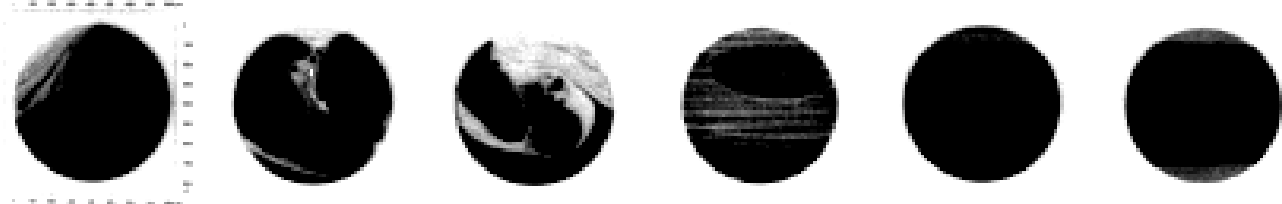
CATEGORY 4

< 10000 μm^2 - 75 - 100 μm^2
(Diameter 175 μm - 300 μm)



CATEGORY 5

> 75 000 μm^2
(Diameter > 300 μm)



10. Oxidative Induction Time

- OIT is an indirect measurement of the amount of antioxidants

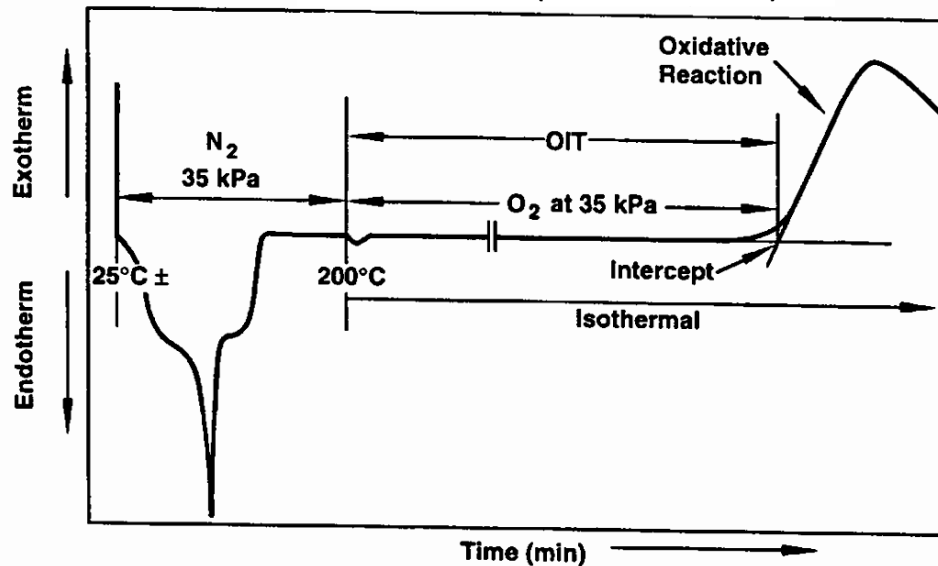
Item	Standard	High Pressure
ASTM	D3985	D5885
Specimen	≈ 2 mg	≈ 2 mg
Pressure	35 kPa (5 lb/in ²)	3500 kPa (500 lb/in ²)
Temperature	200°C in N ₂ ; 1 min. dwell; switch to O ₂	150°C to N ₂ ; 1 min. dwell; switch to O ₂
Spec Value	≥ 100 min.	≥400 min.

- Frequency is each railcar: 90,000 kg (200,000 lb)

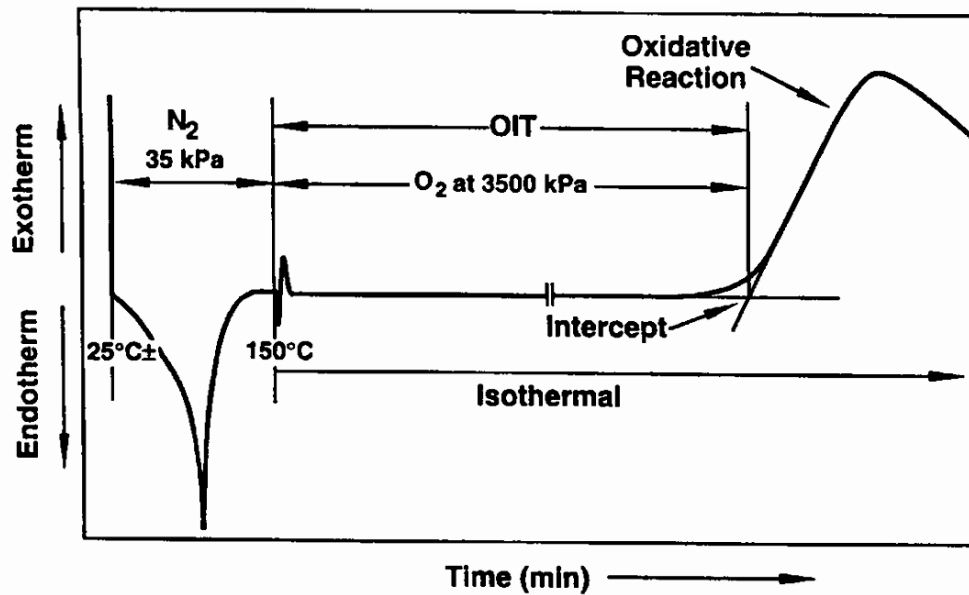


High Pressure (Left) and Standard (Right) Cells for Measuring OIT

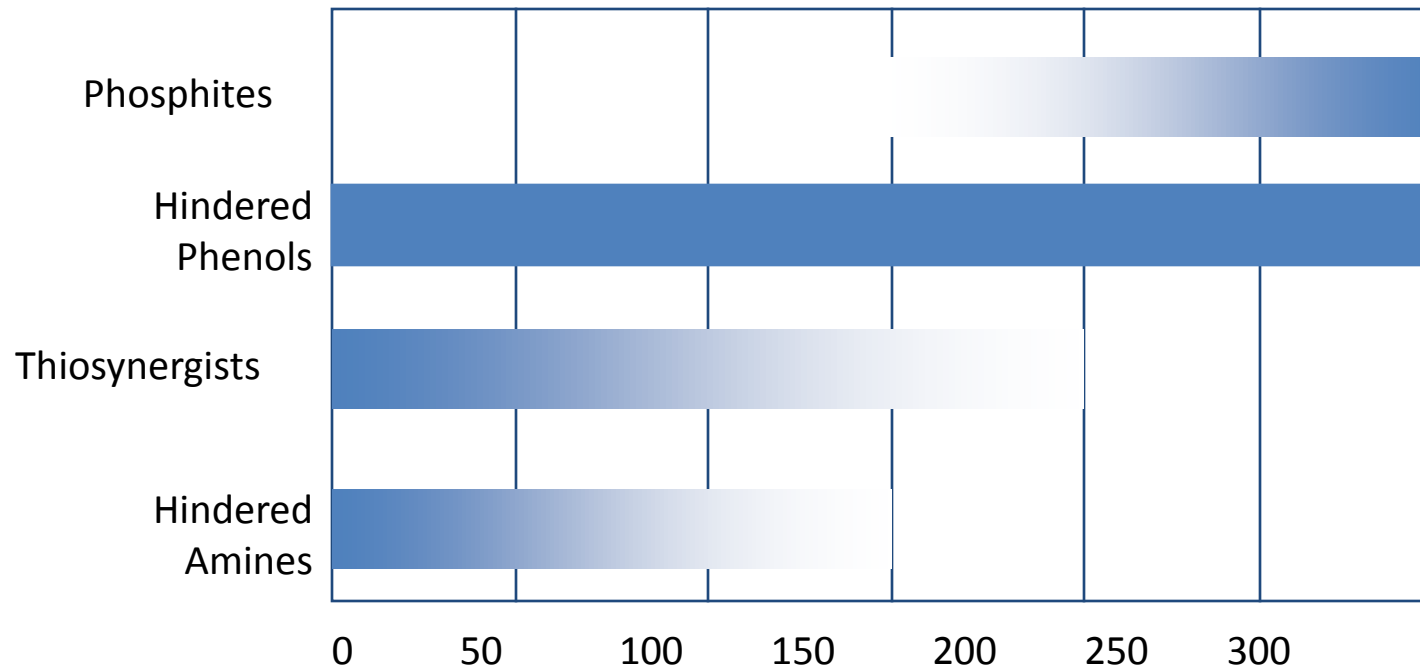
Standard OIT (ASTM D3895)



HP-OIT (ASTM D5885)



On choice of Std. or HP-OIT



(Ref. Fay and King, 1994)

- Std-OIT misrepresents AO packages with thiosynergists and/or hindered amines
- HP-OIT is always applicable (but \$10,000 cell and longer test time)

11. Oven Aging

- assessment of thermal stability of antioxidants (AOs)
- follows ASTM D5721
- forced air oven at 85°C
- Std.-OIT \geq 55% ret. after 90 days exposure
- HP-OIT \geq 80% ret. after 90 days
- frequency is per formulation



D721
Forced Air
Oven

12. Ultraviolet Resistance

- assessment of UV stability of the AOs and CB (there should be synergy)
- uses a laboratory weatherometer
- follows ASTM D7238
- called “ultraviolet fluorescent device”
- 20 hr. UV cycle at 75°C, then 4 hr. condensation at 60°C
- HP-OIT \geq 50% ret. after 1600 hrs.
- frequency is per formulation



ASTM D7238
Ultraviolet
Fluorescent
Weatherometer

Geocells Made From High Density Polyethylene Strips

Test Properties	Test Method	Test Value (S.I. Units)	Testing Frequency (minimum)	Test Value Standard (US) Units	Testing Frequency (minimum)
Wall Thickness Nominal – 10%)	GRI-GS14	1.25 mm	per bundle	50 mils	per bundle
Density (min. ave.)	ASTM D 1505/D 792	0.940 g/cc	90,000 kg	0.940 g/cc	200,000 lb
Seam Efficiency (min. ave.)	GRI-GS13	100%	9,000 kg	100%	20,000 lb
Tensile Properties (min. ave.) (1) • yield strength • break strength • yield elongation • break elongation	ASTM D 6693 Type IV	18 kN/m 13 kN/m 12% 100%	9,000 kg	105 lb/in. 75 lb/in. 12% 100%	20,000 lb
Tear Resistance (min. ave.)	ASTM D 1004	155 N	20,000 kg	35 lbs	45,000 lb
Puncture Resistance (min. ave.)	ASTM D 4833	330 N	20,000 kg	75 lbs	45,000 lb
Direct Shear Friction Angle (4)	ASTM D5321	30°	20,000 kg	30°	45,000 lb
Carbon Black Content (range) (2)	ASTM D 4218	2-3%	9,000 kg	2-3%	20,000 lb
Carbon Black Dispersion (3)	ASTM D 5596	note (5)	20,000 kg	note (5)	45,000 lb
Oxidative Induction Time (OIT) (min. ave.) (5) (a) Standard OIT – or – (b) High Pressure OIT	ASTM D 3895 ASTM D 5885	100 min. 400 min.	90,000 kg	100 min. 400 min.	200,000 lb
Oven Aging at 85°C (5)	ASTM D 5721				
(a) Standard OIT (min. ave.) - % retained after 90 days – or – (b) High Pressure OIT (min. ave.) - % retained after 90 days	ASTM D 3895 ASTM D 5885	55% 80%	per formulation	55% 80%	per formulation
UV Resistance (6) (a) Standard OIT (min. ave.) – or – (b) High Pressure OIT (min. ave.) - % retained after 1600 hrs (8)	ASTM D 7238 ASTM D 3895 ASTM D 5885	N.R. (7) 50%	per formulation	N.R. (7) 50%	per formulation

(1) Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of five 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) Other methods such as D 1603 (tube furnace) or D 6370 (TGA) are acceptable if an appropriate correlation to D 4218 (muffle furnace) can be established.

(3) Carbon black dispersion (only near spherical agglomerates) for 10 different views:

9 in Categories 1 or 2 and 1 in Category 3

(4) Actual geocell strip against well graded sand (see Section 5.3)

(5) The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.

(6) The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.

(7) 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.

(8) UV resistance is based on percent retained value regardless of the original HP-OIT value.