Designation: D5890 – 11

Standard Test Method for Swell Index of Clay Mineral Component of Geosynthetic Clay Liners[1]

This standard is issued under the fixed designation D5890; 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.

1. Scope

1.1 This test method covers an index method that enables the evaluation of swelling properties of a clay mineral in reagent water for estimation of its usefulness for permeability or hydraulic conductivity reduction in geosynthetic clay liners (GCL).

1.2 It is adapted from United States Pharmacopeia (USP) test method for bentonite.

1.3 Powdered clay mineral is tested after drying to constant weight at 105 ± 5°C; granular clay mineral should be ground to a 100 % passing a 100 mesh U.S. Standard Sieve with a minimum of 65 % passing a 200 mesh U.S. Standard Sieve. The bentonite passing the 100 mesh U.S. Standard Sieve is used for testing after drying to constant weight at 105 ± 5°C.

1.4 The values stated in SI units are to be regarded as the standard.

1.5 *his 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 and health practices and determine the applicability of regulatory limitations prior to use.* Specific precautionary statements are given in Section 7.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D1193 Specification for Reagent Water
D4643 Test Method for Determination of Water (Moisture) Content of Soil by Microwave Oven Heating
D4753 Guide for Evaluating, Selecting, and Specifying Balances and Standard Masses for Use in Soil, Rock, and Construction Materials Testing
E1 Specification for ASTM Liquid-in-Glass Thermometers
E145 Specification for Gravity-Convection and Forced-Ventilation Ovens
E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method
E725 Test Method for Sampling Granular Carriers and Granular Pesticides

2.2 *United States Pharmacopeia Standard:*

USP-NF-XVII Bentonite[3]

3. Terminology

3.1 *Definitions:*

3.1.1 *geosynthetic, n*—a planar product manufactured from polymeric material used with soil, rock, earth, or other geotechnical engineering related material as an integral part of a man-made project, structure, or system.

3.1.2 *geosynthetic clay liner, n*—a factory manufactured hydraulic barrier consisting of clay supported by geotextiles, or geomembranes, or both, that are held together by needling, stitching, or chemical adhesives.

3.1.3 *moisture content, n*—that part of the mass of a geosynthetic clay liner that is absorbed water, compared to the mass of dry clay.

3.1.4 *oven-dried, adj*—the condition of a material that has been heated under prescribed conditions of temperature and humidity until there is no further significant change in its mass.

4. Significance and Use

4.1 Clay mineral is a major functional component of GCL systems that reduces the hydraulic conductivity of industrial, waste, or ground water through the liner.

4.2 Clay mineral quality can vary significantly and effect the hydraulic conductivity of the GCL composite. This test method evaluates a significant property of clay mineral that relates to performance.

5. Apparatus

5.1 *Mortar and Pestle or Laboratory Hammer Mill,* for grinding clay mineral to required particle sizing.

[1] This test method is under the jurisdiction of ASTM Committee D35 on Geosynthetics and is the direct responsibility of Subcommittee D35.04 on Geosynthetic Clay Liners.

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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 U.S. Pharmacopeia (USP), 12601 Twinbrook Pkwy., Rockville, MD 20852.

5.2 *U.S. Standard Sieve,* 100 mesh, 200 mesh, and automated sieve shaker.

5.3 *Drying Oven,* thermostatically controlled, preferably forced draft type, meeting requirements of Specification E145 and capable of maintaining a uniform temperature of 105 ± 5°C throughout the drying chamber.

5.4 *Desiccator,* of suitable size containing indicator silica gel. It is preferable to use desiccant which changes color to indicate when it needs reconstitution.

5.5 *Laboratory Balance,* 100-g capacity, ±0.01-g accuracy and precision.

5.6 *Weighing Paper,* or small weighing dish.

5.7 *Glass Cylinder,* graduated TC (to contain), Class A volumetrically calibrated, with 1-mL subdivisions and ground glass stopper, high form with approximately 180-mm height from inside base to 100-mL mark.

5.8 *Wash Bottle,* for dispensing reagent water.

5.9 *Spatula,* flat-blade, to dispense clay mineral powder into cylinder; vibrating spatula should not be used since the delivery quantity may not be adequately controlled.

5.10 *Mechanical Ten-Minute Timer.*

5.11 *ASTM Calibration Immersion Thermometer,* (Specification E1).

5.12 *Drying Oven,* thermostatically-controlled, preferably of the forced-draft type, meeting the requirements of Specification E145 and capable of maintaining a uniform temperature of 105 ± 5°C throughout the drying chamber.

5.13 *Microwave Oven*—A microwave oven, preferably with a vented chamber, is suitable. The required size and power rating of the oven is dependent on its intended use. Ovens with variable power controls and input power ratings of about 700 W have been found to be adequate for this use. Variable power controls are important and reduce the potential for over heating the test specimen.

NOTE 1—Microwave ovens equipped with built-in scales and computer controls have been developed for use in drying soils. Their use is compatible with this test method.

5.14 *Balances*—All balances must meet the requirements of Specification D4753 and this section. A Class GP1 balance of 0.01 g readability is required for samples having a mass of up to 200 g (excluding mass of sample container).

5.15 *Sample Containers,* suitable containers made of material resistant to corrosion and change in mass upon repeated heating, cooling, exposure to materials of varying pH, and cleaning. Microwave sample containers should be microwave safe.

5.16 *Desiccator,* a desiccator cabinet or large desiccator jar of suitable size containing indicator silica gel. It is preferable to use a desiccant that changes color to indicate it needs reconstitution.

5.17 *Container Handling Apparatus,* gloves, tongs, or suitable holder for moving and handling hot containers after drying.

6. Reagents

6.1 *Purity of Reagents*—Unless otherwise indicated, references to water shall be understood to mean reagent water conforming to Specification D1193, Type I, II, or III (see Table X1.1). Such water is best prepared by distillation or the passage of tap water through an ion exchange resin.

6.2 Specification D1193 for reagent water, Type I, II, or III (see Table X1.1).

7. Hazards

7.1 Handle hot containers with a container holder.

7.2 Safety precautions supplied by the manufacturer of the microwave/oven should be observed.

7.3 Do not use metallic containers in a microwave oven (if used).

8. Sampling and Selection

8.1 Carry out sampling in accordance with Test Method E725.

9. Procedure

9.1 Grind the clay mineral sample to 100 % passing a 100 mesh U.S. Standard Sieve and a minimum of 65 % passing a 200 mesh U.S. Standard Sieve with a mortar and pestle or laboratory hammer mill as required.

9.2 The container to be used for drying should be oven dried thoroughly and subsequently placed into a desiccator until ready for use so that the tare weight of the container will be recorded.

9.3 Determine and record the tare of the specimen container.

9.4 Select representative test specimens.

9.5 Place the test specimen in the individual container. Determine the mass of the container and clay specimen as delivered using a balance selected on the basis of the sample mass. Record the value of the clay specimen.

NOTE 2—To prevent mixing of samples and yielding of incorrect results, all containers should be numbered and the container numbers shall be recorded on the laboratory data sheets.

9.6 Place the container with the clay specimen in the drying oven. Dry the clay specimen to a constant mass. Maintain the drying oven at 105 ± 5°C. The time required to obtain constant mass will vary depending on the type of material, oven type and capacity, and other factors.

NOTE 3—In most cases, drying a test sample overnight (about 12 to 16 h) is sufficient for conventional ovens. In cases where there is doubt concerning the adequacy of drying, drying should be continued until the change in mass after two successive periods (greater than 1 h) of drying is less than 0.1 %. In this case it should be verified that excessive drying does not influence the swelling performance of the clay. This can be done i.e. by comparing the swelling values after the first drying period (about 12 to 16 h) and the swelling values of bentonite being dried for a longer time period.

NOTE 4—If a microwave oven is used to dry the test specimen(s), the user of this test method should follow the drying procedures as stated in Test Method D4643. It is also recommended that the total mass of the test specimen(s) be a minimum of 100 g. It is further recommended to run a comparison test between the microwave oven and the drying oven to demonstrate that the microwave oven gives similar values as the drying oven and that excessive drying does not change the swelling performance of the clay.

NOTE 5—Since some dry materials may absorb moisture from moist samples, dried samples should be removed before placing moist samples in the same oven. However, this would not be applicable if the previously dried specimens will remain in the drying oven for an additional time period of about 16 h.

9.7 After the material has dried to constant mass, remove the container from the oven (and replace the lid if used). Allow the material and container to cool to room temperature in a desiccation unit or until the container can be handled comfortably with bare hands and the operation of the balance will not be affected by convection currents or its being heated, or both. Determine the mass of the container and oven-dried material using the same balance as used previously. Subtract the tare of the container from the mass of the sample to determine the samples' constant dry mass. Record this value.

9.8 Weigh 2.00 ± 0.01 g of dried and finely ground clay mineral onto a weighing paper.

9.9 Add 90 mL reagent water to the clean 100-mL graduated cylinder.

9.10 Remove not more than a 0.1-g increment of clay mineral with a volumetric spoon from weighing dish or paper and carefully dust it over the entire surface of water in the graduated cylinder over a period of approximately 30 s. Do not use a funnel that may concentrate the clay mineral in a poorly hydrated agglomerate. Allow the clay mineral to wet, hydrate, and settle to the bottom of the graduated cylinder for a minimum period of 10 min.

9.11 Add additional increments of the clay mineral powder in periods of 10 min, allowing the clay mineral to swell without air being trapped in between, following the details in 9.10, until the entire 2.00-g sample has been added.

9.12 After the final increment has settled, carefully rinse any adhering particles from the sides of the cylinder into the water column, raising the water volume to the 100 mL mark.

9.13 Place the glass stopper on the cylinder and allow it to stand undisturbed for a minimum of 16 h from the last incremental addition. After 2 h, inspect the hydrating clay mineral column for trapped air or water separation in the column. If present, gently tip the cylinder at a 45° angle and roll slowly to homogenize the settled clay mineral mass, allow the graduated cylinder with the hydrating clay mineral to remain undisturbed for a minimum of 16 h before recording the volume of the hydrated clay mass and its temperature.

9.14 After the minimum 16-h hydration period from the last increment addition, record the volume level in millilitres (mL) at the top of the settled clay mineral to the nearest 0.5 mL. Observe the distinct change in appearance at the upper surface of the settled clay mineral. Any low-density flocculated material (sometimes lighter in coloration to white) shall be ignored for this measurement. Record the observed volume of hydrated clay mineral.

NOTE 6—*Optional*—If a recognizable swelling still occurs after the minimum hydration period from the last increment addition (more than 10 % of the previous reading in a 4 hour period), continue recording the volume of the hydrated clay mass and its temperature to a maximum of 48 hours after the last increment addition.

9.15 Carefully immerse the thermometer and measure the temperature of the slurry. Record the temperature of the hydrated clay mineral to ±0.5°C.

10. Report

10.1 Report the following information:

10.1.1 Source of clay mineral, including sample identification or lot number,

10.1.2 Method of sampling used,

10.1.3 ASTM standard test method number used to perform the test,

10.1.4 Any modifications to the test method or unusual observations which may effect the test results, and

10.1.5 Swell index as mL/2 g to the nearest 0.5 mL after the minimum 16-h hydration period from the last clay increment addition and if applicable to the maximum recorded hydration period from the last clay increment addition.

11. Precision and Bias

11.1 *Interlaboratory Test Program*—An interlaboratory study of the test method was run in 1999. The design of the experiment, similar to that of Practice E691. Seven different clay mineral samples were distributed to ten laboratories. Three sets of test results were generated for each sample by each of the laboratories.

11.2 *Test Results*—The precision information is given in Table 1. The average swell index values ranged from 20 to 36 for the seven clay mineral samples tested. However, since the statistics were not related to the magnitude of the test result, the precision values have been presented in terms of coefficients of variation, CV %.

11.3 *Bias*—The procedure in Test Method D5890 for measuring the swell index of clay mineral component of geosynthetic clay liners has no bias because the values of swell index can be defined only in terms of this test method.

12. Keywords

12.1 bentonite; clay; geosynthetic clay liner; microwave; oven drying; swell; swell index

TABLE 1 Test Results

Statistic	ILS Range
Within laboratory repeatability limit, CV %^{r}	2 to 5 %
Between laboratory reproducibility limit, CV %^{R}	7 to 22 %
95 % confidence limit Within laboratory repeatability, 2.8 CV %^{r}	6 to 14 %
95 % confidence limit Between laboratory reproducibility, 2.8 CV %^{R}	20 to 61 %

APPENDIXES

X1. Additional Reagent Information

X1.1 See Table X1.1.

TABLE X1.1 Additional Reagent Information

	Type I	Type II	Type III	Type IV
Electrical conductivity, max, µS/cm at 298 K (25°C)	0.056	1.0	0.25	5.0
Electrical resistivity, min, MΩ·cm at 298 K (25°C)	18	1.0	4.0	0.2
pH at 298 K (25°C)	[A]	[A]	[A]	5.0 to 8.0
Total organic carbon (TOC), max, µg/L	100	50	200	no limit
Sodium, max, µg/L	1	5	10	50
Chlorides, max, µg/L	1	5	10	50
Total silica, max, µg/L	3	3	500	no limit

Microbiological contamination—When bacterial levels need to be controlled, reagent grade types should be further classified as follows:

	Type A	Type B	Type C
Maximum heterotrophic bacteria count	10/1000 mL	10/100 mL	100/10 mL
Endotoxin, EU/mL[B]	<0.03	0.25	not applicable

[A] The measurement of pH in Type I, II, and III reagent waters has been eliminated from this specification because these grades of water do not contain constituents in sufficient quantity to significantly alter the pH.
[B] EU = Endotoxin Units.

X2. Check lists

Check list for ASTM D5890 Swell Index of Clay Mineral Component of GCLs

Source of clay (GCL type, received from, etc.):

____

GCL Roll / Identification number: ____

Method of sampling: ____

9. Procedure

9.1 Grinding: 100% Passing US standard #100 mesh Yes ☐ No ☐
min. 65% passing US standard #200 mesh Yes ☐ No ☐
both passing components mixed together Yes ☐ No ☐

9.2 Thoroughly dried container for weighing Yes ☐ No ☐

9.3 Tare mass of container (9.2): ____

9.4 Representative test specimen selected Yes ☐ No ☐

9.5 Mass of container with clay specimen: ____

9.6 a) Whole composite ground sample dried at 105° C? Yes ☐ No ☐
Duration of drying : ________________ hours
Moisture content of sample before/after drying: ________ / _______ %
After 2 drying periods (>1 hour) moisture change less than 0.1%? Yes ☐ No ☐

9.6 b) If 9.6 a) answered No, was ASTM D4643 followed: Yes ☐ No ☐

Was note 4 followed (specimen min. 100g): Yes ☐ No ☐
Duration of drying: ________________ hours
Moisture content of sample before/after drying ________ / _______ %

9.7 Record mass of container with clay specimen: __________________________________
Subtract tare mass of container (9.3): __________________________________
Result: _______________________________

9.8 Determine mass of 2 g of whole composite ground sample? Yes No ☐

9.9 Selected ASTM D1193 water type (6.1 and 6.2): Type I ☐ Type II ☐ Type II ☐

Other water type: ____

Added 90 mil of water to cylinder Yes ☐ No ☐

9.10 Added of no more than 0.1 g increments of clay (dusty addition) during approx. 30s onto the entire water surface (10 minute waiting period before next clay increment is added): Yes ☐ No ☐

9.11 Added remaining 0.1 g clay increments according to 9.10, without any air traps Yes ☐ No ☐

9.12 10 minutes after final clay increment, carefully rinsing with 10 mil of water Yes ☐ No ☐

9.13 Allow 16 hours to settle after final clay increment added. 2 hours hereafter inspect hydrating clay for e. g. trapped air.
45° cylinder tipping for homogenisation needed? Yes ☐ No ☐
If tipped allow another 16 hours to settle.

9.14 Record volume to nearest 0.5 ml: ____________ ml
Recognizable swelling (more than 10% after 4 hours)? Yes ☐ No ☐
If Yes record swell volume, water temperature and hours after last reading:
Volume [ml] _____ water temperature °C or °F ________ time after 9.13 [h] ________

10.1.4 Modifications / Other findings

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Name and signature of person performing test Date: __________________________

Name, printed: _________________________ Signature: ____________________

Date of test performance _________________________

Name and address of lab performing test:

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