
Test Procedure for**DETERMINING MOISTURE CONTENT IN SOIL MATERIALS****TxDOT Designation: Tex-103-E****Effective Date: August 1999**

1. SCOPE

- 1.1 This method determines the moisture (water) content of soil, rock, and soil-aggregate mixtures, expressed as a percentage of the mass, by means of either a conventional oven or a microwave oven.
- 1.2 This method does not give true representative results for materials containing significant amounts of holloysite, montmorillonite, or gypsum minerals, highly organic soils, or materials in which the pore water contains dissolved solids (such as salt in case of marine deposits). For the above named materials, establish a modified method of testing or data calculation to give results consistent with the purpose of the test.
- 1.3 The values given in parentheses (if provided) are not standard and may not be exact mathematical conversions. Use each system of units separately. Combining values from the two systems may result in nonconformance with the standard.
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2. DEFINITIONS

- 2.1 *Water Content*—Water content of a material is equal to the ratio of the mass of “pore” or “free” water in a given mass of material to the mass of the solid particles in the same mass of material, expressed as a percentage.
- 2.2 *Heat Sink*—Heat sink is a solid or liquid placed in the microwave oven to absorb energy after the moisture has been driven from a test specimen. The heat sink reduces the possibility of over-heating the specimen.
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3. APPARATUS

- 3.1 *Drying oven*, maintained at $110 \pm 5^{\circ}\text{C}$ ($230 \pm 9^{\circ}\text{F}$).
- 3.2 *Microwave oven*, variable power controls and input power ratings of 700 watts preferred.
- 3.3 *Balance*
- Class G1 in accordance with Tex-901-K for specimens with a mass of 200 g or less
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- Class G2 in accordance with Tex-901-K for specimens with a mass greater than 200 g.
- 3.4 *Specimen containers for conventional ovens*, with close fitting lids if specimen is less than 200 g.
- 3.5 *Specimen containers for microwave ovens*, non-metallic, non-absorbent.
- 3.6 *Container handling apparatus*, such as glove or holder suitable for removing hot containers from the ovens.
- 3.7 *Desiccator cabinet, or jar*, containing silica gel or anhydrous calcium sulfate.
- 3.8 *Heat sink*, for microwave ovens.
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4. PREPARATIONS

4.1 *Preparing Test Specimens:*

- 4.1.1 Store samples prior to testing in airtight containers at a temperature between 2.8°C (37°F) and 30°C (86°F) and in an area that prevents direct contact with sunlight.

Note 1—Determine test specimen selection and mass by the proposed application, type of material, and type of sample. Always select a representative sample in all cases. For determination of water contents in conjunction with other test methods, the method of specimen selection is that which is specified in that method.

- 4.1.2 Make water content determination as soon as practical after sampling, especially if potentially corrodible containers (thin-walled Shelby tubes, paint cans, etc.) or sample bags are used.
- 4.1.3 For bulk samples, select the test specimen from the material after thoroughly mixed. The mass of moist material selected should be in accordance with Table 1.

4.2 *Preparing Small Jar Samples:*

4.2.1 Cohesionless Soils:

- Thoroughly mix the material, and then select a test specimen having a mass of moist material in accordance with Table 1.
- Remove about 3 mm (0.12 in.) of material from the exposed periphery of the sample and slice it in half (to check if the material is layered) prior to selecting the test specimen.

4.2.2 Layered soils:

- Select an average portion or individual portions or both, and note which was tested in the report of the results. The mass of moist material selected should not be less than 25 g or if coarse-grained particles are noted, should be according to Table 1.

Note 2—In many cases, when working with a small sample containing a relatively large coarse-grained particle, it is appropriate not to include this particle in the test specimen. If a large particle is not included, note this fact in the results.

- 4.2.3 Using a test specimen smaller than the minimum mass indicated previously requires discretion, though it may be adequate for the purpose of the test. If a specimen has a mass less than the previously indicated value, note this fact in the report of the results.

Table 1—Minimum Mass of Moist Specimens by Sieve Size

Sieve Size Retaining More Than 10% of Sample	Recommended Minimum Mass of Moist Specimen, g
2.00 mm (No. 10)	100–200
4.75 mm (No. 4)	300–500
19.00 mm (3/4 in.)	500–1000
38.10 mm (1 1/2 in.)	1500–3000
76.20 mm (3 in.)	5000–10,000

PART I—CONVENTIONAL OVEN METHOD

5. SCOPE

- 5.1 This part outlines the procedures for determining the moisture (water) content of soil, rock, and soil-aggregate mixtures by using the conventional oven method.

6. PROCEDURE

- 6.1 Select a representative test specimen of the mass designated in Table 1.
- 6.2 Determine the tare mass of a clean, dry container and lid, and record as W_C under Section 7.
- 6.3 Place the moist specimen in the container and secure the lid onto the container.
- 6.4 Determine and record the mass of the container, lid, and moist specimen as W_1 under Section 7.
- 6.5 Remove the lid and place the container with the sample in the drying oven.
- 6.6 Dry for a minimum of 16 hours or to a constant mass.
- 6.7 To oven-dry large test specimens, place the material in containers having a large surface area (such as a pan) and break into smaller aggregations.
- 6.8 After the material has dried to a constant mass, remove the container from the oven and replace the lid firmly.

- 6.9 Allow the material and container to cool to room temperature or until the container can be handled comfortably with bare hands and the operation of the balance will not be affected by the convection currents.
- 6.10 Determine the mass of the container, lid, and dry specimen using the same balance as in Section 6.2 and record as W_2 under Section 7.
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7. CALCULATIONS

- 7.1 Mass of the Water:

$$W_w = W_1 - W_2$$

- 7.2 Mass of the Solid Particle:

$$W_s = W_2 - W_c$$

- 7.3 Water Content (%):

$$WC = 100(W_w / W_s)$$

Where:

W_c = mass of container and lid, g

W_1 = mass of container, lid, and moist specimen, g

W_2 = mass of container, lid, and oven-dried specimen, g.

8. REPORT

- 8.1 Include the following information on the report (data sheet):

- identification of the sample (material) being tested by boring number, sample number, test number, etc.
- water content of the specimen to the nearest 0.1% or 1%, depending on the purpose of the test
- indication of any test specimen having a mass less than the minimum indicated
- indication of any test specimen containing more than one soil type (layered, etc.)
- indication of the method of drying, Part I or Part II
- indication of any material (size and amount) excluded from the test specimen
- time and setting of initial drying period and subsequent incremental drying periods when Part II is used
- initial mass of the test specimen prior to drying, and the mass after the incremental drying periods when Part II is used
- identification of the microwave oven and the drying settings and cycles used when standardized drying is used.

PART II—MICROWAVE OVEN METHOD

9. SCOPE

- 9.1 This part outlines the procedures for determining the moisture (water) content of soil, rock, and soil-aggregate mixtures by using the microwave oven method.

10. HAZARDS

- 10.1 Handle hot containers with insulated container holder. Some soil types can retain considerable heat, and serious burns can result from improper handling.
- 10.2 Observe any safety precautions supplied by the manufacturer of the microwave. Pay particular attention to keeping the door sealing gasket and door interlocks clean and in good working condition.
CAUTION: Manufacturers of microwave ovens may consider using their products to dry soils to be abusive and to constitute the voiding of warranties. Drying soils containing metallic materials may cause arcing in the oven. Highly organic soils and those containing oils and coal may ignite and burn during drying. Continued operation of the oven after the soil has reached constant weight may also cause damage or premature failure of the unit.
- 10.3 When first introduced, microwave ovens were reported to affect heart pacemakers, primarily because of the operating frequencies of the two devices. Since that time, pacemakers have been redesigned, and the microwave oven is not regarded as the health hazard it once was; however, it may be advisable to post warnings that a microwave is in use.
CAUTION: Highly organic soils and soils containing oil or other contaminants may ignite into flames during microwave drying. Means for smothering flames to prevent operator injury or oven damage should be available during testing. Fumes given off from contaminated soils or wastes may be toxic, and the oven should be vented accordingly.
- 10.4 Do not use metallic containers in a microwave oven. Arcing and oven damage may result.
- 10.5 Observe manufacturer's instructions when installing and using the oven.
CAUTION: Placement of the test specimens directly on the glass liner tray provided with some ovens is strongly discouraged. Concentrated heating of specimens may shatter the glass tray, possibly causing injury to the user.
- 10.6 The use of a microwave oven is acceptable in place of a $110 \pm 5^\circ\text{C}$ ($230 \pm 9^\circ\text{F}$) oven for drying soil specimens. Experience and good judgment should dictate sufficient drying time related to using a microwave oven.

11. PROCEDURE

- 11.1 Determine the tare mass of a clean, dry container and lid, and record as W_C under Section 12.
- 11.2 Place the soil specimen in the container.
- 11.3 Replace the lid.
- 11.4 Determine and record the combined mass as W_1 under Section 12.
- 11.5 Place the soil and container, without lid, in a microwave oven.
- 11.6 Turn on the microwave oven for 3 minutes.
- 11.7 Adjust the initial and subsequent drying times if experience with a particular soil type and specimen size indicates that shorter or longer initial drying times can be used without over heating.
- The three-minute initial setting is for a minimum sample mass of 100 g, as indicated in Table 1.
 - Smaller samples are not recommended when using the microwave oven because drying may be too rapid for proper control.
- 11.8 It may be necessary to split the sample into segments and dry them separately to obtain the dry mass of the total sample when very large samples are needed to represent soil containing large gravel particles.
- 11.9 Most ovens have a variable power setting. For the majority of the soils tested, a setting of “high” should be satisfactory; however, for some soils such a setting may be too severe. The proper setting can be determined only through experience with a particular oven for various soil types and sample sizes.
- 11.10 The energy output of microwave ovens may decrease with age and usage; therefore, establish power settings and drying times for each oven.
- 11.11 After set time has elapsed, remove the containers and soil from oven and cool the specimen in the desiccator to allow handling and to prevent damage to the balance.
Note 3—If containers with close-fitting lids are used, the desiccator is not necessary.
- 11.12 Determine and record the combined mass of the container, lid, and oven-dried specimen.
- 11.13 With a small spatula, knife, or short length of glass rod, carefully mix the soil.
- 11.14 Return the container and soil to the oven and reheat in the oven for one minute.
- 11.15 Repeat drying, cooling, and weighing, until the change between two consecutive mass determinations has an insignificant effect on the calculated moisture content. A change of 0.1% or less of the initial wet mass of the soil should be acceptable for most specimens.

- 11.16 Record the final combined mass as W_2 under Section 12.
 - 11.17 Standardize the drying times and number of cycles for each oven when routine testing of similar soils is contemplated.
 - 11.18 Periodically verify standardized drying times and cycles to assure that the results of the final dry mass determination are equivalent to those obtained with the repeated drying, cooling, and weighing procedure.
 - 11.19 Minimize overheating and localized drying of the soil with incremental heating and stirring, thereby achieving results more consistent with those obtained by Part 1. The recommended time increments have been suitable for most specimens having particles smaller than a 4.75 mm (No. 4) sieve and with a mass of approximately 200 g; however, they may not be appropriate for all soils and ovens, and adjustment may be necessary.
 - 11.20 Discard water content specimens after testing and do not use them in any other tests, since they may suffer particle breakdown, chemical changes or losses, melting, or losses of organic constituencies.
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12. CALCULATIONS

- 12.1 Use the same calculations as shown in Section 7
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13. REPORT

- 13.1 Include the same report information as detailed in Section 8.