State of Nevada
Department of Transportation
Materials Division

METHOD OF TEST FOR IN-PLACE DENSITY OF TREATED AND UNTREATED SOILS AND AGGREGATES

SCOPE

This test method is used to determine in-place density of treated and untreated soils, aggregate bases, sub-bases, cement or lime treated bases and selected materials. In-place density is the density of a soil as it exists in its natural state or compacted condition. As used herein, the term soil includes all material types and all particle sizes present in the material to be tested.

Density is defined as the unit weight of the soil or aggregate, usually expressed in terms of Mg/m^3 (lb/ft^3). If oven-dry condition does not prevail, the unit weight is termed wet density. If the soil or aggregate is in an oven-dry condition, the unit weight is termed dry density. Oven-dry condition is the condition of soil after it has been dried to a constant weight at a temperature of 110 ± 5°C (230 ± 9°F).

This test method requires excavating and weighing a sample of soil, measuring the volume of the sample, and calculating its density. If dry density is desired, this procedure also details the determination of the moisture content of an excavated sample and converting it from wet density to dry density.

The use of the maximum density and relative compaction of soils shall be determined in accordance with Test Method Nev. T108. This method shall be used to obtain the maximum density value for volume-to-weight conversion factors.

APPARATUS

1. Sand cone volume apparatus, Figure 1 - three piece sand cone with 200 mm (8 in.) measuring vessel (hat); or Figure 2 - one piece sand cone with 250 mm (10 in.) measuring vessel (hat).

2. Scale, hanging balance or platform type, 31 kg (70 lb) minimum capacity, graduated to 0.05 kg (0.1 lb) or finer.

3. Oven, capable of maintaining a temperature of 110 ± 5°C (230 ± 9°F).

4. Electric hot plate or gas stove.

5. Sand, 20 mesh (24 grit), consisting of clean, dry, free-flowing particles that will not degrade under repeated use. Beach sand containing organic materials, deliquescent salts or sand having any hygroscopic properties is not acceptable.

   If the sand is coarser than the material being excavated, 50 mesh (60 grit) sand may be utilized. Should the use of 50 mesh (60 grit) sand occur, a dust mask shall be used and documented by the Resident Engineer accepting its use.

6. Drum, metal 208 L (55 gal.) with pour spout for sand.

7. Sample containers, any suitable container with a lid that will prevent loss of moisture during transport.

8. Drying pans, scoops, brushes, etc.

9. Digging bar, maximum length of 914 mm (36 in.) and maximum diameter of 25 mm (1 in.).

10. Sample splitter or quartering canvas.

CALIBRATION OF STANDARD TEST SAND

Step 1: Calibration of cone and measuring vessel (hat)

Use a 200 mm ± 12.7 mm (8 in. ± 0.5 in.) measuring vessel (hat) with the three piece sand cone and a 250 mm ± 12.7 mm (10 in. ± 0.5 in.) measuring vessel (hat) with the one piece sand cone. Determine the volume of the measuring cone and volume of the measuring vessel (hat) before calibrating the sand. The calibration of the test sand determines the weight per unit volume of sand when poured into a container under controlled conditions. Calibration of the sand shall be performed in a vibration free location. The function of the sand cones shown in Figures 1 and 2 are to assure that the sand will be poured under identical conditions in each instance. For this calibration procedure, sand is poured into a measuring vessel (hat) rather than into a test-hole.

1. If using the three piece sand cone (Figure 1), it is noted that variations in the volume of the measuring cone differ, therefore the unit shall be calibrated annually. Calibration is performed using water and a glass plate to eliminate entrapped air. The following procedure shall be used: Level the scale; place the overflow vessel on the scale; cover the neck of the cone to avoid losing any water (duct tape, etc.) and place in the overflow vessel (make sure the cone is level in the overflow vessel); place the glass plate over the cone and zero the scale; remove the glass plate and carefully fill the cone with water at 25 ± 3°C (77 ± 5°F); place the glass plate over the opening to ensure there is not any entrapped air under the glass plate. Refer to number 3. of this section for the calculations.

Use the 200 mm ± 12.7 mm (8 in. ± 0.5 in.) measuring vessel (hat) with the three piece sand cone. Determine the volume of the 200 mm ± 12.7 mm (8 in. ± 0.5 in.) measuring vessel (hat) using water and a glass plate. The following procedure shall be used: Level the scale; place the measuring vessel (hat) on the scale with the glass plate over the measuring vessel (hat) and zero the scale; remove the glass plate and carefully fill the measuring vessel (hat) with water at 25 ± 3°C (77 ± 5°F); place the glass plate over the opening to ensure there is not any entrapped air under the glass plate. Refer to number 3. of this section for the calculations.

2. If using the one piece sand cone (Figure 2), it is noted that variations in the volume of the cone differ, therefore the unit shall be calibrated annually. Calibration is performed using water and a glass plate to eliminate entrapped air. The following procedure shall be used: Level the scale; turn the one piece sand cone upside down on the scale; close the sand valve and make sure it is water tight using petroleum jelly (Vaseline, etc.); place the glass plate over the cone and zero the scale; remove the glass plate and carefully fill the measuring cone with water at 25 ± 3°C (77 ± 5°F); place the glass plate over the opening to ensure there is not any entrapped air under the glass plate. Refer to number 3. of this section for the calculations.

   Use the 250 mm ± 12.7 mm (10 in. ± 0.5 in.) measuring vessel (hat) with the one piece sand cone. Determine the volume of the measuring vessel (hat) using water and a glass plate. The following procedure shall be used: Level the scale; place the measuring vessel (hat) on the scale with the glass plate over the measuring vessel (hat) and zero the scale; remove the glass plate and carefully fill the measuring vessel (hat) with water at 25 ± 3°C (77 ± 5°F); place the glass plate over the opening to ensure there is not any air trapped under the glass plate. Refer to number 3. of this section for the calculations.

3. Record the weight of water required to fill the cone or the measuring vessel (hat) to the nearest 0.1 lb and designate as "W". Use the following formula to calculate the volume of the cone and the volume of the measuring vessel (hat):

   Volume = W/62.4 (English units must be used):

   V = Volume in cubic feet
   W = Weight of water used to fill the cone or the measuring vessel (hat) in pounds
   62.4 = Weight of one cubic foot of water

   If the volume is required in cubic meters, multiply the volume in cubic feet by 0.0283168 (rounded to the nearest 0.001)

   Do not write the volume on the equipment. Record it on the appropriate NDOT form.

Step II: Sand Calibration

1. Determine the sand density by filling the sand cone and measuring vessel (hat) with three trial pours of sand, weigh and record to the nearest 0.1 lb. Average the three trial pours and divide by the volume of the cone and measuring vessel (hat), this equals the sand density in lb/ft^3. To obtain Mg/m^3, divide the lb/ft^3 by 62.4. (rounded to the nearest 0.001)

2. The three trial pours shall be within ± 0.2 lb of each other. If the three trial pours are not within 0.2 lb of each other, repeat this procedure.

Calibrate each shipment of sand prior to the start of each project, before using it in any test-hole measurements, and each time new sand is added to the barrel (thoroughly mix old sand with new sand). Do not blend sand supplied by different manufacturers.

Record results on the appropriate NDOT form.

EXCAVATION OF TEST SAMPLE

1. Location of the test site should be such that the soil and degree of compaction encountered will be representative of the average conditions in the area. If large rocks are encountered, it may be necessary to move to a new test site. If organic material (leaves, sticks, etc.) is encountered, it must be removed from the test sample after total wet weight has been obtained.

2. Prior to starting excavation, clear away all loose surface material and level off a test site area at least 0.2 m² (2 ft²). For areas compacted by pneumatic tired or steel wheeled rollers, remove disturbed surface material. Where a sheeps foot or tamping roller are used, remove loose surface material to a depth of not less than 50 mm (2 in.) below the deepest disturbance by the roller after completion of compaction. When testing on a slope, level the testing area as much as possible without building a pad (the cone shall not be tilted, this may result in erroneous density values). The edge of the leveling plate may be used as a scraper to level the surface.

3. Place the leveling plate on the prepared test area and secure the leveling plate to the surface by driving the corner pins into the soil. Using the circular template as a guide and without disturbing the surrounding material, dig a neat, clean-cut hole 250 to 300 mm (10 to 12 in.) in diameter and a depth of 75 to 200 mm (3 to 8 in.). [1] To maintain the necessary degree of accuracy in weighing and measuring operations, test sample excavation shall not be less than 0.0042 m^3 (0.150 ft^3). Scoops or digging bars may be used to excavate the test-hole. When digging bars are used, do not pry back against the wall of the hole in any manner that will compress the area. Regardless of the method of excavation, trim the sides and bottom of the hole as smooth as possible. A small, soft brush shall be used to sweep the sides and bottom of the hole to remove all loose material.

[1] Size of the plate used will depend on the thickness of the soil layer to be tested to obtain the required volume of material. In minimum thickness layers, a 250 mm ± 12.7 mm (10 in. ± 0.5 in.) leveling plate shall be used. When the soil layer is 75 mm (3 in.) or less, a 300 mm ± 12.7 mm (12 in. ±0.5 in.) leveling plate shall be used.

4. Exercise care to prevent loss of any excavated sample or its moisture prior to weighing. Use a tightly covered container to reduce loss of moisture. Weigh and record to the nearest 0.01 kg (0.1 lb).

Where different types of material are deposited in layers, do not penetrate different layers with a single test-hole or combine excavated material into a single sample. Each of these soil types might be compacted to specification requirements based on their individual maximum densities, but test maximum density of the combination may be entirely different, and result in an erroneous test result.

SAND VOLUME MEASUREMENT OF THE TEST-HOLES

1. Obtain at least 23 kg (50 lb) of sand in a suitable pouring container and record to the nearest 0.01 kg (0.1 lb).

2. If using the three piece sand cone, center the three piece sand cone over the leveling plate and test-hole. Pour the calibrated sand into the regulating funnel rapidly enough to maintain a sand level in the funnel at about 19 mm (3/4 in.) below the top edge. Pour until the hole and cone are filled, as indicated by sand overflowing into the overflow vessel. Tests have shown that a steady sand flow while pouring is essential and that an inconsistent flow of sand through the orifice may result in a considerable error. Do not stop the flow of sand once the pouring has begun. Stop the sand pour immediately upon overflow and allow the balance of sand remaining in the regulating funnel to completely empty into overflow vessel. Hold the large measuring cone so it cannot move and rotate the overflow vessel a few turns to free it from the neck of the measuring cone prior to its removal. Remove the regulating funnel and lift the overflow vessel off the measuring cone. Sand that has overflowed into the overflow vessel is not incorporated into the test-hole measurement and is returned to the original sand supply remaining in the pouring container. Weigh and record sand in the pouring container as (weight of residue) to the nearest 0.01 kg (0.1 lb). The difference between initial weight of sand in the pouring container and weight of residue remaining after pouring the sand, represents the weight of sand used to fill the volume of the hole, cone and leveling plate. Use the same sand cone during testing that was used to calibrate the sand.

3. If using the one piece sand cone, center the one piece sand cone over the test-hole and leveling plate. Close the sand valve and pour the weighed sand into the upper portion of the one piece sand cone and cover the opening with a lid. Open the sand valve and let the sand flow into the excavated hole and measuring cone until the sand stops moving. Immediately close the sand valve and place the one piece sand cone on top of the pouring container. Open the sand valve and allow the remaining sand to flow into the container. Weigh and record sand in the pouring container as weight of residue to the nearest 0.01 kg (0.1 lb). The difference between the initial weight of sand in the pouring container and weight of residue remaining after pouring the sand, represents the weight of sand used to fill the volume of the hole, cone and leveling plate. Use the same sand cone during testing that was used to calibrate the sand.

During the pouring of sand, the apparatus must not vibrate or be touched. Stop any equipment causing ground vibration during the pouring process.

If the sand contained in the measuring cone does not become contaminated with the soil in the excavated area, it may be salvaged for reuse. Recover sand from measuring cone by placing the edge of large recovering scoop slightly under the edge of cone, then slide cone onto the scoop and place in an empty pouring container.

The sand in the test-hole may have picked up moisture or foreign matter, therefore salvage may not be possible.

CALCULATION OF TEST-HOLE VOLUME

Knowing both the weight per unit volume of the sand (sand density) when it is poured into the test-hole by the sand cone procedure, and weight of sand used to fill the test-hole, measuring cone and leveling plate (weight of sand used), the test-hole volume in m^3 (ft^3) may be computed from the following formula:

Report all volumes to the nearest 0.001

$$\text{Volume of Test-Hole} = \left(\frac{\text{weight of sand used}}{\text{sand density}} \right) - (\text{volume of cone + leveling plate})$$

Volume of the cone and plate in m^3 (ft^3) may be computed using the following formula:

$$\text{Volume of Cone} = m^3 = W/62.4\ (0.0283168) \quad \text{or} \quad ft^3 = W/62.4$$

$$\text{Volume of Leveling Plate} = m^3 = \frac{\pi r^2 h}{1{,}000{,}000{,}000} \quad \text{or} \quad ft^3 = \frac{\pi r^2 h}{1728}$$

Where $\pi = 3.1416$
r = radius of circular cut-out of plate, mm (in.)
h = thickness of leveling plate, mm (in.)
W = weight of water at 25 ± 3°C (77 ± 5°F) to fill up the measuring cone

IN-PLACE WET DENSITY

Determine the in-place wet density from the following formula:

Report to the nearest 0.1

$$\text{In-place Wet Density} = \left(\frac{\text{wet weight of total excavated sample}}{\text{volume of hole}} \right)$$

MOISTURE DETERMINATION

Where it is desired to ascertain the density of soil in terms of oven-dry weight, it is necessary to perform a moisture determination using a representative portion in accordance with Test Method Nev. T200. Moisture sample must be of sufficient size to represent the total excavated sample with consideration given to the amount and nature of the coarse aggregate fraction. Accurately weigh the amount to be used for moisture determination, then thoroughly dry in accordance with Test Method Nev. T112. Re-weigh after drying and calculate the moisture content from the following formula:

Report to the nearest 0.1

$$\text{Percent Moisture} = \left(\frac{\text{weight of wet soil - weight of dry soil}}{\text{weight of dry soil}} \right) \text{x } 100$$

This moisture content is known as in-place moisture content because it denotes the moisture condition of in-place soil and will be used to determine the in-place dry density. When + 3/4 size material are present, the dried moisture sample shall be screened over the 3/4 sieve to determine the dry weight of the material passing the 3/4 sieve and material retained on the 3/4 sieve, this material will be used for Test Method Nev. T104 (oversized aggregate correction).

CONVERSION OF WET DENSITY TO DRY DENSITY

Convert wet density to dry density from the following formula:

Report to the nearest 0.1

$$\text{In-place Dry Density} = \left(\frac{\text{in-place wet density}}{\text{in-place \% moisture content + 100}} \right) \text{x } 100$$

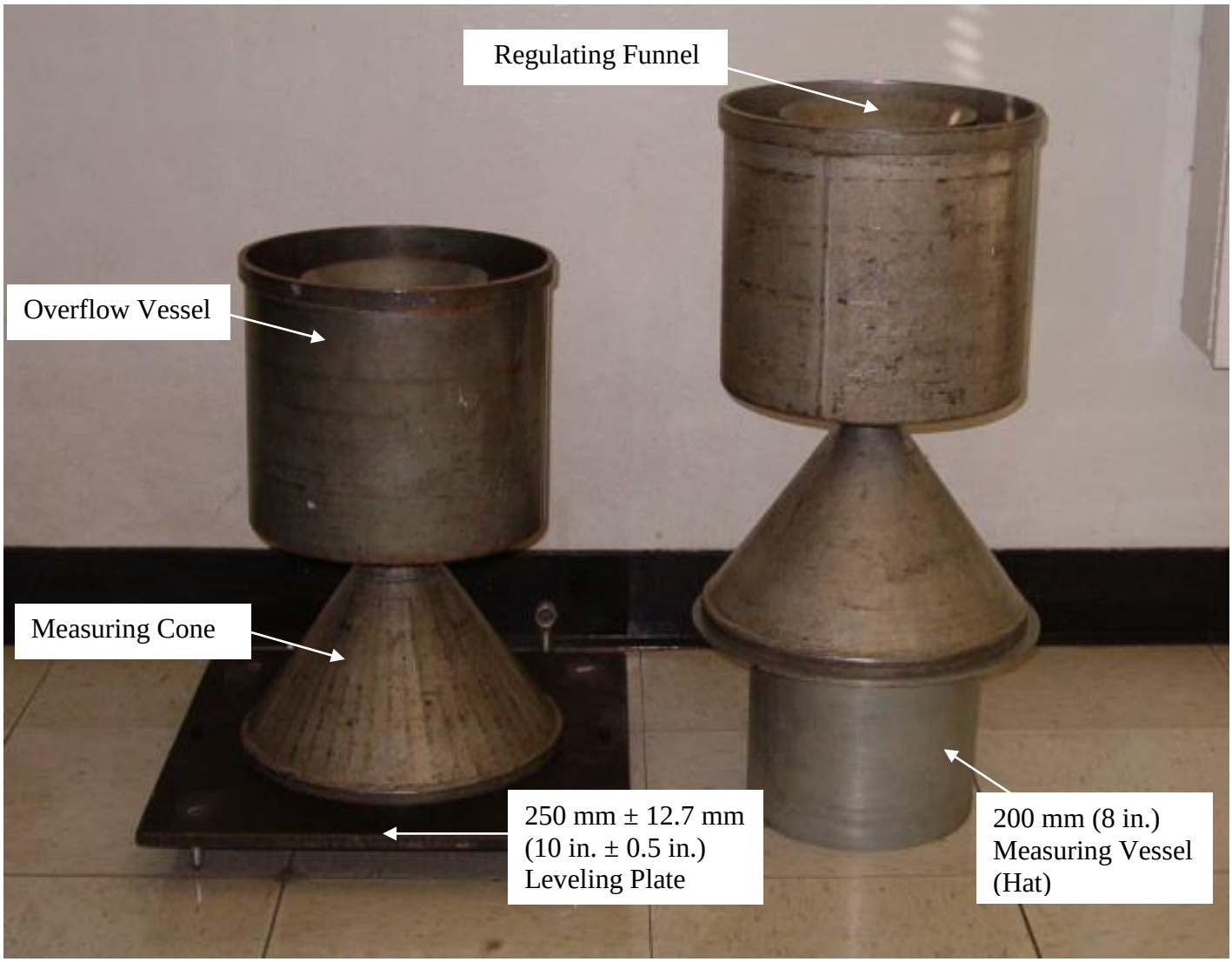
REPORT

Report compaction to the nearest whole percent.

NOTES

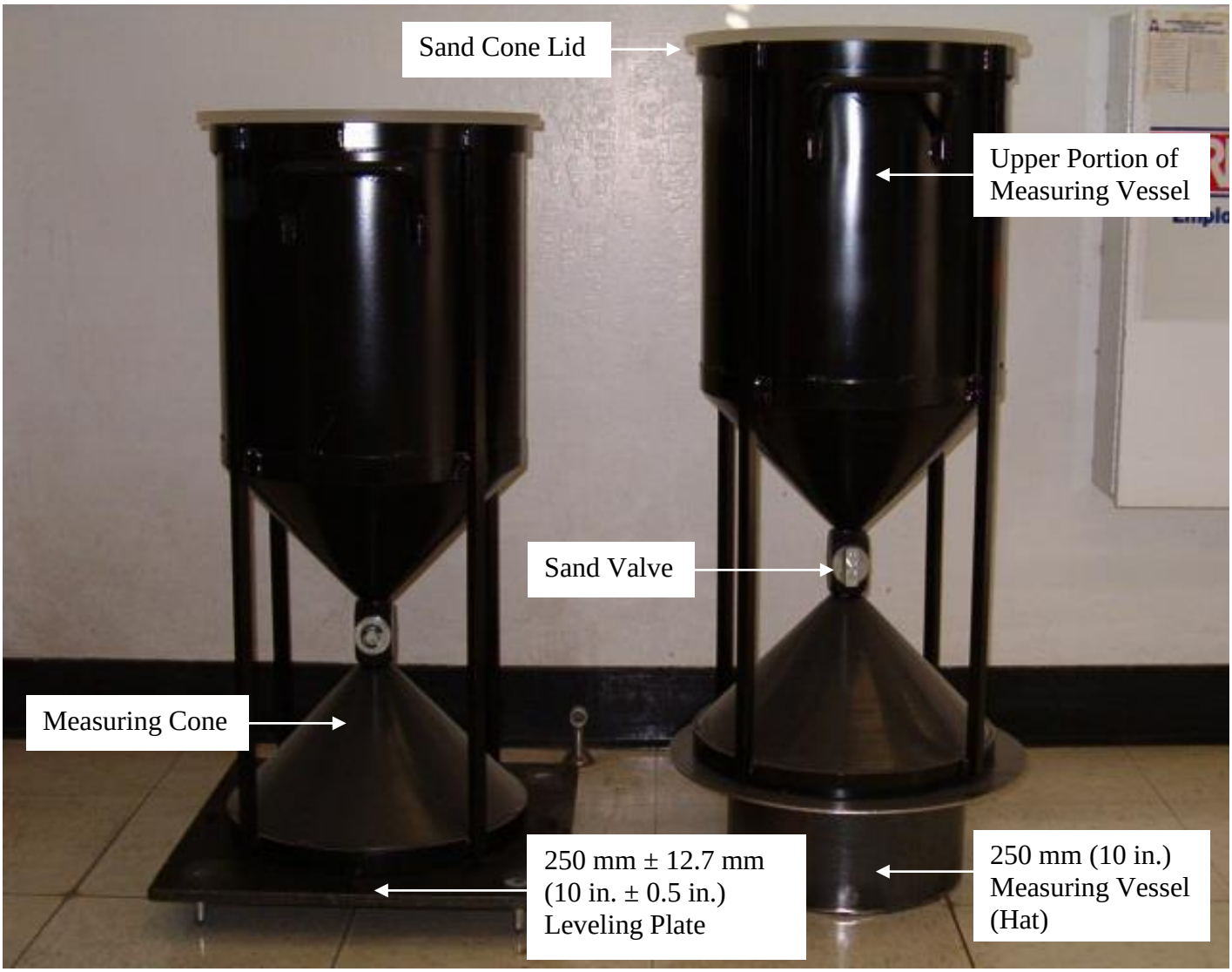
1. Test Method Nev. T104 and T108 must be performed whenever the material changes, a second re-test is required or test results exceed 102 percent compaction. These two test methods shall be performed concurrently.

2. When drying gypsum or material blended with recycled asphalt pavement (RAP), dry in accordance with Test Method Nev. T112, Method A, using a temperature of 60°C (140°F), to avoid changing the nature of the sample.



Three piece sand cone and 200 mm (8 ın.) measuring vessel (hat)

FIGURE 1



One piece sand cone and 250 mm (10 in.) measuring vessel (hat)

FIGURE 2