**Designation: D 2844 – ~~94~~01**

# Standard Test Method for Resistance *R*-Value and Expansion Pressure of Compacted Soils[1]

This standard is issued under the fixed designation D 2844; 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 the procedure for testing both treated and untreated laboratory compacted soils or aggregates with the stabilometer and expansion pressure devices to obtain results indicative of performance when placed in the base, subbase, or subgrade of a road subjected to traffic.

1.2 The values stated in inch-pound units are to be regarded as the standard.

1.3 *This 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.*

## 2. Referenced Documents

2.1 *ASTM Standards:*

C 670 Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials[2]

---

[1] This test method is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.08 on Special and Construction Control Tests.

Current edition approved ~~March 15, 1994.~~ Nov. 10, 2001. Published ~~April 1994.~~ February 2002. Originally published as D 2844 – 69. Last previous edition D 2844 – ~~89~~94.

***A Summary of Changes section appears at the end of this standard.**

E 4 Practices for Force Verification of Testing Machines[3]
E 11 Specification for Wire-Cloth Sieves for Testing Purposes[4]
2.2 *AASHTO Documents:*
T 190 Test Method for Resistance R-Value and Expansion Pressure of Compacted Soils[5]

## 3. Significance and Use

3.1 This test method is used to measure the potential strength of subgrade, subbase, and base course materials for use in road and airfield pavements. The R-value is used by some agencies as a criteria for acceptance of aggregates for base course and bituminous courses.

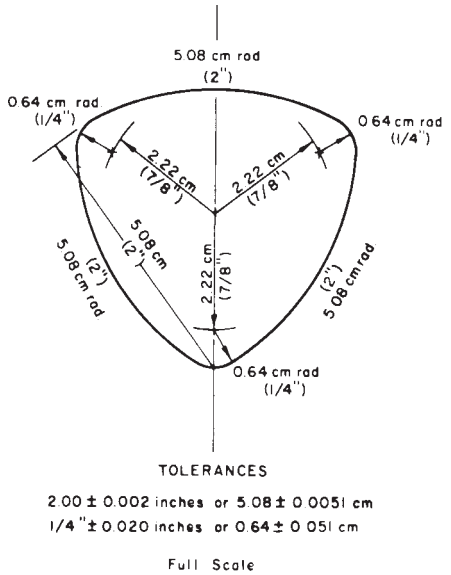



**FIG. 1 Tamper Shoe for Kneading Compactor**

3.2 The expansion pressure testing has been used in conjunction with the R-value test to determine cover requirements (thickness) and construction controls to reduce pavement distortion from expansive subgrade soils.

## 4. Apparatus

4.1 *Kneading Compactor*, capable of applying an average contact pressure of 350 ± 16 psi (2410± 110 kPa) to the tamper foot shown in Fig. 1 and with provisions for maintaining this pressure during changes in sample height. The load-time trace shall be free of "chatter" or evidence of impact-associated changes in slope. The rise time for application of foot pressure, in the range from 35 to 300 psi (240 to 2070 kPa), shall not be less than 0.07 nor more than 0.20: The dwell time, measured at 300 psi foot pressure, shall not be less than 0.15 nor more than 0.45 s: The pressure-release or removal time shall not be greater than 0.60 s.

4.1.1 The compactor shall include a counter or timer for measuring the number of tamps applied to a specimen and a mold holder, for use in compacting specimens, that rotates equally between tamps to give 5 to 7 tamps per revolution of the mold. The holder shall firmly restrain the mold during compaction. The base of the mold holder shall have a metal plate 3 31⁄32 in. (100.8 mm) in diameter and 0.5 in. (12.7 mm) high to which is cemented a rubber disk having a diameter of 3 15⁄16 in. (100.0 mm) and a height of ⅛ in. (3.2 mm). The plate shall be an integral part of the base of the mold holder. The compactor shall also include a trough for feeding the sample into the mold in 20 increments (Fig. 2). Troughs with a semicircular cross section of 6 in. $^3$ (39 cm$^2$) in area and 20 in. (50.8 cm) long have proven satisfactory.

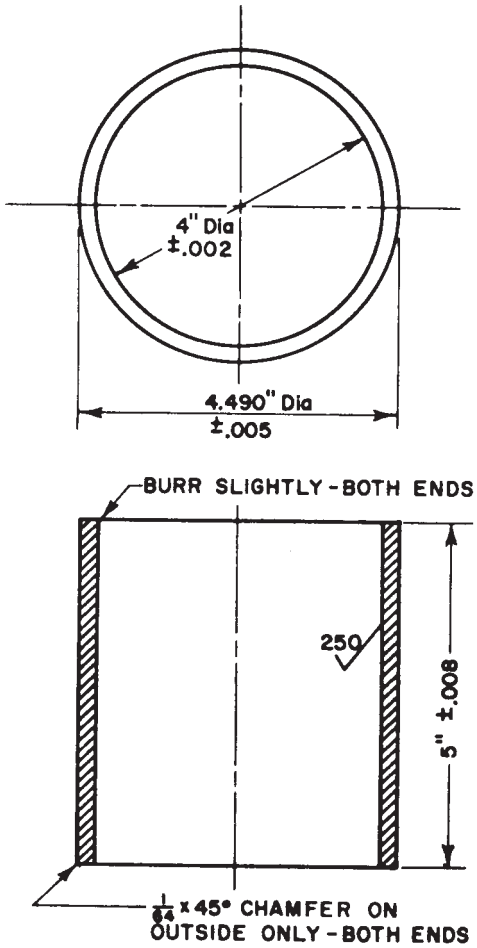
4.2 *Compression Testing Machine*, with a minimum capacity of 10 000 lbf (45 kN) and satisfying the requirements of Practices E 4.

4.3 *Mold*, 4 ± 0.002 in. (101.6 ± 0.05 mm) inside diameter by 5 ± 0.008 in. (127 ± 0.20 mm) high. (See Fig. 3 for surface roughness.)

4.4 *Rubber Disks*, 3 15⁄16 in. (100 mm) in diameter by ⅛ in. (3 mm) thick and having a durometer hardness of 60 ± 15.

---

[2] Annual Book of ASTM Standards, Vol 04.02.
[3] Annual Book of ASTM Standards, Vol 03.01.
[4] Annual Book of ASTM Standards, Vol 14.02.
[5] Available from American Association of State Highway and Transportation Officials, 444 N. Capitol St., NW, Suite 225, Washington, DC 20001.




NOTE 1—Inside roughness is obtained by smooth machining inside to required diameter of 4.000 ± 0.002 in. followed on final operation with a boring tool bit ground to a 90° point with sharp point ground flat measuring 0.001 to 0.003 in. across. Depth of cut is 0.002 in. with 0.010 in. feed using sulfur-based oil coolant.

**FIG. 3 Mold**

4.5 *Metal Follower*, solid-walled, metal specimen follower 3.95 ± 0.005 in. (100.33 ± 0.13 mm) in outside diameter by 5 in. (127 mm) long.

4.6 *Exudation Device*, as shown in Fig. 4.[6]

4.7 *Phosphor Bronze Disk*, as shown in Fig. 5.

4.8 *Filter Paper*, 100 mm in diameter and 0.006 in. (1.5 mm) thick, smooth surface, medium filtering speed, medium retention.

4.9 *Filter Paper*, 110 mm in diameter and 0.006 in. (1.5 mm) thick, creped surface, medium-fast filtering speed, medium retention.

4.10 *Expansion-Pressure Device*, with accessories as shown in Fig. 6. [6] There should be at least three of these devices for each sample to be tested within a day's time.

4.11 *Deflection Gage*, with divisions of 0.0001 in. (0.002 mm) and an allen wrench as shown in Fig. 6.

4.12 *Stabilometer*, with accessories, as shown in Fig. 7 and Fig. 8.[6]

4.13 *Standard Metal Specimen*, 4 in. (101.60 mm) in outside diameter by 6 in. (152.2 mm) high as shown in Fig. 8.

4.14 *Balance*, 5000-g capacity, accurate to 1 g.

4.15 *Sieves*, 1 in. (25.0 mm), ¾ in. (19.0 mm) and No. 4 (4.75 mm) conforming to the requirements of Specification E 11.

4.16 *Miscellaneous Equipment*, including mixing pans, spoons, spatulas, and gallon cans with close-fitting lids.

## 5. Soil Preparation

5.1 Remove any coatings from coarse aggregate and break clay lumps to pass the No. 4 (4.75-mm) sieve.

[6] Copies of detailed drawings of the apparatus shown in Figs. 4 (1 drawing), 6 (4 drawings), 7 and 8 (7 drawings) are available at a nominal cost from the ASTM Headquarters. Request Adjunct No. ADJD284401, ADJD284402, and ADJD284403, respectively.

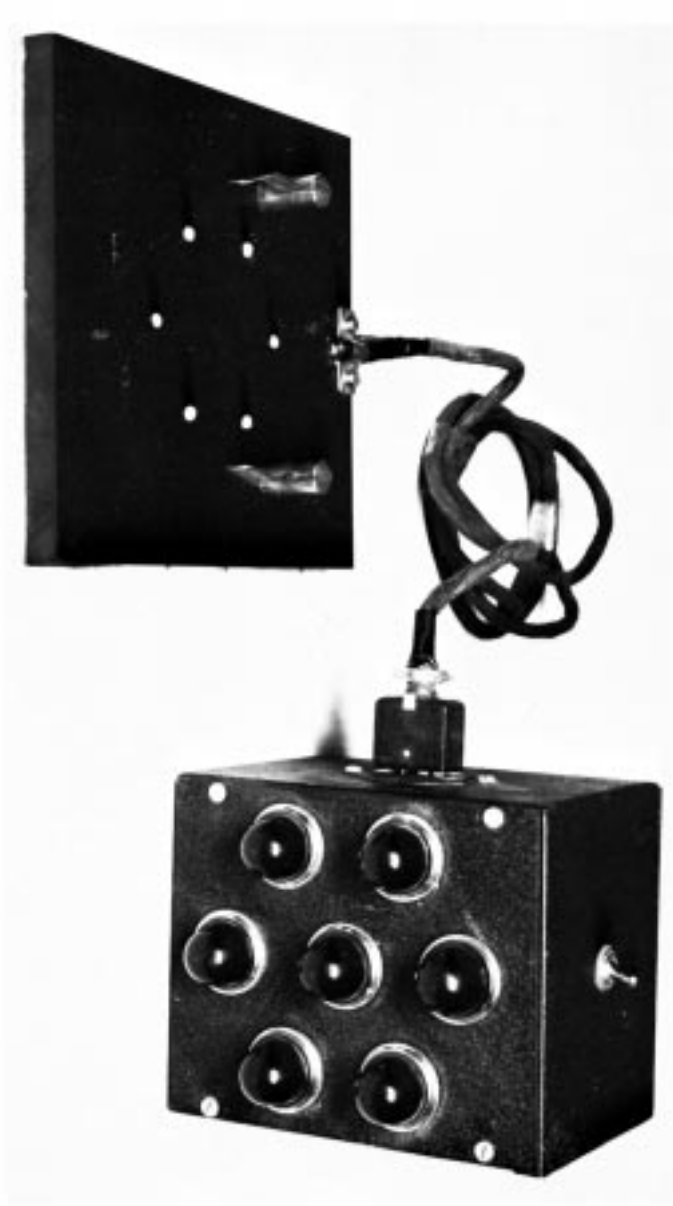


**FIG. 4 Exudation-Indicator Device**

5.2 Adjust the soil graduation when some of the material is retained on the ¾-in. (19.0-mm) sieve. When 75 % or more passes the ¾-in. sieve, use that part of the sample passing the¾-in. sieve. If less than 75 % of the sample passes the 1-in. sieve use that part of the sample passing the 1-in. (25.0-mm) sieve.

## 6. Preparation of Soil Specimens

6.1 Thoroughly mix four 1200-g samples of soil with the amount of water estimated to equal one half to two thirds of the water required to produce saturation as defined in 6.3 and 6.4. Place the samples in covered containers and allow them to stand overnight. Just prior to compaction, mix the samples with the final amount of water required to produce saturation. The first sample is used as a pilot specimen to assist in determining the final amount of water required.

6.2 Weigh out enough material to fabricate a compacted sample 4 in. (101.6 mm) in diameter by 2.5 in. (63 mm) high. Compacted specimens having heights from ~~2.3~~ 2.45 to ~~2.7~~ 2.55 in. ~~(58~~ (62 to ~~68~~ 65 mm) are acceptable. Compact the soil into the mold by means of the kneading compactor as follows: Place the mold in the mold holder which has a rubber disk, 3 15⁄16 in. (100 mm) in diameter and ⅛ in. (3 mm) thick, cemented to the plate. Adjust the mold for approximately ⅛-in. (3-mm) clearance between the lower edge of the mold and base of the mold holder. With the compactor-foot pressure set at 250 ± 25 psi (1720 ± 170 kPa), feed 3 in. (76 mm) of the soil in the trough into the mold. Feed the balance of the soil into the mold in 20 equal increments with one application of the ram after each increment. Allo~~y~~w 10 additional tamps to level the soil, then place a rubber

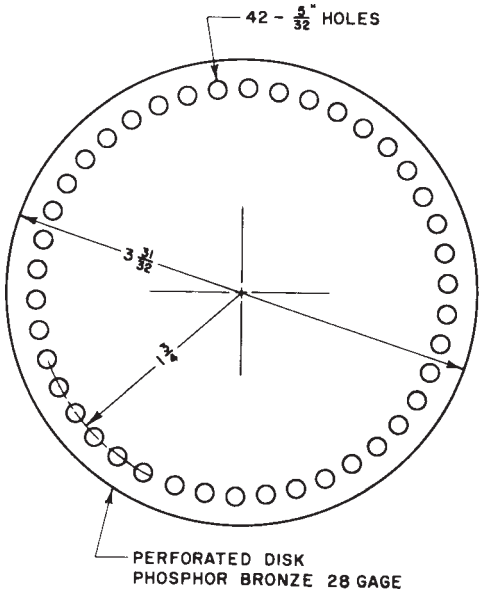



**FIG. 5 Phosphor-Bronze Disk**

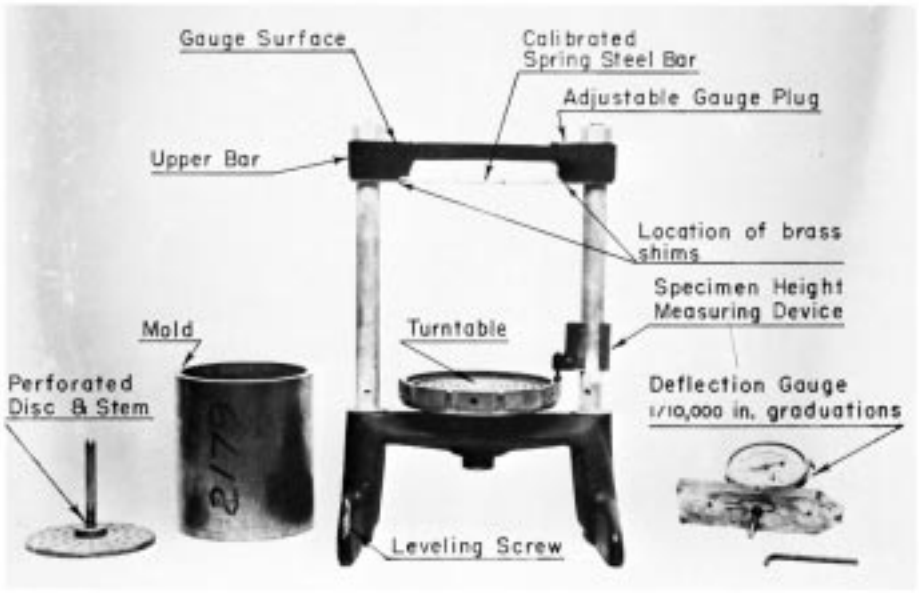



**FIG. 6 Expansion-Pressure Device and Accessories**

disk on top of the specimen. Apply 100 additional tamps with a foot pressure of 350 psi (2410 kPa). Stop compacting the soil at any time before 100 tamps if water appears around the bottom of the mold.

NOTE 1—Use lower compaction pressures when necessary to limit penetration of the ram into the soil to not greater than ¼ in. (6 mm).

6.3 Remove the mold containing the compacted specimen from the compactor. Level the tamped surface by hand tamping with a 1.5-in. (38-mm) diameter rod. Place a phosphor-bronze disk on the tamped surface of the soil and place a filter paper on top of the bronze disk. Invert the mold and place it on the exudation device so that the filter paper is on the bottom. Using the compression testing machine, apply a uniformly increasing pressure to the soil at the rate of 2000 lbf (8900 N)/min. Water should be exuded from the soil at 300 psi (2070 kPa) as evidence that enough moisture is present to produce saturation. Stop the loading and record the exudation pressure when either five of the six outer lights on the exudation pressure device are lighted or three outer lights are lighted and free water is visible around the bottom of the mold. Do not exceed a ~~loading~~ exudation pressure of 800 psi (5520 kPa).

6.4 Mold at least two more specimens with different amounts of moisture so that a range of exudation pressures from 100 to 800 psi (690 to 5520 kPa) (Note 2) is obtained which brackets the 300 psi (2070 kPa) value. For some high volume-change soils, additional specimens having exudation pressures lower than 100 psi may be necessary to obtain expansion pressures that are low enough to provide a suitable range of data for a complete expansion pressure analysis of the soil.

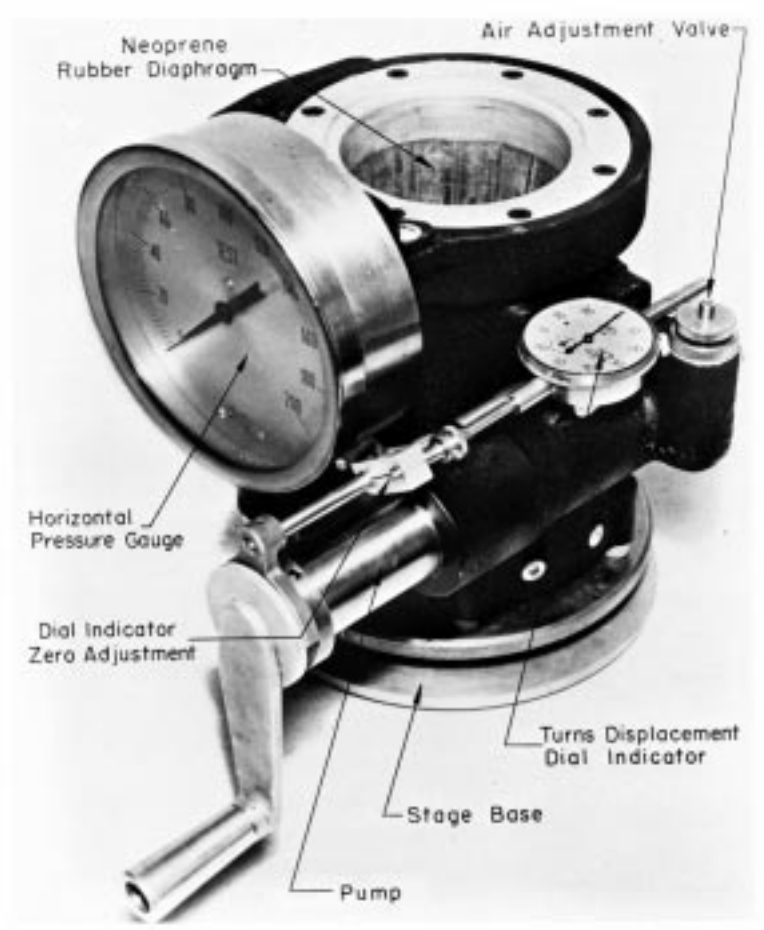



**FIG. 7 Hveem Stabilometer**

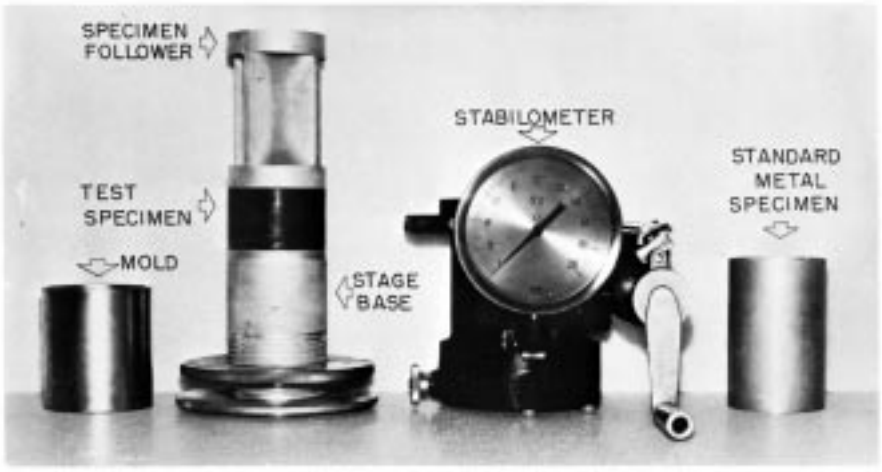



**FIG. 8 Stabilometer and Accessories**

NOTE 2—Occasionally, material from very plastic, clay-test specimens will extrude from under the mold and around the follower ram during the loading operation. If this occurs when the 800-psi (5520-kPa) point is reached and fewer than five lights are lighted, the soil should be reported as less than 5 R-value. Coarse granular materials and clean sands may require the use of paper baskets to permit testing.

## 7. Calibration of Expansion-Pressure Apparatus

7.1 Calibrate the spring-steel bar of the expansion-pressure device (Fig. 6) by applying upward measured loads at the center of the bar and measuring the respective deflections of the bar with the deflection ~~gage.~~ dial indicator.

7.2 The steel spring bar is considered in calibration when the measured deflections are within the following tolerances:

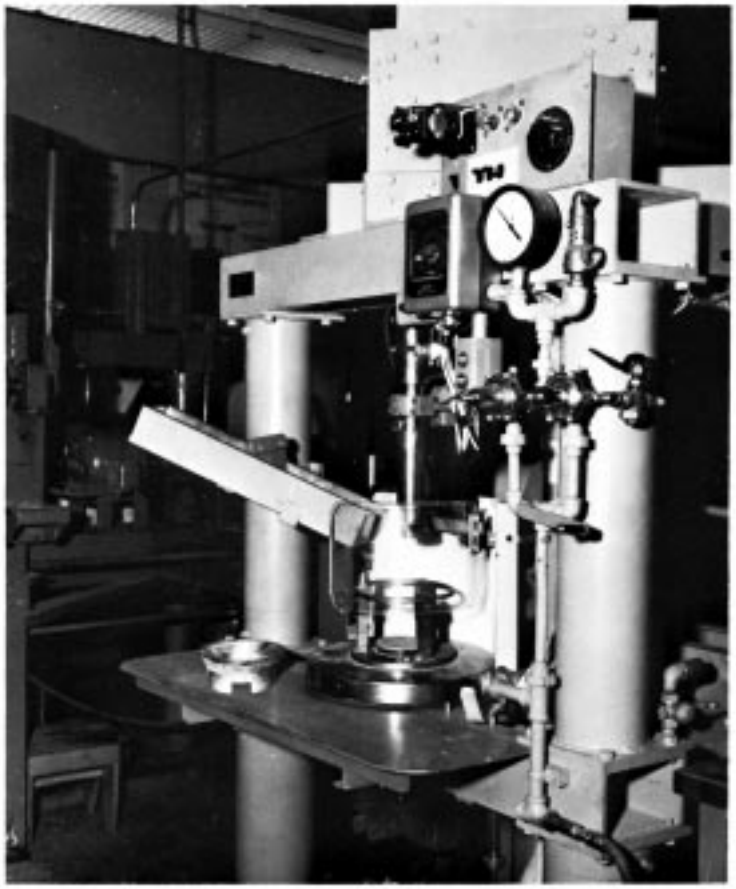


**FIG. 2 Compactor with Sample Feed Trough**

| Applied Load | Dial Reading, in. (mm) |
|---|---|
| 8 (3.75) | 0.0021± 0.0002 (0.055 ± 0.005) |
| 16 (7.50) | 0.0042 ± 0.0002 (0.110 ± 0.005) |
| 24 (11.25) | 0.0063 ± 0.0002 (0.165± 0.005) |
| 32 (15.00) | 0.0084 ± 0.0002 (0.220± 0.005) |

7.3 If the deflection ~~gage~~ dial indicator does not check the above readings, loosen the top frame bar and adjust the position of the shims, between the frame and the spring steel bar, until the required readings are obtained.

NOTE 3—Some models of the expansion-pressure apparatus have set screw adjustments in lieu of shims.

## 8. Expansion-Pressure Testing

8.1 Allow the test specimen to rebound in a covered mold for at least 30 min after determination of the exudation pressure.

8.2 Place deflection ~~gage~~ dial indicator in position on the expansion-pressure device with the single-bearing end of the gage base resting on the adjustment ring.

8.3 Using an allen wrench, raise or lower the adjustment plug until the deflection ~~gage is on − 1.0010~~ dial indicator measures − 1.0010 in. (0.025 mm). The deflection ~~gage~~ dial indicator will read 0.0090 in. (0.229 mm).

8.4 Place the perforated disk with stem firmly on the face of the compacted specimen in the mold and place the mold in the expansion-pressure device after placing creped surface filter paper on the turntable.

8.5 Seat the perforated disk firmly on the specimen with pressure applied by the fingers. Raise the turntable on the expansion device until the deflection ~~gage~~ dial indicator reads zero. If the device was properly adjusted, according to 6.3, this will apply the preset surcharge deflection of 0.0010 in. (0.025 mm).

8.6 Put approximately 200 mL of water into the mold and allow pressure from expansion of the specimen to develop for 16 to 24 h.

NOTE 4—Do not leave a test specimen unconfined by the expansion-pressure device while there is free water on top of the specimen in the mold.

8.7 Read the deflection of the calibrated spring steel bar to 0.0001 in. (0.002 mm). When the deflection is greater than 0.0100 in. (0.254 mm), the expansion-pressure device should be recalibrated before using again.

8.8 Determine the expansion pressure, *P*, as follows:

$$P = kd$$

where:

$k$ = spring constant of steel bar calculated from calibration of the expansion-pressure apparatus and expressed in psi/0.0010 in. (or kPa/0.025 mm), and,

$d$ = deflection shown by deflection ~~gage~~, dial indicator, in. (mm).

## 9. Adjustment of Stabilometer

9.1 Adjust the bronze nut on the stabilometer stage base so that the top of the stage is 3 ½ in. (89 mm) below the bottom of the upper tapered ring of the stabilometer. Perform all tests at this setting.

9.2 Adjust the amount of air in the stabilometer cell so that 2 ± 0.05 turns of the pump handle increases the liquid pressure from 5 to 100 psi (34 to 690 kPa) with the standard metal specimen in the stabilometer chamber.

## 10. Resistance-Value Testing of Specimens

10.1 After testing for expansion pressure, pour water off the top of the specimen (Note 5) and place the mold with the specimen on top of the stabilometer. Place the follower on top of the specimen and force the specimen from the mold into the stabilometer. Lower the testing machine head until it just engages the follower.

NOTE 5—If all the water has drained through the specimen, add water to the top and allow to stand for 15 min. Pour off any excess water and continue test.

10.2 Apply a horizontal pressure of 5 psi (34 kPa) to the specimen by means of the displacement pump then apply a vertical load using a uniform rate of movement of 0.05 in. (1.3 mm)/min.

10.3 Record the horizontal pressure when the vertical load is 2000 lbf (8900 N) and stop loading. Reduce the vertical load to 1000 lbf (4450 N). With the displacement pump, adjust the horizontal pressure down 4 psi (27kPa) then bring up to 5 psi (34 kPa).

NOTE 6—This will result in a further reduction in the applied load, and should be ignored.

10.4 Turn the stabilometer pump handle at approximately two turns per second and measure the number of turns of the pump handle (using the turns-displacement dial indicator on the stabilometer) to raise the horizontal pressure from 5 to 100 psi (34 to 690 kPa). This is the turns displacement, $D$, of the specimen.

10.5 Determine the resistance, $R$, as follows:

$$R = 100 - [100/(2.5/D)(160/P_h - 1) + 1]$$

where:

$P_h$ = horizontal pressure, psi, and

$D$ = number of turns, displacement dial indicator reading.

This is the R-value for specimens with compacted heights from 2.45 to 2.55 in. (62 to 65 mm). If the height of the specimen is between 2.3 and 2.45 in. or 2.55 and 2.7 in. (58 and 62 mm or 65 and 68 mm, respectively) use the chart (Fig. 9) for correcting R-values to a specimen height of 2.5 in. (63 mm).

NOTE 7—If the R-value is desired at a specific exudation pressure, for example, 300 psi (2070 kPa), within the range of pressures measured in tests of the three specimens, it is convenient to construct a graph of R-value versus exudation pressure and interpolate.

## 11. Precision and Bias

11.1 Bias statements are not applicable to this test method.

11.2 The estimates of precision for this test method listed in Table 1 are based on the analysis of data from 13 pairs of AMRL

**TABLE 1 Estimates of Precision [A,B]**

| | Standard Deviation (1*S*) | Acceptable Range of Two Results (*D2S*) |
|---|---|---|
| Single-operator precision: | | |
| *R*-values at 300 psi between 5 and 20 | 3 | 8 |
| Single-operator precision: | | |
| *R*-values at 300 psi between 21 and 50 | 4 | 12 |
| Multilaboratory precision: | | |
| *R*-values at 300 psi between 5 and 20 | 6 | 18 |
| Multilaboratory precision: | | |
| *R*-values at 300 psi between 21 and 50 | 13 | 37 |

[A] These numbers represent the (1*S*) and ( *D2S*) limits as described in Practice C 670.

[B] Supporting data are available from ASTM Headquarters. Request RR: D18-1000.

soil reference samples. Participating laboratories were asked to perform AASHTO Test Method T 190, which is equivalent to

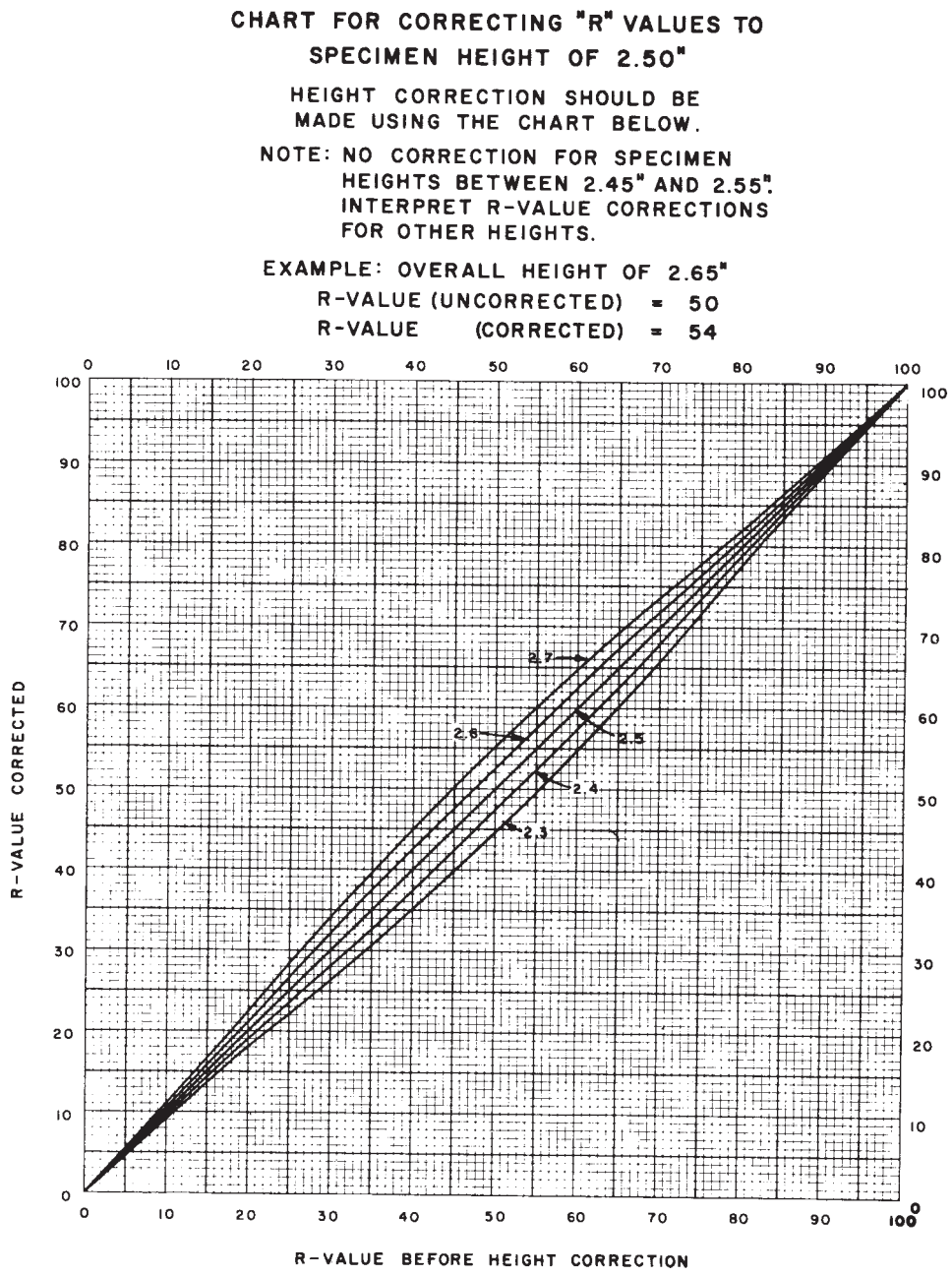



**FIG. 9 Height-Correction Chart**

ASTM Test Method D 2844, at an exudation pressure of 300 psi. More than 100 paired test results from 16 to 23 laboratories were analyzed. Estimates of test precision for R-values greater than 50 have not been developed.

## 12. Keywords

12.1 acceptance tests; base course; bearing capacities; compaction; dynamic bearing capacity; expansion; expansive soils; flexible pavements; foundations; highway loads; inspection; kneading compaction; laboratory tests; materials tests; pavement design; resistance value; specifications; stability; stabilometer; subbase; subbase strength; subgrade; subgrade reaction; subgrade stability; trafficability

## SUMMARY OF CHANGES

This section identifies the principle changes to this guide that have been incorporated since the last issue.

(1) Changed required sample height.

(2) Made various corrections throughout standard.

(3) Added new keywords.