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An American National Standard

Standard Test Method for Measuring Maximum Dry Volume of Utility Vacuum Cleaners[1]

This standard is issued under the fixed designation F1326; 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 is applicable to any vacuum cleaner that is classified as a utility vac.

1.2 The values stated in inch-pound units are to be regarded as standard. The values in parentheses are for information only.

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:*[2]

E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

3. Significance and Use

3.1 This test method describes a procedure to determine the maximum functional dry volume that the utility vac is capable of collecting.

4. Apparatus

4.1 *Temperature and humidity indicators,* to provide temperature measurements accurate to within ±1°F (±½ °C) and humidity measurements accurate to within ±2 % relative humidity.

4.2 *Weighing Scale,* the scale shall be accurate to 4 oz (114 g) and have a weighing capacity of at least 120 lb (54.4 kg).

5. Materials

5.1 Water.

6. Sampling

6.1 A minimum of three units of the same model vacuum cleaner selected at random in accordance with good statistical practice shall constitute the population sample.

6.1.1 To determine the best estimate of maximum dry volume for the population of the vacuum cleaner model being tested, the arithmetic mean of the maximum dry volume of the sample from the population shall be established by testing it to a 90 % confidence level within ±5 % of the mean value of the maximum dry volume.

6.1.2 Annex A1 provides a procedural example for determining the 90 % confidence level and when the sample size shall be increased.

NOTE 1—See Annex A1 for a method for determining 90 % confidence level.

7. Conditioning

7.1 *Test Room*—The test room should be maintained at 70°F ± 5°F (21°C ± 3°C) and 45 to 55 % relative humidity.

7.2 Condition the water in accordance with 7.1.

8. Procedure

8.1 *Dry Pick Up Capacity:*

8.1.1 Calculate the volume in gallons of the dust drum using the appropriate formulas, neglecting all projections into the drum.

8.1.2 Calculate all projections into the drum using the appropriate formulas in gallons.

8.1.3 Subtract the total projection volumes from the dirt drum volume to arrive at the maximum dry volume. Round down to the nearest ¼ gal (0.936 L).

8.1.4 Record the maximum functional volume in gallons (litres) within ¼ gal (0.936 L).

9. Procedure

9.1 *Dry Pick Up Capacity (Alternative Method):*

9.1.1 An alternative method is allowed when the shape of the vacuum cleaner is irregular, and the calculations of Section 8 become complex.

9.1.1.1 Block the inlet of the dust drum and fill it with water.

9.1.1.2 Line the projections into the drum with an appropriate water-proof material and submerse into the dust drum.

[1] This test method is under the jurisdiction of ASTM Committee F11 on Vacuum Cleaners and is the direct responsibility of Subcommittee F11.23 on Filtration.

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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.

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TABLE 1 Repeatability and Reproducibility

Max. Functional Volume (gallons)	Standard Deviation of Repeatability, S_r	Repeatability Limit, r	Standard Deviation of Reproducibility, S_R	Reproducibility Limit, R
5 gal. and less	0.068	0.190	0.380	1.063
Over 5 gal.	0.118	0.3297	0.468	1.3116

9.1.1.3 Allow the excess water to flow out of the dust drum and then measure the volume of the water remaining in the dust drum. Round down to the nearest ¼ gal.

9.1.1.4 Record the maximum functional volume in gallons (litres) within ¼ gal (0.936 L).

9.1.1.5 Repeat steps 9.1.1 – 9.1.1.4 two more times. The average of the three tests represents the maximum dry functional volume that the utility vacuum is capable of collecting.

10. Precision and Bias[3]

10.1 *Precision*—These precision statements are based on an interlaboratory test involving six (6) laboratories and four (4) units. The range of maximum functional volume of the units was from 4.8 to 14.6 gal.

10.2 The statistics have been calculated as recommended in Practice E691.

10.3 The following statements regarding repeatability limit and reproducibility limit are used as directed in Practice E177.

10.4 *Repeatability (Single-Operator-and Laboratory; Multi-Day Testing)*—The ability of a single analyst to repeat the test within a single laboratory.

10.4.1 The expected standard deviation of repeatability of the measured results within a laboratory s_r has been found to be the respective values listed in Table 1.

10.4.2 The 95 % repeatability limit within a laboratory, r, has been found to be the respective values listed on Table 1, where $r = 2.8\ (S_r)$.

10.4.3 With 95 % confidence, it can be stated that within a laboratory a set of measured results derived from testing a unit should be considered suspect if the difference between any two of the three values is greater than the respective value of the repeatability limit r, listed in Table 1.

10.4.4 If the absolute value of the difference of any pair of measured results from three test runs performed within a single laboratory is not equal to or less than the respective repeatability limit listed in Table 1, that set of test results shall be considered suspect.

10.5 *Reproducibility (Multi-day Testing and Single Operator within Multiple Laboratories)*—The ability to repeat the test within laboratories.

10.5.1 The expected standard deviation of reproducibility of the average of a set of measured results between multiple laboratories, S_R has been found to be the respective values listed in Table 1.

10.5.2 The 95 % reproducibility limit within a laboratory, R, has been found to be the respective values listed in Table 1, where $R = 2.8(S_R)$.

10.5.3 With 95 % confidence, it can be stated that the average of the measured results from a set of three test runs performed in one laboratory, as compared to a second laboratory, should be considered suspect if the difference between those two values is greater than the respective values of the reproducibility limit, R, listed in Table 1.

10.5.4 If the absolute value of the difference between the average of the measured results from the two laboratories is not equal to or less than the respective reproducibility limit listed in Table 1, the set of results from both laboratories shall be considered suspect.

10.6 *Bias*—No justifiable statement can be made on the bias of the method to evaluate maximum dry volume of utility vacuum cleaners. Since the true value of the property cannot be established by an acceptable referee method.

11. Keywords

11.1 dry volume; filtration; utility vacuum cleaner

[3] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:F11-1009.

ANNEX

(Mandatory Information)

A1. DETERMINATION OF THE POPULATION MEAN HAVING 90 % CONFIDENCE INTERVAL

A1.1 Theory

A1.1.1 The most common and ordinarily the best single estimate of the population mean, μ, is simply the arithmetic mean, $\bar{X}$, of the individual scores (measurements) of the units comprising a sample taken from the population. The average score of these units will seldom be exactly the same as the population mean; however, it is expected to be fairly close so that in using the following procedure it can be stated with 90 % confidence that the true mean of the population, μ, lies within 5 % of the calculated mean, $\bar{X}$, of the sample taken from the population.

A1.1.2 The following procedure provides a confidence interval about the sample mean that is expected to bracket μ, the true population mean, 100(1 − α) % of the time where α is the chance of being wrong. Therefore, 1 − α is the probability or level of confidence of being correct.

A1.1.3 The desired level of confidence is 1 − α = 0.90 or 90 % as stated in Section 6. Therefore α = 0.10 or 10 %.

A1.1.4 Compute the mean $\bar{X}$, and the standard deviation, s, of the individual scores of the sample taken from the population:

$$\bar{X} = \frac{1}{n}\sum_{i=1}^{n} X_i \tag{A1.1}$$

$$s = \sqrt{\frac{n\sum_{i=1}^{n} X_i^2 - \left(\sum_{i=1}^{n} X_i\right)^2}{n(n-1)}}$$

where:

n = number of units tested, and
X_i = the value of the individual test unit score of the ith test unit. As will be seen in the procedural example to follow, this is the average value of the results from three test runs performed on an individual test unit with the resulting set of data meeting the repeatability requirements of Section 10.

A1.1.5 Determine the value of the t statistic for n − 1 degrees of freedom (df) from Table A1.1 at a 95 % confidence level.

NOTE A1.1—The value of t is defined at $t_{1-\alpha/2}$ and is read as "t at 95 % confidence".

$$t\ statistic = t_{1-\alpha/2} = t_{0.95} \tag{A1.2}$$

where:

1 – α/2 = 1 – 0.10/2 = 1 – 0.05 = 0.95, or 95 %.

A1.1.6 The following equations establish the upper and lower limits of an interval centered about $\bar{X}$ that will provide the level of confidence required to assert that the true population mean lies within this interval:

TABLE A1.1 Percentiles of the t Distribution

df	$t_{0.95}$
1	6.314
2	2.920
3	2.353
4	2.132
5	2.015
6	1.943
7	1.895
8	1.860
9	1.833
10	1.812
11	1.796
12	1.782
13	1.771
14	1.761
15	1.753

$$CI_U = \bar{X} + ts/\sqrt{n} \tag{A1.3}$$

$$CI_L = \bar{X} + ts/\sqrt{n} \tag{A1.4}$$

where:

CI = confidence interval (U – upper limit; L – lower limit),
$\bar{X}$ = mean score of the sample taken from the population,
t = t statistic from Table A1.1 at 95 % confidence level,
s = standard deviation of the sample taken from the population, and
n = number of units tested.

A1.1.7 It is desired to assert with 90 % confidence that the true population mean, μ, lies within the interval, CI_U to CI_L, centered about the sample mean, $\bar{X}$. Therefore, the quantity $ts/\sqrt{n}$ shall be less than some value, A, which shall be 5 % of $\bar{X}$ in accordance with the sampling statement of 6.1.

A1.1.8 As $n \rightarrow \infty$, $ts/\sqrt{n} \rightarrow 0$. As this relationship indicates, a numerically smaller confidence interval may be obtained by using a larger number of test units, n, for the sample. Therefore, when the standard deviation, s, of the sample is large and the level of confidence is not reached after testing three units, a larger sample size, n, shall be used.

A1.2 Procedure

A1.2.1 A graphical flow chart for the following procedure is shown in Fig. A1.1.

A1.2.2 Select three units from the population for testing as the minimum sample size.

A1.2.3 Obtain individual test unit scores by averaging the results of three test runs performed on each of the three individual test units. The data set resulting from the three test runs performed on each individual test unit shall meet the respective repeatability requirement found in Section 10.

A1.2.4 Compute $\bar{X}$ and s of the sample.

A1.2.5 Compute the value of A where A = 0.05 ($\bar{X}$).

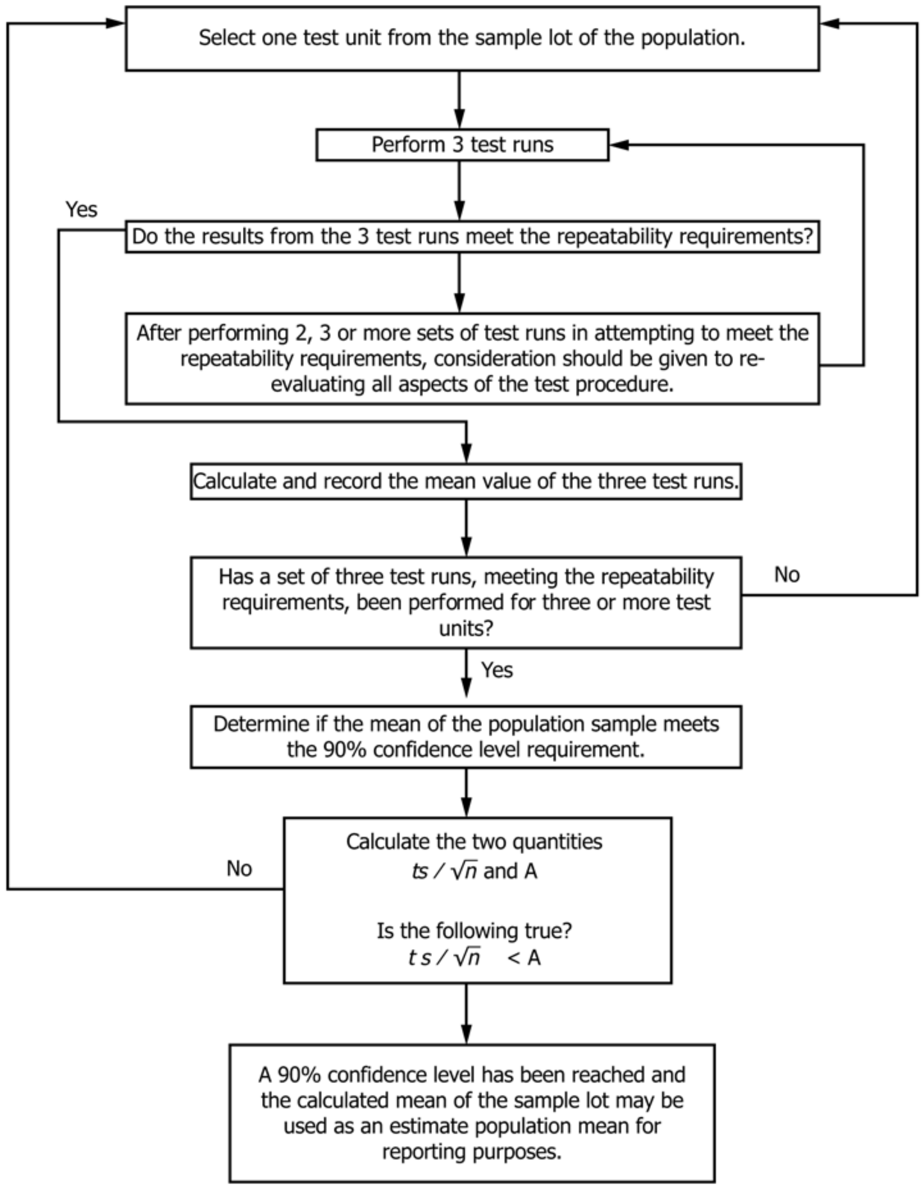

FIG. A1.1 Testing Procedure Flowchart

A1.2.6 Determine the statistic t for n - 1 degrees of freedom from Table A1.1 where n = the number of test units.

A1.2.7 Compute $ts/\sqrt{n}$ for the sample and compare it to the value to A.

A1.2.8 If the value of $ts/\sqrt{n}>A$, an additional unit from the population shall be selected and tested, and the computations of A1.2.3 – A1.2.7 repeated.

A1.2.9 If the value of $ts/\sqrt{n}<A$, the desired 90 % confidence level has been obtained. The value of the final $\bar{X}$ may be used as the best estimate of the maximum dry volume for the population.

A1.3 Example

A1.3.1 The following data are chosen to illustrate how the value of maximum functional volume for the population of utility vacuum cleaners is derived. For this particular example, the measured volume test results from three test runs on each unit are required to have a repeatability limit not exceeding 0.190 as indicated in Table 1 for units of 5 gal and less.

A1.3.2 Select three test units from the vacuum cleaner model population. A minimum of three test runs shall be performed using each test unit.

A1.3.3 Test run scores for test unit No. 1:
Test run No. 1 = 4.9
Test run No. 2 = 5.2
Test run No. 3 = 4.8

A1.3.4 Maximum spread = 5.2 – 4.8 = 0.4. This value is greater than the repeatability limit required in Table 1. The results shall be discarded and three additional test runs performed.

A1.3.5 Test run scores for test unit No. 1:
Test run No. 4 = 4.9

Test run No. 5 = 5.1

Test run No. 6 = 5.1

A1.3.6 Maximum spread = 5.1 – 4.9 = 0.1. This value is less than the repeatability limit requirement of Table 1.

A1.3.7 Unit No. 1 score (4.9 + 5.1 + 5.1)/3 = 5.0.

NOTE A1.2—If it is necessary to continue repeated test run sets (7, 8, 9–10, 11, 12-etc.) because the spread of data within a data set is not less than the repeatability limit requirement stated in Table 1, there may be a problem with the test equipment, the execution of the test procedure, or any of the other factors involved in the test procedure. Consideration should be given to re-evaluating all aspects of the test procedure for the cause(s).

A1.3.8 A minimum of two additional test units must be tested, each meeting the repeatability limit requirement. For this procedural example, assume those units met the repeatability requirement and the individual unit scores area:

Score of test unit No. 1 = 5.0

Score of test unit No. 2 = 5.1

Score of test unit No. 3 = 4.9

A1.3.9 $\bar{X}$ = 1/3 (5.0 + 5.1 + 4.9) = 5.0

A1.3.10

$$s = \frac{\sqrt{3[(5.0)^3 + (5.1)^2 + (4.9)^2] - [5.0 + 5.1 + 4.9]^2}}{3(3-1)} \quad (A1.5)$$

s = 0.1

A1.3.11 A = 0.05 (5.0) = 0.25.

A1.3.12 Degrees of freedom, $n - 1 = 3 - 1 = 2$; $t_{0.95}$ statistic = 2.920.

A1.3.13 $ts/\sqrt{n} = 1.920(0.1) / \sqrt{3} = 0.168$

A1.3.14 The requirement that $ts/\sqrt{n} < A$ has been met because A is larger.

A1.4 Thus, the value of $\bar{X}$, 5.0 gal represents the maximum functional volume of the utility vacuum and may be used as the best estimate of the volume for the population mean.

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