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

This standard is issued under the fixed designation F1410; 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 given 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. Significance and Use

2.1 This test method covers a procedure to determine the maximum functional wet volume that the utility vac is capable of collecting.

3. Apparatus

3.1 *Voltmeter,* to measure input to the cleaner, providing measurements accurate to within ±1 %.

3.2 *Voltage Regulator System*—The regulator shall be capable of maintaining the rated voltage (±1 %) and frequency (±1 Hz) with sinusoidal wave form.

3.3 *Temperature and Relative Humidity Indicators,* to provide temperature measurements accurate to within ±1°F (±½ °C) and humidity measurements accurate to within ±2 % relative humidity.

3.4 *Weighing Scale*—The scale shall be accurate to 1 % of full scale and have a weighing capacity of at least 250 lb (113.4 kg).

4. Materials

4.1 *Water.*

5. Sampling

5.1 Test a sample of each basic model until a 90 % confidence level (about the mean) is established within ±5 % of the mean value. Test a minimum of three samples. Select all samples at random in accordance with good statistical practice.

NOTE 1—See Appendix X1 for method of determining 90 % confidence level.

6. Conditioning

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

7. Procedure

7.1 Equip the vac with a new filter.

7.2 Weigh the empty vac including the power supply cord. (Do not include the hose or any accessories.)

7.3 Unit must be on a level surface and the shut-off device must be in place if the unit is designed to be used with one.

7.4 Level of the water to be picked up shall be lower than the floor level of vac such that no siphoning occurs.

7.5 Tests are to be conducted at the nameplate voltage (±1 %) and frequency (±1 Hz), when measured at the appliance plug. For cleaners with dual nameplate voltage ratings, conduct tests at the highest voltage.

7.6 Using the largest hose supplied with the unit, vacuum water into the vac-tank. Maintain a water pick up rate of 2 gal/min throughout the filling cycle.

7.7 Collect water with the vac until either one of the following occurs:

7.7.1 The unit stops collecting water, or

7.7.2 Water overflows from the vac.

7.8 Stop unit and disconnect hose from the vac. Any water remaining in the hose shall not be included in the maximum functional volume.

7.9 Weigh the filled vac, including the power supply cord.

7.10 Calculate the maximum functional volume by dividing the weight of the water collected by the weight per gallon of water as follows:

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[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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$$\text{volume, gal} = \frac{\text{weight (lb) vac filled} - \text{weight (lb) vac empty}}{8.328 \text{ lb/gal}}$$

7.11 Record the maximum functional wet volume in gallons (litres) to the nearest tenth.

7.12 Repeat steps 7.1 through 7.12 two more times. The average of the three tests represents the maximum wet functional volume that the utility vac is capable of collecting.

8. Precision and Bias[2]

8.1 *Precision*—These statements are based on an interlaboratory test involving six laboratories and four units. The range of maximum functional volume of the units was from 3.8 to 13.5 gal.

8.1.1 *Repeatability (Single-Operator-Laboratory, Multiday):*

8.1.1.1 Repeatability for wet volume values of 5 gal and under, within a laboratory divided by the average (coefficient of variation) was found to be 4.5 % or less. Two values from a sample of three should be considered suspect (at the 95 % confidence level) if they differ by more than 12.8 %.

NOTE 2—The percent difference = (larger − smaller)/(larger) × 100.

8.1.1.2 Repeatability for wet volume values of over 5 gal, the standard deviation within a laboratory divided by the average (coefficient of variation) was found to be 2.5 % or less. Two values from a sample of three should be considered suspect (at the 95 % confidence level) if they differ by more than 7.1 %.

NOTE 3—The percent difference = (larger − smaller)/(larger) × 100.

8.1.2 *Reproducibility (Multilaboratory, Multiday):*

8.1.2.1 Reproducibility for wet volume values of 5 gal and under, the standard deviation divided by the average (coefficient of variation) with a single unit tested in different laboratories was found to be 10.7 % or less. Two such values should be considered suspect (at the 95 % confidence level) if they differ by more than 33 %.

8.1.2.2 Reproducibility for wet volume values over 5 gal, the standard deviation divided by the average (coefficient of variation) with a single unit tested in different laboratories was found to be 3.2 % or less. Two such values should be considered suspect (at the 95 % confidence level) if they differ by more than 11.5 %.

8.2 *Bias*—No justifiable statement can be made on the bias of this test method for the properties listed. The true values of the properties cannot be established by acceptable referee methods.

9. Keywords

9.1 utility vacuum cleaner; wet volume

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

APPENDIX

(Nonmandatory Information)

X1. DETERMINATION OF 90 % CONFIDENCE INTERVAL

X1.1 The most common and ordinarily the best single estimate of the population mean μ is simply the arithmetic mean of the measurements. When a sample is taken from a population, the sample average will seldom be exactly the same as the population average; however, it is hoped to be fairly close so that the statement of confidence interval will bracket the true mean.

X1.2 The following procedure gives an interval which is expected to bracket μ, the true mean, 100(1 − α) % of the time. This provides a 100(1 − α) % confidence level. α is the chance of being wrong, therefore, 1 − α is the probability of being correct.

X1.2.1 Choose the desired confidence level, 1 − α.

X1.2.2 Compute Mean ($\bar{X}$):

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

$$\text{Standard Deviation, } s = \sqrt{\frac{n\,\Sigma X_i^2 - (\Sigma X_i)^2}{n(n-1)}}$$

where:

n = number of units.

X1.2.3 Compute the upper limit (X_μ) and the lower limit (X_L):

$$X_\mu = \bar{X} + ts/\sqrt{n}$$

$$X_L = \bar{X} - ts/n$$

where:

t = value from Table X1.1 at (1 − > α)/2.

X1.3 The interval from X_L to X_μ is a 100(1 − α) % confidence interval for the population mean; that is, we may assert with 100(1 − α) % confidence that $X_L <_\mu < X_\mu$. It can be seen that as $n \rightarrow \infty$, $ts/\sqrt{n} \rightarrow 0$. Thus, a smaller confidence interval for the mean can be obtained by using larger samples. In application, we are interested in a 90 % confidence interval of the population mean (α = 0.10), and we desire the quantity $ts/\sqrt{n}$ to be less than some value, *A*. Values of $t_{(1-\alpha)/2} = t_{0.95}$ will be taken from Table X1.1 and used in the computation.

X1.4 *Procedure:*

TABLE X1.1 Percentiles of the *t* Distribution[A]

df	$t_{0.60}$	$t_{0.70}$	$t_{0.80}$	$t_{0.90}$	$t_{0.95}$	$t_{0.975}$	$t_{0.99}$	$t_{0.995}$
1	0.325	0.727	1.376	3.078	6.314	12.706	31.821	63.657
2	0.289	0.617	1.061	1.886	2.920	4.303	6.965	9.925
3	0.271	0.584	0.978	1.638	2.353	3.182	4.541	5.841
4	0.271	0.569	0.941	1.533	2.132	2.776	3.747	4.604
5	0.267	0.559	0.920	1.476	2.015	2.571	3.365	4.032
6	0.265	0.553	0.906	1.440	1.943	2.447	3.143	3.707
7	0.263	0.549	0.896	1.415	1.895	2.365	2.998	3.499
8	0.262	0.546	0.889	1.397	1.860	2.306	2.896	3.355
9	0.261	0.543	0.883	1.383	1.833	2.262	2.821	3.250
10	0.260	0.542	0.879	1.372	1.812	2.228	2.764	3.169
11	0.260	0.540	0.876	1.363	1.796	2.201	2.718	3.106
12	0.259	0.539	0.873	1.356	1.782	2.179	2.681	3.055
13	0.259	0.538	0.870	1.350	1.771	2.160	2.650	3.012
14	0.258	0.537	0.868	1.345	1.761	2.145	2.624	2.977
15	0.258	0.536	0.866	1.341	1.753	2.131	2.602	2.947
16	0.258	0.535	0.865	1.337	1.746	2.120	2.583	2.921
17	0.257	0.534	0.863	1.333	1.740	2.110	2.567	2.898
18	0.257	0.534	0.862	1.330	1.734	2.101	2.552	2.878
19	0.257	0.533	0.861	1.328	1.729	2.093	2.539	2.861
20	0.257	0.533	0.860	1.325	1.725	2.086	2.528	2.845
21	0.257	0.532	0.859	1.323	1.721	2.080	2.518	2.831
22	0.256	0.532	0.858	1.321	1.717	2.074	2.508	2.819
23	0.256	0.532	0.858	1.319	1.714	2.069	2.500	2.807
24	0.256	0.531	0.857	1.318	1.711	2.064	2.492	2.797
25	0.256	0.531	0.856	1.316	1.708	2.060	2.485	2.787
26	0.256	0.531	0.856	1.315	1.706	2.056	2.479	2.779
27	0.256	0.531	0.855	1.314	1.703	2.052	2.473	2.771
28	0.256	0.530	0.855	1.313	1.701	2.048	2.467	2.763
29	0.256	0.530	0.854	1.311	1.699	2.045	2.462	2.756
30	0.256	0.530	0.854	1.310	1.697	2.042	2.457	2.750
40	0.255	0.529	0.851	1.303	1.684	2.021	2.423	2.704
60	0.254	0.527	0.848	1.296	1.671	2.000	2.390	2.660
120	0.254	0.526	0.845	1.289	1.658	1.980	2.358	2.617
∞	0.253	0.524	0.842	1.282	1.645	1.960	2.326	2.576

[A] Adapted by permission from *Introduction to Statistical Analysis* (2nd ed.) by W. J. Dixon and F. J. Massey, Jr., Copyright, 1957, McGraw-Hill Book Co., Inc. Entries originally from Table III of *Statistical Tables* by R. A. Fisher and F. Yates, 1938, Oliver and Boyd, Ltd., London.

X1.4.1 *Step 1*—Select three units for test as the minimum sample size.

X1.4.2 *Step 2*—Obtain unit scores by averaging three test runs meeting the expected repeatability in 8.1.1.

X1.4.3 *Step 3*—Compute $\bar{X}$ and s for the sample.

X1.4.4 *Step 4*—Compute A; $A = 5\ \%$ of $\bar{X}$ in accordance with the sampling statement of 5.

X1.4.5 *Step 5*—Look up $t_{0.95}$ for $n - 1$ degrees of freedom (df) in the table where n = number of units.

X1.4.6 *Step 6*—Compute $ts/\sqrt{n}$ for the sample and compare to A.

X1.4.7 *Step 7*—If $ts/\sqrt{n} > A$, select another unit for test which increases the sample size, and perform X1.4.2 through X1.4.6 with the larger sample.

X1.4.8 *Step 8*—If $ts/\sqrt{n} < A$, a desired 90 % confidence interval has been obtained. The final $\bar{X}$ can be used as an estimate of the population mean.

X1.5 *Example of Data Chosen to Illustrate Determination of a Mean Maximum Functional Volume for a Model Vacuum Cleaner:*

X1.5.1 *Step 1*—Select three units for functional volume measurements, each to be run a minimum of three times.

X1.5.2 *Step 2*—Obtain unit scores.

Unit No. 1:

Test	Score	Explanation
Run 1	4.9	maximum spread 5.2 – 4.8 = 0.4
Run 2	5.2	% = maximum spread/maximum score = 0.4/5.2 = 7.69 %
Run 3	4.8	greater than the 6 % repeatability in 8.1.1
Avg.	4.97	

X1.5.2.1 Therefore, these results are disregarded and three additional runs are required:

Unit No. 1:

Test	Score	Explanation
Run 4	4.9	maximum spread 5.1 – 4.9 = 0.2
Run 5	5.1	% = maximum spread/maximum score = 0.2/5.1 = 3.92 %
Run 6	5.0	less than the 6 % repeatability in 8.1.1
Avg.	5.0	

Therefore, the average of these three runs is the unit score.

NOTE X1.1—If spread with repeated runs (7, 8, 9 . . . 10, 11, 12 . . . etc.) is not less than the 6 % repeatability of this method, there is a problem with the equipment or in executing this test procedure.

Unit No. 2:

Test	Score	Explanation
Run 1	5.1	maximum spread 5.3 – 5.1 = 0.2
Run 2	5.3	% = maximum spread / maximum score = 0.2 / 5.3 = 3.8 %
Run 3	5.2	less than the 6 % repeatability
Avg.	5.2	

Therefore, the average of these three runs is the unit score.

Unit No. 3:

Test	Score	Explanation
Run 1	5.6	maximum spread 5.6 – 5.4 = 0.2
Run 2	5.4	% = maximum spread / maximum score = 0.2 / 5.6 = 3.57 %
Run 3	5.5	less than the 6 % repeatability
Avg.	5.5	

Therefore, the average of these three runs is the unit score.

X1.5.3 *Step 3*—Compute mean ($\bar{X}$) and standard deviation(s) for the sample.

Unit No. 1	5.0
Unit No. 2	5.2
Unit No. 3	5.5
Total =	15.7

Number of Units = 3 = n.
Mean = $\bar{X}$ = 15.7 / 3 = 5.23.

Standard Deviation,

$$s = \sqrt{\frac{[3(5.0^2+5.2^2+5.5^2)] - [(5.0+5.2+5.5)]^2}{[3(3-1)]}} = 0.252$$

X1.5.4 *Step 4*—Compute A; A = 5 % of X = 0.05 × 5.23 = 0.262.

X1.5.5 *Step 5*—Find t value. For a 90 % confidence α = 10 %; therefore, (1 – α) / 2 = 0.95. $t_{0.95}$ for (df) = n – 1 = (3 units – 1 = 2) = 2.920.

X1.5.6 *Step 6*—Determine the quantity $(t \times s)/\sqrt{n}$ and compare to A.

$$\frac{t \times s}{\sqrt{n}} = \frac{2.920 \times 0.252}{\sqrt{3}} 0.425 > 0.262$$

Therefore proceed to Step 7.

X1.5.7 *Step 7*—If $ts/\sqrt{n} > A$, select another unit for test which increases the sample size, and perform Steps 2 through 6 with the larger sample.

X1.5.8 *Step 2*—Obtain unit scores.

Unit No. 4:

Test	Score	Explanation
Run 1	5.3	maximum spread 5.4 – 5.2 = 0.2
Run 2	5.4	% = maximum spread / maximum score = 0.2 / 5.4 = 3.7 %
Run 3	5.2	less than the 6 % repeatability
Avg.	5.3	

Therefore, the average of these three runs is the unit score.

X1.5.9 *Step 3*—Compute mean ($\bar{X}$) and standard deviation(s) for the samples.

Unit No. 1	5.0
Unit No. 2	5.2
Unit No. 3	5.5
Unit No. 4	5.3
Total =	21.0

Number of Units = 4 = n
Mean = $\bar{X}$ = 21.0 / 4 = 5.25

Standard Deviation,

$$s = \sqrt{\frac{[4(5.0^2+5.2^2+5.5^2+5.3^2)] - [(5.0+5.2+5.5+5.3)]^2}{[4(4-1)]}} = 0.208$$

X1.5.10 *Step 4*—Compute A; A = 5 % of $\bar{X}$ = 0.05 × 5.25 = 0.263.

X1.5.11 *Step 5*—Find t value. For 90 % confidence, α = 10 %; therefore, (1 – α) / 2 = 0.95. $t_{0.95}$ for n – 1 (4 units – 1 = 3) = 2.353.

X1.5.12 *Step 6*—Determine the quantity $(t \times s)/\sqrt{n}$ and compare to A. $\frac{t \times s}{\sqrt{n}} = \frac{2.353 \times 0.208}{\sqrt{4}} 0.245 > 0.263$

Therefore proceed to Step 8.

NOTE X1.2—With sufficient units, $(t \times s)/\sqrt{n}$ will become less than A; and Step 7 is followed (X1.5.7) until this occurs.

X1.5.13 *Step 8*—If $ts/\sqrt{n} < A$, a desired 90 % confidence interval has been obtained. The final $\bar{X}$ can be used as an estimate of the population mean. $\bar{X}$ from Step 3 (X1.5.9) = 5.25; therefore, 5.25 is an acceptable estimate of the mean maximum functional volume for the model line sampled and tested according to this procedure.