Standard Test Method for
Motor Life Evaluation of a Canister, Hand-held, Stick, and Utility Type Vacuum Cleaner Without a Driven Agitator[1]

This standard is issued under the fixed designation F1038; 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 limited to evaluation of canister, hand-held, stick, and utility type vacuum cleaners without a driven agitator.

1.2 This test method provides a test to determine operating life of the motor, before servicing is needed, by an accelerated laboratory procedure. The motor is tested while mounted and is operated in a vacuum cleaner.

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

1.4 *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]

E337 Test Method for Measuring Humidity with a Psychrometer (the Measurement of Wet- and Dry-Bulb Temperatures)

F431 Specification for Air Performance Measurement Plenum Chamber for Vacuum Cleaners

F608 Test Method for Evaluation of Carpet Embedded Dirt Removal Effectiveness of Household/Commercial Vacuum Cleaners

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *failure*—when motor stoppage occurs. This may be due to failure of an armature assembly, field assembly, housing(s), bearings, motor cooling fan and primary air moving fan or both, brush assemblies, motor mounted nonresetable thermal protection devices, or any other component judged to be integral with the motor.

3.1.2 *motor life*—the time at which any failure of the motor occurs.

4. Significance and Use

4.1 The test results provide an indication of the motor life of an electric vacuum cleaner in operating hours. The end of the motor life will be judged in accordance with Section 3.

5. Apparatus and Materials

5.1 *Voltage Regulator System,* to control the input voltage to the vacuum cleaner. The regulator system shall be capable of maintaining the vacuum cleaner's rated voltage ±1 % and rated frequency ±1 Hz, having a waveform that is essentially sinusoidal with 3 % maximum harmonic distortion for the duration of the test.

5.2 *Voltmeter,* to provide measurements accurate to ±1 %.

5.3 *Timer and Switch*—The timer and switch will have the capacity to control on/off duty cycle of the vacuum cleaner during the life test.

5.4 *Sharp Edge Orifice Plate*—The orifice, 0.75 in. (19.05 mm) in diameter, shall be in accordance with the figure illustrating orifice plate detail in Specification F431.

5.5 *Wattmeter,* to provide measurements accurate to ±1 %.

5.6 *Plenum Chamber,* in accordance with the plenum chamber described in Specification F431.

5.7 *Water Manometer,* or equivalent instrument measuring in increments of 0.1 in. (2.54 mm).

5.8 *Thermometer,* having a range of at least 18 to 80°F (-8 to +27°C) and graduated in 1°F (0.5°C) increments.

5.9 *Psychrometer*—The psychrometer shall meet the requirements of Test Method E337, with thermometers in increments of 1°F (0.5°C).

5.10 *Test Fixture*—Any suitable surface that will support the vacuum cleaner in the normal operating position.

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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.

6. Sampling

6.1 Test a minimum of three units (or a larger sample size if desired) of similar models using the same motor style and amperage. Select all samples at random in accordance with good statistical practice. Results shall provide an 80 % confidence level within ±10 % of the mean value. If not, test additional samples or reduce the results by the penalty factor as calculated in 7.8.1.

7. Procedures for Motor Life Evaluation

7.1 Determine initial performance as follows:

7.1.1 Connect the manometer (or equivalent) to the plenum chamber. Install a clean filter in the test vacuum cleaner before conducting performance tests. (This is not required for units which do not use filters).

7.1.2 With the vacuum cleaner hose end (or nozzle) sealed to the plenum chamber and without an orifice plate in the holder, energize the vacuum cleaner at its nameplate rated voltage ±1 % and frequency ±1 Hz until the vacuum cleaner reaches its normal operating temperature. For vacuum cleaners with dual nameplate voltage ratings, conduct testing at the highest voltage.

7.1.3 With the vacuum cleaner operating at a constant rated voltage, insert the 0.75 in. (19.05 mm) diameter sharp-edge orifice into the holder on the plenum chamber.

7.1.4 Record the manometer reading as soon as the reading stabilizes.

7.1.4.1 Take readings as soon as the manometer reaches a true peak. (On higher manometer readings, the liquid level may peak, drop, and peak a second time. The second peak is the true peak reading. A person conducting the test for the first time shall observe at least one run before recording data). See Specification F431 for instructions on how to minimize the overshoot (first peak) of the liquid level.

7.1.4.2 Take all readings within 10 s of the orifice plate insertion.

7.1.5 Record the wattage of the vacuum cleaner connected to the plenum chamber. The wattage reading is used to monitor the vacuum cleaner load.

7.1.6 Monitor the wattage and the suction daily and measure on the plenum chamber every 168 h to ensure that a load is maintained, that no mechanical problem has developed, and that performance has not degraded by more than 40 %. If degradation exceeds 40 %, see 7.7.1 and 7.7.2

7.2 Install the vacuum cleaner on the test fixture with a 0.75 in. (19.05 mm) diameter sharp-edge orifice plate in the vacuum cleaner hose (or nozzle) opening.

7.2.1 If required, the unit may have an adapter which has the specified orifice or provision to mount an orifice plate to the vacuum cleaner.

7.3 If various settings are provided, set the motor speed, suction regulator, or a combination of these, in accordance with the manufacturer's specified settings for using the vacuum cleaner on the level loop test carpet. This setting shall be the same as that used for Test Method F608.

7.4 During the life test, change the disposable filter or clean the reusable filter every 168 h of test time. (This is not required for units which do not use filters). The manufacturer's recommended cleaning procedure is to be used whenever specified in instruction booklets. Where no procedure is specified, replace reusable filters. When a new or cleaned filter is placed in the vacuum cleaner, check the vacuum cleaner on the plenum chamber for degradation of performance in accordance with 7.7.1 and 7.7.2.

7.5 Perform all tests in a controlled ambient atmosphere with a dry bulb temperature of 68 to 81°F (20 to 27°C) and relative humidity of 30 to 50 %.

7.6 Test the vacuum cleaner at the voltage specified in 7.1.2 from a remote on/off switch and timer with a duty cycle of 8 min of operation followed by 2 min off.

7.7 Check for degradation of performance every 168 h of test time.

7.7.1 *Performance Degradation*—In accordance with the procedure in Annex A1, use the suction at the start of the test 7.1.4 as the base for determining the 40 % degradation of performance.

7.7.2 If degradation is present, determine and correct the cause. Replace any part, except the motor or its integral parts, to bring system within performance limits and continue the test until the motor stops.

7.8 Judge the end of the test in conformance with Section 3. Express life in terms of operating (on) hours only.

7.8.1 Calculate the sample mean for units tested and the confidence interval half-width:

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n} \quad (1)$$

$$h = \frac{ts}{\sqrt{n}} \quad (2)$$

where:

x_i = life, in hours of "on" time, for each sample tested,
h = half-width of confidence interval,
t = value from t distribution table for 80 % ($t_{0.90}$) confidence level and degrees of freedom = n – 1 (see Table 1),
s = standard deviation of sample,
n = sample size, and
$\bar{x}$ = mean of sample.

TABLE 1 Percentiles of the *t* Distribution

df	$t_{0.90}$
1	3.078
2	1.886
3	1.638
4	1.533
5	1.476
6	1.440
7	1.415
8	1.397
9	1.383
10	1.372
11	1.363
12	1.356
13	1.350
14	1.345
15	1.341

7.8.2 Compare the sample mean and confidence interval half-width to determine whether a penalty factor is required:

(*1*) If $h < 0.1\bar{x}$, use $\bar{x}$ as the published value.

(*2*) If $h > 0.1\bar{x}$, test additional units to meet the confidence level or use the following penalty factor (Δ):

$$\Delta = h - 0.1\bar{x} \quad (3)$$

Use $\bar{x} - \Delta$ as published value.

8. Precision and Bias

8.1 *Precision*—A meaningful precision statement cannot be made due to the number of components in the motor each of which could constitute failure of the motor.

8.2 Bias does not apply because there is no standard reference for comparison.

9. Keywords

9.1 canister; hand-held; motor life evaluation; stick; vacuum cleaner; utility

ANNEXES

(Mandatory Information)

A1. METHOD FOR DETERMINING 40 % DEGRADATION OF PERFORMANCE

A1.1 One requirement for life test is to ensure that performance at the vacuum cleaner hose (or nozzle) has not degraded by more than 40 % of original. This is to ensure suction loading on the motor. This degradation can be based on a reduction of initial suction, since there is a direct relationship between suction and airflow. Determine the point at which steps must be taken to correct the performance loss based on suction as follows.

A1.2 *Derivation*:

$$Q_1 = 21.844D^2K\sqrt{h_1} \quad (A1.1)$$

Since D^2 and K are constants, then $\frac{Q_1}{Q_2} = \frac{\sqrt{h_1}}{\sqrt{h_2}}$ and $Q_2 = 0.6Q_1$ at the point when servicing may be required. Therefore, $\frac{Q_1}{0.6Q_1} = \frac{\sqrt{h_1}}{\sqrt{h_2}}$, or $h_2 = 0.6Q_1$, or $h_2 = 0.36h_1$ at the servicing point.

A1.3 *Terms*:

Q_1 = initial airflow,
Q_2 = airflow at servicing point,
h_1 = initial suction,
h_2 = suction at servicing point,
D = orifice diameter, and
K = orifice flow coefficient.

A2. CORRECTION OF DATA TO STANDARD CONDITIONS

A2.1 *Air Density Ratio*—The density ratio, D_r, is the ratio of the air density at the time of test, ρ_{test}, to the standard air density, $\rho_{std} = 0.0750\ \text{lb/ft}^3\ (1.2014\ \text{kg/m}^3)$. It is used to correct the vacuum and wattage readings to standard conditions. Find ρ (lb/ft^3 (kg/m^3)) from standard psychrometric charts or ASHRAE tables and calculate D_r as follows:

$$D_r = \frac{\rho_{test}}{\rho_{std}} \quad (A2.1)$$

As an alternative, use the following equation:

$$D_r = \left[17.68B_t - 0.001978T_w^2 + 0.1064T_w + 0.0024575B_t(T_d - T_w) - 2.741\right]/(T_d + 459.7) \quad (A2.2)$$

where:

B_t = test station pressure at time of test (in. Hg),
T_d = dry-bulb temperature at time of test (°F), and
T_w = wet-bulb temperature at time of test (°F).

NOTE A2.1—This equation is intended for use in correcting for ambient conditions where the barometric pressure exceeds 27 in. Hg and the dry- and wet-bulb temperatures are less than 100°F (37.8°C).

A2.2 *Corrected Suction*—Calculate the corrected suction, h_S, as follows: h times the correction factor, C_S, or

$$h_S = C_S h \tag{A2.3}$$

where:

h = manometer reading, and
C_S = correction factor.

A2.2.1 For series universal motors, calculate the correction factor, C_S, as follows:

$$C_S = 1 + 0.667(1 - D_r) \tag{A2.4}$$