Standard Test Method for Motor Life Evaluation of a Built-In (Central Vacuum) Vacuum Cleaner[1]

This standard is issued under the fixed designation F884; 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 motor life evaluation of central vacuum cleaners.

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 central vacuum cleaner.

1.3 The values as stated in inch-pound units are to be regarded as the standard. The values in parentheses are 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*—motor stoppage.

3.1.2 *motor life*—limited by the failure of the motor. Any failure integral with motor, such as armature assembly, field assembly, housing(s), bearings, motor cooling fan and primary air moving fan, or both, brush assemblies, motormounted nonresetable thermal protection devices, or any other component judged to be integral with the motor, shall be judged as motor stoppage.

4. Significance and Use

4.1 The test results provide an indication of the motor life of an electric vacuum cleaner. 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 must be capable of maintaining the Central Vacuum's rated voltage ±1 % and rated frequency ±1 Hz with 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 within ±1 %

5.3 *Timer and Switch*—The timer and switch shall have the capacity to control the off/on duty cycle of the 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 within 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 *Barometer,* with an accuracy to ±0.05 in. (1.27 mm) Hg, capable of measuring uncorrected barometric pressure (test station pressure) with scale division 0.02 in. (0.51 mm) or finer.

5.9 *Thermometer,* having a range from 18 to 80°F (−8 to 27°C) and graduated in 1°F (0.5°C) increments.

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

[1] This test method is under the jurisdiction of ASTM Committee F11 on Vacuum Cleaners and is the direct responsibility of Subcommittee F11.30 on Durability-Reliability.

Current edition approved Oct. 1, 2016. Published October 2016. Originally approved in 1990. Last previous edition approved in 2011 as F884 – 01 (2011). DOI: 10.1520/F0884-01R16.

[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.

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

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 7.9.

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 new filter bag in the test cleaner, if required, before conducting performance tests.

7.1.2 With a minimum length of 2 in. inside diameter tubing sealed to the plenum chamber and to the cleaner, and without an orifice plate in the holder, energize the cleaner at its rated voltage ±1 % and rated frequency ±1 Hz for 5 min to stabilize motor temperatures. For vacuum cleaners with dual nameplate voltage rating, conduct testing at the highest voltage.

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

7.1.4 Record the suction and input power in that order as soon as the manometer reading stabilizes.

7.1.4.1 Take the manometer reading 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 The input power reading is used to monitor the cleaner load.

7.1.6 Monitor the input power, the suction, or both, 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 the performance has not degraded by more than 40 %. If degradation exceeds 40 %, see 7.7.1 and 7.7.2.

7.2 Install the cleaner on the test fixture with a 0.75-in. (19.05-mm) diameter sharp-edge orifice in the cleaner inlet opening.

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

7.4 If the cleaner under test is equipped with a disposable filter bag or reusable filter bag, it should be replaced or cleaned every 168 h of cycling time during the life test. 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 cleaner, check the 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 from 68 to 81°F (20 to 27°C) and a relative humidity of 30 to 50 %.

7.6 Operate the 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 Test for degradation of performance every 168 h of cycling time.

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

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

7.8 Judge the end of the test in conformity with Section 3. Express life in terms of "on" hours only.

7.9 Calculate an estimate of the population mean in accordance with the following procedure:

7.9.1 Calculate sample mean for units tested and confidence interval half-width.

$$\bar{x} = \sum_{i=1}^{n} x_i \qquad h = \frac{ts}{\sqrt{n}}$$

where:

$\bar{x}$ = mean of sample,
n = sample size,
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 df = n−1 (see Table 1), and
s = standard deviation of sample.

7.9.2 Compare sample mean and confidence interval half-width to determine if a penalty factor is required:

A: If $h \leq 0.1\ \bar{x}$, use $\bar{x}$ as published value.
B: If $h > 0.1\ \bar{x}$, test additional units to meet confidence level or use following penalty factor (Δ):

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

$$\Delta = h - 0.1\bar{x}$$

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

9. Keywords

9.1 central vacuum; degraded; failure; life evaluation; motor

ANNEXES

(Mandatory Information)

A1. METHOD FOR DETERMINING 40 % OF PERFORMANCE

A1.1 One requirement for life test is to ensure that airflow/suction performance at the central vacuum cleaner inlet has not degraded below 40 % of original. This ensures 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 airflow loss based on suction as follows:

$$h_2 = 0.36\, h_1$$

where:

h_2 = suction at monitoring point, in. (mm), and
h_1 = initial suction, in. (mm).

Therefore, instead of setting up the test unit on the orifice box to determine airflow for calculating degradation of performance every 168 h during the test, all that is required is to measure the suction, correct it, and as long as $h_2 > 0.36\, h_1$, the test requirement for airflow/suction load is maintained.[3]

[3] A suction fixture as shown in Fig. A1.1 can be used for this purpose.

A1.2 *Derivation:*

$$Q_1 = 21.844 D^2 K \sqrt{h_1}$$

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

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, $\rho_{std} = 0.0750$ lb/ft^3 (1.2014 kg/m^3). It is used to correct the vacuum and wattage readings to standard conditions. Find ρ_{test} from standard psychrometric charts or ASHRAE tables and calculate D_r from the following equation:

$$D_r = \frac{\rho_{test}}{\rho_{std}}$$

As an alternative use the following equation:

$$D_r = (17.68\ B_t - 0.001978\ T_w^2 + 0.1064\ T_w + 0.002475\, B_t (T_d - T_w) - 2.741)$$

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 the ambient conditions where the barometric pressure exceeds 27 in. Hg. and the dry- and wet-bulb temperature 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:

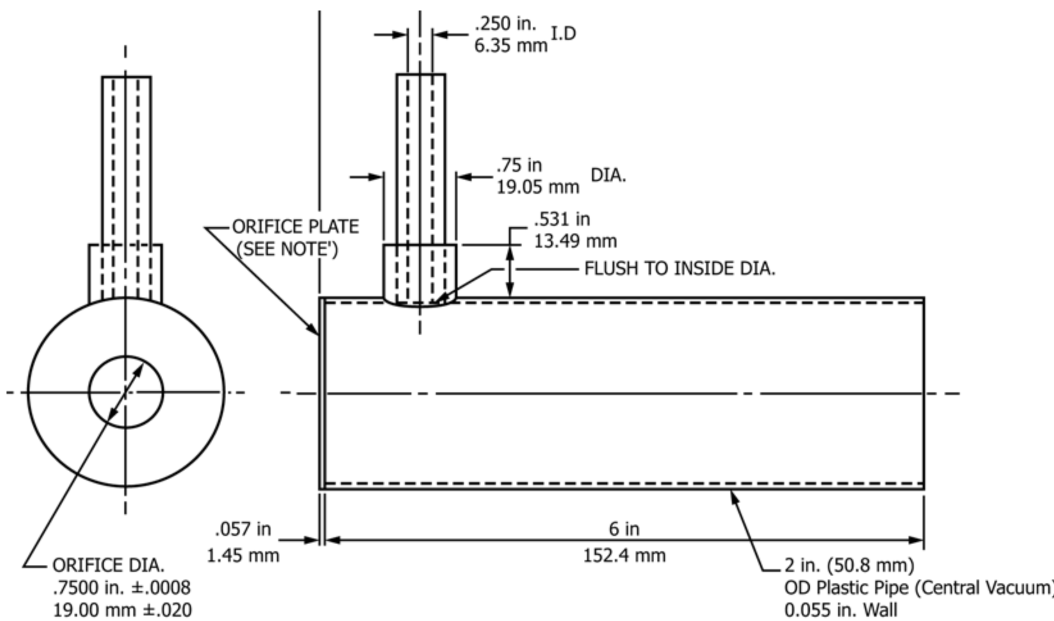
$$h_s = C_s \times h$$

where:

h = manometer reading, and
C_s = correction factor.

A2.3 For series universal motors, calculate the correction factor, C_s as follows:

$$C_s = 1 + 0.667\left(1 - D_r\right)$$



NOTE 1—MAT'L: AISI 4130 STEEL H.T. to RC 42-47
FINISH: BLACK OXIDE
ALT MAT'L 316 STAINLESS STEEL

FIG. A2.1 Suction Fixture