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An American National Standard

Standard Test Method for Life Evaluation of a Turbine-Powered Nozzle for Household Central Vacuum Cleaning Systems[1]

This standard is issued under the fixed designation F1692; 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 turbine-powered nozzle used in household central vacuum cleaning systems.

1.2 This test method provides a test for determining the operating turbine life in hours by an accelerated laboratory procedure. The turbine is tested while mounted and operated in the power nozzle.

1.3 This test method covers only the turbine-powered nozzle. The system used to provide the airflow source is not under consideration.

1.4 This test method is limited to the determination of turbine life for a household turbine-powered nozzle.

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

1.6 *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]

D75 Practice for Sampling Aggregates

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

F655 Specification for Test Carpets and Pads for Vacuum Cleaner Testing

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *turbine stoppage—for turbine-powered nozzles*, any failure integral with the turbine assembly such as housing(s), bearings, or any other component judged to be integral with the turbine.

4. Significance and Use

4.1 The test results provide an indication of the turbine-powered nozzle life. The end of turbine life will be judged in accordance with 3.1.1.

5. Apparatus and Materials

5.1 *Voltage Regulator System*—to control the input voltage to the vacuum cleaner or airflow source. The regulator must be capable of maintaining the vacuum cleaner or the airflow source'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,* having the capacity to control the off/on duty cycle of the nozzle and airflow source during the life test.

5.4 *Wattmeter,* to provide measurements accurate to within ±1 %.

5.5 *Sharp-Edge Orifice Plate*—The orifice, 1¼-in. (32-mm) diameter, shall be in accordance with the orifice plate illustrated in Specification F431.

5.6 *Plenum Chamber,* conforming to the plenum chamber specifications stated 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 of ±0.05 in. (1.27 mm) Hg, capable of measuring uncorrected barometric pressure (test station pressure) with scale divisions of 0.02 in. (0.51 mm) or finer.

[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.

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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.

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

5.10 *Psychrometer,* meeting the requirements of Test Method E337, with thermometers graduated in increments of 1°F (0.5°C).

5.11 *Test Carpet,* conforming to the specifications for level loop carpet as described in Specification F655. A carpet that provides equivalent nozzle loading results may be used.

5.12 *Test Carpet Padding,* conforming to the padding described in Specification F655.

5.13 *Test Cleaner or Airflow Source*—The turbine nozzle life evaluation tests shall be conducted using the airflow source and voltage resulting from the components that compose the combination system with which the turbine nozzle is to be used. If used with several systems, the one with the maximum airflow shall be used.

5.13.1 *Option*—A simulated airflow source and adjusted voltage may be used if they are equal to or exceed the central vacuum cleaning system with which the turbine nozzle is to be used.

5.14 *Test Fixture*—A moving surface, covered by the test carpet supported on the test pad, which moves with a horizontal reciprocating motion, for a stroke distance of 27 in. (686 mm) in each direction at the average rate of 1.8 ft/s (0.55 m/s), resulting in 24 cpm (forward and back). This motion shall be generated by rotating a 13.5-in. (343-mm) radius arm that shall be connected to the platform with a suitable link (see Fig. 1). This device shall provide means to hold the turbine nozzle fixed securely by its handle in the operating position while it is in contact with the reciprocating surface. The turbine nozzle shall be restrained suitably in the horizontal operating plane yet allowed freedom of movement in the vertical plane for operation.

5.14.1 *Option*—The turbine nozzle can be subjected to the same cycle as stated in 5.14 while the carpeted platform is held stationary (see Fig. 1).

5.14.2 For either option, the reciprocating motion shall follow the same duty cycle as specified for the vacuum cleaner or airflow source and turbine nozzle in 7.7.

5.14.3 The turbine nozzle's airflow source shall be stationary and positioned so that the hose will be submitted to minimum stress.

5.15 *Test Dirt,* Wedron sand/talc mixture. See Annex A1.

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 with ±10 % of the mean value. If not, test additional samples or reduce the results of the penalty factor as calculated in 7.12.

7. Procedure for Turbine Life Evaluation

7.1 Determine the initial performance. The suction of the cleaner or airflow source, with the turbine nozzle attached, is to be determined and will be used to ensure that no leaks develop to reduce the load on the nozzle during the test. For this initial test, the nozzle opening is to be sealed to the ASTM plenum chamber with the manometer (or equivalent) connected to the plenum chamber. The turbine nozzle is to have the agitator drive connected and a new filter bag in the cleaner or airflow source. The agitator shall be operating freely, with the handle in operating position, as shown in Fig. 1.

7.1.1 With the turbine nozzle opening sealed to the plenum chamber and without an orifice plate in the holder, energize the cleaner or airflow source at its rated voltage ±1 % and rated frequency ±1 Hz for 5 min. For vacuum cleaners with dual nameplate voltage ratings, conduct the testing at the highest voltage. See 5.13 if an optional airflow source is used.

7.1.2 With the airflow source operating at the regulated voltages stated in 7.1.1, insert the sharp-edge orifice plate in the holder on the orifice box, in accordance with 5.5 and 5.6.

7.1.3 Record the manometer reading of the combined turbine nozzle and airflow source as soon as the reading is stabilized. This manometer reading is to be used as the baseline to monitor the degradation in performance during the test.

7.1.4 Record the wattage of the airflow source while connected to the turbine nozzle and mounted on the plenum chamber. This wattage reading is to be used as the baseline to monitor the nozzle load during the test.

7.1.5 Repeat the initial test sequence described in 7.1 – 7.1.4, recording the manometer and wattage readings of only the cleaner or airflow source connected to the plenum chamber.

7.1.6 The airflow and wattage reading shall be measured every 168 h to determine whether some component has failed

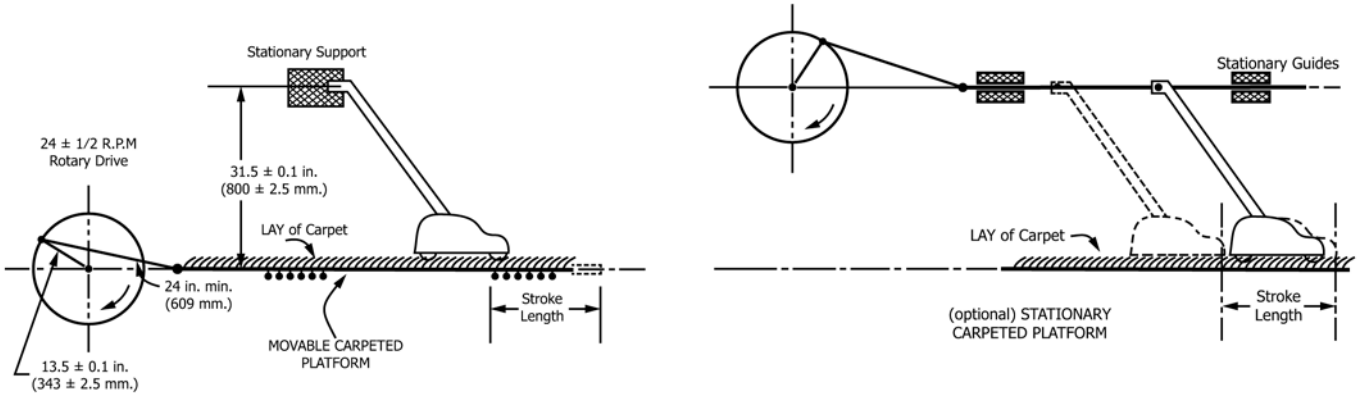

FIG. 1 Test Fixture

and degraded the performance, reducing the load on the nozzle during the life test. See 7.10 if degradation exceeds 40 %.

7.1.7 Monitor the suction at the turbine nozzle daily during the test, in addition to the weekly measurement on the plenum chamber, to maintain loading and to ensure that no mechanical problems exist.

7.2 Use a new section of carpet and padding, in accordance with 5.11 and 5.12, without holes, tears, or other signs of wear, when the test is started. Secure the carpet tautly. The lay of the carpet pile shall be such that, during the forward stroke, the turbine nozzle moves in the direction of the lay of the carpet pile (see Fig. 1). Measure the carpet pile height to determine the carpet wear in accordance with 7.5.1.

7.3 Install the turbine nozzle on the test fixture, as shown in Fig. 1, with the nozzle connected to the airflow source using a hose as provided with the unit. If more than one type of hose can be provided, the hose with the least resistance to airflow (smallest pressure drop) shall be used.

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

7.5 Keep the load within limits by controlling changes in the carpet, agitator brush, drive belt, and airflow source, or by replacing components as determined in 7.5.1 – 7.5.4.

7.5.1 Replace the carpet when one fourth of the pile height is worn away, as measured in the center one third of the stroke, except at the beginning and end of the stroke path.

7.5.2 During the life test, change the agitator brush every 168 h of cycling time.

7.5.3 Change the drive belts every 168 h of cycling time or if they cease to drive the agitator on the test carpet prior to 168 h. Replace the positive drive belts if they cease to function as intended.

7.5.4 During the life test, change the disposable filter, or clean the reusable, primary and secondary filter every 168 h of cycling time or when the airflow decreases 40 % due to filter clogging. To determine whether the filters must be changed or cleaned prior to the 168-h period, an initial dust clogging test shall be conducted in accordance with the procedure described in Annex A2.

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

7.7 Operate the central vacuum cleaning system airflow source (see 5.13) at the regulated and required voltage to obtain the desired airflow through the turbine nozzle. Operate the vacuum cleaner or airflow source from a remote on/off switch that will control the test units to a duty cycle of 8 min of operation followed by 2 min off, following the cyclic criteria in 5.14.

7.8 Initially and daily monitor the suction and wattage input at the airflow source on the test fixture to provide a baseline for identifying whether degradation has occurred. The unit can then be removed and tested on the plenum chamber to determine whether it exceeds the degradation limitation in accordance with 7.10.1.

7.9 Spread 10 g of the standard test dirt mixture on the test carpet (Annex A1) at the start of the test and once every 24 h of cycling time. Spread evenly over the area traversed by the nozzle opening.

7.10 Measure the airflow and wattage readings every 168 h during the test in accordance with the instructions in 7.1 – 7.1.5 to determine whether some component has failed or degraded, or both, in performance, thereby reducing the load on the nozzle or indicating failure.

7.10.1 *Performance Degradation*—In accordance with the procedure described in Annex A2, the suction at the start of the test, as determined in 7.1.3, is to be used as the base for determining the 40 % degradation of performance. If degradation is in the airflow source, replace or repair the airflow source and continue testing. If degradation is in the turbine nozzle, determine and correct the cause. Replace or repair any part, except the turbine in the turbine nozzle, to bring the system within performance limits and continue the test.

7.11 Judge the end of the test in conformance with 3.1.1. Express life in terms of the "on" time only.

8. Calculation

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

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

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i \tag{1}$$

$$h = \frac{ts}{\sqrt{n}} \tag{2}$$

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 a t distribution table for 80 % ($t_{0.90}$) confidence level and degrees of freedom = $n - 1$ (see Table 1), and,
s = standard deviation of sample.

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

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

8.1.2.1 If $h \leq 0.1\ \bar{x}$, use $\bar{x}$ as the published value.

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

$$\Delta = h - 0.1\,\bar{x} \tag{3}$$

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

9. Precision and Bias

9.1 *Precision*—A meaningful statement cannot be made due to the number of components in the turbine nozzle, each of which could constitute failure of the motor.

9.2 *Bias*—A bias statement cannot be applied to this test method as there is no standard reference for comparison.

10. Keywords

10.1 durability; turbine-powered nozzle; vacuum cleaner

ANNEXES

(Mandatory Information)

A1. DIRT MIXTURE

A1.1 Test Dirt

A1.1.1 Ten grams of the test dirt consists of the following:

90 % (weight) 9 g of silica sand[3]
10 % (weight) 1 g of unscented commercial-grade talcum[4]

A1.2 Analysis of Silica Sand

Sieve Range, U.S. No.	Particle Size, μm	Amount Used, g
–30/+40	600–425	0.9
–40/+50	425–300	31.5
–50+70	300–212	41.4
–70/+100	212–150	13.5
–100/+140	150–106	2.7

[3] Wedron No. 540 Unground Silica Sand, or the equivalent, has been found satisfactory for this purpose. It is available from The Wedron Silica Co., Customer Service Department, P.O. Box 119, Wedron, IL 60557. The test dirt must be sieved to ensure conformance with the analysis limits. Use Test Method D75.

[4] USP Grade Supreme Talc, or equivalent, has been found satisfactory for this purpose. It is available from Fischer Scientific Co., 1600 West Glen Avenue, Box 171, Itasca, IL 60143.

A1.3 Analysis of Unscented Commercial-Grade Talcum

%	μm
0.5	>44
12.5	20 to 43.9
27	10 to 19.9
23	5 to 9.9
20	2 to 4.9
8	1 to 1.9
9	<0.9

A1.4 Mixing

A1.4.1 Mix the two dirt quantities thoroughly in a suitable container-dispenser.

A2. METHOD FOR DETERMINING 40 % OF PERFORMANCE

A2.1 One requirement for the life test is to ensure that airflow/suction performance at the *turbine nozzle* 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. The point at which steps must be taken to correct the airflow loss, based on suction, is determined as follows:

$$h_2 = 0.36\, h_1 \tag{A2.1}$$

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 the degradation of performance every 168 h during the test, all that is required is to measure the suction and correct it, and, as long as $h_2 > 0.36\ h_1$, the test requirement for airflow/suction load is maintained.

A2.2 *Derivation:*

$$Q_1 = 21.844\, D^2\ K\sqrt{h_1} \tag{A2.2}$$

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, $Q_2/0.6\ Q_1 = \sqrt{h_1}/\sqrt{h_2}$, or $\sqrt{h_2} = 0.6\ \sqrt{h_1}$, or $h_2 = 0.36\ h_1$ at the servicing point.

A2.3 *Terms:*

Q_1 = initial airflow,
Q_2 = airflow at servicing point,
h_1 = initial suction
h_2 = suction at failure point, an
D = orifice diameter.

A3. CORRECTION OF DATA TO STANDARD CONDITIONS

A3.1 *Air Density Ratio*—The density ratio, D_r, is the ratio of the air density at the time of testing, 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} (lb/ft^3) from standard psychometric charts or ASHRAE tables, and calculate D_r as follows:

$$D_r = \frac{\rho_{test}}{\rho_{std}} \tag{A3.1}$$

As an alternative, use the following equation:

$$D_r = [17.68\, B_t - 0.001978\, T_w^{\,2} + 0.1064\, T_w + 0.0024575\ \ B_t\,(T_d - T_w) - 2.741]/(T_d + 459.7) \tag{A3.2}$$

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 A3.1—This equation is intended for use in correcting the ambient conditions in which the barometric pressure exceeds 27 in. Hg and the dry- and wet-bulb temperatures are below 100°F.

A3.2 *Corrected Suction*—Calculate the corrected suction, h_s, as follows, manometer reading, h, times the correction factor, C_s, as follows:

$$h_s = h \times C_s \tag{A3.3}$$

where:

h = manometer reading, and
C_s = correction factor.

A3.2.1 For series universal motors, calculate the correction factor, C_s, as follows:

$$C_s = 1 + 0.667(1 - D_r) \tag{A3.4}$$