



# Standard Test Method for Straight Line Movement of Vacuum Cleaners While Cleaning Carpets<sup>1</sup>

This standard is issued under the fixed designation F1409; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

## 1. Scope

1.1 This test method covers ~~the~~ measurement of the relative work required to move ~~the carpet cleaning mechanism of an~~ upright, canister, stick, or combination vacuum cleaner in a straight line with forward and backward stroking on a selection of typical carpeted surfaces.

1.1.1 ~~This test method measures only the horizontal component of work required to move the vacuum cleaner on carpet.~~

1.2 This test method can be used in the testing of household and commercial vacuum cleaners.

1.3 This test method measures the relative work needed to move the vacuum cleaner with its motor or motors in operation.

1.4 This test method applies to the vacuum cleaning of carpets only.

1.5 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

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:*<sup>2</sup>

[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](#)

[F884 Test Method for Motor Life Evaluation of a Built-In \(Central Vacuum\) Vacuum Cleaner](#)

[F922 Test Method for Motor Life Evaluation of an Electric Motorized Nozzle](#)

[F1038 Test Method for Motor Life Evaluation of a Canister, Hand-held, Stick, and Utility Type Vacuum Cleaner Without a Driven Agitator](#)

[F1334 Test Method for Determining A-Weighted Sound Power Level of Vacuum Cleaners](#)

2.2 *ASTM Adjunct:*<sup>3</sup>

[Mobility fixture book](#)

## 3. Summary of Test Method

3.1 ~~The carpet cleaning mechanism of~~ Mobility equipment is to be constructed and used to push the vacuum cleaner ~~is moved~~ back and forth on the test carpet in a prescribed manner during the test. ~~A~~ The mobility equipment is to employ a handle clamp assembly with a strain ~~gauge is~~ gauge, to be attached to the vacuum cleaner ~~at the location where the user's working hand usually grips the carpet cleaning mechanism. This handle.~~ This strain gauge measures the ~~force~~ horizontal forces involved in moving only the ~~carpet cleaning mechanism.~~ vacuum on the test carpet.

3.2 Simultaneously, ~~by means of a rod pivotally mounted to the test fixture, the~~ the incremental distance that the vacuum cleaner moves is ~~monitored.~~ also monitored and collected. The force and distance ~~signals~~ measurements are then ~~introduced into an~~ used

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<sup>2</sup> 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.

for calculating X-Y the recorder that produces a plot from which relative work is determined. Alternate data acquisition and computing methods are acceptable work required to push and pull the vacuum on the test carpet.

3.3 The design of the mobility equipment used in this method is left to the user to develop and construct as there are numerous design approaches that may be employed for this evaluation. The mobility equipment may be designed to move the vacuum automatically or manually. Photographs of one design used in the industry to move the vacuum without the assistance of a technician is provided in Figs. 1-3. It is highly recommended that data acquisition and computerization, with a data sampling rate of at least ten samples per second, be utilized to improve the speed and accuracy of data measurements.

#### 4. Significance and Use

4.1 This test method measures the horizontal component of the relative work required by the user during the cleaning operation for the movement of a vacuum cleaner in the home or other cleaning location. Relative work is defined as the work measured by the equipment described in this test method location on standardized laboratory carpeting. Work is determined from the forces measured in the horizontal direction only by the mobility equipment.

4.2 This measurement is relative to the work performed by the user of vacuum cleaners and may be used for comparison between vacuum cleaners.

4.3 The relation between actual vacuum cleaner usage and the method of operation is valid only if the vacuum cleaner user operates the vacuum cleaner properly and in accordance with the manufacturer's instructions.

#### 5. Apparatus

5.1 *Mobility Fixture.*<sup>3</sup>

5.2 *Test Platform* (see 5.1 and Fig. 1).

5.3 *Distance Monitor* (see 5.1 and Fig. 1).

5.1 *Uniform Stroke Speed Indicator-Mobility Equipment*, (see to 5.1 and move Fig. 1), or other type of equipment capable of establishing the rate or movement of the carpet cleaning mechanism as specified in Section the vacuum cleaner for measuring and determining relative work. This equipment is to 9: be designed and developed by the user.

5.2 *Force Measuring Device and Auxiliary Equipment, Calibration Weights*—giving readings accurate to within  $\pm 5\%$ . Precision weights for calibrating the force measuring instrumentation. At least three calibration weights shall be employed to check and ensure linear calibration of the instrumentation. The precision weights are based on the maximum rating of the load cell/strain gage that is used, and shall include a 5 lb weight, a half scale weight, and a full scale weight.

5.5.1 *Strain Gage* (see 5.1 and Fig. 1).

5.5.2 *Load Cell Power Supply* (see 5.1 and Fig. 1).

5.5.3 *X-Y Recorder* (see 5.1 and Fig. 1).

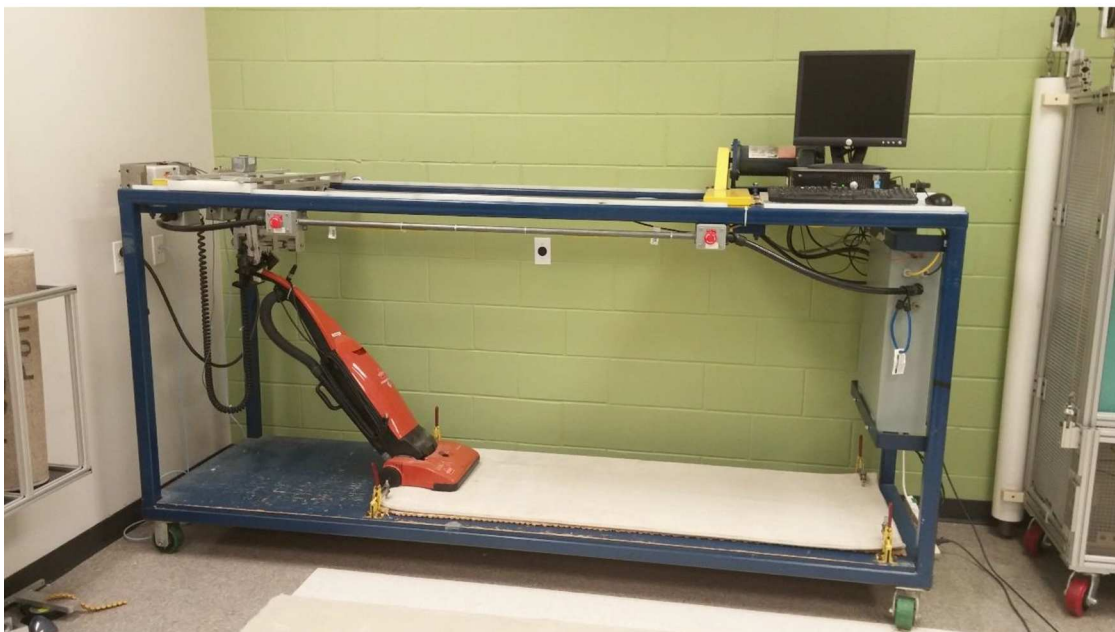


FIG. 1 ASTM Mobility Fixture and Associated Equipment

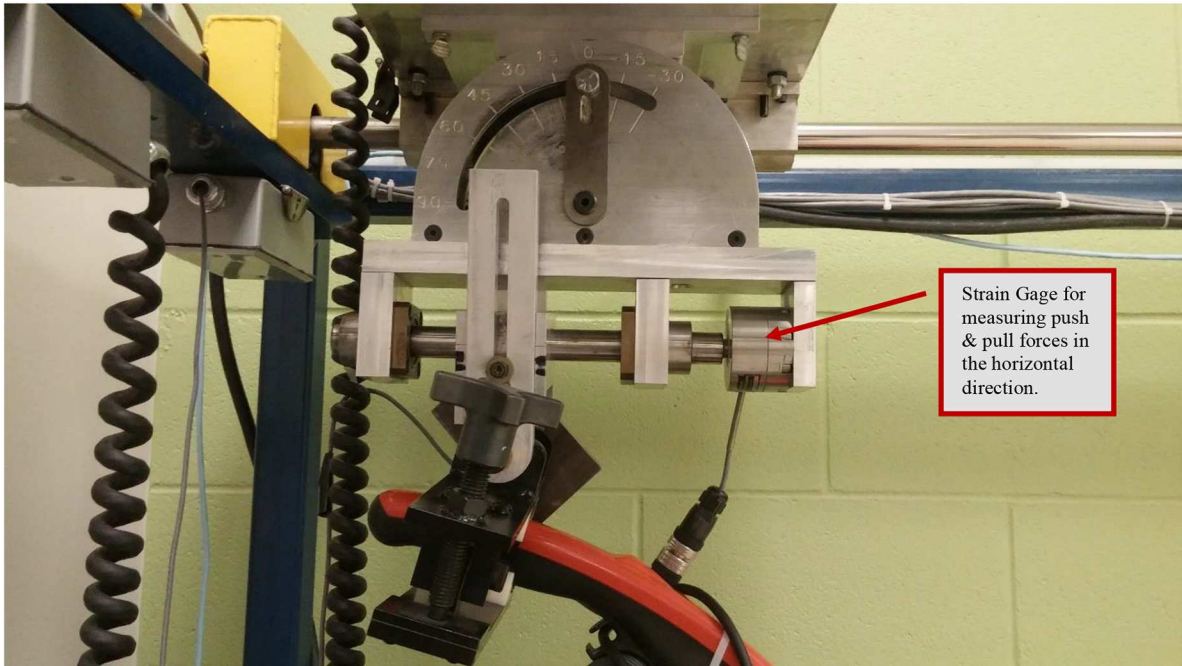


FIG. 2 Adjustment Angle (Pivoting Handle) Strain Gage and Handle Clamp



FIG. 3 Adjustment Angle (Nonpivoting Handle) Motion Drive and Data Collection Computer

FIG. 4 Typical Forward and Reverse Stroke Curve

NOTE 1—The graph paper plot size should be 4 × 4 in. (10 divisions per in. with the smallest increment equal to 0.1 in.). Increments along X axis equal 2 ft/in. Increments along Y axis equal 10 lb/in.

5.5.4 *Planimeter*—Electronic integrator or suitable method of measurement.

5.5.5 *Calibration Weights*—5, 10, and 20 lb.

5.3 *Test Carpets*, as specified in Specification F655. Test carpets shall be stored in a vertical position with no weight on the test surface.

NOTE 2—Test carpets should be stored in a vertical position with no weight on the test surface.

NOTE 1—The test carpets for relative work testing should be limited to that use and not used for other tests such as cleanability.

5.4 *Padding*, beneath test carpet, as specified in Specification **F655**.

5.5 *Temperature and Humidity Indicators*, to provide temperature measurements accurate to  $\pm 1^\circ\text{F}$  ( $\pm 0.5^\circ\text{C}$ ) and  $\pm 2\%$  relative humidity.

5.6 *Voltmeter*, to measure input voltage to the vacuum cleaner, capable of providing measurements accurate within  $\pm 1\%$ .

5.7 *Voltage Regulator System*, to control input voltage to the vacuum cleaner. The regulator system shall be capable of maintaining the vacuum cleaner's rated voltage  $< 1\%$  and rated frequency  $< 1\text{ Hz}$  having a wave form that is essentially sinusoidal with  $3\%$  maximum harmonic distortion for the duration of the test.

5.8 *Rotating Agitator Reference Cleaner*, for calibrating test carpets (see **7.1.3**).

5.9 *Straight Air Canister Reference Cleaner*, for calibrating test carpets (see **7.1.3**).

## 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 the total relative work for the population of the vacuum cleaner model being tested, the arithmetic mean of the relative work of the sample from the population shall be established by testing it to a  $90\%$  confidence level within  ~~$\pm 5\%$~~   $5\%$  of the mean.

6.1.2 **Annex A1** provides a procedural example for determining the  $90\%$  confidence level and when the sample size shall be increased (see **Note 42**).

NOTE 2—See **Annex A1** for method of determining  $90\%$  confidence level.

## 7. Preparation of Apparatus and Test Cleaner

7.1 *Preconditioning for New Test Carpet Samples:*

7.1.1 Cut a sample of each test carpet to a size of 27 by 72 in. (690 by 1830 mm) minimum. If the warp direction or “lay” of the carpet can be determined, it shall be in the 72 in. direction. Carpets shall be bound on all sides.

7.1.2 Precondition the entire carpet by cleaning with a rotating agitator-type cleaner. Continue the operation until less than 2 g of carpet fibers are picked up in 5 min.

7.1.3 After the preconditioning is completed, run calibration tests on each of the carpets to establish a reference rating for one reference rotating agitator cleaner and one reference straight air canister cleaner to determine when the test carpets need to be replaced. The reference rating, or relative work for each cleaner, is established using the procedure described in **9.1 – 9.39.4**. The relative work thus determined for the rotating agitator cleaner and the straight air canister are the reference ratings for the carpets in new condition.

7.1.4 Repeat the calibration tests after every 50 tests on the carpets, using the same reference cleaners. The performance of these reference cleaners should be maintained through the carpet calibration period. When the total for either reference cleaner varies by more than 5 ft-lbf from the original reference rating, replace the test carpet.

7.2 Prior to each of the basic testing segments, lay the padding (see **5.75.4**) on the platform and place the appropriate carpet on top of the padding, without stretching either one. Position the carpet in such a way that the forward test strokes of the cleaner to be tested are with the lay of the carpet.

NOTE 3—The extremes of the stroke can be marked by a tape applied to the test carpet for operator convenience.

7.3 *Preconditioning a Test Cleaner:*

7.3.1 Run-in the test cleaner at a rated voltage  ~~$\pm 1\%$~~   $\pm 1\%$  and rated frequency  $\pm 1\text{ Hz}$  with filters in place, to ensure that the motor brushes are properly seated and to precondition the agitator brushes.

7.3.1.1 *Preconditioning a Rotating Agitator-Type Cleaner*—In a stationary position, operate the cleaner for 1 h with the agitator bristles not engaged on any surface.

7.3.1.2 *Preconditioning a Straight Air Canister Cleaner*—Operate for 1 h with wide open inlet (without hose).

7.4 *Calibration Check of the Recorder and Measuring Device:—Strain Gage:*

NOTE 6—If equipment does not perform properly after the following check procedure, recalibrate in accordance with Adjunct No. 12-614090-47.

7.4.1 Turn on the X-Y recorder, and the X and Y amplifiers  $\frac{1}{2}\text{ h}$  before testing to stabilize the components. If the recorder is covered, remove the cover to ensure adequate ventilation.

7.4.2 Loosen the thumb screw holding the pendulum constant length adjustment rod and lower it to its lowest position to avoid damage to the telescoping pendulum.

7.4.3 Place the handle of the carriage in a level position and move the carriage laterally to a position where the pendulum shaft assembly is vertical from side to side. Adjust the pendulum vertical positioning link forward to backward, if required, so that the pendulum is vertical in the front to rear direction.

7.4.1 Set the handle clamp pivot point at  $32\frac{1}{2}$  of the mobility equipment at  $32.5\frac{1}{2}$  in. above the carpet test platform (carpet and pad not in place) with the support lifting crank assembly. With the pendulum shaft assembly vertical, align the top of the pendulum outer tube with the black line on the pendulum shaft and tighten the thumb screw holding the pendulum constant length adjustment rod in place.

7.4.5 Remove the calibration spring attached to the calibration screw and attach one end of a cord to the rear calibration cord attaching screw on the carriage. Bring the cord over the pulley at the rear end of the stainless steel shaft and attach it to a 5-lb weight resting on the test platform.

7.4.6 Set the recorder pen on a horizontal line on the recorder chart and push the carriage to lift the weight from the floor.

7.4.7 Hold the carriage in a fixed position after the weight has been lifted from the floor and check the pen position. It should move 5 graph increments to indicate 5 lb. If the pen moved more or less than 5 increments, adjust the Y axis VAR SCALE knob on the recorder in the proper direction to give a movement of 5 increments.

7.4.8 Check the recorder pen movement for linearity in a manner similar to that described in 7.4.7 with the 10- and 20-lb weights for pen movements of 10 and 20 increments, respectively. There should be little if any Y axis VAR SCALE knob adjustment required.

7.4.9 Remove the cord from the rear of the carriage and attach it to the calibration cord attaching screw at the front of the carriage. Place the cord over the pulley at the front end of the stainless steel shaft and attach it to a 5-lb weight resting on the test platform.

7.4.2 Pull the carriage backward to lift the weight from the platform. The pen should move 5 chart increments in the opposite direction from that occurring in Using the calibration weights per 7.4.7.5.2. Check the, check calibration and linearity in a similar manner with the 10 and 20-lb weights. Remove the cord and weights from the test fixture and lift the recorder pen from the chart of the mobility equipment's strain gage.

7.4.11 Locate the rear of the carriage at the rear limit line of the stainless steel shaft at the beginning of the forward stroke. Set the pen at the juncture of the two major graph lines at the left side of the graph and lower the recorder pen onto the recorder graph.

7.4.12 Move the carriage through one complete forward stroke to the forward limit line on the stainless steel shaft and back to the rear limit line. Check and adjust the pen VAR SCALE knob on the X axis amplifier to give an X axis pen displacement of the desired dimension representing 8 ft of carriage travel (let 5 increments equal 1 ft). This completes the calibration.

#### 7.5 Test Cleaner Settings:

7.5.1 If various settings are provided, set the motor speed setting, suction regulator, or nozzle height, or combination thereof, using the manufacturer's specifications as provided in the instruction manual for each type of test carpet. Contact the manufacturer if no instructions are given, or if the instructions are unclear or inadequate.

7.5.1.1 The settings used for this test method (nozzle, motor speed, suction regulator, and so forth) for each specific carpet shall be applied for all embedded dirt cleaning effectiveness (Test Method F608), sound power (Test Method F1334), and motor life evaluation (Specification F655, Test Methods F884, F922, and F1038) tests.

#### 7.6 Apparatus Mobility Equipment Set-Up For/for Cleaner Testing:

7.6.1 Turn on the X-Y recorder, X and Y axis amplifier  $\frac{1}{2}$  h before testing to stabilize the components.

7.6.1 The Vacuum the entire test carpet should be vacuumed thoroughly for 2 min minutes with a rotating agitator-type cleaner just prior to the relative work test to remove any residual dirt that may have accumulated.

7.6.2 Place the test carpet and pad on the carpet test platform of the mobility equipment with the lay of the carpet in the forward direction.

7.6.4 Loosen the thumb screw holding the pendulum constant length adjustment rod and lower it to its lowest position.

7.6.3 The cleaner to be tested should be thoroughly cleaned to remove any residual test dirt or dust that could be drawn into the cleaner's filtration system.

7.6.5.1 For vacuum cleaners using disposable filters as the primary filters, use a new disposable primary filter from the manufacturer for each test.

7.6.5.2 For vacuum cleaners using nondisposable dirt receptacles, empty in accordance with the manufacturer's instructions before each test.

7.6.5.3 For vacuum cleaners using water as the primary filter, empty the receptacle and refill as recommended by the manufacturer before each test.

7.6.4 If the cleaner has a pivoting handle, adjust the angle of the carriage and handle assembly so that the strain gage is parallel to a line extending through the center of the handle grip and the center of the pivot point when the center of the handle grip is  $31.5$  in. above the carpet surface (see For vacuum cleaners using disposable filters as the primary filters, use a new disposable primary filter from the manufacturer for each test. Fig. 2).

NOTE 7—This angle may be mathematically determined prior to testing.

7.6.5 If the cleaner has a nonpivoting handle or wand, adjust the angle of the carriage and handle assembly so that the strain gage is parallel to a line extending through the center of the handle grip and the center of the nozzle at its interface with the carpet surface when the cleaner is set For vacuum cleaners using non-disposable dirt receptacles, empty in accordance with 7.5.1 (see the manufacturer's Fig. 3) instructions before each test.

~~NOTE 8—This angle may be mathematically determined prior to testing.~~

~~7.6.6 Adjust the calibration spring assembly so there is no For vacuum cleaners using water as the primary filter, empty Y axis movement of the recorder pen when the carriage is moved from the “kill switch” area to the “forward stroke” area.~~ the receptacle and refill as recommended by the manufacturer before each test.

~~7.6.7 If the cleaner has a pivoting handle or wand, raise or lower the carriage and handle clamp assembly so of the mobility equipment so that the handle clamp pivot point is 31.5 in. (0.8 m) from the top of the carpet pile. If the handle or wand does not pivot, adjust for a handle height that will provide maximum suction at the nozzle and a parallel contact between the carpet pile and the bottom surface of the nozzle as determined in 7.5.1. Ensure that the strain gage of the mobility equipment is adjusted to measure only the horizontal motion forces. A digital level is recommended to ensure accuracy of the strain gage placement.~~

~~7.6.10 Set the pendulum constant length adjustment rod by moving the carriage where the pendulum shaft assembly is vertical and raise the adjustment rod and the pendulum outer tube until the top of the tube is level with the line on the pendulum shaft. Tighten the adjustment rod thumb screw.~~

~~7.6.8 Mount the vacuum cleaner handle to the handle clamping assembly in a manner that securely clamps the handle gripping area so that the center of the clamping assembly is positioned at the center of the handle gripping area.~~

~~7.6.9 Move the carriage Operate the mobility equipment to move the vacuum forward and backward several times and readjust the threaded shafts on the handle clamp, if necessary, carriage handle clamp as necessary to ensure that the cleaning mechanism is straight.~~ vacuum follows a straight path on the test carpet.

~~7.6.10 Set the test cleaner settings in accordance with 7.5.1.~~

~~7.6.14 Insert a blank sheet of graph paper in the X-Y recorder. Position the recorder pen at the desired starting point on the graph.~~

## 8. Conditioning

8.1 *Test Room*—Maintain the test room in which all conditioning and cleaner testing is done at  $70 \pm 5^\circ\text{F}$  ( $21 \pm 3^\circ\text{C}$ ) and 45 to 55 % relative humidity.

8.2 All components involved in the test must remain and be exposed in the controlled environment for at least 16 h prior to the start of the test.

## 9. Procedure

9.1 Perform this procedure on all test carpets specified in [5.65.3](#) with the cleaner motor or motors operating at the cleaners nameplate rated voltage  $\pm 1\%$  and frequency  $\pm 1\text{ Hz}$ . For vacuum cleaners with dual nameplate voltage ratings, conduct testing at the highest voltage.

~~9.2 Grasping the handle of the carriage, handle, and clamp assembly, apply a force Operate the mobility equipment to push the vacuum cleaner forward in a straight line for 48 in. (1.22 m) at a rate of 1.8 ft/s (0.55 m/s), paced by the uniform stroke speed indicator. Take care to go up to, but not over, the forward limit line on the stainless steel shaft. and to pull the cleaner backward in a straight line for the same distance at the same rate.~~ 7.3 ft (2.2 m) at a rate of 1.8 ft/s (0.55 m/s), paced by the uniform stroke speed indicator. Take care to go up to, but not over, the forward limit line on the stainless steel shaft. and to pull the cleaner backward in a straight line for the same distance at the same rate.

~~9.3 In similar fashion to 9.2, pull the cleaner backward in a straight line for the same distance at the same rate up to, but not past, the rear limit line on the stainless steel shaft.~~

9.3 Repeat the operations described in [9.2](#) and [9.39.2](#) for ten uninterrupted cycles recording both the force versus and distance on the X-Y plotter. The X-Y plotter may be replaced by a data acquisition system or electronic integrator. mobility equipment’s data collection system.

9.4 [9.1 – 9.39.4](#) are considered to be one test run. Repeat [9.1 – 9.39.4](#) two additional times, for a total of three test runs. The test results of each test run shall be recorded on separate X-Y plots. separately.

## 10. Calculation

10.1 Using a planimeter, electronic integrator, or data acquisition system to measure the From the data collected by the mobility equipment’s data collection system, calculate the average work in ft-lb for the ten forward strokes of a single test run by multiplying the average force measured for the ten forward strokes by the travel distance of 48 in. This equates to determining the average area under the forward-stroke curve above the zero line only, and under the reverse curves (above the zero line) for ten forward strokes (see Fig. 4 stroke curve below the zero line only, on the), and represents the work in ft-lb required to X-Y push plot (see the vacuum Fig. 4) for in the forward direction on the specified carpet. Repeat this calculation to determine the average work for the ten reverse strokes for each test run. Record the forward and reverse stroke values separately for each test run.

10.1.1 If a planimeter is used to measure the area, measure the average path for the ten traces on the plot three separate times for better accuracy.

~~NOTE 9—The calibration of the planimeter shall be checked carefully and the same planimeter should be used to measure the graph areas obtained throughout the test series with the same flat surfaces under the graph paper.~~

10.2 Make the necessary calculations to determine if the 90 % confidence level has been met along with the repeatability and reproducibility requirements for precision and bias. See [Annex A1](#).