Designation: F510/F510M – 14

Standard Test Method for Resistance to Abrasion of Resilient Floor Coverings Using an Abrader with a Grit Feed Method[1]

This standard is issued under the fixed designation F510/F510M; 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.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope

1.1 This test method[2] describes a laboratory procedure for determining the abrasion resistance of resilient flooring using an abrader with a grit feeder.[3]

1.2 The equipment used in this test method is a modification of the Taber abraser. The regular abrading wheels are replaced by leather clad brass wheels (rollers). As the specimen holder rotates, a grit-feeding device feeds aluminum oxide grit onto the specimen before it passes under the leather clad brass wheels. Using the vacuum system incorporated in the apparatus, the used grit and abraded material are removed after passing under both wheels.

1.3 This test method employs a rotary, rubbing action caused by loose abrasive grit and the two abrading wheels. One wheel rubs the specimen from the center outward and the other from the outside toward the center. The wheels traverse a complete circle and have an abrasive action on the rotating specimen at all angles. This action approaches the twisting action between shoe and floor that occurs when a person turns. The use of loose grit serves the function of an abradant and also aids in the rolling action characteristic of normal walking.

1.4 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.5 *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:*[4]

D792 Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement

E122 Practice for Calculating Sample Size to Estimate, With Specified Precision, the Average for a Characteristic of a Lot or Process

G195 Guide for Conducting Wear Tests Using a Rotary Platform Abraser

2.2 *ANSI Standard:*

B74.12 Checking the Size of Abrasive Grain for Grinding Wheels, Polishing, and General Industrial Uses[5]

3. Terminology

3.1 *Definitions:*

3.1.1 *abrasion—of resilient floor coverings*, a form of wear, in which a gradual removing of a flooring surface is caused by the frictional action of relatively fine hard particles.

3.1.2 *resistance to abrasion— of resilient floor coverings*, the ability of a material to withstand mechanical actions of relatively fine hard particles, which by rubbing, scraping, and eroding remove material from a floor covering surface.

4. Significance and Use

4.1 When subjected to normal in-use traffic conditions, a flooring material is exposed to abrasion caused by the destructive action of fine hard particles. This situation occurs whenever loose debris, dirt and other particulate matter exists between traffic bodies (that is, shoes and a flooring surface).

[1] This test method is under the jurisdiction of ASTM Committee F06 on Resilient Floor Coveringsand is the direct responsibility of Subcommittee F06.30 on Test Methods - Performance.

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[2] This test method is described by W. E. Irwin in "Development of a Method to Measure Wear on Resilient Flooring," *Journal of Testing and Evaluation,* Vol 4, No. 1, January 1976, pp. 15–20.

[3] This grit feed method is frequently referred to as the "Frick Grit Feed Method" because it is based on work done by Otto F. V. Frick as described in "Studies of Wear on Flooring Materials," *Wear,* Vol 14, 1969, pp. 119–131.

[4] 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] Available from American National Standards Institute, 25 West 43rd St., 4th Floor, New York, NY 10036.

FIG. 1 Taber Abraser with Grit Feeder

Under continuing exposure to an "abrasive action," a flooring material may suffer a thickness loss sufficient to reduce its service life.

4.2 Abrasion resistance measurements of resilient floor coverings can be complicated since the resistance to abrasion is affected by many factors. These may include the physical properties of the material in the floor covering surface, particularly its hardness and resilience; type and degree of added substances, such as fillers and pigments; surface characteristics of the specimen, such as type, depth, and amount of embossing. It can also be affected by conditions of the test, including the type and characteristics of the abradant and how it acts on the area of the specimen being abraded; pressure between the specimen and leather clad brass wheels; and vacuum suction.

4.3 This test method is designed to simulate one kind of abrasive action and abradant that a flooring may encounter in the field. However, results should not be used as an absolute index of ultimate life because, as noted, there are too many factors and interactions to consider. Also involved are the many different types of service locations. Therefore, the data from this test method are of value chiefly in the development of materials and should not be used without qualifications as a basis for commercial comparisons.

5. Apparatus

5.1 *Apparatus*[6], as shown in Fig. 1, shall consist of the following:

5.1.1 *Abraser,* as described in Guide G195.

5.1.2 *S-39 Leather-covered brass wheels*[6], the brass hub shall have a diameter of 4.44 cm [1.75 in.], and the width shall be 1.27 cm [0.50 in.]; weight of the brass hub shall be 145 g [5.11 oz]. Width of the leather covering shall be 1.27 cm [0.50 in.], and the weight of the leather strip shall be 5 g [0.202 oz]. The minimum diameter of the leather covered brass wheel shall be 46 mm [1 13⁄16 in.].

5.1.3 *Vacuum unit*[6], or equivalent, and an optional water trap as shown in Fig. 2. The purpose of the water trap is to protect the vacuum equipment motor, reduce the need to empty the vacuum bag frequently, and minimize readjustment of speed. The inlet pipe to the water trap should be far enough away from the water surface so that undue turbulence is avoided and water does not enter the exhaust line.

5.1.4 *Grit Feeding Device*[6], consisting of a storage reservoir for the aluminum oxide grit, grit distribution nozzle, speed control for adjusting grit feed rate, and vacuum pick-up nozzle.

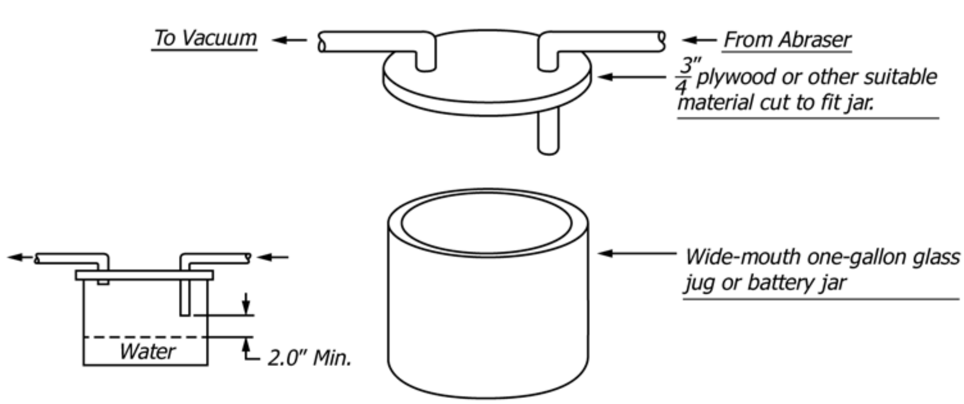
5.2 *S-41 Aluminum Oxide Grit*[6], 240 aluminum oxide grit, ANSI B74.12 unless otherwise specified by the interested parties.

5.3 *S-38 Standardization Plates*[6], 100 mm [4.0 in.] square, cast acrylic sheet with a 7 mm [¼ in.] center hole.

5.4 *Sieve,* No. 80 [180 μm].

5.5 *Equipment,* for determining specific gravity.

[6] The sole source of supply of the apparatus known to the committee at this time is Taber Industries, 455 Bryant St., North Tonawanda, NY 14120. If you are aware of alternative suppliers, please provide this information to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend.



NOTE 1—A vacuum-tight seal between the cover and jar is not required.

FIG. 2 Water Trap

5.6 *Analytical Balance,* for weighing specimens to a precision of 0.001 g.

5.7 *Die or Knife,* for cutting specimens to designated size.

5.8 *Oven,* to dry grit by heating at 82°C [180°F].

5.9 *Static Eliminator Brush.*

6. Test Specimens

6.1 *Specimen Thickness*—The standard material thickness that can be evaluated with the Taber abraser is 6.35 mm [0.25 in.] or less. For materials thicker than 6.35 mm [0.25 in.] but less than 12.7 mm [0.50 in.], an extension nut such as type S-21[6] or equivalent may be used.

6.2 *Specimen Size*—The width of the resulting wear path is 12.7 mm [0.50 in.] and is located 31.75 mm [1.25 in.] from the center of the specimen. For most rigid materials, a sample approximately 100 mm [4 in.] square is recommended. If the material is flexible and can be lifted by the vacuum nozzle, a round specimen approximately 100 mm [4 in.] in diameter is suggested to permit the use of the specimen table hold down ring. A 6.5 mm [0.25 in.] diameter hole is drilled through the precise center of the specimen to allow fastening to the specimen holder.

6.3 The required number of specimens for each test shall be indicated in the material specification. If no number is given, four samples shall be taken from the material and one determination made on each. The average of the four or otherwise specified measurements shall be taken as the abrasion loss for the material.

7. Calibration and Standardization

7.1 Verify the calibration of the abrader as directed by the equipment manufacturer (see Appendix X1).

7.2 Adjust the abrader with the grit feeder for proper operation using cast acrylic sheet[6] such as S-38 standardization plates as the standard material. The equipment, when running properly, shall produce an average weight loss of 127.5 ± 10 mg for four specimens and 127.5 ± 18 mg for an individual test at 2000 revolutions (Note 3). Operation of the equipment for calibration shall be as described in Section 9, except that specific gravity will not need to be determined.

NOTE 1—The average weight loss reported in 7.2 is based on S-41 aluminum oxide grit, and may not be applicable if other abrasive grits are used.

NOTE 2—Prior to use, the leather clad wheels must be broken in. To do this, subject the wheels to an initial test of 2000 cycles on an S-38 standardization plate with results to be discarded.

NOTE 3—If the desired weight loss is not obtained, check on the following: grit feed rate, path of the grit, removal of the grit, condition of the leather on the wheels, free rotation of wheel bearings, specimen slippage, static charge effects, humidity control, faulty revolution counter, and weighing errors.

8. Conditioning

8.1 For those tests where conditioning is required, condition the specimens at 23 ± 2°C [73.4 ± 3.6°F] and 50 ± 5 % relative humidity for not less than 40 h prior to test.

8.2 *Test Conditions*—Conduct tests in the standard laboratory atmosphere of 23 ± 2°C [73.4 ± 3.6°F] and 50 ± 5 % relative humidity unless otherwise agreed upon by the interested parties.

9. Procedure

9.1 Determine the specific gravity of the material to be tested in accordance with standard analytical procedures, such as Method A-1 or A-2 in Test Methods D792. If the specimen as received is not homogeneous but possesses a surface that differs from the body or core, determine the specific gravity of the surface alone. If abrasion is to be carried beyond the surface of the body, also determine the specific gravity of the latter and calculate and report the abrasion resistance of the two components separately.

9.2 Screen the grit through a U.S. Standard Sieve No. 80 [180 μm] and dry for 1 h at 82°C [180°F]. Allow the grit to cool in a temperature and humidity controlled room prior to use.

9.3 Fill the grit reservoir with grit. Adjust the rate of feed to 35 ± 5 g per 100 specimen revolutions. The feed rate may be measured by holding a tared petri dish under the nozzle of the grit feeder for 100 specimen revolutions and weighing the amount of grit delivered. The feed rate may be controlled by adjusting the motor speed. The collected grit may be returned to the grit reservoir. It is suggested that the grit feed rate check be made after every third run.

9.4 When the specimens have been prepared and conditioned, brush with the static eliminator and record the initial values for weight to the nearest 0.001 g. Handle samples with care to eliminate contact with moisture from the hands or other environmental contact.

9.5 Place the specimen face up over the rubber mat on the turntable platform. Secure the specimen using the clamp plate and nut. The hold down ring may be used with circular specimens, to keep the specimen from lifting.

9.6 Adjust the feeder nozzle so that it is no higher than 6.5 mm [0.25 in.] above the specimen and so that the stream of grit delivered will evenly cover the wear path generated by the wheels. This should be done prior to the start of the test.

9.7 It is essential that the grit feeding device is positioned correctly such that the abrasive grit falls in the path of the wheels. The correct location of the feeder can be checked by collecting grit for one revolution on a calibration plate containing concentric circles of various radii. The location of the grit pattern can then be compared with the wear path recorded on a poly(methyl methacrylate) (PMMA) or other transparent plate.

9.8 Place the 1000-g weights provided with the apparatus on each of the abraser arms. Fasten the leather-covered wheels to each arm and lower to the specimen surface. The leather rollers should be replaced when one third of the original thickness of the leather clad is reached. This will occur in approximately 45 000 specimen revolutions.

NOTE 4—Accessory weight references are per arm (not combined), and include the mass of the pivoted arm.

9.9 Position the grit removal vacuum nozzle and adjust the settings so that all grit will be removed after passing under the wheels.

NOTE 5—To ensure proper removal of grit during the test, regularly examine the condition of the vacuum pick-up nozzle and abrader vacuum hose for holes or other types of damage. Replace if necessary.

9.10 Adjust the counter to zero and start the machine.

9.11 When the prescribed number of specimen revolutions have been reached, stop the machine, remove the specimen, clean with a filtered dry air blast, brush with the static eliminator, and reweigh.

10. Calculation and Report

10.1 Report the resistance to abrasion for the number of revolutions employed using one or more of the following equations:

$$\text{Volume loss, cm}^3 = \frac{W_1 - W_2}{S} \tag{1}$$

where:

W_1 = initial weight, g,
W_2 = weight after abrasion g, and
S = density of the material being abraded, g/cm^3.

or:

$$\text{Volume loss, mm}^3/100\text{ revolutions} = \frac{\text{cm}^3 \times 1000}{\text{total revolutions}} \times 100 \tag{2}$$

10.2 The average loss in thickness can be calculated by dividing the loss in volume by the abraded area of the specimen.

11. Precision and Bias[7]

NOTE 6—For further information on the use of statistical methods, refer to the appendix.

11.1 *Precision:*

11.1.1 The repeatability for smooth surfaces is 10 % for this test.[2]

11.1.2 The reproducibility for smooth surfaces is 20 % for this test.[2]

11.1.3 The repeatability and reproducibility for embossed surfaces has not been established.

11.2 *Bias*—This procedure for measuring resistance to abrasion of resilient floor covering using an abrader with a grit feed has no bias because the value of abrasion resistance can only be defined in terms of a test method.

12. Keywords

12.1 abrasion resistance; aluminum oxide; grit feed; resilient flooring; Taber abraser

[7] The method of calculating the coefficient of variation may be found in *MNL 7, Manual on Presentation of Data and Control Chart Analysis,* American Society for Testing and Materials, 1990.

APPENDIXES

X1. CALIBRATION VERIFICATION

X1.1 To facilitate the verification of calibration of the Taber abraser, a kit is available[6] that provides a fast reliable system check. This kit is not meant as a substitute for regular instrument calibration. Procedures in the kit allow the user to verify:

X1.1.1 *Wheel Alignment and Tracking*—The wheels should be spaced equally on both sides from the wheel-mounting flange to the center of the specimen holder. When resting on the specimen, the wheels will have a peripheral engagement with the surface of the specimen, the direction of travel of the periphery of the wheels and of the specimen at the contacting portions being at acute angles, and the angles of travel of one wheel periphery being opposite to that of the other. Wheel internal faces shall be 52.4 ± 1.0 mm apart and the hypothetical line through the two spindles shall be 19.05 ± 0.3 mm away from the central axis of the turntable. (Fig. X1.1).

X1.1.2 *Wheel Bearings Condition*—The Taber abraser wheel bearings should be able to rotate freely about their horizontal spindles and not stick when the wheels are caused to spin rapidly by a quick driving motion of the forefinger.

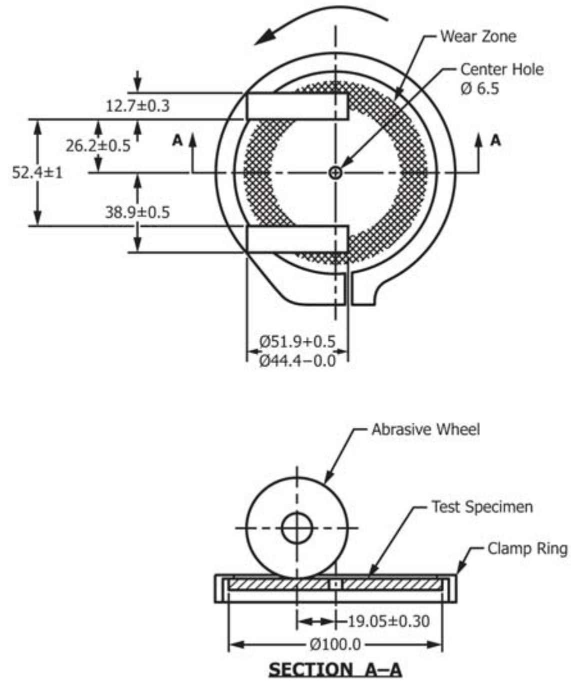
X1.1.3 *Vacuum Suction Force*—Air pressure in the suction device must not be lower than 137 millibar [55 in. of water column], as measured by a suction gage.

NOTE X1.1—Vacuum suction force may be influenced by the condition of the collection bag and filter, which should be replaced on a regular basis. Any connection or seal leaks will also influence suction force.

X1.1.4 *Turntable Platform Position*—The vertical distance from the center of the pivot point of the Taber abraser arms to the top of the turntable platform should be approximately 25 mm. The turntable platform shall rotate substantially in a plane with a deviation at a distance of 1.6 mm [1⁄16 in.] from its periphery of not greater than ±0.051 mm [±0.002 in.].

X1.1.5 *Turntable Speed*—The turntable should rotate at a speed of either 72 ± 2 r/min or 60 ± 2 r/min.

X1.1.6 *Load*—The accessory mass marked 500 g shall weigh 250 ± 1 g and the accessory mass marked 1000 g shall weigh 750 ± 1 g.



This schematic shows the proper wheel position in relation to the turntable platform.

FIG. X1.1 Diagrammatic Arrangement of Taber Abraser Test Set-up

X2. USE OF STATISTICAL METHODS

X2.1 Introduction

X2.1.1 Variability or experimental error in each laboratory is a factor that must be taken into consideration when running any test method. The only acceptable way to deal with these variations is by the use of statistical methods. Statistical methods were used to evaluate the results of the original round robin and also to evaluate the results of the round robin that established cast acrylic as the standard material to check on the proper operation of the equipment. This is why the procedure calls for *four* test specimens (see 6.3). The following outline of statistical procedures is intended to assist in understanding how to apply these techniques so that proper sampling and analyses can be carried out. It is important to keep in mind that the absolute value for volume or weight loss is not known for resilient flooring. The task at hand is to determine what the loss is with a certain degree of confidence.

X2.2 Statistical Equations

X2.2.1 Several equations for the calculation of optimum sample size, standard deviation, and coefficient of variation are used in statistical analysis of data. Calculations can be made using the following equations:

$$S_1 = R/d_2 \quad \text{(X2.1)}$$

$$s_2 = \sqrt{\frac{\sum^{n}_{i=1} (x_i - \bar{x})^2}{(n-1)}} \quad \text{(X2.2)}$$

$$v = (s/\bar{x}) \times 100 \quad \text{(X2.3)}$$

$$n = (1.96\, v/e)^2 \quad \text{(X2.4)}$$

where:

s_1 = standard deviation from the mean (for small sample size, 2 to 10),
s_2 = standard deviation from the mean (for any sample size),
v = coefficient of variation, expressed in %,
x = value of each test result (volume loss in mm^3),
$\bar{x}$ = mean or arithmetic average for n tests,
$\sum x$ = sum total of all test values,
n = number of tests or observations,
e = allowable sampling error expressed in %,
R = difference between the highest and lowest test value, and
d_2 = deviation factor which varies with sample size (see Table X2.1).

TABLE X2.1 Factors for Estimating Standard Deviation From the Range on the Basis of Sample Size

Sample Size, *n*	d_2	$1/d_2$
2	1.128	0.8865
3	1.693	0.5907
4	2.059	0.4857
5	2.326	0.4299
6	2.534	0.3946
7	2.704	0.3698
8	2.847	0.3512
9	2.970	0.3367
10	3.078	0.3249

X2.3 Obtaining Factors for Standard Deviation and Coefficient of Variation

X2.3.1 In statistical analysis, the estimated standard deviations of large sample sizes (over ten) are derived from the square root of the mean square of deviations from the average. A typical user of this test procedure will more likely start out with less than ten test results. In these cases, the standard deviation, s, is more readily derived from the range, r, of the sample observation than from the root mean square. For such specimens, the standard deviation is obtained by multiplying the range of available observations (the difference between the highest and the lowest numerical value) by a deviation factor (Eq X2.1) that varies with the specimen size. Once the standard deviation is obtained, the percent coefficient of variation is obtained by dividing the standard deviation by the average test value, $\bar{x}$, and multiplying by 100. The deviation factor is obtained from Table X2.1.

X2.4 Typical Analysis for Standard Deviation and Coefficient of Variation of Four Tests (for Small Sample Size)

X2.4.1 In the following example, a typical analysis was taken from the first round robin. Note that the 11.62 % coefficient of variation is above the 10 % maximum for intralaboratory results (repeatability) as indicated in 11.1.1.

Number of tests	$n = 4$
Volume loss, mm^3/100 revolutions	$x = 2.710, 2.330, 2.960, 2.530$
Average volume loss, mm^3/100 revolutions	$\bar{x} = 2.632$
Range of test	$R = 2.960 - 2.330 = 0.63$
Standard deviation	$s_1 = R/d_2 = 0.630/2.059 = 0.3059$
Coefficient of variation	$v = (s/\bar{x}) \times 100 = (0.3059/2.632) \times 100 = 11.62\ \%$

X2.5 Determination of Standard Deviation and Coefficient of Variation for Large Sample Size (10 or Over)

X2.5.1 Data were taken from three laboratories for this analysis as follows:

Test	x	$x_i - \bar{x}$	$(x_i - \bar{x})^2$
1	1.800	−0.322	0.1037
2	1.870	−0.252	0.0635
3	1.820	−0.302	0.0912
4	1.820	−0.302	0.0912
5	2.490	0.368	0.1354
6	2.500	0.378	0.1429
7	2.650	1.528	0.2788
8	2.064	−0.058	0.0034
9	2.560	0.438	0.1918
10	1.648	0.474	0.2247
	$\bar{x} = 2.122$		

X2.5.2 The standard deviation is derived from the equation

$$s_2 = \sqrt{\frac{\sum_i^n (x - \bar{x})^2}{(n-1)}} = \sqrt{\frac{1.3266}{9}} = 0.384 \qquad (X2.5)$$

X2.5.3 Coefficient of variation is obtained using the equation $v = (s/\bar{x}) \times 100 = (0.384/2.12) \times 100 = 18.11\ \%$.

X2.5.4 These interlaboratory results fall within the 20 % limits set for the reproducibility of this method.

X2.6 Precision Versus Bias

X2.6.1 Accepted wear loss values have not been established for resilient flooring. However, repeated testing has given some data that some laboratories may accept as suitable for development purposes. For example, in the round robin referred to earlier,[2] 11.0 mm^3/100 revolution loss at a 10 % intralaboratory coefficient of variation was established for one of the test materials (see X2.4.1). In the example that follows, we can see

TABLE X2.4 Minimum Acceptable Sample Size (*n*) for 95 % Confidence Levels

Coefficient of Variation, *v*, %	Allowable Sampling Error (*e*), %								
	1	2	3	4	5	6	7	8	10
1	4	1	...	...	...	...	...	...	...
2	16	4	2	1	...	...	...	...	...
3	35	9	4	3	2	1	...	...	...
4	62	16	7	4	3	2	2	...	...
5	96	24	11	6	4	3	2	2	1
6	...	35	16	9	6	4	3	2	2
7	...	47	21	12	8	6	4	3	2
8	...	62	28	16	10	7	5	4	3
9	...	78	35	20	13	9	7	5	4
10	...	96	43	24	16	11	8	6	4

that the accuracy of 7.52 mm^3/100 revolutions loss compared to the 11.0 mm^3/100 revolution loss on the same material should lead one to inspect his test procedure for possible differences in method.

X2.6.2 *Establishing Accuracy of Wear Test Loss Values* The coefficient of variation is determined as follows:

n = 4
x = 7.930, 7.320, 7.230, 7.620
$\bar{x}$ = 7.52
R = 0.700
d_2 = 2.059
s = 0.700/2.059
$(s/\bar{x}) \times 100 = 4.5\ \%$

X2.7 Estimated Sample Size and Allowable Sampling Error

X2.7.1 As indicated previously, the availabilty of multiple test specimens in abrasion testing is sometimes limited. When this occurs, the user must have some criterion upon which to judge the minimum acceptable sample size for meaningful results. Practice E122 describes the choice of sample size to estimate the average quality of a lot or process.

X2.7.2 The chart in Table X2.2 is based upon the equation $n = (1.96\ v/e)^2$. It indicates a 5 % probability that the difference between the sample estimate of the mean value $\bar{x}$, and that obtainable from averaging all values from a very high number of tests, will exceed the allowable sampling error (e). This corresponds to a 95 % confidence level which is an appropriate criterion for abrasion tests. For example, if the coefficient of variation of the test apparatus as determined by multiple testing is 7 %, the minimum sample size would be eight in order to obtain a 5 % allowable sampling error. Note, however, that if the test results for the eight samples do not generate a coefficient of variation of 7 % or less, the test is not valid and corrective action must be taken.