Testing Packages of Animal Bedding and Peat Moss
with
Compressed/Expanded Volume Declarations

Executive Summary

Animal Bedding (Bedding), also called pet or stall bedding, litter or simply bedding, is generally sold by dry volume in compressed or uncompressed packages. Based on numerous failed inspections of packaged animal bedding, the Office of Weights and Measures (OWM) conducted a study in which compressed and uncompressed packages of animal bedding were measured using a variety of procedures and test equipment. The results from those tests indicate that the current procedures in the 2014 edition of NIST Handbook 133, "Checking the Net Contents of Packaged Goods," the dimensional inspection procedure for testing compressed packages (e.g., peat moss); and the volumetric inspection procedure (e.g., mulch); are inadequate for use in testing animal bedding. Uncompressed volume measurements of animal bedding are dependent on a number of factors, including the size and shape of the measuring container, the method of filling the measuring container, and the means used to break up the bedding prior to measuring. Based on the findings of this study, a draft procedure was developed for testing the uncompressed volume of animal bedding. OWM also designed and constructed new test measures to be used with the procedure, and then brought these measures to several animal bedding packaging plants for on-site verification of the test methods. Preliminary findings indicate that the draft procedure provides more consistent measurement results. Further, the study shows that there is no correlation between compressed and uncompressed volumes of animal bedding, leading to the conclusion that the requirement for compressed volume statements on the package label is unnecessary. The following proposal includes recommended changes to the method of sale for Animal Bedding in NIST Handbook 130, "Uniform Laws and Regulations in the Areas of Legal Metrology and Engine Fuel Quality," a revised test procedure for NIST Handbook 133 relating to the verification of the compressed volume of peat moss (which has been used with animal bedding), new test procedures for measuring the compressed and uncompressed volumes of animal bedding, suggested test equipment and a gravimetric auditing procedure that allows inspectors to avoid destroying all of the packages.

The following amendments to the Method of Sale of Commodities Regulation in NIST Handbook 130 are proposed:

1. For the reasons described in background Section 2(a) (page 27), the OWM recommends that the method of sale for animal bedding be amended to eliminate the requirement that packages bear a declaration of compressed volume. If this recommendation is adopted, the method of sale will require that packages of bedding only have a declaration of the expanded (uncompressed) volume that can be recovered by the consumer.

2. For the reasons described in background Section 2(b) (page 28) the OWM recommends that a new definition for animal bedding and a revised method of sale be adopted to replace the current wording in Section 2.23. Animal Bedding, in the Uniform Method of Sale of Commodities Regulation in NIST Handbook 130. The proposed definition for animal bedding and recommended revisions to the method of sale are presented in the following:

> **2.23. Animal Bedding.** – **~~Packaged animal bedding of all kinds, except for baled straw, shall be sold by volume, that is, by the cubic meter, liter, or milliliter and by the cubic yard, cubic foot, or cubic inch. If the commodity is packaged in a compressed state, the quantity declaration shall include both the quantity in the compressed state and the usable quantity that~~**

~~**can be recovered. Compressed animal bedding packages shall not include pre-compression volume statements.**~~

~~**Example:**~~
~~**250 mL expands to 500 mL (500 in^3 expands to 1000 in^3).**~~

2.23.1. Definitions.

(a) Animal Bedding – any material, except for baled straw, kept, offered or exposed for sale or sold for primary use as a medium for any companion or livestock animal to nest or eliminate waste.

(b) Expanded Volume – the volume of the product that can be recovered from the package by the consumer after it is unwrapped and uncompressed.

2.23.2. Method of Sale.

(a) Packaged animal bedding shall be advertised, labeled, offered and exposed for sale and sold on the basis of the Expanded Volume. If unit pricing is offered to retail consumers, it shall be in terms of the price per liter.

(b) The quantity declaration shall include the terms "Expanded Volume" or wording of similar import that expresses the facts, and shall be in terms of the largest whole unit of the milliliter, liter, or cubic meter. A declaration may also include the quantity in terms of largest whole unit of cubic inches, cubic foot, or cubic yard only.

(c) The display of pre-compression volume, compressed volume or supplementary dry measure units (e.g., dry quart, bushel) anywhere on the package is prohibited.

Examples: Expanded Volume 41 Liters (1.4 Cubic Feet)

Expanded Volume 1.4 Cubic Feet (41 Liters)

Expanded Volume 27.9 Liters (1700 Cubic Inches)

Expanded Volume 113 L (4 Cubic Feet)

Expanded Volume 8 Cubic Feet (226 L)

2.23.~~1.~~3. Exemption - Non-Consumer Packages of Animal Bedding Sold to Laboratory Animal Research Industry. – Packaged animal bedding consisting of granular corncobs and other dry (8 % or less moisture), pelleted, and/or non-compressible bedding materials that are sold to commercial (non-retail) end users in the laboratory animal research industry (government, medical, university, preclinical, pharmaceutical, research, biotech, and research institutions) may be sold on the basis of weight.

(Added 1990) (Amended 2012 **and 20XX**)

The following test procedures and other amendments are proposed for Chapter 3. "Test Procedures for Packages Labeled by Volume" in NIST Handbook 133:

1. For the reasons described in the background of Section 4 (page 46), the OWM recommends adoption of amendments to Section 3.9. "Peat Moss." The proposed amendments revise the dimensional test procedure used in verifying compressed volume declarations on packages of peat moss and, if the requirement that packages bear a declaration of the compressed volume in the package is not eliminated as recommended above, animal bedding (see page 4).

2. For the reasons described in the background of Section 3 (page 30), the OWM recommends adoption of a new Section 3.15. that includes a volumetric test procedure for animal bedding (see page 13).

3. For the reasons described in the background of Section 3(b) (page 31), the OWM recommends that no enforcement action be taken on the 1 % percent Maximum Allowable Variation (MAV) in Table 2-6 (which covers most sizes of the expanded volume declarations on bedding packages) because that value is unreasonable. Instead, the OWM recommends a tentative MAV of 5 % be applied to single measurement determinations of bedding volume and a tentative MAV of 10 % be applied when multiple measurements are used to make volume determinations. OWM recommends these MAV values be used pending further studies of test data collected using large test measures, single measurement determinations and utilizing the new test procedure.

4. For the reasons described in the background of Section 3(e) (page 34), the OWM recommends that test measures not be filled by hand. Instead, the OWM recommends that compressed bedding be uncompressed in suitable sized chutes and then poured into a test measure (see page 39). As described on page 36, Section 3(f), pouring the bedding helps the product volume recover from the compression applied during packaging.

5. For the reasons described in the background of Section 3(h) (page 40), the OWM recommends that for official inspections the volume of the bedding in the test measure be determined without leveling the product and using a modified headspace method (based on NIST Handbook 133, Section 3.7. "Volumetric Test Procedure for Paint…").

6. For the reasons described in the background of Section 3(i) (page 44), the OWM recommends that officials use a gravimetric auditing procedure to identify potentially short measure samples to reduce destructive testing and conserve inspection resources.

7. For the reasons described in the background of Section 3(j) (page 46), the OWM recommends that, unless the sample packages of animal bedding fail the dimensional test **(**of the compressed volume, that the final decision to accept or reject an Inspection Lot be based on the results of a test that verifies the expanded (uncompressed) volume declared on the package.

The current test procedure in NIST Handbook 133, Section 3.9. "Peat Moss" will be modified as shown:

3.9. Dimensional Test Procedure for Verifying the Compressed Quantity Declaration on Packages of Peat Moss

~~3.9.1. Compressed Volume Packages~~

~~3.9.1.1. Test Equipment~~

- ~~Tape measure~~

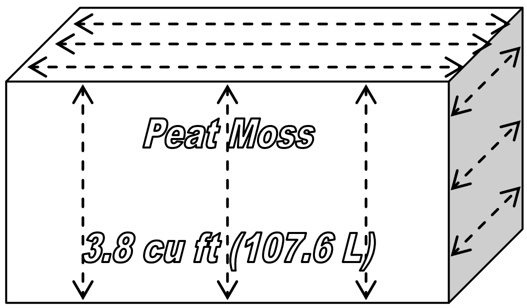


Figure 3-1. Peat Moss

~~3.9.1.2. Test Procedure~~

1. ~~Follow Section 2.3.1. "Define the Inspection Lot." Use a "Category A" sampling plan in the inspection; select a random sample.~~

2. ~~For each dimension (length, width, and height) take three equidistant measurements.~~

3. ~~Calculate the average of each dimension.~~

4. ~~Multiply the averages to obtain the compressed cubic volume as follows:~~

~~*average height × average width × average length = cubic measurement*~~

5. ~~Subtract the labeled volume from the measured volume to determine package error.~~

~~(Amended 2010)~~

~~3.9.2. Uncompressed Volume Packages~~

~~Use the following method to test peat moss sold using an uncompressed volume as the declaration of content. The procedure as defined by the latest version of ASTM D2978-03, "Standard Test Method for Volume of Processed Peat Materials."~~

~~3.9.2.1. Test Equipment~~

- ~~12.7 mm (or ½ in) sieve~~

- ~~Use one of the following measures as appropriate for the package size. (Refer to Table 3-4. "Specifications for Test Measures for Mulch and Soils" for additional information on test measure construction.)~~

- ~~28.3 L (1 ft^3) measure with inside dimensions of 30.4 cm (12 in) by 30.4 cm (12 in) by 30.4 cm (12 in). Mark the inside of the measure with horizontal lines every 1.2 cm (½ in) so that package errors can be directly determined~~

- ~~100 L (3.5 ft^3) measure with inside dimensions of 50 cm (19.68 in) by 50 cm (19.68 in) by 40 cm (15.74 in). The inside of the measure should be marked with horizontal lines every 1.2 cm (½ in) so that package errors can be directly determined~~

- ~~Straight edge, 50.8 cm (20 in) in length~~

- ~~Sheet for catching overflow of material~~

- ~~Level (at least 15.24 cm (6 in) in length)~~

~~3.9.2.2. Test Procedure~~

1. ~~Follow Section 2.3.1. "Define the Inspection Lot." Use a "Category A" sampling plan in the inspection; select a random sample.~~

2. ~~Open each package in turn, remove the contents, and pass them through the sieve directly into the measuring container (overfilling it). Use this method for particulate solids (such as soils or other garden materials) labeled in cubic dimensions or dry volume. Some materials may not pass through the sieve for peat moss; in these instances, separate the materials by hand (to compensate for packing and settling of the product after packaging) before filling the measure.~~

~~Note: Separated material (product not passing through the sieve) must be included in the product volume.~~

3. ~~Shake the measuring container with a rotary motion at one rotation per second for 5 seconds. Do not lift the measuring container when rotating it. If the package contents are greater than the measuring container capacity, level the measuring container contents with a straightedge using a zigzag motion across the top of the container.~~
4. ~~Empty the container. Repeat the filling operations as many times as necessary, noting the partial fill of the container for the last quantity delivered using the interior horizontal markings as a guide.~~
5. ~~Record the total volume.~~

6. ~~To compute each package error, subtract the labeled quantity from the total volume and record it.~~

~~3.9.3. Evaluation of Results~~

~~Follow the procedures in Section 2.3.7. "Evaluate for Compliance" to determine lot conformance for either procedure.~~

3.9.1. Test Equipment

- Calculator or Spreadsheet Software (programmed to make volume calculations)

- Volumetric Package Worksheet (Appendix C at end of this report)
- Non-permanent marking pen.
- Knife or Razor Cutter (for use in opening packages and unwrapping shrink-wrapped pallets in warehouses)
- Cellophane or Duct Tape (for use in securing packaging tails)
- Dimensional Measuring Frame (see Exhibit 1 and drawings at www.nist.gov/owm [to be posted])

Exhibit 1. Picture of a Dimensional Measuring Frame.

- Rigid Rulers – Starrett[1] or equal with 1.0 mm graduations. The edges of a ruler used with a measuring frame must be straight and the edges must be the zero point (see Exhibit 2).
  - 300 mm (12 in)
  - 500 mm (19.5 in)
  - 1 m (39 inch)
- Carpenter Squares
  - 300 mm (12 in)
  - 600 mm (24 in)

[1] Notice: The mention of trade or brand names does not imply endorsement or recommendation by the U.S. Department of Commerce over similar products available from other manufacturers.

3.9.2. Test Procedure

Note: Test Notes

Rounding: When a package measurement falls between graduations on a ruler, round the value up. This practice eliminates the issue of rounding from the volume determination and provides the packager the benefit of the doubt. If a ruler with a graduation of 1.0 mm is used, the rounding error will be limited to 0.5 mm or less. It is good practice to circle a measurement that has been rounded up or make a statement to such effect so that it becomes a part of the record.

Dimension Identification: The following package nomenclature is used to identify the dimensions measured in this test procedure.

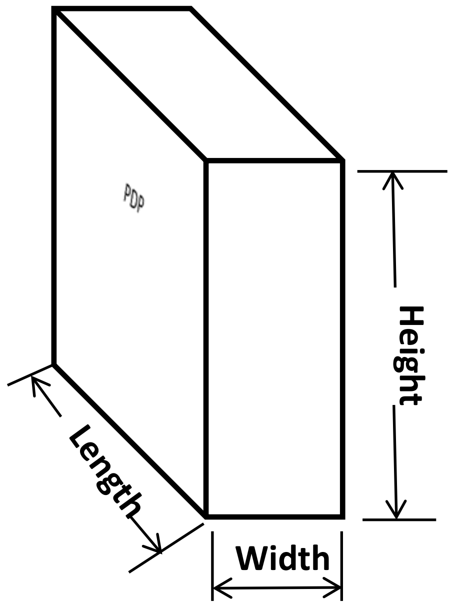


Figure 3-2. Dimension Identification.

Note: Packages of compressed peat moss do not have declaration of expanded volume.

Safety

This procedure does not address all of the safety issues that users need to be aware of in order to carry out the following tasks. Users are sometimes required to conduct tests in warehouse spaces or retail stores where fork-trucks are in motion – care must be taken to warn others to avoid or exercise care around the test site. The procedure requires users to lift heavy objects including large bulky packages and test measures and includes the use of sharp instruments to obtain packages from shrink-wrapped pallets. Users may be required to climb ladders or work platforms to obtain sample packages. When opening and emptying packages, dust, or other particles may be present or escape from the packages, which may cause eye injuries and respiratory or other health problems. Users must utilize appropriate safety equipment and exercise good safety practices. If safe working conditions cannot be ensured, suspend testing until the situation is corrected.

1. Follow the Section 2.3.1. “Define the Inspection Lot.” Use a “Category A” Sampling Plan for the inspection. Collect the sample packages from the Inspection Lot using random sampling. If the packages are not randomly selected, the sample will not be representative of the lot and the test results will not be valid for use in enforcement action. Place the sample packages in a location where there is adequate lighting and ample space for the packages and test equipment.

2. Examine the package for excess packaging material (i.e., packaging tails). Fold the packaging material consistent with design of the packaging and tape the material securely to the package so that its effect on the dimensional measurement is minimized. If the thickness of packaging tail appears excessive, it is appropriate to determine its average thickness by making at least three measurements along its length using a dead weight dial micrometer specified in Section 4.5. “Polyethylene Sheeting” and subtract the thickness from the measurement of length, width or height. Any deduction from a measurement should be noted on the inspection report.

3. If a Dimensional Measuring Frame is used, place it on a solid support. If a table is used, select one of sufficient load capacity to hold the weight of the frame and the heaviest package to be tested.

4. Position the frame so that the zero end of the ruler can be placed squarely and firmly against a surface of the frame and so that the ruler graduations can be read. Position yourself so that you can read both the ruler and the edge of the carpenter square in Exhibit 2.

5. Place the package against two sides of the frame without compressing the package. Place a carpenter square against the package at the point of measurement and align the ruler perpendicular to the edge of the carpenter square as shown in Exhibit 3 where the package length and Exhibit 4 where the package height are being determined.

Using a Measuring Frame for Dimensional Testing
Ruler and Carpenter Square define Zero Reference and Measurement Point

Exhibit 2. The rigid frame allows the observer to hold the zero reference point firmly in place.

Exhibit 3. Length Measurement.

Exhibit 4. Height Measurement – A packaging tail on the end of the package can affect this measurement so it has been folded over and taped against the end of the package.

Exhibit 5. Width Measurement – the frame is rotated on its end to vertical so that the carpenter square does not compress the product.

6. Measurements – take at least five measurements* of each of the dimensions as follows:

*On small packages (height or length dimensions of 152 mm [6 in] or less) at least three measurements are taken using the following the instructions).

Inspect the package for shape and place the flattest surfaces against the measuring frame.

i. **Length** (see Exhibit 3):

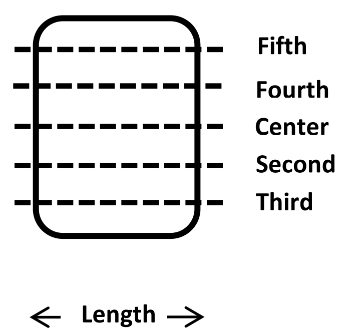
a. take the first measurement across the center line of the Length axis of package.

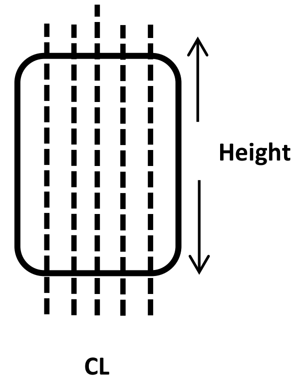
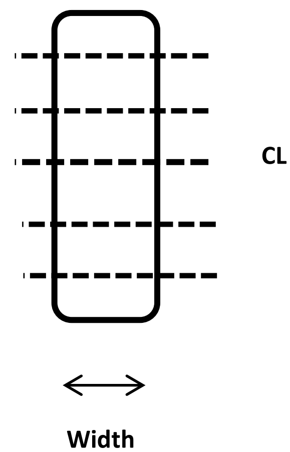
b. take the second measurement at half the distance between the center Line and either of the package edges.

c. take the third measurement half the distance between the second measurement and the package edge.

d. take the fourth measurement on the opposite end of the package at half of the distance between the center line and the package edge.

e. take the fifth measurement at half of the distance between the fourth measurement and the package edge.



ii.	**Height:** (see Exhibit 4): a. take the first measurement across the center line of the Height axis of the package. b. take the second measurement at half the distance between the center line and the package edge. c. take the third measurement half the distance between the second measurement and the package edge. d. take the fourth measurement on the opposite end of the package at half of the distance between the center line and the package edge. e. take the fifth measurement at half of the distance between the fourth measurement and the package edge. 
iii.	**Width:** (see Exhibit 5): If using one, turn the measuring frame on end and place the package on its bottom and against the frame as shown in the picture and on the right where the package width is being measured. a. take the first measurement across the center line of Width axis of the package. b. take the second measurement at half the distance between the center line and the package edge. c. take the third measurement half the distance between the second measurement and the package edge. d. take the fourth measurement on the opposite end of the package at half of the distance between the center line and the package edge. f. take the fifth measurement at half of the distance between the fourth measurement and the package edge. 

7. Record the dimensions of each package in millimeters in a software program or inspection form that includes the information shown in the sample worksheet "Calculate the Compressed Volume of the Package in Liters" (below). Enter the measurements in the appropriate spaces and calculate the volume in liters. Calculate the package error by following the steps listed in the table and then calculate the average error for the sample.

   Note: The following table is an example of the information from an actual test that is included in a worksheet for verifying the compressed volume on packages of peat moss. The Inspection Worksheet for Dimensional Testing (see Appendix C) has space for a sample of 12 packages and includes the steps for calculating the Average Package Error. Here, the package error in the dimensional volume was + 6.8 L (+ 0.24 ft^3). Apply a tentative MAV of 5 % to a dimensional measured volume.

Note: Reasonable values for the MAVs for the uncompressed volumes of bedding must be developed once a uniform test procedure is adopted.

SAMPLE WORKSHEET **Calculate the Compressed Volume of the Package in Liters**				
Unit of Measure = 1.0 mm		**Length (L)**	**Width (W)**	**Height (H)**
	1.	*482*	*282*	*690*
	2.	*490*	*278*	*690*
	3. (Center Line)	*493*	*276*	*681*
	4.	*499*	*272*	*677*
	5.	*493*	*269*	*657*
a.	Average:	*491*	*275.4*	*679*
b.	L × W × H = Volume/1 000 000	*91.8 L*		
c.	Labeled Compressed Quantities:	*85* L	*NA* cu in	*3.0* cu ft
d.	Conversion Factors	NA	(b) × 61.02374	(b) × 0.03531467
e.	Converted Volume	*85* L	*NA* cu in	*3.24* cu ft
f.	Package Error = (b – c)	*6.8* L	*NA* cu in	*0.24* cu ft

3.9.3. Evaluation of Results

Follow the procedures in Chapter 2, Section 2.3.7. “Evaluate for Compliance” to determine lot conformance.

Section 3.15. Test Procedure for Verifying the Expanded Volume Declaration on Packages of Animal Bedding

3.15.1. Test Equipment

- Calculator or Spreadsheet Software
- Modified Standard Package Report Form – Appendix D (at end of report).
- Package Inspection Worksheet Appropriate for Test Measure:
  - Appendix A – 26 Point Measurement Grid and Package Error Worksheet for Cylindrical Test Measures (at the end of the report)
  - Appendix B – 25 Point Measurement Grid and Package Error Worksheet for Square or Rectangular Test Measures (at the end of the report)
- Permanent Ink - Marking Pen.
- Knife or Razor Cutter (for use in opening packages and unwrapping shrink-wrapped pallets in warehouses)
- Cellophane Tape, Duct Tape (for repairing chutes and sealing packages)
- Polyethylene Bags (49 L to 113.5 L [13 gal to 30 gal]) (to hold product once it is uncompressed)
- Rigid Rulers – Starrett[2] or equal with 1.0 mm graduations. The edges of a ruler used with a measuring frame must be straight and the edges must be the zero point (see Exhibit 2).
  - 300 mm (12 in)
  - 500 mm (19.5 in)
  - 1 m (39 in)
- Tarp - Canvas 3 m × 3 m (10 ft × 10 ft)
- Broom and Dust Pan
- Levels – for verifying the level of the test measure and taking headspace readings.
  - 152 mm (6 in) Bubble Level
  - 1 m (40 in) Carpenter Level
- Scale 15 kg (30 lb) (only used if the audit procedure is utilized.)

[2] Notice: The mention of trade or brand names does not imply endorsement or recommendation by the U.S. Department of Commerce over similar products available from other manufacturers.

- Chutes for Uncompressing and Pouring the Bedding into a Test Measure

Table 1. Recommended Chute Dimensions

Nominal Capacity	Height	Width	Length
70 L (2.5 ft^3)	254 mm (10 in)	228 mm (9 in)	1219 mm (48 in)
100 L (3.5 ft^3)	254 mm (10 in)	279 mm (11 in)	1397 mm (55 in)
170 L (6 ft^3)	279 mm (11 in)	355 mm (14 in)	1727 mm (68 in)
240 L (8.5 ft^3)	304 mm (12 in)	406 mm (16 in)	2006 mm (79 in)
283 L (10 ft^3)	304 mm (12 in)	406 mm (16 in)	2286 mm (90 in)

NOTE: Chutes (see examples below) may be constructed using hinges and pins so that they lie flat for transporting. They can be constructed of sheet metal or with other slick surface material which enable the bedding to flow easily. The construction of the chutes used in this study allows the sides to move in or out slightly so that the bedding does not become clogged at the outlet. The heights and lengths may be adjusted slightly to fit into vehicles for transport but the widths should not be reduced because narrowing the opening can restrict material flow and result in "bridging" where the bedding collects and creates a block. Also, the width should be kept smaller than the opening of the test measure so that spillage does not occur during pouring.

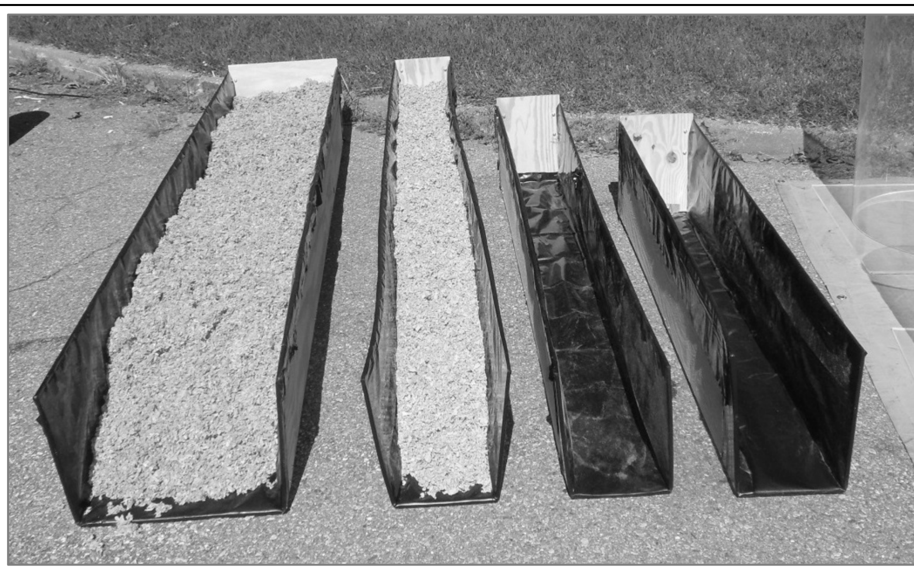


Figure 1. Testing Chutes.

- Test Measures (see Table 2. "Test Measures for Animal Bedding")

Table 2. Test Measures for Animal Bedding [NOTES: a, b, c, and d]

Only Interior Dimensions are Used for Volume Calculations
Must Be Calibrated with Traceable Measurement Standards Prior to Use

Rectangular & Square Test Measures

Actual Volume of the Measure [b & d]	Interior Wall Dimensions			Surface Area	Marked Increments on Ruler	Increment Volume
	Length	Width	Height[d]			
31.9 L 1.13 ft^3	213.4 mm (8.4 in)	203.2 mm (8 in)	736.6 mm (29 in)	43 362 mm^2 (67.2 in^2)	12.7 mm (0.5 in)	550.6 mL* 0.55 L (33.6 in^3)
28.3 L 1 ft^3	304.8 mm (12 in)	304.8 mm (12 in)	304.8 mm (12 in)	92 903 mm^2 (144 in^2)		1.18 L** (72 in^3)
63.7 L 2.25 ft^3	304.8 mm (12 in)	304.8 mm (12 in)	685.8 mm (27 in)			
	406.4 mm (16 in)	228.6 mm (9 in)	685.8 mm (27 in)			
92 L 3.25 ft^3	304.8 mm (12 in)	304.8 mm (12 in)	990.6 mm (39 in)			
	406.4 mm (16 in)	228.6 mm (9 in)	990.6 mm (39 in)			

*1.0 mm = 43 mL (2.6 cu in)   ** 1.0 mm = 92 mL or 0.09 L (5.6 cu in)

Square Test Measures

Actual Volume of the Measure [b & d]	Interior Wall Dimensions			Surface Area	Marked Increments On Ruler	Increment Volume
	Length	Width	Height[d]			
77.4 L (2.73 ft^3)	381 mm (15 in)	381 mm (15 in)	533.4 mm (21 in)	145 161 mm^2 (225 in^2)	1.0 mm (0.03937 in)	0.14 L (8.5 in^3)
144 L (5.09 ft^3)	508 mm (20 in)	508 mm (20 in)	558.8 mm (22 in)	258 064 mm^2 (400 in^2)		0.25 L (15.2 in^3)
283 L (10 ft^3)	609.6 mm (24 in)	609.6 mm (24 in)	762 mm (30 in)	371 612 mm^2 (576 in^2)		0.37 L (22.5 in^3)

Table 2. Test Measures for Animal Bedding NOTES: a, b, c, and d

Only Interior Dimensions are Used for Volume Calculations
Must Be Calibrated with Traceable Measurement Standards Prior to Use

Cylindrical Test Measures

These dimensions are based on the tube having a ¼ inch wall thickness. Other tube thicknesses may be used.

Actual Volume *Volume* = $\pi r^2 h$	**Interior Diameter (Outside Diameter)**	**Height**	**Surface Area** *Area* = πr^2	**Increment**	**Increment Volume**
52 L (1.8 ft^3)	292.1 mm (304.8 mm) 11.5 in (12 in)	780 mm (30.70 in)	67 012 mm^2 (103.8 in^2)	1.0 mm (0.03937 in)	0.06 L (4 in^3)
124 L (4.3 ft^3)	444.5 mm (457.2 mm) 17.5 in (18 in)	800 mm (31.49 in)	155 179 mm^2 (240.52 in^2)		0.15 L (9.4 in^3)
279 L (9.8 ft^3)	596.9 mm (609.6 mm) 23.5 in (24 in)	1000 mm (39.37 in)	279 829 mm^2 (433.76 in^2)		0.27 L (16.4 in^3)

Notes for Table 2:

a. Rectangular and Square Based Dry Measures are typically constructed of 12.7 mm to 19.05 mm (0.5 in to 0.75 in) Marine Plywood. A 4.76 mm ($^3/_{16}$ in) transparent sidewall is useful for determining the level of fill, but must be reinforced or be made of thicker material if it distorts when the measure is filled. If the measure has a clear front, place the level gage at the back (inside) of the measure so that the markings are read over the top of the mulch. Any of these measures may be made without an attached bottom for ease of emptying if they are placed on a solid level base during filling and measurement.

b. Other size measures may be used if calibrated and the volume equivalence of the increment of 1.0 mm is no greater than $^1/_6$ the MAV. Widening the base of a measure reduces the column height of the product and will reduce compression but the trade-off is that the larger surface area increases the volume so the potential for measurement errors increase. One of the benefits of the cylindrical design is that, in addition to eliminating the 90 degree angles of the corners where gaps in fill frequently occur, the surface area of a cylinder is less than an equal volume square measure and that results in better resolution in the volume measurements (i.e., compare the readability of a 24 in sq box which has a surface area of 576 in^2, to the 24 in cylinder which has a surface area of 433 in^2). The height of the test measure may be reduced, but this will limit the volume of the package that can be tested.

c. If lines are marked in any test measures, they should extend around all sides of the measure if possible to improve readability. It is recommended that a line indicating the MAV level also be marked to reduce the possibility of reading errors when the level of the product is at or near the MAV.

d. If the measures are built to the dimensions shown above, the actual volume of most of the measures will be larger than the nominal volume so that plus errors (overfill) can be measured accurately.

3.15.2. Test Procedure

Test Notes:

Rounding: When a volume measurement falls between graduations on a ruler, round the value in the direction that favors the packer. This practice eliminates the issue of rounding from the volume determination and provides packagers the benefit of the doubt. The ruler graduation is 1.0 mm so the rounding error will be limited to 0.5 mm or less. It is good practice to circle a measurement that has been rounded up or make a statement to such effect so that it becomes a part of the inspection record.

Safety:

This procedure does not address all of the safety issues that users need to be aware of in order to carry out the following tasks. Users are sometimes required to conduct test in warehouse spaces or retail stores where fork-trucks are in motion – care must be taken to warn others to avoid or exercise care around the test site. The procedure requires users to lift heavy objects including large bulky packages and test measures and includes the use of sharp instruments to obtain packages from shrink-wrapped pallets. Users may be required to climb ladders or work platforms to obtain packages. When opening and emptying packages, dust, and other particles may be present or escape from the packages which may cause eye injuries and respiratory or other health problems. Users must utilize appropriate safety equipment and exercise good safety practice. If safe working conditions cannot be ensured, suspend testing until the situation is corrected.

1. Follow the Section 2.3.1. "Define the Inspection Lot," select "Category A – Sampling Plan" in this Inspection. Determine the Sample Size based on the size of the Inspection Lot using Category A. Collect the sample packages from the Inspection Lot using Section 2.3.4. "Random Sampling Selection."

Test Note: Place the test equipment and sample packages in a location where there is adequate lighting and ample space around the packages and equipment so the packages can be opened and the chutes and test measures used safely.

Optional – Audit Screening by Weight

The full test procedure requires that all of the packages be opened for testing. Regardless of the type of bedding, the product cannot be returned to the original package. An alternative gravimetric auditing procedure may be used to reduce the amount of destructive testing and conserve inspection resources.

Audit Procedure: After randomly selecting the sample packages from the Inspection Lot, obtain the gross weight for each package. Select the lightest and heaviest packages and conduct an expanded volumetric test on these two packages. If the lightest and heaviest packages pass (i.e., each contains at least the expanded volume declared on the label), it is highly likely that the remaining packages in the sample will also pass. Accept these two package samples as an AUDIT TEST and move on to inspect other types of bedding or Inspection Lots of other types or brands of bedding. If either of the two packages is found to have a minus error that exceeds the Maximum Allowable Variation, the sample fails. No further testing is required (i.e., assuming no MAV is allowed for the sample size (see Appendix A, Table 2-1. "Sampling Plans for Category A"). If either of the packages is found to have a minus error that does not exceed the MAV, continue to test all of the packages and take action based on the final results from the complete sample.

Test Note: If the gravimetric audit procedure is used, ensure that the scale is placed on a solid level support and that its accuracy has been verified to a test load that is at least 10 percent more than the gross weight of the packages (e.g., to estimate that load, place one of the packages on the scale and then test the scale with a load above the package's gross weight). See Section 2.2. "Measurement Standards and Test Equipment" for additional information.

2. Select the appropriate test measure for the package size**.**

   - Spread a tarp large enough to hold a chute and test measure.

   - Place the chute and test measure on the tarp. Verify that the test measure is level.

3. Select a chute of appropriate capacity (see Table 1) for the package size and position it on the tarp**.**

4. Open the Packaging, Uncompressing and Pouring the Bedding into the Test Measure Twice.

   - **Open Package:** Place the package in the chute and use a knife or box cutter to open and remove the wrapper. Spread the bedding uniformly along the length of the chute. The bedding is uncompressed in two steps. The first step is to loosen the clumps of bedding by gently pulling them apart (do not tear the fibers of cellulose bedding or "grind" any bedding between your hands because these practices break the material down). Spread your fingers and pick the material up using your hands from beneath to loosen it up. There should be no clumps of bedding in the chute. If any bedding has fallen out of the chute onto the tarp, collect it and return it to the chute. The following pictures illustrate this step of the procedure. The second step of the expanded volume recovery process is to pour the bedding into a test measure as described in Step 2.

Exhibit 6.

Exhibit 7.

Exhibit 8. First pour into the test measures.

- **First Pour:** The first pour into the test measure is only used to further un-compress the bedding so no measurements are taken. Hold the chute above the test measure and tilt it so that you pour the bedding into the center of the test measure. The bedding should be poured slowly into the test measure in one continuous stream and not "dumped" (if it is "dumped" or poured too quickly some of the bedding will blow out of the measure or the bedding will be packed down and its volume reduced). The flow rate should be controlled by the tilt angle of the chute. The chute itself can be shaken but DO NOT HIT OR SHAKE THE TEST MEASURE. (Do not adjust the flow by closing the opening of the chute as that may cause the bedding to heap up and then fall into the measure in clumps which may result in impact compression). Empty the bedding back into the chute and spread it out evenly along its length.

Exhibit 9. Showing how to hold a chute for the pour.

Exhibit 10. Showing how to cradle the chute on one arm and holding it with one hand while tilting it with the other hand.

- **Second Pour:** The second pour into the test measure is used to make the volume determination. Hold the chute above the test measure and tilt it so that you pour the bedding into the center of the test measure. The bedding should be poured slowly into the test measure in one continuous stream and not "dumped." The flow rate should be controlled by the tilt angle of the chute. The chute can be shaken but DO NOT HIT OR SHAKE THE TEST MEASURE.

Test Note: Stop filling the measure if it appears that the test measure will overflow. The overflow product should be measured separately (use a smaller test measure of adequate size and capacity if one is available) and the multiple measurement volumes are added. If pouring into a square test measure, pour at an angle to two corners for the widest opening (see Exhibit 12).

Exhibit 11. Filling a 44 L Test Measure.

Exhibit 12. Filling a Square Test Measure at an Angle to use the Larger Opening.

5. Volume Determination.

   DO NOT HAND LEVEL THE SURFACE OF THE BEDDING AS MANUAL LEVELING "PACKS" THE BEDDING AND REDUCES ITS VOLUME. DO NOT JAR OR SHAKE THE TEST MEASURE

   Test Note: Before using a test measure for volume determinations, place a level of adequate length on top of the test measure at five approximately equal measuring points across the top. A permanent marking pen can be used to evenly space the marks across the top edge of the test measure so that it can be positioned to take the measurements (see Exhibit 13).

Exhibit 13. Marking the evenly spaced measuring points across the top of the test measure.

- Place a rigid level or straight edge of adequate size on top the test measure and select a ruler of adequate length to reach to the lowest level of the top surface of the bedding. Start at the measuring points to your left or right, place the ruler against the side of the level, and hold it with either hand. The zero graduation is pointed down so the ruler can be lowered into the test measure for measurement. Lower the ruler into the test measure slowly until its end is at the surface level of the bedding (see Exhibits 14 and 15).

Exhibit 14. Placing ruler into the test measure with zero end down.

Exhibit 15. Ruler shown with zero end at surface of the bedding.

- Determine the depth of each measurement point from the surface of the bedding to the bottom edge of the straight edge and record the value in the appropriate space on the worksheet. Take a minimum of 25 measurements (at least 26 for cylindrical measures) across the top of the test measure in a grid pattern. Read the graduations on the ruler from a position that minimizes errors caused by parallax.

Table 2. Illustrations of Depth Determinations with Cylindrical Test Measures

Figure 1. Shows how to read the depth of container.

The picture on the left (Figure1) shows how to read the depth from the bottom of the straightedge (top edge of measure) down to the to bedding in a 44 L test measure from a position that reduces parallax. The graphic below (Figure 2) illustrates the actual worksheet with the headspace procedure on the 44 L cylinder test measure (its internal radius is 151 mm and its height is 610 mm). The bedding was poured into the test measure but not leveled. Then 26 measurements were made at the locations shown on the grid to determine the depth of the product from the top edge of the measure. The average of the 26 values was 500.7 mm which was subtracted from the height of the test measure to obtain 109.26 mm for the average height of the column of bedding in the measure.

The volume was calculated using: *Volume in liters* $= \pi r^2 h$
Pi) 3.14159265 × 23035.69 × 109.26 mm = 7.90 L*

*After the calculation was completed the result was divided by 1 000 000 to obtain the volume in liters.

Figure 2. Illustration of Worksheet.

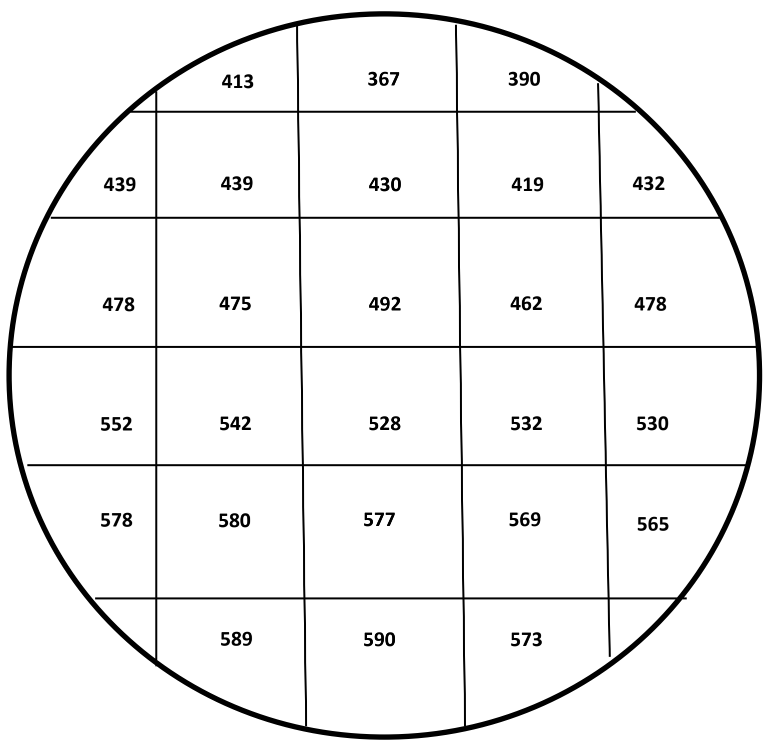


Table 2. Illustrations of Depth Determinations with Cylindrical Test Measures	
	**Figure 3. Using the headspace measurement on a 279 L test measure. The ruler is read from the bottom edge of a straight edge or level from a position that reduces parallax.**
	**Figure 4. Illustrating how the ruler is placed on the bedding with the headspace method. The ruler is red from the bottom edge of a straight edge or level from a position that reduces parallax.**

Table 3. Illustrations of Depth Determinations with Square Test Measures

Figure 1.

246	162	81	132	177
195	115	43	46	112
111	77	51	95	146
220	138	46	98	131
264	193	118	148	180

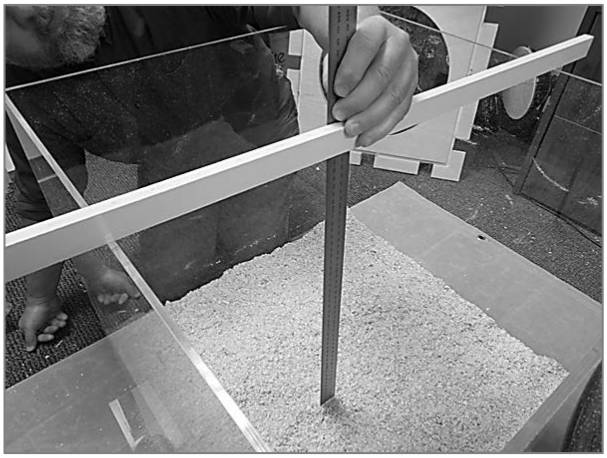
Figure 2.

The picture on the left (Figure 1) shows how to read the depth from the bottom of the straightedge (top edge of measure) down to the bedding in a 283 L square test measure from a position that reduces parallax. The graphic on the right (Figure 2) illustrates the actual worksheet with the headspace procedure on the square test measure (its internal dimensions are 609.6 mm × 609.6 mm × 762 mm (24 in × 24 in × 30 in). The bedding was poured into the test measure but not leveled. Then 25 measurements were made at the locations shown on the grid to determine the depth of the product from the top edge of the measure. The average of the 25 values was 133 mm that was subtracted from the height of the test measure to obtain 629 mm for the average height of the column of bedding in the measure.

The volume was calculated using: Volume in liters = lwh 609.6 mm × 609.6 mm × 629 mm = 233.74 L*

*After the calculation was completed, the result was divided by 1 000 000 to obtain the volume in liters.

Figure 3. Using the headspace measurement on 56.6 L (2 cu ft) test measure. The ruler is read from the bottom edge of a straight edge or level from a position that reduces parallax.

Table 3. Illustrations of Depth Determinations with Square Test Measures	
	**Figure 4. Showing how the ruler is placed on the bedding with the headspace method. The ruler is read from the bottom edge of a straight edge or level from a position that reduces parallax.**

6. Using a Worksheet for Volume Calculation

- Enter the sample number of the package on the worksheet along with its labeled expanded volume.

- Test Measure Information

    - For a cylindrical test measure, enter its interior height and radius in the spaces labeled A and B.

    - For a square or rectangular test measure enter its interior height and the area of its base (i.e., length × width) in spaces labeled A and B.

- Sum the measurements in the grid, divide the value by the number of measurements (i.e., 25 or 26), and enter this value in the space labeled C, Average Depth.

- Calculate the Average Height of the Bedding (subtract C [Average Depth] from A [Interior Height of Test Measure]) and enter this value in the space labeled D.

- Calculate the Volume of Bedding in the Package:

    - For a cylindrical test measure, the formula (*Volume in Liters* = $\pi r^2 h$) is shown in E on the worksheet. It is *Volume* (Liters) = 3.14159265 × r^2 (B^2) ____ × Average Height (D)____ ÷ 1 000 000. Enter the package volume in the space provided for this value in E.

    - For a square or rectangular test measure the formula (*Volume in Liters = LWH)* is shown in E on the worksheet. It is *Volume* (Liters) = B (Area of Test Measure Base) ___ × D (Average Height) ___ ÷ 1 000 000. Enter the package volume in the space provided for this value in E.

- Calculate the Package Error using the following formula:

- Package Error = Labeled Expanded Volume (Liters) ____ − E Package Volume (Liters) ____

Package Error (Liters) = Labeled Expanded Volume – Package Volume

- Transfer the individual package errors (verify whether they are positive or negative) to the "Modified Standard Package Report for Animal Bedding" in Appendix D. Fill in the required header information. For Box 7, "Number of Unreasonable Package Errors Allowed for Sample Size," use Appendix A, Table 2-1. "Sampling Plans for Category A, Column 4." Based on the sample size, determine how many packages may have minus package errors that exceed the MAV (i.e., unreasonable package error).

  Then:

- Calculate the Total Error (Enter in Box 8 "Total Error").

7. Evaluation of the Test Results and Determination of Pass or Fail

   - Determine if any of the minus package errors exceeds the MAV. Apply a tentative MAV value of 5 % (0.05 × labeled expanded volume) to single measurement volume determinations and a tentative MAV value of 10 % (0.10 × labeled expanded volume) on multiple-measurement volume determinations (enter in Box 4 "MAV"). If none of the minus package errors exceeds the MAV, go to Step 3. If any of the minus package errors exceed the MAV, enter the number of packages in Box 9 "Number of Unreasonable Minus Errors." Go to Box 10 "Is Box 9 Greater than Box 7?" and determine if the value exceeds the number in Box 7 "Number of Unreasonable Package Errors Allowed for Sample Size." If the number of packages with unreasonable errors exceeds the number permitted in Box 7 "Number of Unreasonable Package Errors Allowed for Sample Size," the sample fails. Go to Box 17 "Disposition of the Inspection Lot" and reject the Inspection Lot.

   - Calculate the Average Error for the sample by dividing Box 8 "Total Error" by Box 6 "Sample Size" and enter the value in Box 11 "Calculate Average Error," then go Box 12 "Does Box 11 equal Zero or Plus?" If the Average Error is zero or a positive number, the sample passes, go to Box 17 "Disposition of the Inspection Lot" and approve the Inspection Lot. If the Average Error is a negative value go to Step 4.

   - Calculate the Sample Standard Deviation and enter in Box 13 "Compute Sample Standard Deviation." To obtain the Sample Correction Factor for the sample size use Appendix A, Table 2-1. "Sampling Plans for Category A," Column 3 "Sample Correction Factor" and enter that in Box 14 "Sample Correction Factor." Then calculate the Sample Error Limit by multiplying Box 13 "Compute Sample Standard Deviation" and Box 14 "Sample Correction Factor." Enter the value in Box 15 "Compute Sample Error Limit."

   - Disregarding the signs, determine if the minus in Box 11 "Calculate Average Error" is larger than the value in Box 15 "Compute Sample Error Limit."

     - If yes, the sample fails, go to Box 17 "Disposition of Inspection" and reject the Inspection Lot.

- If no, the sample passes, go to Box 17 “Disposition of Inspection” and approve the Inspection Lot

➢ Prepare a comprehensive report of the test results and enforcement action taken and present the information to the party responsible for the product.

Background

1. Animal Bedding

Animal Bedding (Bedding), also called pet or stall bedding, litter or simply bedding, is generally sold by dry volume in compressed or uncompressed packages. A survey of several Internet retailers and retail stores conducted near the NIST revealed that a few packers sell bedding (e.g., pelletized) by net weight, which is prohibited by the current method of sale. Quantity declarations are often presented in a mixture of customary volume measurements including dry quart, cubic inch, and the cubic foot. Quantity declarations in metric units are predominantly by the liter and milliliter. For compressed packages, a declaration of both the compressed volume and uncompressed volume is required according to the NIST Handbook 130, Section B. Uniform Method of Sale of Commodities, 2.23. "Animal Bedding." Package sizes vary widely. For example, compressed volumes can range from about 4 L (230 cu in) to 85 L (3 cu ft). The uncompressed (expanded) volumes can range from about 6 L (600 cu in) up to 340 L (12 cu ft). It is consumer preference that determines how much bedding is used to "surface" a cage or stall. Unlike compressed peat moss, which is also labeled in volume, there are no user instructions on packages of bedding recommending a specific depth for a consumer to fill a cage or litter box or to "surface" a stall (see Section 2. "Method of Sale and Terminology" for more on this subject). Also, unlike packages of peat moss, the shape of packages of bedding is subject to wide variations due to the packaging stretching and plumping because of the pressure exerted by the compressed material they hold. Several manufacturers describe the "ideal" bedding as having minimal dust and "fines" (small particles of the bedding material), a moisture of 8 % to 15 %, and good "loft" so that the product provides good absorption of liquids.

2. Method of Sale and Terminology

a. Compressed Volume Declaration

The presence of a declaration of compressed volume is of little or no value to consumers. Several packers were asked what value was the compressed volume information to consumers. The unanimous response was that a compressed volume declaration does not help consumers to make value comparisons and it is ineffective in preventing unfair competitive practices. The packers agreed that it is the expanded volume declared on packages of bedding that is the most useful information for consumers. The primary reason is that it helps the purchaser estimate the size of package to buy or how many packages are needed to "bed" a cage or "surface" a stall. The area coverage obtained from a compressed package depends in large part on the characteristics of the material and the packaging process (e.g., force of compression). An expanded volume declaration is the only quantity declaration that is reliable and that aids consumers. Even a net weight declaration on bedding packages would not be useful. This is because the bedding in a heavier package may not expand as much as the bedding in a lighter package. For example, in this study packages of one product were found to vary in weight by only one or two grams but differed in volume yields by almost two liters. For bedding the weight/volume relationship is counter-intuitive because of variations in the raw material, moisture content; the size of the material, "fines" or small particles, and the amount of "dust" that varies from package to package. Packers and consumers alike would benefit if the National Conference on Weights and Measures (NCWM) would remove the requirement for a compressed volume declaration from the method of sale regulation and require bedding to be advertised, sold and unit priced on the basis of the expanded (uncompressed) volume declaration.

NOTE: At the beginning of this study the OWM reviewed the existing dimensional test procedures in Section 3.9. "Peat Moss" and found the procedures lacked some generally accepted good practices inherent in dimensional metrology to reduce measurement uncertainty. As a result, OWM developed a new dimensional test procedure for use in verifying the compressed volume of packages of bedding that is a significant improvement over the current method in Section 3.9. "Peat Moss." It was only during the second phase of the study that it became clear that it was the expanded volume test that was critical in ensuring that consumers receive full measure. If the recommendation to remove the compressed volume declaration requirement for packages of bedding is not accepted, the proposed dimensional test methods and equipment recommendations will improve the measurement process and increase the accuracy of volumetric results for packages of bedding and peat moss alike. If the requirement for bedding packages to include a compressed volume declaration is eliminated, the OWM recommends Section 3.9. "Peat Moss" be amended to adopt the proposed dimensional test procedure.

b. Proposed Terminology and Prohibited Terms

Typically bedding is a material offered for sale for use with pets, animals, reptiles, birds or other creatures but it may be offered for sale for other purposes such as providing a 'surface' for stalls, paddocks or arenas. Bedding or surfacing materials may be used with horses, dogs, cats, birds, ferrets, rabbits, guinea pigs, exotic animals, chinchillas, hamsters, rats, gerbils, mice, turtles, snakes and many other creatures from the wild or domesticated pets and farm animals. The following suggested definition is written to include any material intended for use with any creature that is labeled by volume but is not intended to apply to straw or hay sold by the bale.

Definition of Animal Bedding

In 2013 the NCWM considered the following definition for Animal Bedding but did not accept it. The NCWM's reticence was only due to concerns that the proposal might not cover all types of animal bedding.

> *Animal bedding is defined as "any product or material, except for baled straw or peat moss, that is advertised, offered for sale, or sold for primary use as a medium for animals to bed, nest or eliminate waste, such as compressed wood pulp or cellulose fibers (confetti, granules, or pellets), softwood shavings, shredded paper, compressed coconut fiber, ground corn cob, pelleted paper or wheat straw, cotton fibers, and bamboo products or any other material."*

While an all-encompassing list of raw materials helps improve clarity, manufacturers are always identifying new raw materials for use as bedding. The NCWM usually chooses open-ended definitions for products to be covered by a method of sale. This places more emphasis on the way that the product is used to be determinative of whether or not a product falls under a method of sale so there are no "loopholes" and packers understand what is expected. Adopting a definition that is all inclusive of the raw materials that are currently used to make bedding as well as still being able to encompass new materials that may enter the stream of production is the most flexible and efficient approach.

The OWM recommends the following:

> **Animal Bedding –** any material, except baled straw, that is kept , offered or exposed for sale or sold for primary use as a medium for any companion or livestock animal to nest or eliminate waste.

Units of Measure

The Federal Trade Commission considers "pet care" products to be exempt from its regulatory control under the Fair Packaging and Labeling Act. Because the labeling of bedding falls solely under the jurisdiction of states who have adopted the Uniform Packaging and Labeling Regulation (UPLR) in NIST Handbook 130, "Uniform Laws in the Areas of Legal Metrology…,"[3] the display of customary units is optional. Since 1999 the UPLR has required metric units to be declared on all packages which fall under its regulations but it also allows packagers the option of displaying customary units such as the cubic foot or cubic inches. As a result, quantity declarations may be shown on packages of bedding in terms of the milliliter (mL), liter (L), or cubic meter (m^3). As currently written, the method of sale for bedding in Section 2.23. of the Method of Sale of Commodities Regulation in NIST Handbook 130 requires units in both systems of measurement to be displayed. That provision is inconsistent with the requirements in the UPLR that were adopted to encourage the use of voluntary metric only labeling. Also the current regulation does not prohibit the use of other customary dry measurements such as the dry quart or bushel which, if used instead of liters, cubic inches, or cubic feet, may frustrate value comparisons since most consumers may not know the volume of a dry quart and bushel are equivalent to 0.388 cubic foot and 1.244 cubic feet respectively.

Proposed Method of Sale

A proposal to revise the current method of sale in Section 2.23. "Animal Bedding" is presented below. The proposal includes a new definition for "animal bedding," limits the units of measure that can be used, and includes other restrictions to ensure that label terms are used consistently. The requirement for a "compressed volume" declaration of quantity is eliminated. The proposal replaces the term "usable" with the term "expanded volume." The term "expanded volume" is preferred because it informs consumers that the quantity declaration represents the volume of product to be recovered once it is unwrapped and uncompressed. The proposal requires the use of the term "expanded volume" only in conjunction with the quantity statement on the lower 30 % of the Principal Display Panel and does not prohibit the use of the terms "compressed," "expands to," or "usable" elsewhere on the label. However, the proposed language prohibits the display of "pre-compression" and "compressed" volume declarations anywhere on the package. Finally, it clarifies that metric units are required to appear on the Principal Display Panel and that specific customary units such as cubic inches and cubic feet (e.g., dry quart and bushel are not permitted to appear on the package) may be included at the option of the packer. Because these products will all bear expanded volume in metric units and because consumers have a good comprehension of the volume contained in a liter, OWM is recommending that the method of sale include a provision that, while it does not require unit prices be posted, requires all unit pricing when it is voluntarily provided by the retailer be unit priced on the basis of price per liter.

2.23. Animal Bedding.

<u>2.23.1. Definitions.</u>

<u>(a) Animal Bedding – any material, except for baled straw, kept, offered or exposed for sale or sold for primary use as a medium for any companion or livestock animal to nest or eliminate waste.</u>

<u>(b) Expanded Volume – the volume of the product that can be recovered from the package by the consumer after it is unwrapped and uncompressed.</u>

[3] http://www.nist.gov/pml/wmd/pubs/hb130-14.cfm

2.23.2 Method of Sale.

(a) Packaged animal bedding shall be advertised, labeled, offered and exposed for sale and sold on the basis of the Expanded Volume. If unit pricing is offered to retail consumers it shall be in terms of the price per liter.

(b) The quantity declaration shall include the terms "Expanded Volume" or wording of similar import that expresses the facts, and shall be in terms of the largest whole unit of the milliliter, liter, or cubic meter. A declaration may also include the quantity in terms of largest whole unit of cubic inches, cubic foot, or cubic yard only.

(c) The display of pre-compression volume, compressed volume, or supplementary dry measure units (e.g., dry quart, bushel) anywhere on the package is prohibited.

Examples: Expanded Volume 41 Liters (1.4 Cubic Feet)

Expanded Volume 1.4 Cubic Feet (41 Liters)

Expanded Volume 27.9 Liters (1700 Cubic Inches)

Expanded Volume 113 L (4 Cubic Feet)

Expanded Volume 8 Cubic Feet (226 L)

2.23.~~1.~~3. Exemption - Non-Consumer Packages of Animal Bedding Sold to Laboratory Animal Research Industry. – Packaged Animal Bedding consisting of granular corncobs and other dry (8 % or less moisture), pelleted, and/or non-compressible Bedding materials that are sold to commercial (non-retail) end users in the laboratory animal research industry (government, medical, university, preclinical, pharmaceutical, research, biotech, and research institutions) may be sold on the basis of weight.

3. Technical Issues and Recommendations

a. A Test Procedure and New Designs of Test Measure for Use with Bedding are needed to Ensure Accurate and Repeatable Results.

There is no test procedure for animal bedding in NIST Handbook 133 "Checking the Net Contents of Packaged Goods"[4] (NIST Handbook 133). When there is no test procedure for such a unique product, weights and measures officials must either develop new methods or modify existing ones for use.[5] Most weights and measures officials use the peat moss dimensional procedure (see Section 3.9.

[4] http://www.nist.gov/pml/wmd/pubs/hb133-15.cfm

[5] The fact that test procedures for a specific product are absent from NIST Handbook 133 does not preclude the inspection of any package by weights and measures officials. That is because they have the authority to verify the quantity of any package sold by weight, measure or count as well as the duty to prevent fraud and unfair competition in the marketplace. Since there are literally thousands of products for which no specific test procedure will be found in NIST Handbook 133 officials are encouraged to contact NIST Office of Weights and Measures and other weights and measures colleagues for assistance when they encounter new or unique products.

"Peat Moss") to verify a declaration of compressed volume on bedding. They use the mulch test procedure and the volumetric measures designed for use in testing bags of mulch (see Section 3.10. "Mulch and Soils by Volume") to verify uncompressed volume declarations. The mulch test procedure, like other volumetric methods, (such as those used in determining the weight-per-bushel for grain), require that the product be poured into a test measure from a consistent height, and there are strict limits on the handling of the product. Handling must be kept to a minimum because it reduces product volume. The way that bedding should be handled is significantly different from how pine bark and other mulches are handled when testing mulch because bedding has to be uncompressed or broken up before it can be tested. This has led to the practice of breaking the product up on a tarp and then placing the product into a test measure by hand. Packagers have concerns with this practice because they know from their testing experience at the point-of-pack that hand-filling reduces the volume delivered to the test measure, increasing the variability of tests. Another factor that contributes to the measurement uncertainty in testing bedding is the size of the packages, which can range from a few hundred cubic inches to more than 10 cu ft. Most states and packers only have test measures with capacities up to 3 cu ft so they have to take multiple measurements to test a 10 cu ft package. Because uncertainties associated with multiple readings of a single test measure are additive, the resulting measurement has a large uncertainty and may be only an approximation of the true volume contained in the package instead of one that is accurate and repeatable within reasonable limits.

b. Reasonable Maximum Allowable Variations for both the compressed and expanded volume declarations must be developed in the near future or packages of Bedding should be exempted from the Individual Package Requirement in NIST Handbook 133[6]

Ideally, the same test procedures and equipment specifications should be used by both packagers and weights and measures officials. This will allow for the collection of data that can be used to develop a reasonable MAV for bedding. Currently, the MAV Tables in NIST Handbook 133, Appendix A. (See Table 2-6. "Maximum Allowable Variations for Packages Labeled by Liquid and Dry Volume") define an unreasonable package error as a package found to have a minus error greater than one percent (1 %) of the labeled quantity. In 2013 the NIST Office of Weights and Measures (OWM) reviewed limited data from inspections conducted in 2012 and 2013 by several states. This data revealed that most of the packages failed to meet the expanded volume declarations. In addition, the standard deviations found in the results were such that OWM recommended against enforcement of the 1 % percent MAV in Table 2-6, because the value appears to be unreasonable. Since these packages are required to bear two volume declarations, compressed and expanded, values for the MAV for both the compressed and expanded volumes will need to be quantified. (See discussion of the usefulness of the compressed quantity declaration elsewhere in this paper.) It is recommended, given the nature of the product, the uncertainty inherent in reading the test measures and other issues discussed in the following, more data from a wider range of bedding materials and package sizes will be needed before a final recommendation for a reasonable MAV can be proposed. However, based on current test results and anecdotal information and comments from several state officials who have tested a great deal of bedding, it is anticipated that an MAV of between 5 % to 10 % for tests where the volume of bedding is determined in a single measurement will ultimately be found to be reasonable. The tentative 5 % MAV recommendation would only be reasonable for a single measurement test. For example, if a 2 cu ft test measure is used to test a bag with an 8 cu ft expanded

[6] Currently the average error of a lot, shipment or delivery of bedding, where the sample size is 12 or fewer packages, must be at least equal to the labeled quantity and no individual package may have an unreasonable minus error (i.e., exceed the permitted Maximum Allowable Variation).

volume; four measurements are needed, so the MAV value must be at least doubled. For multiple measurements of volume for a single package, it is recommended that the tentative MAV be increased to 10 %. Note that previous data obtained using hand-filling cannot be combined with data obtained using the recommended test procedures to develop recommendations for the MAV values. If reasonable values for the MAVs cannot be developed in the near future, it is recommended that bedding be exempted from the Individual Package Requirement just as the NCWM has done with prepackaged firewood.

c. Uniform Specifications for Test Measures of Appropriate Sizes for Packages of Bedding

It is known that industry and weights and measures officials use a variety of test measures, dimensional determinations, and volumetric procedures to verify the quantity declarations on packages of bedding. Because there are no specifications for test measures, officials typically use the measures specified in NIST Handbook 133 for testing packages of bark mulch. The dimensions of the mulch test measures were selected to replicate the package cross-section of bags of mulch that are sold in uncompressed quantities of 57 L (2 cu ft) or more. It is obvious that the cross-sections of bedding packages differ substantially from those of packages of mulch, and most bedding is compressed while bark mulch is not.

The maximum capacity of the mulch test measures is 2 cu ft or 3 cu ft.[7] When officials test large packages of bedding, they currently use multiple fills of the test measures to verify the quantity of an 8 cu ft, 10 cu ft, or 12 cu ft bag. Each of those individual measurements includes errors resulting from reading and rounding the results. When 4, 5, or 6 readings are combined, the measurement errors are added up, and the resulting action may be taken on faulty data. The Office of Weights and Measures recommends that multiple measurements of bedding be avoided whenever possible and a test measure of adequate size be used so that a single measurement can be made to determine the volume of bedding in a package.

To avoid the multiple-measurement issue, we constructed several large capacity test measures of square and cylindrical designs so that the volume of a package could be determined in a single measurement. The larger test measure designs also enlarge the area of the bottom of the column of product in the test measure. The larger area allows the height of the column to be reduced which reduces compression (see Exhibit 18). The OWM has developed specifications and some notes on test measure design and construction, which are presented in the following. Unlike mulch, where there are typically a few package sizes such as 56 L (2 cu ft) or 85 L (3 cu ft), bedding is sold (as mentioned above) in a variety of package sizes so test measures with a fixed volume marked on a scale with a few graduations above and below a set volume are impractical for use in testing bedding. For this reason, the OWM recommended designs for the test measures that are specific to bedding, and can be used to test most package sizes in a single measurement.

One reason for using the cylindrical design typically used for dry measures is that its shape reduces the occurrence of the voids frequently seen in the corners of square test measures. Voids in bedding cannot be completely avoided but with the cylindrical design their number is reduced so that they have less impact on the measurement result. The voids that appeared in the cylindrical measures in this study appeared less frequently than in square test measures. (See Exhibit 17 showing void in corner of square test measure.) As noted, the cylindrical design is preferred for dry measures as stated in NIST Handbook 44, "Specifications, Tolerances and Other Technical Requirements for

[7] We understand that some packers (and at least one weights and measures jurisdiction) use a 1 cu ft test "struck" measure for volume measurements which further demonstrates the need for test measure specifications.

Commercial Weighing and Measuring Devices," Section 4.45. Dry Measures. A cylinder is one of the most structurally sound and strongest of the geometrical shapes. That strength derives from the geometrical shape which disperses stress throughout walls of the vessel. (See Exhibit 16 of the cylindrical and square test measures used in this study.) In addition, the surface area of a cylinder is smaller than the surface area of a square test measure of similar capacity so the volume can be determined with greater accuracy.

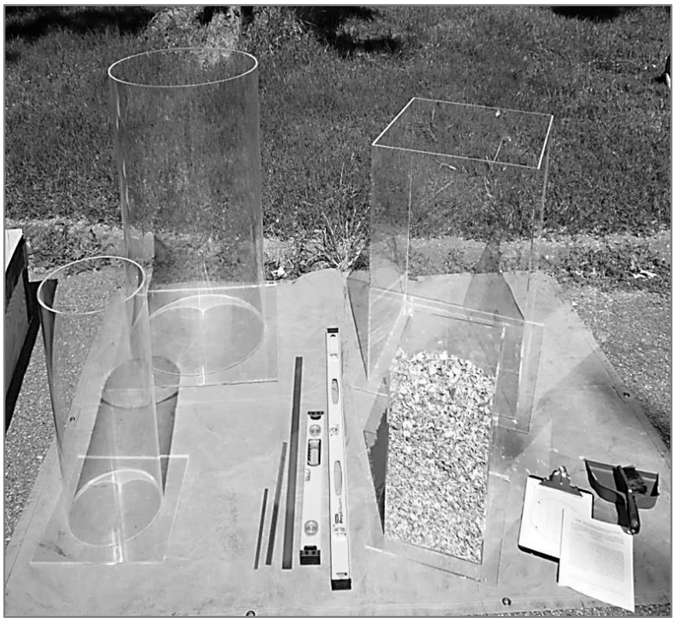


Exhibit 16. Test Measures Used in Study. The large test measures hold up to 279 L (10 cu ft) while the small measures hold up to 52 L (1.5 cu ft).

Exhibit 17. Gap in Corner of Test Measure.

Exhibit 18. Two Different Test Measures. The test measure on the left contains 226 L (8 cu ft) of bedding while the test measure on the right contains 56 L (2 cu ft).

d. Traceability of Measuring Instruments and Test Measures

Another issue of concern is whether not the measurement standards (i.e., test measures and measuring instruments such as tape measures) used by officials and industry have been calibrated and that certificates have been issued indicating that they are traceable to national measurements standards. If untraceable measuring equipment is used in volumetric determinations, the data is questionable. When questionable measurements are involved there will be disagreements over test results and there is the likelihood that packages will be misbranded.[8] To achieve uniformity and to ensure confidence in test data, all test measures, and measuring devices used by weights and measures officials and that are used in industry quantity control must be calibrated to be traceable to the SI. Calibrations can be provided by NIST recognized state metrology laboratories or other accredited facilities. (See pictures in Exhibit 19 of a calibrated internal diameter micrometer being used to verify the actual dimensions of the test measures used in this study.)

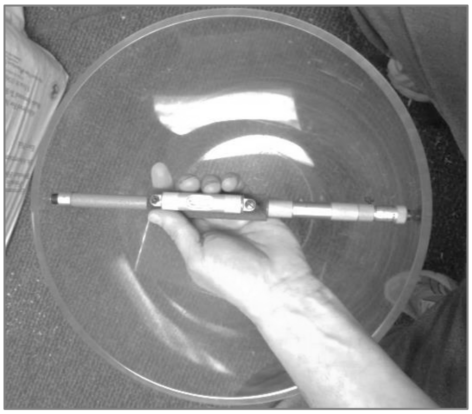


Exhibit 19. Calibrated Internal Diameter Micrometer.

e. Hand Filling Reduces the Product Volume

The standard test method for determining the weight per bushel of grain is determined using a cylindrical dry measure, which is filled using a pour method. This test method has been adapted in NIST Handbook 133 for determining the volume of Borax to verify the net weight of packages of that product. The accuracy and reliability of the pour method and the use of cylindrical dry measures is established, and it dates back to reports to the NCWM issued in 1913 and before.[9] A pour filling method is also used in testing mulch and some states use that method (after breaking up the compressed product) to test bedding, while other states use hand filling. Hand filling is used because the compressed product has to be broken up before placing it in a test measure. It is important to note that most of the packaging machines, which fill packages of bedding, have measurement chambers that are filled to a predetermined level with loose bedding using a “pouring” system, and then

[8] Misbranding means overstating the net quantity of contents, misleads consumers, frustrates value comparisons, and is an unfair trade practice.

[9] See “Testing of Capacity Measures” by R.Y. Ferner, National Bureau of Standards on pages 181 - 200 in the Report of the 8th National Conference on Weights and Measures (1913). Cylindrical Test Measures: in addition to its strength which reduces the chance of deflection in the cylinder walls, another benefit of the cylindrical design is that it eliminates the 90 degree angles of the corners (where gaps in product fill frequently occur). Still another advantage of the design is that the surface area of a cylinder is less than that of an equal size square. It is the smaller surface area that improves the resolution in the volume measurements (i.e., using a 1.0 mm increment to compare the 0.37 L readability of a 24 in^2 square box with a surface area of 576 in^2, to 0.27 L readability of a 24 in cylinder which has a surface area of 433 in^2).

compressed into the package form and then wrapped. Thus, using a pour method to fill a test measure somewhat replicates the process followed in making the original volume measurement.

In this study we compared the volume obtained by pouring the bedding into a test measure to the volume obtained by hand filling the test measure. We found that hand-filling test measures consistently reduced the volume obtained regardless of the type or size of the bedding (i.e., large and small flake). We also found that hand filling has a larger standard deviation than the pour method, which results in a larger uncertainty in test results. We verified the effect of hand-filling by first determining a specific volume of each product using a pour method and adjusting the volume. We then transferred the bedding to the test measure by hand. As shown in the following tables, we consistently found the resulting volume was substantially reduced. We then transferred the product into the test measure using a plastic lined chute and the pour filling method. We performed ten tests for each fill method and found the product volumes from the pouring tests were consistently higher than those found in the hand-filling method. We also found the standard deviations in the pour filling method were consistently lower than those found using the hand-filling method (see Tables 1, 2, and 3). It is important to note that at the end of the ten tests with hand filling we retested the bedding using the pour method and found that the volume of the product recovered close to the original amount.

Table 1. 42 L – Large Flake Wood Product

Fill Method	Average Volume	Standard Deviation
Hand	41.64 L	1.32
Pour	42.14 L	0.17

Table 2. 35 L – Small Flake Wood Product

Fill Method	Average Volume	Standard Deviation
Hand	33.69 L	0.22
Pour	35.05 L	0.19

Table 3. 38 L – Shredded Paper

Fill Method	Average Volume	Standard Deviation
Hand	38.35 L	0.97
Pour	38.78 L	0.36

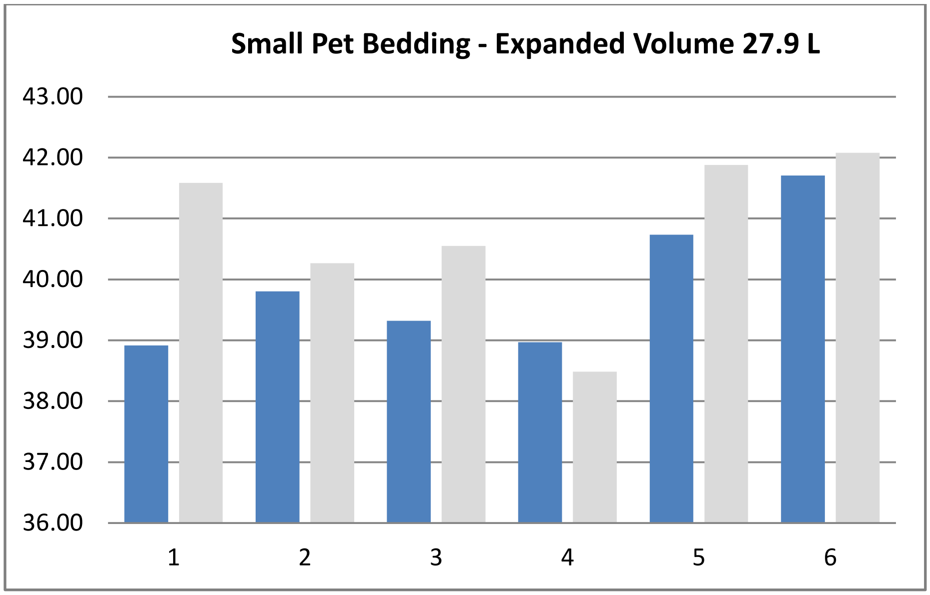
Exhibit 20. Photo to the right shows the use of a chute to pour small flake bedding into a 283 L (10 cu ft) test measure.

Exhibit 21. Photo to the left shows the use of a chute to pour shredded paper bedding into a 44 L (1.5 cu ft) test measure.

Even though we found the repeatability of pour filled tests to be significantly better than hand filling, more testing will be needed to confirm that the results are reproducible with all types of bedding.

f. The Pour Filling Method aids in the Recovery of Product Volume

More than 100 measurements were made using the pour filling method pictured above and it was found that the volume quantities obtained on second pour were generally greater than those obtained during the first pour. The increase in volume found on the second pour was common with most products and makes sense after examining the packaging process. The compression bagging machines are designed to compress product in different ratios but in one example the product is compressed in a ratio of 5 to 1 using up to 1000 or more pounds per square inch of pressure (i.e., 10 cu ft of loose bedding is compressed to 2 cu ft). Even though the test procedure calls for compressed product to be “uncompressed” by hand, that process in itself does not appear to be sufficient to completely loosen the product on its own. The pouring aids in uncompressing the product and allows it to recover more of it original pre-compression volume. The findings indicate that the volumetric test procedure should require at least two pours for each package with the expanded volume being determined on the second pour. The graph below illustrates the findings on a sample of six packages of small pet bedding of shredded paper. The results illustrate (the first pour volume is illustrated by the dark column and the second pour volume is illustrated by the lightly shaded column) how the product volume typically, but not always (see package 4, which also happened to be the lightest weight package in the sample), increases on the second pour. Some of the differences between the first and second pour were 2 L (122 cu in or 7 %) or more. We found similar increases of volume with all other products, further supporting the suggested requirement for at least two pours before the volume is determined.

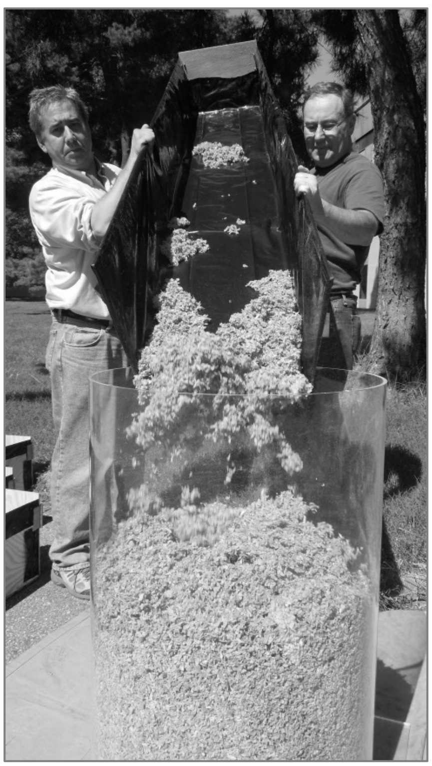


g. Chutes – Used for Uncompressing Bedding and Pouring into the Test Measure

Because the compressed bedding must be uncompressed by hand before it can be poured into a test measure, it was decided that a tray or chute of adequate size could be used for both purposes. When experimenting with plain cardboard chutes, it was found that the bedding would not flow into the test measures evenly and without a lot of shaking. Cardboard chutes were then lined with polyethylene sheeting creating a smooth slippery surface that allowed the bedding to flow freely and evenly into the test measure. The latest generation of the chutes was constructed of wood in various dimensions to hold the expanded volume of various size packages of bedding. Constructed of ¼ inch plywood, they are lined with thick poly sheeting to ensure the product flows out smoothly. In Exhibit 22 upper left picture, a 280 L (10 cu ft) chute is being used to uncompress the bedding. In the picture on the right the bedding has been uncompressed and is ready to be poured into the test measure. The pictures on the next page show how the bedding is uncompressed in a chute by hand. The last picture shows the four sizes of chutes used in this study.

Exhibit 22. These pictures show a package of bedding being opened and the product being uncompressed and prepared for measuring.

Exhibit 23. The following pictures show how a larger chute (over 280 L) and smaller chutes are used to fill the test measures.



The specifications for the chutes corresponding to typical size packages of bedding are shown below and will be included in the equipment list for the expanded volume test procedure.

Chute Specifications			
Chute Nominal Capacity	**Height**	**Width**	**Length**
70 L (2.5 ft^3)	254 mm (10 in)	228 mm (9 in)	1219 mm (48 in)
100 L (3.5 ft^3)	254 mm (10 in)	279 mm (11 in)	1397 mm (55 in)
170 L (6 ft^3)	279 mm (11 in)	355 mm (14 in)	1727 mm (68 in)
240 L (8.5 ft^3)	304 mm (12 in)	406 mm (16 in)	2006 mm (79 in)
283 L (10 ft^3)	304 mm (12 in)	406 mm (16 in)	2286 mm (90 in)
NOTES: The chutes are constructed using hinges and pins so that they can lay flat for transportation. They can be constructed of sheet metal or other slick surface material which enable the bedding to flow easily. The construction of the chutes used in this study allows the sides to move in or out slightly so that the bedding does not become clogged at the outlet. The heights and lengths may be adjusted slightly to fit into vehicles for transport but the widths should not be reduced because narrowing the opening can restrict material flow. Also, the width should be kept smaller than the opening of the test measure so that spillage does not occur during pouring.			

h. Calculating the Volume of Bedding in a Test Measure Using a Headspace Method

i. Hand Leveling of the Bedding causes "Packing" and Reduces Volume

Whenever dry measures are used, NIST Handbook 133 cautions inspectors that measures should be filled "without agitating" (Section 2.4. "Borax"), or that the inspector should "not rock, shake, drop, rotate, or tamp the test measure" (Section 3.10. "Mulch"). This study was conducted following the handbook's guidance and the test measures were filled using the pour method. Following the instructions in Section 3.10. "Mulch," care was exercised "in leveling the surface" of the bedding so that visual readings could be taken across the top surface of the bedding to determine the volume. In Exhibit 25 below, a level is being used to check for level. For this study multiple measurements were taken (e.g., 4 to 12 readings which were averaged) of the height of the bedding inside the test measures. One of the advantages of using the transparent test measures was that the amount of "packing" that was taking place inside the test measure could be seen and measured as the surface of the product was leveled. The term "packing" is used here to clearly distinguish the unintentional, but unavoidable, reduction of volume that results from the act of hand-leveling the bedding. This seems to be a reasonable distinction to make since some level of compression of all of the bedding types tested occurred, and cannot be eliminated. However, larger surface areas of the recommended test measure designs reduce the height of the column in the measure substantially, which in turn will reduce the amount of compression that occurs during testing.

Exhibit 24. Leveling the Surface. Showing the use of a 150 mm mesh to level the surface of large flake bedding.

Exhibit 25. Checking Level. Checking the surface of large flake bedding for an approximation of a level condition.

The impact of "packing" was first observed when leveling out a test measure filled with small flake bedding. It was determined that using hands to level the product would not result in consistent results between inspectors. A 150 mm piece of rigid stainless steel mesh was then used to level the product. However, even when all three testers used the same mesh to level the small flake bedding, there were wide variations over the surface of the product as well as a reduction in volume. Samples of large flake and cellulose bedding were tested and it was found that "packing" occurred with those products.

It should be noted that measurements were made in millimeters because that size increment is easily readable in field situations and it simplifies the calculations. "Packing" is a concern because a 1.0 mm change in height of the bedding has a significant impact on the resulting volume in any test measure (the errors vary depending on the surface area of the test measure). For the 63.7 L (2 cu ft) wooden test measure used for measuring mulch, a 1.0 mm error in a height measurement will result in an error of 92 mL (5.6 cu in) while a 1.0 mm error in a 283 L (10 cu ft) square wooden test measure recommended for use in testing bedding will result in a volume error of 0.37 L (22.6 cu in). On the other hand, due to its smaller surface area, a 1.0 mm error in measurement in the 279 L (9.8 cu ft) cylindrical measure is equivalent to 0.27 L (16.4 cu in).

To find a way to address the issue of the "packing" caused by hand leveling, the bedding was repoured into the test measure and, without leveling the product, the headspace measurement procedure was used as described in the following Item ii. "Headspace Measurement Procedure Adapted for Bedding." Twenty six measurements were taken across the surface area of the bedding to determine its volume. Those values were averaged and subtracted from the height of the test measure to ascertain the volume as illustrated in Figure 1. The bedding was then leveled with the 150 mm wire mesh and another 26 measurements were taken across the surface to determine the volume. The differences were significant and verified that leveling the product by hand reduced the volume. The volume, after leveling on the smaller test measures, ranged from

0.2 L to 0.5 L less than the unleveled volume and up to 5 L less than the unleveled volume on the larger test measures. Because these significant differences were discovered early in this study no further leveling of the bedding was done, and the headspace method was used for all subsequent volume determinations. It was found, after a little practice, the measurements were easily made and the improvements in accuracy were well worth the added effort.

ii. Headspace Measurement Procedure Adapted for Bedding

Testing any product (from grain to Borax) using a dry measure can be fraught with opportunities for measurement errors from "packing" when the product is leveled.[10] Measurements were taken inside the test measure rather than around the outside of the test measure. This allowed more accurate measurements to be made directly on the product so that the variations in the surface (which cannot be eliminated) could be "smoothed" out by averaging multiple measurements. This headspace method is used in NIST Handbook 133 for determining the volume of paint in a can and is described in Section 3.7. "Volumetric Test Procedure for Paint, Varnish, and Lacquers." In that procedure the volume is determined by measuring from the bottom of a spanner bar down to the surface of the liquid and this value is subtracted from the interior height of the can to obtain a height measurement, which can then be used to calculate the volume of the paint. The surface of a liquid is level so only three measurements are taken and averaged. Because the surface of bedding is very irregular, a greater number of measurements must be taken in a uniform pattern across the surface of the bedding to obtain a representative depth from the top of the test measure. By taking at least 25 measurements spaced across the surface area of the square or cylindrical measures, good results were obtained with a good representation of the average depth. The follow graphics illustrate how the headspace method works:

[10] See page 191 in "Testing of Capacity Measures" by R.Y. Ferner, National Bureau of Standards on pages 181 - 200 in the Report of the 8th National Conference on Weights and Measures for 1913 for an earlier discussion of the "packing" effect."

Picture 1. This picture shows how to read the depth of container.

The picture on the left (Picture 1) shows how to read the depth from the bottom of the straightedge (top edge of measure) down to the to bedding in a 44 L test measure from a position that reduces parallax. Picture 2 below illustrates the actual worksheet with the headspace procedure on the 44 L cylinder test measure (its internal radius is 151 mm and its height is 610 mm). The bedding was poured into the test measure but not leveled. Then 26 measurements were made at the locations shown on the grid to determine the depth of the product from the top edge of the measure. The average of the 26 values was 500.7 mm which was subtracted from the height of the test measure to obtain 109.26 mm for the average height of the column of bedding in the measure.

The volume was calculated using: *Volume in liters* = $\pi r^2 h$
3.14159265 × 23035.69 × 109.26 mm = 7.90 L*

*After the calculation was completed, the result was divided by 1 000 000 to obtain the volume in liters.

Figure 4. Illustration of Worksheet.

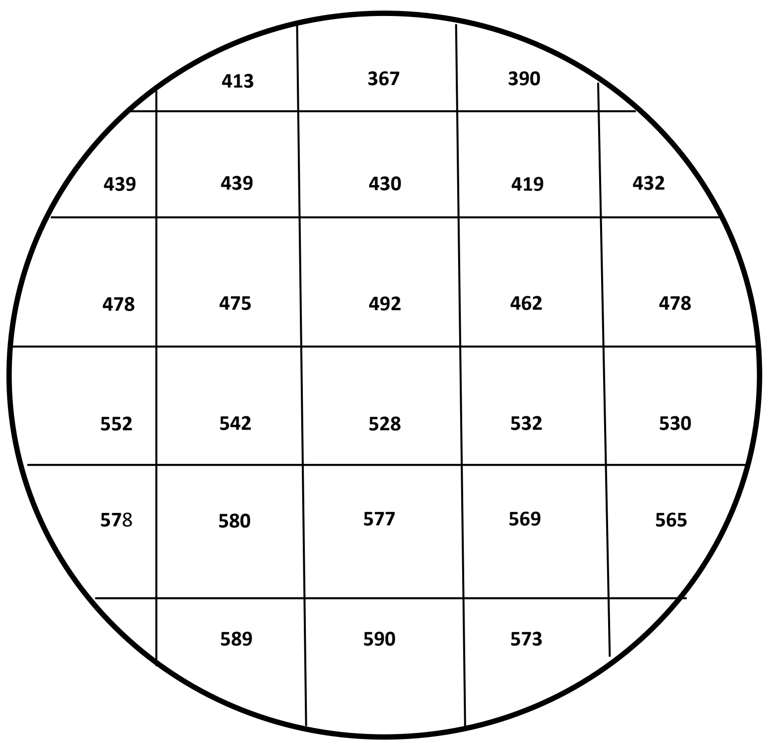


Figure 3. Using the headspace measurement on a 279 L test measure. The ruler is read from the bottom edge of a straight edge or level from a position that reduces parallax.

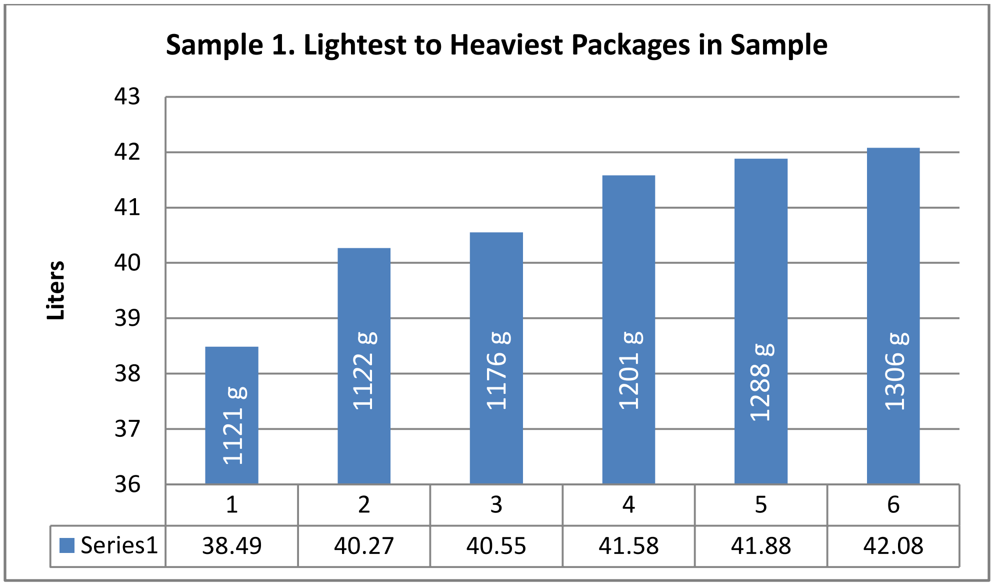
Figure 4. Showing how the ruler is placed on the bedding with the headspace method. The ruler is read from the bottom edge of a straight edge or level from a position that reduces parallax.

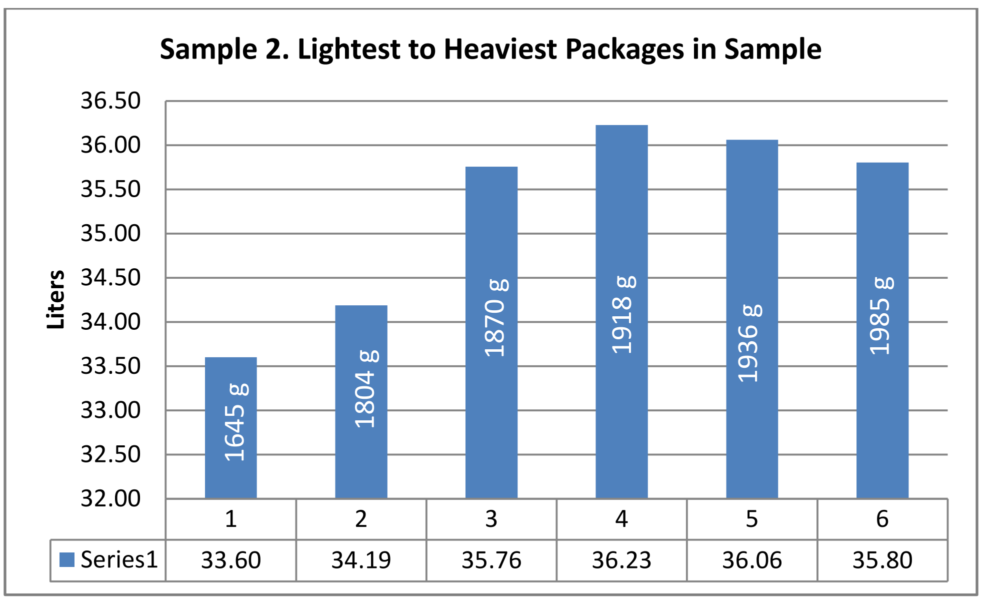
Some packers may choose to level the product in a test measure or take fewer readings across the surface to determine if the package passes or fails a quantity control test in a production environment. But, in official inspections by weights and measures officials, it is recommended that the product be poured into the test measure and measured without leveling so that the "packing" (volume reduction) that is known to occur whenever the product is handled can be avoided. Also, for official tests, it is critical that variations be measured so the data can be utilized in the calculations of sample standard deviations and sample error limits to decide if a sample passes or fails.

i. Optional Audit Screening by Weight

The verification of the expanded volume of animal bedding outside of a production plant requires the inspector to destroy the package and un-compress the product. After the product is tested, it cannot be returned to the original packaging so it will need to be discarded or placed in a large trash bag to be held for disposition by the retail store. In carrying out this study, the packages were weighed prior to opening them for the volumetric test to see if there was a consistent relationship between weight and volume. In reviewing the test data, it was found that the net weight of the packages did not correlate with the expanded volume found in testing. However, it was determined that the package gross weights could be used in an audit procedure. For example, if the expanded volumes of the lightest and heaviest packages in a sample passed, it could be expected that all of the remaining packages in the sample would also contain at least the expanded volume. The Industry experts we spoke with agreed that this type of weight screening was workable could be used to save both time and labor expenses and also reduce destructive testing and product waste.

To see if a weight screening approach would work in the real world, two sets of samples comprised of six packages from two different lots of a bedding product made of cellulose were collected. The expanded volume declared for both samples was 27.9 L (1700 cu in). All of the packages in each sample were weighed to obtain their gross weights and then each was tested to verify the expanded volume. The results from both samples revealed that the expanded volumes of the four intermediate weight packages fell well within the range in volume between the lightest and heaviest packages in the sample (the gross weights of each bag are shown on the bars of the graphs).





Regardless of the type of product under test, the volumetric test destroys the packaging and the product cannot be repackaged. This is a suggested alternative approach to reduce destructive testing and to save inspection resources The test procedure will contain the recommendation that after randomly selecting the sample packages from the inspection lot, a gross weight be taken on all, select the lightest and heaviest packages first, and conduct a volumetric test on them to verify the expanded volume. If the lightest and heaviest packages pass the volumetric test, it is likely that the remaining packages in the sample will also pass. Jurisdictions may want to accept the sample as an AUDIT TEST and inspect another lot. If either of the two packages are found to have a minus error that exceeds the MAV the sample fails and no further testing should be done (assuming 0 MAVs are allowed for the sample size (see NIST Handbook 133, Appendix A, Table 2-1. “Sampling Plans for Category A”). However, if either of the first two packages has a minus error that does not exceed the MAV the inspector should test all of the packages in the sample as they normally would in a NIST

Handbook 133 test procedure. If the gravimetric audit procedure is used, the inspector will be advised to ensure that the scale is sitting on a solid level support and that its accuracy has been verified to a test load that is at least 10 % more than the gross weight of one of the packages (e.g., to estimate that value place one of the packages on the scale and then test the scale with a load above the package's gross weight).

j. There is Little Benefit for Consumers in Verifying the Compressed Quantity Declaration

Based on a review of test data provided by states from the 2012 - 2013 testing, it is noted that in most instances the fact that a package passed the compressed dimensional test did not ensure that the package would pass the uncompressed volume test. Test findings for the compressed and uncompressed quantities in this study were consistent with the state results. Furthermore, in the opinion of industry experts, even if the compressed quantity is correct that does not mean that the expanded (uncompressed) volume declaration will be accurate.

It is unlikely that most packages of animal bedding would fail the dimensional test. If the sample packages do not measure up, the Inspection Lot should be rejected without further testing. However, if should a sample passes the dimensional test, the volumetric test must be carried out before a final decision on whether or not the lot passes both tests is made.

4. Packages of Compressed Bedding

a. How Manufacturers determine a Compressed Volume Declaration.

A compressed volume declaration on a package of bedding is determined from the target dimensions of the finished goods package as designed. Manufacturers design these packages as cuboids with all right angles and flat surfaces. Typically the natural variability of the fibers they package will almost always create some "plumping" along the surfaces and rounding on the edges resulting in irregular package dimensions. For most manufacturers the target compressed volume design intentionally errs on the side of a smaller compressed volume declaration than could be reasonably claimed, but that approach ensures compliance with the stated compressed volume (assuming the package is adequately filled). Because packers tend to understate the compressed volume declaration, these products routinely pass the compressed package (peat moss) test procedure in NIST Handbook 133.

b. A Dimensional Test is used to Verify Compressed Volume.

This method of determining the volume has a large uncertainty. This is due to the difficulty in obtaining exact measurements of irregularly shaped packages in flexible packaging. Typically bedding packages (like peat moss) are formed in a rectangular cuboid, but the edges of most bags are rounded and there is expansion (or "plumping") of the panels of a bag (including the ends and sides). Some packages of compressed bedding are irregular in shape and so loosely packed such that they do not hold a cuboid form firmly enough for reproducible measurements to be made. Exhibit 26 on the left shows a package of peat moss, which is the product that the original test procedure was developed to verify. Exhibit 27 on the right is a package of "compressed" bedding that is too loosely packed to utilize the peat moss dimension procedure.

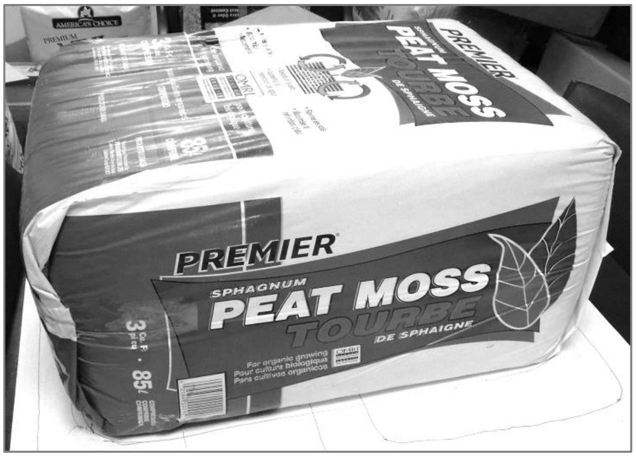


Exhibit 26. Peat Moss.

Exhibit 27. Compressed Bedding.

Note: For the purpose of providing uniform identity of the dimensions recorded for this study, a cuboid is shown in Exhibit 28 with the dimensions identified and oriented with the Principal Display Panel (PDP) as it is defined in the NIST Handbook 130, "Uniform Packaging and Labeling Regulation."

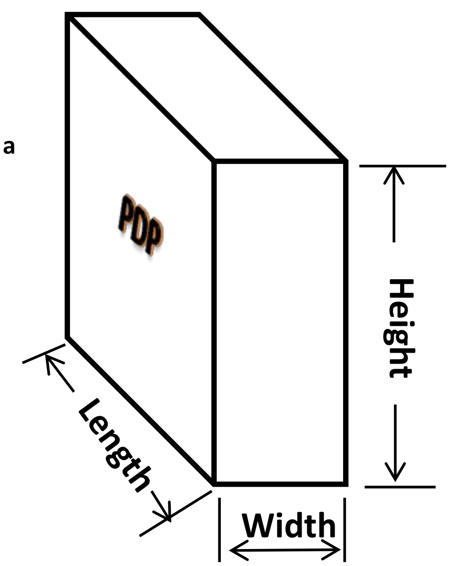


Exhibit 28. Determining the Volume of a Cuboid.

The formula for determining the volume of a cuboid[11] is *Volume = Length × Width × Height* (Note: an alternative formula *Volume = Height × Area of the Base (where L × W give the area of the base).* In the case of packages of bedding, this formula may not provide an accurate determination of volume. This is because the geometric formula for a cuboid is based on the 6 panels of the cuboid being flat and the 12 edges meeting at 90 degree right angles. On most compressed bedding, the package edges are rounded and there can be "plumping" or depressions in the package panels (excess

[11] A cuboid has six rectangle faces, twelve edges and eight vertices. It is also called a right cuboid because the edges meet at right angles of exactly 90 degrees.

packaging tails[12] can also cause errors) making it difficult to visually define a measurement point. The following picture shows the rounded edge of a 16 L package of red cedar bedding. The "plumping" of the package and rounded edges (angles) make it difficult to define a measurement point for the length, width, and height of the package.

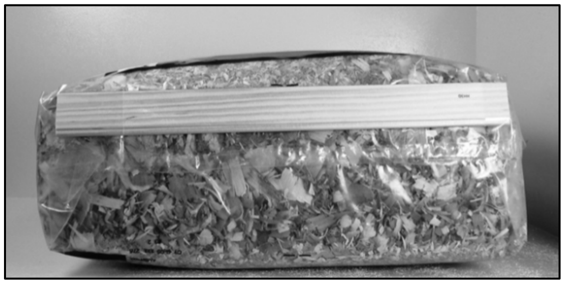


Exhibit 29. Plumped bedding package illustrating rounded edges (angles), which hinders getting accurate measurement points.

A packaging "tail" is the part of the packaging remaining after the package is heat sealed and cut. Typically tails are found only on the top or bottom of the package and can be avoided in taking the length and width measurements along one side of the package. As shown in the photographs in Exhibit 32 the size of a "tail" can vary greatly from product to product. If, for some reason, they cannot be avoided for the dimensional test, they must be folded consistent with the packaging design and taped against the body of the package to provide a clear field of view and placement of measuring equipment during the dimensional test.

Exhibit 30. Package Tails.

[12] A packaging "tail" is that part of the flexible packaging remaining after the package is heat sealed and cut.

Package Tails: The "tail" on the package shown at right was folded and taped so that dimensional measurements of height could be made. The thickness of single layer of this wrapper was 0.0035 in. At several measurement points on one end of this package there were seven layers (0.024 in) of packaging. In addition, the "tail" on the other end of the package totaled three layers (0.010 in). The total thickness for both ends was 0.034 in). In NIST Handbook 44, "Specifications, Tolerances and other Technical Requirements for Commercial Weighing and Measuring Devices," Section 5.52. "Linear Measures" the Acceptance Tolerance for a 36 in ruler is ± 0.046 in. In this example, the error caused by not deducting for the thickness of the packaging equaled at least 70 % of the tolerance allowed for a 36 in ruler.

Unlike the ASTM International test method for peat,[13] NIST Handbook 133 does not require adjustment of the net volume to reduce measurements to account for the thickness of the packaging (e.g., on a 3 mil thick package [0.003 in], each measurement would be reduced by twice the bag thickness or (0.006 in) which benefits packers). (See the discussion in the table above for an example of how the packaging thickness with multiple thicknesses relates to the tolerance for the measuring device.) By not deducting for the thickness of the packaging, the calculated volume is increased to the benefit of the packer.

NIST Handbook 133 requires the measurements to represent the dimensions of the cuboid of the bedding so the inspector must ensure that tails are folded and measurement points taken such that multiple folds of packaging material do not affect the accuracy of the measurements. The following pictures (Exhibit 32) show the edges from 16 L (1000 cu in), 85 L (3 cu ft) and 113 L (4 cu ft) packages of mini and large flake bedding showing how rounded "angles" make it difficult to define a measurement point for the length, width, and height of the package.

[13] See Section 6.2 of ASTM International D2978-03 (Reapproved 2010) "Standard Test Method for Volume of Processed Peat Materials."

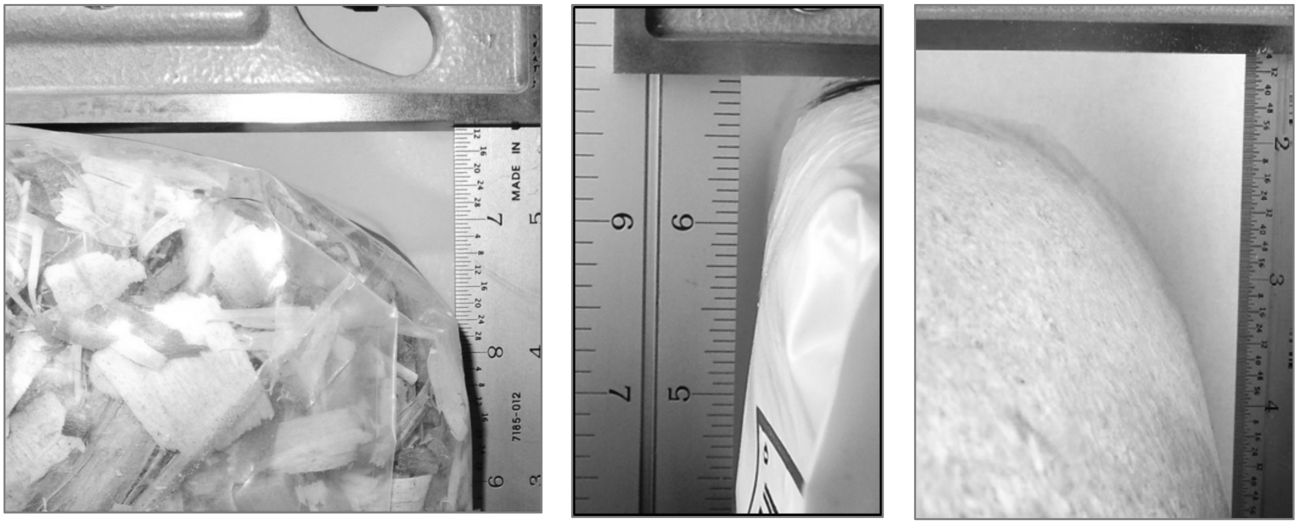


Exhibit 31. Measurement Technique.

The radius of the edges of the packages tested with quantities of 16 L to 156 L ranged from about $^{3}/_{16}$ in to more than 2.5 in. The following graphics illustrate how the radius impacts the accuracy of the area determination. The area of the colored rectangle with 90 degree angles shown below is 96 sq in.

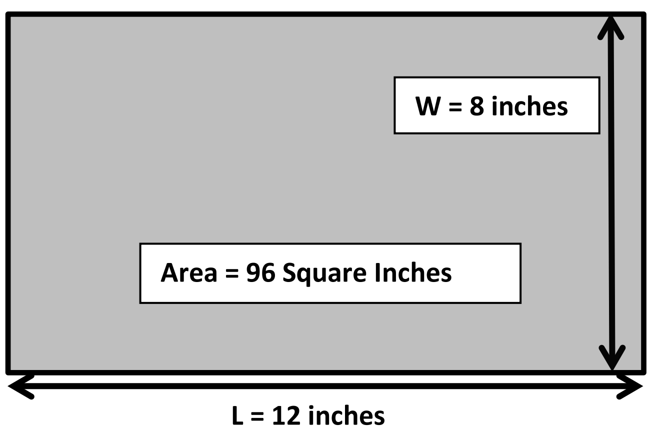


Exhibit 32. Graphics illustrating impacts the accuracy of the area.

If this rectangle is redrawn with rounded corners the area will decrease as the radius increases.

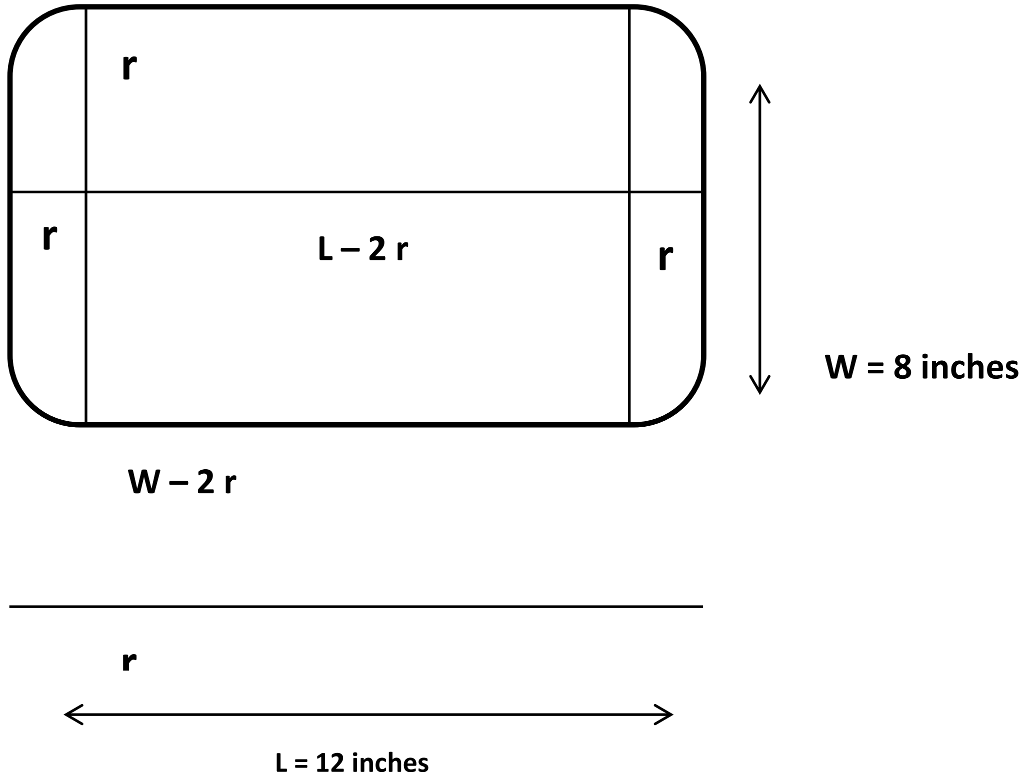


Exhibit 33. The impact of rounded corners on determining the accuracy of Volume Determinations.

This table illustrates how rounded corners impact the accuracy of a volume determination. The comparison of radius measurements show how the cuboid volume differs from the actual volume of the package from 1 cu in to 86 cu in as the radius of the corners increases.

Radius (r) of Corners in Inches	Length (in Inches)	Width (in Inches)	Height (in Inches)	Volume with Rounded Corners $H \times (L \times W - (4 - 3.14159265)\ r^2)$ Volume in Cubic Inches	Cuboid Volume $L \times W \times H$	Difference from Cuboid in Cubic Inches
$^3/_{16}$	12	8	16	1535.5	1536 cu in	− 0.5
0.25				1535		− 1.0
0.5				1532		− 4.0
1.0				1522		− 14.0
2.5				1450		− 86.0

c. Product Variations are Common in Other Dimensional Tests in NIST Handbook 133

It is important to remember that dimensional testing is used for other packaged goods in NIST Handbook 133 such as bundled and boxed firewood as well as polyethylene sheeting and even paint. Similar measurement challenges are encountered in defining the measurement point and in accounting for irregular shapes. However, bedding can be distinguished from packages of firewood because packages of bedding are required to bear declarations of the quantity in terms of the usable (expanded) volume which can be verified in a test measure.

Average of Multiple Measurements

One approach that NIST Handbook 133 uses to deal with variations in product sizes is to take multiple measurements along each panel and then average the results. The assumption for this approach is that the greater the number of measurements taken, the better the average value reflects the actual dimensions of the product under test. Because the shapes of bedding packages vary significantly, additional measurements improve the accuracy of the measurements. For the test procedure recommended NIST is advises that <u>at least</u> five measurements be taken for each dimension being verified (i.e., length, width, and height) and that these values be averaged.

5. Errors

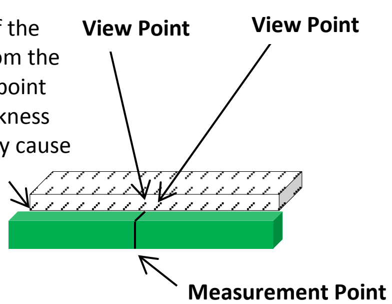
a. Observational Error

For this test procedure a linear measurement is understood to be the distance between two points in a straight plane, that is a reference (or zero) point and a measurement point. There are many possibilities for error in testing packages dimensionally. One of the most difficult issues with bedding packages is identifying measurement points due to the irregular surfaces of the planes (e.g., plumping of the package). Several recommendations are provided below that may help reduce measurement errors and uncertainty. Some basic measurement issues which are problematic in most measuring processes will be reviewed so that every reader has an understanding of the factors that were considered in developing these test procedures.

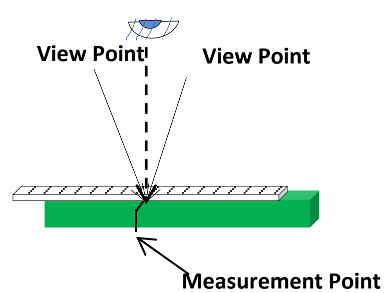
i. Parallax

When the graduations are too far from the measurement point, such as when a thick ruler is used, there is a possibility that measurement errors will occur as a result of parallax. Parallax is the apparent displacement of a graduation due to a slight change in the position of the observer. This is illustrated in the exaggerated graphic on the left.

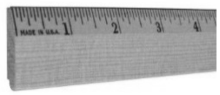
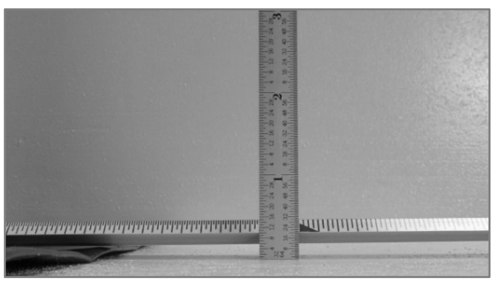
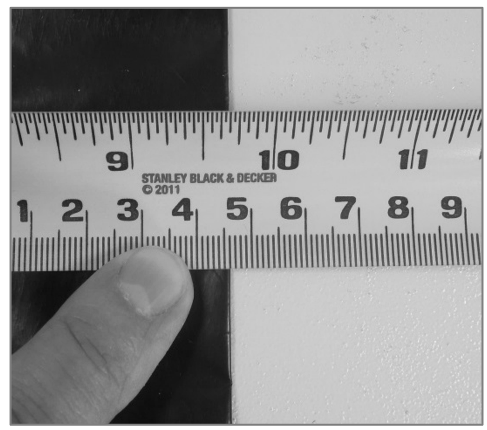
The distance of the graduations from the measurement point due to the thickness of the ruler may cause parallax errors.



The distance of the graduations from the measurement point is reduced by the thinner ruler which minimizes parallax errors.



One way to reduce parallax error is to use a thin ruler and place it so that its graduations are as close to the measurement point as possible. By understanding parallax you can usually reduce it to a minimum by using suitable test equipment and aligning your eyes so that they are perpendicular to the graduation (see dashed line) and the measurement point. See graphic above right.

	Note how the graduations are on the tapered portion of the ruler so that they lay close to the measurement point.
	A thin rigid stainless steel ruler reduces parralax because the graduations lay close to the measurement point. Metal rulers are available that have a thickness of 0.4 mm.
A rigid tape measure can also cause parallax errors. This is because the curve in the blade (which strenthens the tape) will hold the markings up off the package being measured by as much as $^{9}/_{32}$ in or more on a 1 in wide tape. To eliminate this problem the inspector must push the tape flat against the package. See picture at right. 	

b. Manipulative Errors

i. Bending a Tape or Using Improper Angles on a Ruler or Tape will Result in Measurement Errors

For this test procedure a linear measurement is considered the distance between two points in a straight plane. When a linear measuring device is used, it is important that the measuring instrument not bend or "deflect" because any measurement taken that is not parallel to the edge of the package (i.e., the straight plane mentioned before) will introduce trigonometric errors (these are typically cumulative). This is one reason that flexible tapes are not recommended for use in this NIST Handbook 133 test procedure. As mentioned above, most tape measures have a curve in the blade to stiffen it. Because tapes are flexible, it is essential that the inspector reduce the deflection to a minimum before taking a reading of any measurement. Another source of error is the angle of the measurement. Always keep a 90 degree angle to the edges of the package to avoid introducing errors (see photos exaggerated examples.)

Do not bend the tape.

Wrong! Keep the angle of the tape or ruler perpendicular to the edges of the package or trigonometric errors will occur.

Exhibit 34. Proper Measurements are required to avoid errors.

ii. Rounding

Another source of error occurs when the measurement point falls halfway between two graduations on a ruler. Here the error can be as much as half the graduation. For example if you use a ruler with $^{1}/_{16}$ in (1.58 mm) graduations, the potential rounding error is $^{1}/_{32}$ in (0.75 mm) or more. To avoid disputes over the possibility of subjective judgments, the draft procedure requires rounding of measurements that fall between two graduations up in favor of the packer as a matter of practice. The use of millimeters will help to further reduce the errors in volumetric determinations and will simplify the calculations as well.

iii. Slippage

It is difficult to keep the zero "reference point" stabilized when you are measuring any object free handed. Packages of bedding are much more difficult to measure because of their irregular shapes. When measuring most items, you place the zero of the ruler at one edge of the object and then move your head to read the ruler at the measurement point. Experts in dimensional measurement have found that when the observer moves their head from the reference point to view the measurement point they frequently move their hands apart and lose the zero reference.[14] See Exhibit 35. This draft procedure recommends that at least 5 measurements be taken to determine the length, width, and height of a package so there will be a potential for 15 instances of slippage, which can have significant impact on the accuracy of the volume determination. Several inspectors who recognize the problem of slippage and who routinely test bedding reported that they use a clipboard or place the package against a wall to provide a solid base for the zero reference. Using that concept, an inexpensive but rigidly constructed three-sided "Measurement Frame" was built to aid in keeping the reference point stable against a solid surface to improve the accuracy of the measurements. See Exhibit 36.

[14] See Chapter 5, "Measurement with Graduated Scales and Scaled Instruments in "Fundamentals of Dimensional Metrology" for additional information on good measurement practices.

Exhibit 35. Taking Measurement Points.

Exhibit 36. Measurement Frame built as an aid to keep reference point stable.

Another step to improve the process is the use of a carpenter square or straight edge to help define the measurement point. The square or straight edge is moved to five points along the package to allow the inspector to make measurements of variations in the dimension. By combining the use of the measurement frame, a rigid rule with 1.0 mm graduations and the carpenter square or straight edge, the accuracy and reproducibility of the measurements (and so the compressed volume measurement) are improved substantially.

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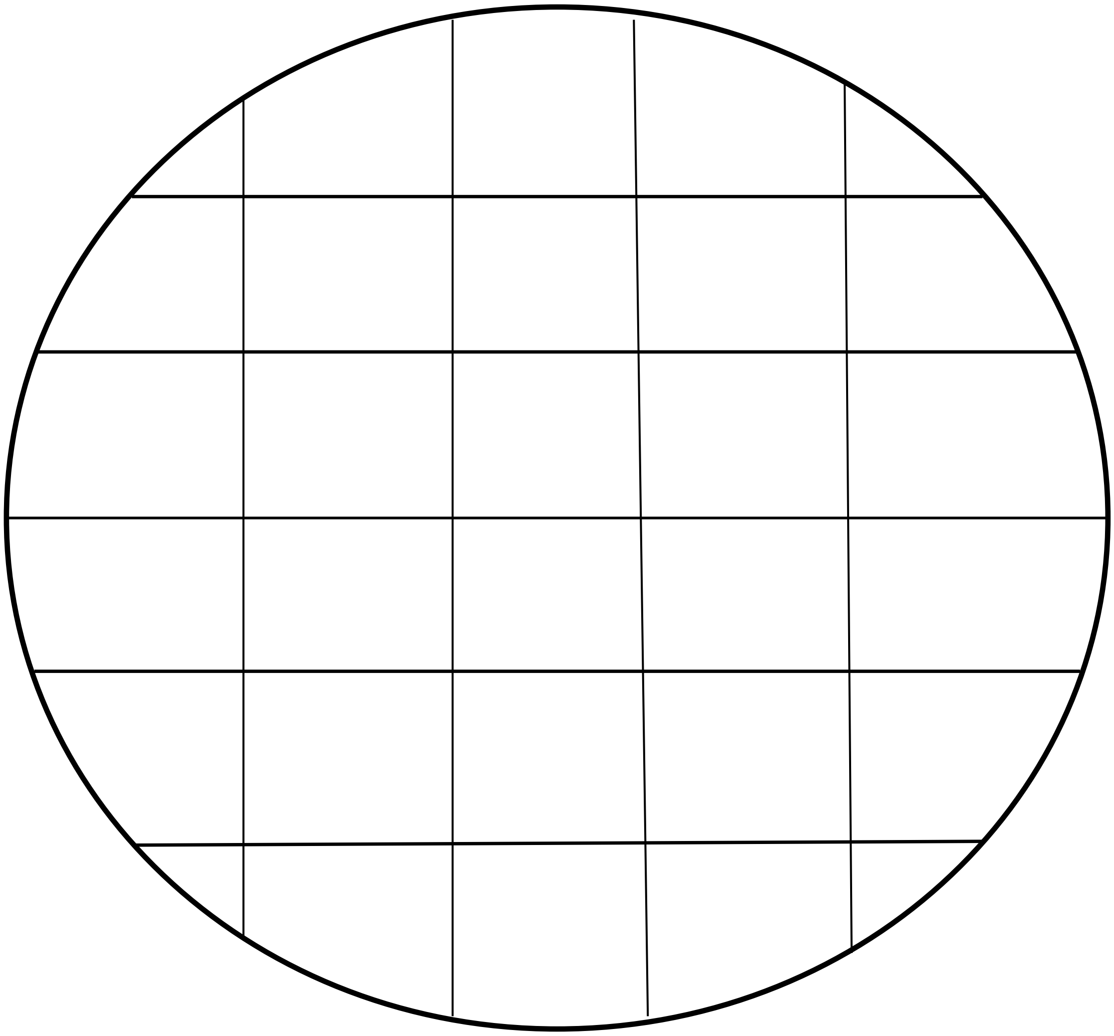
Appendix A. 26 Point Measurement Grid and Package Error Worksheet for Cylindrical Test Measures



Sample Package _______________ Labeled Expanded Volume (L): ________________

A. Interior Height of Test Measure: ___________________ B. Radius of Test Measure (r): ____________

C. Average Depth (Sum of Measurements ÷ 26): ________________

D. Average Height of Bedding (= A − C): ___________________

E. Volume (L): ______________ = 3.14159265 × r^2 (B^2): ___________ × D: _________ ÷ 1 000 000

F. Package Error (L): _____________ = Labeled Volume (L): _____________ − E (L): ______________

Volume is calculated using: *Volume in liters = $\pi r^2 h$ For example: if r^2 is 23035 and height of bedding is 109.26 then*
((Pi) 3.14159265 × r^2 (23035) × 109.26) ÷ 1 000 000 = 7.90 L

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Appendix B. 25 Point Measurement Grid and Package Error Worksheet for Square or Rectangular Test Measures

Sample Package _______________ Labeled Expanded Volume (L): ________________

A. Interior Height of Test Measure: ___________ B. Area of Test Measure Base (L× W): ___________

C. Average Depth (Sum of Measurements ÷ 25): ________________

D. Average Height of Bedding (= A − C): ___________________

E. Volume (L): ___________ = B. Area of Test Measure Base: __________ × D: ________ ÷ 1 000 000

F. Package Error (L): ____________ = Labeled Volume (L): ____________ − E (L): ______________

Volume is calculated using: *Volume in liters = (lw)h For example: If length and width are 609.6 the area of the measure's base is 371612. If the Average Height of the Bedding is 109.26 then:*

B. Area of Test Measure Base (371612) × Average Height of Bedding (109.26) ÷ 1 000 000 = 40.6 L

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Appendix C. Inspection Worksheet for Dimensional Testing

Date:	**NIST Handbook 133 - Category A** **Lot Size ________Sample Size _______** **Worksheet for Packages of Animal Bedding and Peat Moss Labeled by Volume – Dimensional Procedure**			
Labeled Quantity	**Converted to Fluid Ounce or Metric**	**Largest Quantity**	**Manufacturer :**	
			Product:	
			Lot Code:	**Plant Number:**

1 cubic foot = 1728 cu in   *Total Volume (cu ft) (measure in in) = L × W × H ÷ 1728 or *Total Volume (L) (measure in mm) = L × W × H ÷ 1 000 000
Dimensional Measurements **Dimensions Measured in:** ☐ **mm** ☐ **in**   **Package Error in:** **mL** **cu in**

	Length					**Avg**	**Width**					**Avg**	**Height**					**Avg**	**Total**	
1.																				+ –
2.																				+ –
3.																				+ –
4.																				+ –
5.																				+ –
6.																				+ –
7.																				+ –
8.																				+ –
9.																				+ –
10.																				+ –
11.																				+ –
12.																				+ –

Appendix C. Inspection Worksheet for Dimensional Testing

<table>
<tr><td colspan="12">Step 1. What is the MAV for this labeled quantity in Table 2-6?

☐ __________ mL ☐ ________ cu in</td><td>Total Package Error</td></tr>
<tr><td colspan="12">Step 2. How many minus errors exceed the MAV _______? If the number of unreasonable errors exceeds the number permitted for the sample size in Table 2-1., the sample fails; go to Step 7. If there are no Unreasonable Errors, sum the package errors, and calculate the Average Error entering it in Step 3. Go to Step 4.</td><td>Step 3: Average Package Error</td></tr>
<tr><td colspan="12">Step 4. If the Average Error is zero or a positive number, the sample passes; go to Step 7. If the Average Error is a negative number, go to Step 5.

Step 5. Calculate the Sample Standard Deviation (s) and multiply (s) by the Sample Correction Factor (SCF) for the sample size to obtain the Sample Error Limit (SEL); go to Step 6.

(s)______________ × (SCF) ___________ = SEL ________________</td><td>Box 6. Disregarding the signs, is the SEL in Step 5 larger than the Average Package Error in Step 3? If yes, the sample passes, go to Step 7 and approve the lot. If no, the sample fails, go to Step 7 and reject the lot.</td></tr>
<tr><td colspan="13">Step 7. Action Taken: ☐ Lot Rejected ☐ Lot Approved</td></tr>
<tr><td colspan="13">Random Numbers: Enter the numbers as you select them in the top row and reorder them in the bottom row.</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Appendix D. Modified Standard Package Report for Animal Bedding

Date:	**Modified Standard Package Report for Animal Bedding**		**Sampling Plan A – Table 2-1., Appendix A in NIST Handbook 133**		**Report Number:**
Location (name, address)		**Product/Brand Identity** **Lot Codes**	**Manufacturer**		**Container Description:**
1. Labeled Quantity (Expanded Volume):	**2. Unit of Measure: Liter**	**3. MAV:** **- Single Volume Determination 5 %** **- Multiple Volume Determinations 10 %**	**4. MAV (0.05 × Box 1. Expanded Volume) or (0.10 x Box 1. Expanded Volume)**	**5. Inspection Lot Size:**	**6. Sample Size (n):** **7. Number of Unreasonable Package Errors Allowed for Sample Size:**

Gross Weight for Audit Testing		**Package Error**		**Test Notes**
		–	**+**	
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
12.				
		Total:	Total:	

8. Total Error:	**9. Number of unreasonable minus (−) errors (compare each package error with Box 4):**	**10. Is Box 9 greater than Box 7?** ☐ **Yes, lot <u>fails</u> go Box 17** ☐ **No, go to Box 11.**	**11. Calculate Average Error: (Box 8 ÷ Box 6 =)**
12. Does Box 11 = Zero (0) or Plus (+)? ☐ **Yes, lot <u>passes</u>, go to Box 17** ☐ **No, go to Box 13, 14, 15 & 16**	**13. Compute Sample Standard Deviation:**	**14. Sample Correction Factor:**	**15. Compute Sample Error Limit (Box 13 × Box 14 =)**
***16*. Disregarding the signs, is Box 11 larger than Box 15?** ☐ **Yes, lot <u>fails</u>, go to Box 17** ☐ **No, lot <u>passes</u>, go to Box 17**		**17. Disposition of Inspection Lot** ☐ **Approve** ☐ **Reject**	
Comments:		**Official's Signature** **Acknowledgement of Report**	

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APPENDIX E. EXPERTS IN THE ANIMAL BEDDING INDUSTRY CONTACTED FOR TECHNICAL ASSISTANCE.

NIST EXTENDS ITS SINCERE APPRECIATION TO THESE EXPERTS FOR THEIR ADVICE AND ASSISTANCE.

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