
Chapter 3. Test Procedures – For Packages Labeled by Volume

3.1. Scope

a. **What types of packaged goods can be tested using these procedures?**

Use this procedure to determine the net contents of packaged goods labeled in fluid volume such as milk, water, beer, oil, paint, distilled spirits, soft drinks, juices, liquid cleaning supplies or chemicals. This chapter also includes procedures for testing the capacities of containers such as paper cups, bowls, glass tumblers, and stemware.

b. **What types of packages are not covered by these procedures?**

These procedures do not cover berry baskets and rigid-dry measures that are covered by specific code requirements in NIST Handbook 44. “Specifications, Tolerances, and Other Technical Requirements for Weighing and Measuring Devices.”

c. **When can the gravimetric test procedure be used to verify the net quantity of contents of packages labeled by volume?**

The gravimetric procedure may be used to verify the net quantity of contents of packages labeled in volume when the density (density means the weight of a specific volume of liquid determined at a reference temperature) of the product being tested does not vary excessively from one package to another.

d. **What procedure is followed if the gravimetric test procedure cannot be used?**

Test each package as described in Section 3.3. “Volumetric Test Procedure for Liquids.”

e. **What considerations besides density affect measurement accuracy?**

In addition to possible package-to-package variations in product density, the temperature of the liquid will affect the volume of product. The product will expand or contract based on a rise or fall in product temperature.

Example: *The volume of a liquid cleaning product might be 5 L (1.32 gal) at 20 °C (68 °F) and 5.12 L (1.35 gal) at 25 °C (77 °F), which represents a 2.2 % change in volume.*

Note: This extreme example is for illustrative purposes, a 2.2 % volume change will not occur in normal testing.

f. What reference temperature should be used to determine the volume of a liquid?

Use the reference temperature specified in Table 3-1. “Reference Temperatures for Liquids” to determine volume. When checking liquid products labeled by volume using the gravimetric procedure, maintain the packages used to determine product densities at reference temperatures. If testing the packages in a sample volumetrically, each package in the sample must be maintained at or corrected to the reference temperature when its volume is determined.

Note: When checking liquid products using a volumetric or gravimetric procedure, the temperature of the samples must be maintained at the reference temperature $\pm 2\text{ }^{\circ}\text{C}$ ($\pm 5\text{ }^{\circ}\text{F}$).

Table 3-1. Reference Temperatures for Liquids		
If the liquid commodity is:	Volume is determined at the reference temperature of:	Code of Federal Regulation Reference*
Beer	4 °C (39.1 °F)	27 CFR, Part 7.10
Distilled Spirits	15.56 °C (60 °F)	27 CFR, Part 5.11
Frozen food - sold and consumed in the frozen state	At the frozen temperature	21 CFR §101.105(b)(2)(i)
Petroleum	15.6 °C (60 °F)	16 CFR §500.8(b)
Refrigerated food (e.g., milk and other dairy products labeled “KEEP REFRIGERATED”)	4 °C (40 °F)	21 CFR §101.105(b)(2)(ii)
Other liquids and wine (e.g., includes liquids sold in a refrigerated state for immediate customer consumption such as soft-drinks, bottled water and others that do not require refrigeration)	20 °C (68 °F)	Food: 21 CFR 101.105(b)(2)(iii) Non-Food: 16 CFR §500.8(b) Wine: 27 CFR, Part 4.10 (b)
*The Code of Federal Regulations can be accessed online at: http://www.gpoaccess.gov/		

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3.2. Gravimetric Test Procedure for Liquids

Test Equipment

- A scale that meets the requirements in Chapter 2, Section 2.2. “Measurement Standards and Test Equipment.”

Note: To verify that the scale has adequate resolution for use, it is first necessary to determine the density of the liquid; next verify that the scale division is no larger than MAV/6 for the package size under test. The smallest graduation on the scale must not exceed the weight value for MAV/6.

Example: Assume the inspector is using a scale with 1 g (0.002 lb) increments to test packages labeled 1 L (33.8 fl oz) that have an MAV of 29 mL (1 fl oz). Also, assume the inspector finds that the weight of 1 L of the liquid is 943 g (2.078 lb). This will result in an MAV/6 value in weight of 4.715 g (0.010 lb):

$$29 \text{ mL}/6 = 4.8 \text{ mL}$$

$$(1 \text{ fl oz}/6 = 0.166 \text{ 6 fl oz})$$

$$943 \text{ g}/1000 \text{ mL} = 0.943 \text{ g/mL}$$

$$(2.078 \text{ lb}/33.6 \text{ fl oz} = 0.0618 \text{ lb/fl oz})$$

$$4.8 \text{ mL} \times 0.943 \text{ g/mL} = 4.5264 \text{ g}$$

$$(0.166 \text{ 6 fl oz} \times 0.0618 \text{ lb/fl oz} = 0.010 \text{ lb})$$

In this example, the 1 g (0.002 lb) scale division is smaller than the MAV/6 value of 4.5264 g (0.010 lb) so the scale is suitable for making a density determination.

- A partial immersion thermometer (or equivalent) with a range of $-35\text{ }^{\circ}\text{C}$ to $+50\text{ }^{\circ}\text{C}$ ($30\text{ }^{\circ}\text{F}$ to $120\text{ }^{\circ}\text{F}$), at least $1\text{ }^{\circ}\text{C}$ ($1\text{ }^{\circ}\text{F}$) graduations, and with a tolerance of $\pm 1\text{ }^{\circ}\text{C}$ ($\pm 2\text{ }^{\circ}\text{F}$).
- Volumetric measures

Example: When checking packages labeled in SI units, flask sizes of 100 mL, 200 mL, 500 mL, 1 L, 2 L, 4 L, and 5 L and a 50 mL cylindrical graduate with 1 mL divisions may be used. When checking packages labeled in inch-pound units the use of measuring flasks and graduates with capacities of gill, half-pint, pint, quart, half-gallon, gallon, and a 2 fl oz cylindrical graduate, graduated to $\frac{1}{2}$ fl dr is recommended.

- Defoaming agents may be necessary for testing liquids such as beer and soft drinks that effervesce or are carbonated. Two such products are Hexanol or Octanol (Capryl Alcohol*).

***Note:** The mention of trade or brand names does not imply that these products are endorsed or recommended by the U.S. Department of Commerce over similar products commercially available from other manufacturers.

- Bubble level at least 15.24 cm (6 in) in length
- Stopwatch

Test Procedure

Steps:

1. Follow Section 2.3.1. "Define the Inspection Lot." Use a "Category A" sampling plan in the inspection. Select a random sample; then use the following procedure to determine lot compliance.

Steps:

2. Bring the sample packages and their contents to the reference temperature as specified in Table 3-1. "Reference Temperatures for Liquids." To determine if the liquid is at its reference temperature, immerse the thermometer in the liquid before starting the test. Verify the temperature again immediately after the flask and liquid is weighed. If the product requires mixing for uniformity, mix it before opening in accordance with any instructions specified on the package label. Shaking liquids, such as flavored milk, often entraps air that will affect volume measurements, so use caution when testing these products. Often, less air is entrapped if the package is gently rolled to mix the contents.
3. For milk, select a volumetric measure equal to or one size smaller than the label declaration. For all other products, select a volumetric measure that is one size smaller than the label declaration.
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Example: *If testing a 1 L bottle of juice or a soft drink, select a 500 mL volumetric measure.*

Note: When determining the density of milk, if the product from the first container does not fill the volumetric measure to the nominal capacity graduation, product may be added from another container as long as product integrity is maintained (i.e., brand, identity, lot code, and temperature).

4. Prepare a clean volumetric measure to use according to the following procedures:
 - Because flasks are ordinarily calibrated on a "to deliver" basis, they must be "wet down" before using. Immediately before use, fill the volumetric flask(s) or graduate with water. The water should be at the reference temperature of the product being tested. Fill the flask(s) with water to a point slightly below the top graduation on the neck. The flask should be emptied in 30 seconds (± 5 seconds). Tilt the flask gradually so the flask walls are splashed as little as possible as the flask is emptied. When the main flow stops, the flask should be nearly inverted. Hold the flask in this position for 10 seconds more and touch off the drop of water that adheres to the tip. If necessary, dry the outside of the flask. The flask or graduate is then ready to fill with liquid from a package. This is called the "wet down" condition.

Note: When using a volumetric measure that is calibrated "to contain," the measure must be dry before each measurement.

- If the liquid effervesces or foams when opened or poured (such as carbonated beverages), add two drops of a defoaming agent to the bottom of the flask before filling with the liquid. If working with a carbonated beverage, make all density determinations immediately upon placing the product into the standard. This reduces the chance of volume changes occurring from the loss of carbonization.

Steps:

5. If the flask capacity is equal to the labeled volume, pour the liquid into the volumetric measure tilting the package to a nearly vertical position. If the flask capacity is smaller than the package's labeled volume, fill the flask to its nominal capacity graduation. If conducting a volumetric test, drain the container into the flask for 1 minute after the stream of liquid breaks into drops.
6. Position the flask on a level surface at eye level. For clear liquids, place a material of some dark color outside the flask immediately below the level of the meniscus. Read the volume from the lowest point of the meniscus. For opaque liquids, read volume from the center top rim of the liquid surface.
7. Use the gravimetric procedure to determine the volume if the limit specified for the difference in density is not exceeded.
 - Select a volumetric measure equal to or one size smaller than the labeled volume (depending on the product) and prepare it as described in step 4 of this section. Then determine and record its empty weight.
 - Determine acceptability of the liquid density variation, using two packages selected for tare according to Section 2.3.5. "Tare Procedures" as follows:
 - Determine the gross weight of the first package.
 - Pour the liquid from the first package into a flask. Measure exactly to the nominal capacity marked on the neck of the measure.
 - Weigh the filled flask and subtract its empty weight to obtain the weight of the liquid. Determine density by dividing the weight of the liquid by the capacity of the flask.
 - Determine the weight of the liquid from a second package using the same procedure.
 - If the difference between the densities of the two packages exceeds one division, use the volumetric procedure in Section 3.3. "Volumetric Test Procedure for Liquids."
8. Determine the Average Used Dry Tare Weight of the sample according to provisions of Section 2.3.5. "Tare Procedures."
9. Calculate the Average Product Density by adding the densities of the liquid from the two packages and dividing the sum by two.
10. Calculate the "nominal gross weight" using the following formula if the flask capacity is equal to the labeled volume:

$$\text{Nominal Gross Weight} = (\text{Average Product Density [in weight units]}) + (\text{Average Used Dry Tare Weight})$$

Steps:

Note: If the flask size is smaller than the labeled volume, the following formula is used:

$$\text{Nominal Gross Weight} = (\text{Average Product Density} \times [\text{Labeled Volume/Flask Capacity}]) + (\text{Average Used Dry Tare Weight})$$

a. **How is “nominal gross weight” determined?**

Determine the “nominal gross weight” as follows:

Steps:

1. Determine the Average Used Dry Tare Weight of the sample according to provisions of Section 2.3.5. “Tare Procedures.”
2. Calculate the Average Product Density by adding the densities of the liquid from the two packages and dividing the sum by two.
3. Calculate the “nominal gross weight” using the following formula if the flask capacity is equal to the labeled volume.

$$\text{Nominal Gross Weight} = (\text{Average Product Density [in weight units]} + (\text{Average Used Dry Tare Weight})) \times \text{Labeled Volume}$$

Note: If the flask size is smaller than the labeled volume, the following formula is used:

$$\text{Nominal Gross Weight} = (\text{Average Product Density} \times [\text{Labeled Volume/Flask Capacity}]) + (\text{Average Used Dry Tare Weight}).$$

b. **How are the errors in the sample determined?**

Steps:

1. Weigh the remaining packages in the sample.
2. Subtract the nominal gross weight from the gross weight of each package to obtain package errors in terms of weight. All sample packages are compared to the nominal gross weight.
3. To convert the average error or package error from weight to volume, use the following formula:

$$\text{Package Error in Volume} = \text{Package Error in Weight} / \text{Average Product Density Per Volume Unit of Measure}.$$

Evaluation of Results

Follow the procedures in Chapter 2, Section 2.3.7. “Evaluating Results” to determine lot conformance.

3.3. Volumetric Test Procedure for Liquids

a. **How is the volume of liquid contained in a package determined volumetrically?**

Follow steps 1 through 6 in Section 3.2. “Gravimetric Test Procedure for Liquids” for each package in the sample.

b. **How are the errors in the sample determined?**

Read the package errors directly from the graduations on the measure. The reference temperature must be maintained within ± 2 °C (± 5 °F) for the entire sample.

Evaluation of Results

Follow the procedures in Chapter 2, Section 2.3.7. “Evaluating Results” to determine lot conformance.

3.4. Other Volumetric Test Procedures

a. **What other methods can be used to determine the net contents of packages labeled by volume?**

Depending on how level the surface of the commodity is, use one of two headspace test procedures. Use the headspace test procedure in Section 3.4.b. to determine volume where the liquid has a level surface (e.g., oils, syrups, and other viscous liquids). Use the procedure in Section 3.4.c. to determine volume where the commodity does not have a level surface (e.g., mayonnaise and salad dressing).

Test Procedure

Before conducting any of the following volumetric test procedures follow Section 2.3.1. “Define the Inspection Lot.” Use a “Category A” sampling plan in the inspection; select a random sample; then use the following procedure to determine lot compliance.

Test Equipment

- Micrometer depth gage (ends of rods fully rounded) 0 mm to 225 mm (0 in to 9 in) or longer
- Level (at least 15 cm (6 in) in length)
- Laboratory pipets and/or buret
 - Class A 500 mL buret that conforms to ASTM E287-2(2007), “Standard Specification for Laboratory Glass Graduated Burets.”
 - Class A pipets, calibrated “to deliver” that conform to ASTM E969S-S02(2007), “Standard Specification for Glass Volumetric (Transfer) Pipets.”

- Volumetric measures
 - Water
 - Rubber bulb syringe
 - Plastic disks that are 3 mm ($\frac{1}{8}$ in) thick with diameters equal to the seat diameter or larger than the brim diameter of each container to be tested. The diameter tolerance for the disks is 50 μm (± 0.05 mm [± 0.002 in]). The outer edge should be smooth and beveled at a 30° angle with the horizontal to 800 μm (0.8 mm [$\frac{1}{32}$ in]) thick at the edge. Each disk must have a 20 mm ($\frac{3}{4}$ in) diameter hole through its center and a series of 1.5 mm ($\frac{1}{16}$ in) diameter holes 25 mm (1 in) apart around the periphery of the disk and 3 mm ($\frac{1}{8}$ in) from the outer edge. All edges must be smooth.
 - Stopwatch
 - Partial immersion thermometer (or equivalent) with 1°C (2 °F) graduations and a range of – 35 °C to + 50 °C (– 30 °F to + 120 °F) accurate to $\pm 1^\circ\text{C}$ ($\pm 2^\circ\text{F}$)
- b. **How is the volume of oils, syrups, and other viscous liquids that have smooth and level surfaces determined?**

Note: Make all measurements on a level surface.

Steps:

1. Bring the temperature of both the liquid and the water to be used to measure the volume of the liquid to the reference temperature specified in Table 3-1. “Reference Temperatures for Liquids.” Verify with a thermometer that product has maintained the reference temperature.
2. Measure the headspace of the package at the point of contact with the liquid using a depth gauge with a fully rounded, rather than a pointed, rod end. If necessary, support the package to prevent the bottom of the container from distorting.
3. Empty, clean, and dry the package.
4. Refill the container with water measured from a volumetric standard to the original liquid headspace level measured in step 2 of this section until the water touches the depth gauge.
5. Determine the amount of water used in step 4 of this section to obtain the volume of the liquid and calculate the “package error” based on that volume.

Evaluation of Results

Follow the procedures in Section 2.3.7. “Evaluating Results” to determine lot conformance.

c. How is the volume of mayonnaise and salad dressing, and water immiscible products that do not have smooth and level surfaces determined?

Use the volumetric headspace procedure described in this section to determine volume when the commodity does not have a level surface (e.g., mayonnaise, salad dressing, and other water immiscible products without a level liquid surface). The procedure guides the inspector to determine the amount of headspace above the product in the package and the volume of the container. Determine the product volume by subtracting the headspace volume from the container volume. Open every package in the sample.

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Note: Make all measurements on a level surface.

Steps:

1. Bring the temperature of both the commodity and the water used to measure the volume to the appropriate temperature designated in Table 3-1. “Reference Temperatures for Liquids.”
2. Open the first package and place a disk larger than the package container opening over the opening.
3. Measurement Procedure
 - Deliver water from a flask (or flasks), graduate, or buret, through the central hole in the disk onto the top of the product until the container is filled. If it appears that the contents of the flask may overflow the container, do not empty the flask. Add water until all of the air in the container has been displaced and the water begins to rise in the center hole of the disk. Stop the filling procedure when the water fills the center disk hole and domes up slightly due to the surface tension. Do not add additional water after the level of the water dome has dropped.
 - If the water dome breaks on the surface of the disk, the container has been overfilled and the test is void; dry the container and start over.
4. To obtain the headspace capacity, record the volume of water used to fill the container and subtract 1mL (0.03 fl oz), which is the amount of water held in the hole in the disk specified.
5. Empty, clean, and dry the package container.
6. Using steps 3 and 4 of this section. Refill the package container with water measured from a volumetric measure to the maximum capacity of the package, subtract 1 mL (0.03 fl oz), and record the amount of water used as the container volume; and
7. From the container volume determined in step 6 of this section, subtract the headspace capacity in step 4 of this section to obtain the measured volume of the product and calculate the “package error” for that volume where “package error” equals labeled volume minus the measured volume of the product.

Evaluation of Results

Follow the procedures in Section 2.3.7 “Evaluating Results” to determine lot conformance.”

3.5. Goods Labeled by Capacity – Volumetric Test Procedure

a. **What type of measurement equipment is needed to perform the headspace test procedures?**

Use the test equipment in Section 3.4. “Other Volumetric Test Procedures” (except for the micrometer depth gage) to perform these test procedures.

b. **How do you determine if goods labeled by capacity meet the average and individual requirements?**

Note: Make all measurements on a level surface.

Steps:

1. Before conducting any of the following volumetric test procedures, refer to Section 2.3.1. “Define the Inspection Lot.” Use a “Category A” sampling plan in the inspection; select a random sample; then use the following test procedure to determine lot compliance.
2. When testing goods labeled by capacity, use water at a reference temperature of $20\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$ ($68\text{ }^{\circ}\text{F} \pm 5\text{ }^{\circ}\text{F}$).
3. Select a sample container and place a disk larger than the container opening over the opening.
4. Measurement Procedure
 - Add water to the container using flask (or flasks), graduate, or buret corresponding to labeled capacity of the container. If it appears that the contents of the flask may overflow the container, do not empty the flask. Add water until all of the air in the container has been displaced and the water begins to rise in the center hole of the disk. Stop filling the container when the water fills the center disk hole and domes up slightly due to the surface tension.
 - If the water dome breaks on the surface of the disk, the container has been overflowed and the test is void; dry the container and start over.
 - Record the amount of water used to fill the container and subtract 1 mL (0.03 fl oz) (this is the amount of water held in the hole in the disk specified) to obtain the total container volume.
5. Test the other containers in the sample according to in step 4 of this procedure.

Steps:

6. To determine package errors, subtract the total container volume obtained in steps 4 and 5 of this section from the labeled capacity of the container.

Evaluation of Results

Follow the procedures in Section 2.3.7. “Evaluating Results” to determine lot compliance.

3.6. Pressed and Blown Glass Tumblers and Stemware

- a. **What requirements apply to pressed and blown glass tumblers and stemware?**

This handbook provides a tolerance to the labeled capacity of glass tumblers and stemware. The average requirement does not apply to the capacity of these products. See Table 3-2. “Allowable Differences for Pressed and Blown Glass Tumblers and Stemware.”

- b. **How is it determined if tumblers and stemware meet the individual package requirement?**

Follow Section 2.3.1. “Define the Inspection Lot” and determine which sampling plan to use in the inspection, select a random sample, and then use the volumetric test procedure to determine container capacity and volume errors.

- c. **What type of measuring equipment is needed to perform the test procedures?**

Use the equipment specified in Section 3.4. “Other Volumetric Test Procedures,” (except for the micrometer depth gage) to perform these test procedures.

- d. **What are the steps of the test procedure?**

Follow steps 1 through 7 in Section 3.5.b. “Goods Labeled by Capacity – Volumetric Test Procedure.”

- e. **How is it determined if the samples conform to the allowable difference?**

Compare the individual container error with the allowable difference that applies in Table 3-2. “Allowable Differences for Pressed and Blown Glass Tumblers and Stemware.” If a package contains more than one container, all of the containers in the package must meet the allowable difference requirements in order for the package to pass.

Table 3-2. Allowable Differences for Pressed and Blown Glass Tumblers and Stemware	
Unit of Measure	
If the capacity in metric units is:	The allowable difference is:
200 mL or less	± 10 mL
More than 200 mL	± 5 % of the labeled capacity
If the capacity in inch-pound units is:	Then the allowable difference is:
5 fl oz or less	± ¼ fl oz
More than 5 fl oz	± 5 % of the labeled capacity

Evaluation of Results

Count the packages in the sample with volume errors greater than the allowable difference and compare the resulting number with the number given in Column 3. (Table 2-11, Appendix A)

- If the number of containers in the sample with errors exceeding the allowable difference exceeds the number allowed in Column 3, the lot fails.
- If the number of packages with errors exceeding the allowable difference is less than or equal to the number in Column 3, the lot passes.

Note: The average capacity error is not calculated because the lot passes or fails based on the individual volume errors. Act on the individual units containing errors exceeding the allowable difference individually even though the lot passes the requirement.

3.7 Volumetric Test Procedure for Paint, Varnish, and Lacquers – Non-aerosol

a. How is the volume of paint, varnish, and lacquers contained in a package determined?

Use one of three different test methods depending upon the required degree of accuracy and the location of the inspection. The procedures include both retail and in-plant audits, and a “possible violation” method that is designed for laboratory or in plant use because of cleanup and product collection requirements. The procedures are suitable to use with products labeled by volume and packaged in cylindrical containers with separate lids that can be resealed.

Test Equipment

- A scale that meets the requirements in Section 2.2. “Measurement Standards and Test Equipment”
- Volumetric measures
- Micrometer depth gage (ends of rods fully rounded), 0 mm to 225 mm (0 in to 9 in)
- Diameter (Pi) tape measure, 5 cm to 30 cm (2 in to 12 in)

- Spanning bar, 2.5 cm by 2.5 cm by 30 cm or (1 in by 1 in by 12 in)
- Rule, 30 cm (12 in)
- Paint solvent or other solvent suitable for the product being tested
- Cloth, 30 cm (12 in) square
- Wood, 5 cm (2 in) thick, by 15 cm (6 in) wide, by 30 cm (12 in) long
- Rubber mallet
- Metal disk, 6.4 mm ($\frac{1}{4}$ in) thick and slightly smaller than the diameter of package container bottom
- Rubber spatula
- Level at least 15 cm (6 in) in length
- Micrometer (optional)
- Stopwatch

Test Procedures

Note: When instructed to record a measurement in a column, refer to the numbered columns in the “Audit Worksheet for Checking Paint” in this section.

Steps:

1. Select a random sample. A tare sample is not needed.
2. For containers less than 4 L or (1 gal):
 - Measure the outside diameter of each container near its middle to the closest 0.02 mm (0.001 in).
 - Use a diameter tape measure to record the measurements in Column 3.
 - Place the containers on a level surface and using the micrometer depth gage, record their heights in Column 1 on the worksheet.
 - If the range of outside diameters exceeds 0.125 mm (0.005 in) or the range in heights exceeds 1.58 mm (0.062 5 in), do not use this procedure. If the ranges are within the specified limits, weigh all cans in the sample, select the container with the lightest gross weight, and remove its lid. Continue with step 4 below.

Steps:

3. For 4 L (1 gal) containers:
 - Gross weigh each package in the sample.
 - Select the package with the lightest gross weight and remove its lid.
4. Use a direct reading diameter tape measure to measure the outside diameter of the selected container near its top, middle (already measured if step 2 was followed), and bottom to the closest 0.02 mm (0.001 in). Record these measurements in Columns 2, 3, and 4. Add the three diameter values and divide by three to obtain the average diameter and record this value in Column 5.
5. If a micrometer is available, measure the wall and the paper label thickness of the container; otherwise, assume the wall and label thicknesses given in Table 3-3. “Thickness of Paint Can Walls and Labels” below:

Subtract twice the thickness of the wall of the can and paper label from the average can diameter (step 4) to obtain the average liquid diameter. Record the liquid diameter in Column 6.

6. On a level surface, place the container on the circular metal disk that is slightly smaller in diameter than the lower rim of the can so the bottom of the container nests on the disk to eliminate any “sag” in the bottom of the container.
7. Place the spanning bar and depth gage across the top of the paint can and mark the location of the spanning bar on the rim of the paint container. Measure the distance to the liquid level, to the nearest 20 μm (0.02 mm) (0.001 in), at three points in a straight line. Take measurements at points approximately 1 cm ($\frac{3}{8}$ in) from the inner rim for cans 12.5 cm (5 in) in diameter or less (and at 1.5 cm [$\frac{1}{2}$ in] from the rim for cans exceeding 12.5 cm [5 in]) in diameter and at the center of the can. Add the three readings and divide by three to obtain the average distance to the liquid level in the container. Record the average distance to the liquid level in Column 7.
8. Measure the distance to the bottom of the container at three points in a straight line in the same manner as outlined in step 7. Add the three readings and divide by three to obtain the average height of the container and record it in Column 8.
9. Subtract the average distance to the liquid level (Column 7) from the average height of the container (Column 8) to obtain the average height of the liquid column and record it in Column 9.
10. Determine the volume of paint in the container by using the following formula:

$$Volume = 0.7854 D^2 H$$

Where D = average liquid diameter (Column 6) and
H = average liquid height (Column 9)

Steps:

11. Record this value in Column 10. If the calculated volume is less than labeled volume, go to the Section 3.8.1. “Violation Procedure”.

Table 3-3. Thickness of Paint Can Walls and Labels	
Can Size	Wall Thickness
4 L (1 gal)	250 μm (0.25 mm) [0.010 in]
2 L (½ gal)	
1 L (1 qt)	230 μm (0.23 mm) [0.009 in]
500 mL (1 pt)	
250 mL	200 μm (0.20 mm) [0.008 in]
Label Thickness* for all can sizes: 100 μm (0.10 mm) [0.004 in] (*Paper only – ignore labels lithographed directly onto the container)	

Note: Use the following format to develop worksheets to perform audits and determine the volume when checking paint. Follow the procedure and it will indicate the column in which the various measurements made can be recorded.

Example: Audit Worksheet for Checking Paint (add additional rows as needed)									
1. Can Height	Can Diameter				6. Avg. Liquid Diameter	7. Avg. Liquid Level	8. Avg. Container Depth	9. Avg. Liquid Depth	10. Volume¹
	2. Top	3. Middle	4. Bottom	5. Average					

¹10. Volume = 0.7854 x 6 x 6 x 9

b. What test procedure is used to conduct a retail audit test?

Conduct a retail audit using the following test procedure that is suitable for checking cylindrical containers up to 4 L (1 gal) in capacity. Use step 2 in the retail audit test procedure with any size container except 4 L (1 gal), but step 3 must be used for containers with capacities of 4 L (1 gal). The method determines the volume of a single can in the sample selected as most likely to contain the smallest volume of product. Do not empty any containers because only their critical dimensions are being measured.

c. How accurate is the dimensional test procedure?

The configuration of the bottom of the can, paint clinging to the lid, and slight variations in the wall and label thicknesses of the paint container may produce an uncertainty estimated to be at least 0.6 % in this auditing procedure. Therefore, this method is recommended solely to eliminate from more rigorous testing those packages that appear to be full measure. Use the violation procedures when the volume determined in step 10 is less than the labeled volume or in any case where short measure is suspected.

d. How is an in-plant audit conducted?

Use the following procedures to conduct an in-plant audit inspection. This method applies to a container that probably contains the smallest volume of product. Duplicate the level of fill with water in a can of the same dimensions as the one under test. Use this method to check any size of package if the liquid level is within the measuring range of the depth gage. If any paint is clinging to the sidewall or lid, carefully scrape the paint into the container using a rubber spatula.

Note: When instructed to record a measurement in a column, refer to the numbered columns in the “Audit Worksheet for Checking Paint” in the Test Procedure of this section (3.7.).

Steps:

1. Follow steps 1 through 6 of the retail audit test in Section 3.7.b.
2. Place the spanning bar and depth gage across the top of the paint can. Measure the liquid level at the center of the surface and record the level in Column 7.
3. Select an empty can with the same bottom configuration as the container under test and with a diameter and height equal to that of the container under test within plus or minus the following tolerances:
 - a. For 500 mL or (1 pt) cans – within 25 μm (0.025 mm) (0.001 in)
 - b. For 1 L or (1 qt) cans – within 50 μm (0.05 mm) (0.002 in)
 - c. For 2 L or ($\frac{1}{2}$ gal) cans – within 75 μm (0.075 mm) (0.003 in)
 - d. For 4 L or (1 gal) cans – within 100 μm (0.1 mm) (0.004 in)
4. Set the empty can on a level work surface with a circular metal disk that is slightly smaller in diameter than the bottom can rim underneath the can to eliminate sag. Set up the spanning bar and depth gage as in step 2 above. Fill the container with water from a volumetric measure of the same volume as the labeled volume. Measure the distance to the liquid level at the center of the container and record this level in Column 7 below the reading recorded in step 2. If this distance is equal to or greater than the distance determined in step 2, assume that the package is satisfactory. If the distance is less than the distance determined in step 2, the product may be short measure. When the audit test indicates that short measure is possible use the “Violation Procedure” in Section 3.7.1.

(Amended 2010)

3.7.1. Violation Procedure

a. How is it determined if the containers meet the package requirements?

Use the following method if the liquid level is within the measuring range of the micrometer.

Note: Do not shake or invert the containers selected as the sample.

Steps:

1. The first step is to follow Section 2.3.1. “Define the Inspection Lot” to determine which “Category A” sampling plan to use; select a random sample; and then use the following procedure. The steps noted with an (*) are required if there is paint adhering to the lid and it cannot be removed by scraping into the can.
2. Determine the gross weight of these packages and record in Column 2 of the “Example Worksheet for Possible Violation in Checking Paint” worksheet. (in this section).
3. Record the labeled volume of the first tare sample package in Column 1 of the worksheet. Use a circular metal disk to eliminate can “sag” and remove the lid. If paint clings to the lid of the container, scrape it off with a spatula
- 4.* If paint that adheres to the lid cannot be completely removed by scraping the paint into the can, determine the weight of the lid plus any adhering paint. Clean the paint lid with solvent and weigh again. Subtract the clean lid weight from the lid weight with paint to determine the weight of the paint adhering to the lid. Record this weight in Column 3.
5. Place the spanning bar and depth gage across the top of the paint can. Mark the location of the spanning bar on the rim of the paint container. Measure the distance to the liquid level at the center of the container to the nearest 20 μm (0.02 mm) (0.001 in). Record the distance in Column 4.
6. Empty and clean the sample container and lid with solvent; dry and weigh the container and lid. Record the tare weight in Column 5.
7. Set up the container in the same manner as in step 2.
8. Place the spanning bar at the same location on the rim of the paint container as marked in step 5. With the depth gage set as described in step 5, deliver water into the container in known amounts until the water reaches the same level occupied by the paint as indicated by the depth gage. Record this volume of water (in mL or fl oz) in Column 6 of the worksheet. This is the volume occupied by the paint in the container. Follow steps, 9a, 10a, and 11a if scraping does not remove the paint from the lid. In order to determine if gravimetric testing can be used to test the other packages in the sample, follow only steps 9, 10, and 11 when no paint adheres to the lid.
9. Subtract the weight of the container (Column 5) from the gross weight (Column 2) to arrive at the net weight of paint in the selected container. Record the net weight in Column 7 of the worksheet.

Steps:

9a.* Subtract the weight of the container (Column 5) and the weight of product on the lid (Column 3) from the gross weight (Column 2) to arrive at the net weight of paint in the container. Record in Column 7 (excluding the weight of the paint on the lid).

10. Calculate the weight of the labeled volume of paint (for the first package opened for tare).

$$\text{net weight (Column 7)} \times \text{labeled volume (Column 1)} \div \text{volume of paint in can (Column 6)}$$

Record this value in Column 8.

10a.* Calculate the package volume =

$$\frac{\text{volume in can (Column 6)} + (\text{lid paint weight [Column 3]} \times \text{volume in can [Column 6]} \div \text{net weight [Column 7]})}{\text{volume in can [Column 6]} \div \text{net weight [Column 7]}}$$

Record it in Column 9 of the worksheet.

11. Calculate the package error. Use the following formula if paint does not adhere to the lid.

$$\text{Package error} = (\text{Column 6 value}) - (\text{labeled volume})$$

11a.* Use the following formula if paint does adhere to the lid and will not come off by scraping.

$$\text{Package error} = (\text{Column 9 value}) - (\text{labeled volume})$$

12. Repeat steps 2 through 11 for the second package chosen for tare.

Example Worksheet for Possible Violation in Checking Paint (add additional rows as needed)								
1. Labeled Volume	2. Gross Weight	3. Lid Paint Weight (Wet - Dry)	4. Liquid Level	5. Tare	6. Water Volume	7. Net Wt. = 2 - 5	8. Weight of Labeled Volume = 7 x 1 ÷ 6	9. Package Volume = 6 + [(3 ÷ 7) x 6]

b. When can a gravimetric procedure be used?

A gravimetric procedure is used if the weights of the labeled volume for the first two packages do not differ from each other by more than one division on the scale (if they meet this criterion, check the rest of the sample gravimetrically and record in Column 8).

c. How is “nominal gross weight” determined?

Use Section 2.3.6. to determine the “Nominal Gross Weight” as follows:

The nominal gross weight equals the sum of the average weight of the labeled volume (average of values recorded in Column 8) plus the average tare (average of values recorded in Column 3) for the packages selected for tare. Note that the weight of a given volume of paint often varies considerably from container to container; therefore, volumetric measurements may prove necessary for the entire sample.

Evaluation of Results

Follow the procedures in Section 2.3.7. “Evaluating Results” to determine lot conformance.

3.8. Testing Viscous Materials – Such As Caulking Compounds and Pastes

a. How are viscous materials such as caulking compounds and paste tested?

Use the following procedure for any package of viscous material labeled by volume. It is suitable for very viscous materials such as cartridge-packed caulking compounds, glues, pastes, and other similar products. It is best to conduct this procedure in a laboratory using a hood to ventilate solvent fumes. If used in the field, use in a well ventilated area. Except for the special measurement procedures to determine the weight of the labeled volume, this procedure follows the basic test procedure.

Steps:

1. For each weight of a known volume determination, pack a portion of the packaged product into a pre-weighed cup of known volume (called a “density cup” or “pycnometer”) and weigh.
2. From the weight of the known volume, determine the weight of the labeled volume.
3. Compare the nominal gross weight with the gross weight to determine the package error.

b. What type of measurement equipment is needed to test packages of caulk, pastes, and glues?

- A scale that meets the requirements in Section 2.2. “Measurement Standards and Test Equipment.”
- Pycnometer, a vessel of known volume used for weighing semifluids. The pycnometer can be bought or made. If it is made, refer to it as a “density cup.” To make a 150 mL or 5 fl oz density cup, cut off the lip of a 150 mL beaker with an abrasive saw and grind the lip flat on a lap wheel. The slicker plate is available commercially. The metrology laboratory should calibrate the density cup gravimetrically with respect to the contained volume using the procedure in ASTM E542-01 (2007), “Standard Practice for Calibration of Laboratory Volumetric Apparatus.”

- Appropriate solvents (water, Stoddard solvent, kerosene, alcohol, etc.)
 - Caulking gun (for cartridge packed products)
- c. **How is a pycnometer prepared for use?**

Before using, the metrology laboratory should calibrate the pycnometer (or the density cup and slicker plate) with respect to volume (mL or fl oz). If applicable, comply with any special instructions furnished by the manufacturer to calibrate a pycnometer that has not been calibrated. It is not necessary to reweigh or recalibrate for each test; however, mark the pieces of each unit to prevent interchange of cups and slicker plates.

- d. **How is it determined if the containers meet the package requirements?**

Steps:

Follow the procedures in Section 2.3.1. “Define the Inspection Lot.” Use a “Category A” sampling plan in the inspection; select a random sample; then, use the following procedure to determine lot compliance.

1. Weigh a calibrated pycnometer and slicker plate and record as “pycnometer weight” and record the volume of the pycnometer.
2. Determine the gross weight of the first package and record the weight value. Open the package and transfer the product to the pycnometer by filling it to excess. Use a caulking gun to transfer product from the caulking cartridges. If using a pycnometer, cover it with a lid and screw the cap down tightly. Excess material will be forced out through the hole in the lid, so the lid must be clean. If using a density cup, place the slicker plate over $\frac{3}{4}$ of the cup mouth, press down and slowly move the plate across the remainder of the opening. With the slicker plate in place, clean all the exterior surfaces with solvent and dry.
3. Completely remove the product from the package container; clean the package container with solvent; dry and weigh it to determine the tare weight.
4. Weigh the filled pycnometer or filled density cup with slicker plate and record this weight. Subtract the weight of the empty pycnometer from the filled weight to determine the net weight of the product contained in the pycnometer and record this weight.
5. Clean the pycnometer and repeat steps 3, 4, and 5 for the second package in the tare sample.

Determine acceptability of the density variation on the two packages selected for tare. If the difference between the densities of both packages exceeds one division of the scale, do not use the gravimetric procedure to determine the net quantity of contents. Instead, use the procedure in steps 8 and 9.

Note: If the gravimetric procedure can be used, perform steps 8 and 10.

Steps:

6. Calculate the weight of product corresponding to the labeled volume of product according to the following formula:

$$\begin{aligned} & \text{Product Density} \times \text{Labeled Volume} = \text{Labeled Weight} \\ & \text{Weight of Product in Pycnometer} \div \text{Pycnometer Volume} = \text{Product Density} \end{aligned}$$

7. Test each package individually by determining the product density in each package using the pycnometer and record the gross, tare, and net weight of each package. Subtract the weight of the labeled volume (determined for each package) from the net weight of product to arrive at each individual package error in units of weight.
8. Convert the package errors to units of volume using the following formula:

$$\begin{aligned} & \text{Package Error (volume)} = \\ & (\text{Package Error [weight]} \times \text{Pycnometer Volume}) \div (\text{Weight of Product in Pycnometer}) \end{aligned}$$

9. Record the package errors on the report form, using an appropriate unit of measure.

Evaluation of Results

Follow the procedures in Section 2.3.7. “Evaluating Results” to determine lot conformance.

3.9. Peat Moss

- a. How are packages of peat and peat moss labeled by compressed volume tested?

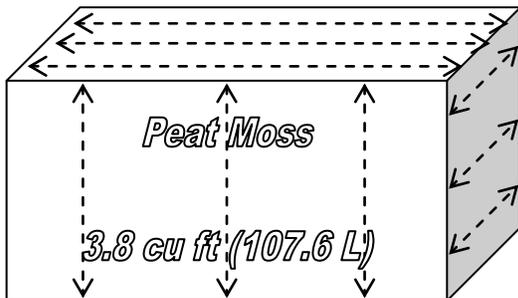


Figure 3-1. Peat Moss

Steps:

1. Measure the dimensions of the compressed material to determine if it contains the labeled quantity.
2. Take three measurements (both ends and middle) of each dimension and calculate their average.
3. Multiply the averages to obtain the compressed cubic volume.

4. For each dimension (length, width, and height) take three equidistant measurements, take the average of each respective dimension and multiply to determine the cubic measure as follows:

$$\text{Average height} \times \text{average width} \times \text{average length} = \text{cubic measurement}$$

5. Compare measured volume with labeled volume to determine package error.
(Amended 2010)

b. How are packages of peat and peat moss labeled by uncompressed volume tested?

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

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 ft³) 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 ft³) 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)

Test Procedure

Steps:

1. Follow Section 2.3.1. "Define the Inspection Lot." Use a "Category A" sampling plan in the inspection; select a random sample; then, use the following procedure to determine lot compliance.
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

Steps:

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 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.

Evaluation of Results

Follow the procedures in Section 2.3.7. “Evaluating Results” to determine lot conformance.

3.10. Mulch and Soils Labeled by Volume

a. What products are defined as mulch and soil?

- Mulch is defined as “any product or material except peat or peat moss that is advertised, offered for sale, or sold for primary use as a horticultural, above-ground dressing, for decoration, moisture control, weed control, erosion control, temperature control, or other similar purposes.”
- Soil is defined as “any product or material, except peat or peat moss that is advertised or offered for sale, or sold for primary use as a horticultural growing media, soil amendment, and/or soil replacement.”

b. What type of measurement equipment is needed to test packages of mulch and soil?

- A test measure appropriate for the package size that meets the specifications for test measures in Table 3-4. “Specifications for Test Measures for Mulch and Soils”
- Drop cloth/polyethylene sheeting for catching overflow of material
- Level (at least 15 cm [6 in] in length)

Table 3-4. Specifications for Test Measures for Mulch and Soils						
Nominal Capacity of Test Measure⁴	Actual Volume of the Measure⁴	Interior Wall Dimensions¹			Marked Intervals on Interior Wall³	Volume Equivalent of Marked Intervals
		Length	Width	Height²		
30.2 L (1.07 cu ft) for testing packages that contain less than 28.3 L (1 cu ft or 25.7 dry qt)	31.9 L (1.13 cu ft)	213.4 mm (8.4 in)	203.2mm (8 in)	736.6 mm (29 in)	12.7 mm (¹ / ₂ in)	524.3 mL (32 in ³)
28.3 L (1 cu ft)	28.3 L (1 cu ft)	304.8 mm (12 in)	304.8 mm (12 in)	304.8 mm (12 in)		1179.8 mL (72 in ³)
56.6 L (2 cu ft)	63.7 L (2.25 cu ft)	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)		
84.9 L (3 cu ft)	92 L (3.25 cu ft)	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)		

Measures are typically constructed of 1.27 cm (¹/₂ in) marine plywood. A transparent sidewall is useful for determining the level of fill, but must be reinforced if it is not thick enough to resist distortion. 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.

Notes

¹ Other interior dimensions are acceptable if the test measure approximates the configuration of the package under test and does not exceed a base configuration of the package cross-section.

²The height of the test measure may be reduced, but this will limit the volume of the package that can be tested.

³When lines are marked in boxes, they should extend to all four 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 mulch is at or near the MAV.

⁴The Nominal Capacity is given to identify the size of packages that can be tested in a single measurement using the dry measure with the listed dimensions. It is based on the most common package sizes of mulch in the marketplace. If the measures are built to the dimensions shown above the actual volume will be larger than the nominal volume so that plus errors (overflow) can be measured accurately.

(Amended 2010)

c. **How is it determined if the packages meet the package requirements?**

Use the following procedure:

Steps:

1. Follow the Section 2.3.1. “Define the Inspection Lot.” Use a “Category A” sampling plan in the inspection, and select a random sample, then use the following procedure to determine lot conformance.
2. Open each package in turn. Empty the contents of the package into a test measure and level the contents by hand. Do not rock, shake, drop, rotate, or tamp the test measure. Read the horizontal marks to determine package net volume.

Note: Some types of mulch are susceptible to clumping and compacting. Take steps to ensure that the material is loose and free flowing when placed into the test measure. Gently roll the bag before opening to reduce the clumping and compaction of material.

3. Exercise care in leveling the surface of the mulch/soil and determine the volume reading from a position that minimizes errors caused by parallax.

d. **How are package errors determined?**

Determine package errors by subtracting the labeled volume from the package net volume in the measure. Record each package error.

$$\text{Package Error} = \text{Package Net Volume} - \text{Labeled Volume}$$

Evaluation of Results

Follow the procedures in Section 2.3.7. “Evaluating Results” to determine lot conformance.

Note: In accordance with Appendix A, Table 2-10. Exceptions to the Maximum Allowable Variations for Textiles, Polyethylene Sheeting and Film, Mulch and Soil Labeled by Volume, Packaged Firewood and Packages Labeled by Count with 50 Items or Fewer, apply an MAV of 5 % of the declared quantity to mulch and soil sold by volume. When testing mulch and soil with a net quantity in terms of volume, one package out of every 12 in the sample may exceed the 5 % MAV (e.g., one in a sample of 12 packages; two in a sample of 24 packages; four in a sample of 48 packages). However, the sample must meet the average requirement of the “Category A” Sampling Plan.

3.11. Ice Cream Novelties

Note: The following procedure can be used to test packaged products that are solid or semisolid and that will not dissolve in, mix with, absorb, or be absorbed by the fluid into which the product will be immersed. For example, ice cream labeled by volume can be tested using ice water or kerosene as the immersion fluid.

Exception: Pelletized ice cream is beads of ice cream which are quick frozen with liquid nitrogen. The beads are relatively small, but can vary in shape and size. On April 17, 2009, the FDA issued a letter

stating that this product is considered semisolid food, in accordance with 21 CFR 101.105(a). The FDA also addresses that the appropriate net quantity of content declaration for pelletized ice cream products be in terms of net weight.

(Added 2010)

a. **How are ice cream novelties inspected to see if the labeled volume meets the package requirements?**

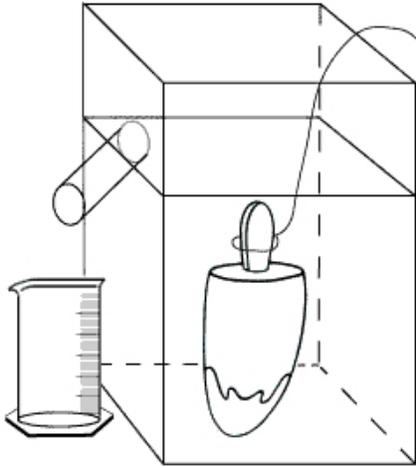
Use the following volume displacement procedure that uses a displacement vessel specifically designed for ice cream novelties such as ice cream bars, ice cream sandwiches, or cones. The procedure determines the volume of the novelty by measuring the amount of water displaced when the novelty is submerged in the vessel. Two displacements per sample are required to subtract the volume of sticks or cups.

The procedure first determines if the densities of the novelties are the same from package to package (in the same lot) so that a gravimetric test can be used to verify the labeled volume. If a gravimetric procedure is used, compute an average weight for the declared volume from the first two packages and weigh the remainder of the sample. If the gravimetric procedure cannot be used, use the volume displacement procedure for all of the packages in the sample.

Test Equipment

- A scale that meets the requirements in Section 2.2. “Measurement Standards and Test Equipment”
- Volumetric measures
- Displacement vessel with dimensions that is appropriate for the size of novelties being tested. Figure 3-2, *Example of a Displacement Vessel* shows an example of a displacement vessel. It includes an interior baffle that reduces wave action when the novelty is inserted and the downward angle of the overflow spout reduces dripping. Other designs may be used.

Figure 3-2. Example of a Displacement Vessel



Note: This displacement vessel can be constructed or similar devices may be obtained from any laboratory equipment or science education suppliers. The U.S. Department of Commerce does not endorse or recommend any particular device over similar commercially available products from other manufacturers.

- Thin wire, clamp, or tongs
 - Freezer or ice chest and dry ice
 - Single-edged razor or sharp knife (for sandwiches only)
 - Ice water/kerosene maintained at 1 °C (33 °F) or below
-
- Indelible marker (for ice pops only)
 - Level, at least 15.24 cm (6 in) in length
 - A partial immersion thermometer (or equivalent) with a range of – 1 °C to + 50 °C (30 °F to 120 °F), at least 1 °C (1 °F) graduations, and with a tolerance of ± 1 °C (± 2 °F)
 - A table-top, laboratory-type jack of sufficient size to hold the displacement vessel
 - Stopwatch

Test Procedure

Steps:

1. Follow the procedures in Section 2.3.1. “Define the Inspection Lot.” Use a “Category A” sampling plan in the inspection; select a random sample; then use the following steps to determine lot compliance.
2. Maintain the samples at the reference temperature for frozen products that is specified in Table 3-1. “Reference Temperatures for Liquids” (i.e., – 18 °C [0 °F]). Place the samples in the freezer or ice chest until they are ready to be tested, and then remove packages from the freezer one at a time.
3. According to the type of novelty, prepare the sample products as follows:
 - **Ice-pop.** Mark on the stick(s) with the indelible marker the point to which the pop will be submerged in the ice water. (After the ice-pop contents have been submerged, remove the novelty to determine the volume of the stick.)
 - **Cone.** Make a small hole in the cone below the ice cream portion to allow air to escape.
 - **Sandwich.** Determine whether the declared volume is (a) the total volume of

Steps:

the novelty (that is, including the cookie portion) or (b) the volume of the ice-cream-like portion only. If the declared volume is the volume of only the ice-cream-like portion, shave off the cookie with a razor or knife, leaving some remnants of cookie to ensure that no ice cream is accidentally shaved off. Work quickly, and return the novelty to the freezer before the sandwich softens.

- **Cup.** Remove the cap from the cup. (After the cup and novelty contents have been submerged, remove the novelty from the cup to determine the volume of the cup.)

b. How is it determined if the ice cream novelty packages meet the requirements in this handbook?

Steps:

1. Follow Section 2.3.1. “Define the Inspection Lot.” Use a “Category A” sampling plan in the inspection; select a random sample; then use the following procedure to determine lot compliance.
2. Fill the displacement vessel with ice water until it overflows the spout. Allow it to sit until dripping stops. Raise the displacement vessel as necessary and place the graduate beneath the spout.
3. Remove a package from the freezer, determine its gross weight and record it.
4. Submerge the novelty as suggested until it is below the surface level of the water.
 - **Ice-pop.** Use a clamp, tongs, or your fingers to hold the stick(s) and submerge the pop to the level marked in step 3 of the Test Procedures.
 - **Cone.** Shape the wire into a loop, and use it to push the cone, headfirst (ice cream portion first) into the ice water. Do not completely submerge the cone immediately: let water fill the cone through the hole made in step 3 of the Test Procedures before completely submerging the novelty.
 - **Sandwich or cup.** Skewer the novelty with the thin wire or form a loop on the end of the wire to push the sandwich or ice-cream portion or cup completely below the liquid level.
5. Record the total water volume in the graduate. For a cone or sandwich, record the water volume as the net volume and go to step 8. For ice-pops or cups, record the water volume in the graduate as the gross volume and go to step 7.
6. Refill the displacement vessel with water to overflowing and reposition the empty graduate under the spout.
 - **Ice-pop.** Melt the ice pop off the stick or sticks. Submerge the stick or sticks to the line marked in step 5. Record the volume of tare material (i.e., stick) by measuring the water displaced into the graduate. The net volume for the ice-pop

Steps:

is the gross volume recorded in step 6 minus the volume of the tare materials in this step. Record this volume as the “volume of novelty.” To determine the error in the package, subtract the labeled quantity from the volume of novelty.

- **Cup.** Remove the novelty from the cup. Rinse the cup, and then submerge it in the displacement vessel. Small pinholes in the base of the cup can be made to make submersion easier. Record the volume of water displaced into the graduate by the cup as the volume of tare material. The net volume for the novelty is the gross volume determined in step 6 minus the volume of the tare materials determined in this step. Record this as the net volume of the novelty. To determine the error in the package, subtract the labeled quantity from the volume of novelty.

7. Clean and air-dry the tare materials (sticks, wrappers, cup, lid, etc.). Weigh and record the weight of these materials for the package.
8. Subtract the tare weight from the gross weight to obtain the net weight and record this value.
9. Compute the weight of the labeled volume for the package using the following formula and then record the weight:

$$\begin{aligned} \text{Product Density} &= (\text{gross weight in item 4}) \div (\text{the total water volume in step 6}) \\ \text{Weight of labeled volume} &= (\text{labeled volume}) \times (\text{Product Density}) \end{aligned}$$

10. Repeat steps 4 through 10 for a second package.
11. If the weight of the labeled volume in steps 11 and step 12 differ from each other by more than one division on the scale, the gravimetric test procedure cannot be used to test the sample for compliance. If this is the case, steps 3 through 7 for each of the remaining packages in the sample must be used to determine their net volumes and package errors. Then go to evaluation of results.

c. **How is “nominal gross weight” determined?**

Steps:

1. Use Section 2.3.5. “Tare Procedure” to determine the Average Used Dry tare Weight of the sample.
2. Using the weight of labeled volume determined in step 10 calculate the Average Product Weight by adding the densities of the product from the two packages and dividing the sum by two.

$$\text{Average Product Density Weight} = \text{Labeled Volume} \times \text{Average Product Density}$$

3. Calculate the “nominal gross weight“ using the formula:

$$\text{Nominal Gross Weight} = \text{Average Product Weight} + \text{Average Used Dry Tare Weight}$$

d. **How are the errors in the sample determined?**

Steps:

1. Weigh the remaining packages in the sample.
2. Subtract the nominal gross weight from the gross weight of each package to obtain package errors in terms of weight.

Note: Compare the sample packages to the nominal gross weight.

3. Follow Section 2.3. “Basic Test Procedure.”

To convert the average error or package error from weight to volume, use the following formula:

$$\text{Package Error in Volume} = (\text{Package Error in Weight}) \div (\text{Product Density})$$

Evaluation of Results

Follow the procedures in Section 2.3.7. “Evaluating Results” to determine lot conformance.

3.12. Fresh Oysters Labeled by Volume

a. **What requirements apply to packages of fresh oysters labeled by volume?**

Packaged fresh oysters removed from the shell must be labeled by volume. The maximum amount of permitted free liquid is limited to 15 % by weight. Testing the quantity of contents of fresh oysters requires the inspector to determine total volume, total weight of solids and liquid, and the weight of the free liquid.

Test Equipment

- A scale that meets the requirements in Section 2.2. “Measurement Standards and Test Equipment”
- Volumetric measures
- Micrometer depth gage (ends of rods fully rounded), 0 mm to 228 mm (0 in to 9 in)
- Strainer for determining the amount of drained liquid from shucked oysters. Use as a strainer a flat bottom metal pan or tray constructed to the following specifications:
 - Sides: 5.08 cm (2 in)
 - Area: 1935 cm² (300 in²) or more for each 3.78 L (1 gal) of oysters

Note: Strainers of smaller area dimensions are permitted to facilitate testing smaller containers.

➤ Perforations:

Diameter: 6.35 mm (¼ in)

Location: 3.17 cm (1¼ in) apart in a square pattern, or perforations of equivalent area and distribution.

- Spanning bar, 2.54 cm by 2.54 cm by 30.48 cm (1 in by 1 in by 12 in)
- Rubber spatula
- Level, at least 15.24 cm (6 in) in length
- Stopwatch

b. **How is it determined if the containers meet the package requirements?**

Steps:

1. Follow the Section 2.3.1. “Define the Inspection Lot.” Use a “Category A” sampling plan in the inspection; select a random sample; then, use the following test procedure to determine lot compliance.
2. Determine and record the gross weight of a sample package.
3. Set the container on a level surface and open it. Use a depth gage to determine the level of fill. Lock the depth gauge. Mark the location of the gauge on the package.
4. Weigh a dry 20.32 cm or 30.48 cm (8 in or 12 in) receiving pan and record the weight. Set strainer over the receiving pan.
5. Pour the contents from the container onto the strainer without shaking it. Tip the strainer slightly and let it drain for 2 minutes. Remove strainer with oysters. It is normal for oysters to include mucous (which is part of the product) that will not pass through the strainer, so do not force it.
6. Weigh the receiving pan and liquid and record the weight. Subtract the weight of the dry receiving pan from the weight of pan and liquid to obtain the weight of free liquid and record the value.
7. Clean, dry, and weigh the container and record the tare weight. Subtract the tare weight from the gross weight to obtain the total weight of the oysters and liquid and record this value.
8. Determine and record the percent of free liquid by weight as follows:

$$\text{Percent of free liquid by weight} = \frac{(\text{weight of free liquid})}{(\text{weight of oysters} + \text{liquid})} \times 100.$$

Steps:

9. Set up the depth gauge on the dry package container as in step 3. Pour water from the flasks and graduate as needed to re-establish the level of fill obtained in step 3. Add the volumes delivered as the actual net volume for the container and record the value.

Note: Some containers will hold the declared volume only when filled to the brim; they may have been designed for other products, rather than for oysters. If the net volume is short measure (per step 9), determine if the container will reach the declared volume only if filled to the brim. Under such circumstance, the package net volumes will all be short measure because the container cannot be filled to the brim with a solid and liquid mixture. A small headspace is required in order to get the lid into the container without losing any liquid.

Evaluation of Results

Follow the procedures in Section 2.3.7. “Evaluating Results” to determine lot conformance.

3.13. Determining the Net Contents of Compressed Gas in Cylinders

- a. **What type of compressed gases may be tested with these procedures?**

These procedures are for industrial compressed gas. Compressed gas may be labeled by weight (for example, Liquefied Petroleum [LP] gas, or carbon dioxide) or by volume. Acetylene, liquid oxygen, nitrogen, nitrous oxide, and argon are all filled by weight. Acetylene is sold by liters or by cubic feet. Helium, gaseous oxygen, nitrogen, air, and argon are filled according to pressure and temperature tables.

- b. **What type of test procedures must be used?**

Checking the net contents of compressed gas cylinders depends on the method of labeling; those labeled by weight are generally checked by weight. Cylinders filled by using pressure and temperature charts must be tested using a pressure gauge that is connected to the cylinder. Determine the volume using the pressure and temperature of the cylinder.

- c. **Should any specific safety procedures be followed?**

Yes, be aware of the hazards of the high pressure found in cylinders of compressed gas. An inspector should handle compressed gas only if the inspector has been trained and is knowledgeable regarding the product, cylinder, fittings, and proper procedures (see *Compressed Gas Association [CGA] pamphlet P-1, “Safe Handling of Compressed Gases in Containers,”* for additional information). Additional precautions that are necessary for personal safety are described in the CGA Handbook of Compressed Gases. All personnel testing compressed gases should have this manual for reference and be familiar with its contents. It is essential that the inspector be certain of the contents before connecting to the cylinder. Discharging a gas or cryogenic liquid through a system for which the material is not intended could result in a fire and/or explosion or property damage due to the incompatibility of the system and the product. Before connecting a cylinder to anything, be certain of the following:

1. Always wear safety glasses.
2. The cylinder is clearly marked or labeled with the correct name of the contents and that no conflicting marks or labels are present. Do not rely on the color of the cylinder to identify the contents of a cylinder. Be extremely careful with all gases because some react violently when mixed or when coming in contact with other substances. For example, oxygen reacts violently when it comes in contact with hydrocarbons.
3. The cylinder is provided with the correct Compressed Gas Association (CGA) connection(s) for the product. A proper connection will go together smoothly; so excessive force should not be used. Do not use an adapter to connect oxygen to non-oxygen cleaned equipment. When a cylinder valve is opened to measure the internal pressure, position the body away from the pressure gauge blowout plug or in front of the gauge if the gauge has a solid cast front case. If the bourdon tube should rupture, do not be in a position to suffer serious injuries from gas pressure or fragments of metal.

Note: The acetone in acetylene cylinders is included in the tare weight of the cylinder. Therefore, as acetylene is withdrawn from the cylinder, some acetone will also be withdrawn, changing the tare weight.

4. Thoroughly know the procedure and place emphasis on safety precautions before attempting any tests. Do not use charts referred to in the procedure until the necessary training has been completed. When moving a cylinder, always place the protective cap on the cylinder. Do not leave spaces between cylinders when moving them. This can lead to a “domino” effect if one cylinder is pushed over.
5. Open all valves slowly. A failure of the gauge or other ancillary equipment can result in injuries to nearby persons. Remember that high gas pressure can propel objects with great force. Gas ejected under pressure can also cause serious bodily injuries if someone is too close during release of pressure.
6. One of the gauges will be reserved for testing oxygen only and will be prominently labeled “For Oxygen Use Only.” This gauge must be cleaned for oxygen service and maintained in that “clean” condition. The other gauge(s) may be used for testing a variety of gases if they are compatible with one another.
7. Observe special precautions with flammable gas in cylinders in addition to the several precautions necessary for the safe handling of any compressed gas in cylinders. Do not “crack” cylinder valves of flammable gas before connecting them to a regulator or test gauge. This is extremely important for hydrogen or acetylene.

d. What type of measurement equipment is needed to test cylinders of compressed gas?

Test Equipment

- Use a scale that meets the requirements in Section 2.2. “Measurement Standards and Test Equipment.” Use a wooden or non-sparking metal ramp to roll the cylinders on the scale to reduce shock loading.

- Two calibrated precision bourdon tube gauges or any other approved laboratory-type pressure-measuring device that can be accurately read within plus or minus 40 kPa (5 psi). A gauge having scale increments of 200 kPa (25 psi) or smaller shall be considered as satisfactory for reading within plus or minus 40 kPa (5 psi). The range of both gauges shall be a minimum of 0 kPa to 23 MPa (0 psi to 5000 psi) when testing cylinders using standard industrial cylinder valve connections. These standardized connections are listed in “*CGA Standard V-1, Standard for Compressed Gas Cylinder Valve Outlet and Inlet Connections for use with Gas Pressures up to 21 MPa (3000 psi)*.” For testing cylinders with cylinder valve connections rated for over 21 MPa (3000 psi), the test gauge and its inlet connection must be rated at 14 MPa (2000 psi) over the maximum pressure that the connection is rated for in CGA V-1.

Notes:

1. There are standard high-pressure industrial connections on the market that are being used up to their maximum pressure of 52 MPa (7500 psi).
 2. Any gauge or connectors used with oxygen cylinders must be cleaned for oxygen service, transported in a manner which will keep them clean and never used for any other gas including air or oxygen mixtures. Oxygen will react with hydrocarbons and many foreign materials that may cause a fire or explosion.
- An approved and calibrated electronic temperature measuring device or three calibrated liquid-in-glass thermometers having either a digital readout or scale division of no more than 1 °F (0.5 °C). The electronic device equipped with a surface temperature sensor is preferred over a liquid-in-glass thermometer because of its shorter response time.
 - Two box-end wrenches of 29 mm (1¹/₈ in) for oxygen, nitrogen, carbon dioxide, argon, helium, and hydrogen and 22 mm (⁷/₈ in) for some sizes of propane. All industrial CGA connections are limited to these two hex sizes. Avoid using an adjustable wrench because of the tendency to round the edges of the fittings, which can lead to connections not being tightened properly.
 - Use a separate gauge and fitting for each gas to be tested. If adapters must be used, do not use on oxygen systems.

3.13.1. Test Procedure for Cylinders Labeled by Weight

- a. **How is it determined if the containers meet the package requirements using the gravimetric test procedure?**

Steps:

1. Follow Section 2.3.1. “Define the Inspection Lot.” Use a “Category A” sampling plan in the inspection; select a random sample; then use the following test procedure to determine lot compliance.
2. The cylinder should be marked or stenciled with a tare weight. The marked value may or may not be used by the filling plant when determining the net weight of those cylinders sold or filled by weight. If there is a tare weight marked on the net contents tag or directly on the cylinder, then an actual tare weight was determined at the time of

Steps:

fill. If there is no tare weight marked on a tag or on the cylinder, then the stamped or stenciled tare weight is presumed to have been used to determine the net contents.

Note: Check the accuracy of the stamped tare weights on empty cylinders whenever possible. The actual tare weight must be within (a) $\frac{1}{2}$ % of the stamped tare weight for 9.07 kg (20 lb) tare weights or less or (b) $\frac{1}{4}$ % of the stamped tare weight for greater than 9.07 kg (20 lb) tare weights. (See NIST Handbook 130, “Method of Sale Regulation.”)

3. Place cylinder on scale and remove protective cap. The cap is not included in the tare weight. Weigh the cylinder and determine net weight, using either the stamped or stenciled tare weight, or the tare weight marked on the tag. Compare actual net weight with labeled net weight, or use the actual net weight to look up the correct volume declaration (for Acetylene Gas), and compare that with the labeled volume.

Most producers will replace acetone in the cylinder before the cylinder is refilled, filling the cylinder with acetone to the stamped tare weight. Other producers, although not following recommended procedures, do not replace the acetone until it drops to a predetermined weight. In the latter situation, the refilling plant must note the actual tare weight of the cylinder and show it on the tag containing the net content statement or on the cylinder itself. Refer to tables for acetylene if necessary (if the acetylene is labeled by volume).

3.13.2 Test Procedure for Cylinders Labeled by Volume

- a. **How is it determined if the containers meet the package requirements using the volumetric test procedure?**

Steps:

1. Follow Section 2.3.1. “Define the Inspection Lot.” Use a “Category A” sampling plan in the inspection; select a random sample; then use the following test procedure to determine lot compliance.
2. Determine the temperature of the cylinders in the sample. Place the thermometer approximately halfway up a cylinder in contact with the outside surface. Take the temperature of three cylinders selected at random and use the average temperature of the three values.
3. Using the appropriate pressure gauge, measure the pressure of each cylinder in the sample.
4. Determine the cylinder nominal capacity from cylinder data tables or from the manufacturer. (These tables must be obtained in advance of testing.)
5. Using NIST Technical Note 1079 “Tables of Industrial Gas Container Contents and Density for Oxygen, Argon, Nitrogen, Helium, and Hydrogen” (available on-line at (<http://www.nist.gov/pml/wmd>), determine the value (SCF/CF) from the content tables at

Steps:

- the temperature and pressure of the cylinder under test.
- 6. Multiply the cylinder nominal capacity by the value (SCF/CF) obtained from the content tables. This is the actual net quantity of gas.
- 7. Subtract the labeled net quantity from the actual net quantity to determine the error.

Evaluation of Results

Follow Section 2.3.7. “Evaluating Results” to determine lot conformance.

3.14. Firewood

3.14.1. Volumetric Test Procedure for Packaged Firewood with a Labeled Volume of 113 L (4 ft³) or Less

a. How are packages of firewood tested?

Follow Section 2.3.1. “Define the Inspection Lot.” Use a “Category A” sampling plan in the inspection; select a random sample, then use the test procedure provided in Section 3.14.3. “Crosshatched Firewood” to determine lot compliance.

Unless otherwise indicated, take all measurements without rearranging the wood or removing it from the package. If the layers of wood are crosshatched or not ranked in discrete sections in the package, remove the wood from the package, re-stack, and measure accordingly.

Test Equipment

- Linear Measure. Take all measurements in increments of 0.5 cm (³/₁₆ in) or less and round up.
- Binding Straps. Binding straps are used to hold wood bundles together if the bundles need to be removed from the package/wrapping material.

3.14.2. Boxed Firewood

a. How is the volume of firewood contained in a box determined?

Steps:

1. Follow Section 2.3.1. “Define the Inspection Lot.” Use a “Category A” sampling plan in the inspection; select a random sample; then use the following test procedure to determine lot conformance.
2. Open the box to determine the average height of wood within the box; measure the

Steps:

internal height of the box. Take three measurements (record as “d₁, d₂, . . .etc.”) along each end of the stack. Measure from the bottom of a straightedge placed across the top of the box to the highest point on the two outermost top pieces of wood and the center-most top piece of wood. Round measurements down to the nearest 0.5 cm (¹/₈ in). If pieces are obviously missing from the top layer of wood, take additional height measurements at the highest point of the uppermost pieces of wood located at the midpoints between the three measurements on each end of the stack. Calculate the average height of the stack by averaging these measurements and subtracting from the internal height of the box according to the following formula.

$$\text{Average Height of Stack} = (\text{Internal Height of Box}) - (\text{sum of measurements}) \div (\text{number of measurements})$$

- Determine the average width of the stack of wood in the box by taking measurements at three places along the top of the stack. Measure the inside distance from one side of the box to the other on both ends and in the middle of the box. Calculate the average width.

$$\text{Average Width} = (W_1 + W_2 + W_3) \div (3)$$

- To determine the average length of the pieces of wood, remove the wood from the box and select the five pieces with the greatest girth. Measure the length of each of the five pieces from center-to-center. Calculate the average length of the five pieces.

$$\text{Average Length} = (L_1 + L_2 + L_3 + L_4 + L_5) \div (5)$$

- Calculate the volume of the wood within the box. Use dimensions for height, width, and length.

$$\text{Volume in liters} = (\text{height in cm} \times \text{width in cm} \times \text{length in cm}) \div (1000)$$

$$\text{Volume in cubic feet} = (\text{height in inches} \times \text{width in inches} \times \text{length in inches}) \div (1728)$$

- For boxes of wood that are packed with the wood ranked in two discrete sections perpendicular to each other, calculate the volume of wood in the box as follows: (1) determine the average height, width, and length as in 1, 2 and 3 above for each discrete section, compute total volume, and (2) total the calculated volumes of the two sections. Take the width measurement for Volume 2 (V₂) from the inside edge of the box adjacent to V₂ to the plane separating VR₁ and V₂. Compute total volume by adding Volume 1 (V₁) and V₂ according to the following formula.

$$\text{Total Volume} = V_1 + V_2$$

- Follow Section 2.3.7. “Evaluating Results” to determine lot conformance.

3.14.3. Crosshatched Firewood

- a. **How must the volume of stacked or crosshatched firewood be measured?**

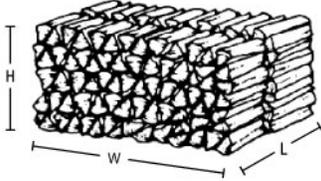


Figure 3-3. Stacked Firewood

Steps:

1. Follow Section 2.3.1. “Define the Inspection Lot.” Use a “Category A” sampling plan in the inspection; select a random sample; and use the following test procedure to determine lot compliance.
2. Stack the firewood in a ranked and well-stowed geometrical shape that facilitates volume calculations (i.e., rectangular). The number of measurements for each dimension given below is the minimum that should be taken.
3. Determine the average measurements of the stack:
 - Height: Start at one end of the stack; measure the height of the stack on both sides at four equal intervals. Calculate and record the average height.
 - Length: Start at the base of the stack; Measure the length of the stack in four equal intervals. Calculate and record the average length.
 - Width: Select the five pieces with the greatest girth. Measure the length of the pieces, calculate and record the average piece length.

4. Calculate Volume:

$$\text{Volume in liters} = (\text{Avg. Height [cm]} \times \text{Avg. Width [cm]} \times \text{Avg. Length in [cm]}) \div 1000$$

$$\text{Volume in cubic feet} = (\text{Avg. Height [in]} \times \text{Avg. Width [in]} \times \text{Avg. Length [in]}) \div 1728$$

5. Follow Section 2.3.7. “Evaluating Results” to determine lot conformance.

3.14.4. Bundles and Bags of Firewood

- a. **How is the volume of bundles and bags of firewood measured?**



Figure 3-4. Bundle of Firewood

Steps:

1. Follow Section 2.3.1. “Define the Inspection Lot.” Use a “Category A” sampling plan in the inspection; select a random sample; then use the following test procedure to determine lot compliance.
2. Average area of ends: secure a strap around each end of the bundle or bag of wood to prevent movement during testing and to provide a definite perimeter. Use two or more straps to secure the wood.
3. Set one end of the bundle or bag on tracing paper large enough to cover the end completely. Draw a line around the perimeter of the bundle or bag on the tracing paper.
4. Transfer the tracing paper to a template graduated in square centimeters or square inches. Count the number of square centimeters or square inches that are enclosed within the perimeter line. Estimate portions of square centimeters or square inches not completely within the perimeter line to the nearest one-quarter square inch.
5. Repeat this process on the opposite end of the bundle or bag.
6. Calculate the Average Area:

$$\text{Average Area} = (\text{Area 1} + \text{Area 2}) \div 2$$

7. Average length of the pieces of wood – select the five pieces with the greatest girth and measure the length of the pieces. Calculate the average length of the pieces of wood:

$$\text{Average Length} = (L_1 + L_2 + L_3 + L_4 + L_5) \div 5$$

8. Calculate Volume:

$$\text{Volume in liters} = (\text{Average Area [cm}^2\text{]} \times \text{Average Length [cm]}) \div 1000$$

$$\text{Volume in cubic feet} = (\text{Average Area [in}^2\text{]} \times \text{Average Length [in]}) \div 1728$$

Evaluation of Results

Follow Section 2.3.7. “Evaluating Results” to determine lot conformance.

Note: Specified in Appendix A, Table 2-10. “Exceptions to the Maximum Allowable Variations for Textiles, Polyethylene Sheeting and Film, Mulch and Soil Labeled by Volume, Packaged Firewood, and Packages Labeled by Count with 50 Items or Fewer.” – Maximum allowable variations for individual packages are not applied to packages of firewood.

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