



# Standard Test Method for Measurement of Backpack Capacity<sup>1</sup>

This standard is issued under the fixed designation F2153; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

## 1. Scope

1.1 This test method determines and standardizes an unextended and extended capacity for backpacks and related bags. Related bags include lumbar packs, soft rucksacks, internal and external frame packs, duffel bags, and travel packs.

1.2 This test method is designed to provide a means whereby manufacturers and consumers may have a consistent means to compare pack volumes.

1.3 This test method does not take into consideration areas of the backpack that are not completely enclosed by fabric such as mesh pockets, water bottle holders, and compressor pockets.

1.4 For practical purposes this test method cannot be used to measure capacities less than 4 L.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

## 2. Terminology

### 2.1 Definitions:

2.1.1 *backpack, n*—any carrying device constructed of fabric that utilizes a single or double shoulder strap as the means for the wearer to carry the bag on the users back.

2.1.2 *backpack back, n*—part of the backpack that is against the user's back.

2.1.3 *backpack front, n*—part of the backpack that is away from the user's back.

2.1.4 *extended capacity, n*—maximum achievable volume of a backpack including all compartments and extensions maximized to their largest usable volume.

2.1.4.1 *full for panel loaded:* Zipped shut and all expansion panels open. When placed on a person the pack looks usable and the top pocket appears level or in alignment with rest of the pack style (that is, not tipped forward or back excessively).

<sup>1</sup> This test method is under the jurisdiction of ASTM Committee F08 on Sports Equipment, Playing Surfaces, and Facilities and is the direct responsibility of Subcommittee F08.22 on Camping Softgoods.

Current edition approved May 1, 2012. Published August 2012. Originally approved in 2001. Last previous edition approved in 2007 as F2153 – 07. DOI: 10.1520/F2153-07R12.

2.1.4.2 *full for top loader:* 12 in.<sup>2</sup> maximum opening of extension collar draw cord, with pack body draw cord completely open. When placed on a person the pack looks usable and the top pocket appears level or in alignment with rest of the pack style (that is, not tipped forward or back excessively).

2.1.4.3 *roll top:* In accordance with the manufacturer's design with all extension panels open.

2.1.5 *extension skirt, n*—fabric extension which is attached to the top of the pack body and extends over and above the actual pack body.

2.1.6 *external frame pack, n*—backpack that uses a rigid or semirigid frame on the outside of the pack bag.

2.1.7 *frame sheet, n*—sheet generally constructed of foam or polyethylene, which forms the support in the back of the backpack.

2.1.8 *internal frame pack, n*—backpack that uses one or more supports, or stays, made from a rigid or semirigid material, and incorporated into the inside of the backpack (usually made of aluminum, graphite, or carbon-fiber).

2.1.9 *lumbar pack, n*—backpack that is designed to fit in the small of the back. Many lumbar packs do not have shoulder straps.

2.1.10 *soft rucksack, n*—backpack that does not have a rigid frame and is generally of smaller size. This backpack may have a back constructed of foam, or a light frame sheet.

2.1.11 *unextended backpack capacity, n*—maximum achievable volume of a backpack including all compartments maximized to their largest usable volume. All extensions closed.

2.1.11.1 *full for panel loaded:* Zipped shut. When placed on a person the pack looks usable and the top pocket appears level or in alignment with rest of the pack style (that is, not tipped forward or back excessively).

2.1.11.2 *full for top loader:* 12 in.<sup>2</sup> maximum opening of pack body draw cord. When placed on a person the pack looks usable and the top pocket appears level or in alignment with rest of the pack style (that is, not tipped forward or back excessively).

2.1.11.3 *roll top:* In accordance with the manufacturer's design.

## 3. Summary of Test Method

3.1 *Determining Backpack Capacity*—All compartments (including main pack body, top pocket, exterior pockets) are

filled with 20-mm plastic balls to their extended capacity. Balls are removed to bring the pack down to its unextended capacity. The removed balls are temporarily stored. The rest of the pack is emptied and the capacity measured in the graduated cylinder as the unextended capacity. The balls removed in the first step are then added to the cylinder to measure the extended capacity.

#### 4. Significance and Use

4.1 Many consumers use the capacity measurement as a key specification to determine the backpack size suitable for their requirements.

#### 5. Apparatus

5.1 *Spheres* (see Fig. 1)—15 to 20-mm hollow polypropylene, polyethylene, or other functionally incompressible plastic, measurement units with net density between 6 and 14 lb/1000 in<sup>3</sup>. (A useful quantity is 19 000 20-mm balls or 19 cases of 1000 = 7500 in.<sup>3</sup> (approximate).)

5.2 *Cylinder* (see Fig. 2)—A vertical walled flat-bottomed cylinder made of rigid material with a diameter between 14 and 18 in.

5.3 *Measurement Tool*—A piston that will apply a force of 0.01 psi on the balls and be used to measure the height of the balls in the cylinder.

#### 6. Calibration and Standardization

6.1 Purchase or create a rigid cylinder that conforms to the requirements of 5.2.

6.2 Place the cylinder on a flat surface and fill with 25 L of water. The most accurate method is to tare a scale with the cylinder on it. Then fill the cylinder with 25 kg of water. Alternatively, measurement of the inside diameter of the cylinder may be used with the formula for the volume of a cylinder. However, the precision of the diameter measurement must be 1 % or better.

6.3 Mark the water height on the cylinder.

6.4 Remove the water.



FIG. 1 20-mm Spheres



FIG. 2 Typical 18-in. Diameter Cylinder: Measurement Tool in Hand

6.5 Build the Tamper plunger piston.

6.6 Cut a disk out of flat 3/4-in. plywood with a diameter that will just clear the inner diameter of the coupler and the end cap.

6.7 Create a measurement tool that combined with the disk will place a load of 0.01 psi on the balls, and measure the height of the balls.

NOTE 1—For an 18-in. diameter, the load is 2.55 lb.

6.8 Calibrate the measurement tool to measure in litres based on the height of the water in 6.3, and the “zero” height.

6.9 The units on the scale need to be no finer than litres or 50 in.<sup>3</sup>.

#### 7. Procedure

7.1 Determine capacity as follows:

7.1.1 Remove all hangtags and packaging.

7.1.2 Note the backpack manufacturer, model, size, weight, technician, and date.

7.1.3 Loosen all straps to eliminate any constrictions so the pack may achieve its largest capacity.

7.1.4 Fill the main compartment with the spheres, making sure the spheres are occupying all the corners. Tamp the filled pack to fill all voids. Continue filling and tamping until the main compartment is full in accordance with the definition for extended capacity (2.1.4).

7.1.5 Continue to fill all enclosed compartments to their maximum capacity, making sure the compartments are filled and closed.

7.1.6 Tamp and massage the pockets to remove areas not filled with balls, and continue until full.

7.1.7 Remove and store the balls that will reduce the pack from its extended capacity to its unextended capacity.

7.1.8 Continue to remove all the balls from the pack, and place them in the cylinder.

7.1.9 Using the measurement tool calculate the volume as the unextended capacity.

7.1.10 Add the stored balls from 7.1.7 to calculate the extended capacity.

7.1.11 Report results to the nearest litre or 50 in.<sup>3</sup>.

## 8. Calculation

8.1 *Converting Litres to Cubic Inches*—To convert litres to cubic inches, multiply the litres by 61.04.

8.2 The volume of a cylinder is given as follows:

$$\text{Volume} = \text{height} \times (\text{diameter}^2) \times 3.1416/4$$

*ASTM International takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.*

*This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, at the address shown below.*

*This standard is copyrighted by ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, United States. Individual reprints (single or multiple copies) of this standard may be obtained by contacting ASTM at the above address or at 610-832-9585 (phone), 610-832-9555 (fax), or service@astm.org (e-mail); or through the ASTM website (www.astm.org). Permission rights to photocopy the standard may also be secured from the ASTM website (www.astm.org/COPYRIGHT/).*

## 9. Precision and Bias

9.1 Precision and bias for this test method has not yet been determined.

## 10. Keywords

10.1 backpack; capacity; extended capacity; measurement; pack; unextended capacity