Designation: D4321 – 15

Standard Test Method for Package Yield of Plastic Film[1]

This standard is issued under the fixed designation D4321; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 This test method covers the determination of yield (area per unit mass) of plastic film.

1.2 Also described in this test method is the means for calculating nominal yield, given values for nominal density, and nominal thickness. This is needed since, in material specifications, limits for yield are normally stated in terms of the percent deviation of actual yield from nominal yield.

1.3 The values stated in SI units are to be regarded as the standard. The values given in brackets are for information only.

1.4 *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.*

NOTE 1—This standard and ISO 4591 address the same subject matter, but differ in technical content.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

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

D883 Terminology Relating to Plastics

D1505 Test Method for Density of Plastics by the Density-Gradient Technique

D4883 Test Method for Density of Polyethylene by the Ultrasound Technique

D6988 Guide for Determination of Thickness of Plastic Film Test Specimens

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

3. Terminology

3.1 *Definitions:*

3.1.1 *density, apparent*—the weight in air of a unit volume of a material.

3.1.2 *yield*—the area per unit mass of a material.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *measured density*—the density of the fabricated film as determined by actual measurement.

3.2.1.1 *Discussion*—The measured density is *not* the value used to classify the material in accordance with a standard material specification. The measured value will depend on the manufacturing process of the film.

3.2.2 *measured thickness*—the thickness of the fabricated film as determined by actual measurement.

3.2.3 *nominal density*—an estimated value of density of film as agreed upon between the user and the supplier.

3.2.4 *nominal thickness*—the target value of film thickness as agreed upon between the user and the supplier.

3.2.5 *nominal yield*—the target value of yield as agreed upon between the user and the supplier.

3.2.6 *package yield*—the calculated value of yield as determined by this test method.

4. Significance and Use

4.1 Actual yield is important to the film converter as this determines the actual number of units or packages that he can derive in a particular conversion from any given mass of film.

5. Apparatus

5.1 Means for preparing test specimens of accurately known area and weighing at least 1 g.

5.1.1 When film width and thickness are such that a specimen weighing at least 1 g will be produced, a rectangular metal template, nominally 100-mm (4-in.) wide, having a length greater than the width of the film from which the specimens are to be taken and having accurately parallel edges in the length direction, is to be used for preparing specimens. The width is to be accurately measured for subsequent use in calculating the specimen area. If slippage of film beneath the template during the cutting operation is a problem, cement a thin layer of cork, felt, or other suitable material onto the contact face of the template.

5.1.2 For narrower, thinner films for which the above template would not produce a specimen weighing at least 1 g,

[1] This test method is under the jurisdiction of ASTM Committee D20 on Plastics and is the direct responsibility of Subcommittee D20.19 on Film, Sheeting, and Molded Products.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

***A Summary of Changes section appears at the end of this standard**

a steel straightedge is an option. Using the steel straightedge, make cuts as far apart as necessary to produce a specimen weighing at least 1 g.

5.2 *Horizontal Flat Surface,* of a size large enough to accommodate film samples from which test specimens are to be cut.

5.3 *Sharp Utility Knife or Razor Blade,* or equivalent.

5.4 *Analytical Balance having a resolution of at least 0.001 gram.*

5.5 *Steel Tape Measure having a resolution of at least 0.001 metre (0.040 inch).*

6. Sampling

6.1 For a lot or a commercial shipment, sample as directed in the appropriate film standard or specification. In the absence of a reference standard or specification, the sampling frequency shall be agreed upon between the supplier and user.

6.2 If results are to be obtained for only a single roll, obtain a sample with a length sufficient for three test specimens. Usually, a length of 3 m (10 ft) is sufficient.

6.3 In obtaining a sample from a roll, unwind and discard at least two turns before taking the sample. In obtaining a sample, cut across the full width of the film perpendicular to its length.

7. Procedure

7.1 Smooth out the sample onto a flat surface. If the sample is a flat tubular film, the test specimen shall be taken in double thickness. If the sample is gusseted or multi-folded, spread out the gussets or folds until the sample is a sheet or flat tube.

7.2 Measure the sample width to the nearest 0.001 m (0.040 in.) using a steel tape measure. Record this as the test specimen width, W_a, in metres (inches), for single thickness film. For flat tubular film, multiply the measured width value by 2 and record as W_a.

7.3 Cut out a specimen weighing at least 1 g by one of the following techniques.

7.3.1 Lay the template across the full width of the film with the length of the template perpendicular to the edge of the film. Press down on the top of the template in the area where the cut is being made. Cut across the entire film width on both sides of the template. Retrieve the cutout specimen. Record the pre-measured width of the template as the length, L_a, in metres [inches] of the test specimen.

7.3.2 Lay the steel straightedge across the film width perpendicular to the edges of the film. Make one cut across the film width along the straightedge. Pick up the straightedge and reposition it at an appropriate distance from the first cut. Again cut across the film width with the straightedge. Measure the length of the test specimen using a steel tape measure to the nearest 0.001 m (0.040 in.). Record this as the length, L_a, in metres [inches] of the test specimen.

7.4 If yield of a single roll is being measured, obtain two more specimens from the roll. These specimens must be at least 1 m (3 ft) apart in accordance with 7.3. Discard the scrap between where the specimens are taken. If yield of a lot or shipment is being determined, obtain one specimen from each sampling unit from the lot or shipment.

7.5 Weigh each test specimen and record its mass, M_a, in kilograms to the nearest 0.001 g.

8. Calculation

8.1 Calculate the measured yield for each specimen as follows:

$$Y_a = (W_a \times L_a)/(M_a) \quad (1)$$

where:

Y_a = measured yield, m^2 /kg ($in.^2$ /lb),
W_a = measured specimen width, m (in.),
L_a = measured specimen length, m (in.), and
M_a = measured specimen mass, kg (lb).

8.2 For reporting on the measured yield of a specific roll, average the three values obtained of Y_a for the roll. For reporting on the measured yield of a lot or shipment, average the n values of Y_a obtained for the n samples from the lot.

8.3 Calculate nominal yield for the roll, lot, or shipment as follows:

$$Y_n = (C)/(dt) \quad (2)$$

where:

Y_n = nominal yield, m^2/kg ($in.^2$ /lb),
C = constant,
d = nominal density, and
t = nominal thickness.

8.3.1 When d is in kg/m^3 and t is in μm, the value of C is 10^6 in order to give Y_n in m^2/kg.

8.3.2 When d is in g/cm^3 and t is in inches, the value of C is 27.68 in order to give Y_n in $in.^2$/lb.

8.4 Calculate the percent deviation D of measured yield from nominal yield as follows:

$$D = (Y_a - Y_n)/(Y_n) \times 100 \quad (3)$$

where Y_a and Y_n are as found in 8.2 and calculated in 8.3.

NOTE 2—If needed, calculate the length of film per roll, per lot, or per shipment can be found as follows:

$$L = (Y_a \times M)/(W_a) \quad (4)$$

where:

L = length, m (in.), per roll or shipment,
M = net mass, kg (lb), of film on the roll or in the lot or shipment, and
Y_a *and* W_a = are as previously defined.

NOTE 3—High values of D found in 8.4 are attributable to deviations between the measured density and the nominal density or deviations between the measured thickness and the nominal thickness, or both. This requires confirmation of the measured density by Test Method D1505 (Test Method D792 is also acceptable as is D4883 provided instrument calibration is traceable to D792 or D1505) and confirmation of the measured thickness by Guide D6988.

9. Report

9.1 Report the following information:

9.1.1 Complete identification of the roll of film or of the lot or shipment, including nominal density, nominal thickness, and nominal yield.

9.1.2 For one roll, the (mean) measured yield and the range of the three replicates for measured yield.

9.1.3 For a lot or shipment, the (mean) measured yield for the number of samples tested and the range of determinations of measured yield.

9.1.4 Percent deviation of measured yield from nominal yield for the roll, lot, or shipment.

9.1.5 Operator and date of test.

10. Precision and Bias[3]

10.1 Table 1 is based on a round robin conducted in accordance with Practice E691, involving four materials tested by six laboratories. In this study, considering a test result to be the average value of actual yield derived from testing three specimens of a material in a short time span, all six laboratories obtained one test result for each material by use of templates, and four of the six obtained one test result for each material by use of straightedges. For the four materials employed in this study, indexes of precision, as defined in Practice E691, were found to be as shown in Table 1.

[3] Supporting data are available from ASTM Headquarters. Request RR:D20-1103.

TABLE 1 Indices of Precision for a Test Result of Actual Yield

Material		Mean, $in.^2$/lb	Repeatability, V_r, %	Reproducibility, V_R, %
Type	Thickness, mil			
PE	2.5	12994	1.0	2.4
PP	2.0	14913	0.9	1.2
PET	0.5	43398	0.7	1.2
PET	2.0	9849	0.6	1.0

NOTE 4—The following explanations of "r" and "R" (10.2– 10.2.3) are only intended to present a meaningful way of considering the approximate precision of this test method. The data in Table 1 should not be rigorously applied to acceptance or rejection of material, as those data are specific to the round robin and may not be representative of other lots, conditions, materials, or laboratories. Users of this test method should apply the principles outlined in Practice E691 to generate data specific to their laboratory and materials, or between specific laboratories. The principles of 10.2– 10.2.3 would then be valid for such data.)

10.2 *Concept of r and R in* Table 1—If S_r and S_R have been calculated from a large enough body of data, and for test results that were the result of testing ten specimens for each test result then:

10.2.1 *Repeatability*—Two results obtained within one laboratory shall be judged not equivalent if they differ by more than the "r" value for that material. "r" is the interval representing the critical difference between two test results for the same material, obtained by the same operator using the same equipment on the same day in the same laboratory.

10.2.2 *Reproducibility*—Two test results obtained by different laboratories shall be judged not equivalent if they differ by more than the "R" value for that material. "R" is the interval representing the critical difference between two test results for the same material, obtained by different operators using different equipment in different laboratories.

10.2.3 Any judgment in accordance with 10.2.1 or 10.2.2 would have an approximate 95 % (0.95) probability of being correct.

10.3 There are no recognized standards by which to estimate of this method.

11. Keywords

11.1 nominal yield; package yield; plastic film

SUMMARY OF CHANGES

Committee D20 has identified the location of selected changes to this standard since the last issue (D4321 - 09) that may impact the use of this standard. (May 1, 2015)

(1) Updated ISO equivalency statement (Note 1) in accordance with Guide D4968 (the revision guide).
(2) Edited permissive language in 5.1.2.
(3) Revised precision and bias section (Section 10) to reflect language in Guide D4968.