# Standard Test Methods for Evaluating Primary Disposable Bag Integrity for Vacuum Cleaners[1]

This standard is issued under the fixed designation F494; 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 These test methods cover the evaluation of the integrity of the primary disposable bag used for vacuum cleaners.

1.2 The intent of these test methods is to verify that the design of the primary disposable bag will perform satisfactorily for the consumer in a wide range of normal use conditions. The filtering capability of the disposable bag is not evaluated with the use of these test methods.

1.3 The following tests are included:

| | Section |
|---|---|
| Installation and Removal | 3 |
| Workmanship | 4 |
| Durability | 5 |
| Seams and Joints | 6 |

1.4 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.

1.5 *This standard does not purport to address all of the safety problems, 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. Significance and Use

2.1 These test methods are useful for routine control, design of end-use products, and acceptance testing for conformance to specifications. Good workmanship, seams, and joints that remain strong over a wide range of atmospheric conditions and have the ability to withstand repeated cycles are necessary for satisfactory end use to the consumer.

## TEST METHODS

## 3. Installation and Removal

3.1 *Scope*—These test methods provide guidelines for the installation and removal of the primary disposable bag.

3.2 *Apparatus*—The vacuum cleaner model for which the primary disposable bag is intended.

3.3 *Test Specimens*—Test specimens shall be representative of the primary disposable bag system being tested.

3.4 *Procedure*—The primary disposable bag shall be installed in accordance with the instructions of the vacuum cleaner manufacturer.

3.4.1 Construction of the primary disposable bag shall be such that no holes or tears will be made when it is prepared for installation.

3.4.2 When installed or removed, in accordance with instructions, the primary disposable bag shall not be damaged or its function impaired.

3.5 *Report*—The report shall include any problems encountered during installation and removal of the primary disposable bag.

## 4. Workmanship

4.1 *Scope*—This test method provides a means of evaluating workmanship of the primary disposable bag.

4.2 *Test Specimens*—Test specimens shall be representative of the primary disposable bag system being tested.

4.3 *Procedure*—Inspect primary disposable bag for conformance to the following:

4.3.1 Complete sealing or fastening of all seams, tucks, joints, and attachments,

4.3.2 No tears, rips, holes, or other manufacturing type faults,

4.3.3 Printed instructions, when they appear, shall be clear and legible,

4.3.4 Dimensions shall agree with drawing specifications, or the primary disposable bag as defined by the vacuum cleaner manufacturer, and

4.3.5 If adhesives are used for seams and joints, there shall be no bleed through to adjacent plys or misplacements.

4.4 *Report*—The report shall include any defects in workmanship noted in the inspection in 4.3.

[1] These test methods are under the jurisdiction of ASTM Committee F11 on Vacuum Cleaners and are the direct responsibility of Subcommittee F11.23 on Filtration.

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## 5. Durability

5.1 *Scope*—The durability of the primary disposable bag is determined by a life test within the vacuum cleaner for which the bag is intended.

5.2 *Apparatus:*

5.2.1 *Vacuum Cleaner.*

5.2.2 *Conditioning Chamber or Cabinet,* in which specimens may individually be exposed to circulating air and conditioning relative humidity and temperature within the limits specified in 5.5.

5.2.3 *Temperature-Measuring Equipment,* accurate to within ±1°F (±0.5°C).

5.2.4 *Humidity-Measuring Equipment,* accurate to within ±2 % relative humidity.

5.2.5 *Solenoid,* to control the movement of a spring-loaded plate.

5.2.6 *Timer,* to control the activation of the solenoid on the basis of time.

5.2.7 *Plate,* to seal the intake of the test cleaner. This plate, connected directly to the solenoid shaft, must open sufficiently so as not to restrict air flow and must open and close the intake within 0.1 s. Motion of the plate must not be a sliding action.

5.2.7.1 *Canister Cleaners*—The plate seals the nozzle end of the hose normally supplied with the vacuum cleaner. The hose is attached to the vacuum cleaner in the normal manner with no attempts to seal leaks.

5.2.7.2 *Upright Cleaners*—The plate seals a 1.75 ± 0.02-in. (44.5 ± 0.5-mm) diameter hole located in an adapter cover. The adapter cover closes off the nozzle intake opening of the cleaner without interfering with the rotating agitator.

5.2.8 *Voltage Regulator*—The regulator shall be capable of maintaining 120 ± 1 V rms 60 Hz with a wave form that is essentially sinusoidal with 3 % maximum harmonic distortion for the duration of the test.

5.2.9 *Voltmeter,* to measure input to the cleaner and provide measurements accurate to within ±1 %.

5.3 *Test Specimens*—Test specimens shall be representative of the primary disposable bag being tested.

5.4 *Material*—Coarse grade air cleaner test dust.

NOTE 1—The particle size distribution by volume of the test dust is given in Table 1.

**TABLE 1 Analysis of Coarse Grade Air Cleaner F11 Test Dust**[A, B]

| Particle Size Distribution by Volume | |
|---|---|
| Size, µm | Coarse Grade (% less than) |
| 5.5 | 13 ± 3 |
| 11 | 24 ± 3 |
| 22 | 37 ± 3 |
| 44 | 56 ± 3 |
| 88 | 84 ± 3 |
| 176 | 100 |

[A] The information in Table 1 is contained in "Air Cleaner Test Code," *SAE Technical Report J726b.*

[B] The sole source of supply of the test dust known to the committee at this time is Powder Technology, Inc., 1119 Riverwood Drive, Burnsville, MN 55337. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

5.5 *Conditioning*— Allow test specimens to age at ambient conditions of 68 to 81°F (20 to 27°C) and 45 to 55 % relative humidity for a minimum of 24 h before starting tests.

5.6 *Procedure:*

5.6.1 Perform all tests on the vacuum cleaner in a controlled ambient with a dry-bulb temperature of 68 to 81°F (20 to 27°C) and 30 to 55 % relative humidity.

5.6.2 Measure and calculate the total primary disposable bag area excluding seams, joints, treated seal area, mounting means, and multiple thickness of media. Measure multiple thicknesses that are intended for a specific filtering purpose as a single ply.

5.6.3 Prepare 0.0023 oz of coarse grade air cleaner test dust per square inch of primary disposable bag area (0.010 g/cm$^2$).

5.6.4 Close vacuum bleed control and seal all openings normally closed off with operation of tools.

5.6.5 Install the primary disposable bag in the intended manner in the vacuum cleaner for which it was designed. Energize the cleaner and adjust the voltage regulator to rated voltage ±1 V.

5.6.5.1 Operate the cleaner at the maximum speed setting provided for the carpet cleaning mode.

5.6.6 Feed the amount of test dust specified in 5.6.3 at the rate of 0.7 ± 0.07 oz (20 ± 2 g)/min into the intake port.

5.6.7 After loading and with the cleaner operating at rated voltage, subject the cleaner to a test of 7.5 s open and 7.5 s closed for a period of 12 h.

5.6.7.1 For the canister cleaner, alternately open and close the nozzle end of the hose with the plate described in 5.2.7, while the cleaner remains running. For an upright cleaner, alternately open and close the intake hole as described in 5.2.7.2, while the cleaner remains running.

5.7 *Report*—The report shall include any failure of the primary disposable bag.

5.7.1 Any rupture of the primary disposable bag material or separation of seams, tucks, joints, or attachments shall constitute a failure. Pinhole leaks are not considered to be ruptures.

## 6. Seams and Joints

6.1 *Scope*—The evaluation of seams, tucks, joints, and attachments used to fabricate the primary disposable bag is accomplished by means of temperature and humidity cycling followed by visual inspection and durability tests.

6.2 *Apparatus:*

6.2.1 *Conditioning Chamber or Cabinet,* in which specimens may individually be exposed to circulating air and conditioning relative humidity and temperature within the limits specified in 6.4.

6.2.2 *Oven,* with forced ventilation, that will maintain 156 ± 2°F (68.9 ± 1.1°C) at the test conditions where the specimens are located and shielded from direct radiation from the heating element.

6.2.3 *Cold Box,* that will maintain specimens at −20 ± 2°F (−28.9 ± 1.1°C) at the test conditions.

6.2.4 *Temperature-Measuring Equipment,* accurate to within ±1°F (±0.5°C).

6.2.5 *Humidity-Measuring Equipment,* accurate to within ±2 % relative humidity.

6.3 *Test Specimens*—Test specimens shall be representative of the primary disposable bag being tested. Use fresh samples for each of the tests in 6.5.1 and 6.5.2, and 6.5.3.

6.4 *Conditioning*—Age all test specimens at least 24 h at ambient conditions of 68 to 81°F (20 to 27°C) and 30 to 55 % relative humidity to prepare them for the hot, cold, and humidity test cycles.

6.4.1 Simultaneously condition specimens for the hot, cold, and humidity test cycles.

6.5 *Procedure:*

6.5.1 *Hot Test Cycle:*

6.5.1.1 Place the test specimens in an oven at 156 ± 2°F (68.9 ± 1.1°C) for 4 weeks.

6.5.1.2 Allow test specimens to condition at ambient conditions of 68 to 81°F (20 to 27°C) and 30 to 55 % relative humidity for 30 min minimum after removal from oven.

6.5.1.3 Examine the specimens visually for any obvious failure and subject each of the test specimens to a durability evaluation similar to that in Section 5. For this test, the operating period in 5.6.7 shall be 5 min instead of 12 h.

6.5.2 *Cold Test Cycle:*

6.5.2.1 Place test specimens in a cold box for 24 h at −20 ± 2°F (−28.9 ± 1.1°C).

6.5.2.2 Condition at ambient conditions of 68 to 81°F (20 to 27°C) and 30 to 55 % relative humidity for 30 min minimum after removal from cold box.

6.5.2.3 Repeat the cycle (6.5.2.1 and 6.5.2.2) three times.

6.5.2.4 Examine the specimens visually for any obvious bond failures. If there is no obvious failure, subject each of the test specimens to a durability evaluation similar to that in Section 5. For this test, the operating period in 5.6.7 shall be 5 min instead of 12 h.

6.5.3 *Humidity Test Cycle:*

6.5.3.1 Place test specimens in the conditioning chamber at 89.6 ± 3.6°F (32 ± 2°C) and 86 to 90 % relative humidity for 24 h.

6.5.3.2 After removing the test specimens from the conditioning chamber, condition them for 4 h minimum at 68 to 81°F (20 to 27°C) and 30 to 55 % relative humidity.

6.5.3.3 Repeat the cycle (6.5.3.1 and 6.5.3.2) three times.

6.5.3.4 Examine the specimens visually for any obvious bond failures. If there is no obvious failure, subject each of the test specimens to a durability evaluation similar to that in Section 5. For this test, the operating period in 5.6.7 shall be 5 min instead of 12 h.

6.6 *Report*—The report for each of the tests in 6.5 shall include any failure of the primary disposable bag.

6.6.1 Any rupture of the primary disposable bag material or separation of seams, tucks, joints, or attachments shall constitute a failure. Pinhole leaks are not considered to be ruptures.

## 7. Sampling

7.1 A sample of sufficient size for each primary disposable bag shall be tested until a 90 % confidence interval for the true percent defective is established.

7.2 The minimum number of tests required is defined to be that number which will give a 90 % confidence interval for the true percent defective that is less than 0.20 in width (see Annex A1).

## 8. Precision and Bias

8.1 Precision and bias do not apply for this test method since this is a procedure for a test that is conducted to a specified end point.

## 9. Keywords

9.1 vacuum cleaner disposable bag integrity

# ANNEX

### (Mandatory Information)

## A1. DETERMINATION OF 90 % CONFIDENCE INTERVAL (PROPORTION)

A1.1 The most common and ordinarily the best single estimate ($p$) of the true proportion (or percentage) ($P$) of items that have a given quality characteristic is simply the number of items ($r$) that possess this characteristic divided by the total number of items ($n$).

$$p = r/n \quad \text{(A1.1)}$$

When a sample is taken from a population, the sample proportion that possesses the characteristic will seldom be exactly the same proportion as the population. It is hoped to be fairly close so that a statement of the confidence interval will bracket the true proportion.

A1.2 *Glossary of Additional Terms:*

$\alpha$ = probability of being wrong,
$1 - \alpha$ = probability of being correct,
$P_u$ = upper limit of the confidence interval for $P$,
$P_l$ = lower limit of the confidence interval for $P$, and
$A$ = chosen limit for the width of the confidence interval (in accordance with 7.2, $A = 0.20$).

A1.3 The following procedure gives an interval which is expected to bracket ($P$), the true proportion, 100 (1 − α) % of the time:

A1.3.1 Choose the desired confidence level, 1 − α.

A1.3.2 Compute $p = r/n$.

A1.3.3 If $n$ w- 30, use Table A1.1.

**TABLE A1.1 Confidence Limits for a Proportion (Two-Sided)**[A]

NOTE 1—Upper limits are in boldface. The observed proportion in a random sample is *r/n*.

| *r* | 90 % | | 95 % | | 99 % | | *r* | 90 % | | 95 % | | 99 % | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | ***n* = 1** | | | | | | | ***n* = 2** | | | |
| **0** | 0 | **0.900** | 0 | **0.950** | 0 | **0.990** | **0** | 0 | **0.684** | 0 | **0.776** | 0 | **0.900** |
| **1** | 0.100 | **1** | 0.050 | **1** | 0.010 | **1** | **1** | 0.051 | **0.949** | 0.025 + | 0.975– | 0.005 + | **0.995–** |
| | | | | | | | **2** | 0.316 | **1** | 0.024 | 1 | 0.100 | **1** |
| | | | ***n* = 3** | | | | | | | ***n* = 4** | | | |
| **0** | 0 | **0.536** | 0 | **0.632** | 0 | **0.785–** | **0** | 0 | **0.500** | 0 | **0.527** | 0 | **0.684** |
| **1** | 0.035– | **0.804** | 0.017 | **0.865–** | 0.003 | **0.941** | **1** | 0.026 | **0.680** | 0.013 | **0.751** | 0.003 | **0.859** |
| **2** | 0.196 | **0.965 +** | 0.135 + | **0.983** | 0.059 | **0.997** | **2** | 0.143 | **0.857** | 0.098 | **0.902** | 0.042 | **0.958** |
| **3** | 0.464 | **1** | 0.368 | **1** | 0.215 + | **1** | **3** | 0.320 | **0.974** | 0.249 | **0.987** | 0.141 | **0.997** |
| | | | | | | | **4** | 0.500 | **1** | 0.473 | **1** | 0.316 | **1** |
| | | | ***n* = 5** | | | | | | | ***n* = 6** | | | |
| **0** | 0 | **0.379** | 0 | **0.500** | 0 | **0.602** | **0** | 0 | **0.345–** | 0 | **0.402** | 0 | **0.536** |
| **1** | 0.021 | **0.621** | 0.010 | **0.657** | 0.002 | **0.778** | **1** | 0.017 | **0.542** | 0.009 | **0.598** | 0.002 | **0.706** |
| **2** | 0.112 | **0.753** | 0.076 | **0.811** | 0.033 | **0.894** | **2** | 0.093 | **0.667** | 0.063 | **0.729** | 0.027 | **0.827** |
| **3** | 0.247 | **0.888** | 0.189 | **0.924** | 0.106 | **0.967** | **3** | 0.201 | **0.799** | 0.153 | **0.847** | 0.085– | **0.915 +** |
| **4** | 0.379 | **0.979** | 0.343 | **0.990** | 0.222 | **0.998** | **4** | 0.333 | **0.907** | 0.271 | **0.937** | 0.173 | **0.973** |
| **5** | 0.621 | **1** | 0.500 | **1** | 0.398 | **1** | **5** | 0.458 | **0.983** | 0.402 | **0.991** | 0.294 | **0.998** |
| | | | | | | | **6** | 0.655 + | **1** | 0.598 | **1** | 0.464 | **1** |
| | | | ***n* = 7** | | | | | | | ***n* = 8** | | | |
| **0** | 0 | **0.316** | 0 | **0.377** | 0 | **0.500** | **0** | 0 | **0.255–** | 0 | **0.315 +** | 0 | **0.451** |
| **1** | 0.015– | **0.500** | 0.007 | **0.554** | 0.001 | **0.643** | **1** | 0.013 | **0.418** | 0.006 | **0.500** | 0.001 | **0.590** |
| **2** | 0.079 | **0.684** | 0.053 | **0.659** | 0.023 | **0.764** | **2** | 0.069 | **0.582** | 0.046 | **0.685–** | 0.020 | **0.707** |
| **3** | 0.170 | **0.721** | 0.129 | **0.775–** | 0.071 | **0.858** | **3** | 0.147 | **0.745 +** | 0.111 | **0.711** | 0.061 | **0.802** |
| **4** | 0.279 | **0.830** | 0.225 + | **0.871** | 0.142 | **0.929** | **4** | 0.240 | **0.760** | 0.193 | **0.807** | 0.121 | **0.879** |
| **5** | 0.316 | **0.921** | 0.341 | **0.947** | 0.236 | **0.977** | **5** | 0.255– | **0.853** | 0.289 | **0.889** | 0.198 | **0.939** |
| **6** | 0.500 | **0.985 +** | 0.446 | **0.993** | 0.357 | **0.999** | **6** | 0.418 | **0.931** | 0.315 + | **0.954** | 0.293 | **0.980** |
| **7** | 0.684 | **1** | 0.623 | **1** | 0.500 | **1** | **7** | 0.582 | **0.987** | 0.500 | **0.994** | 0.410 | **0.980** |
| | | | | | | | **8** | 0.745 + | **1** | 0.685– | **1** | 0.549 | **1** |
| | | | ***n* = 9** | | | | | | | ***n* = 10** | | | |
| **0** | 0 | **0.232** | 0 | **0.289** | 0 | **0.402** | **0** | 0 | **0.222** | 0 | **0.267** | 0 | **0.376** |
| **1** | 0.012 | **0.391** | 0.006 | **0.443** | 0.001 | **0.598** | **1** | 0.010 | **0.352** | 0.005 + | **0.397** | 0.001 | **0.512** |
| **2** | 0.061 | **0.515 +** | 0.041 | **0.558** | 0.017 | **0.656** | **2** | 0.055– | **0.500** | 0.037 | **0.603** | 0.016 | **0.624** |
| **3** | 0.129 | **0.610** | 0.098 | **0.711** | 0.053 | **0.750** | **3** | 0.116 | **0.648** | 0.087 | **0.619** | 0.048 | **0.703** |
| **4** | 0.210 | **0.768** | 0.169 | **0.749** | 0.105 + | **0.829** | **4** | 0.188 | **0.659** | 0.150 | **0.733** | 0.093 | **0.782** |
| **5** | 0.232 | **0.790** | 0.251 | **0.831** | 0.171 | **0.895–** | **5** | 0.222 | **0.778** | 0.222 | **0.778** | 0.150 | **0.850** |
| **6** | 0.390 | **0.871** | 0.289 | **0.902** | 0.250 | **0.947** | **6** | 0.341 | **0.812** | 0.267 | **0.850** | 0.218 | **0.907** |
| **7** | 0.485– | **0.939** | 0.442 | **0.959** | 0.344 | **0.983** | **7** | 0.352 | **0.884** | 0.381 | **0.913** | 0.297 | **0.952** |
| **8** | 0.609 | **0.988** | 0.557 | **0.994** | 0.402 | **0.999** | **8** | 0.500 | **0.945 +** | 0.397 | **0.963** | 0.376 | **0.984** |
| **9** | 0.768 | **1** | 0.711 | **1** | 0.598 | **1** | **9** | 0.618 | **0.990** | 0.603 | **0.995–** | 0.488 | **0.999** |
| | | | | | | | **10** | 0.778 | **1** | 0.733 | **1** | 0.624 | **1** |
| | | | ***n* = 11** | | | | | | | ***n* = 12** | | | |
| **0** | 0 | **0.197** | 0 | **0.250** | 0 | **0.359** | **0** | 0 | **0.184** | 0 | **0.236** | 0 | **0.321** |
| **1** | 0.010 | **0.315 +** | 0.005– | **0.369** | 0.001 | **0.500** | **1** | 0.009 | **0.294** | 0.004 | **0.346** | 0.001 | **0.445 +** |
| **2** | 0.049 | **0.423** | 0.033 | **0.500** | 0.014 | **0.593** | **2** | 0.045 + | **0.398** | 0.030 | **0.450** | 0.013 | **0.555–** |
| **3** | 0.105– | **0.577** | 0.079 | **0.631** | 0.043 | **0.660** | **3** | 0.096 | **0.500** | 0.072 | **0.550** | 0.039 | **0.679** |
| **4** | 0.169 | **0.685–** | 0.135 + | **0.667** | 0.084 | **0.738** | **4** | 0.154 | **0.602** | 0.123 | **0.654** | 0.076 | **0.698** |
| **5** | 0.197 | **0.698** | 0.200 | **0.750** | 0.134 | **0.806** | **5** | 0.184 | **0.706** | 0.181 | **0.706** | 0.121 | **0.765 +** |
| **6** | 0.302 | **0.803** | 0.250 | **0.800** | 0.194 | **0.866** | **6** | 0.271 | **0.729** | 0.236 | **0.764** | 0.175– | **0.825 +** |
| **7** | 0.315 + | **0.831** | 0.333 | **0.865–** | 0.262 | **0.916** | **7** | 0.294 | **0.816** | 0.294 | **0.819** | 0.235– | **0.879** |
| **8** | 0.423 | **0.895 +** | 0.369 | **0.921** | 0.340 | **0.957** | **8** | 0.398 | **0.846** | 0.346 | **0.877** | 0.302 | **0.924** |
| **9** | 0.577 | **0.951** | 0.500 | **0.967** | 0.407 | **0.986** | **9** | 0.500 | **0.904** | 0.450 | **0.928** | 0.321 | **0.961** |
| **10** | 0.685– | **0.990** | 0.631 | **0.995 +** | 0.500 | **0.999** | **10** | 0.602 | **0.955–** | 0.550 | **0.970** | 0.445 + | **0.987** |
| **11** | 0.803 | **1** | 0.750 | **1** | 0.641 | **1** | **11** | 0.706 | **0.991** | 0.654 | **0.996** | 0.555– | **0.999** |
| | | | | | | | **12** | 0.0816 | **1** | 0.764 | **1** | 0.679 | **1** |
| | | | ***n* = 13** | | | | | | | ***n* = 14** | | | |
| **0** | 0 | **0.173** | 0 | **0.225 +** | 0 | **0.302** | **0** | 0 | **0.163** | 0 | **0.207** | 0 | **0.286** |
| **1** | 0.008 | **0.276** | 0.004 | **0.327** | 0.001 | **0.429** | **1** | 0.007 | **0.261** | 0.004 | **0.312** | 0.001 | **0.392** |
| **2** | 0.042 | **0.379** | 0.028 | **0.434** | 0.012 | **0.523** | **2** | 0.039 | **0.365 +** | 0.026 | **0.389** | 0.011 | **0.500** |
| **3** | 0.088 | **0.470** | 0.066 | **0.520** | 0.036 | **0.594** | **3** | 0.081 | **0.422** | 0.061 | **0.500** | 0.033 | **0.608** |
| **4** | 0.142 | **0.545–** | 0.113 | **0.587** | 0.069 | **0.698** | **4** | 0.131 | **0.578** | 0.104 | **0.611** | 0.064 | **0.636** |
| **5** | 0.173 | **0.621** | 0.166 | **0.673** | 0.111 | **0.727** | **5** | 0.163 | **0.594** | 0.153 | **0.629** | 0.102 | **0.714** |
| **6** | 0.246 | **0.724** | 0.224 | **0.740** | 0.159 | **0.787** | **6** | 0.224 | **0.645 +** | 0.206 | **0.688** | 0.146 | **0.751** |
| **7** | 0.276 | **0.754** | 0.260 | **0.776** | 0.213 | **0.841** | **7** | 0.261 | **0.739** | 0.207 | **0.793** | 0.195– | **0.805 +** |

**TABLE A1.1** *Continued*

| *r* | 90 % | | 95 % | | 99 % | | *r* | 90 % | | 95 % | | 99 % | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **8** | 0.379 | **0.827** | 0.327 | **0.834** | 0.273 | **0.889** | **8** | 0.355– | **0.776** | 0.312 | **0.794** | 0.249 | **0.854** |
| **9** | 0.455 + | **0.858** | 0.413 | **0.887** | 0.302 | **0.931** | **9** | 0.406 | **0.837** | 0.371 | **0.847** | 0.286 | **0.898** |
| **10** | 0.530 | **0.912** | 0.480 | **0.934** | 0.406 | **0.964** | **10** | 0.422 | **0.869** | 0.389 | **0.896** | 0.364 | **0.936** |
| **11** | 0.621 | **0.958** | 0.566 | **0.972** | 0.477 | **0.988** | **11** | 0.578 | **0.919** | 0.500 | **0.939** | 0.392 | **0.967** |
| **12** | 0.724 | **0.992** | 0.673 | **0.996** | 0.571 | **0.999** | **12** | 0.635– | **0.961** | 0.611 | **0.974** | 0.500 | **0.989** |
| **13** | 0.827 | **1** | 0.775– | **1** | 0.698 | **1** | **13** | 0.739 | **0.993** | 0.688 | **0.996** | 0.608 | **0.999** |
| | | | | | | | **14** | 0.837 | **1** | 0.793 | **1** | 0.714 | **1** |
| | | | ***n* = 15** | | | | | | | ***n* = 16** | | | |
| **0** | 0 | **0.154** | 0 | **0.191** | 0 | **0.273** | **0** | 0 | **0.147** | 0 | **0.179** | 0 | **0.264** |
| **1** | 0.007 | **0.247** | 0.003 | **0.302** | 0.001 | **0.373** | **1** | 0.007 | **0.235 +** | 0.003 | **0.273** | 0.001 | **0.357** |
| **2** | 0.036 | **0.326** | 0.024 | **0.369** | 0.010 | **0.461** | **2** | 0.034 | **0.305 +** | 0.023 | **0.352** | 0.010 | **0.451** |
| **3** | 0.076 | **0.400** | 0.057 | **0.448** | 0.031 | **0.539** | **3** | 0.071 | **0.381** | 0.053 | **0.429** | 0.029 | **0.525–** |
| **4** | 0.122 | **0.500** | 0.097 | **0.552** | 0.059 | **0.627** | **4** | 0.114 | **0.450** | 0.090 | **0.500** | 0.055 + | **0.579** |
| **5** | 0.154 | **0.600** | 0.142 | **0.631** | 0.094 | **0.672** | **5** | 0.147 | **0.550** | 0.132 | **0.571** | 0.088 | **0.643** |
| **6** | 0.205 + | **0.674** | 0.191 | **0.668** | 0.135– | **0.727** | **6** | 0.189 | **0.619** | 0.178 | **0.648** | 0.125 + | **0.705–** |
| **7** | 0.247 | **0.675–** | 0.192 | **0.706** | 0.179 | **0.771** | **7** | 0.235 + | **0.695–** | 0.179 | **0.727** | 0.166 | **0.739** |
| **8** | 0.325 + | **0.753** | 0.294 | **0.808** | 0.229 | **0.821** | **8** | 0.299 | **0.701** | 0.272 | **0.728** | 0.212 | **0.788** |
| **9** | 0.326 | **0.795–** | 0.332 | **0.809** | 0.273 | **0.865 +** | **9** | 0.305 + | **0.765–** | 0.273 | **0.821** | 0.261 | **0.834** |
| **10** | 0.400 | **0.846** | 0.369 | **0.858** | 0.328 | **0.906** | **10** | 0.381 | **0.811** | 0.352 | **0.822** | 0.295 + | **0.875–** |
| **11** | 0.500 | **0.878** | 0.448 | **0.903** | 0.373 | **0.941** | **11** | 0.450 | **0.853** | 0.429 | **0.868** | 0.357 | **0.912** |
| **12** | 0.600 | **0.924** | 0.552 | **0.943** | 0.461 | **0.969** | **12** | 0.550 | **0.886** | 0.500 | **0.910** | 0.421 | **0.945–** |
| **13** | 0.674 | **0.964** | 0.631 | **0.976** | 0.539 | **0.990** | **13** | 0.619 | **0.929** | 0.571 | **0.947** | 0.475 + | **0.971** |
| **14** | 0.753 | **0.993** | 0.698 | **0.997** | 0.627 | **0.999** | **14** | 0.695– | **0.966** | 0.648 | **0.977** | 0.549 | **0.990** |
| **15** | 0.846 | **1** | 0.809 | **1** | 0.727 | **1** | **15** | 0.765– | **0.993** | 0.727 | **0.997** | 0.643 | **0.999** |
| | | | | | | | **16** | 0.853 | **1** | 0.821 | **1** | 0.736 | **1** |
| | | | ***n* = 17** | | | | | | | ***n* = 18** | | | |
| **0** | 0 | **0.140** | 0 | **0.167** | 0 | **0.243** | **0** | 0 | **0.135–** | 0 | **0.157** | 0 | **0.228** |
| **1** | 0.006 | **0.225 +** | 0.003 | **0.254** | 0.001 | **0.346** | **1** | 0.006 | **0.216** | 0.003 | **0.242** | 0.001 | **0.318** |
| **2** | 0.032 | **0.290** | 0.021 | **0.337** | 0.009 | **0.413** | **2** | 0.030 | **0.277** | 0.020 | **0.325–** | 0.008 | **0.397** |
| **3** | 0.067 | **0.364** | 0.050 | **0.417** | 0.027 | **0.500** | **3** | 0.063 | **0.349** | 0.047 | **0.381** | 0.025 + | **0.466** |
| **4** | 0.107 | **0.432** | 0.085– | **0.489** | 0.052 | **0.587** | **4** | 0.101 | **0.419** | 0.080 | **0.444** | 0.049 | **0.534** |
| **5** | 0.140 | **0.500** | 0.124 | **0.544** | 0.082 | **0.620** | **5** | 0.135– | **0.482** | 0.116 | **0.556** | 0.077 | **0.603** |
| **6** | 0.175 + | **0.568** | 0.166 | **0.594** | 0.117 | **0.662** | **6** | 0.163 | **0.536** | 0.156 | **0.619** | 0.110 | **0.682** |
| **7** | 0.225 + | **0.636** | 0.167 | **0.663** | 0.155 + | **0.757** | **7** | 0.216 | **0.584** | 0.157 | **0.625 +** | 0.145 + | **0.686** |
| **8** | 0.277 | **0.710** | 0.253 | **0.746** | 0.197 | **0.758** | **8** | 0.257 | **0.651** | 0.236 | **0.675 +** | 0.184 | **0.772** |
| **9** | 0.290 | **0.723** | 0.254 | **0.747** | 0.242 | **0.803** | **9** | 0.277 | **0.723** | 0.242 | **0.758** | 0.226 | **0.774** |
| **10** | 0.364 | **0.775–** | 0.337 | **0.833** | 0.243 | **0.845** | **10** | 0.349 | **0.743** | 0.325– | **0.764** | 0.228 | **0.816** |
| **11** | 0.432 | **0.825–** | 0.406 | **0.834** | 0.338 | **0.883** | **11** | 0.416 | **0.784** | 0.375– | **0.843** | 0.314 | **0.855–** |
| **12** | 0.500 | **0.860** | 0.456 | **0.876** | 0.380 | **0.918** | **12** | 0.464 | **0.837** | 0.381 | **0.844** | 0.318 | **0.890** |
| **13** | 0.568 | **0.893** | 0.511 | **0.915 +** | 0.413 | **0.948** | **13** | 0.518 | **0.865 +** | 0.444 | **0.884** | 0.397 | **0.923** |
| **14** | 0.636 | **0.933** | 0.583 | **0.950** | 0.500 | **0.973** | **14** | 0.581 | **0.899** | 0.556 | **0.920** | 0.466 | **0.951** |
| **15** | 0.710 | **0.968** | 0.663 | **0.979** | 0.587 | **0.991** | **15** | 0.651 | **0.937** | 0.619 | **0.953** | 0.534 | **0.975–** |
| **16** | 0.775– | **0.994** | 0.746 | **0.997** | 0.654 | **0.999** | **16** | 0.723 | **0.970** | 0.675 + | **0.980** | 0.603 | **0.992** |
| **17** | 0.860 | **1** | 0.833 | **1** | 0.757 | **1** | **17** | 0.784 | 0.994 | 0.758 | **0.997** | 0.682 | **0.999** |
| | | | | | | | **18** | 0.865 + | **1** | 0.843 | **1** | | **1** |
| | | | ***n* = 19** | | | | | | | ***n* = 20** | | | |
| **0** | 0 | **0.130** | 0 | **0.150** | 0 | **0.218** | **0** | 0 | **0.126** | 0 | **0.143** | 0 | **0.209** |
| **1** | 0.006 | **0.209** | 0.003 | **0.232** | 0.001 | **0.305 +** | **1** | 0.005 + | **0.203** | 0.003 | **0.222** | 0.001 | **0.293** |
| **2** | 0.028 | **0.265 +** | 0.019 | **0.316** | 0.008 | **0.383** | **2** | 0.027 | **0.255–** | 0.018 | **0.294** | 0.008 | **0.375–** |
| **3** | 0.059 | **0.337** | 0.044 | **0.365–** | 0.024 | **0.455 +** | **3** | 0.056 | **0.328** | 0.042 | **0.351** | 0.023 | **0.424** |
| **4** | 0.095 + | **0.387** | 0.075 + | **0.426** | 0.046 | **0.515 +** | **4** | 0.090 | **0.367** | 0.071 | **0.411** | 0.044 | **0.500** |
| **5** | 0.130 | **0.440** | 0.110 | **0.500** | 0.073 | **0.564** | **5** | 0.126 | **0.422** | 0.104 | **0.467** | 0.069 | **0.576** |
| **6** | 0.151 | **0.560** | 0.147 | **0.574** | 0.103 | **0.617** | **6** | 0.141 | **0.500** | 0.140 | **0.533** | 0.098 | **0.601** |
| **7** | 0.209 | **0.613** | 0.150 | **0.635 +** | 0.137 | **0.695–** | **7** | 0.201 | **0.578** | 0.143 | **0.589** | 0.129 | **0.637** |
| **8** | 0.238 | **0.614** | 0.222 | **0.655 +** | 0.173 | **0.707** | **8** | 0.221 | **0.633** | 0.209 | **0.649** | 0.163 | **0.707** |
| **9** | 0.265 + | **0.663** | 0.232 | **0.688** | 0.212 | **0.782** | **9** | 0.255– | **0.642** | 0.222 | **0.706** | 0.200 | **0.726** |
| **10** | 0.337 | **0.735–** | 0.312 | **0.768** | 0.218 | **0.788** | **10** | 0.325 | **0.675 +** | 0.293 | **0.707** | 0.209 | **0.791** |
| **11** | 0.386 | **0.762** | 0.345– | **0.778** | 0.293 | **0.827** | **11** | 0.358 | **0.745 +** | 0.294 | **0.778** | 0.274 | **0.800** |
| **12** | 0.387 | **0.791** | 0.365– | **0.850** | 0.305 + | **0.863** | **12** | 0.367 | **0.779** | 0.351 | **0.791** | 0.293 | **0.837** |
| **13** | 0.440 | **0.849** | 0.426 | **0.853** | 0.383 | **0.897** | **13** | 0.422 | **0.799** | 0.411 | **0.857** | 0.363 | **0.871** |
| **14** | 0.560 | **0.870** | 0.500 | **0.890** | 0.436 | **0.927** | **14** | 0.500 | **0.859** | 0.467 | **0.860** | 0.399 | **0.902** |
| **15** | 0.613 | **0.905–** | 0.574 | **0.925–** | 0.485– | **0.954** | **15** | 0.578 | **0.874** | 0.533 | **0.896** | 0.424 | **0.931** |
| **16** | 0.663 | **0.941** | 0.635 + | **0.956** | 0.545– | **0.976** | **16** | 0.633 | **0.910** | 0.589 | **0.929** | 0.500 | **0.956** |
| **17** | 0.735– | **0.972** | 0.684 | **0.981** | 0.617 | **0.992** | **17** | 0.672 | **0.944** | 0.649 | **0.958** | 0.576 | **0.977** |
| **18** | 0.791 | **0.994** | 0.768 | **0.997** | 0.695– | **0.999** | **18** | 0.745 + | **0.973** | 0.706 | **0.982** | 0.625 + | **0.992** |
| **19** | 0.870 | **1** | 0.850 | **1** | 0.782 | **1** | **19** | 0.797 | **0.995–** | 0.778 | **0.997** | 0.707 | **0.999** |

TABLE A1.1 *Continued*

| *r* | 90 % | | 95 % | | 99 % | | *r* | 90 % | | 95 % | | 99 % | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | **20** | 0.874 | **1** | 0.857 | **1** | 0.791 | **1** |
| | | | ***n* = 21** | | | | | | | ***n* = 22** | | | |
| **0** | 0 | **0.123** | 0 | **0.137** | 0 | **0.201** | **0** | 0 | **0.116** | 0 | **0.132** | 0 | **0.194** |
| **1** | 0.005 + | **0.192** | 0.002 | **0.213** | 0.000 | **0.283** | **1** | 0.005– | **0.182** | 0.002 | **0.205 +** | 0.000 | **0.273** |
| **2** | 0.026 | **0.245–** | 0.017 | **0.277** | 0.007 | **0.347** | **2** | 0.024 | **0.236** | 0.016 | **0.264** | 0.007 | **0.334** |
| **3** | 0.054 | **0.307** | 0.040 | **0.338** | 0.022 | **0.409** | **3** | 0.051 | **0.289** | 0.038 | **0.326** | 0.021 | **0.396** |
| **4** | 0.086 | **0.353** | 0.068 | **0.398** | 0.041 | **0.466** | **4** | 0.082 | **0.340** | 0.065– | **0.389** | 0.039 | **0.454** |
| **5** | 0.121 | **0.407** | 0.099 | **0.455 +** | 0.065 + | **0.534** | **5** | 0.115– | **0.393** | 0.094 | **0.424** | 0.062 | **0.505–** |
| **6** | 0.130 | **0.458** | 0.132 | **0.506** | 0.092 | **0.591** | **6** | 0.116 | **0.444** | 0.126 | **0.500** | 0.088 | **0.550** |
| **7** | 0.191 | **0.542** | 0.137 | **0.551** | 0.122 | **0.653** | **7** | 0.181 | **0.500** | 0.132 | **0.576** | 0.116 | **0.604** |
| **8** | 0.192 | **0.593** | 0.197 | **0.602** | 0.155– | **0.661** | **8** | 0.182 | **0.556** | 0.187 | **0.582** | 0.147 | **0.666** |
| **9** | 0.245– | **0.647** | 0.213 | **0.662** | 0.189 | **0.717** | **9** | 0.236 | **0.607** | 0.205 + | **0.617** | 0.179 | **0.682** |
| **10** | 0.306 | **0.693** | 0.276 | **0.723** | 0.201 | **0.743** | **10** | 0.289 | **0.660** | 0.260 | **0.674** | 0.194 | **0.727** |
| **11** | 0.307 | **0.694** | 0.277 | **0.724** | 0.257 | **0.799** | **11** | 0.290 | **0.710** | 0.264 | **0.736** | 0.242 | **0.758** |
| **12** | 0.353 | **0.755 +** | 0.338 | **0.787** | 0.283 | **0.811** | **12** | 0.340 | **0.711** | 0.326 | **0.740** | 0.273 | **0.806** |
| **13** | 0.407 | **0.808** | 0.398 | **0.803** | 0.339 | **0.845 +** | **13** | 0.393 | **0.764** | 0.383 | **0.795–** | 0.318 | **0.821** |
| **14** | 0.458 | **0.809** | 0.449 | **0.863** | 0.347 | **0.878** | **14** | 0.444 | **0.818** | 0.418 | **0.813** | 0.334 | **0.853** |
| **15** | 0.542 | **0.870** | 0.494 | **0.868** | 0.409 | **0.908** | **15** | 0.500 | **0.819** | 0.424 | **0.868** | 0.396 | **0.884** |
| **16** | 0.593 | **0.879** | 0.545– | **0.901** | 0.466 | **0.935–** | **16** | 0.556 | **0.884** | 0.500 | **0.874** | 0.450 | **0.912** |
| **17** | 0.647 | **0.914** | 0.602 | **0.932** | 0.534 | **0.959** | **17** | 0.607 | **0.885 +** | 0.576 | **0.906** | 0.495 + | **0.938** |
| **18** | 0.693 | **0.946** | 0.662 | **0.960** | 0.591 | **0.978** | **18** | 0.660 | **0.918** | 0.611 | **0.935 +** | 0.546 | **0.961** |
| **19** | 0.755 + | **0.974** | 0.723 | **0.983** | 0.653 | **0.993** | **19** | 0.711 | **0.949** | 0.674 | **0.962** | 0.604 | **0.979** |
| **20** | 0.808 | **0.995–** | 0.787 | **0.998** | 0.717 | **1.000** | **20** | 0.764 | **0.976** | 0.736 | **0.984** | 0.666 | **0.993** |
| **21** | 0.877 | **1** | 0.863 | **1** | 0.799 | **1** | **21** | 0.818 | **0.995 +** | 0.795– | **0.998** | 0.727 | **1.000** |
| | | | | | | | **22** | 0.884 | **1** | 0.868 | **1** | 0.806 | **1** |
| | | | ***n* = 23** | | | | | | | ***n* = 24** | | | |
| **0** | 0 | **0.111** | 0 | **0.127** | 0 | **0.187** | **0** | 0 | **0.105 +** | 0 | **0.122** | 0 | **0.181** |
| **1** | 0.005– | **0.174** | 0.002 | **0.198** | 0.000 | **0.265 +** | **1** | 0.004 | **0.165 +** | 0.002 | **0.191** | 0.000 | **0.259** |
| **2** | 0.023 | **0.228** | 0.016 | **0.255–** | 0.007 | **0.323** | **2** | 0.022 | **0.221** | 0.015 + | **0.246** | 0.006 | **0.313** |
| **3** | 0.049 | **0.274** | 0.037 | **0.317** | 0.020 | **0.386** | **3** | 0.047 | **0.264** | 0.035– | **0.308** | 0.019 | **0.364** |
| **4** | 0.078 | **0.328** | 0.062 | **0.361** | 0.038 | **0.429** | **4** | 0.075– | **0.317** | 0.059 | **0.347** | 0.036 | **0.416** |
| **5** | 0.110 | **0.381** | 0.090 | **0.409** | 0.059 | **0.500** | **5** | 0.105– | **0.370** | 0.086 | **0.396** | 0.057 | **0.464** |
| **6** | 0.111 | **0.431** | 0.120 | **0.457** | 0.084 | **0.571** | **6** | 0.105 + | **0.423** | 0.115– | **0.443** | 0.080 | **0.536** |
| **7** | 0.173 | **0.479** | 0.127 | **0.543** | 0.111 | **0.580** | **7** | 0.165– | **0.448** | 0.122 | **0.500** | 0.106 | **0.584** |
| **8** | 0.174 | **0.522** | 0.178 | **0.591** | 0.140 | **0.616** | **8** | 0.165 + | **0.552** | 0.169 | **0.557** | 0.133 | **0.636** |
| **9** | 0.228 | **0.569** | 0.198 | **0.639** | 0.171 | **0.677** | **9** | 0.221 | **0.553** | 0.191 | **0.604** | 0.163 | **0.638** |
| **10** | 0.273 | **0.619** | 0.247 | **0.640** | 0.187 | **0.702** | **10** | 0.259 | **0.587** | 0.234 | **0.653** | 0.181 | **0.687** |
| **11** | 0.274 | **0.672** | 0.255– | **0.683** | 0.229 | **0.735–** | **11** | 0.264 | **0.630** | 0.246 | **0.661** | 0.216 | **0.720** |
| **12** | 0.328 | **0.726** | 0.317 | **0.745 +** | 0.265 + | **0.771** | **12** | 0.317 | **0.683** | 0.308 | **0.692** | 0.257 | **0.743** |
| **13** | 0.381 | **0.727** | 0.360 | **0.753** | 0.298 | **0.813** | **13** | 0.370 | **0.736** | 0.339 | **0.754** | 0.280 | **0.784** |
| **14** | 0.431 | **0.772** | 0.361 | **0.802** | 0.323 | **0.829** | **14** | 0.413 | **0.741** | 0.347 | **0.766** | 0.313 | **0.819** |
| **15** | 0.478 | **0.826** | 0.409 | **0.822** | 0.384 | **0.860** | **15** | 0.447 | **0.779** | 0.396 | **0.809** | 0.362 | **0.837** |
| **16** | 0.521 | **0.827** | 0.457 | **0.873** | 0.420 | **0.889** | **16** | 0.448 | **0.835–** | 0.443 | **0.831** | 0.364 | **0.867** |
| **17** | 0.569 | **0.889** | 0.543 | **0.880** | 0.429 | **0.916** | **17** | 0.552 | **0.835 +** | 0.500 | **0.878** | 0.416 | **0.894** |
| **18** | 0.619 | **0.890** | 0.591 | **0.910** | 0.500 | **0.941** | **18** | 0.577 | **0.895–** | 0.557 | **0.885 +** | 0.464 | **0.920** |
| **19** | 0.672 | **0.922** | 0.639 | **0.938** | 0.571 | **0.962** | **19** | 0.630 | **0.895 +** | 0.604 | **0.914** | 0.536 | **0.943** |
| **20** | 0.726 | **0.951** | 0.683 | **0.963** | 0.614 | **0.980** | **20** | 0.683 | **0.925 +** | 0.653 | **0.941** | 0.584 | **0.964** |
| **21** | 0.772 | **0.977** | 0.745 + | **0.984** | 0.677 | **0.993** | **21** | 0.736 | **0.953** | 0.692 | **0.965 +** | 0.636 | **0.981** |
| **22** | 0.826 | **0.995 +** | 0.802 | **0.998** | 0.735– | **1.000** | **22** | 0.779 | **0.978** | 0.754 | **0.985–** | 0.687 | **0.994** |
| **23** | 0.889 | **1** | 0.873 | **1** | 0.813 | **1** | **23** | 0.835– | **0.996** | 0.809 | **0.998** | 0.741 | **1.000** |
| | | | | | | | **24** | 0.895– | **1** | 0.878 | **1** | 0.819 | **1** |
| | | | ***n* = 25** | | | | | | | ***n* = 26** | | | |
| **0** | 0 | **0.102** | 0 | **0.118** | 0 | **0.175 +** | **0** | 0 | **0.098** | 0 | **0.114** | 0 | **0.170** |
| **1** | 0.004 | **0.159** | 0.002 | **0.185 +** | 0.000 | **0.246** | **1** | 0.004 | **0.152** | 0.002 | **0.180** | 0.000 | **0.235–** |
| **2** | 0.021 | **0.214** | 0.014 | **0.238** | 0.006 | **0.305–** | **2** | 0.021 | **0.209** | 0.014 | **0.230** | 0.006 | **0.298** |
| **3** | 0.045– | **0.255–** | 0.034 | **0.303** | 0.018 | **0.352** | **3** | 0.043 | **0.247** | 0.032 | **0.283** | 0.017 | **0.342** |
| **4** | 0.072 | **0.307** | 0.057 | **0.336** | 0.034 | **0.403** | **4** | 0.069 | **0.299** | 0.054 | **0.325 +** | 0.033 | **0.393** |
| **5** | 0.101 | **0.362** | 0.082 | **0.384** | 0.054 | **0.451** | **5** | 0.097 | **0.343** | 0.079 | **0.374** | 0.052 | **0.442** |
| **6** | 0.102 | **0.390** | 0.110 | **0.431** | 0.077 | **0.500** | **6** | 0.098 | **0.377** | 0.106 | **0.421** | 0.073 | **0.487** |
| **7** | 0.158 | **0.432** | 0.118 | **0.475–** | 0.101 | **0.549** | **7** | 0.151 | **0.419** | 0.114 | **0.465–** | 0.097 | **0.526** |
| **8** | 0.159 | **0.500** | 0.161 | **0.525 +** | 0.127 | **0.597** | **8** | 0.152 | **0.460** | 0.154 | **0.506** | 0.122 | **0.562** |
| **9** | 0.214 | **0.568** | 0.185 + | **0.569** | 0.155 + | **0.648** | **9** | 0.209 | **0.540** | 0.180 | **0.542** | 0.149 | **0.607** |
| **10** | 0.246 | **0.610** | 0.222 | **0.616** | 0.175 + | **0.658** | **10** | 0.233 | **0.581** | 0.212 | **0.579** | 0.170 | **0.658** |
| **11** | 0.255– | **0.611** | 0.238 | **0.664** | 0.205 + | **0.695 +** | **11** | 0.247 | **0.623** | 0.230 | **0.626** | 0.195– | **0.678** |
| **12** | 0.307 | **0.640** | 0.296 | **0.683** | 0.245 + | **0.754** | **12** | 0.299 | **0.657** | 0.282 | **0.675–** | 0.234 | **0.702** |

**TABLE A1.1** *Continued*

| r | 90 % | | 95 % | | 99 % | | r | 90 % | | 95 % | | 99 % | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 13 | 0.360 | 0.693 | 0.317 | 0.704 | 0.246 | 0.755– | 13 | 0.342 | 0.658 | 0.283 | 0.717 | 0.235– | 0.765 + |
| 14 | 0.389 | 0.745 + | 0.336 | 0.762 | 0.305– | 0.795– | 14 | 0.343 | 0.701 | 0.325 + | 0.718 | 0.298 | 0.766 |
| 15 | 0.390 | 0.754 | 0.384 | 0.778 | 0.342 | 0.825– | 15 | 0.377 | 0.753 | 0.374 | 0.770 | 0.322 | 0.805 + |
| 16 | 0.432 | 0.786 | 0.431 | 0.815– | 0.352 | 0.845– | 16 | 0.419 | 0.767 | 0.421 | 0.788 | 0.342 | 0.830 |
| 17 | 0.500 | 0.841 | 0.475– | 0.839 | 0.403 | 0.873 | 17 | 0.460 | 0.791 | 0.458 | 0.820 | 0.393 | 0.851 |
| 18 | 0.568 | 0.842 | 0.525 + | 0.882 | 0.451 | 0.899 | 18 | 0.540 | 0.848 | 0.494 | 0.846 | 0.438 | 0.878 |
| 19 | 0.610 | 0.898 | 0.569 | 0.890 | 0.500 | 0.923 | 19 | 0.581 | 0.849 | 0.535– | 0.886 | 0.474 | 0.903 |
| 20 | 0.638 | 0.899 | 0.616 | 0.918 | 0.549 | 0.946 | 20 | 0.623 | 0.902 | 0.579 | 0.894 | 0.513 | 0.927 |
| 21 | 0.693 | 0.928 | 0.664 | 0.943 | 0.597 | 0.966 | 21 | 0.657 | 0.903 | 0.626 | 0.921 | 0.558 | 0.948 |
| 22 | 0.745 + | 0.955 + | 0.697 | 0.966 | 0.648 | 0.982 | 22 | 0.701 | 0.931 | 0.675– | 0.946 | 0.607 | 0.967 |
| 23 | 0.786 | 0.979 | 0.762 | 0.986 | 0.695 + | 0.994 | 23 | 0.753 | 0.957 | 0.717 | 0.968 | 0.658 | 0.983 |
| 24 | 0.841 | 0.996 | 0.815– | 0.998 | 0.754 | 1.000 | 24 | 0.791 | 0.979 | 0.770 | 0.986 | 0.702 | 0.994 |
| 25 | 0.898 | 1 | 0.882 | 1 | 0.825– | 1 | 25 | 0.848 | 0.996 | 0.820 | 0.998 | 0.765 + | 1.000 |
| | | | | | | | 26 | 0.902 | 1 | 0.886 | 1 | 0.830 | 1 |
| | | | *n* = 27 | | | | | | | *n* = 28 | | | |
| 0 | 0 | 0.093 | 0 | 0.110 | 0 | 0.166 | 0 | 0 | 0.090 | 0 | 0.106 | 0 | 0.162 |
| 1 | 0.004 | 0.146 | 0.002 | 0.175– | 0.000 | 0.225– | 1 | 0.004 | 0.140 | 0.002 | 0.170 | 0.000 | 0.218 |
| 2 | 0.020 | 0.204 | 0.013 | 0.223 | 0.006 | 0.297 | 2 | 0.019 | 0.201 | 0.013 | 0.217 | 0.005 + | 0.273 |
| 3 | 0.042 | 0.239 | 0.031 | 0.270 | 0.017 | 0.332 | 3 | 0.040 | 0.232 | 0.030 | 0.259 | 0.016 | 0.323 |
| 4 | 0.066 | 0.291 | 0.052 | 0.316 | 0.032 | 0.384 | 4 | 0.064 | 0.284 | 0.050 | 0.307 | 0.031 | 0.365– |
| 5 | 0.093 | 0.327 | 0.076 | 0.364 | 0.050 | 0.419 | 5 | 0.089 | 0.312 | 0.073 | 0.357 | 0.048 | 0.408 |
| 6 | 0.094 | 0.365 + | 0.101 | 0.415– | 0.070 | 0.461 | 6 | 0.090 | 0.355– | 0.098 | 0.384 | 0.068 | 0.449 |
| 7 | 0.145 + | 0.407 | 0.110 | 0.437 | 0.093 | 0.539 | 7 | 0.139 | 0.396 | 0.106 | 0.424 | 0.089 | 0.500 |
| 8 | 0.146 | 0.447 | 0.148 | 0.500 | 0.117 | 0.581 | 8 | 0.140 | 0.435 + | 0.142 | 0.463 | 0.112 | 0.551 |
| 9 | 0.204 | 0.500 | 0.175– | 0.563 | 0.143 | 0.587 | 9 | 0.197 | 0.473 | 0.170 | 0.537 | 0.137 | 0.592 |
| 10 | 0.221 | 0.553 | 0.202 | 0.570 | 0.166 | 0.617 | 10 | 0.208 | 0.527 | 0.192 | 0.576 | 0.162 | 0.635 + |
| 11 | 0.239 | 0.593 | 0.223 | 0.598 | 0.185– | 0.668 | 11 | 0.232 | 0.565– | 0.217 | 0.616 | 0.175 + | 0.636 |
| 12 | 0.291 | 0.635– | 0.269 | 0.636 | 0.224 | 0.702 | 12 | 0.284 | 0.604 | 0.258 | 0.619 | 0.214 | 0.677 |
| 13 | 0.326 | 0.673 | 0.270 | 0.684 | 0.225– | 0.716 | 13 | 0.310 | 0.645 + | 0.259 | 0.645 + | 0.218 | 0.727 |
| 14 | 0.327 | 0.674 | 0.316 | 0.730 | 0.284 | 0.775 + | 14 | 0.312 | 0.688 | 0.307 | 0.693 | 0.272 | 0.728 |
| 15 | 0.365 + | 0.709 | 0.364 | 0.731 | 0.298 | 0.776 | 15 | 0.355– | 0.690 | 0.355– | 0.741 | 0.273 | 0.782 |
| 16 | 0.407 | 0.761 | 0.402 | 0.777 | 0.332 | 0.815– | 16 | 0.396 | 0.716 | 0.381 | 0.742 | 0.323 | 0.786 |
| 17 | 0.447 | 0.779 | 0.430 | 0.798 | 0.383 | 0.834 | 17 | 0.435 + | 0.768 | 0.384 | 0.783 | 0.364 | 0.825– |
| 18 | 0.500 | 0.796 | 0.437 | 0.825 + | 0.413 | 0.857 | 18 | 0.473 | 0.792 | 0.424 | 0.808 | 0.365– | 0.838 |
| 19 | 0.553 | 0.854 | 0.500 | 0.852 | 0.419 | 0.883 | 19 | 0.527 | 0.803 | 0.463 | 0.830 | 0.408 | 0.863 |
| 20 | 0.593 | 0.855– | 0.563 | 0.890 | 0.461 | 0.907 | 20 | 0.565– | 0.860 | 0.537 | 0.858 | 0.449 | 0.888 |
| 21 | 0.635– | 0.906 | 0.585 + | 0.899 | 0.539 | 0.930 | 21 | 0.604 | 0.861 | 0.576 | 0.894 | 0.500 | 0.911 |
| 22 | 0.673 | 0.907 | 0.636 | 0.924 | 0.581 | 0.950 | 22 | 0.645 + | 0.910 | 0.616 | 0.902 | 0.551 | 0.932 |
| 23 | 0.709 | 0.934 | 0.684 | 0.948 | 0.616 | 0.968 | 23 | 0.688 | 0.911 | 0.643 | 0.927 | 0.592 | 0.952 |
| 24 | 0.761 | 0.958 | 0.730 | 0.969 | 0.668 | 0.983 | 24 | 0.716 | 0.936 | 0.693 | 0.950 | 0.635 + | 0.969 |
| 25 | 0.796 | 0.980 | 0.777 | 0.987 | 0.703 | 0.994 | 25 | 0.768 | 0.960 | 0.741 | 0.970 | 0.677 | 0.984 |
| 26 | 0.854 | 0.996 | 0.825 + | 0.998 | 0.775 + | 1.000 | 26 | 0.799 | 0.981 | 0.783 | 0.987 | 0.727 | 0.995– |
| | | | | | | 1 | | | | | | | |
| 27 | 0.907 | 1 | 0.890 | 1 | 0.0834 | 1 | 27 | 0.860 | 0.996 | 0.830 | 0.998 | 0.782 | 1.000 |
| | | | | | | | 28 | 0.910 | 1 | 0.894 | 1 | 0.838 | 1 |
| | | | *n* = 29 | | | | | | | *n* = 30 | | | |
| 0 | 0 | 0.087 | 0 | 0.103 | 0 | 0.160 | 0 | 0 | 0.084 | 0 | 0.100 | 0 | 0.152 |
| 1 | 0.004 | 0.135– | 0.002 | 0.166 | 0.000 | 0.211 | 1 | 0.004 | 0.130 | 0.002 | 0.163 | 0.000 | 0.206 |
| 2 | 0.018 | 0.190 | 0.012 | 0.211 | 0.005 + | 0.263 | 2 | 0.018 | 0.183 | 0.012 | 0.205 + | 0.005 + | 0.256 |
| 3 | 0.039 | 0.225– | 0.029 | 0.251 | 0.015 + | 0.316 | 3 | 0.037 | 0.219 | 0.028 | 0.244 | 0.015– | 0.310 |
| 4 | 0.062 | 0.279 | 0.049 | 0.299 | 0.030 | 0.354 | 4 | 0.059 | 0.266 | 0.047 | 0.292 | 0.028 | 0.345– |
| 5 | 0.086 | 0.303 | 0.070 | 0.340 | 0.046 | 0.397 | 5 | 0.083 | 0.295– | 0.068 | 0.325– | 0.045– | 0.388 |
| 6 | 0.087 | 0.345– | 0.094 | 0.374 | 0.065 + | 0.438 | 6 | 0.084 | 0.336 | 0.091 | 0.364 | 0.063 | 0.430 |
| 7 | 0.134 | 0.385 + | 0.103 | 0.413 | 0.086 | 0.477 | 7 | 0.129 | 0.376 | 0.100 | 0.403 | 0.083 | 0.469 |
| 8 | 0.135– | 0.425– | 0.136 | 0.451 | 0.108 | 0.523 | 8 | 0.130 | 0.416 | 0.131 | 0.440 | 0.104 | 0.505 + |
| 9 | 0.189 | 0.463 | 0.166 | 0.500 | 0.132 | 0.562 | 9 | 0.182 | 0.455 + | 0.163 | 0.476 | 0.127 | 0.538 |
| 10 | 0.190 | 0.500 | 0.184 | 0.549 | 0.157 | 0.603 | 10 | 0.183 | 0.492 | 0.175 + | 0.524 | 0.151 | 0.570 |
| 11 | 0.225– | 0.537 | 0.211 | 0.587 | 0.165 + | 0.646 | 11 | 0.219 | 0.524 | 0.205 + | 0.560 | 0.152 | 0.612 |
| 12 | 0.276 | 0.575 + | 0.247 | 0.626 | 0.206 | 0.654 | 12 | 0.265– | 0.554 | 0.236 | 0.597 | 0.198 | 0.655 + |
| 13 | 0.294 | 0.615– | 0.251 | 0.660 | 0.211 | 0.684 | 13 | 0.266 | 0.584 | 0.244 | 0.636 | 0.206 | 0.671 |
| 14 | 0.303 | 0.655 + | 0.299 | 0.661 | 0.260 | 0.737 | 14 | 0.295– | 0.624 | 0.292 | 0.675 + | 0.249 | 0.692 |
| 15 | 0.345– | 0.697 | 0.339 | 0.701 | 0.263 | 0.740 | 15 | 0.336 | 0.664 | 0.324 | 0.676 | 0.256 | 0.744 |

**TABLE A1.1** *Continued*

| *r* | 90 % | | 95 % | | 99 % | | *r* | 90 % | | 95 % | | 99 % | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **16** | 0.385 + | **0.706** | 0.340 | **0.749** | 0.316 | **0.789** | **16** | 0.376 | **0.705 +** | 0.325– | **0.708** | 0.308 | **0.751** |
| **17** | 0.425– | **0.724** | 0.374 | **0.753** | 0.346 | **0.794** | **17** | 0.416 | **0.734** | 0.364 | **0.756** | 0.329 | **0.794** |
| **18** | 0.463 | **0.775 +** | 0.413 | **0.789** | 0.354 | **0.835–** | **18** | 0.446 | **0.735 +** | 0.403 | **0.764** | 0.345– | **0.802** |
| **19** | 0.500 | **0.810** | 0.451 | **0.816** | 0.397 | **0.843** | **19** | 0.476 | **0.781** | 0.440 | **0.795–** | 0.388 | **0.848** |
| **20** | 0.537 | **0.811** | 0.500 | **0.834** | 0.438 | **0.868** | **20** | 0.508 | **0.817** | 0.476 | **0.825–** | 0.430 | **0.849** |
| **21** | 0.575 + | **0.865 +** | 0.549 | **0.864** | 0.477 | **0.892** | **21** | 0.545– | **0.818** | 0.524 | **0.837** | 0.462 | **0.873** |
| **22** | 0.615– | **0.866** | 0.587 | **0.897** | 0.523 | **0.914** | **22** | 0.584 | **0.870** | 0.560 | **0.869** | 0.495– | **0.896** |
| **23** | 0.655 + | **0.913** | 0.626 | **0.906** | 0.562 | **0.935–** | **23** | 0.624 | **0.871** | 0.597 | **0.900** | 0.531 | **0.917** |
| **24** | 0.697 | **0.914** | 0.660 | **0.930** | 0.603 | **0.954** | **24** | 0.664 | **0.916** | 0.636 | **0.909** | 0.570 | **0.937** |
| **25** | 0.721 | **0.938** | 0.701 | **0.951** | 0.646 | **0.970** | **25** | 0.705 + | **0.917** | 0.675 + | **0.932** | 0.612 | **0.955 +** |
| **26** | 0.775 + | **0.961** | 0.749 | **0.971** | 0.684 | **0.985** | **26** | 0.734 | **0.941** | 0.708 | **0.953** | 0.655 + | **0.972** |
| **27** | 0.810 | **0.982** | 0.789 | **0.988** | 0.737 | **0.995** | **27** | 0.781 | **0.963** | 0.756 | **0.972** | 0.690 | **0.985 +** |
| **28** | 0.865 + | **0.996** | 0.834 | **0.998** | 0.789 | **1.000** | **28** | 0.817 | **0.982** | 0.795– | **0.988** | 0.744 | **0.995–** |
| **29** | 0.913 | **1** | 0.897 | **1** | 0.840 | **1** | **29** | 0.870 | **0.996** | 0.837 | **0.998** | 0.794 | **1.000** |
| | | | | | | | **30** | 0.916 | **1** | 0.900 | **1** | 0.848 | **1** |

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A1.3.4 If $n > 30$, look up $Z = Z_1 - \alpha/2$ in Table A1.2 and compute:

$$P_u = p + Z \frac{p\,(1-p)}{n} \quad \text{(A1.2)}$$

$$P_l = p - Z \sqrt{\frac{p\,(1-p)}{n}}$$

The interval from $P_l$ to $P_u$ is a $100(1 - \alpha)$ % confidence interval for the true proportion; that is, we may assert with $100(1 - \alpha)$ % confidence that $P_l < P < P_u$. It can be seen that as $n \rightarrow \infty$, $p(l - p)/n \rightarrow 0$. Thus smaller confidence intervals for the true proportion can be obtained by using larger samples.

A1.4 In application, we are interested in a 90 % confidence interval if the true proportion ($\alpha = 0.10$) and we desire the width of the interval to be less than some value $A$. Values of $Z = Z_{0.95}$ will be taken from Table A1.2 and used in the computation.

A1.4.1 Repeat the test $n$ times to establish a minimum sample size.

A1.4.2 Compute $p$ for the sample.

A1.4.3 If $n \leq 30$, use Table A1.1 to find values. For example, if $n = 20$ and $r = 6$, at the 90 % confidence level, $P_l = 0.141$ and $P_u = 0.500$.

A1.4.4 If $n > 30$, $Z_{0.95} = 1.645$ from Table A1.2. Compute:

$$P_u = Z_{0.95} \sqrt{p\,(1-p)/n} \quad \text{(A1.3)}$$

$$P_l = Z_{0.95} \sqrt{p\,(1-p)/n}$$

For example, if $n = 40$ and $r = 12$; $p = 0.3$, $P_u = 0.419$, and $P_l = 0.181$.

A1.4.5 Compare $(P_u - P_l)$ to $A$.

A1.4.6 If $(P_u - P_l) > A$, repeat the test that increases the sample size to $n + 1$ and perform A1.4.2 through A1.4.5 with the larger sample.

A1.4.7 If $(P_u - P_l) < A$, a desired 90 % confidence interval has been obtained.

**TABLE A1.2 Cumulative Normal Distribution—Values of $P^A$**

NOTE 1—Values of $P$ corresponding to $z_p$ for the normal curve. $z$ is the standard normal variable. The value of $P$ for $-z_p$ equals one minus the value of $P$ for $+z_p$. For example, the $P$ for $-1.62$ equals $1 - 0.9474 = 0.0526$.

| $z_p$ | 0.00 | 0.01 | 0.02 | 0.03 | 0.04 | 0.05 | 0.06 | 0.07 | 0.08 | 0.09 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | 0.5000 | 0.5040 | 0.5080 | 0.5120 | 0.5160 | 0.5199 | 0.5239 | 0.5279 | 0.5319 | 0.5359 |
| 0.1 | 0.5398 | 0.5438 | 0.5478 | 0.5517 | 0.5557 | 0.5596 | 0.5636 | 0.5675 | 0.5714 | 0.5753 |
| 0.2 | 0.5793 | 0.5832 | 0.5871 | 0.5910 | 0.5948 | 0.5987 | 0.6026 | 0.6064 | 0.6103 | 0.6141 |
| 0.3 | 0.6179 | 0.6217 | 0.6255 | 0.6293 | 0.6331 | 0.6368 | 0.6406 | 0.6443 | 0.6480 | 0.6517 |
| 0.4 | 0.6554 | 0.6591 | 0.6628 | 0.6664 | 0.6700 | 0.6736 | 0.6772 | 0.6808 | 0.6844 | 0.6879 |
| 0.5 | 0.6915 | 0.6950 | 0.6985 | 0.7019 | 0.7054 | 0.7088 | 0.7123 | 0.7157 | 0.7190 | 0.7224 |
| 0.6 | 0.7257 | 0.7291 | 0.7324 | 0.7357 | 0.7389 | 0.7422 | 0.7454 | 0.7486 | 0.7517 | 0.7549 |
| 0.7 | 0.7580 | 0.7611 | 0.7642 | 0.7673 | 0.7704 | 0.7734 | 0.7764 | 0.7794 | 0.7823 | 0.7852 |
| 0.8 | 0.7881 | 0.7910 | 0.7939 | 0.7967 | 0.7995 | 0.8023 | 0.8051 | 0.8078 | 0.8106 | 0.8133 |
| 0.9 | 0.8159 | 0.8186 | 0.8212 | 0.8238 | 0.8264 | 0.8289 | 0.8315 | 0.8340 | 0.8365 | 0.8389 |
| 1.0 | 0.8413 | 0.8438 | 0.8461 | 0.8485 | 0.8508 | 0.8531 | 0.8554 | 0.8577 | 0.8599 | 0.8621 |
| 1.1 | 0.8643 | 0.8665 | 0.8686 | 0.8708 | 0.8729 | 0.8749 | 0.8770 | 0.8790 | 0.8810 | 0.8830 |
| 1.2 | 0.8849 | 0.8869 | 0.8888 | 0.8907 | 0.8925 | 0.8944 | 0.8962 | 0.8980 | 0.8997 | 0.9015 |
| 1.3 | 0.9032 | 0.9049 | 0.9066 | 0.9082 | 0.9099 | 0.9115 | 0.9131 | 0.9147 | 0.9162 | 0.9177 |
| 1.4 | 0.9192 | 0.9207 | 0.9222 | 0.9236 | 0.9251 | 0.9265 | 0.9279 | 0.9292 | 0.9306 | 0.9319 |
| 1.5 | 0.9332 | 0.9345 | 0.9357 | 0.9370 | 0.9382 | 0.9394 | 0.9406 | 0.9418 | 0.9429 | 0.9441 |
| 1.6 | 0.9452 | 0.9463 | 0.9474 | 0.9484 | 0.9495 | 0.9505 | 0.9515 | 0.9525 | 0.9535 | 0.9545 |
| 1.7 | 0.9554 | 0.9564 | 0.9573 | 0.9582 | 0.9591 | 0.9599 | 0.9608 | 0.9616 | 0.9625 | 0.9633 |
| 1.8 | 0.9641 | 0.9649 | 0.9656 | 0.9664 | 0.9671 | 0.9678 | 0.9686 | 0.9693 | 0.9699 | 0.9706 |
| 1.9 | 0.9713 | 0.9719 | 0.9726 | 0.9732 | 0.9738 | 0.9744 | 0.9750 | 0.9756 | 0.9761 | 0.9767 |
| 2.0 | 0.9772 | 0.9778 | 0.9783 | 0.9788 | 0.9793 | 0.9798 | 0.9803 | 0.9808 | 0.9812 | 0.9817 |
| 2.1 | 0.9821 | 0.9826 | 0.9830 | 0.9834 | 0.9838 | 0.9842 | 0.9846 | 0.9850 | 0.9854 | 0.9857 |
| 2.2 | 0.9861 | 0.9864 | 0.9868 | 0.9871 | 0.9875 | 0.9878 | 0.9881 | 0.9884 | 0.9887 | 0.9890 |
| 2.3 | 0.9893 | 0.9896 | 0.9898 | 0.9901 | 0.9904 | 0.9906 | 0.9909 | 0.9911 | 0.9913 | 0.9916 |
| 2.4 | 0.9918 | 0.9920 | 0.9922 | 0.9925 | 0.9927 | 0.9929 | 0.9931 | 0.9932 | 0.9934 | 0.9936 |
| 2.5 | 0.9938 | 0.9940 | 0.9941 | 0.9943 | 0.9945 | 0.9946 | 0.9948 | 0.9949 | 0.9951 | 0.9952 |
| 2.6 | 0.9953 | 0.9955 | 0.9956 | 0.9957 | 0.9959 | 0.9960 | 0.9961 | 0.9962 | 0.9963 | 0.9964 |
| 2.7 | 0.9965 | 0.9966 | 0.9967 | 0.9968 | 0.9969 | 0.9970 | 0.9971 | 0.9972 | 0.9973 | 0.9974 |
| 2.8 | 0.9974 | 0.9975 | 0.9976 | 0.9977 | 0.9977 | 0.9978 | 0.9979 | 0.9979 | 0.9980 | 0.9981 |
| 2.9 | 0.9981 | 0.9982 | 0.9982 | 0.9983 | 0.9984 | 0.9984 | 0.9985 | 0.9985 | 0.9986 | 0.9986 |
| 3.0 | 0.9987 | 0.9987 | 0.9987 | 0.9988 | 0.9988 | 0.9989 | 0.9989 | 0.9989 | 0.9990 | 0.9990 |
| 3.1 | 0.9990 | 0.9991 | 0.9991 | 0.9991 | 0.9992 | 0.9992 | 0.9992 | 0.9992 | 0.9993 | 0.9993 |
| 3.2 | 0.9993 | 0.9993 | 0.9994 | 0.9994 | 0.9994 | 0.9994 | 0.9994 | 0.9995 | 0.9995 | 0.9995 |
| 3.3 | 0.9995 | 0.9995 | 0.9995 | 0.9996 | 0.9996 | 0.9996 | 0.9996 | 0.9996 | 0.9996 | 0.9997 |
| 3.4 | 0.9997 | 0.9997 | 0.9997 | 0.9997 | 0.9997 | 0.9997 | 0.9997 | 0.9997 | 0.9997 | 0.9998 |

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