# ASAE S341.3 FEB04
# Procedure for Measuring Distribution Uniformity and Calibrating Granular Broadcast Spreaders

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STANDARD

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## 1 Purpose and scope

**1.1 Purpose.** The purpose of this Standard is to establish a uniform method of determining and reporting performance data on broadcast spreaders designed to apply granular materials on top of the ground. Tests performed according to this Standard make it possible to predict distribution uniformity of the spreader and to compare spreader distribution patterns.

**1.2 Scope.** This Standard pertains to centrifugal, pendulum, and other types of broadcast spreaders designed for dry granular application while operating on the soil surface. Portions of the test procedures outlined herein are suitable for determining the delivery rate of gravity or drop spreaders; however, additional tests not covered in this Standard are needed to completely evaluate the performance of gravity spreaders. This Standard does not cover dry pneumatic granular applicators.

## 2 Normative references

ANSI Z23.1, *Specifications for Wire-Cloth Sieves for Testing Purposes*
ASAE S281.3 DEC96, *Capacity Designation for Fertilizer Pesticide Hoppers and Containers*
ASAE S327.2 DEC95, *Terminology and Definitions for Agricultural Chemical Application*

## 3 Definitions

**3.1 application, one-direction:** An application method in which successive adjacent swaths are made in the same direction of travel (racetrack or circuitous application). This method produces a right-on-left overlapping of adjacent patterns.

**3.2 application, progressive:** An application method in which the spreader applies adjacent swaths in alternate directions (back and forth application). This method produces a right-on-right pattern overlap alternately with a left-on-left pattern overlap.

**3.3 application rate:** Application rates are as defined in ASAE S327.

**3.4 application, single-pass:** An application method in which the spreader applies one swath over the collection trays.

**3.5 collector efficiency:** The percentage of true application rate caught in a collection device; ie, the weight of material caught in the collection device divided by the area of the collection device and expressed as a percentage of the true application rate at that point in the pattern.

**3.6 swath spacing:** The lateral distance between spreader centerlines for adjacent swaths.

**3.7 swath width, effective:** The swath spacing that will produce acceptable field deposition uniformity for the intended application.

## 4 Test conditions

**4.1** The spreader to be tested shall be in good mechanical condition and shall be properly adjusted.

**4.2** Tests may be conducted on a spreader to evaluate an experimental model, to qualify a new production model, or to verify the distribution uniformity of an existing production model. Tests may also be conducted to evaluate the distribution uniformity of a spreader and to verify the adjustment of a spreader for a specific granular material being spread under conditions similar to actual field conditions.

**4.3** The geometric specifications shall be checked with the machine standing on an impenetrable, horizontal surface in normal operating position. Dimensions of length and width shall be measured along horizontal lines and dimensions of height along vertical lines.

**4.4** It is recommended that the manufacturer be notified well in advance of any test in which the manufacturer's current production model will be compared with those of other manufacturers. The manufacturer shall be entitled to have his representative present during the test.

**4.5** The test may be conducted with a standardized test material such as uniform size spherical prills, a specific granular product, or an inert product simulant. A description of the material including sieve size, moisture content, bulk density, and product name shall be specified in the test report (see ASAE S281).

**4.5.1** Results of a sieve analysis shall be reported. The percent of material retained on each screen shall be stated. The sieves used shall conform to ANSI Z23.1.

**4.5.2** A description of the test material's particle shape and surface texture shall be included in the test report.

## 5 Test procedure

### 5.1 Guidelines for test setup

**5.1.1** The accuracy of the test can be influenced by wind, granule or particle size, critical relative humidity of the product, rate of application, ground slope, travel speed, ground roughness, temperature, relative humidity, and method of collecting samples. Conducting tests on a hard surface can also affect the observed patterns. This effect is more pronounced as particle size increases. The following recommendations should be followed to maintain test accuracy:

**5.1.1.1** All spreading shall be done when the wind velocity is less than 8 km/h (5 mile/h) at a height of 1.5 m (5 ft) above the ground. If a wind exists, the direction of travel shall be parallel (within $\pm$15 deg) to the direction of the wind.

**5.1.1.2** Tests shall be conducted on a surface having a slope of less than 2%. If desired, the spreaders may also be tested on a sloping surface, provided all spreaders in the comparison are tested on the same slope and the degree and direction of slope reported.

**5.1.1.3** The spreader should be operated for a period long enough for the flow or output to stabilize. This will vary with spreader design; however, operating the spreader over a distance of 10 m (33 ft) is generally adequate.

**5.1.1.4** If the test results are to be used for the specific purpose of adjusting the field performance of an individual spreader, it is recommended that the test be conducted under field conditions that represent normal use. This implies conducting the test on a surface similar to the field surface, since the effective swath width, rate, and pattern uniformity will be affected by particle bounce into the collection devices when tests are conducted on hard surfaces.

**5.1.2** The spreader shall be filled the day of the test. If the test is not conducted within 4 h after filling, the spreader shall be emptied and refilled.

**5.1.3** Tests shall be run with the spreader hopper or box filled and leveled to 40% to 50% of capacity as defined by ASAE S281.

**5.2 Collection devices**

**5.2.1** Width of each collecting tray (measured perpendicular to the direction of travel) shall not exceed 10% of the anticipated effective swath width. The length shall be equal to or greater than the width with a minimum length of 30 cm (1 ft). The maximum wall thickness of the tray sides shall be 2.3 mm (0.09 in.).

**5.2.2** Trays should be of sufficient size to collect samples, from one pass of the spreader, that are large enough to accurately measure with available measuring equipment.

**5.2.3** To decrease the possibility of particles ricocheting out of the trays, each tray should be divided into compartments. The maximum size of the compartments shall be 10 cm (4 in.) wide by 10 cm (4 in.) long. The minimum size of the compartments should be 5 cm (2.0 in.) by 5 cm (2.0 in.). The depth of the compartments shall be at least 50% of the maximum horizontal dimension. Precautions such as covering the tray floor with soft material may be taken if the granule being tested contains no small particles that may lodge in the covering material.

**5.2.4** Sufficient trays shall be used to provide at least 10 trays within the effective swath width. Spacing of the trays shall be uniform, except that trays may be rearranged or omitted to allow passage of spreader and vehicle wheels. Additional trays shall be spaced out on either side of the anticipated effective swath width to a distance equal to at least 50% of the swath width on each side.

**5.2.5** During all tests, the tops of the trays shall not be more than 10 cm (4 in.) above the ground level with the spreader in the normal operating position. If the height of the discharge point on the spreader is less than 0.5 m (20 in.), the tops of the trays shall not be more than 5 cm (2 in.) above the ground level.

**5.2.6** Power take-off–driven units shall be operated at the speed specified by the spreader manufacturer. For truck-mounted units the spinner shall be rotated at the speed recommended by the manufacturer. For electrically driven units, supply voltage shall conform to that recommended by the manufacturer; any deviation shall be stated in the report.

**5.2.7** Relative travel speed between the spreader and the collection trays shall be in the range recommended in the manufacturer's literature and shall be kept constant during the conduct of the test. The actual speed of the spreader and/or collection trays at which the tests were conducted shall be reported.

**5.3 Description of the test procedure.** The test should consist of two parts: (1) determination of application rate and (2) determination of the distribution pattern by measurement of applied materials from collectors as specified in clause 5.2. Each part of the test should be replicated to account for random variation.

**5.4 Determination of application rates**

**5.4.1** The preferred method of determining application rates is by measuring the amount of material exiting the spreader during operation over a known area.

**5.4.2** Weight of material applied can be determined by collecting and weighing spreader output while traveling a measured distance or weighing the spreader and its contents before and after spreading material over a known distance.

**5.4.3** Using the methods described in clause 5.4.2, the application rate for a specific swath spacing should be calculated as follows:

$$R = QK/LW$$

where:

- $R$ is application rate, kg/ha (lb/acre)
- $Q$ is mass applied, kg (lb)
- $L$ is distance spreader operated, m (ft)
- $W$ is swath spacing, m (ft)
- $K$ is constant, 10,000 (43,560).

**5.4.4** An alternate method for determining application rate is by calculation from the amount of material collected in spread pattern tests (see clause 5.5.2). The accuracy of this method is influenced by collector design and type of surface around the collectors. If the collector surface is such that particles entering the collector bounce out, this method will yield rates that are lower than actual rates. If the test is conducted on a hard surface, it is more likely that granules will bounce into the collectors, thus causing the apparent rate to be too high. This problem can be eliminated either by operating on a surface similar to the proposed field surface or by using collectors that prevent granules bouncing in *or* out.

**5.4.5** Application rates based on material collected in spread pattern tests can be calculated using the following equation (if the collector efficiency is not known, 100% must be assumed):

$$R = KW/AE$$

where:

- $R$ is application rate, kg/ha (lb/a)
- $K$ is constant, 100,000 (13,829)
- $W$ is sample mass, g (lb)
- $A$ is area of collector opening, $cm^2$ ($in.^2$)
- $E$ is collector efficiency, normally 0% to 100%, but can exceed 100% (expressed as a decimal in this equation).

**5.4.6** The volume (in cubic centimeters) of material collected in spreader pattern tests can be used to determine application rates. Using the bulk density of the material being applied (see ASAE S281), the mass of material collected can be calculated by the following equation:

$$W = DV/K$$

where:

- $W$ is mass, g
- $D$ is bulk density, $kg/m^3$ ($lb/ft^3$)
- $V$ is volume, $cm^3$
- $K$ is constant, 1,000 (62.4).

**5.5 Spread pattern test**

**5.5.1** Spread pattern tests indicate the degree of uniformity of distribution of material across the swath being spread.

**5.5.2** The spread pattern test shall be accomplished by operating the spreader in a line perpendicular to a line of collection trays spaced equally on the ground. An odd number of trays should be used, and the spreader should be driven astride the center pan. Material collected in each tray should be weighed or measured volumetrically.

**5.5.3** The actual delivery rate and the spreader settings used to achieve these rates shall be reported. All spreaders to be compared shall be tested at the same rate, if possible. If field performance of an individual spreader is desired, the application rate shall be selected based upon the agronomic requirements of the test. Application rates of approximately 25%, 50%, and 75% of the maximum application rate for the test material are suggested if multiple rates are to be used. Additional tests may be conducted and reported at other rates selected from within the manufacturer's recommended range of application rates.

**5.5.4 Uniformity of distribution.** The spreader tested shall be rated for uniformity of distribution. The coefficient of variation (CV) shall be used to determine and express the uniformity of distribution of applications. When overlapping of swaths occurs, a simulated field application of multiple adjacent swaths shall be used to compute the CV. The simulated field distribution for each swath width to be evaluated is constructed by accumulating the sample weights from the simulated overlapping swaths at each collection tray location. Individual replicates of the swath distribution pattern (not averages) shall be used. The method of spreading used shall be reported; ie, either progressive (back and forth) or one direction (race track).

**5.5.4.1** The mean value, standard deviation, and CV shall be determined as follows:

**Table 1 – Example of CV values for different swath spacings and driving methods**

| Swath spacing | One-direction application | Progressive pass application |
|---|---|---|
| (m) | (CV) | (CV) |
| 4 | 0.5 | 1.3 |
| 6 | 2.1 | 2.4 |
| 8 | 7.7 | 7.8 |
| 10 | 1.4 | 1.3 |
| 12 | 17 | 17 |
| 14 | 24 | 24 |
| 16 | 22 | 22 |
| 18 | 13 | 13 |
| 20 | 2.6 | 2.9 |
| 22 | 21 | 21 |
| 24 | 42 | 42 |
| 26 | 59 | 59 |

Mean $= X = \Sigma X_i / N$

Standard deviation $= \{\Sigma[(X_i - X)^2]/(N-1)\}^{1/2}$

CV = (standard deviation)(100)/$X$

where:

$X$ is arithmetic mean

$X_i$ is accumulated sample weight for each collector location for the overlapped swaths

$N$ is number of collector locations used.

**5.5.4.2** Only the central portion of the simulated or measured overlapped distribution data is needed to compute the CV. Regardless of application pattern, data from a width equal to the estimated (or trial) swath width is adequate. Data points equidistant from the centerline to a distance halfway to the centerline of the next pass on each side shall be used. Data from enough adjacent swaths shall be included so that the region for calculation as indicated above would be unaffected by the addition of distribution data resulting from additional overlapping swaths.

**5.5.5 Effective swath width.** Data shall be reported on the most effective swath width symmetrical about the centerline of travel as well as any other trial swath widths used to determine this effective swath width.

**5.5.5.1** Frequently, the effective swath width will be the distance between the points on either side of a single swath where the rate of deposit equals one-half of the effective application rate. The effective swath width shall be determined in a manner that will give the most uniform overall application rate. The manufacturer's recommendation shall be used as a guide in determining the most effective swath width.

**5.5.5.2** Another method for determining the effective swath width of the spreader is by inspecting values for CV, computed from simulated overlapped distribution data, versus swath width. Table 1 is an example listing of CV's versus swath spacing and driving method. The largest swath width associated with the minimum acceptable CV shall be considered the effective swath width of the test.

**5.5.6** The results of this test may also be presented graphically as shown in figure 1.

**5.5.6.1** In plotting test data, the vertical axis shall indicate the application rate in kg/ha (lb/acre or lb/1,000 ft$^2$) and the horizontal axis shall represent the spread width in m (ft).

**5.5.6.2** The coefficient of variation and the assumed width at which it was determined shall be stated.

**5.5.6.3** When indicating spreader overlap as shown in figure 1, it is necessary to report the method of spreading assumed, ie, either progressive or one direction, and plot the graph accordingly.

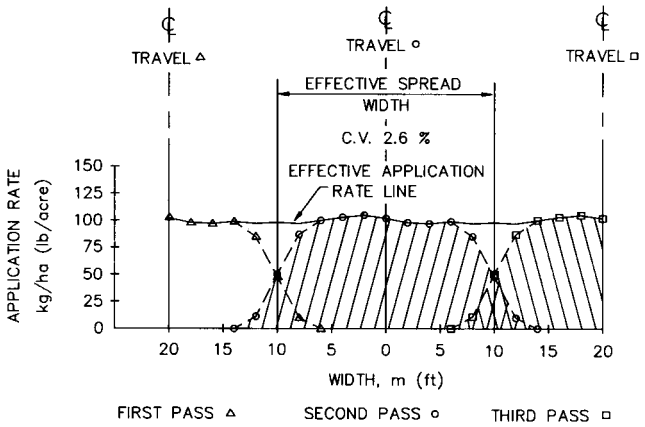


**Figure 1 – Graphical presentation of spread pattern—one-direction application method**

## 6 Method of reporting results

**6.1** If the test has been conducted as described by this Standard, the test results should be identified as follows:

**6.1.1** A note in the report shall state: "These results have been obtained from a test made in accordance with ASAE S341, Procedure for Measuring Distribution Uniformity and Calibrating Granular Broadcast Spreaders."

**6.1.2** A descriptive statement shall be included in the report to explain the coefficient of variation. For example: "This 18% variation means that at a setting of 100 kg/ha (89 lb/acre) the actual application rate would be expected to range between 82 and 118 kg/ha (73 and 105 lb/acre) on 68% of the area."

**6.2** A brief description of the spreader shall precede the dimensions. If the spreader can be adjusted to deliver one side at a time (for headlands and row-crops), this should be mentioned. Adjustable spreader variables and their settings shall be reported. The following data should be included in the description:

- type (centrifugal, pendulum, etc);
- manufacturer's name, model number, and year of manufacture (serial number if available);
- minimum and maximum application rates: kg/ha (lb/acre);
- minimum and maximum output rates: kg/min (lb/min);
- overall length: cm (in.);
- overall height: cm (in.);
- overall width: cm (in.);
- height of particle release above ground level (in operation): cm (in.);
- metering system used;
- number of spinners or delivery points;
- manufacturer's recommended spread width: m (ft);
- hopper capacity: m$^3$ and kg (ft$^3$ and lb);
- track width (c-to-c): cm (in.); and
- number of wheels.

**6.3** All test results shall be stated as listed in clause 6.1 and include the following:

- application rate as indicated by the rate setting;
- actual application rate and method used to measure actual rate;
- standard deviation (for each application rate);
- CV (for each application rate);
- material tested (sieve analysis, bulk density, moisture content, product name);

— granule shape and surface texture;
— forward travel speed;
— relative travel speed;
— effective swath width;
— information concerning exceptions or additions which are peculiar to this test;
— wind speed and direction relative to spreader line of travel (see clause 5.1.1.1);
— description of test surface; and
— tractor PTO or impeller speed.