# Explanation of Performance Testing Under the WaterSense® Specification for Showerheads

## I. Introduction

The WaterSense label helps consumers identify products that offer both water efficiency and performance. Performance is critical to ensure that consumers are satisfied with WaterSense labeled products and continue to use them.

When more water-efficient plumbing products first entered the market, some were found to have inferior performance compared to standard products. As a result, these products were not widely adopted, limiting their overall water savings potential. Learning from this experience, WaterSense includes performance criteria for all products it labels, allowing the program to distinguish water-efficient products that perform as well or better than their standard counterparts. When consumers purchase a WaterSense labeled product, they can be confident that it will perform well and save water.

WaterSense evaluates showerhead performance through three key performance metrics:

- Spray force
- Spray coverage
- Minimum flow rate (i.e., pressure compensation)

The testing procedures for each of these requirements are incorporated into the *WaterSense Specification for Showerheads* by reference to the American Society of Mechanical Engineers (ASME) A112.18.1/Canadian Standards Association (CSA) B125.1 *Plumbing Supply Fittings* standard.

This document explains the performance testing requirements in the *WaterSense Specification for Showerheads,* Version 1.1.

## II. Background on Development of Performance Requirements

WaterSense developed the requirements and testing procedures for the three key performance criteria included in the *WaterSense Specification for Showerheads* – spray force, spray coverage, and minimum flow – based on consumer testing and through coordination with the ASME/CSA Technical Committee on Plumbing Fittings.

During the development of the *WaterSense Specification for Showerheads,* Version 1.0, consumers tested a variety of showerheads and provided feedback about their preferences for different performance features. WaterSense worked with testing laboratories to translate the user preferences into repeatable and reproducible test methods that could be evaluated by any independent third-party certifying body.

WaterSense continues to coordinate with the ASME/CSA Technical Committee to align requirements of the *WaterSense Specification for Showerheads* with ASME A112.18.1/CSA B125.1. This cooperative relationship 1) engaged experts from the manufacturing, utility, and certification communities; and 2) worked through an existing public process established in the United States and Canada for developing standards and specifications for plumbing fittings.

The collaboration has also facilitated the incorporation of rain showers in the *WaterSense Specification for Showerheads*. As defined in ASME A112.18.1/CSA B125.1, rain showers are showerheads mounted directly over the bather with the faceplate parallel to the floor. The showerhead can be mounted on the ceiling or attached to an extended shower arm. Because of the intended operation of this subcategory of showerheads, WaterSense worked with the ASME/CSA Technical Committee to modify the spray force test protocol and criteria to accommodate these products, while also ensuring an equivalent performance metric is met. More information is provided below.

## III. Spray Force

The spray force requirements were established based on the lower bounds of user satisfaction reported in consumer testing. To be eligible for WaterSense labeling, showerheads must meet the minimum force requirement as assessed with a testing apparatus. The force criteria are intended to exclude showerheads whose spray force is less than that preferred by consumers. As described below, the apparatus was originally designed for standard showerheads and has been modified for rain showers.

The force test apparatus required in the *WaterSense Specification for Showerheads*, Version 1.0, depicted in Figure 1, was designed for standard showerheads that spray water at a 45° angle from the wall. The center of the force target and the center of the showerhead faceplate are aligned and 18 ± 0.25 inches (457 millimeters [mm] ± 6 mm) apart.

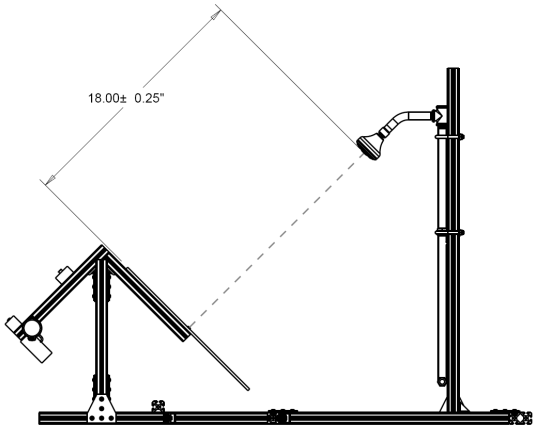


**Figure 1.** The spray force test protocol apparatus for standard fixed showerheads.

Once the water flow is initiated, the showerhead is adjusted only using its standard components, such that the center of the spray pattern aligns with the center of the force target. In this configuration, the shower spray is perpendicular to the force plate, as depicted in Figure 2. As a result, the effective force of the spray equals the actual force required to move the force balance. If the force of the spray equals or exceeds 2.0 ounces-force (ozf) [0.56 Newtons (N)], it will cause the force gauge located between the force plate and the counterweight to register a positive value. This indicates that the showerhead passes the 2.0 ozf criteria stipulated in the specification.

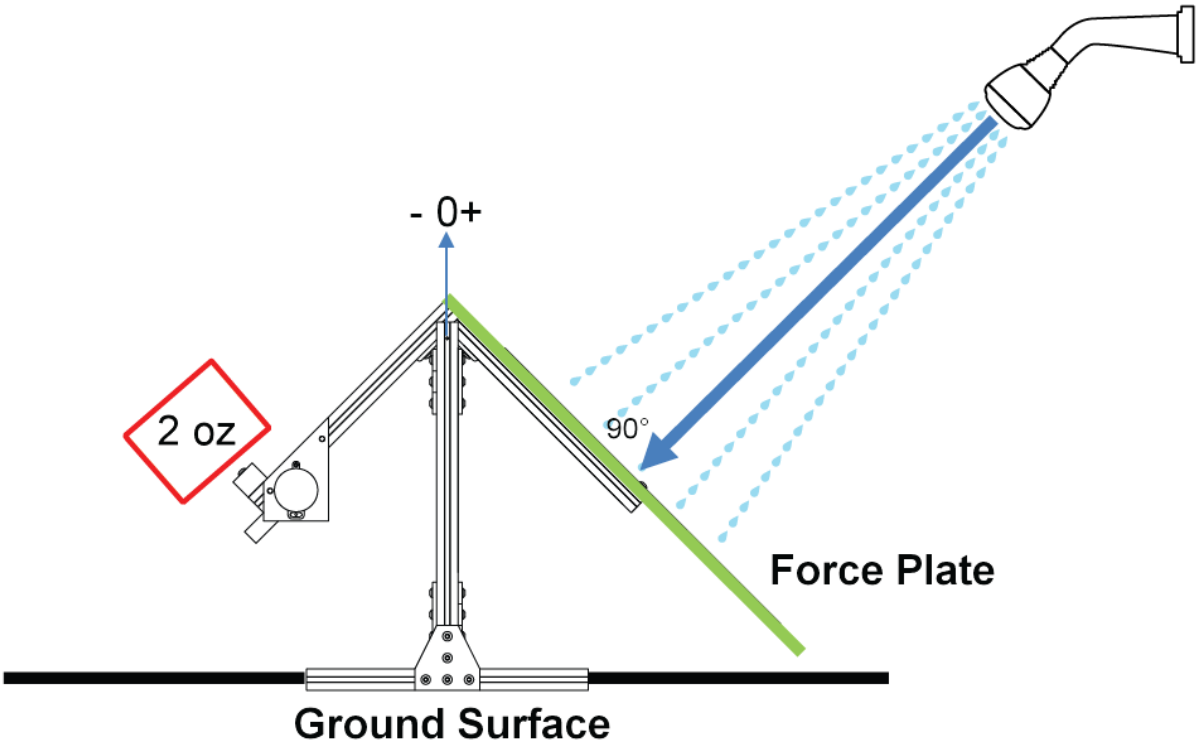


**Figure 2.** Visualization of the spray force test protocol apparatus for standard fixed showerheads. The water spray hits the force plate at a 90° angle.

Version 1.1 of the *WaterSense Specification for Showerheads* updates the criteria to facilitate testing of rain showers. The original requirements were not crafted to assess rain showers, which have different spray mechanics than standard showerheads. The updated spray force criteria for rain showers are mathematically equivalent to the criteria for standard showerheads and make it possible for rain showers to be evaluated for WaterSense labeling.

Rain showers are intended to be mounted directly overhead and spray water vertically from the ceiling, perpendicular to the floor. Flow from a rain shower mounted at a 45° angle, consistent with the Version 1.0 test protocol depicted above, may not fully reach the force plate, since rain showers primarily function by gravity and may have minimal horizontal force. As a result, many rain showers were not able to meet the force requirements in Version 1.0 of the specification and could not earn the WaterSense label. To account for rain showers' typical mounting configuration and ensure consistent and equivalent testing requirements to standard showerheads, EPA worked with the ASME/CSA Technical Committee to update the spray force test protocol currently included in the ASME A112.18.1/CSA B125.1 standard.

To effectively measure the force of a rain shower, Version 1.1 of the *WaterSense Specification for Showerheads* (by reference to the ASME A112.18.1/CSA B125.1 standard) allows rain showers to be mounted vertically over the force plate in their intended mounting position. In this mounting position, the water spray hits the force plate at a 45° angle, as opposed to a 90° angle (see Figure 3).

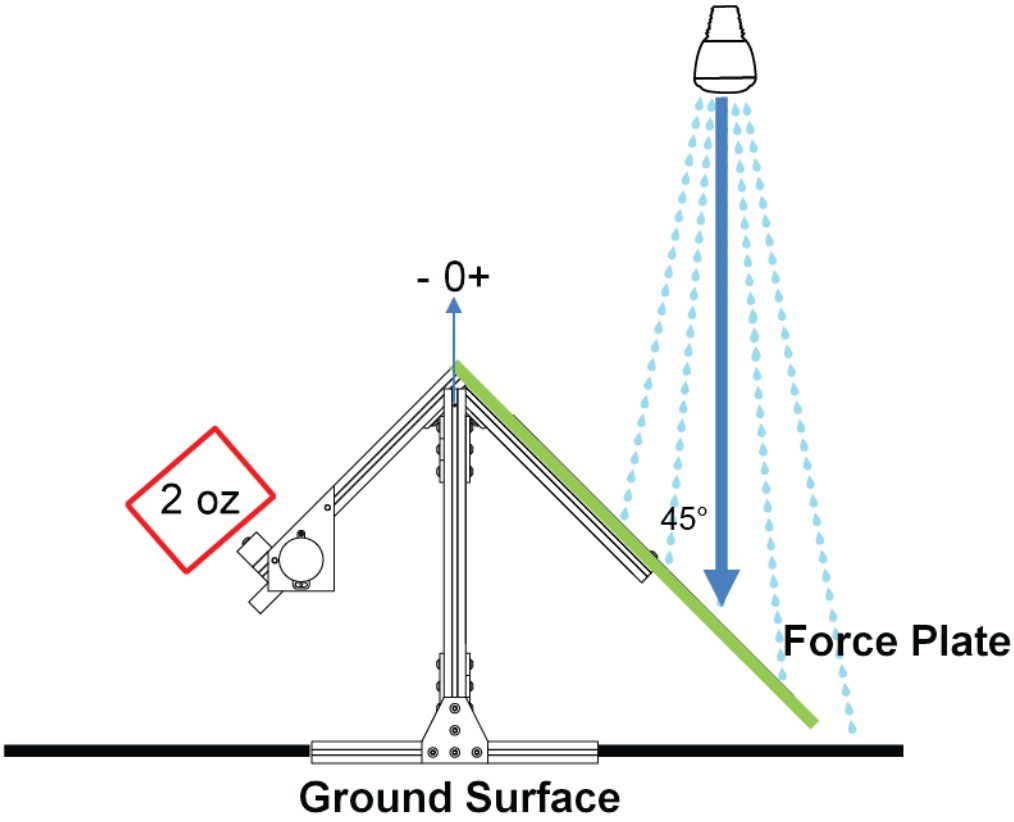


**Figure 3.** Visualization of the test apparatus with a rain shower. The spray from the rain shower hits the force plate at a 45° angle.

However, in this configuration, by simple geometry (shown on the left in Figure 4), the rain shower would require an actual spray force of 2.8 ozf to move the counterbalance weight of 2.0 oz.[1] WaterSense intends for rain showers to meet the same minimum spray force as standard fixed showerheads (i.e., 2.0 ozf). Therefore, WaterSense has adopted the revised testing protocol for rain showers outlined in the ASME A112.18.1/CSA B125.1 standard, but has modified the effective force requirement. Using the same geometric relationships, an actual force of 2.0 ozf will register an effective force of 1.4 ozf when hitting the force plate at a 45° angle (shown on the right in Figure 4).[2] Therefore, WaterSense has adjusted the counterweight

[1] As determined using the following geometric relationship, where $x_{act}$ is actual spray force:

$$\cos(\theta) = \frac{Adjacent}{Hypotenuse}$$

$$\cos(45°) = \frac{2}{x_{act}}$$

$$x_{act} = \frac{2}{\cos(45°)} = 2.8\ ozf$$

[2] As determined using the following geometric relationship, where $x_{eff}$ is effective spray force:

$$\cos(\theta) = \frac{Adjacent}{Hypotenuse}$$

to approximately 1.4 oz for a rain shower spray to meet the equivalent 2.0 ozf performance criteria.

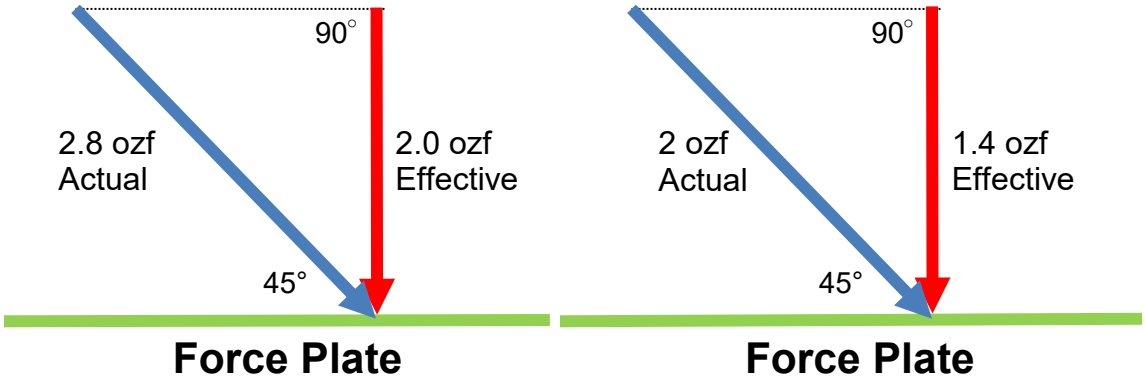


**Figure 4.** Visualization of the actual and effective forces of a rain shower spray. If the spray achieves the recommended minimum actual force of 2.0 ozf, the force plate will register an effective force of 1.4 ozf.

The new test protocol and performance criteria for rain showers are mathematically equivalent to the protocol and criteria currently used to test standard fixed showerheads; this update simply serves to equalize requirements for the two types of showerheads and reflect their typical mounting configurations.

## IV. Spray Coverage

WaterSense established spray coverage criteria because consumer test data showed general dissatisfaction with showerheads that spray with a hollow spot in the center or that have too much water flowing in the center to form a very narrow beam. The criteria contained in the specification were crafted to identify and disqualify showerheads with sprays that are too wide or too narrow.

The spray coverage component of the specification requires the use of an annular ring apparatus consisting of a series of concentric rings, starting with a 2-inch diameter center ring and each successive ring increasing in diameter by 2 inches out to 20 inches (see Figure 5). The showerhead is positioned with its faceplate horizontal and parallel to a set of annular rings so that the center of the annular rings is directly below the center of the showerhead's faceplate (see Figure 6). When the showerhead's flowing pressure has stabilized, water flow is initiated for at least 1 minute and water is collected in the annular rings. The relative amount of water captured in each set of concentric rings represents the distribution of the spray pattern and can be used to evaluate the showerhead's spray coverage.

$$\cos(45°) = \frac{x_{eff}}{2}$$
$$x_{eff} = 2 * \cos(45°) = 1.4\ ozf$$

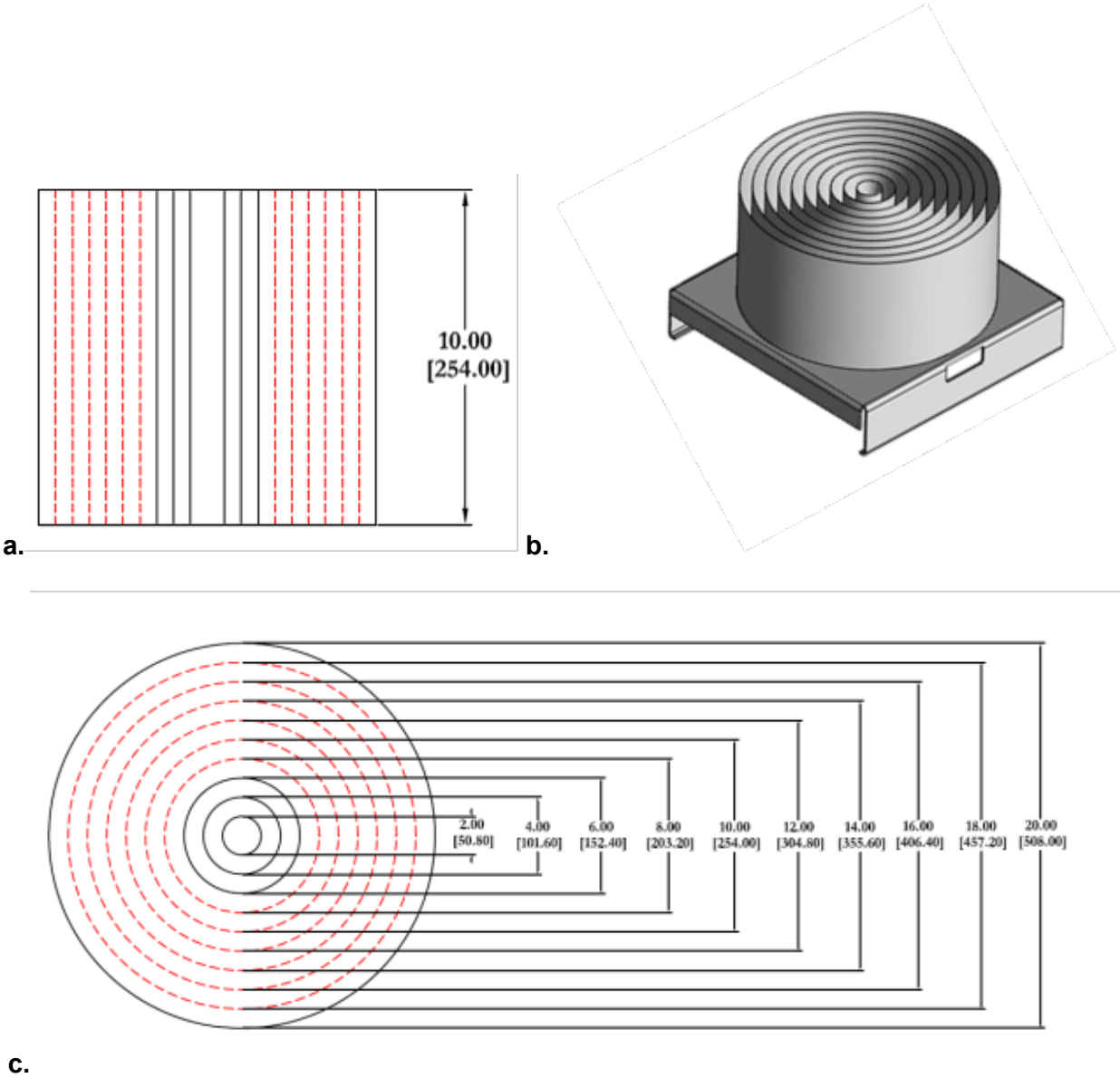


**Figure 5. a)** A cross-section of the annular rings. **b)** A three-dimensional diagram of the annular rings. **c)** A top-down view of the annular rings showing the spacing of each concentric ring. All dimensions are in inches [millimeters (mm)] with a tolerance of ± 0.06 inches [1.6 mm]. The red dotted lines indicate optional 8-inch – 18inch rings.

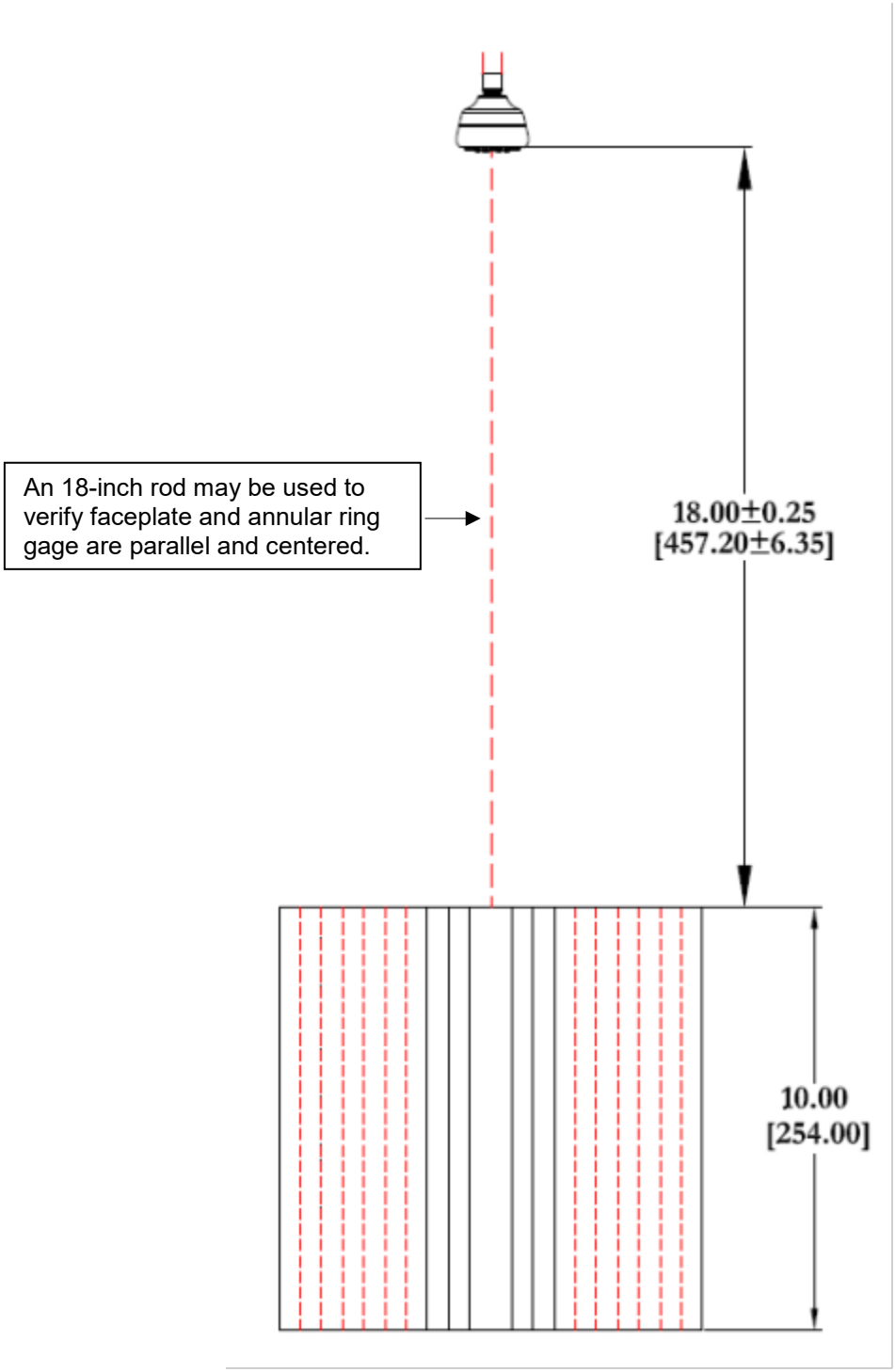


**Figure 6.** An illustration of the test configuration for spray coverage (shown in cross-section). The center of the showerhead is directly above the center of the annular ring apparatus.

Following operation of the showerhead, the volume of water collected in each annular ring is measured. The total volume of water collected by all annular rings is compared to the volume predicted by the flow rate and duration of water flow. If the difference is greater than ±5 percent, the test procedure is repeated.

To satisfy the spray coverage criteria, the total combined maximum volume of water collected in the 2- and 4-inch annular rings must not exceed 75 percent of the total volume of water collected. This ensures that the showerhead spray coverage is not too narrow. Additionally, the total combined minimum volume of water collected in the 2-, 4-, and 6-inch annual rings must not be less than 25 percent of the total volume collected, indicating that the showerhead does not provide spray coverage with a hollow center. The spray coverage criteria are intended to ensure that water flow is distributed in a way consistent with user preference, as indicated by consumer test data.

## V. Minimum Flow Rate

WaterSense has stipulated requirements for minimum flow rates to ensure consistent water flow across various household water pressures. Minimum flow requirements ensure that WaterSense labeled showerheads will meet consumer performance expectations by meeting or exceeding minimum flow rates, even in households with low water pressure. This showerhead feature is known as pressure compensation.

To earn the WaterSense label, a showerhead's minimum flow rate is required to be greater than 60 percent of the maximum flow rate when tested at a flowing pressure of 20 ± 1 psi, and greater than 75 percent of the maximum flow rate when tested at flowing pressures of 45 and 80 ± 1 psi. WaterSense requires testing at 45 psi so consumers can match showerheads with compatible automatic-compensating mixing valves, which are rated at 45 psi. The 20 ± 1 and 80 ± 1 psi requirements are intended to evaluate flow rate under minimum and maximum flowing pressures.