Energy Research and Development Division
FINAL PROJECT REPORT

# DEVELOPMENT OF NEW TESTING PROTOCOLS FOR MEASURING THE PERFORMANCE OF SHOWERHEADS

Prepared for: California Energy Commission
Prepared by: Robert Mowris & Associates

MARCH 2010
CEC-500-2013-130

**PREPARED BY:**

***Primary Author(s):***
Robert Mowris
Brian Woody

Robert Mowris & Associates
Olympic Valley, CA 96146

***Contract Number: 500-06-029***

***Prepared for:***

**California Energy Commission**

Brad Meister
***Contract Manager***

Virginia Lew
***Office Manager***
***Energy Efficiency Research Office***

Laurie ten Hope
***Deputy Director***
***ENERGY RESEARCH AND DEVELOPMENT DIVISION***

Robert P. Oglesby
***Executive Director***

ACKNOWLEDGEMENTS

This Public Interest Energy Research project was funded by the California Energy Commission. The California Energy Commission project manager was Brad Meister, Senior Mechanical Engineer. Owen Howlett was the project manager for Heschong Mahone Group, Inc. Guidance and inspiration for the study was provided by Michael Martin a pioneer in water and energy efficiency.

The authors appreciate the guidance, comments and suggestions provided by the following:

- California Energy Commission PIER Project Advisory Committee
- Canadian Standards Association (CSA)
- Joint Harmonization Task Force (JHTF)
- American Society of Mechanical Engineers (ASME)
- WaterSense®
- Kim Wagoner, Eastern Research Group (ERG) Inc.
- Sally Remedios, ASME Chair and Delta Faucet Company
- Carl Trendelman, Delta Faucet Company

# PREFACE

The California Energy Commission Energy Research and Development Division supports public interest energy research and development that will help improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

The Energy Research and Development Division conducts public interest research, development, and demonstration (RD&D) projects to benefit California.

The Energy Research and Development Division strives to conduct the most promising public interest energy research by partnering with RD&D entities, including individuals, businesses, utilities, and public or private research institutions.

Energy Research and Development Division funding efforts are focused on the following RD&D program areas:

- Buildings End-Use Energy Efficiency
- Energy Innovations Small Grants
- Energy-Related Environmental Research
- Energy Systems Integration
- Environmentally Preferred Advanced Generation
- Industrial/Agricultural/Water End-Use Energy Efficiency
- Renewable Energy Technologies
- Transportation

*Development of New Testing Protocols for Measuring the Performance of Showerheads* is the final report for the Hot Water Distribution Systems Research project (contract number 500-06-029) conducted by Robert Mowris & Associates. The information from this project contributes to Energy Research and Development Buildings End-Use Energy Efficiency Program.

For more information about the Energy Research and Development Division, please visit the Energy Commission's website at www.energy.ca.gov/research/ or contact the Energy Commission at 916-327-1551.

# ABSTRACT

Robert Mowris & Associates under subcontract to Heschong Mahone Group, Inc. prepared this report. The effectiveness of new showerhead testing protocols was evaluated based on market research, laboratory tests and consumer satisfaction survey responses regarding flow rate, force, and coverage for 43 efficient and 30 standard showerheads.

The new showerhead test protocols were developed by the Joint Harmonization Task Force consisting of the American Society of Mechanical Engineers and the Canadian Standards Association. The new showerhead test protocols measured flow rate, force and coverage over a range of flowing pressures from 20 to 80 pounds per square inch gauge. The current showerhead standard is 2.5 gallons per minute at 80 per square inch gauge flowing pressure. The United States Environmental Protection Agency WaterSense® and their consultant, Eastern Research Group collaborated with the Joint Harmonization Task Force on new showerhead test protocols. The purpose was to develop a WaterSense® showerhead specification of two gallons per minute at 80 per square inch gauge flowing pressure.

Approximately 65 to 78 percent of showerheads tested in this study did not meet the WaterSense® specification for flow rate, force or coverage. Based on this finding it is not recommended that California  adopt a flow rate standard lower than 2.5 gallons per minute at 80 per square inch gauge flowing pressure as specified in the California Green Building standards. The authors recommended that the voluntary WaterSense® showerhead specification of 2.0 gallons per minute at 80 per square inch gauge flowing pressure be supported to give manufacturers time to redesign their products.

**Keywords**: Efficient and standard showerheads, showerhead performance, new showerhead test protocols, water efficiency, flow rate, gallons per minute, flowing pressure, force, coverage, consumer satisfaction survey, retail cost survey, manufacturer survey, laboratory test, United States Environmental Protection Agency (US EPA), California Energy Commission (CEC), American Society of Mechanical Engineers (ASME), Canadian Standards Association (CSA), Joint Harmonization Task Force (JHTF), WaterSense® showerhead specification, voluntary standards, labels.

Please use the following citation for this report:

Mowris, Robert; Brian Woody. (Robert Mowris & Associates). 2010. ***Development of New Testing Protocols for Measuring the Performance of Showerheads.*** California Energy Commission. Publication number: CEC-500-2013-130.

# TABLE OF CONTENTS

# LIST OF FIGURES



# LIST OF TABLES

# EXECUTIVE SUMMARY

## Introduction

The potential water and energy savings from improved showerhead performance can be substantial. Current showerhead standards allow for one flow rate of 2.5 gallons per minute (gpm) and one flow rate pressure. The current standard allows for multiple showerheads on one fixture to circumvent the 2.5 gpm requirement. Some manufacturers are making multiple showerheads on one arm or in one shower stall that deliver 5 to 20 gpm or greater flow rates. The WaterSense® specification flow rate developed through the United States Environmental Protection Agency resulted in showerhead specifications of 2 gpm.

## Project Purpose

The goal of this project was to develop new testing protocols for measuring the performance of showerheads, in part by assisting the Joint Harmonization Task Force that was established by the American Society of Mechanical Engineers and Canadian Standards Association in 2006. The current American Society of Mechanical Engineer's A112.18.1/Canadian Standards Association B125.1-2005 standards were based on the American Society of Mechanical Engineer's 112.18.1M-1996 standard, which was 10 years old when this report was written. Another goal of the project was to conduct a showerhead market survey to understand the showerhead market and to obtain water-efficient and standard showerheads for laboratory testing and consumer satisfaction surveys.

The specific objectives included:

- Developing new test procedures for measuring the performance of showerheads, including measuring showerhead flow rates at multiple pressures (20, 45, 80 pounds per square inch gauge), quality of the flow rate pertaining to spray force or impact and flow radius or spray coverage.
- Developing a database of performance measurements and consumer satisfaction for currently available showerheads that would include models from major manufacturers available to California consumers.

## Project Results

The effectiveness of new showerhead testing protocols was evaluated based on market research covering 43 efficient and 30 standard showerheads. The new showerhead testing protocols were developed by the Joint Harmonization Task Force to verify performance attributes in the laboratory. The task force was open to public participation and included showerhead manufacturers, water and energy utilities, testing laboratories, consultants, and other water-efficiency and conservation specialists. Robert Mowris & Associates (RMA) worked with the task force to develop the new showerhead laboratory measurement protocol over a two-year period through a consensus process. The task force conducted a series of round robin comparative tests with the same set of showerheads at multiple laboratories as the new test protocols were developed. These laboratories included those located at Robert Mowris & Associates as well as several third party certifying bodies and several manufacturers.

The Eastern Research Group simultaneously conducted consumer satisfaction testing on the same set of showerheads to determine whether there was a uniform preference or a uniform dislike of certain showerhead attributes and to determine whether the performance attributes adequately defined user satisfaction.

The new showerhead test protocol required measuring showerhead flow rates at various flowing pressures of 20, 45, and 80 ± 1 pounds per square inch gauge (psig) with water temperatures at 100 ± 10 degrees Fahrenheit (°F) maintained for at least one minute. Showerhead spray force was measured at a flowing pressure of 20 ± 1 psig. Showerhead spray coverage was measured at a water temperature of 100 ± 10 °F maintained for at least one minute with water pressure at 45 ± 1 psig at the inlet when water was flowing per the new showerhead test protocol.

Approximately 65 to 78 percent of the showerheads tested failed to meet the WaterSense® specification for flow rate, force or coverage. Either the maximum measured flow rate was greater than that specified by the manufacturer or the minimum flow rate was less than the 60 to 75 percent of the maximum rate specified by the WaterSense® specifications.

This study also showed that there was manufacturer and consumer support for low flow showerheads that save energy and water. However, nearly all manufacturers supported the voluntary WaterSense® standard. The market appeared to value standard flow units at a premium price compared to water saving products, indicating a perception of inferior performance associated with water saving showerheads.

The authors did not recommend that California adopt a flow rate standard lower than 2.5 gallons per minute at a 80 psig flowing pressure as specified in the California Green Building standards. They recommended that the voluntary WaterSense® showerhead specification of two gallons per minute at 80 psig flowing pressure be supported to give manufacturers time to redesign their products.

## Project Benefits

The potential annual savings from adopting new showerhead testing protocols and voluntary WaterSense® specifications in the United States to counteract the trend towards multiple showerheads was estimated at:

- 64,605 million gallons of water.
- 188 million therms.
- 3,066 gigawatt-hours.
- $93.5 million in lower energy and water costs.

The annual savings for California were estimated at:

- 6,405 million gallons.
- 18.8 million therms.
- 307 gigawatt-hours.
- $85 million in lower energy and water costs.

# CHAPTER 1: Introduction

This project assists the Joint Harmonization Task Force (JHTF) consisting of the American Society of Mechanical Engineers (ASME) and the Canadian Standards Association (CSA) to develop new testing protocols for measuring the performance of showerheads. The current standard is over 10 years old and allows inefficient end-use plumbing fittings (i.e., showerheads) based on one flow rate at one pressure. The current showerhead standard is 2.5 gallons per minute (gpm) at flowing pressure of 80 pounds per square inch gauge (psig).

The effectiveness of new showerhead testing protocols is evaluated based on market research, laboratory tests and consumer satisfaction survey responses regarding flow rate, force, and coverage for 43 efficient and 30 standard showerheads. The new showerhead testing protocols measure flow rate, force, and coverage over a range of flowing pressures from 20 to 80 pounds per square inch gauge (psig). The United States Environmental Protection Agency (US EPA) WaterSense® and their consultant, Eastern Research Group (ERG), collaborated with JHTF on new showerhead testing protocols to develop a WaterSense® showerhead specification of 2 gpm at 80 psig flowing pressure. Pressure-compensating showerheads provide relatively constant water flow rates and satisfactory performance over a range of flowing pressures.

Approximately 65 to 78 percent of the showerheads collectively tested in this study currently available on the market in California do not meet the WaterSense® specification for flow rate, force or coverage criteria.[1] Most showerheads failed to pass the WaterSense® criteria due to the maximum flow rate being greater than manufacturer specified flow rate required in the WaterSense® specification. Other showerheads failed due to the minimum flow rate being less than the maximum flow rate specified by the manufacturer per WaterSense®.

Based on this finding, the authors recommend that California not adopt a flow rate standard lower than 2.5 gpm at 80 psig flowing pressure as specified in the California Green Building standards.[2] Instead the study findings support the voluntary WaterSense® showerhead specification of 2.0 gpm at 80 psig flowing pressure to give manufacturers time to redesign their products.

The following describes the report sections:

---

[1] US EPA. March 4, 2009. WaterSense® Specification for Showerheads. Washington, DC.: US Environmental Protection Agency.

[2] 2010 California Green Building Standards Code. Chapter 4, Section 4.303 Indoor Water Use, Table 4.303.2 Fixture Flow Rates, Maximum flow rate at ≥ 20% reduction or 2 gpm @ 80 psi. http://www.bsc.ca.gov/default.htm.

**Section 1-Introduction**: provides an overview of the report

**Section 2- Study Objectives**: describes the study objectives, showerhead market and consumer satisfaction surveys and laboratory measurement protocols developed and conducted.

**Section 3-Study Findings**: discusses study findings including results of market research and surveys and laboratory testing.

**Section 4-Conclusions**: discusses the project conclusions and recommendations

**Section 5-References**: contains references cited in the report

**Appendix AA-**WaterSense® Specification for Showerheads

**Appendix A-**Showerhead Spray Force Procedure

**Appendix B-**Showerhead Spray Coverage Procedure

**Appendix C-**Requirements for WaterSense® Labeling

**Appendix D-**Manufacturer Survey

**Appendix E-**Consumer Satisfaction Survey

**Appendix F-** Assumption and Acknowledgement of Risks and Release of Liability Waiver

# CHAPTER 2:
# Study Objectives

The overall goal of this project is to help the ASME/CSA Joint Harmonization Task Force (JHTF) develop a new testing protocol for measuring the performance of showerheads and help US EPA WaterSense® develop criteria to test and label high efficiency showerheads. The current ASME A112.18.1/CSA B125.1-2005 voluntary standard is based on the ASME 112.18.1M-1996 standard which is 10 years old. The standard allows inefficient end-use plumbing technologies (i.e., showerheads, aerators) based on one flow rate at one pressure. The current showerhead standard is 2.5 gallons per minute (gpm) at a flowing pressure of 80 pounds per square inch gauge (psig); the aerator standard is 2.2 gpm at 60 psig.

The project provides market research, technical information, measurement data, and consumer satisfaction survey results to support revisions to the current ASME voluntary standard and the US EPA WaterSense® Specification for showerheads. The US EPA WaterSense® showerhead specification allows a maximum flow rate of 2.0 gallons per minute (gpm) (7.6 L/min) at 20, 45 and 80±1 psi (140, 310 and 550 ±7 kPa). The minimum flow rate value at a flowing pressure of 20 ±1 psi (140 ±7 kPa), shall not be less than 60 percent of the maximum flow rate or 1.2 gpm. The minimum flow rate value at  flowing pressures of 45 ±1 psi (310 ±7 kPa) and 80 ±1 psi (550 ±7 kPa), shall not be less than 75 percent of the maximum flow rate value or 1.5 gpm.

The current standard code allows for multiple showerheads on one fixture to circumvent the 2.5 gpm at 80 psi standard. Some manufacturers are making multiple showerheads on one arm or in one shower stall that deliver 5 to 20 gpm or greater flow rates.

The general objectives of this project are defined as follows.

- To develop new test procedures for measuring the performance of showerheads to include flow rates (gpm) at multiple pressures (i.e., 20, 45, 80 psi), quality of the flow rate pertaining to spray force or impact and flow radius or spray coverage.
- To develop a database of performance measurements and consumer satisfaction of currently available showerheads to include models from major manufacturers available to California consumers.

These goals relate to the following Public Interest Energy Research (PIER) Program objectives:

- Lower energy consumption, and thus lower energy bills for consumers, through improved end use efficiency of showerheads , and
- Lower water consumption and thus lower water bills and embedded energy use for consumers through improved end use efficiency of showerheads.

The water and energy savings associated with development of new testing protocols for measuring the performance of showerheads can be inferred from a report entitled, *Trends in Shower Design and Their Effect on Energy and Water Use*, published in the Proceedings of 2006 American Council for Energy Efficient Economy (ACEEE) Summer Study on Energy Efficiency in Buildings.[3] According to the report, baseline water usage for showers in the United States is 3.7 billion gallons, or approximately 9,000 acre-feet, of water every day. The potential water savings by providing improved showerhead performance data to consumers to counteract the trend to multiple showerheads has been estimated at 177 million gallons per day or 64,605 million gallons per year. The potential energy savings from improved showerhead performance data has been estimated at 188 million therms per year and 3,066 GWh per year. The estimated savings in California are 10 percent of these savings or 6,405 million gallons per year, 18.8 million therms per year, and 307 GWh per year. The net annual benefits to California are estimated at approximately $85 million per year.

## 2.1 Project Advisory Committee

An ongoing project advisory committee (PAC) was organized at the beginning of the project consisting of JHTF members, showerhead manufacturers and industry experts to provide suggestions to improve the work products resulting from the study. The PAC committee members are shown in the Table 2.1. PAC members reviewed and performed round robin beta testing of proposed testing protocols and evaluate and perform market research and consumer satisfaction surveys to correlate to the test protocols. Round robin beta testing of the showerhead test protocol provided real-world feed-back regarding likely success of the project. PAC members were encouraged to perform research in their facilities to evaluate the protocols.

[3] Ibid.

**Table 2.1: CEC PIER Showerhead Study Program Advisory Committee Members**

| Name | Company | City | State |
|---|---|---|---|
| P. Biermayer | Lawrence Berkeley National Laboratory | Berkeley | CA |
| M. Brook | California Energy Commission | Sacramento | CA |
| B. Chapin | CASH ACME, A Division Reliance Worldwide Corp | Cullman | AL |
| L. Himmelblau | The Chicago Faucet Company | Des Plaines | IL |
| G. Klein | California Energy Commission | Sacramento | CA |
| J. Koeller | California Urban Water Conservation Council | Yorba Linda | CA |
| J. Bertrand | Moen Incorporated | North Olmsted | OH |
| M. Miller | Alsons Corporation - A MASCO Company | Hillsdale | MI |
| S. Rawalpindiwala | Kohler Co. | Kohler | WI |
| S. Remedios | Delta Faucet Company | Indianapolis | IN |
| C. Trendelman | Delta Faucet Company | Indianapolis | IN |
| M. Campos | IAPMO | Ontario | CA |
| C. Carunana | CSA-International | Toronto | ON |
| F. Luedke | Neoperl, Inc. | Waterbury | CT |
| P. DeMarco | American Standard | Piscataway | NJ |
| K. Fromme | Bradley | Menomonee Falls | WI |
| T. Eberhardy | Bradley | Menomonee Falls | WI |
| B. McDonnell | Metropolitan Water District of So. Cal. | Los Angeles | CA |
| R. George | Ron George Design & Consult. Serv. | Newport | MI |
| S. Martin | Plumbing Manufacturers Institute | Rolling Meadows | IL |
| J. Watson | Sloan Valve Company | Franklin Park | IL |
| F. Fernandez | Toto USA | Ontario | CA |
| K. Wagoner | Eastern Research Group (ERG) for WaterSense® | Chantilly | VA |
| L. Christensen | Hansgrohe | Alpharetta | GA |
| L. DeLaura | Sempra Utilities | Los Angeles | CA |
| M. Martin | California Energy Commission | Sacramento | CA |
| O. Howlett | HMG | Fair Oaks | CA |
| K. Hair | Waterpik, Inc. | Fort Collins | CO |

## 2.2 Showerhead Market Survey

The showerhead market survey involved interviewing approximately twenty five (25) showerhead manufacturers, showerhead industry experts, water and energy utility representatives, testing laboratories, consultants, hardware and home improvement retail store representatives, and other water-efficiency and conservation specialists. The objective was to understand the showerhead market and obtain water-efficient and standard showerheads for laboratory testing and consumer satisfaction surveys. Some manufacturers provided free samples for testing. Some products were purchased directly from manufacturers or through internet and retail stores. More than 100 showerheads were evaluated and considered for the study and 73 showerheads were included in the study. The WaterSense®/ERG sample included 22 fixed showerheads and the California Energy Commission (Energy Commission) PIER sample included 41 fixed showerheads and 10 hand held showerheads.4 The WaterSense®/ERG showerheads were included in the round-robin laboratory testing by CSA, Alsons, IAPMO, and RMA and the WaterSense®/ERG and the RMA consumer satisfaction survey. The PIER sample of 41 fixed and 10 handheld showerheads were included in the RMA laboratory testing and RMA consumer satisfaction survey. The retail cost data are provided in Section 3.1.

## 2.3 Development of New Showerhead Test Protocols

The JHTF developed new showerhead test protocols to verify performance attributes in the laboratory. As the new test protocols were developed the JHTF conducted a series of round robin comparative tests with the same set of showerheads at multiple laboratories including RMA, several third party certifying bodies, and several manufacturers. The American Society of Mechanical Engineers (ASME) and the Canadian Standards Association (CSA) established a Joint Harmonization Task Force in 2006 to evaluate showerhead efficiency and performance, with the intent of developing new showerhead test protocols and performance standards.5 The task force was open to public participation and included showerhead manufacturers, water and energy utilities, testing laboratories, consultants and other water-efficiency and conservation specialists. RMA worked with the ASME/CSA JHTF to develop the new showerhead laboratory measurement protocol over a two-year period through a consensus process. Eleven JHTF meetings were convened starting in June 2006 and running through January 2010. The United States (US) Environmental Protection Agency (EPA) WaterSense® and their consultant, Eastern Research Group (ERG), became actively involved with the JHTF in 2007 to collaborate on new showerhead test protocols and a WaterSense® showerhead specification.6 EPA published its WaterSense® Notice of Intent (NOI) to develop a specification for high-efficiency showerheads in August 2007. In its notice, WaterSense® identified its goal with respect to water efficiency to label products that are about 20 percent more water-efficient than average comparable products on the market. The benchmark for showerheads, as specified in the Energy Policy Act of 1992, is

---

[4] The WaterSense®/ERG sample included 16 unique models and 6 duplicates.

[5] Tanner, S., Remedios, S. 2009. WaterSense: A consensus-based, common sense approach for high-efficiency Showerheads, February 2009. Northbrook, IL.: Plumbing Engineer.

[6] Some information in this section is from Tanner, S., Remedios, S. 2009. WaterSense: A consensus-based, common sense approach for high-efficiency Showerheads, February 2009. Northbrook, IL.: Plumbing Engineer.

a maximum water use of 2.5 gallons per minute (gpm) when measured at a flowing pressure of 80 pounds per square inch (psi), as determined through testing in accordance with the ASME A112.18.1 standard. Showerhead efficiency cannot be specified without considering potential performance impacts on consumer satisfaction, including health and safety issues, in the plumbing system.

JHTF members identified an important health and safety concern regarding the potential for increasing the risk of thermal shock or scalding caused when a hot or cold water-using device is activated while a shower is operating. Water can be diverted away from the shower fitting, causing a pressure drop in either the hot or cold water supply line to the shower. As a consequence, the balance of hot and cold water is shifted either to a hotter or colder temperature mix. This sudden change in temperature can either cause a user to have an abrupt physical reaction that could result in an injury or fall or, if the temperature increase is severe enough, scalding can occur. Because more efficient fittings use lower volumes of water than standard fittings, they can be more sensitive to changes in water pressure. As a consequence, temperature change may be amplified when the same amount of water is diverted from the shower. To reduce the risks of temperature-related shower injuries, most U.S. plumbing codes require showers to use individual automatic-compensating valves that comply with either the American Society of Sanitary Engineers (ASSE) 10162 or ASME A112.18.1/CSA B125.1 standards. An automatic-compensating mixing valve is a device that is installed as part of the shower's flow control (not as part of the showerhead) that helps to regulate water temperature, either through balancing the incoming hot and cold water pressures or through controlling the mixed outlet temperature with a thermostatic element that can maintain water temperature to within +/- 3.6 °F.

Despite advances in plumbing codes and mixing valve technology, there are at least two scenarios under which the thermal shock and scalding risks must be carefully evaluated. First, automatic-compensating mixing valves are currently only required to be tested and certified at a flow rate of 2.5 gpm. When these devices are outfitted in conjunction with a showerhead that has a lower flow rate, there may not be adequate assurance that the valve is sensitive enough to provide the required protection. Second, not all homes are equipped with an automatic-compensating mixing valve. This is of particular concern for showerhead retrofits in homes built prior to the mid-1990s.

As a part of the development of criteria for high-efficiency showerheads, the JHTF evaluated the link between flow rate and temperature deviations associated with pressure and temperature changes. The JHTF gathered and presented data to compare temperature profiles that result from a drop in hot and cold water pressure for both conventional and high-efficiency showerheads under two scenarios: 1) installation with various types of auto-compensating mixing valves (thermostatic, pressure balancing or combination) designed for a flow rate of 2.5 gpm and 2) installation without the protection of an auto-compensating mixing valve. The JHTF evaluated the data before it recommended a flow rate designation for high-efficiency showerheads.

The JHTF members of ASME, ASSE, and CSA also reviewed the performance of automatic-compensating mixing valves with high-efficiency showerheads to alleviate potential risks associated with installation of high-efficiency showerheads in new construction or retrofit installations when mixing valves are also replaced with a device with the same flow rating as the showerhead.

Establishing performance-based criteria for high efficiency showerheads ensures user satisfaction. The current testing protocols for showerhead performance did not address performance issues that can negatively impact user satisfaction. The JHTF identified a number of attributes to define a showerhead's performance, including: rinsing efficiency and time to remove soap and shampoo, spray force or comfort of the shower, spray coverage or distribution of water over the body, temperature drop as the distance from the showerhead increases, noise and variation of flow rate with changes in water pressure, and coverage. The JHTF worked cooperatively to qualitatively and quantitatively understand showerhead performance attributes to develop meaningful specification criteria. Quantitative attributes were converted into measureable parameters that can be tested in a laboratory under reproducible test conditions to yield repeatable results. The quantitative attributes were correlated with qualitative user satisfaction data to understand how to balance each attribute into a meaningful shower head laboratory testing protocol to eliminate poor performing products and expansive enough to satisfy a broad range of consumer preferences. Considering laboratory testing and user satisfaction, the JHTF developed a list of recommended key performance attributes including: consistent flow over a wider range of flowing pressure (i.e., pressure compensation), spray coverage (or water distribution), and spray force or rinsing efficiency. The set of 22 showerheads included in the round robin comparative tests are referred to as the "WaterSense®/ERG" models. The round-robin comparative tests evaluated the reproducibility of the new showerhead test protocol methods and the repeatability of the results. Simultaneously, ERG conducted consumer satisfaction testing on this same set of showerheads to determine whether there is a uniform preference or a uniform dislike of certain showerhead attributes and to determine whether the performance attributes adequately define user satisfaction. RMA conducted additional consumer satisfaction testing to verify the ERG results for "WaterSense®/ERG" models. RMA conducted consumer satisfaction surveys on 51 other showerheads to evaluate how the new test protocol performed on a larger sample of showerheads. If the consumer testing provided conclusive results, the JHTF correlated these attributes against the laboratory test protocols and used the output values to establish performance levels in the new test protocol. Section 3 of the report provides the results of the round-robin laboratory testing and consumer satisfaction surveys.

## 2.4 Description of the Showerhead Test Protocol

The new showerhead test protocol requires measuring showerhead flow rates at flowing pressures of 20, 45, and 80 ± 1 pounds per square inch gauge (psig) (140, 310, and 550 ± 7 kilopascal [kPa]) with water temperature at 100 ± 10 °F (38 ± 6 °C) maintained for at least one minute. Showerhead spray force is measured at a flowing pressure of 20 ± 1 psig (140 Pa ± 7 kPa). Showerhead spray coverage is measured at a water temperature of 100 ± 10 °F (38 ± 6 °C) maintained for at least one minute with water pressure at 45 ± 1 psig (310 ± 7 kPa) at the inlet when water is flowing per the new showerhead test protocol. The showerhead force balance test apparatus is shown in Figure 2.1. The force balance calibration setup is shown in Figure 2.2, and the force calibration procedure is shown in Figure 2.3. The annular ring specifications are shown in Figure 2.4.[7] The annular ring test setup is shown in Figure 2.5. Appendix AA provides the WaterSense® specification for showerheads, Appendix A provides the showerhead spray force procedure and Appendix B provides the showerhead spray coverage procedure.

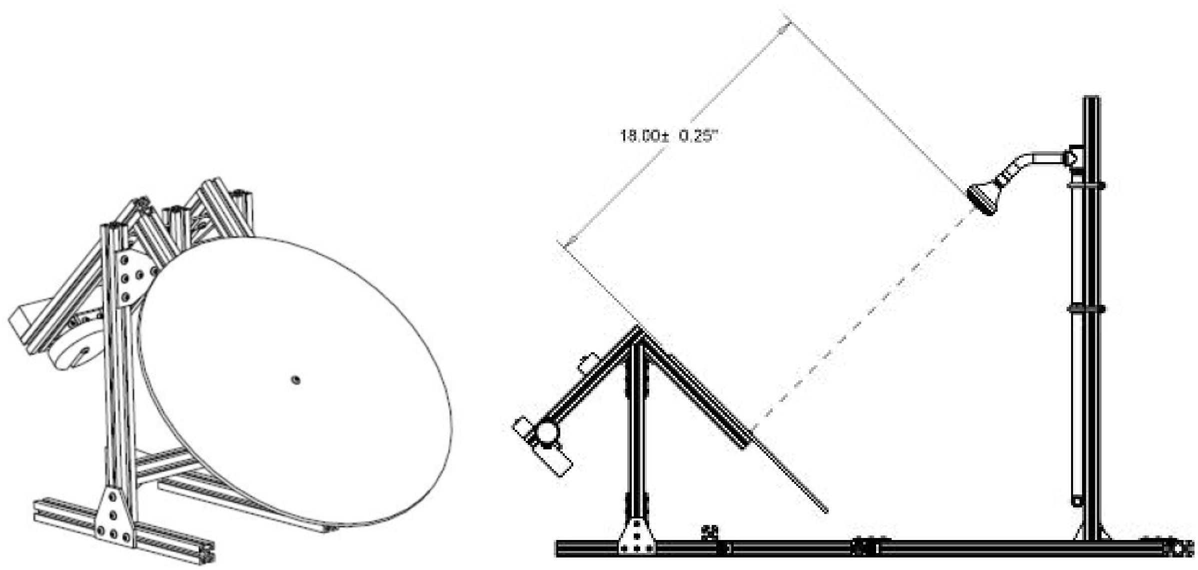



**Figure 2.1: Force Balance Test Apparatus**

[7] Detailed drawings of the force balance test apparatus are available on the WaterSense® Web site, www.epa.gov/watersense/pp/showerheads.htm.

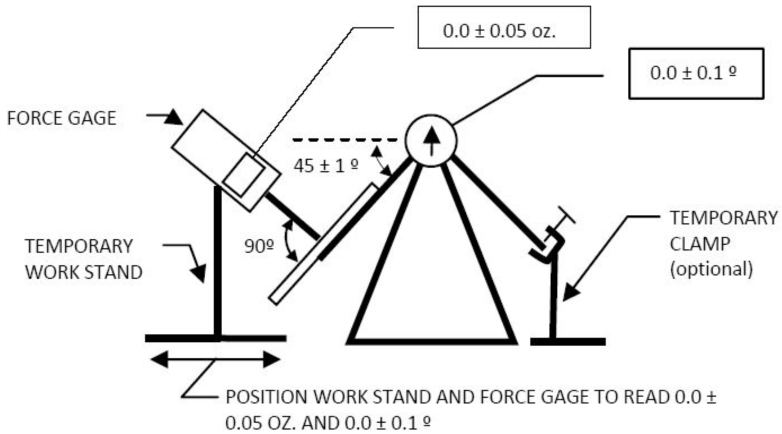



**Figure 2.2: Force Balance Calibration Setup**

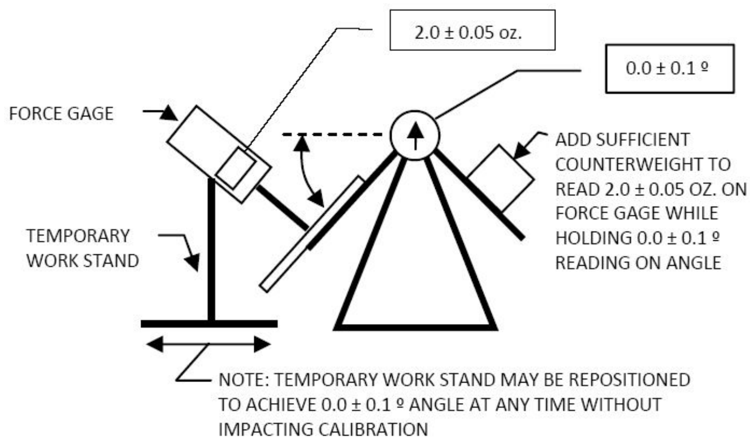



**Figure 2.3: Force Balance Calibration Procedure**

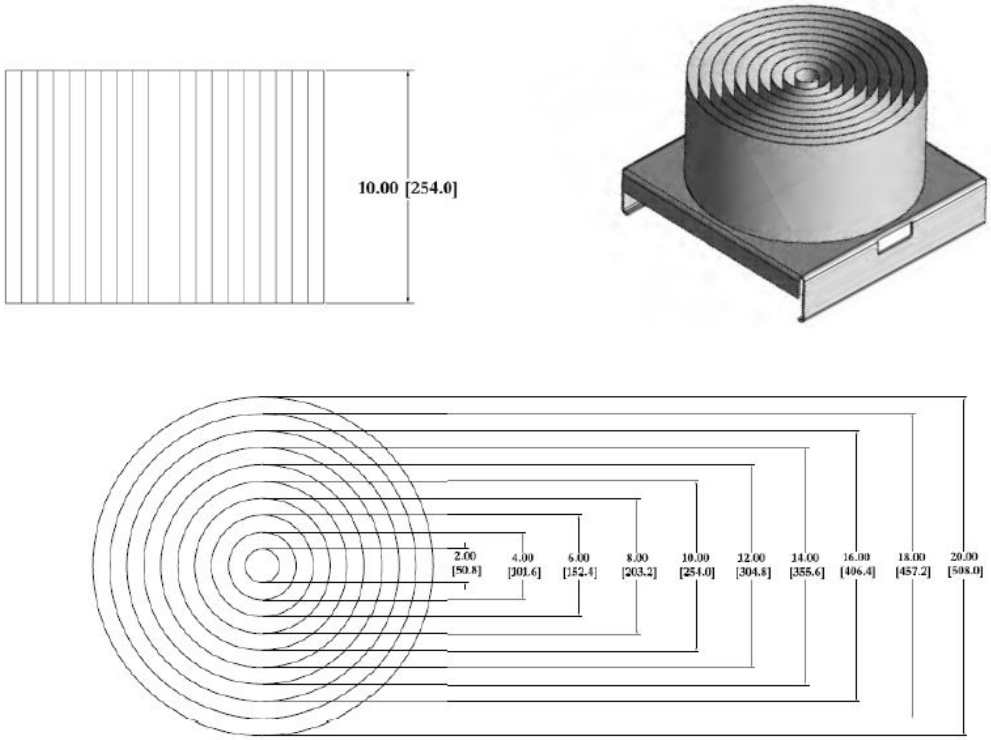



**Figure 2.4: Annular Ring Specifications**

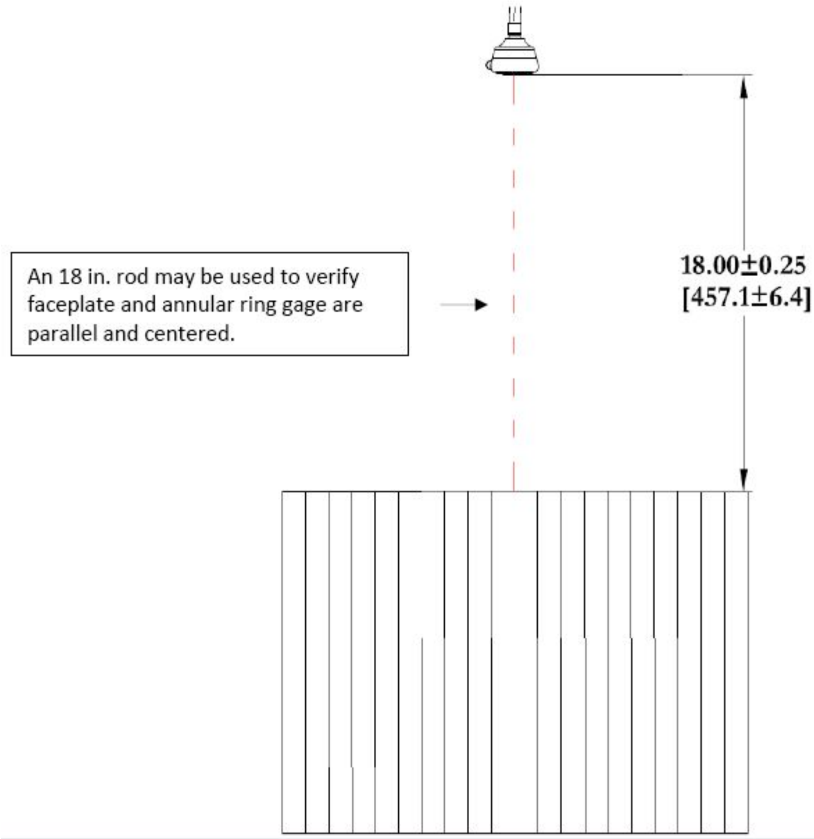



**Figure 2.5: Annular Ring Test Setup**

## 2.5 Robert Mowris Associates Round-Robin Laboratory Testing

In order to participate in the round-robin comparative laboratory tests RMA developed a wireless data logger to measure flow, pressure, and temperature.8 RMA used an electronic controller to regulate flowing pressure with a variable pressure pump, pressurized dilatation tank, inline pressure sensor (connected to the electronic controller), and a flow restrictor to accurately and precisely perform showerhead tests according to the new showerhead test protocol. For the round-robin testing, RMA measured showerhead flow rates at 20, 40, 45, 60, and 80 ± 1 psig (138, 276, 310, 414, 552 Pa ± 7 kPa). RMA measured showerhead spray force at a flowing pressure of 20, 40, 45, 60, and 80 ± 1 psig (138, 276, 310, 414, 552 Pa ± 7 kPa). RMA measured showerhead spray coverage at a water temperature of 100 ± 10 °F (38 ± 6 °C) maintained for at least one minute with water pressure at 45 ± 1 psig (310 ± 7 kPa) at the inlet when water is flowing per the new showerhead test protocol. Section 3 of the report provides the results of the round-robin laboratory testing.

[8] The RMA wireless data logger transmits data to notebook computer data capture software. RMA used pressure sensors accurate to ± 0.5%, temperature sensors accurate to ± 0.1°F, and tangential turbine flow meters accurate to ±2% of the full scale at 0.2 to 2 gpm and 0.5 to 5 gpm.

## 2.6 CEC PIER Consumer Satisfaction Survey

The CEC PIER consumer satisfaction survey participant characteristics are described in Table 2.2. RMA recruited 72 participants including 34 females and 38 males ranging in age from 17 to 55 years. None of the survey participants worked for RMA and none worked on the WaterSense® or ASME/CSA specification development.

**Table 2.2: CEC PIER Consumer Satisfaction Participant Characteristics**

| Participant | Gender | Age | Height | Weight | Hair Length | Hair Type |
|---|---|---|---|---|---|---|
| P1 | M | 17 - 55 | over 6' | over 150 lbs | Medium | straight/reg |
| P2 | M | 17 - 55 | 5' 6" to 6' | over 150 lbs | Short | straight/thin |
| P3 | M | 17 - 55 | 5' 6" to 6' | over 150 lbs | Short | straight/thin |
| P4 | M | 17 - 55 | over 6' | 100 to 150 lbs | Medium | straight/reg |
| P5 | M | 17 - 55 | 5' 6" to 6' | over 150 lbs | Medium | straight/reg |
| P6 | F | 17 - 55 | under 5' 6" | 100 to 150 lbs | Long | straight/thick |
| P7 | M | 17 - 55 | over 6' | over 150 lbs | Long | wavy/thick |
| P8 | F | 17 - 55 | 5' 6" to 6' | 100 to 150 lbs | Long | straight/thick |
| P9 | M | 17 - 55 | over 6' | over 150 lbs | Medium | wavy/thick |
| P10 | F | 17 - 55 | 5' 6" to 6' | 100 to 150 lbs | Long | straight/reg |
| P11 | F | 17 - 55 | under 5' 6" | 100 to 150 lbs | Long | straight/reg |
| P12 | M | 17 - 55 | 5' 6" to 6' | over 150 lbs | Long | straight/reg |
| P13 | F | 17 - 55 | 5' 6" to 6' | 100 to 150 lbs | Long | straight/thick |
| P14 | F | 17 - 55 | under 5' 6" | 100 to 150 lbs | Long | curly/thick |
| P15 | F | 17 - 55 | 5' 6" to 6' | 100 to 150 lbs | Long | wavy/thick |
| P16 | M | 17 - 55 | 5' 6" to 6' | over 150 lbs | Long | dreads/thick |
| P17 | M | 17 - 55 | over 6' | over 150 lbs | Long | straight/thick |
| P18 | F | 17 - 55 | 5' 6" to 6' | 100 to 150 lbs | Long | straight/thick |
| P19 | F | 17 - 55 | under 5' 6" | 100 to 150 lbs | Medium | straight/reg |
| P20 | M | 17 - 55 | over 6' | over 150 lbs | Long | thick/curly |
| P21 | F | 17 - 55 | 5' 6" to 6' | over 150 lbs | Long | thick/straight |
| P22 | M | 17 - 55 | 5' 6" to 6' | over 150 lbs | Medium | thick/wavy |
| P23 | M | 17 - 55 | over 6' | over 150 lbs | Medium | thick/wavy |
| P24 | M | 17 - 55 | 5' 6" to 6' | over 150 lbs | Short | straight/thin |
| P25 | M | 17 - 55 | 5' 6" to 6' | 100 to 150 lbs | Long | thick/wavy |
| P26 | F | 17 - 55 | under 5' 6" | 100 to 150 lbs | Long | straight/thick |
| P27 | F | 17 - 55 | 5' 6" to 6' | 100 to 150 lbs | Long | straight/thick |
| P28 | M | 17 - 55 | over 6' | over 150 lbs | Short | straight/thin |

**Table 2.2: CEC PIER Consumer Satisfaction Participant Characteristics**

| Participant | Gender | Age | Height | Weight | Hair Length | Hair Type |
|---|---|---|---|---|---|---|
| P29 | M | 17 - 55 | 5' 6" to 6' | over 150 lbs | Medium | wavy/thick |
| P30 | F | 17 - 55 | 5' 6" to 6' | 100 to 150 lbs | Long | dreads/thick |
| P31 | F | 17 - 55 | under 5' 6" | 100 to 150 lbs | Long | straight/thin |
| P32 | F | 17 - 55 | under 5' 6" | 100 to 150 lbs | Long | straight/thin |
| P33 | F | 17 - 55 | 5' 6" to 6' | over 150 lbs | Long | straight/reg |
| P34 | M | 17 - 55 | 5' 6" to 6' | over 150 lbs | Long | straight/reg |
| P35 | M | 17 - 55 | over 6' | over 150 lbs | Long | straight/thick |
| P36 | F | 17 - 55 | under 5' 6" | 100 to 150 lbs | Long | straight/thick |
| P37 | M | 17 - 55 | 5' 6" to 6' | over 150 lbs | Long | straight/reg |
| P38 | F | 17 - 55 | 5' 6" to 6' | over 150 lbs | Long | straight/thick |
| P39 | F | 17 - 55 | under 5' 6" | 100 to 150 lbs | Long | straight/reg |
| P40 | F | 17 - 55 | under 5' 6" | 100 to 150 lbs | Long | straight/thick |
| P41 | M | 17 - 55 | 5' 6" to 6' | over 150 lbs | Long | straight/reg |
| P42 | F | 17 - 55 | 5' 6" to 6' | 100 to 150 lbs | Long | straight/reg |
| P43 | F | 17 - 55 | under 5' 6" | 100 to 150 lbs | Long | straight/reg |
| P44 | F | 17 - 55 | 5' 6" to 6' | 100 to 150 lbs | Long | straight/reg |
| P45 | F | 17 - 55 | 5' 6" to 6' | over 150 lbs | Medium | straight/thick |
| P46 | M | 17 - 55 | over 6' | over 150 lbs | Short | straight/reg |
| P47 | M | 17 - 55 | 5' 6" to 6' | 100 to 150 lbs | Medium | straight/reg |
| P48 | F | 17 - 55 | under 5' 6" | 100 to 150 lbs | Long | wavy/reg |
| P49 | F | 17 - 55 | under 5' 6" | 100 to 150 lbs | Long | straight/reg |
| P50 | F | 17 - 55 | under 5' 6" | 100 to 150 lbs | Long | straight/reg |
| P51 | F | 17 - 55 | 5' 6" to 6' | 100 to 150 lbs | Long | straight/reg |
| P52 | M | 17 - 55 | 5' 6" to 6' | over 150 lbs | Medium | straight/reg |
| P53 | M | 17 - 55 | 5' 6" to 6' | over 150 lbs | Short | straight/reg |
| P54 | M | 17 - 55 | 5' 6" to 6' | over 150 lbs | Medium | straight/reg |
| P55 | M | 17 - 55 | over 6' | over 150 lbs | Long | straight/reg |
| P56 | M | 17 - 55 | 5' 6" to 6' | 100 to 150 lbs | Short | bald |
| P57 | M | 17 - 55 | 5' 6" to 6' | over 150 lbs | Short | bald |
| P58 | M | 17 - 55 | 5' 6" to 6' | 100 to 150 lbs | Medium | straight/reg |
| P59 | M | 17 - 55 | over 6' | over 150 lbs | Long | straight/reg |
| P60 | M | 17 - 55 | 5' 6" to 6' | over 150 lbs | Long | curly/reg |
| P61 | M | 17 - 55 | 5' 6" to 6' | over 150 lbs | Long | straight/thick |

**Table 2.2: CEC PIER Consumer Satisfaction Participant Characteristics**

| Participant | Gender | Age | Height | Weight | Hair Length | Hair Type |
|---|---|---|---|---|---|---|
| P62 | M | 17 - 55 | 5' 6" to 6' | over 150 lbs | Short | straight/reg |
| P63 | M | 17 - 55 | over 6' | over 150 lbs | Long | straight/reg |
| P64 | M | 17 - 55 | 5' 6" to 6' | over 150 lbs | Long | wavy/thick |
| P65 | F | 17 - 55 | 5' 6" to 6' | 100 to 150 lbs | Long | straight/reg |
| P66 | F | 17 - 55 | 5' 6" to 6' | over 150 lbs | Long | straight/thick |
| P67 | F | 17 - 55 | under 5' 6" | 100 to 150 lbs | Long | straight/reg |
| P68 | F | 17 - 55 | under 5' 6" | 100 to 150 lbs | Long | straight/thin |
| P69 | F | 17 - 55 | under 5' 6" | 100 to 150 lbs | Long | straight/thick |
| P70 | M | 17 - 55 | over 6' | over 150 lbs | Medium | straight/reg |
| P71 | M | 17 - 55 | 5' 6" to 6' | over 150 lbs | Medium | straight/reg |
| P72 | F | 17 - 55 | 5' 6" to 6' | 100 to 150 lbs | Long | straight/reg |

The CEC PIER consumer satisfaction pre-survey included three statements to evaluate the degree of bias participants might have regarding water and energy conservation practices as shown in Table 2.3.

**Table 2.3: CEC PIER Consumer Satisfaction Pre-Survey Statements**

| |
|---|
| **S1** - Saving water and energy are important to my selection of which showerhead to use in my home or business (1=strongly agree, 2=neutral 3=strongly disagree). |
| **S2** - I wish to save water and energy when I take a shower. (1=strongly agree, 2=neutral 3=strongly disagree). |
| **S3** - I don't mind waiting longer (20 seconds) for hot water to take a water conserving shower. (1=strongly agree, 2=neutral 3=strongly disagree). |

Eighty one percent of CEC PIER consumer satisfaction survey participants (58 of 72) strongly agreed with the first statement (S1), 19 percent were neutral, and 0 percent strongly disagreed. Regarding S2, 81 percent strongly agreed, 18 percent were neutral, and 1 percent strongly disagreed with the statement. Regarding S3, 68 percent strongly agreed, 26 percent were neutral, and 6 percent strongly disagreed with this statement. CEC PIER pre-survey responses indicate most participants are biased towards saving water and energy, and they do not mind waiting longer for hot water to take a water conserving shower. In spite of the obvious conservation bias, CEC PIER survey participants provided similar responses to WaterSense®/ERG survey participants with both groups agreeing on 80 percent of models, i.e., where there was uniform “no buy” rating of 11 models and uniform “buy” for 6 models. The two groups disagreed on only three units.

Participants listed their state residencies in the pre-survey registration from, with 88 percent from California, 10 percent from Nevada, and 2 percent visiting from New England (one from Massachusetts and another from Connecticut.)

The WaterSense®/ERG and CEC PIER studies asked six similar survey questions with the same scoring criteria (see Table 2.4, Q1, Q2, Q4, Q5, and Q8). The CEC PIER study also asked participants to rate each showerhead on noise (Q6), overall satisfaction (Q7), and time required (seconds) to rinse a small amount of conditioner from their hair (Q3). The amount of conditioner is about the size of a United States quarter or 25 millimeters diameter in the palm of a hand. After applying a measured amount of conditioner to their hair, CEC PIER consumer survey participants entered the shower to rinse conditioner from their hair and pressed the “start” button on a waterproof wristwatch or stopwatch. When all conditioner is rinsed from hair, the participant pressed the “stop” button on the stopwatch, and recorded “rinsing time” in the survey response form.

**Table 2.4: Consumer Satisfaction Survey Questions**

| |
|---|
| **Q1** - Coverage (1=Excellent, 3=Poor)? ___ (1 to 3) |
| **Q2** - Rinsing Action (1=Excellent, 3=Poor) ___ (1 to 3) |
| **Q3** - Rinsing Time to remove conditioner (seconds)? ___ CEC PIER Study Only |
| **Q4** – Force (1=excellent, 3=too soft or too hard)? ___ (1 to 3) |
| **Q5** - Temperature (3=Poor, 1=Excellent) ___ (1 to 3) |
| **Q6** – Noise (1=Quiet, 3=too loud)? ___ (1 to 3) CEC PIER Study Only |
| **Q7** - Overall Satisfaction (3=Poor, 1=Excellent)? ___ (1 to 3) CEC PIER Study Only |
| **Q8** - Purchase showerhead (No Buy, Buy)? ___ (0 or 1) |

The CEC PIER showerhead consumer satisfaction testing was conducted in two phases. Phase I required 13 days, with one 5-hour shift per day. Four participants each shift tested 48 showerheads per shift during Phase I. Phase II required 7 days, with two 3-hour shifts per day. Four participants each tested 25 showerheads per shift during Phase II.

Consumer satisfaction surveys were conducted at the Hampton Inn & Suites, in Truckee, California. The entire north-west wing of the first floor was reserved and committed entirely to CEC PIER showerhead testing. This included five separate rooms; four private testing rooms (room numbers 100, 101, 102, and 105) and one control room (room number 103).

A consumer satisfaction pre-survey registration form was designed using Google Docs, and distributed through several previously generated community email rosters (see Figure 2.6).

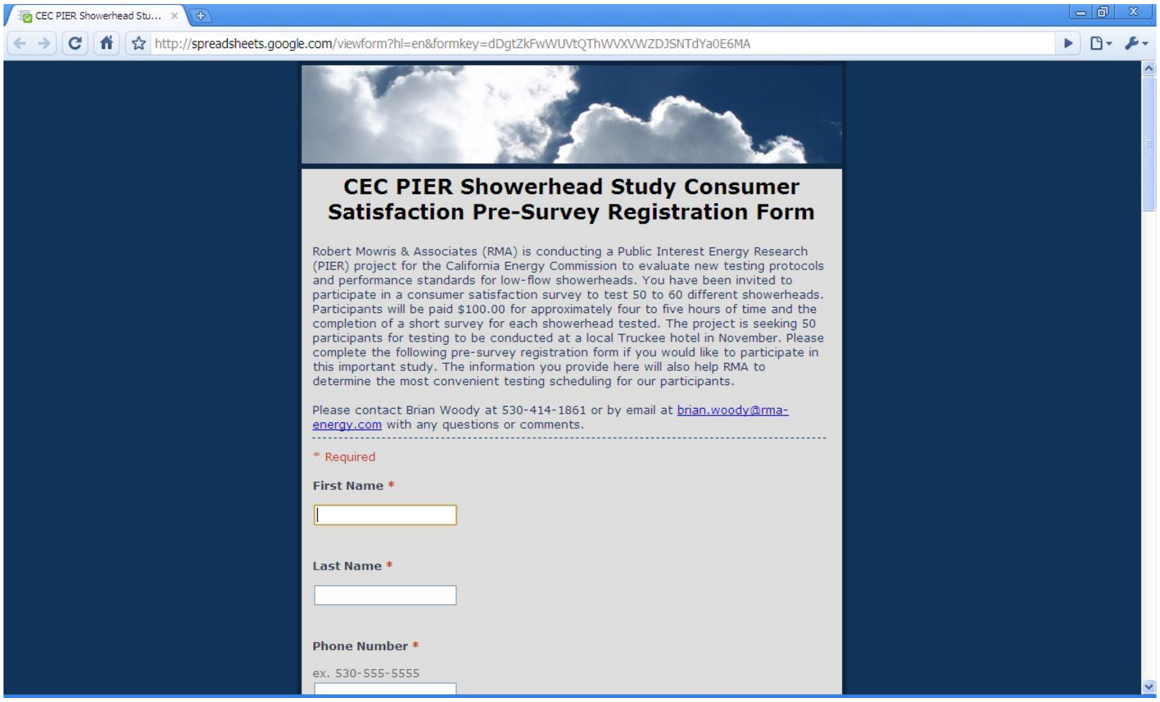
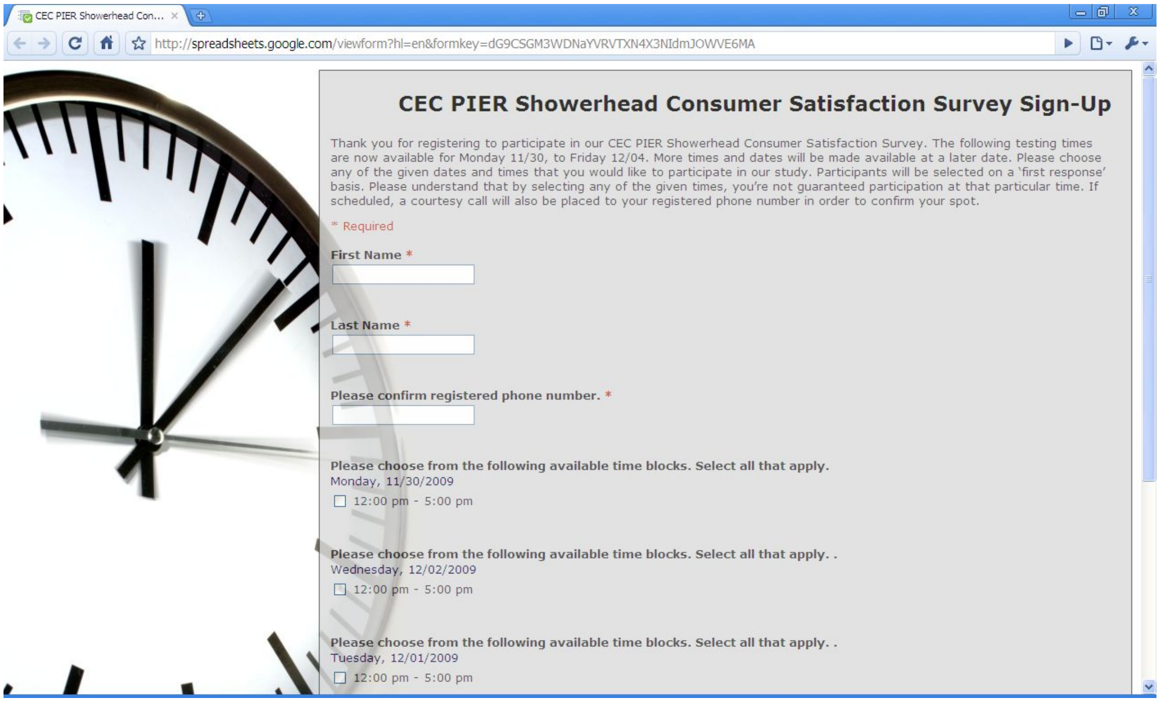



**Figure 2.6: Consumer Satisfaction Pre-Survey Registration Form**

Ninety-five people completed the pre-survey online registration form, and from this information an email list was generated of potential participants. A sign-up form was also generated using Google Docs and emailed to the roster of possible participants one week prior to the first day of testing (see Figure 2.7). Each sign-up form was time-stamped and participants were contacted on a first-come, first-served basis. Out of ninety-five people that completed the pre-survey online registration form, seventy-two were successfully contacted and participated in the study. Participants from Phase I were invited back to take part in Phase II. Only thirty of the original fifty-two Phase I participants were available to participate in Phase II. An additional twenty-two people were contacted from the original pre-survey registration roster to participate in Phase II.

Survey test groups consisted of four participants, as well as one survey proctor. Participants were asked to arrive at the Hampton Inn, Room 103, at least 15 minutes prior to testing in order to be briefed on proper testing practices and procedures.

Participants were provided with 11 ounce Turkish terry cloth bath robes (as needed,) one water-resistant wristwatch/stopwatch, a clipboard, a supply of ballpoint pens, paper copies of the survey (Appendix E) and unlimited bath towels. Comfortable seating and cable television was provided throughout the day, as well as several varieties of coffee, hot chocolate, fresh apples and bananas, Gatorade, cheese and crackers, and any requested items available from the Fast Lane Deli or the Hampton Inn Snack Shop.


CEC PIER Showerhead Con...

http://spreadsheets.google.com/viewform?hl=en&formkey=dG9CSGM3WDNaYVRVTXN4X3NIdmJOWVE6MA

**CEC PIER Showerhead Consumer Satisfaction Survey Sign-Up**

Thank you for registering to participate in our CEC PIER Showerhead Consumer Satisfaction Survey. The following testing times are now available for Monday 11/30, to Friday 12/04. More times and dates will be made available at a later date. Please choose any of the given dates and times that you would like to participate in our study. Participants will be selected on a 'first response' basis. Please understand that by selecting any of the given times, you're not guaranteed participation at that particular time. If scheduled, a courtesy call will also be placed to your registered phone number in order to confirm your spot.

* Required

**First Name** *

**Last Name** *

**Please confirm registered phone number.** *

**Please choose from the following available time blocks. Select all that apply.**
Monday, 11/30/2009
☐ 12:00 pm - 5:00 pm

**Please choose from the following available time blocks. Select all that apply. .**
Wednesday, 12/02/2009
☐ 12:00 pm - 5:00 pm

**Please choose from the following available time blocks. Select all that apply. .**
Tuesday, 12/01/2009
☐ 12:00 pm - 5:00 pm

**Figure 2.7: Survey Sign-Up Form**

Upon arrival, participants were welcomed and introductions were made among all of those present. All participants signed a Liability Release Waiver (Appendix F). The proctor then distributed a copy of a list of questions participants are required to answer after each showerhead survey (Appendix E). The proctor then clarified each question, addressed questions, and briefed participants on proper testing practices and procedures. Testing was conducted in five rooms of the first floor of the north-west wing of Truckee's Hampton Inn. These rooms are numbered 100, 101, 102, 103, and 105 where room 103 is committed entirely to participant leisure and data collection. Each of the four remaining rooms has a fully operational shower, and each are equipped with a pre-selected showerhead.

Participants were instructed to each take a designated room key, a robe, a wristwatch or stopwatch, and towel, and retire to that room. Participants disrobed in the first room that they entered for the day and secured their belongings there. Each participant then entered the shower and wet their hair. A bottle of conditioner was available in each shower. The participant applied a small amount of conditioner to the hair (approximately the size of one United States quarter or 25 millimeters diameter in the palm of the hand). When water is applied to hair for rinsing, the participant pressed the "start" button on the wristwatch or stopwatch. As soon as all of the conditioner is rinsed from the hair, the participant pressed the "stop" button on the stopwatch. Participants were required to take note of the coverage, force, temperature, noise, and overall quality of the showerhead. Upon completion of these tasks, participants turned off the shower, used a towel to dry off, put on their robes, and then returned to room 103 to answer the short survey. Each shower took approximately 90 seconds.

The participants exchanged keys after completing and submitted surveys to the proctor. Participants then went to the room designated by the given room key and repeated the testing procedure. The maximum time allowed to complete each survey and exchange keys was five minutes. Once four participants visited all four rooms and completed surveys for each, they took a five minute break while the proctor changed out the showerheads in each room. Each session that occurred between showerhead change-outs is referred to as a “Round.” The maximum time allowed to complete each Round is five minutes. Phase I consisted of 12 Rounds total, where 48 showerheads were tested. Phase II consisted of 6 Rounds, where 25 showerheads were tested. The extra showerhead in Round 6, of Phase II, was conducted in room 103. Upon completing daily testing, participants returned wristwatches or stopwatches and robes. Participants were each paid $20.00 per hour for testing. A receipt for payment was issued to each participant by the proctor, and the participants were dismissed. All wristwatch or stopwatches and robes were thoroughly sanitized between uses.

## 2.7 WaterSense®/ERG Consumer Satisfaction Survey

The WaterSense®/ERG consumer satisfaction study participant characteristics are presented in Table 2.5. The WaterSense®/ERG consumer satisfaction study included 38 participants from 22 households who were either employees of ERG or relatives of ERG employees. None of the participants work on WaterSense® specification development. The 38 participants included 17 females and 21 males ranging in age from 22 to 78, with a majority falling in the 20 to 40 range.

**Table 2.5: WaterSense®/ERG Consumer Satisfaction Participant Characteristics**

| Participant | Gender | Age | Height | Weight | Hair Length | Hair Type |
|---|---|---|---|---|---|---|
| C1a | F | 28 | 5.17 | 110 | Long | straight/thick |
| C2a | F | 44 | 5.7 | 155 | Medium | Thin |
| C3a | M | 36 | 6 | 210 | Short | curly, thick |
| C3b | F | 39 | 5.3 | 140 | short | straight, thin |
| C4a | M | 51 | 6 | 230 | short | Thin |
| C5a | M | 27 | 6.25 | 185 | short | Straight |
| C5b | M | 27 | 6.08 | 200 | short | Straight |
| C5c | M | 26 | 6 | 175 | short | curly, thick |
| C6a | F | 25 | 5.25 | 125 | long | curly, thick |
| C6b | M | 27 | 6 | 150 | short | straight/thick |
| C7a | M | 29 | 5.8 | 175 | short | curly, thick |
| C7b | F | 27 | 5.8 | 150 | medium | straight/thick |
| C8a | M | 23 | 6.3 | 165 | short | straight/thick |
| C8b | F | 22 | 5.25 | 125 | long | wavy |

**Table 2.5: WaterSense®/ERG Consumer Satisfaction Participant Characteristics**

| Participant | Gender | Age | Height | Weight | Hair Length | Hair Type |
|---|---|---|---|---|---|---|
| C9a | F | 44 | 5 | 130 | medium | straight |
| C10a | F | 25 | 5.3 | 150 | long | straight/thick |
| C10b | M | 26 | 5.8 | 185 | short | straight/thick |
| C10c | M | 54 | 5.8 | 170 | short | straight/thick |
| C12a | M | 29 | 5.7 | 170 | medium | straight/thick |
| C13a | F | 37 | 5.5 | 120 | long | curly, thick |
| C13b | M | 38 | 5.8 | 175 | short | thin |
| C14a | M | 26 | 5.7 | 190 | short | thick |
| A1a | M | 29 | 5 9 | 180 | short | straight/thin |
| A1b | F | 29 | | | medium | straight/thick |
| A2a | F | 35 | 5.7 | 140 | medium | straight |
| A2b | M | 39 | 6 | 175 | short | straight |
| A3a | F | 37 | 5.7 | 165 | medium | very thick |
| A3b | M | 50 | 5.1 | 180 | short | wavy |
| A4a | F | 25 | 5 7 | 127 | medium | straight, thick |
| A5a | F | 25 | 5.6 | 112 | long | thick |
| A5b | M | 25 | 6.1 | 150 | short | thin |
| A6a | M | 29 | 6 0 | 180 | short | Thin |
| A6b | F | 29 | 5 8 | 145 | long | Thick |
| A7a | F | 61 | 5.1 | 165 | short | Thick |
| A7b | M | 78 | 6 | 165 | short | Straight |
| A8a | F | 24 | 5 | 116 | medium | thin, wavy |
| A8b | M | 24 | 5.75 | 140 | short | medium, straight |

The WaterSense®/ERG participants were asked to measure the flow rate of their existing showerhead before installing the test showerheads to provide a rough baseline for each household. Participants were asked to provide general information to understand user characteristics. Participants were informed that they would be testing a variety of showerheads with varying flow rates and performance characteristics and that their feedback was going to be used to help WaterSense® develop showerhead performance measures. Participants were unaware they were intentionally testing some presumed poor performing showerheads. Each household tested 4 showerheads, assigned at random, each for one week at a time. Nearly every household also tested a control. At the end of each weekly evaluation, participants were asked to provide feedback on the performance of the showerheads. Participants were also instructed to measure and record the flow rate of each showerhead at the end of the weekly evaluation period. Note:  Flow data may be unreliable as it was not uniformly measured and reported.  No pressure data was collected.

# CHAPTER 3: Study Findings

The study findings include retail cost survey data, manufacturer survey data, laboratory test data regarding flow rate, force, and coverage, and consumer satisfaction survey data.

## 3.1 Retail Cost Survey Data

The retail cost survey data for the WaterSense® ERG model samples are provided in Table 3.1. The retail cost survey data for the CEC PIER model samples are provided in Table 3.2. The average retail cost for 2.5 gpm showerheads is $49.68 +/- $3.04 per unit with a sample size of 79 units. The average price for water saving showerheads is $36.72 +/- $0.89 per unit and average rated flow rate of 1.5 +/- 0.02 gpm @ 80 psig with a sample size of 196 units. The average retail cost of water saving showerheads are generally less than the average retail cost of standard showerheads even from the same manufacturer. The market appears to value standard flow units at a premium price compared to water saving products indicating a perception of inferior performance associated with water saving showerheads.

**Table 3.1: Retail Cost Survey Data for WaterSense®/ERG Model Samples**

| WaterSense®/ERG Model | Retail Cost | Rated gpm at 80 psig | Samples | Type |
|---|---|---|---|---|
| A | $25.00 | 2.5 | 3 | Fixed |
| B | $29.95 | 2 | 3 | Fixed |
| C | $29.95 | 0.5 | 4 | Fixed |
| D | $29.95 | 2.5 | 3 | Fixed |
| E | $10.99 | 2.5 | 6 | Fixed |
| F | $74.95 | 0.995 | 3 | Fixed |
| **G** | $74.95 | 1.5 | NA | Fixed |
| H | $5.49 | 2.5 | 3 | Fixed |
| I | $7.49 | 2.5 | 3 | Fixed |
| J | $17.98 | 2.5 | 3 | Fixed |
| K | $23.00 | 1.6 | 3 | Fixed |
| L | $14.88 | 2 | 3 | Fixed |
| M | $14.88 | 2 | 3 | Fixed |
| N | $14.88 | 1.5 | 7 | Fixed |
| O | $14.88 | 1.5 | same | Fixed |
| P | $79.95 | 1.5 | 3 | Fixed |
| Q | $79.95 | 1.5 | same | Fixed |
| R | $14.95 | 2.5 | 6 | Fixed |

**Table 3.1: Retail Cost Survey Data for WaterSense®/ERG Model Samples**

| WaterSense®/ERG Model | Retail Cost | Rated gpm at 80 psig | Samples | Type |
|---|---|---|---|---|
| S | $14.95 | 2.5 | same | Fixed |
| T | $109.95 | 1.5 | 3 | Fixed |
| U | $109.95 | 1.5 | same | Fixed |
| V | $38.19 | 2.5 | same | Fixed |

**Table 3.2: Retail Cost Survey Data for CEC PIER Model Samples**

| CEC PIER Model | Retail Cost | Rated gpm at 80 psig | Samples | Type |
|---|---|---|---|---|
| AA | $74.95 | 0.5525 | 3 | Fixed |
| AB | $14.88 | 1.25 | 3 | Fixed |
| AC | $59.95 | varies with disc | 3 | Fixed |
| AD | $11.99 | 1.9 | 3 | Fixed |
| AE | $4.49 | 1.5 | 3 | Fixed |
| AF | $9.63 | 1.5 | 3 | Fixed |
| AG | $9.63 | 1.75 | 3 | Fixed |
| AH | $12.99 | 2 | 3 | Fixed |
| AI | $44.20 | 2 | 3 | Fixed |
| AJ | $17.00 | 1.5 | 3 | Fixed |
| AK | $56.85 | 1.5 | 3 | Fixed |
| AL | $58.25 | 2.5 | 3 | Fixed |
| AM | $20.69 | 1.5 | 3 | Fixed |
| AN | $65.86 | 2 | 3 | Fixed |
| AO | $54.42 | 1.75 | 3 | Fixed |
| AR | $63.70 | 1.5 | 3 | Fixed |
| AU | $39.99 | 1.5 | 3 | Fixed |
| AV | $6.49 | 1.6 | 3 | Fixed |
| AW | $19.99 | 1.5 | 3 | Fixed |
| AX | $24.99 | 2 | 3 | Fixed |
| BD | $55.00 | 1.75 | 3 | Fixed |
| BE | $39.95 | 1.59 | 3 | Fixed |
| BF | $12.89 | 1.75 | 3 | Fixed |
| BG | $24.56 | 1.6 | 3 | Fixed |
| BH | $59.95 | 1.75 | 3 | Fixed |

**Table 3.2: Retail Cost Survey Data for CEC PIER Model Samples**

| CEC PIER Model | Retail Cost | Rated gpm at 80 psig | Samples | Type |
|---|---|---|---|---|
| BI | $59.95 | 1.5 | 3 | Fixed |
| BJ | $59.95 | 1.3 | 3 | Fixed |
| BK | $24.95 | 1.5 | 4 | Fixed |
| BL | $16.88 | 1.5 | 3 | Fixed |
| BM | $16.95 | 1.75 | 3 | Fixed |
| BN | $44.10 | 1.75 | 4 | Fixed |
| BO | $59.00 | 2 | 3 | Fixed |
| BP | $44.10 | 1.5 | 4 | Fixed |
| HHA | $39.76 | 1.5 | 2 | Handheld |
| HHB | $29.88 | 1.5 | 2 | Handheld |
| HHC | $29.99 | 2 | 2 | Handheld |
| HHD | $38.95 | 2.5 | 2 | Handheld |
| HHE | $29.99 | 1.5 | 3 | Handheld |
| HHF | $107.00 | 2.5 | 4 | Handheld |
| HHG | $194.40 | 2.5 | 3 | Handheld |
| HHH | $148.65 | 2.5 | 3 | Handheld |
| HHI | $53.00 | 2.5 | 4 | Handheld |
| HHJ | $103.52 | 2.5 | 3 | Handheld |

## 3.2 Manufacturer Survey Data

The manufacturer survey is provided in Appendix D and summary of survey response data are provided in Table 3.3. The summary answers to each question are provided below. Responses from each manufacturer are confidential.

Question 1: Are you a member of ASME A112.18.1 /CSAB125.1 Joint Harmonization Task Force? (Yes, No, DK)

Answer 1: Seventy one percent of manufacturers (17 out of 24) surveyed are members of the ASME/CSA A112.18.1 Joint Harmonization Task Force.

Question 2: Is your company an EPA WaterSense® Partner? (Yes, No, DK)

Answer 2: Fifty percent of manufacturers (12 out of 24) are EPA WaterSense® partners.

Question 3: Is your company a member of the US Green Building Council Water Efficiency Technology Advisory Group (WETAG)? (Yes, No, DK)

Answer 3: Twenty one percent of manufacturers surveyed (5 out of 24) are members of the US Green Building Council Water Efficiency Technology Advisory Group.

Question 4: What is your company's estimated showerhead market share? (%, DK)

Answer 4: The market share of the 24 manufacturers surveyed ranges from less than 1 percent to 12 percent and the average market share is 4 percent +/- 1 percent.

Question 5: Does your company promote water conservation? (Yes, No, DK)

Answer 5: One hundred percent of manufacturers surveyed promote water conservation.

Question 6: Has your company received complaints about "thermal shock" with showerheads rated at <2.5 gpm at 80 psi are installed in existing or new homes? (Yes, No, DK)

Answer 6: Only one company reported receiving complaints (for another manufacturer valve) about thermal shock with their showerhead rated at less than 2.5 gpm at 80 psig.

Question 7: Has your company conducted any showerhead quality tests using shower heads rated at less than 2.5 gpm at 80 psig? (Yes, No, DK)

Answer 7: Eighty eight percent of manufacturers surveyed (21 out of 24) have conducted showerhead quality tests using showerheads rated at less than 2.5 gpm at 80 psig.

Question 8: Do you give special guidance to consumers about retrofitting shower heads rated at less than 2.5 gpm at 80 psig? (Yes, No, DK)

Answer 8: Fifty percent of manufacturers surveyed (12 out of 24) give special guidance to consumers about retrofitting showerheads rated at less than 2.5 gpm at 80 psig.

Question 9: Deleted

Question 10: Approximately what percentage of total sales do conserving showerheads account for? (%, DK)

Answer 10: Fifty eight percent of manufacturers surveyed (14 out of 24) reported 47 percent average of total sales are water saving showerheads.

Question 11: Do conserving showerheads cost more than 2.5 gpm shower heads? (Yes, No, DK)

Answer 11: Seventeen percent of manufacturers surveyed (4 out of 24) report that water saving showerheads cost more than conventional showerheads rated at 2.5 gpm at 80 psig.

Question 12: Are your company's water conserving showerheads available in California? (Yes, No, DK)

Answer 12: Eighty three percent of manufacturers surveyed (20 out of 24) report that water saving showerheads are available for sale in California.

Question 13: Deleted

Question 14: What is your company's percentage of total sales of multi-shower units? (%, DK)

Answer 14: Six manufacturers surveyed sell multi-shower units with average sales of 3 percent of total sales.

Question 15: Deleted

Question 16: Would you support a mandatory standard for new construction that reduced the maximum showerhead flow rate below 2.5 gpm to conserve energy and water? (Yes, No, DK)

Answer 16: Fifty four percent of manufacturers surveyed (13 out of 24) support a mandatory standard for new construction to reduce the maximum showerhead flow rate below 2.5 gpm to conserve energy and water. Manufacturers who support a mandatory standard for new construction represent less than 11 percent of the overall showerhead market share.

Question 17: If so, would 2.0 gpm be the right value? (Yes, No, DK)

Answer 17: Thirty nine percent of manufacturers surveyed (9 out of 24) support 2.0 gpm at 80 psi as an appropriate mandatory standard for new construction.

Question 18: Would you support a mandatory appliance standard for shower heads that reduces maximum showerhead flow rates below 2.5 gpm to conserve energy and water? (Yes, No, DK)

Answer 18: Forty six percent of manufacturers surveyed (11 out of 24) support a mandatory appliance standard to reduce the maximum showerhead flow rate below 2.5 gpm to conserve energy and water. The manufacturers who support a mandatory appliance standard represent a small market segment of less than 10 percent of the overall showerhead market share.

Question 19: If so, would 2.0 gpm be the right value? (Yes, No, DK)

Answer 19: Thirty eight percent of manufacturers surveyed (9 out of 24) support 2.0 gpm at 80 psi as an appropriate mandatory appliance standard for water efficient showerheads.

Question 20: Do you support a voluntary WaterSense® standard for showerheads to conserve water and energy? (Yes, No, DK)

Answer 20: Ninety six percent of manufacturers surveyed (23 out of 24) support the WaterSense® standard for water efficient showerheads.

Question 21: If so, what would be the right combination of flow rates and pressures for this standard (i.e., 2.0 gpm at 20, 40, 60, 80 psig)? (GPM at psig, DK)

Answer 21: Eighty three percent of manufacturers surveyed (20 out of 24) support a WaterSense® standard of 1.8 to 2.0 gpm at 80 psig.

Question 21a: Would you support a voluntary showerhead standard like the Australian voluntary standard of 1 star for 2.0 gpm max at 20-80 psig, 2 stars for 1.5 gpm max at 20-80 psig, and 3 stars for less than 1.5 gpm max at 20-80 psig? (Yes, No, DK)

Answer 21a: Fifty eight percent of manufacturers surveyed (14 out of 24) support a voluntary standard like the Australian voluntary standard.

Question 22: Do you manufacture water conserving showerheads with flow rates less than 2.5 gpm? (Yes, No, DK)

Answer 22: Eighty three percent of manufacturers surveyed (20 out of 24) manufacture water conserving showerheads with rated flow rates less than 2.5 gpm at 80 psig.

Question 23: If so, how many models have flow rates less than 2.5 gpm? (Number, No, DK)

Answer 23: Seventy five percent of manufacturers surveyed (18 out of 24) offer models with flow rates less than 2.5 gpm at 80 psig and the average manufacturer offers 5 models.

Question 24: If so, what are the rated flowrates at 80 psig? (Number, No, DK)

Answer 24: The average rated flow rates range from 1.5 to 2.0 gpm at 80 psig and two manufacturers offer units with rated flow rates of 0.5 gpm at 80 psig.

Question 25: Are you willing to donate 2 - 3 showerheads (3 of each) for the CEC PIER study, the results of which we will use to make a recommendation to ASME? (Yes, No, DK)

Answer 25: Fifty eight percent of manufacturers surveyed (14 out of 24) donated showerheads for testing in the CEC PIER study.

**Table 3.3: Manufacturer Survey Data Summary**

| | Manufacturer Survey Questions | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mfgr | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 10 | 11 | 12 | 14 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
| 1 | Y | N | N | 12 | Y | N | Y | N | 4 | Y | Y | 5 | N | N | N | N | Y | 2 | Y | 10 | 1.6- 1.8 | Y |
| 2 | Y | N | N | D | Y | N | Y | Y | 100 | N | Y | D | Y | Y | Y | Y | Y | 2 | Y | 6 | 1.5-2.0 | Y |
| 3 | Y | N | N | D | Y | N | Y | Y | D | N | Y | D | Y | Y | Y | Y | Y | 2 | Y | 6 | 1.5-2.0 | Y |
| 5 | N | N | N | D | Y | N | Y | Y | 100 | N | Y | N | Y | Y | Y | Y | Y | 0.5 | Y | 1 | 0.5 | Y |
| 6 | Y | Y | D | 1 | Y | N | N | N | 0 | N | N | 0 | D | D | D | D | Y | 2 | N | 0 | N | Y |
| 7 | Y | N | N | 3 | Y | N | Y | N | 0 | N | N | 0 | Y | Y | Y | D | Y | 2 | N | N | N | N |
| 8 | N | Y | N | 1 | Y | N | Y | N | 100 | N | Y | 0 | N | N | N | N | Y | 1.5 | Y | 5 | 0.5-1.5 | N |
| 9 | Y | Y | N | D | Y | N | N | N | N | N | N | 0 | N | N | D | N | Y | 2 | N | N | N | N |
| 10 | Y | N | N | 1 | Y | N | Y | Y | 100 | N | Y | 1 | Y | N | Y | N | Y | 2.25 | Y | 5 | 2 | N |
| 11 | Y | Y | N | 10 | Y | N | Y | N | 1 | N | Y | 1 | N | N | N | N | Y | 2 | Y | 2 | 1.5 | Y |
| 12 | N | N | N | D | Y | N | Y | Y | 100 | N | Y | 0 | Y | N | Y | Y | Y | 1.25 | Y | 1 | 1.3-1.8 | Y |
| 13 | Y | N | N | N | Y | N | Y | Y | N | N | Y | N | Y | Y | Y | Y | Y | 2 | Y | 2 | 1.5- 1.6 | Y |
| 14 | N | Y | N | D | Y | N | Y | N | 2 | N | Y | 0 | Y | N | N | N | Y | 1.5 | Y | 4 | 1.6-1.9 | N |
| 15 | Y | Y | Y | 3 | Y | N | Y | Y | 6 | Y | Y | 5 | N | N | N | N | Y | 2 | Y | 8 | 1.6- 1.8 | Y |
| 16 | N | N | N | 1 | Y | N | Y | Y | 100 | N | Y | 0 | Y | Y | Y | Y | Y | 1.5 | Y | 6 | 1.5- 2.0 | N |
| 17 | Y | Y | Y | N | Y | N | Y | Y | N | N | Y | D | N | N | D | N | D | N | Y | 11 | N | Y |
| 18 | Y | Y | N | N | Y | N | Y | N | N | D | Y | N | N | N | N | N | Y | D | Y | N | N | N |
| 19 | D | Y | N | D | Y | N | Y | N | D | N | Y | 0 | Y | Y | Y | Y | Y | 2 | Y | 10 | 1.5-2.0 | N |
| 20 | N | Y | Y | N | Y | N | Y | N | 100 | N | Y | 0 | Y | Y | Y | Y | Y | 1.75 | Y | 5 | 1.5-2.0 | Y |
| 23 | Y | Y | Y | 4 | Y | N | Y | Y | 50 | N | Y | 0 | Y | Y | Y | Y | Y | 2 | Y | 3 | 2 | Y |
| 24 | Y | D | N | N | Y | Y | Y | N | N | D | Y | 1 | Y | D | N | N | Y | D | Y | N | N | N |
| 27 | Y | Y | Y | 1 | Y | N | Y | Y | 0 | Y | N | 0 | D | D | D | N | Y | 1.75 | N | 0 | N | N |
| 28 | Y | N | N | 5 | Y | N | N | Y | 13 | N | Y | 5 | N | N | N | N | Y | D | Y | 2 | 1.5-2.0 | Y |
| 29 | Y | N | N | 4 | Y | N | Y | N | 30 | Y | Y | 0 | N | N | N | N | Y | 2.2 | Y | 12 | 1.5-2.0 | Y |
| Sum | 17 | 12 | 5 | 4 | 24 | 1 | 21 | 12 | 47 | 4 | 20 | 1 | 13 | 9 | 11 | 9 | 23 | 1.8 | 20 | 5.0 | | 14 |

Notes: Y = Yes, N = No, D = Do Not Know

## 3.3 CEC PIER and WaterSense®/ERG Showerhead Sample

The CEC PIER showerhead sample includes 22 showerheads from the WaterSense®/ERG sample plus 51 additional showerheads including 41 fixed showerheads and 10 handheld showerheads with rated flow rates ranging from 0.55 to 2.5 gpm at 80 psig flowing pressure. The CEC PIER model samples were selected to compare to qualitatively and quantitatively test the EPA WaterSense® flow rate, force, and coverage criteria.

WaterSense®/ERG showerhead sample includes 22 showerhead models with 12 “poor performing” showerheads from several manufacturers, 5 showerheads of unknown performance, and 5 “control” showerheads selected based on success in several utility rebate programs and units frequently installed in hotel rooms. The WaterSense®/ERG models were selected to determine if users could uniformly differentiate qualitative performance and provide recommendations for showerheads to test quantitatively against the proposed ASME/CSA showerhead testing protocols in a laboratory setting. The WaterSense®/ERG consumer satisfaction survey study included a variety of showerheads with rated flow rates ranging from 0.7 gpm to 2.5 gpm at 80 psig flowing pressure.

## 3.4 Water Efficiency Flow Rate Data

The WaterSense® water efficiency flow rate criteria are defined as follows.

3.0 Water Efficiency (Flow Rate) Criteria

3.1.1 The manufacturer shall specify a maximum flow rate value (rated flow) of the showerhead. This specified value must be equal to or less than 2.0 gpm (7.6 liters per minute (L/min)).

3.1.2 The maximum flow rate value shall meet testing and verification protocols for sampling as described in 10 CFR 430 Subpart F, Appendix B at flowing pressures of 20, 45 and 80 ± 1 psi (140, 310 and 550 ± 7 kPa), and shall not exceed the specified value in Section 3.1.1.

3.1.3 The maximum flow rate value specified in Section 3.1.1 shall be used for determining the minimum flow rates in Section 3.1.4 and 3.1.5.

3.1.4 The minimum flow rate value, determined through testing, at a flowing pressure of 20 ± 1 psi (140 ± 7 kPa), shall not be less than 60 percent of the maximum flow rate value specified in Section 3.1.1.

3.1.5 The minimum flow rate value, determined through testing, at flowing pressures of 45 ± 1 psi (310 ±7 kPa) and 80 ± 1 psi (550 ±7 kPa), shall not be less than 75 percent of the maximum flow rate value specified in Section 3.1.1.

Flow rate data and information regarding whether or not each tested model meets required tolerance established by the WaterSense® flow rate criteria are provided in the following tables. The flow rate data for WaterSense®/ERG models from the Canadian Standards Association (CSA) are provided in Table 3.4. The flow rate data for WaterSense®/ERG models from the International Association of Plumbing and Mechanical Officials (IAPMO, www.iapmo.org) are provided in Table 3.5. The flow rate data for WaterSense®/ERG models from Alsons are provided in Table 3.6. The flow rate data for WaterSense®/ERG models from RMA are provided in Table 3.7.

Sixty four percent of WaterSense®/ERG models tested by CSA, IAPMO, and Alsons failed to meet required tolerance of the WaterSense® flow rate criteria (14 out of 22 models). Seventy seven percent of the WaterSense®/ERG models tested by RMA failed to meet required tolerance of the WaterSense® flow rate criteria (17 out of 22 models).

The flow rate data for the CEC PIER models from RMA are provided in Table 3.8. Seventy eight percent of CEC PIER fixed showerhead models tested by RMA failed to meet required tolerance of the WaterSense® flow rate criteria (32 out of 41 models). Eighty percent of CEC PIER hand held models tested by RMA failed to meet required tolerance of the WaterSense® flow rate criteria (8 out of 10 models).

Most showerheads failed due to the maximum flow rate determined through testing at a flowing pressure of 80 ± 1 psi being greater than manufacturer specified flow rate at 80 psig as required in Section 3.1.2 of the WaterSense® Specification for Showerheads. Other showerheads failed due to the minimum flow rate determined through testing at a flowing pressure of 20 ± 1 psi being less than 60 percent of the maximum flow rate specified by the manufacture per Section 3.1.4 of the WaterSense® Specification for Showerheads. Other showerheads failed due to the minimum flow rate required in Section 3.1.5 of the WaterSense® Specification for Showerheads, determined through testing, at flowing pressures of 45 ± 1 psi and 80 ± 1 psi, being less than 75 percent of the maximum flow rate specified by the manufacturer per Section 3.1.1 of the WaterSense® Specification for Showerheads.

**Table 3.4: Flow Rate Data WaterSense®/ERG Models - CSA**

| | | CSA | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Flow Rate (GPM) | | | 3.1.2 | | 3.1.4 | | 3.15 | | |
| **Model** | **Rated Flow Rate** | **20 PSI** | **45 PSI** | **80 PSI** | **Maximum Tested Flow Rate** | **Max Exceed Rated?** | **Min Allowed @ 20 psi** | **Flow @ 20 psi less than Min?** | **Min Allowed @ 45 and 80 psi** | **Flow @ 45 and 80 psi less than Min?** | **Meets Required Tolerance?** |
| A | 2.5 | 1.40 | 1.83 | 2.33 | 2.33 | No | 1.50 | Yes | 1.88 | Yes | **No** |
| B | 2.0 | 1.04 | 1.51 | 2.00 | 2.00 | No | 1.20 | Yes | 1.50 | No | **No** |
| C1 | 0.7 | 0.43 | 0.70 | 1.15 | 1.15 | Yes | 0.42 | No | 0.53 | No | **No** |
| C2 | 0.7 | 0.43 | 0.70 | 1.20 | 1.20 | Yes | 0.42 | No | 0.53 | No | **No** |
| D | 2.5 | 0.56 | 0.89 | 1.18 | 1.18 | No | 1.50 | Yes | 1.88 | Yes | **No** |
| E | 2.5 | 1.35 | 1.97 | 2.55 | 2.55 | Yes | 1.50 | Yes | 1.88 | No | **No** |
| F | 1.0 | 0.37 | 0.56 | 0.76 | 0.76 | No | 0.60 | Yes | 0.75 | Yes | **No** |
| G | 1.5 | 0.82 | 1.23 | 1.63 | 1.63 | Yes | 0.90 | Yes | 1.13 | No | **No** |
| H | 2.5 | 1.31 | 1.79 | 2.29 | 2.29 | No | 1.50 | Yes | 1.88 | Yes | **No** |
| I | 2.5 | 1.18 | 1.65 | 2.14 | 2.14 | No | 1.50 | Yes | 1.88 | Yes | **No** |
| J | 2.5 | 1.36 | 1.80 | 2.38 | 2.38 | No | 1.50 | Yes | 1.88 | Yes | **No** |
| K | 1.6 | 1.14 | 1.34 | 1.58 | 1.58 | No | 0.96 | No | 1.20 | No | Yes |
| L | 2.0 | 1.43 | 1.64 | 1.78 | 1.78 | No | 1.20 | No | 1.50 | No | Yes |

## Table 3.4: Flow Rate Data WaterSense®/ERG Models - CSA

| Model | Rated Flow Rate | CSA | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Flow Rate (GPM) | | | 3.1.2 | | 3.1.4 | | 3.15 | | |
| | | 20 PSI | 45 PSI | 80 PSI | Maximum Tested Flow Rate | Max Exceed Rated? | Min Allowed @ 20 psi | Flow @ 20 psi less than Min? | Min Allowed @ 45 and 80 psi | Flow @ 45 and 80 psi less than Min? | Meets Required Tolerance? |
| M | 2.0 | 1.36 | 1.78 | 1.94 | 1.94 | No | 1.20 | No | 1.50 | No | Yes |
| N | 1.5 | 1.11 | 1.21 | 1.27 | 1.27 | No | 0.90 | No | 1.13 | No | Yes |
| O | 1.5 | 1.22 | 1.38 | 1.40 | 1.40 | No | 0.90 | No | 1.13 | No | Yes |
| P | 1.5 | 1.15 | 1.65 | 2.20 | 2.20 | Yes | 0.90 | No | 1.13 | No | **No** |
| Q | 1.5 | 1.19 | 1.66 | 2.21 | 2.21 | Yes | 0.90 | No | 1.13 | No | **No** |
| R | 2.5 | 2.25 | 2.43 | 2.37 | 2.43 | No | 1.50 | No | 1.88 | No | Yes |
| S | 2.5 | 2.04 | 2.12 | 2.45 | 2.45 | No | 1.50 | No | 1.88 | No | Yes |
| T | 1.5 | 0.94 | 1.42 | 1.85 | 1.85 | Yes | 0.90 | No | 1.13 | No | **No** |
| U | 1.5 | 0.90 | 1.38 | 1.84 | 1.84 | Yes | 0.90 | No | 1.13 | No | **No** |
| V | 2.5 | 2.12 | 2.48 | 2.49 | 2.49 | No | 1.50 | No | 1.88 | No | Yes |

## Table 3.5: Flow Rate Data WaterSense®/ERG Models - IAPMO

| Model | Rated Flow Rate | IAPMO | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Flow Rate (GPM) | | | 3.1.2 | | 3.1.4 | | 3.15 | | |
| | | 20 PSI | 45 PSI | 80 PSI | Maximum Tested Flow Rate | Max Exceed Rated? | Min Allowed @ 20 psi | Flow @ 20 psi less than Min? | Min Allowed @ 45 and 80 psi | Flow @ 45 and 80 psi less than Min? | Meets Required Tolerance? |
| A | 2.5 | 1.34 | 1.82 | 2.31 | 2.31 | No | 1.50 | Yes | 1.88 | Yes | **No** |
| B | 2.0 | 0.97 | 1.49 | 1.99 | 1.99 | No | 1.20 | Yes | 1.50 | Yes | **No** |
| C1 | 0.7 | 0.40 | 0.68 | 1.15 | 1.15 | Yes | 0.42 | Yes | 0.53 | No | **No** |
| C2 | 0.7 | 0.40 | 0.69 | 1.16 | 1.16 | Yes | 0.42 | Yes | 0.53 | No | **No** |
| D | 2.5 | 0.67 | 1.01 | 1.41 | 1.41 | No | 1.50 | Yes | 1.88 | Yes | **No** |
| E | 2.5 | 1.33 | 1.99 | 2.47 | 2.47 | No | 1.50 | Yes | 1.88 | No | **No** |
| F | 1.0 | 0.31 | 0.53 | 0.73 | 0.73 | No | 0.60 | Yes | 0.75 | Yes | **No** |
| G | 1.5 | 0.80 | 1.21 | 1.60 | 1.60 | Yes | 0.90 | Yes | 1.13 | No | **No** |
| H | 2.5 | 1.30 | 1.80 | 2.30 | 2.30 | No | 1.50 | Yes | 1.88 | Yes | **No** |

### Table 3.5: Flow Rate Data WaterSense®/ERG Models - IAPMO

| Model | Rated Flow Rate | IAPMO | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Flow Rate (GPM) | | | 3.1.2 | | 3.1.4 | | 3.15 | | |
| | | 20 PSI | 45 PSI | 80 PSI | Maximum Tested Flow Rate | Max Exceed Rated? | Min Allowed @ 20 psi | Flow @ 20 psi less than Min? | Min Allowed @ 45 and 80 psi | Flow @ 45 and 80 psi less than Min? | Meets Required Tolerance? |
| I | 2.5 | 1.12 | 1.60 | 2.11 | 2.11 | No | 1.50 | Yes | 1.88 | Yes | **No** |
| J | 2.5 | 1.19 | 1.62 | 2.04 | 2.04 | No | 1.50 | Yes | 1.88 | Yes | **No** |
| K | 1.6 | 1.16 | 1.45 | 1.59 | 1.59 | No | 0.96 | No | 1.20 | No | Yes |
| L | 2.0 | 1.32 | 1.71 | 1.83 | 1.83 | No | 1.20 | No | 1.50 | No | Yes |
| M | 2.0 | 1.30 | 1.84 | 1.81 | 1.84 | No | 1.20 | No | 1.50 | No | Yes |
| N | 1.5 | 1.13 | 1.31 | 1.22 | 1.31 | No | 0.90 | No | 1.13 | No | Yes |
| O | 1.5 | 1.11 | 1.30 | 1.26 | 1.30 | No | 0.90 | No | 1.13 | No | Yes |
| P | 1.5 | 1.36 | 1.60 | 2.20 | 2.20 | Yes | 0.90 | No | 1.13 | No | **No** |
| Q | 1.5 | 1.09 | 1.66 | 2.20 | 2.20 | Yes | 0.90 | No | 1.13 | No | **No** |
| R | 2.5 | 2.31 | 2.44 | 2.34 | 2.44 | No | 1.50 | No | 1.88 | No | Yes |
| S | 2.5 | 2.06 | 2.28 | 2.18 | 2.28 | No | 1.50 | No | 1.88 | No | Yes |
| T | 1.5 | 0.89 | 1.31 | 1.70 | 1.70 | Yes | 0.90 | Yes | 1.13 | No | **No** |
| U | 1.5 | 0.89 | 1.32 | 1.74 | 1.74 | Yes | 0.90 | Yes | 1.13 | No | **No** |
| V | 2.5 | 2.23 | 2.46 | 2.35 | 2.46 | No | 1.50 | No | 1.88 | No | Yes |

### Table 3.6: Flow Rate Data WaterSense®/ERG Models – Alsons

| Model | Rated Flow Rate | Alsons | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Flow Rate (GPM) | | | 3.1.2 | | 3.1.4 | | 3.15 | | |
| | | 20 PSI | 45 PSI | 80 PSI | Maximum Tested Flow Rate | Max Exceed Rated? | Min Allowed @ 20 psi | Flow @ 20 psi less than Min? | Min Allowed @ 45 and 80 psi | Flow @ 45 and 80 psi less than Min? | Meets Required Tolerance? |
| A | 2.5 | 1.37 | 1.85 | 2.33 | 2.33 | No | 1.50 | Yes | 1.88 | Yes | **No** |
| B | 2.0 | 1.01 | 1.49 | 2.03 | 2.03 | Yes | 1.20 | Yes | 1.50 | Yes | **No** |
| C1 | 0.7 | 0.43 | 0.72 | 1.17 | 1.17 | Yes | 0.42 | No | 0.53 | No | **No** |
| C2 | 0.7 | 0.43 | 0.72 | 1.18 | 1.18 | Yes | 0.42 | No | 0.53 | No | **No** |
| D | 2.5 | 0.57 | 0.90 | 1.15 | 1.15 | No | 1.50 | Yes | 1.88 | Yes | **No** |

### Table 3.6: Flow Rate Data WaterSense®/ERG Models – Alsons

| Model | Rated Flow Rate | Alsons | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Flow Rate (GPM) | | | 3.1.2 | | 3.1.4 | | 3.15 | | |
| | | 20 PSI | 45 PSI | 80 PSI | Maximum Tested Flow Rate | Max Exceed Rated? | Min Allowed @ 20 psi | Flow @ 20 psi less than Min? | Min Allowed @ 45 and 80 psi | Flow @ 45 and 80 psi less than Min? | Meets Required Tolerance? |
| E | 2.5 | 1.31 | 2.00 | 2.46 | 2.46 | No | 1.50 | Yes | 1.88 | No | **No** |
| F | 1.0 | 0.37 | 0.60 | 0.78 | 0.78 | No | 0.60 | Yes | 0.75 | Yes | **No** |
| G | 1.5 | 0.81 | 1.26 | 1.64 | 1.64 | Yes | 0.90 | Yes | 1.13 | No | **No** |
| H | 2.5 | 1.31 | 1.86 | 2.31 | 2.31 | No | 1.50 | Yes | 1.88 | Yes | **No** |
| I | 2.5 | 1.11 | 1.64 | 2.13 | 2.13 | No | 1.50 | Yes | 1.88 | Yes | **No** |
| J | 2.5 | 1.22 | 1.65 | 2.07 | 2.07 | No | 1.50 | Yes | 1.88 | Yes | **No** |
| K | 1.6 | 1.22 | 1.45 | 1.57 | 1.57 | No | 0.96 | No | 1.20 | No | Yes |
| L | 2.0 | 1.37 | 1.70 | 1.82 | 1.82 | No | 1.20 | No | 1.50 | No | Yes |
| M | 2.0 | 1.30 | 1.84 | 1.82 | 1.84 | No | 1.20 | No | 1.50 | No | Yes |
| N | 1.5 | 1.18 | 1.35 | 1.29 | 1.35 | No | 0.90 | No | 1.13 | No | Yes |
| O | 1.5 | 1.19 | 1.35 | 1.26 | 1.35 | No | 0.90 | No | 1.13 | No | Yes |
| P | 1.5 | 1.35 | 1.68 | 1.91 | 1.91 | Yes | 0.90 | No | 1.13 | No | **No** |
| Q | 1.5 | 1.38 | 1.70 | 1.91 | 1.91 | Yes | 0.90 | No | 1.13 | No | **No** |
| R | 2.5 | 2.26 | 2.41 | 2.40 | 2.41 | No | 1.50 | No | 1.88 | No | Yes |
| S | 2.5 | 2.26 | 2.33 | 2.23 | 2.33 | No | 1.50 | No | 1.88 | No | Yes |
| T | 1.5 | 0.91 | 1.25 | 1.80 | 1.80 | Yes | 0.90 | No | 1.13 | No | **No** |
| U | 1.5 | 0.90 | 1.25 | 1.82 | 1.82 | Yes | 0.90 | No | 1.13 | No | **No** |
| V | 2.5 | 2.31 | 2.41 | 2.42 | 2.42 | No | 1.50 | No | 1.88 | No | Yes |

### Table 3.7: Flow Rate Data WaterSense®/ERG Models – RMA

| Model | Rated Flow Rate | RMA | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Flow Rate (GPM) | | | 3.1.2 | | 3.1.4 | | 3.15 | | |
| | | 20 PSI | 45 PSI | 80 PSI | Maximum Tested Flow Rate | Max Exceed Rated? | Min Allowed @ 20 psi | Flow @ 20 psi less than Min? | Min Allowed @ 45 and 80 psi | Flow @ 45 and 80 psi less than Min? | Meets Required Tolerance? |
| A | 2.5 | 1.35 | 1.80 | 2.30 | 2.30 | No | 1.50 | Yes | 1.88 | Yes | **No** |

**Table 3.7: Flow Rate Data WaterSense®/ERG Models – RMA**

| Model | Rated Flow Rate | RMA | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Flow Rate (GPM) | | | 3.1.2 | | 3.1.4 | | 3.15 | | |
| | | 20 PSI | 45 PSI | 80 PSI | Maximum Tested Flow Rate | Max Exceed Rated? | Min Allowed @ 20 psi | Flow @ 20 psi less than Min? | Min Allowed @ 45 and 80 psi | Flow @ 45 and 80 psi less than Min? | Meets Required Tolerance? |
| B | 2.0 | 0.90 | 1.52 | 2.10 | 2.10 | Yes | 1.20 | Yes | 1.50 | No | **No** |
| C1 | 0.7 | 0.40 | 0.70 | 1.10 | 1.10 | Yes | 0.42 | Yes | 0.53 | No | **No** |
| C2 | 0.7 | 0.40 | 0.70 | 1.18 | 1.18 | Yes | 0.42 | Yes | 0.53 | No | **No** |
| D | 2.5 | 1.29 | 1.70 | 2.20 | 2.20 | No | 1.50 | Yes | 1.88 | Yes | **No** |
| E | 2.5 | 1.35 | 2.00 | 2.60 | 2.60 | Yes | 1.50 | Yes | 1.88 | No | **No** |
| F | 1.0 | 0.40 | 0.60 | 0.80 | 0.80 | No | 0.60 | Yes | 0.75 | Yes | **No** |
| G | 1.5 | 0.99 | 1.59 | 2.31 | 2.31 | Yes | 0.90 | No | 1.13 | No | **No** |
| H | 2.5 | 1.20 | 1.80 | 2.40 | 2.40 | No | 1.50 | Yes | 1.88 | Yes | **No** |
| I | 2.5 | 1.13 | 1.60 | 2.20 | 2.20 | No | 1.50 | Yes | 1.88 | Yes | **No** |
| J | 2.5 | 1.20 | 1.80 | 2.10 | 2.10 | No | 1.50 | Yes | 1.88 | Yes | **No** |
| K | 1.6 | 1.20 | 1.26 | 1.41 | 1.41 | No | 0.96 | No | 1.20 | No | Yes |
| L | 2.0 | 1.35 | 1.65 | 1.80 | 1.80 | No | 1.20 | No | 1.50 | No | Yes |
| M | 2.0 | 1.35 | 1.65 | 1.80 | 1.80 | No | 1.20 | No | 1.50 | No | Yes |
| N | 1.5 | 1.20 | 1.40 | 1.40 | 1.40 | No | 0.90 | No | 1.13 | No | Yes |
| O | 1.5 | 1.20 | 1.40 | 1.40 | 1.40 | No | 0.90 | No | 1.13 | No | Yes |
| P | 1.5 | 1.10 | 1.60 | 2.20 | 2.20 | Yes | 0.90 | No | 1.13 | No | **No** |
| Q | 1.5 | 1.10 | 1.60 | 2.20 | 2.20 | Yes | 0.90 | No | 1.13 | No | **No** |
| R | 2.5 | 2.30 | 2.60 | 2.40 | 2.60 | Yes | 1.50 | No | 1.88 | No | **No** |
| S | 2.5 | 2.30 | 2.60 | 2.40 | 2.60 | Yes | 1.50 | No | 1.88 | No | **No** |
| T | 1.5 | 1.00 | 1.45 | 2.00 | 2.00 | Yes | 0.90 | No | 1.13 | No | **No** |
| U | 1.5 | 1.00 | 1.45 | 2.00 | 2.00 | Yes | 0.90 | No | 1.13 | No | **No** |
| V | 2.5 | 2.30 | 2.60 | 2.40 | 2.60 | Yes | 1.50 | No | 1.88 | No | **No** |

## Table 3.8: Flow Rate Data CEC PIER Models - RMA

| Model | Rated Flow Rate | RMA | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Flow Rate (GPM) | | | 3.1.2 | | 3.1.4 | | 3.15 | | |
| | | 20 PSI | 45 PSI | 80 PSI | Maximum Tested Flow Rate | Max Exceed Rated? | Min Allowed @ 20 psi | Flow @ 20 psi less than Min? | Min Allowed @ 45 and 80 psi | Flow @ 45 and 80 psi less than Min? | Meets Required Tolerance? |
| AA | 0.55 | 0.35 | 0.5 | 0.9 | 0.90 | Yes | 0.33 | No | 0.41 | No | **No** |
| AB | 1.25 | 1.7 | 1.85 | 1.6 | 1.85 | Yes | 0.75 | No | 0.94 | No | **No** |
| AD | 1.90 | 1.5 | 2.1 | 2.4 | 2.40 | Yes | 1.14 | No | 1.43 | No | **No** |
| AE | 1.50 | 1.1 | 1.5 | 1.65 | 1.65 | Yes | 0.90 | No | 1.13 | No | **No** |
| AF | 1.50 | 0.8 | 1.35 | 1.8 | 1.80 | Yes | 0.90 | Yes | 1.13 | No | **No** |
| AG | 1.75 | 1.45 | 2.1 | 2.4 | 2.40 | Yes | 1.05 | No | 1.31 | No | **No** |
| AH | 2.00 | 1.8 | 2.45 | 3 | 3.00 | Yes | 1.20 | No | 1.50 | No | **No** |
| AI | 2.00 | 2.45 | 2.85 | 2.65 | 2.85 | Yes | 1.20 | No | 1.50 | No | **No** |
| AJ | 1.50 | 1.35 | 1.55 | 1.65 | 1.65 | Yes | 0.90 | No | 1.13 | No | **No** |
| AK | 1.50 | 1.4 | 1.6 | 1.7 | 1.70 | Yes | 0.90 | No | 1.13 | No | **No** |
| AL | 2.50 | 3.05 | 3.3 | 3.3 | 3.30 | Yes | 1.50 | No | 1.88 | No | **No** |
| AM | 1.50 | 0.8 | 1.4 | 1.8 | 1.80 | Yes | 0.90 | Yes | 1.13 | No | **No** |
| AN | 2.00 | 2.1 | 2.45 | 2.5 | 2.50 | Yes | 1.20 | No | 1.50 | No | **No** |
| AO | 1.75 | 1.6 | 1.9 | 1.7 | 1.90 | Yes | 1.05 | No | 1.31 | No | **No** |
| AP | 2.50 | 2.65 | 2.55 | 2.4 | 2.65 | Yes | 1.50 | No | 1.88 | No | **No** |
| AQ | 2.50 | 1.3 | 1.75 | 1.6 | 1.75 | No | 1.50 | Yes | 1.88 | Yes | **No** |
| AR | 1.50 | 1.9 | 1.6 | 1.7 | 1.90 | Yes | 0.90 | No | 1.13 | No | **No** |
| AS | 2.50 | 1.7 | 1.6 | 1.6 | 1.70 | No | 1.50 | No | 1.88 | Yes | **No** |
| AT | 2.50 | 1.4 | 2.25 | 2.3 | 2.30 | No | 1.50 | Yes | 1.88 | No | **No** |
| AU | 1.50 | 1.35 | 1.6 | 1.5 | 1.60 | Yes | 0.90 | No | 1.13 | No | **No** |
| AV | 1.60 | 1.2 | 1.55 | 1.6 | 1.60 | No | 0.96 | No | 1.20 | No | Yes |
| AW | 1.50 | 0.85 | 1.2 | 1.25 | 1.25 | No | 0.90 | Yes | 1.13 | No | **No** |
| AX | 2.00 | 1.8 | 2.3 | 2.4 | 2.40 | Yes | 1.20 | No | 1.50 | No | **No** |
| AY | 2.50 | 2 | 2.35 | 2.4 | 2.40 | No | 1.50 | No | 1.88 | No | Yes |
| AZ | 2.50 | 2.1 | 2.4 | 2.4 | 2.40 | No | 1.50 | No | 1.88 | No | Yes |
| BA | 2.50 | 2.1 | 2.3 | 2.1 | 2.30 | No | 1.50 | No | 1.88 | No | Yes |
| BB | 2.50 | 1.5 | 2.35 | 2.6 | 2.60 | Yes | 1.50 | No | 1.88 | No | **No** |
| BC | 2.50 | 1.2 | 1.85 | 2.55 | 2.55 | Yes | 1.50 | Yes | 1.88 | Yes | **No** |

**Table 3.8: Flow Rate Data CEC PIER Models - RMA**

| Model | Rated Flow Rate | RMA | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Flow Rate (GPM) | | | 3.1.2 | | 3.1.4 | | 3.15 | | |
| | | 20 PSI | 45 PSI | 80 PSI | Maximum Tested Flow Rate | Max Exceed Rated? | Min Allowed @ 20 psi | Flow @ 20 psi less than Min? | Min Allowed @ 45 and 80 psi | Flow @ 45 and 80 psi less than Min? | Meets Required Tolerance? |
| BD | 1.75 | 1.1 | 1.65 | 1.65 | 1.65 | No | 1.05 | No | 1.31 | No | Yes |
| BE | 1.59 | 0.45 | 0.6 | 0.5 | 0.60 | No | 0.95 | Yes | 1.19 | Yes | **No** |
| BF | 1.75 | 0.95 | 1.4 | 1.6 | 1.60 | No | 1.05 | Yes | 1.31 | No | **No** |
| BG | 1.60 | 1.2 | 1.4 | 1.4 | 1.40 | No | 0.96 | No | 1.20 | No | Yes |
| BH | 1.75 | 1.6 | 1.6 | 1.45 | 1.60 | No | 1.05 | No | 1.31 | No | Yes |
| BI | 1.50 | 1.2 | 1.2 | 1 | 1.20 | No | 0.90 | No | 1.13 | Yes | **No** |
| BJ | 1.30 | 1.05 | 1.1 | 1.2 | 1.20 | No | 0.78 | No | 0.98 | No | Yes |
| BK | 1.50 | 1 | 1.2 | 1.25 | 1.25 | No | 0.90 | No | 1.13 | No | Yes |
| BL | 1.50 | 1.35 | 1.5 | 1.6 | 1.60 | Yes | 0.90 | No | 1.13 | No | **No** |
| BM | 1.75 | 1.3 | 1.5 | 1.1 | 1.50 | No | 1.05 | No | 1.31 | Yes | **No** |
| BN | 1.75 | 1.75 | 1.8 | 1.5 | 1.80 | Yes | 1.05 | No | 1.31 | No | **No** |
| BO | 2.00 | 2 | 2.4 | 2.2 | 2.40 | Yes | 1.20 | No | 1.50 | No | **No** |
| BP | 1.50 | 1.7 | 2 | 1.4 | 2.00 | Yes | 0.90 | No | 1.13 | No | **No** |
| HHA | 1.50 | 0.3 | 0.5 | 0.65 | 0.65 | No | 0.90 | Yes | 1.13 | Yes | **No** |
| HHB | 1.50 | 0.9 | 1.15 | 1.2 | 1.20 | No | 0.90 | No | 1.13 | No | Yes |
| HHC | 2.00 | 1.5 | 2.2 | 2.25 | 2.25 | Yes | 1.20 | No | 1.50 | No | **No** |
| HHD | 2.50 | 0.95 | 1.65 | 2.35 | 2.35 | No | 1.50 | Yes | 1.88 | Yes | **No** |
| HHE | 1.50 | 1.2 | 1.4 | 1.5 | 1.50 | No | 0.90 | No | 1.13 | No | Yes |
| HHF | 2.50 | 2.1 | 3.25 | 3.35 | 3.35 | Yes | 1.50 | No | 1.88 | No | **No** |
| HHG | 2.50 | 2.15 | 2.75 | 3.05 | 3.05 | Yes | 1.50 | No | 1.88 | No | **No** |
| HHH | 2.50 | 2.15 | 2.75 | 3.05 | 3.05 | Yes | 1.50 | No | 1.88 | No | **No** |
| HHI | 2.50 | 2.1 | 3.35 | 3.3 | 3.35 | Yes | 1.50 | No | 1.88 | No | **No** |
| HHJ | 2.50 | 1.9 | 2.9 | 2.8 | 2.90 | Yes | 1.50 | No | 1.88 | No | **No** |

## 3.5 Spray Force Data

The WaterSense® spray force criteria are defined as follows.

4.0 Spray Force Criteria

4.1 The spray force of the showerhead shall be tested in accordance with the procedures outlined in Appendix A (of the WaterSense® Criteria) and shall meet the following criteria:

4.1.1 The minimum spray force shall not be less than 2.0 ounces (0.56N) at a pressure of 20 ± psi (140 ± kPa) at the inlet, when water is flowing.

Spray force data and information regarding whether or not each tested model meets required WaterSense® spray force criteria are provided in the following tables. The spray force data for WaterSense®/ERG models from the Canadian Standards Association (CSA) are provided in Table 3.9. The spray force data for WaterSense®/ERG models from the International Association of Plumbing and Mechanical Officials (IAPMO, www.iapmo.org) are provided in Table 3.10. The spray force data for WaterSense®/ERG models from Alsons are provided in Table 3.11. The spray force data for WaterSense®/ERG models from RMA are provided in Table 3.12.

Five percent of WaterSense®/ERG models tested by CSA (1 out of 22 models), 9 percent of the models tested by IAPMO (2 out of 22 models) 23 percent of the models tested by Alsons and RMA (5 out of 22 models) failed to meet the required minimum WaterSense® spray force of not be less than 2.0 ounces (0.56N) at a pressure of 20 ± psi (140 ± kPa) at the inlet, when water is flowing.

Spray force data for the CEC PIER sample models from RMA are provided in Table 3.13. Ten percent of CEC PIER fixed showerhead models tested by RMA failed to meet required minimum WaterSense® spray force criteria (4 out of 41 models). Ten percent of CEC PIER hand held models tested by RMA failed to meet required minimum WaterSense® spray force criteria (1 out of 10 models).

**Table 3.9: Spray Force Data WaterSense®/ERG Models - CSA**

| Shower Head | Rated Flow Rate (gpm) | > 2 is unsatisfied | | CSA | | | |
|---|---|---|---|---|---|---|---|
| | | Force Satisfaction Score | % No Buy | Force (Oz) @ 20 psi | | | |
| | | | | 1.7 oz | 2 oz | 2.3 oz | 2.6 oz |
| A | 2.5 | **2.3** | **67%** | Pass | Pass | Pass | Pass |
| B | 2.0 | **2.3** | **100%** | Pass | Pass | Pass | Pass |
| C1 | 0.7 | 2.0 | **83%** | Pass | Pass | Pass | Pass |
| C2 | 0.7 | | | Pass | Pass | Pass | Pass |
| D | 2.5 | **2.3** | **100%** | **Fail** | **Fail** | **Fail** | **Fail** |
| E | 2.5 | 1.3 | 25% | Pass | Pass | Pass | Pass |
| F | 1.0 | **2.4** | **71%** | Pass | Pass | **Fail** | **Fail** |
| G | 1.5 | **3.0** | **83%** | Pass | Pass | Pass | **Fail** |
| H | 2.5 | **2.1** | **63%** | Pass | Pass | Pass | **Fail** |
| I | 2.5 | 2.0 | **75%** | Pass | Pass | Pass | **Fail** |

### Table 3.9: Spray Force Data WaterSense®/ERG Models - CSA

| Shower Head | Rated Flow Rate (gpm) | > 2 is unsatisfied | | CSA | | | |
|---|---|---|---|---|---|---|---|
| | | Force Satisfaction Score | % No Buy | Force (Oz) @ 20 psi | | | |
| | | | | 1.7 oz | 2 oz | 2.3 oz | 2.6 oz |
| J | 2.5 | **2.3** | **83%** | Pass | Pass | Pass | Pass |
| K | 1.6 | **2.2** | 40% | Pass | Pass | Pass | Pass |
| L | 2.0 | 1.7 | 14% | Pass | Pass | Pass | Pass |
| M | 2.0 | 1.3 | 14% | Pass | Pass | Pass | Pass |
| N | 1.5 | 1.8 | **60%** | Pass | Pass | Pass | Pass |
| O | 1.5 | 1.8 | **63%** | Pass | Pass | Pass | Pass |
| P | 1.5 | 1.4 | **83%** | Pass | Pass | Pass | Pass |
| Q | 1.5 | 1.6 | 43% | Pass | Pass | Pass | Pass |
| R | 2.5 | 1.2 | 11% | Pass | Pass | Pass | Pass |
| S | 2.5 | 1.0 | 0% | Pass | Pass | Pass | Pass |
| T | 1.5 | 2.0 | **100%** | Pass | Pass | Pass | Pass |
| U | 1.5 | 1.6 | **57%** | Pass | Pass | Pass | Pass |
| V | 2.5 | 1.0 | 20% | Pass | Pass | Pass | Pass |

### Table 3.10: Spray Force Data WaterSense®/ERG Models - IAPMO

| Shower Head | Rated Flow Rate (gpm) | > 2 is unsatisfied | | IAPMO | | | |
|---|---|---|---|---|---|---|---|
| | | Force Satisfaction Score | % No Buy | Force (Oz) @ 20 psi | | | |
| | | | | 1.7 oz | 2 oz | 2.3 oz | 2.6 oz |
| A | 2.5 | **2.3** | **67%** | Pass | Pass | Pass | Pass |
| B | 2.0 | **2.3** | **100%** | Pass | Pass | Pass | Pass |
| C1 | 0.7 | 2.0 | **83%** | Pass | Pass | **Fail** | **Fail** |
| C2 | 0.7 | | | Pass | Pass | **Fail** | **Fail** |
| D | 2.5 | **2.3** | **100%** | **Fail** | **Fail** | **Fail** | **Fail** |
| E | 2.5 | 1.3 | 25% | Pass | Pass | Pass | Pass |
| F | 1.0 | **2.4** | **71%** | **Fail** | **Fail** | **Fail** | **Fail** |
| G | 1.5 | **3.0** | **83%** | Pass | Pass | Pass | **Fail** |
| H | 2.5 | **2.1** | **63%** | Pass | Pass | Pass | Pass |
| I | 2.5 | 2.0 | **75%** | Pass | Pass | Pass | Pass |
| J | 2.5 | **2.3** | **83%** | Pass | Pass | Pass | Pass |
| K | 1.6 | **2.2** | 40% | Pass | Pass | Pass | Pass |

## Table 3.10: Spray Force Data WaterSense®/ERG Models - IAPMO

| Shower Head | Rated Flow Rate (gpm) | > 2 is unsatisfied | | IAPMO | | | |
|---|---|---|---|---|---|---|---|
| | | Force Satisfaction Score | % No Buy | Force (Oz) @ 20 psi | | | |
| | | | | 1.7 oz | 2 oz | 2.3 oz | 2.6 oz |
| L | 2.0 | 1.7 | 14% | Pass | Pass | Pass | Pass |
| M | 2.0 | 1.3 | 14% | Pass | Pass | Pass | Pass |
| N | 1.5 | 1.8 | **60%** | Pass | Pass | Pass | Pass |
| O | 1.5 | 1.8 | **63%** | Pass | Pass | Pass | Pass |
| P | 1.5 | 1.4 | **83%** | Pass | Pass | Pass | Pass |
| Q | 1.5 | 1.6 | 43% | Pass | Pass | Pass | Pass |
| R | 2.5 | 1.2 | 11% | Pass | Pass | Pass | Pass |
| S | 2.5 | 1.0 | 0% | Pass | Pass | Pass | Pass |
| T | 1.5 | 2.0 | **100%** | Pass | Pass | Pass | Pass |
| U | 1.5 | 1.6 | **57%** | Pass | Pass | Pass | Pass |
| V | 2.5 | 1.0 | 20% | Pass | Pass | Pass | Pass |

## Table 3.11: Spray Force Data WaterSense®/ERG Models - Alsons

| Shower Head | Rated Flow Rate (gpm) | > 2 is unsatisfied | | Alsons | | | |
|---|---|---|---|---|---|---|---|
| | | Force Satisfaction Score | % No Buy | Force (Oz) @ 20 psi | | | |
| | | | | 1.7 oz | 2 oz | 2.3 oz | 2.6 oz |
| A | 2.5 | **2.3** | **67%** | Pass | Pass | Pass | **Fail** |
| B | 2.0 | **2.3** | **100%** | Pass | Pass | Pass | Pass |
| C1 | 0.7 | 2.0 | **83%** | Pass | **Fail** | **Fail** | **Fail** |
| C2 | 0.7 | | | Pass | **Fail** | **Fail** | **Fail** |
| D | 2.5 | **2.3** | **100%** | **Fail** | **Fail** | **Fail** | **Fail** |
| E | 2.5 | 1.3 | 25% | Pass | Pass | Pass | **Fail** |
| F | 1.0 | **2.4** | **71%** | **Fail** | **Fail** | **Fail** | **Fail** |
| G | 1.5 | **3.0** | **83%** | **Fail** | **Fail** | **Fail** | **Fail** |
| H | 2.5 | **2.1** | **63%** | Pass | Pass | Pass | **Fail** |
| I | 2.5 | 2.0 | **75%** | Pass | Pass | Pass | **Fail** |
| J | 2.5 | **2.3** | **83%** | Pass | Pass | **Fail** | **Fail** |
| K | 1.6 | **2.2** | 40% | Pass | Pass | **Fail** | **Fail** |
| L | 2.0 | 1.7 | 14% | Pass | Pass | Pass | Pass |
| M | 2.0 | 1.3 | 14% | Pass | Pass | Pass | Pass |

### Table 3.11: Spray Force Data WaterSense®/ERG Models - Alsons

| Shower Head | Rated Flow Rate (gpm) | > 2 is unsatisfied | | Alsons | | | |
|---|---|---|---|---|---|---|---|
| | | Force Satisfaction Score | % No Buy | Force (Oz) @ 20 psi | | | |
| | | | | 1.7 oz | 2 oz | 2.3 oz | 2.6 oz |
| N | 1.5 | 1.8 | **60%** | Pass | Pass | Pass | Pass |
| O | 1.5 | 1.8 | **63%** | Pass | Pass | Pass | Pass |
| P | 1.5 | 1.4 | **83%** | Pass | Pass | **Fail** | **Fail** |
| Q | 1.5 | 1.6 | 43% | Pass | Pass | **Fail** | **Fail** |
| R | 2.5 | 1.2 | 11% | Pass | Pass | Pass | Pass |
| S | 2.5 | 1.0 | 0% | Pass | Pass | Pass | Pass |
| T | 1.5 | 2.0 | **100%** | Pass | Pass | Pass | **Fail** |
| U | 1.5 | 1.6 | **57%** | Pass | Pass | Pass | **Fail** |
| V | 2.5 | 1.0 | 20% | Pass | Pass | Pass | Pass |

### Table 3.12: Spray Force Data WaterSense®/ERG Models from RMA

| Shower Head | Rated Flow Rate (gpm) | > 2 is unsatisfied | | RMA | | | |
|---|---|---|---|---|---|---|---|
| | | Force Satisfaction Score | % No Buy | Force (Oz) @ 20 psi | | | |
| | | | | 1.7 oz | 2 oz | 2.3 oz | 2.6 oz |
| A | 2.5 | **2.3** | **67%** | Pass | Pass | Pass | **Fail** |
| B | 2.0 | **2.3** | **100%** | Pass | Pass | Pass | Pass |
| C1 | 0.7 | 2.0 | **83%** | Pass | **Fail** | **Fail** | **Fail** |
| C2 | 0.7 | | | Pass | **Fail** | **Fail** | **Fail** |
| D | 2.5 | **2.3** | **100%** | Pass | **Fail** | **Fail** | **Fail** |
| E | 2.5 | 1.3 | 25% | Pass | Pass | Pass | **Fail** |
| F | 1.0 | **2.4** | **71%** | **Fail** | **Fail** | **Fail** | **Fail** |
| G | 1.5 | **3.0** | **83%** | **Fail** | **Fail** | **Fail** | **Fail** |
| H | 2.5 | **2.1** | **63%** | Pass | Pass | **Fail** | **Fail** |
| I | 2.5 | 2.0 | **75%** | Pass | Pass | **Fail** | **Fail** |
| J | 2.5 | **2.3** | **83%** | **Fail** | **Fail** | **Fail** | **Fail** |
| K | 1.6 | **2.2** | 40% | Pass | Pass | **Fail** | **Fail** |
| L | 2.0 | 1.7 | 14% | Pass | Pass | Pass | Pass |
| M | 2.0 | 1.3 | 14% | Pass | Pass | Pass | Pass |
| N | 1.5 | 1.8 | **60%** | Pass | Pass | Pass | Pass |
| O | 1.5 | 1.8 | **63%** | Pass | Pass | Pass | Pass |

## Table 3.12: Spray Force Data WaterSense®/ERG Models from RMA

| Shower Head | Rated Flow Rate (gpm) | > 2 is unsatisfied | | RMA | | | |
|---|---|---|---|---|---|---|---|
| | | Force Satisfaction Score | % No Buy | Force (Oz) @ 20 psi | | | |
| | | | | 1.7 oz | 2 oz | 2.3 oz | 2.6 oz |
| P | 1.5 | 1.4 | **83%** | Pass | Pass | **Fail** | **Fail** |
| Q | 1.5 | 1.6 | 43% | Pass | Pass | **Fail** | **Fail** |
| R | 2.5 | 1.2 | 11% | Pass | Pass | Pass | Pass |
| S | 2.5 | 1.0 | 0% | Pass | Pass | Pass | Pass |
| T | 1.5 | 2.0 | **100%** | Pass | Pass | Pass | Pass |
| U | 1.5 | 1.6 | **57%** | Pass | Pass | Pass | Pass |
| V | 2.5 | 1.0 | 20% | Pass | Pass | Pass | Pass |

## Table 3.13: Spray Force Data CEC PIER Models - RMA

| Shower Head | Rated Flow Rate (gpm) | > 2 is unsatisfied | | RMA | | | |
|---|---|---|---|---|---|---|---|
| | | Force Satisfaction Score | % No Buy | Force (Oz) @ 20 psi | | | |
| | | | | 1.7 oz | 2 oz | 2.3 oz | 2.6 oz |
| AA | 0.55 | 2.8 | 100% | **Fail** | **Fail** | **Fail** | **Fail** |
| AB | 1.25 | 2.0 | 63% | Pass | Pass | Pass | Pass |
| AD | 1.90 | 1.8 | 73% | Pass | Pass | Pass | Pass |
| AE | 1.50 | 2.5 | 94% | Pass | Pass | **Fail** | **Fail** |
| AF | 1.50 | 2.3 | 81% | Pass | Pass | **Fail** | **Fail** |
| AG | 1.75 | 1.8 | 63% | Pass | Pass | Pass | Pass |
| AH | 2.00 | 2.0 | 73% | Pass | Pass | Pass | Pass |
| AI | 2.00 | 1.5 | 40% | Pass | Pass | Pass | Pass |
| AJ | 1.50 | 2.1 | 81% | Pass | Pass | Pass | Pass |
| AK | 1.50 | 1.8 | 61% | Pass | Pass | Pass | Pass |
| AL | 2.50 | 1.2 | 10% | Pass | Pass | Pass | Pass |
| AM | 1.50 | 2.3 | 90% | **Fail** | **Fail** | **Fail** | **Fail** |
| AN | 2.00 | 1.7 | 33% | **Fail** | **Fail** | **Fail** | **Fail** |
| AO | 1.75 | 2.0 | 50% | Pass | Pass | Pass | Pass |
| AP | 2.50 | 1.5 | 21% | Pass | Pass | Pass | Pass |
| AQ | 2.50 | 1.8 | 46% | Pass | Pass | Pass | Pass |
| AR | 1.50 | 1.6 | 37% | Pass | Pass | Pass | Pass |
| AS | 2.50 | 1.9 | 44% | Pass | Pass | Pass | Pass |

**Table 3.13: Spray Force Data CEC PIER Models - RMA**

| Shower Head | Rated Flow Rate (gpm) | > 2 is unsatisfied | | RMA | | | |
|---|---|---|---|---|---|---|---|
| | | Force Satisfaction Score | % No Buy | Force (Oz) @ 20 psi | | | |
| | | | | 1.7 oz | 2 oz | 2.3 oz | 2.6 oz |
| AT | 2.50 | 1.5 | 38% | Pass | Pass | Pass | Pass |
| AU | 1.50 | 1.4 | 35% | Pass | Pass | Pass | Pass |
| AV | 1.60 | 2.1 | 83% | Pass | Pass | Pass | Pass |
| AW | 1.50 | 2.1 | 75% | Pass | Pass | **Fail** | **Fail** |
| AX | 2.00 | 1.3 | 27% | Pass | Pass | Pass | Pass |
| AY | 2.50 | 1.4 | 31% | Pass | Pass | Pass | Pass |
| AZ | 2.50 | 1.6 | 35% | Pass | Pass | Pass | Pass |
| BA | 2.50 | 2.1 | 48% | Pass | Pass | Pass | Pass |
| BB | 2.50 | 1.4 | 29% | Pass | Pass | Pass | Pass |
| BC | 2.50 | 2.3 | 76% | Pass | Pass | Pass | Pass |
| BD | 1.75 | 1.8 | 35% | Pass | Pass | Pass | **Fail** |
| BE | 1.59 | 2.5 | 81% | Pass | **Fail** | **Fail** | **Fail** |
| BF | 1.75 | 2.7 | 98% | Pass | Pass | Pass | Pass |
| BG | 1.60 | 1.9 | 67% | Pass | Pass | Pass | Pass |
| BH | 1.75 | 1.5 | 50% | Pass | Pass | Pass | Pass |
| BI | 1.50 | 2.0 | 65% | Pass | Pass | Pass | **Fail** |
| BJ | 1.30 | 2.0 | 65% | Pass | Pass | Pass | Pass |
| BK | 1.50 | 1.9 | 55% | Pass | Pass | Pass | **Fail** |
| BL | 1.50 | 1.6 | 29% | Pass | Pass | Pass | Pass |
| BM | 1.75 | 1.8 | 63% | Pass | Pass | Pass | Pass |
| BN | 1.75 | 2.2 | 85% | Pass | Pass | Pass | Pass |
| BO | 2.00 | 1.4 | 19% | Pass | Pass | Pass | Pass |
| BP | 1.50 | 2.4 | 83% | Pass | Pass | Pass | **Fail** |
| HHA | 1.50 | 1.8 | 38% | **Fail** | **Fail** | **Fail** | **Fail** |
| HHB | 1.50 | 1.4 | 27% | Pass | Pass | **Fail** | **Fail** |
| HHC | 2.00 | 1.3 | 17% | Pass | Pass | Pass | Pass |
| HHD | 2.50 | 1.5 | 58% | Pass | Pass | Pass | Pass |
| HHE | 1.50 | 1.4 | 48% | Pass | Pass | Pass | Pass |
| HHF | 2.50 | 1.8 | 50% | Pass | Pass | Pass | Pass |
| HHG | 2.50 | 1.5 | 40% | Pass | Pass | Pass | **Fail** |
| HHH | 2.50 | 1.8 | 44% | Pass | Pass | Pass | **Fail** |

**Table 3.13: Spray Force Data CEC PIER Models - RMA**

| Shower Head | Rated Flow Rate (gpm) | > 2 is unsatisfied | | RMA | | | |
|---|---|---|---|---|---|---|---|
| | | Force Satisfaction Score | % No Buy | Force (Oz) @ 20 psi | | | |
| | | | | 1.7 oz | 2 oz | 2.3 oz | 2.6 oz |
| HHI | 2.50 | 1.6 | 25% | Pass | Pass | Pass | Pass |
| HHJ | 2.50 | 1.5 | 27% | Pass | Pass | Pass | Pass |

## 3.6 Spray Coverage Data

The WaterSense® spray coverage criteria are defined as follows.

5.0 Spray Coverage Criteria

5.1 The spray coverage of the showerhead shall be tested in accordance with the procedures outlined in Appendix B (of the WaterSense® Criteria) and shall meet the following criteria:

5.1.1 The total combined maximum volume of water collected in the 2 and 4 inch (50, 101 mm) annular rings shall not exceed 75 percent of the total volume of water collected and;

5.1.2 The total combined minimum volume of water collected in the 2, 4, and 6 inch (50, 101, 152 mm) annular rings shall not be less than 25 percent of the total volume of water collected.

Spray coverage data and information regarding whether or not each tested model meets required WaterSense® spray coverage criteria are provided in the following tables. The spray coverage data for WaterSense®/ERG models from the Canadian Standards Association (CSA) are provided in Table 3.14. The spray coverage data for WaterSense®/ERG models from the International Association of Plumbing and Mechanical Officials (IAPMO, www.iapmo.org) are provided in Table 3.15. The spray coverage data for WaterSense®/ERG models from Alsons are provided in Table 3.16. The spray coverage data for WaterSense®/ERG models from RMA are provided in Table 3.17.

Seventeen percent of WaterSense®/ERG models tested by CSA, IAPMO, and Alsons (4 out of 23 models) failed to meet the required minimum WaterSense® spray coverage of total combined maximum volume of water collected in the 2 and 4 inch (50, 101 mm) annular rings shall not exceed 75 percent of the total volume of water collected and; total combined minimum volume of water collected in the 2, 4, and 6 inch (50, 101, 152 mm) annular rings shall not be less than 25 percent of the total volume of water collected. Nine percent of the WaterSense®/ERG models tested by RMA failed to meet the required minimum WaterSense® spray coverage criteria.

Spray coverage data for the CEC PIER sample models from RMA are provided in Table 3.18. Ten percent of CEC PIER fixed showerhead models tested by RMA failed to meet required minimum WaterSense® spray coverage criteria (4 out of 41 models). Ten percent of CEC PIER hand held models tested by RMA failed to meet required minimum WaterSense® spray coverage criteria (1 out of 10 models).

## Table 3.14: Spray Coverage Data WaterSense®/ERG Models - CSA

| | >2 is not satisfied | Percent of Water in Each Annular Ring | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Model | Coverage Satisfaction Score | No Buy % | 2” | 4” | 6” | 8” | 10” | 12” | 14” | 16” | 18” | 20” | Sum in Rings 2, 4 % | Sum in Rings 2, 4, 6 % | Screen Out? |
| A | 2.2 | 67 | 48.8 | 43.5 | 6.9 | 0.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 00 | 92.3 | 99.3 | Fail |
| B | 2.4 | 100 | 2.1 | 12.5 | 44.2 | 36.6 | 4.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 14.7 | 58.9 | Pass |
| C1 | 2.7 | 83 | 0.0 | 0.3 | 0.1 | 0.9 | 16.6 | 49.5 | 30.4 | 2.2 | 0.0 | 0.0 | 0.3 | 0.4 | Fail |
| C2 | | | 21.8 | 39.9 | 21.0 | 9.7 | 4.5 | 1.5 | 1.2 | 0.4 | 0.0 | 0.0 | 61.6 | 82.6 | Pass |
| D | 1.3 | 100 | 7.4 | 9.7 | 34.3 | 45.1 | 1.4 | 2.2 | 0.0 | 0.0 | 0.0 | 0.0 | 17.1 | 51.4 | Pass |
| E | 1.5 | 25 | 7.8 | 17.2 | 25.2 | 33.9 | 15.3 | 0.6 | 0.0 | 0.0 | 0.0 | 0.0 | 25.1 | 50.3 | Pass |
| F | 2.1 | 71 | 42.8 | 49.0 | 8.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 91.8 | 100.0 | Fail |
| G | 2.3 | 83 | 11.6 | 37.7 | 46.5 | 4.1 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 49.3 | 95.8 | Pass |
| H | 2.0 | 63 | 8.1 | 48.1 | 41.1 | 2.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 56.2 | 97.3 | Pass |
| I | 2.0 | 75 | 0.6 | 22.4 | 25.0 | 26.7 | 22.8 | 2.4 | 0.2 | 0.0 | 0.0 | 0.0 | 22.9 | 47.9 | Pass |
| J | 2.3 | 83 | 0.3 | 0.7 | 17.5 | 20.7 | 41.3 | 18.7 | 0.8 | 0.0 | 0.0 | 0.0 | 1.0 | 18.5 | Fail |
| K | 1.2 | 40 | 4.0 | 24.1 | 31.5 | 20.8 | 17.3 | 2.2 | 0.0 | 0.0 | 0.0 | 0.0 | 28.1 | 59.6 | Pass |
| L | 1.6 | 14 | 1.5 | 20.7 | 57.8 | 19.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 22.3 | 80.1 | Pass |
| M | 1.1 | 14 | 1.4 | 14.3 | 51.5 | 32.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 15.7 | 67.3 | Pass |
| N | 2.0 | 60 | 2.5 | 10.5 | 55.5 | 31.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 13.0 | 68.4 | Pass |
| O | 1.6 | 63 | 2.2 | 7.6 | 54.6 | 35.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 9.8 | 64.4 | Pass |
| P | 1.8 | 83 | 12.9 | 39.3 | 34.3 | 12.9 | 0.5 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 52.2 | 86.5 | Pass |
| Q | 1.0 | 43 | 13.2 | 40.2 | 36.7 | 7.6 | 2.2 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 53.3 | 90.0 | Pass |
| R | 1.0 | 11 | 17.6 | 26.1 | 35.7 | 12.8 | 7.5 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 43.7 | 79.5 | Pass |
| S | 1.0 | 0 | 14.5 | 22.0 | 36.0 | 19.0 | 6.7 | 1.8 | 0.0 | 0.0 | 0.0 | 0.0 | 36.5 | 72.5 | Pass |
| T | 2.7 | 100 | 11.4 | 55.3 | 26.7 | 5.2 | 1.3 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 66.6 | 93.4 | Pass |
| U | 2.1 | 57 | 10.3 | 44.6 | 34.3 | 8.6 | 1.9 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 55.0 | 89.3 | Pass |
| V | 1.4 | 20 | 9.6 | 27.0 | 20.8 | 26.0 | 14.0 | 2.6 | 0.0 | 0.0 | 0.0 | 0.0 | 36.6 | 57.4 | Pass |

## Table 3.15: Spray Coverage Data WaterSense®/ERG Models - IAPMO

| Model | >2 is not satisfied<br>Coverage Satisfaction Score | Percent of Water in Each Annular Ring<br>No Buy % | 2" | 4" | 6" | 8" | 10" | 12" | 14" | 16" | 18" | 20" | Sum in Rings 2, 4<br>% | Sum in Rings 2, 4, 6<br>% | Screen Out? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | 2.2 | 67 | 64.5 | 30.1 | 5.1 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 94.6 | 99.7 | Fail |
| B | 2.4 | 100 | 2.8 | 14.3 | 41.3 | 33.3 | 7.9 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 17.1 | 58.3 | Pass |
| C1 | 2.7 | 83 | 0.0 | 0.0 | 0.0 | 0.0 | 1.8 | 38.6 | 43.9 | 15.8 | 0.0 | 0.0 | 0.0 | 0.0 | Fail |
| C2 | | | 9.6 | 40.7 | 29.8 | 9.9 | 4.5 | 2.7 | 1.8 | 0.8 | 0.0 | 0.0 | 50.3 | 80.2 | Pass |
| D | 1.3 | 100 | 14.1 | 34.1 | 43.5 | 8.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 48.2 | 91.8 | Pass |
| E | 1.5 | 25 | 0.9 | 9.4 | 68.1 | 19.5 | 2.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 10.3 | 78.4 | Pass |
| F | 2.1 | 71 | 64.1 | 34.8 | 1.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 98.9 | 100.0 | Fail |
| G | 2.3 | 83 | 11.4 | 38.6 | 44.1 | 5.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 50.0 | 94.1 | Pass |
| H | 2.0 | 63 | 11.7 | 2.7 | 43.3 | 39.6 | 0.3 | 0.3 | 0.3 | 0.3 | 1.1 | 0.3 | 14.3 | 57.6 | Pass |
| I | 2.0 | 75 | 2.6 | 11.4 | 22.5 | 48.0 | 15.1 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 14.0 | 36.5 | Pass |
| J | 2.3 | 83 | 0.5 | 1.1 | 20.9 | 25.5 | 39.9 | 10.3 | 1.5 | 0.3 | 0.0 | 0.0 | 1.6 | 22.6 | Fail |
| K | 1.2 | 40 | 2.6 | 22.3 | 36.1 | 14.6 | 22.7 | 1.7 | 0.0 | 0.0 | 0.0 | 0.0 | 24.9 | 60.9 | Pass |
| L | 1.6 | 14 | 0.0 | 16.2 | 55.7 | 28.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 16.2 | 72.0 | Pass |
| M | 1.1 | 14 | 0.0 | 16.1 | 60.5 | 23.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 16.1 | 76.6 | Pass |
| N | 2.0 | 60 | 0.0 | 15.7 | 53.8 | 30.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 15.7 | 69.5 | Pass |
| O | 1.6 | 63 | 1.9 | 11.4 | 55.5 | 31.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 13.3 | 68.7 | Pass |
| P | 1.8 | 83 | 9.1 | 39.8 | 43.8 | 7.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 48.9 | 92.7 | Pass |
| Q | 1.0 | 43 | 20.0 | 41.4 | 34.6 | 3.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 61.4 | 96.1 | Pass |
| R | 1.0 | 11 | 17.1 | 16.6 | 36.2 | 25.8 | 4.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 33.7 | 70.0 | Pass |
| S | 1.0 | 0 | 14.4 | 21.4 | 32.9 | 22.5 | 8.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 35.8 | 68.7 | Pass |
| T | 2.7 | 100 | 7.1 | 35.1 | 50.2 | 7.1 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 42.2 | 92.4 | Pass |
| U | 2.1 | 57 | 8.6 | 54.1 | 32.7 | 3.6 | 0.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 62.7 | 95.5 | Pass |
| V | 1.4 | 20 | 11.0 | 23.9 | 21.0 | 28.0 | 12.0 | 4.1 | 0.0 | 0.0 | 0.0 | 0.0 | 34.9 | 55.9 | Pass |

## Table 3.16: Spray Coverage Data WaterSense®/ERG Models - Alsons

| Model | >2 is not satisfied<br>Coverage Satisfaction Score | No Buy % | Percent of Water in Each Annular Ring 2” | 4” | 6” | 8” | 10” | 12” | 14” | 16” | 18” | 20” | Sum in Rings 2, 4 % | Sum in Rings 2, 4, 6 % | Screen Out? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | 2.2 | 67 | 51.3 | 36.1 | 11.4 | 0.93 | 0.29 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 87.37 | 98.79 | Fail |
| B | 2.4 | 100 | 2.84 | 14.1 | 43.1 | 34.5 | 5.22 | 0.29 | 0.00 | 0.00 | 0.00 | 0.00 | 16.95 | 60.03 | Pass |
| C1 | 2.7 | 83 | 0.00 | 0.00 | 0.39 | 0.77 | 16.6 | 51.0 | 31.3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.39 | Fail |
| C2 | | | 19.8 | 40.4 | 22.1 | 9.52 | 5.14 | 3.05 | 0.00 | 0.00 | 0.00 | 0.00 | 60.19 | 82.29 | Pass |
| D | 1.3 | 100 | 10.9 | 38.0 | 42.9 | 8.13 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 48.93 | 91.87 | Pass |
| E | 1.5 | 25 | 6.36 | 23.0 | 25.5 | 35.5 | 9.65 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 29.40 | 54.86 | Pass |
| F | 2.1 | 71 | 43.9 | 42.5 | 13.3 | 0.46 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 86.37 | 99.54 | Fail |
| G | 2.3 | 83 | 10.9 | 41.6 | 39.9 | 7.30 | 0.21 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 52.58 | 92.49 | Pass |
| H | 2.0 | 63 | 12.9 | 2.5 | 33.2 | 50.1 | 1.15 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 15.48 | 48.74 | Pass |
| I | 2.0 | 75 | 0.79 | 10.1 | 30.6 | 40.9 | 17.2 | 0.36 | 0.00 | 0.00 | 0.00 | 0.00 | 10.89 | 41.52 | Pass |
| J | 2.3 | 83 | 0.00 | 0.75 | 20.2 | 22.5 | 45.1 | 10.1 | 1.31 | 0.00 | 0.00 | 0.00 | 0.75 | 20.99 | Fail |
| K | 1.2 | 40 | 0.84 | 26.9 | 34.8 | 13.3 | 23.9 | 0.28 | 0.00 | 0.00 | 0.00 | 0.00 | 27.76 | 62.52 | Pass |
| L | 1.6 | 14 | 0.00 | 22.8 | 54.5 | 22.8 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 22.77 | 77.23 | Pass |
| M | 1.1 | 14 | 0.00 | 17.4 | 46.9 | 35.6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 17.45 | 64.36 | Pass |
| N | 2.0 | 60 | 0.00 | 18.3 | 55.1 | 26.6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 18.29 | 73.36 | Pass |
| O | 1.6 | 63 | 2.40 | 3.8 | 52.4 | 41.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 6.19 | 58.54 | Pass |
| P | 1.8 | 83 | 8.93 | 43.5 | 40.0 | 7.18 | 0.32 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 52.47 | 92.50 | Pass |
| Q | 1.0 | 43 | 12.6 | 42.5 | 38.7 | 3.83 | 2.40 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 55.11 | 93.77 | Pass |
| R | 1.0 | 11 | 15.7 | 22.2 | 38.4 | 17.3 | 4.88 | 1.55 | 0.00 | 0.00 | 0.00 | 0.00 | 37.92 | 76.27 | Pass |
| S | 1.0 | 0 | 16.6 | 21.2 | 37.7 | 21.1 | 3.45 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 37.74 | 75.49 | Pass |
| T | 2.7 | 100 | 4.11 | 31.7 | 51.6 | 10.4 | 2.0 | 0.33 | 0.00 | 0.00 | 0.00 | 0.00 | 35.78 | 87.33 | Pass |
| U | 2.1 | 57 | 3.3 | 26.6 | 57.1 | 10.6 | 2.04 | 0.38 | 0.00 | 0.00 | 0.00 | 0.00 | 29.87 | 86.97 | Pass |
| V | 1.4 | 20 | 10.8 | 25.9 | 19.9 | 29.1 | 10.4 | 3.72 | 0.00 | 0.00 | 0.00 | 0.00 | 36.77 | 56.75 | Pass |

## Table 3.17: Spray Coverage Data WaterSense®/ERG Models – RMA

| Model | >2 is not satisfied<br>Coverage Satisfaction Score | Percent of Water in Each Annular Ring<br>No Buy % | 2” | 4” | 6” | 8” | 10” | 12” | 14” | 16” | 18” | 20” | Sum in Rings 2, 4 % | Sum in Rings 2, 4, 6 % | Screen Out? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | 2.2 | 67 | 24.4 | 43.8 | 25.5 | 6.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 68.24 | 93.71 | Pass |
| B | 2.4 | 100 | 2.6 | 19.1 | 50.0 | 24.0 | 4.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 21.72 | 71.70 | Pass |
| C1 | 2.7 | 83 | 0.0 | 0.0 | 0.0 | 0.5 | 54.8 | 44.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.00 | 0.00 | Fail |
| C2 | | | 20.7 | 44.1 | 21.9 | 9.8 | 3.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 64.80 | 86.69 | Pass |
| D | 1.3 | 100 | 7.9 | 19.6 | 36.5 | 35.4 | 0.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 27.45 | 63.97 | Pass |
| E | 1.5 | 25 | 3.3 | 29.8 | 32.5 | 32.5 | 2.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 33.03 | 65.48 | Pass |
| F | 2.1 | 71 | 32.9 | 56.4 | 10.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 89.33 | 100.00 | Fail |
| G | 2.3 | 83 | 10.3 | 40.4 | 43.5 | 5.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 50.73 | 94.25 | Pass |
| H | 2.0 | 63 | 10.1 | 24.7 | 50.4 | 14.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 34.83 | 85.25 | Pass |
| I | 2.0 | 75 | 4.9 | 5.6 | 25.2 | 47.9 | 15.5 | 0.8 | 0.0 | 0.0 | 0.0 | 0.0 | 10.53 | 35.77 | Pass |
| J | 2.3 | 83 | 22.2 | 39.0 | 38.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 61.20 | 100.00 | Pass |
| K | 1.2 | 40 | 3.1 | 26.8 | 33.5 | 17.5 | 17.2 | 2.0 | 0.0 | 0.0 | 0.0 | 0.0 | 29.88 | 63.35 | Pass |
| L | 1.6 | 14 | 0.0 | 19.9 | 65.0 | 15.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 19.91 | 84.89 | Pass |
| M | 1.1 | 14 | 0.0 | 20.4 | 59.8 | 19.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 20.43 | 80.26 | Pass |
| N | 2.0 | 60 | 0.0 | 14.6 | 60.0 | 25.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 14.62 | 74.63 | Pass |
| O | 1.6 | 63 | 0.0 | 10.1 | 64.1 | 25.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 10.13 | 74.19 | Pass |
| P | 1.8 | 83 | 11.1 | 53.4 | 34.4 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 64.53 | 98.97 | Pass |
| Q | 1.0 | 43 | 12.9 | 53.8 | 32.3 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 66.66 | 98.96 | Pass |
| R | 1.0 | 11 | 17.5 | 22.9 | 28.2 | 23.7 | 7.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 40.40 | 68.58 | Pass |
| S | 1.0 | 0 | 9.7 | 26.6 | 26.8 | 29.5 | 7.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 36.29 | 63.10 | Pass |
| T | 2.7 | 100 | 5.4 | 24.1 | 53.8 | 14.3 | 2.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 29.48 | 83.24 | Pass |
| U | 2.1 | 57 | 2.8 | 30.4 | 53.4 | 11.2 | 2.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 33.19 | 86.58 | Pass |
| V | 1.4 | 20 | 9.5 | 25.5 | 28.1 | 29.0 | 7.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 34.92 | 63.05 | Pass |

**Table 3.18: Spray Coverage Data CEC PIER Models – RMA**

| Model | >2 is not satisfied<br>Coverage Satisfaction Score | Percent of Water in Each Annular Ring<br>No Buy % | 2” | 4” | 6” | 8” | 10” | 12” | 14” | 16” | 18” | 20” | Sum in Rings 2, 4<br>% | Sum in Rings 2, 4, 6<br>% | Screen Out? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AA | 2.8 | 100 | 20.3 | 36.1 | 35.5 | 8.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 56.36 | 91.81 | Pass |
| AB | 1.6 | 63 | 0.0 | 28.3 | 62.0 | 9.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 28.35 | 90.36 | Pass |
| AD | 1.9 | 73 | 3.4 | 21.5 | 48.5 | 23.5 | 3.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 24.91 | 73.37 | Pass |
| AE | 2.2 | 94 | 1.1 | 7.6 | 38.2 | 42.1 | 7.3 | 3.6 | 0.0 | 0.0 | 0.0 | 0.0 | 8.74 | 46.97 | Pass |
| AF | 1.8 | 81 | 0.0 | 27.8 | 42.2 | 30.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 27.85 | 70.04 | Pass |
| AG | 1.6 | 63 | 0.0 | 9.2 | 34.1 | 47.6 | 9.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 9.24 | 43.39 | Pass |
| AH | 1.9 | 73 | 0.0 | 0.0 | 17.1 | 48.7 | 30.5 | 3.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.00 | 17.14 | Fail |
| AI | 1.4 | 40 | 2.0 | 25.6 | 55.5 | 14.3 | 2.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 27.60 | 83.13 | Pass |
| AJ | 1.8 | 81 | 1.7 | 8.6 | 41.9 | 38.4 | 9.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 10.34 | 52.26 | Pass |
| AK | 1.8 | 61 | 24.3 | 39.4 | 25.9 | 10.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 63.67 | 89.52 | Pass |
| AL | 1.0 | 10 | 7.7 | 26.2 | 19.8 | 26.9 | 19.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 33.92 | 53.71 | Pass |
| AM | 2.4 | 90 | 18.1 | 57.3 | 24.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 75.46 | 100.00 | Fail |
| AN | 1.5 | 33 | 0.0 | 21.4 | 41.0 | 28.3 | 9.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 21.37 | 62.32 | Pass |
| AO | 1.4 | 50 | 0.0 | 9.8 | 41.3 | 41.8 | 7.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 9.80 | 51.10 | Pass |
| AP | 1.1 | 21 | 5.9 | 10.9 | 27.7 | 13.5 | 28.3 | 13.6 | 0.0 | 0.0 | 0.0 | 0.0 | 16.82 | 44.56 | Pass |
| AQ | 1.6 | 46 | 1.7 | 29.8 | 49.1 | 18.7 | 0.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 31.46 | 80.56 | Pass |
| AR | 1.7 | 37 | 24.9 | 47.5 | 25.3 | 2.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 72.35 | 97.70 | Pass |
| AS | 1.4 | 44 | 10.9 | 31.1 | 35.8 | 22.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 42.01 | 77.78 | Pass |
| AT | 1.7 | 38 | 5.7 | 42.4 | 51.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 48.13 | 100.00 | Pass |
| AU | 1.4 | 35 | 4.2 | 22.8 | 45.0 | 28.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 26.99 | 72.00 | Pass |
| AV | 2.1 | 83 | 0.0 | 13.8 | 34.8 | 28.7 | 17.6 | 5.1 | 0.0 | 0.0 | 0.0 | 0.0 | 13.80 | 48.62 | Pass |
| AW | 1.8 | 75 | 0.0 | 41.5 | 50.2 | 8.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 41.49 | 91.71 | Pass |
| AX | 1.5 | 27 | 3.0 | 50.4 | 46.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 53.40 | 100.00 | Pass |
| AY | 1.4 | 31 | 9.3 | 46.2 | 44.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 55.52 | 100.00 | Pass |
| AZ | 1.3 | 35 | 4.2 | 26.7 | 42.5 | 23.3 | 2.4 | 0.8 | 0.0 | 0.0 | 0.0 | 0.0 | 30.89 | 73.40 | Pass |
| BA | 1.7 | 48 | 15.6 | 45.2 | 35.8 | 3.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 60.75 | 96.55 | Pass |
| BB | 1.7 | 29 | 32.9 | 67.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 100.00 | 100.00 | Fail |
| BC | 1.8 | 76 | 4.4 | 20.5 | 51.1 | 21.1 | 2.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 24.95 | 76.04 | Pass |
| BD | 1.3 | 35 | 6.0 | 16.1 | 34.9 | 37.0 | 6.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 22.05 | 56.97 | Pass |

**Table 3.18: Spray Coverage Data CEC PIER Models – RMA**

| | >2 is not satisfied | Percent of Water in Each Annular Ring | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Model | Coverage Satisfaction Score | No Buy % | 2” | 4” | 6” | 8” | 10” | 12” | 14” | 16” | 18” | 20” | Sum in Rings 2, 4 % | Sum in Rings 2, 4, 6 % | Screen Out? |
| BE | 2.2 | 81 | 18.1 | 57.3 | 24.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 75.46 | 100.00 | Fail |
| BF | 2.3 | 98 | 4.8 | 14.3 | 19.6 | 22.0 | 19.1 | 13.9 | 6.2 | 0.0 | 0.0 | 0.0 | 19.09 | 38.73 | Pass |
| BG | 1.9 | 67 | 18.0 | 34.7 | 28.5 | 14.8 | 4.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 52.72 | 81.23 | Pass |
| BH | 1.7 | 50 | 5.8 | 37.0 | 34.0 | 21.2 | 2.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 42.86 | 76.84 | Pass |
| BI | 2.0 | 65 | 7.1 | 34.8 | 34.1 | 24.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 41.90 | 75.99 | Pass |
| BJ | 2.0 | 65 | 12.0 | 31.6 | 46.0 | 10.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 43.67 | 89.65 | Pass |
| BK | 1.8 | 55 | 1.8 | 33.2 | 57.8 | 7.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 35.01 | 92.85 | Pass |
| BL | 1.6 | 29 | 0.0 | 55.3 | 44.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 55.27 | 100.00 | Pass |
| BM | 2.4 | 63 | 0.0 | 33.0 | 67.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 32.96 | 100.00 | Pass |
| BN | 2.1 | 85 | 7.8 | 9.2 | 20.5 | 41.0 | 21.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 16.94 | 37.44 | Pass |
| BO | 1.3 | 19 | 10.5 | 20.7 | 29.8 | 27.8 | 9.9 | 1.4 | 0.0 | 0.0 | 0.0 | 0.0 | 31.21 | 60.98 | Pass |
| BP | 2.1 | 83 | 14.2 | 12.1 | 24.8 | 31.3 | 17.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 26.27 | 51.05 | Pass |
| HHA | 1.5 | 38 | 0.0 | 15.2 | 53.7 | 28.6 | 2.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 15.21 | 68.91 | Pass |
| HHB | 1.5 | 27 | 0.0 | 33.1 | 66.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 33.09 | 100.00 | Pass |
| HHC | 1.5 | 17 | 8.3 | 54.9 | 29.5 | 7.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 63.29 | 92.80 | Pass |
| HHD | 1.7 | 58 | 0.0 | 13.7 | 41.5 | 37.0 | 7.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 13.67 | 55.20 | Pass |
| HHE | 1.8 | 48 | 0.0 | 54.0 | 46.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 54.04 | 100.00 | Pass |
| HHF | 1.7 | 50 | 0.0 | 7.2 | 11.8 | 23.2 | 27.3 | 15.4 | 15.1 | 0.0 | 0.0 | 0.0 | 7.20 | 18.98 | Fail |
| HHG | 1.7 | 40 | 0.0 | 8.2 | 63.2 | 28.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 8.18 | 71.34 | Pass |
| HHH | 1.6 | 44 | 0.0 | 17.8 | 14.5 | 43.9 | 23.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 17.85 | 32.33 | Pass |
| HHI | 1.3 | 25 | 3.4 | 13.8 | 21.9 | 25.3 | 31.2 | 4.3 | 0.0 | 0.0 | 0.0 | 0.0 | 17.23 | 39.17 | Pass |
| HHJ | 1.5 | 27 | 11.3 | 44.3 | 42.7 | 1.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 55.59 | 98.29 | Pass |

## 3.7 WaterSense®/ERG Consumer Satisfaction Data

Average consumer satisfaction responses for the WaterSense®/ERG models from CEC PIER participants are provided in Table 3.19. Average consumer satisfaction responses for the WaterSense®/ERG models from WaterSense®/ERG participants are provided in Table 3.20. The two groups of consumers agreed on 80 percent of the models, i.e., where there was uniform “no buy” rating of 11 models and uniform “buy” for 6 models. The two groups disagreed on only three units. Based on RMA’s lab data, only 5 models pass the WaterSense® criteria while 17 fail primarily due to the maximum measured flow rate at 80 psig being greater than manufacturer specified flow rate, or minimum flow rate at 20 psig being less than 60 percent of the maximum manufacturer specified flow rate, or measured flow rate at 45 psig being less than 75 percent of the maximum manufacturer specified flow rate or not meeting the force or coverage criteria. The rinse time required to remove hair conditioner was included in the CEC PIER consumer satisfaction survey but not in the WaterSense®/ERG survey. The CEC PIER "no buy" percentage is correlated to rinse time required to remove hair conditioner as shown in Figure 3.1. The polynomial curve fit has R-squared coefficient of 0.746 indicating 74.6 percent of the variation in the "no buy" response variable can be explained by the explanatory rinse time variable. The remaining 23.4 percent can only be explained by inherent variability in consumer preference.

**Table 3.19: Consumer Responses for WaterSense®/ERG Models - CEC PIER Participants**

| Model | Rated Flow Rate at 80 psig | Coverage | Rinsing Action | Rinsing Time (seconds) | Force | Temp-erature | Noise | Overall Satis-faction | No Buy % | Water Sense Specifi-cation |
|---|---|---|---|---|---|---|---|---|---|---|
| A | 2.5 | 1.6 | 1.5 | 20.2 | 1.7 | 1.3 | 1.5 | 1.5 | 50% | **Fail** |
| B | 2.0 | **2.1** | **2.1** | 21.5 | **2.2** | 1.7 | **2.3** | **2.3** | **88%** | **Fail** |
| C | 0.7 | **2.6** | **2.6** | 25.5 | **2.7** | **2.2** | **2.4** | **2.8** | **94%** | **Fail** |
| D | 2.5 | 1.5 | 2.1 | 21.6 | **2.3** | 1.4 | 1.4 | 1.9 | **62%** | **Fail** |
| E | 2.5 | **2.0** | 1.6 | 19.3 | 1.7 | 1.3 | 1.6 | 1.8 | **56%** | **Fail** |
| F | 1.0 | **2.4** | **2.5** | 26.7 | **2.6** | 1.6 | 1.7 | **2.5** | **88%** | **Fail** |
| G | 1.5 | 1.5 | 1.3 | 18.4 | 1.4 | 1.2 | 1.8 | 1.4 | 46% | **Fail** |
| H | 2.5 | **2.1** | **2.1** | 22.1 | **2.3** | 1.5 | 1.7 | **2.3** | **87%** | **Fail** |
| I | 2.5 | **2.2** | **2.4** | 23.6 | **2.4** | 1.5 | 1.8 | **2.3** | **90%** | **Fail** |
| J | 2.5 | 1.5 | 1.2 | 16.8 | 1.2 | 1.2 | 1.4 | 1.3 | 27% | **Fail** |
| K | 1.6 | 1.7 | **2.2** | 22.6 | **2.3** | 1.4 | 1.5 | **2.1** | **75%** | Pass |
| L | 2.0 | 1.5 | 1.5 | 19.7 | 1.6 | 1.4 | 1.5 | 1.6 | 40% | Pass |
| M | 2.0 | 1.6 | 1.4 | 19.0 | 1.5 | 1.2 | 1.4 | 1.4 | 33% | Pass |
| N | 1.5 | 1.8 | 1.9 | 20.9 | **2.0** | 1.4 | 1.6 | 1.8 | **60%** | Pass |
| O | 1.5 | 1.7 | **2.1** | 24.9 | **2.2** | 1.4 | 1.4 | **2.0** | **62%** | Pass |
| P | 1.5 | 1.6 | 1.5 | 19.2 | 1.7 | 1.4 | **2.1** | 1.8 | **73%** | **Fail** |
| Q | 1.5 | 1.7 | 1.4 | 18.8 | 1.5 | 1.4 | 1.8 | 1.6 | 50% | **Fail** |
| R | 2.5 | 1.1 | 1.1 | 16.6 | 1.3 | 1.2 | 1.4 | 1.3 | 17% | **Fail** |
| S | 2.5 | 1.1 | 1.1 | 16.4 | 1.3 | 1.1 | 1.3 | 1.1 | 15% | **Fail** |
| T | 1.5 | **2.1** | 1.9 | 19.8 | **2.0** | 1.6 | 1.9 | **2.2** | **88%** | **Fail** |
| U | 1.5 | 1.5 | 1.7 | 20.8 | 1.8 | 1.6 | 1.9 | 1.9 | **67%** | **Fail** |
| V | 2.5 | 1.1 | 1.1 | 17.2 | 1.2 | 1.2 | 1.3 | 1.2 | 13% | **Fail** |

**Table 3.20: Consumer Responses for WaterSense®/ERG Models - ERG Participants**

| Model | Rated Flow Rate at 80 psig | Coverage | Rinsing Action | Rinsing Time (seconds) | Force | Temp-erature | Noise | Overall Satis-faction | No Buy % | Water Sense Specifi-cation |
|---|---|---|---|---|---|---|---|---|---|---|
| A | 2.5 | **2.2** | **2.3** | NA | 2 | 1.3 | NA | NA | **67%** | **Fail** |
| B | 2.0 | **2.4** | **2.3** | NA | **2.3** | **2.1** | NA | NA | **100%** | **Fail** |
| C | 0.7 | **2.7** | **2.3** | NA | 1.8 | **2.6** | NA | NA | **83%** | **Fail** |
| D | 2.5 | 1.3 | 1.5 | NA | 2 | 1 | NA | NA | **100%** | **Fail** |
| E | 2.5 | 1.5 | 1.3 | NA | 1.3 | 1.3 | NA | NA | 25% | **Fail** |
| F | 1.0 | **2.1** | **2.3** | NA | **2.4** | 2 | NA | NA | **71%** | **Fail** |
| G | 1.5 | **2.3** | **2.2** | NA | **2.8** | 1.3 | NA | NA | **83%** | **Fail** |
| H | 2.5 | 2 | 1.9 | NA | **2.3** | 1.6 | NA | NA | **63%** | **Fail** |
| I | 2.5 | **2.5** | 2 | NA | **2.5** | 1.3 | NA | NA | **75%** | **Fail** |
| J | 2.5 | **2.3** | 1.8 | NA | **2.3** | **2.2** | NA | NA | **83%** | **Fail** |
| K | 1.6 | 1.2 | 1.8 | NA | **2.2** | 2 | NA | NA | 40% | Pass |
| L | 2.0 | 1.6 | 1.4 | NA | 1.7 | 1 | NA | NA | 14% | Pass |
| M | 2.0 | 1.1 | 1 | NA | 1 | 1 | NA | NA | 14% | Pass |
| N | 1.5 | 2 | 2 | NA | 1.8 | 1 | NA | NA | **60%** | Pass |
| O | 1.5 | 1.6 | 1.4 | NA | 2 | 1.7 | NA | NA | **63%** | Pass |
| P | 1.5 | 1.8 | 1.5 | NA | 1.4 | 1 | NA | NA | **83%** | **Fail** |
| Q | 1.5 | 1 | 1.6 | NA | 1 | 1 | NA | NA | 43% | **Fail** |
| R | 2.5 | 1.4 | 1.6 | NA | 1.7 | 1.6 | NA | NA | 11% | **Fail** |
| S | 2.5 | 1 | 1 | NA | 1 | 1 | NA | NA | 0% | **Fail** |
| T | 1.5 | **2.4** | **2.1** | NA | **2.2** | 1.6 | NA | NA | **100%** | **Fail** |
| U | 1.5 | **2.1** | 1.3 | NA | 1.8 | 1.4 | NA | NA | **57%** | **Fail** |
| V | 2.5 | 1.4 | 1 | NA | 1 | 1 | NA | NA | 20% | **Fail** |

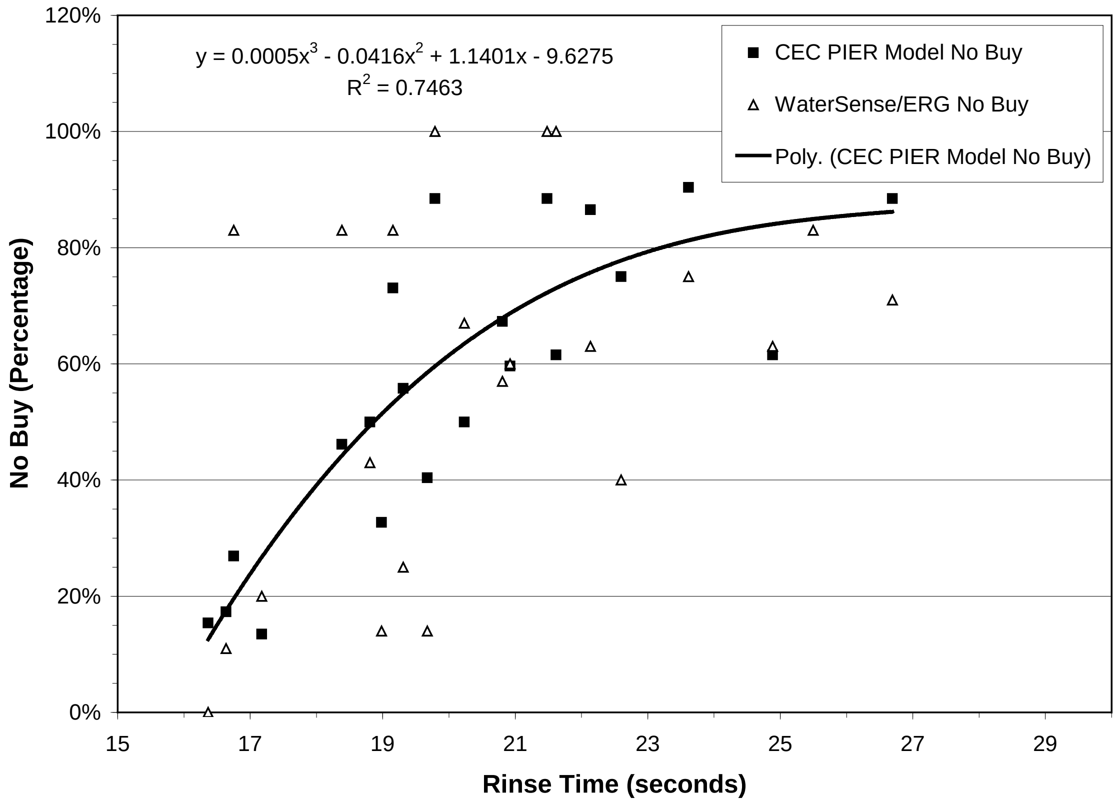



**Figure 3.1: No Buy Percentage versus Rinse Time for CEC PIER and WaterSense®/ERG**

## 3.8 CEC PIER Consumer Satisfaction Data

Average consumer satisfaction responses for the CEC PIER models from CEC PIER participants are provided in Table 3.20. The survey participants identified 23 models as "no buy" and 28 models as "buy." Only 11 models pass the WaterSense® specification while 40 fail primarily due to the maximum measured flow rate at 80 psig being greater than manufacturer specified flow rate, or minimum flow rate at 20 psig being less than 60 percent of the maximum manufacturer specified flow rate, or measured flow rate at 45 psig being less than 75 percent of the maximum manufacturer specified flow rate or not meeting the force or coverage criteria. The CEC PIER model "no buy" percentage is correlated to rinse time required to remove hair conditioner as shown in Figure 3.2. The polynomial curve fit has a 0.7048 R-squared coefficient indicating 70.48 percent of the variation in the "No buy" response variable can be explained by the explanatory rinse time variable.

**Table 3.21: Consumer Responses for CEC PIER Models - CEC PIER Participants**

| Model | Rated Flow Rate at 80 psig | Coverage | Rinsing Action | Rinsing Time (sec.) | Force | Temp-erature | Noise | Overall Satis-Faction | No Buy % | Water Sense Specifi-cation |
|---|---|---|---|---|---|---|---|---|---|---|
| AA | 0.6 | **2.8** | **2.8** | 28.8 | **2.8** | 1.7 | **2.0** | **2.9** | **100%** | **Fail** |
| AB | 1.3 | 1.6 | 1.8 | 20.7 | 2.0 | 1.3 | 1.3 | 1.7 | **63%** | **Fail** |
| AD | 1.9 | 1.9 | 1.8 | 19.5 | 1.8 | 1.5 | **2.0** | **2.0** | **73%** | **Fail** |
| AE | 1.5 | **2.2** | **2.6** | 26.3 | **2.5** | 1.8 | 1.8 | **2.6** | **94%** | **Fail** |
| AF | 1.5 | 1.8 | **2.1** | 22.0 | **2.3** | 1.4 | 1.6 | **2.0** | **81%** | **Fail** |
| AG | 1.8 | 1.6 | 1.8 | 19.9 | 1.8 | 1.4 | 1.4 | 1.8 | **63%** | **Fail** |
| AH | 2.0 | 1.9 | **2.0** | 22.4 | 2.0 | 1.4 | 1.4 | 1.9 | **73%** | **Fail** |
| AI | 2.0 | 1.4 | 1.3 | 18.3 | 1.5 | 1.3 | 1.7 | 1.5 | 40% | **Fail** |
| AJ | 1.5 | 1.8 | 1.9 | 22.2 | **2.1** | 1.5 | 1.8 | **2.2** | **81%** | **Fail** |
| AK | 1.5 | 1.8 | 1.7 | 20.3 | 1.8 | 1.3 | 1.5 | 1.8 | **61%** | **Fail** |
| AL | 2.5 | 1.0 | 1.2 | 16.3 | 1.2 | 1.1 | 1.3 | 1.1 | 10% | **Fail** |
| AM | 1.5 | **2.4** | **2.2** | 22.0 | **2.3** | 1.5 | **2.4** | **2.6** | **90%** | **Fail** |
| AN | 2.0 | 1.5 | 1.6 | 20.0 | 1.7 | 1.3 | 1.4 | 1.6 | 33% | **Fail** |
| AO | 1.8 | 1.4 | 1.8 | 21.1 | **2.0** | 1.3 | 1.3 | 1.6 | 50% | **Fail** |
| AP | 2.5 | 1.1 | 1.4 | 18.7 | 1.5 | 1.2 | 1.3 | 1.3 | 21% | **Fail** |
| AQ | 2.5 | 1.6 | 1.2 | 16.2 | 1.8 | 1.3 | 1.4 | 1.7 | 46% | **Fail** |
| AR | 1.5 | 1.7 | 1.4 | 17.4 | 1.6 | 1.2 | 1.4 | 1.6 | 37% | **Fail** |
| AS | 2.5 | 1.4 | 1.6 | 20.1 | 1.9 | 1.3 | 1.4 | 1.5 | 44% | **Fail** |
| AT | 2.5 | 1.7 | 1.5 | 17.4 | 1.5 | 1.2 | 1.5 | 1.7 | 38% | **Fail** |
| AU | 1.5 | 1.4 | 1.5 | 17.2 | 1.4 | 1.2 | 1.5 | 1.5 | 35% | **Fail** |
| AV | 1.6 | **2.1** | **2.2** | 22.5 | **2.1** | 1.4 | 1.6 | **2.3** | **83%** | Pass |
| AW | 1.5 | 1.8 | **2.1** | 20.5 | **2.1** | 1.4 | 1.6 | **2.0** | **75%** | **Fail** |
| AX | 2.0 | 1.5 | 1.2 | 16.5 | 1.3 | 1.1 | 1.6 | 1.4 | 27% | **Fail** |
| AY | 2.5 | 1.4 | 1.4 | 17.2 | 1.4 | 1.3 | 1.4 | 1.4 | 31% | Pass |
| AZ | 2.5 | 1.3 | 1.5 | 17.8 | 1.6 | 1.2 | 1.4 | 1.4 | 35% | Pass |
| BA | 2.5 | 1.7 | 1.4 | 18.2 | 1.4 | 1.3 | 1.5 | 1.6 | 48% | Pass |
| BB | 2.5 | 1.7 | 1.4 | 18.2 | 1.4 | 1.3 | 1.5 | 1.6 | 29% | **Fail** |
| BC | 2.5 | 1.8 | 1.7 | 18.6 | **2.3** | 1.5 | **2.2** | **2.3** | **76%** | **Fail** |
| BD | 1.8 | 1.3 | 1.6 | 18.9 | 1.8 | 1.3 | 1.4 | 1.5 | 35% | Pass |
| BE | 1.6 | **2.2** | **2.4** | 26.8 | **2.5** | 1.7 | 1.4 | **2.5** | **81%** | **Fail** |
| BF | 1.8 | **2.3** | **2.5** | 22.0 | **2.7** | 1.9 | **2.3** | **2.7** | **98%** | **Fail** |

**Table 3.21: Consumer Responses for CEC PIER Models - CEC PIER Participants**

| Model | Rated Flow Rate at 80 psig | Coverage | Rinsing Action | Rinsing Time (sec.) | Force | Temp-erature | Noise | Overall Satis-Faction | No Buy % | Water Sense Specifi-cation |
|---|---|---|---|---|---|---|---|---|---|---|
| BG | 1.6 | 1.9 | 1.9 | 20.0 | 1.9 | 1.5 | 1.7 | **2.1** | **67%** | Pass |
| BH | 1.8 | 1.7 | 1.6 | 17.9 | 1.5 | 1.3 | 1.6 | 1.5 | 50% | Pass |
| BI | 1.5 | **2.0** | **2.0** | 21.5 | **2.0** | 1.4 | 1.6 | **2.1** | **65%** | **Fail** |
| BJ | 1.3 | **2.0** | 1.9 | 21.2 | **2.0** | 1.4 | 1.4 | **2.1** | **65%** | Pass |
| BK | 1.5 | 1.8 | **2.2** | 19.9 | 1.9 | 1.3 | 1.4 | 1.8 | **55%** | Pass |
| BL | 1.5 | 1.6 | 1.6 | 18.8 | 1.6 | 1.2 | 1.4 | 1.5 | 29% | **Fail** |
| BM | 1.8 | **2.4** | 1.6 | 19.2 | 1.8 | 1.4 | 1.5 | 1.9 | **63%** | **Fail** |
| BN | 1.8 | **2.1** | **2.2** | 23.0 | **2.2** | 1.4 | 1.7 | **2.3** | **85%** | **Fail** |
| BO | 2.0 | 1.3 | 1.3 | 17.8 | 1.4 | 1.2 | 1.2 | 1.3 | 19% | **Fail** |
| BP | 1.5 | **2.1** | **2.3** | 22.0 | **2.4** | 1.5 | 1.6 | **2.3** | **83%** | **Fail** |
| HHA | 1.5 | 1.5 | 1.8 | 20.2 | 1.8 | 1.4 | 1.4 | 1.7 | 38% | **Fail** |
| HHB | 1.5 | 1.5 | 1.4 | 17.4 | 1.4 | 1.3 | 1.4 | 1.4 | 27% | Pass |
| HHC | 2.0 | 1.5 | 1.3 | 16.9 | 1.3 | 1.2 | 1.4 | 1.4 | 17% | **Fail** |
| HHD | 2.5 | 1.7 | 1.5 | 18.6 | 1.5 | 1.2 | 1.9 | 1.8 | **58%** | **Fail** |
| HHE | 1.5 | 1.8 | 1.5 | 18.8 | 1.4 | 1.4 | 1.4 | 1.7 | 48% | Pass |
| HHF | 2.5 | 1.7 | 1.6 | 20.2 | 1.8 | 1.4 | 1.6 | 1.8 | 50% | **Fail** |
| HHG | 2.5 | 1.7 | 1.7 | 18.0 | 1.5 | 1.3 | 1.4 | 1.7 | 40% | **Fail** |
| HHH | 2.5 | 1.6 | 1.7 | 19.7 | 1.8 | 1.4 | 1.3 | 1.8 | 44% | **Fail** |
| HHI | 2.5 | 1.3 | 1.3 | 17.1 | 1.6 | 1.4 | 1.4 | 1.4 | 25% | **Fail** |
| HHJ | 2.5 | 1.5 | 1.4 | 17.6 | 1.5 | 1.3 | 1.3 | 1.5 | 27% | **Fail** |

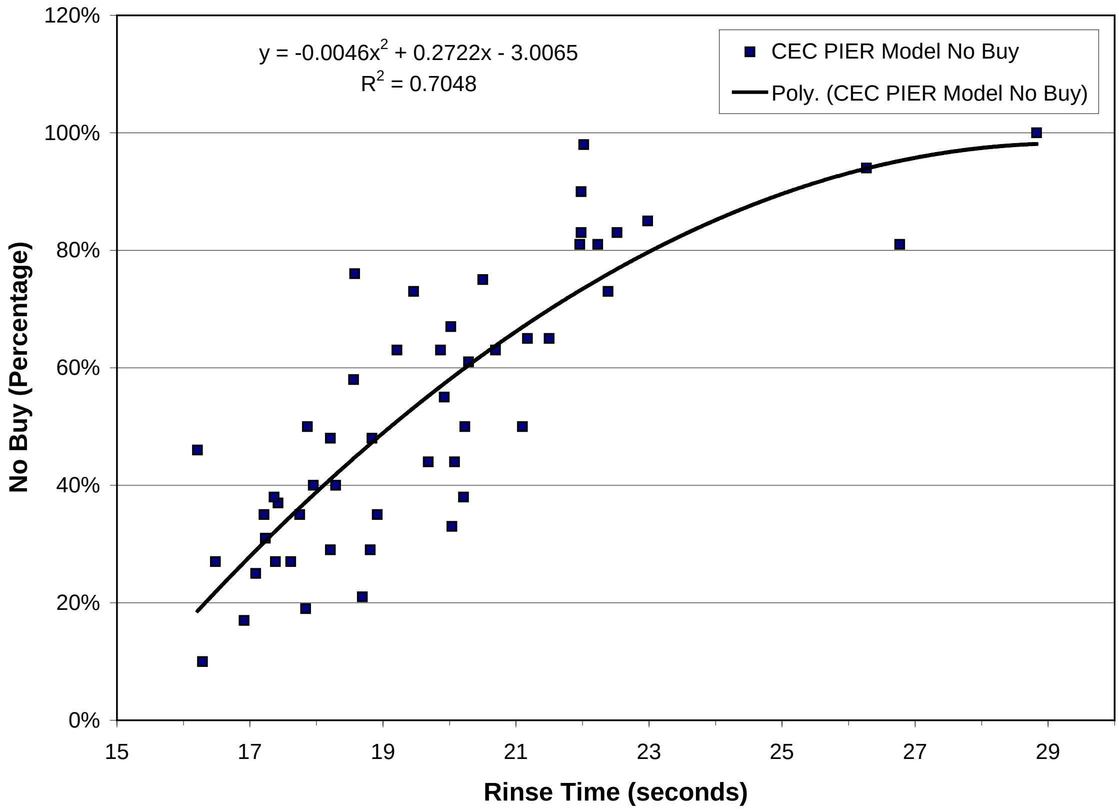



**Figure 3.2: No Buy Percentage versus Rinse Time for CEC PIER Models**

# CHAPTER 4: Conclusions

Robert Mowris & Associates (RMA) worked with the ASME/CSA Joint Harmonization Task Force (JHTF) to develop new showerhead test protocols to measure flow rate, force, and coverage over a range of flowing pressures from 20 to 80 psig. The current showerhead standard is 2.5 gpm at 80 psig flowing pressure (A112.18.1/CSA-B125.1-1992/2005). The US EPA WaterSense® and their consultant, ERG, collaborated with ASME/CSA JHTF on new showerhead test protocols to develop a WaterSense® showerhead specification of 2 gpm at 80 psig flowing pressure. The effectiveness of the new showerhead testing protocols is evaluated based on market research, laboratory tests and consumer satisfaction survey responses regarding flow rate, force, and coverage for 43 efficient and 30 standard showerheads. Average consumer satisfaction responses for WaterSense®/ERG models indicate that CEC PIER participants and WaterSense®/ERG participants agreed on 80 percent of the models, i.e., where there was uniform "no buy" rating of 11 models and uniform "buy" for 6 models. The two participant groups disagreed on only three units. The "no buy" percentage is correlated to rinse time required to remove hair conditioner with R-squared coefficient of 0.746. Average consumer satisfaction responses for the CEC PIER models from CEC PIER participants identified 23 models as "no buy" and 28 models as "buy." The CEC PIER model "no buy" percentage is correlated to rinse time required to remove hair conditioner with R-squared coefficient of 0.705.

Approximately 65 to 78 percent of the showerheads tested in this study do not meet the WaterSense® specification for flow rate, force, or coverage criteria. Most showerheads failed to pass the WaterSense® criteria due to the maximum flow rate determined through testing at a flowing pressure of 80 ± 1 psi being greater than manufacturer specified flow rate at 80 psig as required in the WaterSense® specification. Other showerheads failed due to the minimum flow rate determined through testing at a flowing pressure of 20 ± 1 psi being less than 60 percent of the maximum flow rate specified by the manufacture per WaterSense®. Other showerheads failed due to the minimum flow rate required in WaterSense®, determined through testing, at flowing pressures of 45 ± 1 psi and 80 ± 1 psi, being less than 75 percent of the maximum flow rate specified by the manufacturer per WaterSense®.

Based on this finding , it is recommended that California not adopt a flow rate standard lower than 2.5 gpm at 80 psig flowing pressure as specified in the California Green Building standards. To give manufacturers time to redesign their products, it is recommended that the voluntary EPA WaterSense® showerhead specification of 2.0 gpm at 80 psig flowing pressure be supported.

Showering in the United States consumes 15 to 20 percent of total residential indoor water use or 1.4 trillion gallons per year, or approximately 9,000 acre-feet, of water every day. Due to poor showerhead performance and dissatisfaction, residential and non-residential consumers are replacing single showerheads with multiple showerheads that use more than the maximum water flow regulations allow. The potential nationwide annual savings from new showerhead testing protocols and voluntary standards to counteract the trend to multiple showerheads is estimated at 64,605 million gallons of water, 188 million therms and 3,066 gigawatt-hours (GWh). The estimated annual savings in California are 10 percent of these savings or 6,405 million gallons , 18.8 million therms, and 307 GWh. The net annual benefits to California are estimated to be $85 million in reduced energy and water costs.

# REFERENCES

1. US EPA. 2009. WaterSense® Specification for Showerheads. Washington, DC.: US Environmental Protection Agency (see Appendix AA).

2. Wagoner, K. 2007. 2008. Showerhead User Satisfaction Study. Prepared for US EPA and ASME/CSA Joint Harmonization Task Force. Chantilly, VA.: Eastern Research Group (ERG).

3. Biermayer, P. 2005. Trends in Shower Design and Their Effect on Energy and Water Use. Lawrence Berkeley National Laboratory. In Proceedings of 2006 ACEEE Summer Study on Energy Efficiency in Buildings, Washington, D.C.: American Council for an Energy-Efficient Economy.

5. Mayer P., DeOreo W., et. al. 1999. Residential End Uses of Water, American Water Works Association Research Foundation.

6. Vickers, A. 2001. Handbook of Water Use and Conservation, Waterplow Press.

7. DOE, Office of Energy Efficiency and Renewable Energy, 10 CFR Part 430, Energy Conservation Program for Consumer Products: Test Procedures and Certification and Enforcement Requirements for Plumbing Products; and Certification and Enforcement Requirements for Residential Appliances; Final Rule., March 18, 1998, section 430.32, p. 13317 of the Federal Register.

8. Impact Evaluation of PG&E's Energy-Saver Showerhead Coupon Program, Report number RAE-92-H03, Pacific Gas & Electric, prepared by HBRS, Inc., 1992.

9. California Energy Commission, Informal Staff Draft of Express Terms of Proposed Regulations, California Code of Regulations, Title 20, November, 2004, p.123.

10. Mayer, P., DeOreo W., Lewis, D. 2000. Seattle Home Water Conservation Study, The Impacts of High Efficiency Plumbing Fixture Retrofits in Single-Family Homes. Prepared by Aquacraft,

Inc. Water Engineering and Management for Seattle Public Utilities and the U.S. Environmental Protection Agency., December 2000.

11. Critchley, R. Phipps, D. 2007. Water and Energy Efficient Showers: Project Report. United Utilities. Liverpool John Moores University

12. 2010 California Green Building Standards Code. Chapter 4, Section 4.303 Indoor Water Use, Table 4.303.2 Fixture Flow Rates, Maximum flow rate at ≥ 20 percent reduction or 2 gpm @ 80 psi. http://www.bsc.ca.gov/default.htm.

13. Liverpool John Moores University. 2007. Characteristics of water flow performance of domestic showers. Report for United Utilities, prepared as part of the Water Efficient Showers project. www.ljmu.ac.uk.

14. Water Research Centre. 2007. Analysis of shower event data captured using Identiflow Report for United Utilities, prepared as part of the Water Efficient Showers project. www.wrcplc.co.uk.

15. Woolf, D, et al. 2006. Shower head design: increasing performance at lower flow rates. Paper presented at CIB W062 Symposium.

16. American Society of Sanitary Engineers (ASSE) 10162 or ASME A112.18.1/CSA B125.1.

17. Tanner, S., Remedios, S. 2009. WaterSense®: A consensus-based, common sense approach for high-efficiency Showerheads, February 2009. Northbrook, IL.: Plumbing Engineer.

18. Hotel and Motel Management. 2004. "Holiday Inn Express Hits the Showers." http://www.hotelmotel.com/hotelmotel/article/articleDetail.jsp?id=126192, Oct. 1, 2004.

19. Plumbing & Mechanical Magazine, www.pmmag.com, June 6, 2002

# APPENDIX A:
# WaterSense® Specification for Showerheads

## 1.0 Scope and Objective

This specification establishes the criteria for showerheads labeled under the U.S. Environmental Protection Agency's (EPA's) WaterSense® program. It is applicable to showerhead fixture fittings, inclusive of:

- Fixed showerheads that direct water onto a user (excluding body sprays) for bathing purposes; and
- Hand-held showers, a subset of showerheads that are moveable devices for directing water onto a user. Hand-held showers can be installed on a support to function as a fixed showerhead.

When used in this document the term "showerhead" shall also include hand-held showers.

This specification is designed to ensure sustainable, efficient water use and a high level of user satisfaction with showerhead performance.

## 2.0 General Requirements

2.1 The showerhead shall conform to applicable requirements in ASME A112.18.1/CSA B125.1.[9]

2.2 If the showerhead has more than one mode, all modes must meet the maximum flow rate requirement outlined in Section 3.1.1 and at least one of the modes, as specified by the manufacturer, must meet all of the requirements outlined in this specification.

2.3 The showerhead shall not be packaged, marked, or provided with instructions directing the user to an alternative water-use setting that would override the maximum flow rate, as established by this specification. Any instruction related to the maintenance of the product, including changing or cleaning showerhead

[9] References to this and other standards apply to the most current version of those standards.

components, shall direct the user on how to return the product to its intended maximum flow rate.

**3.0 Water-Efficiency Criteria**

3.1 The flow rate of the showerhead shall be tested in accordance with the procedures in ASME A112.18.1/CSA B125.1 and shall meet the following criteria:

3.1.1 The manufacturer shall specify a maximum flow rate value (rated flow) of the showerhead. This specified value must be equal to or less than 2.0 gallons per minute (gpm) (7.6 liters per minute [L/min]).

3.1.2 The maximum flow rate shall be the highest value obtained through testing at flowing pressures of 20, 45, and 80 ± 1 pounds per square inch (psi) (140, 310, and 550 ± 7 kilopascal [kPa]), when evaluated in accordance with 10 CFR 430 Subpart F, Appendix B, Step 6(b). This maximum flow rate shall not exceed the maximum flow rate value specified in Section 3.1.1.

3.1.3 The minimum flow rate, determined through testing at a flowing pressure of 20 ± 1 psi (140 ± 7 kPa) and when evaluated in accordance with 10 CFR 430 Subpart F, Appendix B, Step 6(a), shall not be less than 60 percent of the maximum flow rate value specified in Section 3.1.1.

3.1.4 The minimum flow rate shall be the lowest value obtained through testing at flowing pressures of 45 and 80 ± 1 psi (310 and 550 ± 7 kPa), when evaluated in accordance with 10 CFR 430 Subpart F, Appendix B, Step 6(a). This minimum flow rate shall not be less than 75 percent of the maximum flow rate value specified in Section 3.1.1.

**4.0 Spray Force Criteria**

4.1 The spray force of the showerhead shall be tested in accordance with the procedures outlined in Appendix A and shall meet the following criteria:

4.1.1 The minimum spray force shall not be less than 2.0 ounces (0.56 Newtons [N]) at a pressure of 20 ± 1 psi (140 ± 7 kPa) at the inlet when water is flowing.

**5.0 Spray Coverage Criteria**

5.1 The spray coverage of the showerhead shall be tested in accordance with the procedures outlined in Appendix B and shall meet the following criteria:

5.1.1 The total combined maximum volume of water collected in the 2- and 4-inch [in.] (50-, 101-millimeter [mm]) annular rings shall not exceed 75 percent of the total volume of water collected, and;

5.1.2 The total combined minimum volume of water collected in the 2-, 4-, and 6-in. (50-, 101-, 152-mm) annular rings shall not be less than 25 percent of the total volume of water collected.

**6.0 Marking**

In addition to the marking requirements in ASME A112.18.1/CSA B125.1, the following markings shall apply:

6.1 The product shall be marked with the maximum flow rate value in gpm and L/min as specified by the manufacturer, verified through testing and in compliance with this specification.

6.2 The product packaging shall be marked with the maximum flow rate value in gpm and L/min as specified by the manufacturer, verified through testing and in compliance with this specification.

6.3 The product packaging shall be marked with the minimum flow rate value in gpm and L/min at 45 psi, calculated in Section 3.1.4 as 75 percent of the manufacturer's specified maximum flow rate value, verified through testing and in compliance with this specification.

6.4 Flow rate marking shall be in gpm and L/min in two or three digit resolutions (e.g., 2.0 gpm [7.6 L/min]).

## 7.0 Effective Date

This specification is effective on February 9, 2010.

## 8.0 Future Specification Revisions

EPA reserves the right to revise this specification should technological and/or market changes affect its usefulness to consumers, industry, or the environment. Revisions to the specification would be made following discussions with industry partners and other interested stakeholders.

## 9.0 Definitions

Definitions within ASME A112.18.1/CSA B125.1 are included by reference

ASME – American Society of Mechanical Engineers

ASME PTC – American Society of Mechanical Engineers Performance Test Codes

ANSI – American National Standards Institute

CFR – Code of Federal Regulations

CSA – Canadian Standards Association

ISA – International Society of Automation

# APPENDIX B:
# Showerhead Spray Force Procedure

**A1 Showerhead Spray Force**

The minimum showerhead spray force shall meet requirements specified in Section 1.4.

**A2 Test procedure**

**A2.1 Set-Up**

The specimen shall

(a) be thoroughly flushed before measuring the spray force;
(b) be connected to a smooth-interior pipe or tubing with a length equal to at least 20 times the inside diameter of the pipe or tubing at the inlet(s) of the fitting;
(c) be connected to a pipe or tubing of the same nominal size as the fitting connections;
(d) have its standard components installed, when tested;
(e) have a test set-up that utilizes a direct force measurement or utilizes a force balance fixture, as shown in Figure 1, using the method in section A2.2

**A2.2 Force Balance Method**

(a) the force balance fixture must have a means for measuring the rotation of the balance and/or determining the point of balance;
(b) the force balance is calibrated using the method in section A2.3;
(c) the showerhead is tested in accordance with section A2.5;
(d) the showerhead spray force exceeds the minimum force specified in Section 4.1 when the fixture rotates past 0.0 ± 0.1 degrees

**A2.3 Force Balance Calibration**

(a) establish the zero angle position when the target is at a 45º ±1º position and the fixture is at a point of balance;
(b) position a force gage to be in perpendicular contact with the center of the target, as shown in Figure 2;
(c) zero the force gage;
(d) place calibrated counterweights on the fixture, such that it balances a force applied at the center and perpendicular to the target, which is equivalent to the minimum force

as specified in section 4.1, while maintaining the zero angle position, as shown in Figure 3;

(e) remove the force gage from the force balance fixture;

(f) the angle position will become a non-zero value, calibrated to force specified in section 4.1

**A2.4 Other Test Conditions**

Other test conditions shall be as follows:

(a) the upstream pressure tap shall have the pressure gage located 8 ± 2 in. (203 ± 51mm) before the inlet of the specimen;

(b) pressure tap size and configuration shall conform to ASME PTC 19.2 or ANSI/ISA-75.02;

(c) if a fluid meter is used to measure flow rate, the installation shall be in accordance with ASME PTC 19.5;

(d) the water temperature shall be 100 ± 10 °F (38 ± 6 °C) maintained for at least 1 minute;

(e) the water pressure shall be 20 ± 1 psi (140 ± 7 kPa) at the inlet when water is flowing;

**A2.5 Test Procedure**

The test procedure shall be as follows:

(a) mount the showerhead so the distance from the center of the force target and the center of the showerhead faceplate is 18 ± 0.25 inches (457 mm ± 6 mm) measured prior to the water flowing;

(b) once the water flow has been initiated, the showerhead or fixture is to be adjusted such that the center of the spray pattern aligns with the center of the force target, while maintaining the 18 ± 0.25 inches (457 mm ± 6 mm) distance from the center of the force target and the center of the showerhead faceplate;

(c) if the center of the spray pattern cannot hit the center of the force target, the showerhead does not meet the criteria for spray force as defined in this specification;

(d) maintain water flow for at least 1 min;

(e) evaluate and verify the spray force meets the minimum value as specified in Section 4.1.

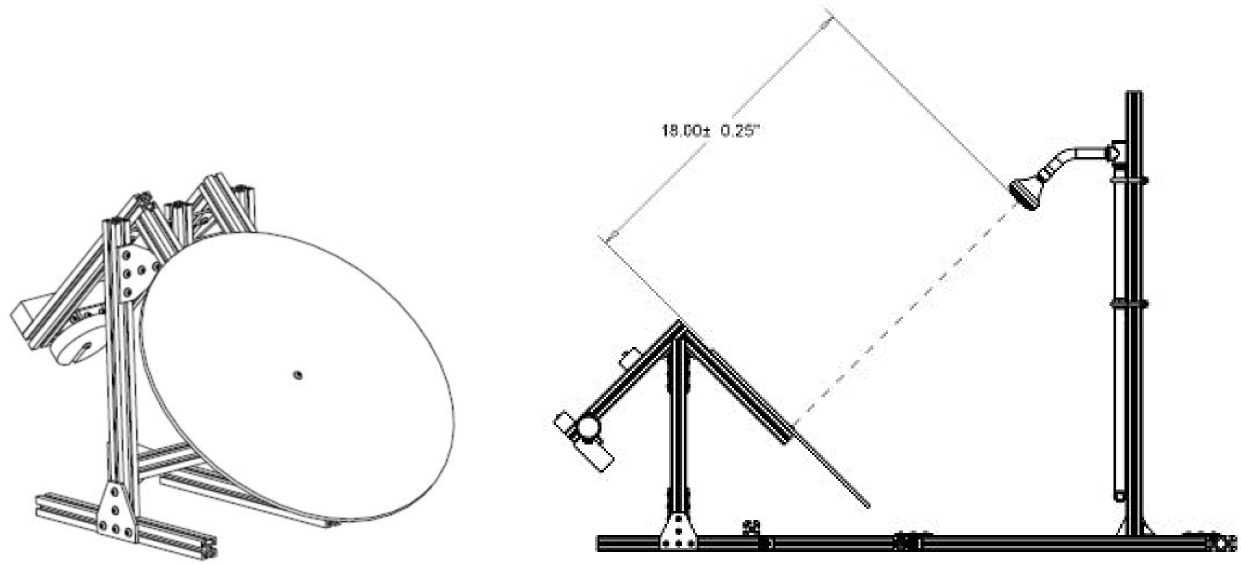



**Figure 1 Force Balance Test Apparatus**

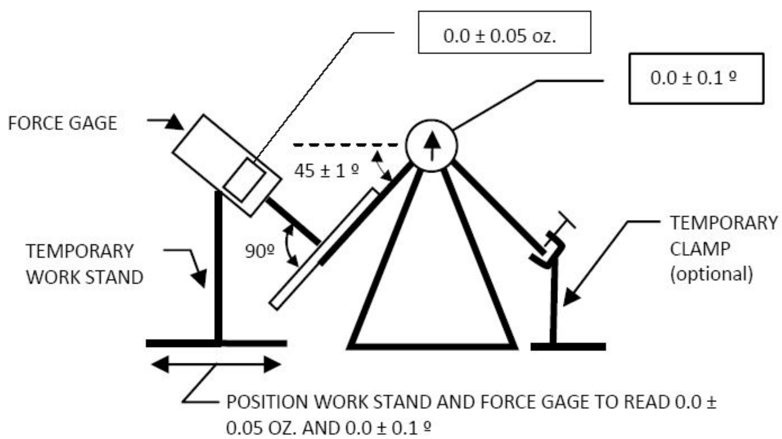



**Figure 2 Force Balance Calibration Setup**

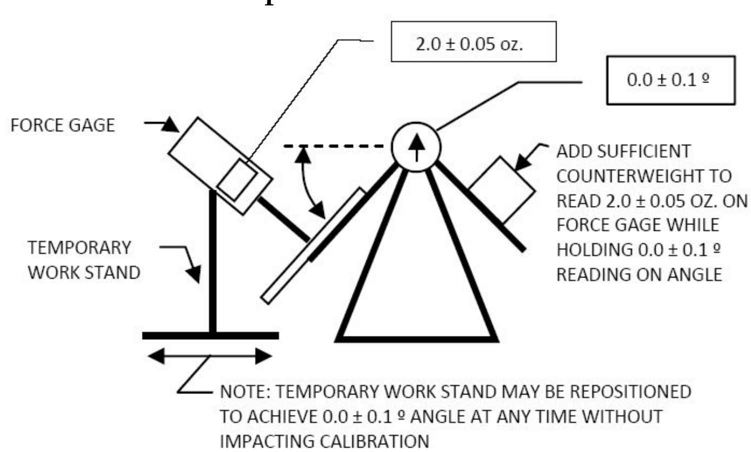


**Figure 3 Force Balance Calibration Procedure**

# APPENDIX C:
# Showerhead Spray Coverage Procedure

**B1 Showerhead Spray Coverage**

The showerhead spray coverage shall meet the requirements specified in Section 5.1.

**B2 Test Procedure**

B2.1 Set-Up

The specimen shall:

(a) Be thoroughly flushed before measuring the spray coverage.
(b) Be connected to a smooth-interior pipe or tubing with a length equal to at least 20 times the inside diameter of the pipe or tubing at the inlet(s) of the fitting.
(c) Be connected to a pipe or tubing of the same nominal size as the fitting connections.
(d) Have its standard components installed, when tested for compliance with the minimum and maximum spray coverage specified in Section 5.1.
(e) Use the annular ring test setup shown in Figures 4 and 5.

B2.2 Other Test Conditions

(a) Install the device in accordance with Figure 5.
(b) The upstream pressure tap shall have the pressure gage located 8 ± 2 in. (203 ± 51mm) before the inlet of the specimen.
(c) Pressure tap size and configuration shall conform to ASME PTC 19.2 or ANSI/ISA-75.02.
(d) If a fluid meter is used to measure flow rate, the installation shall be in accordance with ASME PTC 19.5.
(e) If the volume/time method is used for the flow rate measurement, the container shall be of sufficient size to hold the collected water for a minimum of one minute.
(f) The water temperature shall be 100 ± 10 °F (38 ± 6 °C) maintained for at least one minute.

(g) The water pressure shall be 45 ± 1 psi (310 ± 7 kPa) at the inlet when water is flowing.

B2.3 Test Procedure

(a) Mount the showerhead so the faceplate is horizontal and parallel with the top surface of the annular rings.

(b) Position the annular rings underneath the showerhead so the center line of the faceplate and the center ring are in vertical alignment and the top of the annular gage is 18 ± 0.25 in. (457 ± 6mm) from the faceplate (see Figure 5).

(c) Initiate the flow of water, where the specified water pressure is stabilized within ± 1 psi (7 kPa) within two seconds.

*Note: Before initiating the flow of water, if the water pressure cannot be stabilized within two seconds, a cover may be placed over the annular rings and then removed once the pressure has stabilized.*

(d) Allow the water to flow through the showerhead and into the annular rings for a minimum of one minute.

(e) Record the measured flow rate and the time the water flowed through the showerhead and into the annular rings to the nearest second on a stopwatch.

(f) Calculate the total volume collected from the measured flow rate and time.

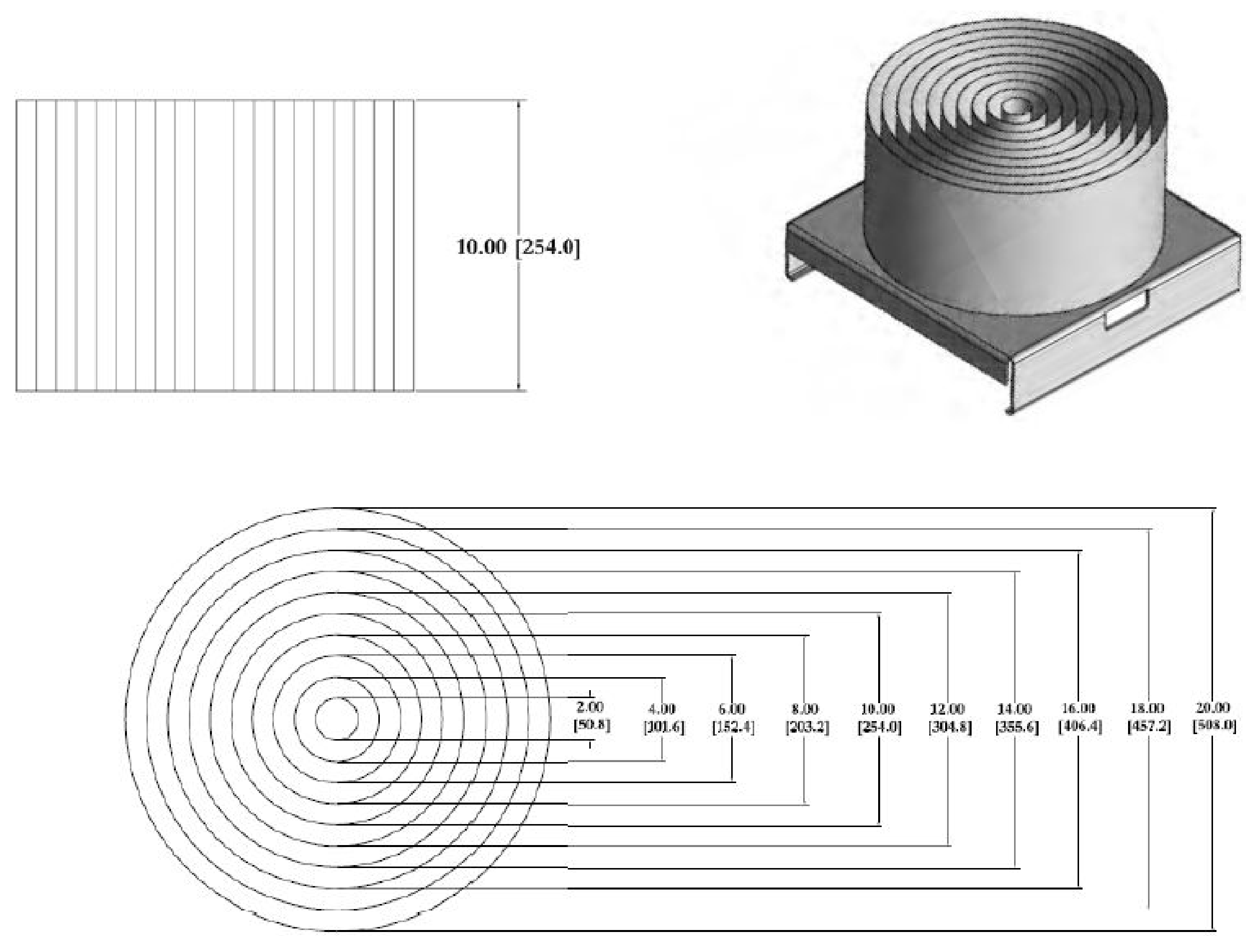
(g) Collect, measure, and record the volume of water in each annular ring.

(h) Determine the total volume collected in all rings.

(i) Calculate and record the percentage of the total recorded volume collected in each ring.

(j) If the total volume collected varies by more than ± 5 percent of the total volume calculated from the recorded flow rate and time, correct and repeat this procedure and record the results.

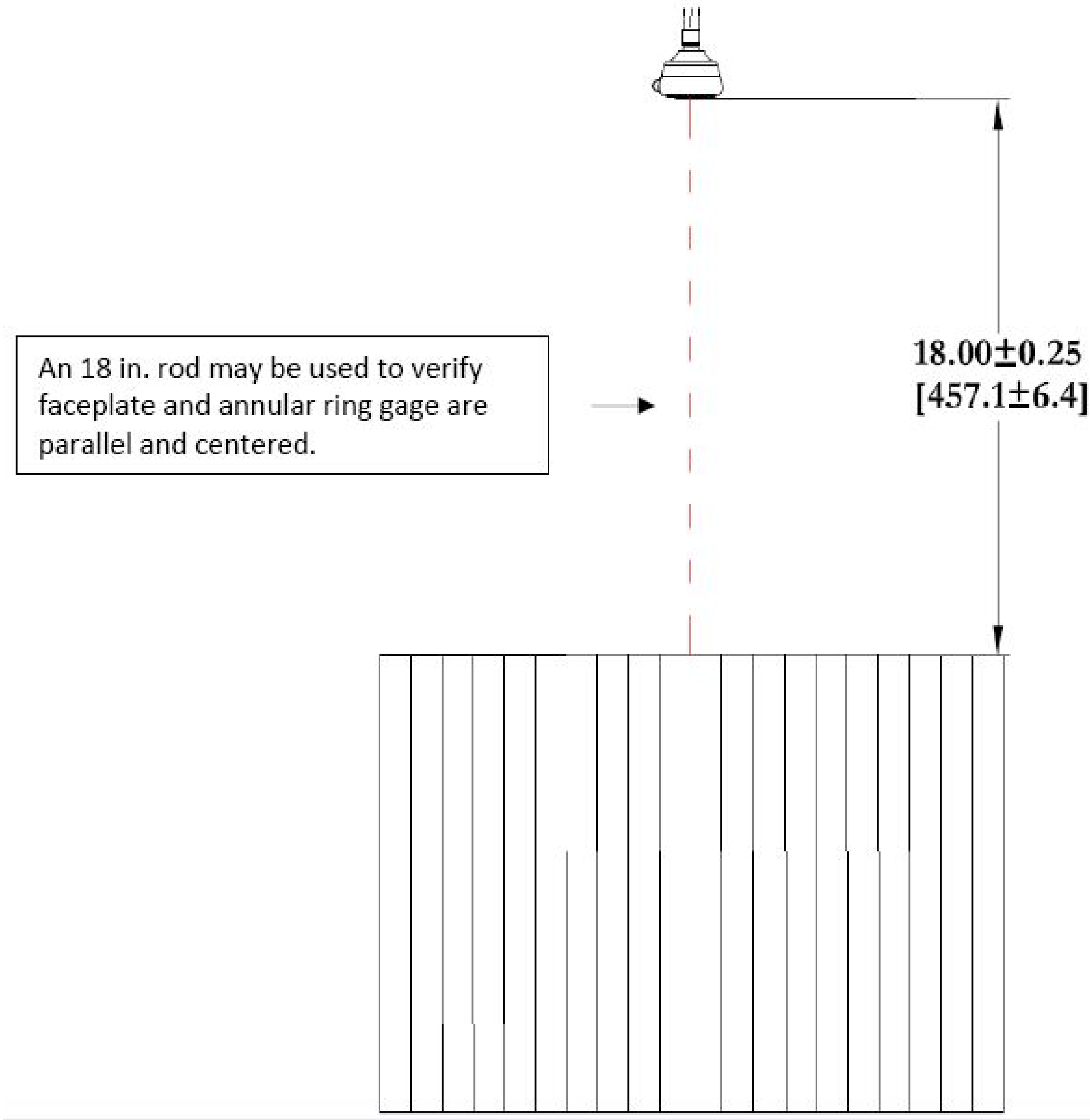
(k) Evaluate and verify that the spray coverage meets the minimum and maximum values specified in Section 5.1.




Notes:

1. All dimensions in inches [mm]
2. Tolerance: +/- 0.06" [1.6]
3. Suggested Material: (0.03" [0.75mm]) 304 Stainless Steel

**Figure 4. Annular Ring Specifications**




Notes:

1. All dimensions in inches [mm]

**Figure 5. Annular Ring Test Setup**

# APPENDIX D: Requirements for WaterSense® Labeling

The following requirements must be met for products to bear the WaterSense® label.

### 1.0 Scope Clarification – Combination Showerheads

In cases where more than one showerhead or hand-held shower is provided in combination with others in a single device intended to be connected to a single shower outlet, the product and/or its packaging may be marked with the WaterSense® label only if each showerhead (or hand-held shower) meets all of the requirements of this specification and the entire device meets the maximum flow rate requirement of this specification in all possible operating modes.

### 2.0 WaterSense® Partnership

The manufacturer[10] of the product must have a signed partnership agreement in place with EPA.

### 3.0 Conformity Assessment

Conformance to this specification must be certified by an EPA licensed certifying body accredited in accordance with the WaterSense® product certification system.

[10] Manufacturer, as defined in the WaterSense® Program Guidelines, means: "Any organization that produces a product for market that might be eligible to meet WaterSense criteria for efficiency and performance. Manufacturers may also produce 'private label' products that are sold under the brand name of a separate organization, which is treated as a separate partner/application from the original product manufacturer."

# APPENDIX E: Manufacturer Survey

## Introduction

Robert Mowris and Associates is conducting a showerhead research project for the California Energy Commission's Public Interest Energy Research (PIER) program. The project is cooperating with the ASME A112.18.1 /CSAB125.1 Joint Harmonization Task Force (JHTF) on the Development of New Testing Protocols for Measuring the Performance of Showerheads. The current ASME A112.18.1/CSAB125.1-2005 voluntary standard is based on the ASME 112.18.1M-1996 standard which is more than 10 years old. The current showerhead standard is 2.5 gallons per minute (gpm) at a flowing pressure of 80 pounds per square inch (psi). We need to obtain a sample of 2-3 showerheads to test within the following flow rate categories: 2.5 gpm, 2.0 gpm, 1.5 to <2.0 gpm, 1.0 to <1.5, 0.5 to <1.0 gpm. We will conduct customer satisfaction surveys to evaluate the "best" performing showerheads across the categories and minimum acceptable flow rates. The challenge to manufacturers is to design water conserving showerheads that perform well over a range of flowing pressures from 20 to 80 psig. Currently, there are few products offered at lower flow rates and little is known about customer satisfaction of showerhead flow rates below 2.0 gpm. Customers do not know the showerhead flow rates at flowing pressures lower than 80 psig and most customers have showerheads with flowing pressures less than 80 psig. The following survey is being conducted by Robert Mowris and Associates on behalf of the California Energy Commission's Public Interest Energy Research (PIER) program.

## Survey (deleted questions are strikethrough)

1. Are you a member of ASME A112.18.1 /CSAB125.1 Joint Harmonization Task Force? (Yes, No, DK)
2. Is your company an EPA WaterSense® Partner? (Yes, No, DK)
3. Is your company a member of the US Green Building Council Water Efficiency Technology Advisory Group (WETAG)? (Yes, No, DK)
4. What is your company's estimated showerhead market share? (, DK)
5. Does your company promote water conservation? (Yes, No, DK)
6. Has your company received complaints about "thermal shock" with showerheads rated at <2.5 gpm at 80 psi are installed in existing or new homes? (Yes, No, DK)
7. Has your company conducted any showerhead quality tests using shower heads rated at less than 2.5 gpm at 80 psig? (Yes, No, DK)
8. Do you give special guidance to consumers about retrofitting shower heads rated at less than 2.5 gpm at 80 psig? (Yes, No, DK)
9. ~~Approximately how many showerheads rated at less than 2.5 gpm at 80 psig does your company sell each year? (~~
10. Approximately what percentage of total sales do conserving showerheads account for? (, DK)
11. Do conserving showerheads cost more than 2.5 gpm shower heads? (Yes, No, DK)

11b. How much more do your company's water conserving showerheads cost compared to Nonconserving? (, DK)

12. Are your company's water conserving showerheads available in California? (Yes, No, DK)
13. ~~Approximately how many multi-head showers or "shower spa" systems do you sell each year?~~

14. What is your company's percentage of total sales of multi-shower units? (, DK)
15. ~~What is the approximate cost of a multi-head shower and/or shower spa system?~~
16. Would you support a mandatory standard for new construction that reduced the maximum showerhead flow rate below 2.5 gpm to conserve energy and water? (Yes, No, DK)
17. If so, would 2.0 gpm be the right value? (Yes, No, DK)
18. Would you support a mandatory appliance standard for shower heads that reduced the maximum showerhead flow rate below 2.5 gpm to conserve energy and water? (Yes, No, DK)
19. If so, would 2.0 gpm be the right value? (Yes, No, DK)

19a. Comments regarding new standard. (Comments, No, DK)

20. Do you support a voluntary WaterSense® standard for showerheads to conserve water and energy? (Yes, No, DK)
21. If so, what would be the right combination of flow rates and pressures for this standard (i.e., 2.0 gpm at 20, 40, 60, 80 psig)? (GPM at psig, DK)

21a. Would you support a voluntary showerhead standard like the Australian voluntary standard of 1 star for 2.0 gpm max at 20-80 psig, 2 stars for 1.5 gpm max at 20-80 psig, and 3 stars for less than 1.5 gpm max at 20-80 psig? (Yes, No, DK)

22. Do you manufacture water conserving showerheads with flow rates less than 2.5 gpm? (Yes, No, DK)
23. If so, how many models have flow rates less than 2.5 gpm? (Number, No, DK)
24. If so, what are the rated flowrates at 80 psig? (Number, No, DK)
25. Are you willing to donate 2 - 3 showerheads (3 of each) for the CEC PIER study, the results of which we will use to make a recommendation to ASME? (Yes, No, DK)

25a. If you wish to donate showerheads for our study, and want us to return them to you, then please provide a return shipping label. (Provide address for returning samples, No, DK)

Thank you for participating in the California Energy Commission Public Interest Energy Research Project Manufacturer Showerhead Survey.

# APPENDIX F: Consumer Satisfaction Survey

**Customer** ______________________________ **Site** ___________________________ **Unit** ________
**Address** _______________________________ **City** ____________________________**ZIP** ________
**Technician** _____________________________ **Phone Number**_____________________

# Survey

The study evaluated consumer satisfaction within the following flow rate categories: 2.5 gpm, 2 gpm, 1.5 to <2 gpm, and less than 1.5 gpm. The study evaluated consumer satisfaction across flow rate categories. Participants were selected in the following age groups: 17 to 55 years old. The study attempted to capture a sample of participants representing the US population by conducting surveys of consumers from Nevada and California. Pressure and flow rate were measured with flow meters. Temperature was recorded with digital temperature data loggers. The showerhead valve manufacturer and model was recorded. No modifications were made to the in-situ shower enclosures or valves. Showerhead testing was conducted with participants who were given the choice of performing tests in one or more days depending on the time and availability of the participants and testing locations. General demographic questions were asked of participants.

The study attempted to identify responses from participants that are not biased towards conservation and responses from participants that are biased towards conservation. The "conservation" bias of participant responses was quantified by asking the following statements. Participants who score a total of 3 points on the statements will be considered to be biased towards conservation. Participants who score greater than 3 points will be considered unbiased towards conservation.

- Surveys will be conducted at hotels and residential sites with paid participants.
- Evaluate consumer satisfaction at 2.5, 2.0, 1.5 to <2.0, and <1.5 gpm.
- Participants ages: <17, 17-55, >55 yrs.
- Weight, height, race, gender, education, income, occupation, fitness level.
- Measure temperature, pressure, flow rate.
- Evaluate bias (1=agree, 3=disagree)
- “Saving water and energy are important to my selection of which showerhead to use.”
- “I wish to save water and energy when I take a shower.”
- “I don't mind waiting longer (30 sec) for hot water to take a conserving shower.”

# Pre-Survey Questions

**Demographic Information (only ask each participant once)**

D1 – First Name? _____________

D2 – Last Name? _____________

D3 – Phone Number? _____________

D4 – Email? _____________

D5 – City? _____________

D6 – State? _____________

D7 – Age? ___ A) <17 ___ B) 17-55 ___ C) >55 yrs

D8 – Height? ___ A) <5'6" ___ B) 5'6" to 6' ___ C) >6 feet

D9 – Weight? ___ A) <100 ___ B) 100-150 ___ C) >150 lbs

D10 – Gender? ___ A) Female ___ B) Male

D11 – Educ.? ___ A) H.S. ___ B) College ___ C) College Grad. __D) Grad. School

D12 – Household Income? ___ A) <$50,000 ___ B) $50-$75000 ___ C) >$75000

D13 – Fitness (Exercise)? ___ A) 1/Week ___ B) 2-4/Week ___ C) Daily

D14 – Occupation?

__ A) Food Service __ B) Agricultural __ C) Construction __ D) Maintenance

__ E) Technical/Computer __ F) Sales __ G) Education __ H) Healthcare __ I) Management

__ J) Police/Military __ K) Legal __ L) Other

D15 – Race?

__ A) African American __ B) Caucasian __ C) Latino __ E) Asian American

__ F) Native American __ H) Other

**Attitude Information (only ask each participant once)**

Please tell us on a scale of 1 to 3 of whether or not you agree with the following statements where 1 is strongly agree and 3 is strongly disagree.

S1 - "Saving water and energy are important to my selection of which showerhead to use in my home or business." (1=strongly agree, 2=neutral 3=strongly disagree)___ (1 to 3)

S2 - “I wish to save water and energy when I take a shower.” (1=strongly agree, 2=neutral 3=strongly disagree) ___ (1 to 3)

S3 - “I don't mind waiting longer (20 seconds) for hot water to take a water conserving shower." (1=strongly agree, 2=neutral 3=strongly disagree) ___ (1 to 3)

# Survey Questions

**Survey Information (ask for each showerhead tested)**

The participants will enter the shower enclosure and be instructed to first adjust each shower valve to a comfortable temperature (we will not record the showering temperature since it will vary with each product and participant). The participant will be asked to rate each showerhead by answering the following questions.

**Consumer Satisfaction Survey Questions**

| |
|---|
| Q1 - Coverage (1=Excellent, 3=Poor)? ___ (1 to 3) |
| Q2 - Rinsing Action (1=Excellent, 3=Poor) ___ (1 to 3) |
| Q3 - Rinsing Time to remove conditioner (seconds)? ___ CEC PIER Study Only |
| Q4 – Force (1=excellent, 3=too soft or too hard)? ___ (1 to 3) |
| Q5 - Temperature (3=Poor, 1=Excellent) ___ (1 to 3) |
| Q6 - Noise (1=Quiet, 3=too loud)? ___ (1 to 3) CEC PIER Study Only |
| Q7 - Overall Satisfaction (3=Poor, 1=Excellent)? ___ (1 to 3) CEC PIER Study Only |
| Q8 - Purchase showerhead (No Buy, Buy)? ___ (0 or 1) |

***** END SURVEY QUESTIONS *****

Showerheads were scored in each category (Q1 through Q9) and the showerheads with highest scores were selected as the "best" showerheads. The highest scoring or "best" showerheads were compared across categories to evaluate relative satisfaction as a function of flow rate. The cross comparison provided the basis for an evaluation of flow rate (i.e., how do water conserving showerheads compare with non-conserving showerheads in terms of consumer satisfaction?).

Laboratory Testing was conducted of each showerhead in the survey to measure flow rate at 20, 40, 60, and 80 psig. Additional laboratory tests were performed consistent with the WaterSense® criteria and proposed ASME/CSA A112.18 protocols.

# APPENDIX G: Assumption & Acknowledgement of Risks & Liability Release Agreement

In consideration of being allowed to participate in any way for the ***CEC PIER Consumer Satisfaction Survey and Showerhead Study*** its related events and activities, the undersigned, acknowledges, appreciates, and agrees that:

1) The risk of injury from the activities involved in this program is significant, including the potential for permanent paralysis and death, and while particular rules, equipment, and personal discipline may reduce this risk, the risk of serious injury does exist; and,
2) I KNOWINGLY AND FREELY ASSUME ALL SUCH RISKS, both known and unknown, EVEN IF ARISING FROM THE NEGLIGENCE OF THE RELEASEES or others, and assume full responsibility for my participation; and,
3) I willingly agree to comply with the stated and customary terms and conditions for participation. If, however, I observe any unusual significant hazard during my presence or participation, I will bring such to the attention of the nearest official immediately; and
4) I, for myself and on behalf of my heirs, assigns, personal representatives and next of kin, HEREBY RELEASE, INDEMNIFY, AND HOLD HARMLESS the ***Robert Mowris & Associates*****,** its officers, officials, agents and/or employees, other participants sponsoring agencies, sponsors, advertisers, and, if applicable, owners and leasers of premises used to conduct the event ("Releases"), WITH RESPECT TO ANY AND ALL INJURY, DISABILITY, DEATH, or loss or damage to person or property, WHETHER ARISING FROM THE NEGLIGENCE OF THE RELEASEES OR OTHERWISE, to the fullest extent permitted by law.

I HAVE READ THIS RELEASE OF LIABILITY AND ASSUMPTION OF RISK AGREEMENT, FULLY UNDERSTAND ITS TERMS, UNDERSTAND THAT I HAVE GIVEN UP SUBSTANTIAL RIGHTS BY SIGNING IT, AND SIGN IT FREELY AND VOLUNTARILY WITHOUT ANY INDUCEMENT.

X________________________________________ Age: ____ Date Signed: _________________
PARTICIPANT'S SIGNATURE

__________________________________________
PARTICIPANT'S NAME