Substantiating Documents for Proposed Changes

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ROOF SURFACES

WALL PRODUCT RATING PROGRAM MANUAL
CRRC-2

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PREFACE

The CRRC Wall Rating Program has been developed under the direction of the Cool Roof Rating Council. The Cool Roof Rating Council is a non-profit organization whose mission is:

- To implement and communicate fair, accurate, and credible radiative properties for roof and exterior wall surfaces;
- To support research on the radiative properties of roof and exterior wall surfaces, including durability of those properties and durability of the affected roof and exterior wall system(s); and
- To provide education and objective support to parties interested in understanding and comparing various roofing and exterior wall options.

By pursuing this mission, the CRRC will become the recognized informational resource for reducing the urban heat island effect, increasing building energy efficiency, improving occupant comfort, and mitigating the global climate effects of greenhouse gas emissions.

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ADVISORY NOTE: ALL REFERENCED DOCUMENTS SUCH AS CRRC AGREEMENTS, APPLICATIONS, FORMS, PROCEDURES OR OTHER ITEMS MAY BE FOUND AT

http://coolroofs.org/product-rating/overview

CHAPTER 1.0 FOREWORD

1.1 Scope

The Cool Roof Rating Council, Inc. (CRRC) operates a uniform rating system for the Radiative Properties of exterior Wall Products ("Wall Rating Program"). The system is supported by a rating program under which manufacturers and sellers ("Wall Licensees") have the opportunity to label exterior Wall Products with measured Initial and Aged Radiative Properties. These properties are determined through testing by CRRC Accredited Independent Testing Laboratories (AITLs) and, in some cases, Accredited Manufacturer Testing Laboratories (AMTLs).

Advisory Note: *The CRRC does not specify minimum threshold values for Radiative Properties. The Wall Rating Program is not intended to be used as a primary law or regulation, but rather as an authoritative resource that complements adopted laws or regulations. If the CRRC Wall Rating Program is referenced by a law or regulation, the provisions of that law or regulation may dictate specific requirements that are in addition to or conflict with the CRRC Wall Rating Program. It is therefore the responsibility of the user to comply with applicable laws and regulations.*

1.2 Liability

1.2.1 Disclaimer

The CRRC is the copyright owner of the CRRC Wall Product Label, which bears one or more radiative property values reported by AITLs. The AITLs act independently from the CRRC.

A product rating authorization does not constitute a warranty by the CRRC regarding the Radiative Properties of an exterior Wall Product. A rating is not an endorsement of, or recommendation for, any exterior Wall Product. The CRRC is not a merchant in the business of selling exterior Wall Products, and therefore, cannot warrant products as to their merchantability or fitness for a particular use.

The CRRC therefore disclaims any and all liability, including but not limited to, damages for personal or other injury, lost profits, lost savings or other consequential or incidental damages that may arise from or in connection with:

1. services provided by, decisions made by, or reports issued or granted by any AITL or Wall Licensee;
2. reliance on any CRRC product description, specification, rating or test, whether appearing in a report, product rating authorization, printed or electronic directory or on a product label; or
3. the sale or use of any CRRC rated exterior Wall Product.

1.2.2 Indemnification

Wall Licensees are required to enter into a license agreement with the CRRC, which contains, among other provisions, an indemnification of the CRRC, its Board of Directors (CRRC Board), officers, and agents from and against liability.

1.3 Membership and License Applications

The use of official CRRC forms is required when applying for CRRC membership, CRRC licenses, and to become an approved CRRC testing laboratory or test farm. Official CRRC forms can be found online at www.coolroofs.org.

1.3.3 Limitations

Product rating applications shall be limited to the holder of the rights of materials and products for which the rating authorization is sought. For applications that reference another rated product, the application shall include documentation that the applicant has authorization from the manufacturer to use the test report data.

1.4 Glossary of Terms

1.4.1 Scope

Unless otherwise expressly stated, the following words and terms shall have the meanings as indicated in this document.

1.4.2 Definitions

Accredited Testing Laboratory – A laboratory that has received formal recognition by the CRRC as having demonstrated technical competency to perform specific types of tests in accordance with Chapter 2.0 of this manual.

Accredited Independent Testing Laboratory – An accredited testing laboratory that is approved by the CRRC to test exterior Wall Products and is completely independent from any manufacturing company.

Accredited Manufacturer Testing Laboratory – An accredited testing laboratory affiliated with a Wall Licensee that is approved by the CRRC to test the Radiative Properties of Wall Products.

Agreement, Accredited Laboratory – A written agreement that is entered into between the CRRC and a CRRC-approved testing laboratory.

Agreement, Wall Licensee – A written agreement that is entered into between the CRRC and a Wall Licensee.

Agreement, Approved Test Farm – A written agreement that is entered into between the CRRC and a CRRC Approved Test Farm.

Approved Test Farm – A company that the CRRC has approved to conduct exposure activities for products that are undergoing the process to obtain aged ratings.

Batch – A single quantity of product processed at one time as a mixture or combination of raw materials.

Coating Thickness – The dry film thickness of a coating when applied to a substrate, measured in accordance with ASTM D1005 or ASTM D7091.

Color Family – A predefined range of Hunter or CIE "L," "a," and "b" color coordinates that establishes the color space for a CRRC-predefined set of colors.

Color Family Additional Element – A uniquely formulated Architectural Coating Wall Product or Factory-Coated Metal Wall Product intended for application to an exterior wall that is CRRC-rated as a member of a Color Family Group and is not a Representative Element.

Color Family Group – One or more Architectural Coating or Factory-Coated Metal products rated by a Wall Licensee that are part of the same Product Line and that have color properties that fall within the ranges established for the respective CRRC Color Family.

Color Family Representative Element – A uniquely formulated Architectural Coating or Factory-Coated Metal intended for application to an exterior wall that is used to initially establish a Wall Licensee's Color Family Group.

Cooling Degree Day (CDD) – For any one day when the mean temperature is more than 10 °C or 50 °F, there are as many degree-days as degrees Celsius or Fahrenheit temperature difference between the mean temperature for the day and 10 °C or 50 °F. Annual cooling degree-days (CDDs) are the sum of the degree-days over a calendar year. *(Source: ASHRAE Standard 169)*.

Compound Product Rating – A compound product rating applies to two or more products that have the same surface formulation and same Radiative Properties that are listed together as one product entry on the CRRC Rated Wall Products Directory and CRRC Label. Products of any type may be eligible for a Compound Product Rating.

Embossed Panel – A three-dimensional grain pattern that is transferred to the extruded panel.

Estimate of Sample Mean Standard Error – The sample (rather than population) standard deviation divided by the square root of the number of specimens.

Emittance, Thermal – The ratio of the radiant heat flux emitted by a specimen to that emitted by a blackbody radiator at the same temperature.

Formula Change – Individual or accumulated changes in a product (e.g., pigment or resin) that changes the Solar Reflectance or Thermal Emittance by ±0.05 or more.

Heating Degree Day (HDD) – For any one day, when the mean temperature is less than 18 °C or 65 °F, there are as many degree-days as degrees Celsius or Fahrenheit temperature difference between the mean temperature for the day and 18 °C or 65 °F. Annual heating degree-days (HDDs) are the sum of the degree-days over the calendar year. (*Source: ASHRAE Standard 169*)

Heavily Textured Panel – An uneven surface that contains a grain texture and defining shadow lines transferred to the injection molded panel.

Heterogeneous – Consisting of dissimilar or diverse ingredients or constituents.

Hunter/CIE "L," "a," "b" Color Coordinates – Numeric measurements of a color's lightness (L), redness/greenness (a) and yellowness/blueness (b) in accordance with ASTM E805, Section 9. Color Measurement Equipment Specification: 0°/45° or 45°/0° (illuminant angle/viewing angle) geometry with 10° standard observer, D65 illuminant.

Inactive or Inactivated Product Rating – Any product rating that is removed from the CRRC Wall Rated Products Directory due to a Wall Licensee's request or non-payment of fees.

Label, CRRC – The distinctive informational mark that contains the CRRC Wall Rating Program logo and other pertinent radiative property information specific to a Wall Product.

Licensee, Wall – A manufacturer and/or seller of exterior wall products that is licensed by the CRRC to participate in the Wall Rating Program.

Licensed Party – An entity that is a Wall Licensee or approved testing Laboratory.

Logo, CRRC – The distinctive registered service mark of the CRRC.

Manufacturer, Wall Product – A company that produces wall products.

Population – A group of Sample values in which conclusions are to be drawn, such as a set of Solar Reflectance values determined from non-overlapping spots (small regions) that cover an entire Test Surface.

Population Mean – The arithmetic mean of the Radiative Property values measured for all members of a Population.

Population Standard Deviation – The square root of the arithmetic mean of the squares of the deviation from the Population mean.

Product Line, Architectural Coating – A set of Architectural Coating products sold under the same brand name. Product Lines may include multiple gloss levels (e.g., Semi-Gloss, Eggshell).

Production Line – A Wall Licensee's standard color offerings that are promoted in general product information and in marketing materials.

Radiative Properties – The Solar Reflectance and Thermal Emittance of a Wall Product.

Radiative Properties, Rated – The Solar Reflectance and Thermal Emittance of a Wall Product reported on a CRRC Label and published on the CRRC Rated Wall Products Directory.

Radiative Properties, Aged – The Solar Reflectance and Thermal Emittance of a Wall Product weathered and tested in accordance with Section 4.5 and S.2.6 of Appendix 1 of this manual.

Radiative Properties, Initial – The Solar Reflectance and Thermal Emittance of a Wall Product that tested in accordance with Section 4.5 of this manual.

Radiative Properties, Tested – The measured Solar Reflectance and Thermal Emittance of a Wall Product as reported by a CRRC-approved test lab.

Rating Authorization – An official notification from the CRRC to a Wall Licensee regarding the approval of a CRRC product rating.

Reactivated Product – An Inactive Product Rating that is reactivated by the CRRC upon request by the Wall Licensee.

Reference Rating – a product rating application that relies on the rated values from a different application for an identical product (e.g., private labeling)

Reflectance, Solar – The fraction of solar energy that is reflected by an exterior Wall Product.

Relative Humidity (RH) – The ratio of the partial pressure or density of water vapor to the saturation pressure or density, respectively, at the same dry-bulb temperature, and barometric pressure of the ambient air. (*Source: ASHRAE Terminology of Heating, Ventilation, Air-Conditioning, & Refrigeration*)

Responsible Person – An individual employee of a CRRC-approved test lab who has participated in a CRRC laboratory training workshop and who will supervise or perform all CRRC-related testing at that laboratory.

Retested Product – A CRRC-rated product that replaces an original product rating due to product reformulation, Validation Testing failure, test method change, or discontinuation for any other reason.

Sample – A set of test Specimens.

Sample Mean – The arithmetic mean of the Radiative Property values measured for all members of a Sample set.

Sample Mean Standard Error – The Population Standard Deviation divided by the square root of the sample size.

Sample Set – A subset of the Population, such as a set of non-overlapping Spots (i.e., small regions) on a Test Surface.

Sample Standard Deviation – The square root of the ratio of the sum of the squares of the deviation from the Sample Mean to a number one less than the number of Samples.

Specimen – A portion of a product used for Radiative Property testing and weathering.

Smooth Panel – A panel that contains no visual pattern, embossment, or texture.

Solar Reflectometer – A device that measures Solar Reflectance.

Spot – A small region of a test surface, such as a 2.54 centimeter by 2.54-centimeter (1 inch by 1 inch) square or a 2.54-centimeter (1 inch) diameter circle, in which *solar reflectance* can be measured.

Test Farm Site – An authorized location where product Specimens are placed for three-year

weathering exposure before aged testing is conducted.

Test Surface – Outer surface of a product test Specimen.

Test Surface Mean Solar Reflectance – The ratio of solar energy reflected from a Test Surface to the solar energy incident on a Test Surface.

Thickness, Dry Film – The thickness of liquid-applied a paint or coating, when dried, as applied to a substrate.

Terminated Product Rating – Any product rating permanently removed from the CRRC Rated Wall Products Directory due to a Validation Testing failure, retesting requirements, or reformulation. Terminated products are not eligible for reactivation.

Uncharacteristically Damaged – A Specimen that is unusable for weathering exposure placement or unusable after weathering exposure through no fault of specimen preparation by the Wall Licensee or specimen preparer. "Unusable" refers to the inability to accurately measure the Aged Radiative Properties of the product Specimen. Uncharacteristically Damaged shall include, but not be limited to, the following: damage during transit of the product by improper handling; animal excrement that stained the specimen; irreparable damage or destruction due to a natural disaster, such as a hurricane, tornado, flooding, or other disaster; or any other unforeseen event that might harm the Specimen beyond normal weather exposure.

Wall Licensee – A manufacturer or seller of exterior Wall Products that has met and maintains compliance with the Wall Rating Program requirements and has signed the CRRC Wall Rating Program License Agreement. Wall Licensees may manufacture their products, purchase them from another manufacturer, or both.

Wall Product – A material designed, manufactured and constructed as the outermost part of the wall assembly that is in direct contact with solar radiation.

Wall Product, Architectural Coating – A paint that is applied directly to an exterior wall.

Wall Product, CRRC Rated – An exterior Wall Product that has received a CRRC Rating Authorization and is published on the CRRC Rated Wall Products Directory.

Wall Product, Factory-Coated Metal – A paint or coating that is applied to a metal substrate in a factory or coating facility (i.e., not in the field).

Wall Product, Insulated Vinyl Siding – A Vinyl Siding Wall Product containing an additional insulative layer with an R-value no less than 2.0.

Wall Product, Polypropylene Siding – An exterior Wall Product that is manufactured from polypropylene resin in conformance with ASTM D7254.

Wall Product, Privately-Labeled – A Wall Product manufactured by an entity other than the Wall Licensee that is bringing it to market.

Wall Product, Standard – A CRRC-rated production line Wall Product that is not part of a Color Family Group or rated under a Compound Rating.

Wall Product, Variegated – A Wall Product with a varied surface color or discrete markings of different colors.

Wall Product, Vinyl Siding – A dual layer co-extruded wall product manufactured from plastic, typically Polyvinyl Chloride (PVC).

1.5 References

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CHAPTER 2.0 LABORATORY AND TEST FARM REQUIREMENTS

2.1 General

This chapter contains the requirements for Accredited Independent Testing Laboratories (AITL), Accredited Manufacturer Testing Laboratories (AMTL), and Approved Test Farms. AITLs and Approved Test Farms are to remain separate and unaffiliated entities.

2.2 Requirements for All Accredited Testing Laboratories

Product testing for a CRRC product rating must be conducted by CRRC-approved accredited testing laboratories. The requirements for testing laboratory approval are:

(A) The laboratory must submit a completed application to the CRRC for consideration as a

recognized CRRC Accredited Testing Laboratory, and pay the required fee. AITLs that have been approved to participate in the CRRC Roof Rating Program do not need to re-apply or pay a separate fee to participate in the Wall Rating Program. However, they will need to provide evidence that they have the proper test equipment to perform the measurements in accordance with this manual.

(B) At least one employee of the Accredited Testing Laboratory must participate in a CRRC laboratory training workshop. This employee shall be designated as a Responsible Person for CRRC testing. All testing for CRRC product ratings shall be performed or supervised by the Responsible Person, who shall ensure that test results are reported in accordance with section 3.9 of this manual. The laboratory shall notify the CRRC within 10 business days of any personnel changes as they pertain to the Responsible Person(s). A CRRC-approved laboratory must retain at least one Responsible Person to perform testing and ensure the accurate reporting of test results to the CRRC.

(C) After participating in a CRRC laboratory training workshop, the laboratory must demonstrate competency prior to CRRC approval by completing testing on a set of specimens provided by the CRRC. The CRRC's evaluation of the laboratory's test results shall adhere to the same criteria used to evaluate product rating data.

(D) The laboratory must demonstrate ongoing competency by participating in the CRRC's Interlaboratory Comparison Study in accordance with section 2.2.1 of this manual.

(E) The laboratory must not be a CRRC Approved Test Farm or an affiliate of a CRRC Approved Test Farm.

2.2.1 Interlaboratory Comparison Study

As part of ongoing compliance with CRRC approval, AITLs, AMTLs, and Approved Test Farms are required to participate in the biennial Interlaboratory Comparison Study (ILC). The purpose of the ILC is to conduct a periodic evaluation to ensure consistency and competency of the testing laboratory by evaluating the test results against the test results of the other participants.

Participants shall report the solar reflectance, thermal emittance, and thickness (where applicable) for a sample set of products provided by the CRRC in accordance with Chapter 3.0 and Appendix 1 of this manual. Test Farms and laboratories that test colorimetry must also report color measurements, where applicable.

The CRRC will notify participants of the results at the completion of the Interlaboratory Comparison Study, and shall notify the participants of any corrective actions that may be necessary.

2.3 Special Requirements for Accredited Manufacturer Testing Laboratories

All AMTLs shall be subject to the provisions contained in Sections 2.2, 2.6, Appendix 2 of this manual, and the following:

(A) All AMTLs shall participate in the Interlaboratory Comparison Study in accordance with Section 2.2.1 of this manual. Accredited Manufacturer Testing Laboratories will be responsible for testing only their respective product type from the Interlaboratory Comparison Study sample set.

(B) All AMTLs shall submit proof to the CRRC that the following procedures are in place:

1. Written procedures for the operation of any CRRC-approved test methods.
2. Written training records of laboratory personnel who can perform testing and reporting of the test results to the CRRC.
3. System for documenting and retaining testing records.
4. System for calibrating any and all equipment used for product testing.

2.4 Special Requirements for Accredited Independent Testing Laboratories

An AITL shall demonstrate that it meets the CRRC's requirements through submission of the following information at the time of application to become an AITL, or at the request of the CRRC:

(A) Evidence of accreditation by an official accreditation body as complying with the International Standard ISO 17025.

(B) A list of test methods that the accrediting body has found the AITL capable of performing for the CRRC.

(C) A statement of independence that shows the laboratory has no significant ownership or commercial interest in a supplier, roofing

and/or wall product company, and is also not owned by such a company.

2.5 Requirements for Test Farms

2.5.1 Test Farm Application Requirements

A test farm shall demonstrate that it meets the CRRC's requirements through submission of the following information at the time of application to become an Approved Test Farm, or at the request of the CRRC:

(A) Evidence of accreditation by an official accreditation body as complying with ISO 17025.

(B) Exposure locations as specified in Section S.2.6 of Appendix 1 of this manual.

(C) A listing of exposure methods that an accrediting body has found the test farm capable of performing for the CRRC.

(D) A statement that shows the test farm has no significant ownership or commercial interest in a supplier, roofing and/or wall product company, and is also not owned by such a company.

(E) A statement that the test farm is not an AITL or an affiliate of an AITL.

(F) Participation in the Interlaboratory Comparison Study upon CRRC request, in accordance with Section 2.2.1, if the test farm measures colorimetry. The test farm will only be responsible for testing colorimetry of applicable products in the sample set.

2.6 Renewal Requirements for Laboratories and Test Farms

Approved Test Farms, AITLs, and AMTLs must renew participation with the CRRC on an annual basis by paying the annual renewal fees.

Approved Test Farms and AITLs shall also provide a current copy of their ISO 17025 scope of accreditation certificate during annual renewals and each time the accreditation scope changes.

CHAPTER 3.0 PRODUCT TESTING, WEATHERING & REPORTING REQUIREMENTS

3.1 General

This chapter, and the requirements of Appendix 1 of this manual, contains the product testing, weathering, and reporting requirements for the Wall Rating Program.

3.2 Test Specimen Measurements

(A) The AITL shall verify that the test Specimens meet the required dimensions for that product type in accordance with Section S.3 of Appendix 1 of this manual. If the Specimen(s) do not meet the size requirements, the AITL will notify the Wall Licensee to obtain new test Specimens that meet the stated size requirements for that product type.

(B) The AITL shall conduct one measurement per Specimen width and length.

3.3 Solar Reflectance Tests

Solar Reflectance tests shall be conducted in accordance with S.2.2 of Appendix 1 or Appendix 3 of this manual.

Results shall be reported to three decimal places.

3.4 Thermal Emittance Tests

Thermal Emittance tests shall be conducted in accordance with Section S.2.3 of Appendix 1 of this manual. Results shall be reported to two decimal places.

3.5 Thickness Tests

Thickness tests shall be conducted for Architectural Coating Wall Products in accordance with Section S.2.5 of Appendix 1 of this manual.

3.6 Colorimetry

Color measurements shall be conducted for Architectural Coating Wall Products and Factory-Coated Metal Wall Products in accordance with Section S.2.4 of Appendix 1 and Appendix 2 of this manual.

3.7 Weathering

After initial testing, the AITL shall forward the test Specimens directly to an Approved Test Farm for weathering exposure.

The AITL must send the test Specimens to the Approved Test Farm no later than twenty-eight (28) calendar days prior to the next test farm placement date to ensure that the specimens reach the test farm in time for that placement. Exposures will begin on the first day of every other month throughout the year beginning with January 1. The test farm will conduct weathering of the specimens in accordance with ASTM G7.

Product weathering exposure and removal requirements, which shall include specimen mounting, exposure, and removal, shall be in accordance with S.2.6 of Appendix 1 in this manual.

The test farm shall notify the CRRC within 30 calendar days if specimens have been pulled before the official three-year exposure completion date.

Approved Test Farms are required to photograph specimens during three-year weathering at each exposure site. The photographs shall be taken every year over the course of three-year weathering (i.e., after 12, 24, and 36 months of exposure) and sent to the CRRC. Photographs must adhere to the following requirements:

(A) During three-year exposure, the Approved Test Farm shall submit photos to the CRRC using the following file nomenclature template:

FL/AZ/OH_12m/24m/36m_YYYY-MM-DD_[Specimen]#

1. The date in the file name shall be the date that the photo was taken.
2. Specimen numbers:
    i. If the label is on the back of the specimen, a photo of the front and back of the specimen must be taken.
    ii. If the label is placed next to the front of the specimen, only the front of the specimen must be photographed.

(B) Multiple specimens can be grouped together in a single photograph (front and back, depending on label placement) as long as the entire surface of each specimen is clearly visible in the photograph.

(C) Proper lighting and high-resolution image quality are required.

After three-year weathering is complete, the test farm must ship the weathered Specimens directly to the AITL specified by the Wall Licensee.

After conducting aged testing of the weathered Specimens, the AITL shall retain the Specimens for a period of 90 calendar days or until the rated Radiative Properties are approved by the CRRC. The AITL must use the current CRRC-approved test methods applicable to the Wall Product type for the Radiative Property tests of the aged products regardless of the test methods used for initial testing.

All AITLs, AMTLs, and Approved Test Farms shall adhere to select sections of ASTM G147 for the proper handling of weathered product samples, in accordance with Section 2.5.2 and Section S.2.6 of Appendix 1 of this manual.

3.7.1 Damage to Test Specimens

In the event that a test Specimen is Uncharacteristically Damaged in transit to the test farm or during weathering exposure to a degree that its Radiative Properties cannot be accurately measured, it shall be removed from the calculation of the Aged Radiative Properties. As a result of such an occurrence, the Aged Radiative Properties shall be reported as the arithmetic mean of the remaining Specimens from each test farm site.

Up to two Specimens per test farm site are permitted to be discarded if Uncharacteristically Damaged. Should all three specimens from one test farm site be Uncharacteristically Damaged, the Wall Licensee shall submit new specimens to the AITL for retesting.

In the event that all three specimens from one test farm site are Uncharacteristically Damaged and retesting is required, the product is permitted to be listed on the CRRC Rated Wall Products Directory until retesting is completed by the AITL. Retesting includes taking new initial measurements as well as going through the three-year exposure process to obtain the Aged Radiative Properties. If the new initial ratings differ from the original initial ratings by no more than ±0.05, then the initial ratings on the CRRC Rated Wall Products Directory will be updated to reflect the new initial ratings. The Wall Licensee shall be responsible for ensuring that the CRRC Wall Product Label and any reference to the original initial ratings are appropriately updated based on the new initial ratings. If the CRRC has not received a retesting submission within six (6) months of being notified of the damage to the original Specimens, the product will be removed from the

CRRC Rated Products Directory, and the Wall Licensee will be notified.

All other conditions of damage will be assumed to be outside of the intent and application of Uncharacteristically Damaged. Should all three specimens from one test farm be rendered unusable from damage outside of what is defined as Uncharacteristically Damaged, the Wall Rating Program Committee shall review the case and provide a recommendation to the CRRC Board on whether the product needs to go through the rating process again. The CRRC Board shall take appropriate actions that may include removal of the product from the CRRC Rated Wall Products Directory, in which case, the Wall Licensee would be required to start the rating process over if a rating is desired. Alternatively, the Wall Licensee may elect to start the product rating process over again by having a new product sample tested in advance or in place of the CRRC Board's evaluation.

3.8 Specific Testing Considerations for Certain Product Types

See Section S.3.2 of Appendix 1 of this manual, and the following provisions:

(A) Architectural Coating Wall Products shall be applied to a standard wall substrate at the minimum dry mil thickness or coverage recommended by the manufacturer for use in the field. For products that will undergo weathering (Standard Products and Color Family Representative Elements), the standard wall substrate shall be a metal panel with a Solar Reflectance less than 0.20. For paints that are designed for application to a specific substrate, the manufacturer can choose to use an alternative substrate to the default substrate, so long as the Solar Reflectance of the substrate is less than 0.20. For products not undergoing weathering (Color Family Additional Elements), the product shall be applied to the Standard substrate, a Leneta Form BK plain black chart, or the black portion of a Leneta Form 2C opacity chart. The manufacturer shall either supply prepared panels, or supply the substrate to the AITL along with instructions on how to properly apply the coating to the substrate.

(B) Polypropylene Siding Wall Products with multiple product shapes that share the same surface formulation are eligible for a Compound Rating. The Licensee will submit nine (9) specimens of each shape for the initial rating in accordance with Section S.3.2 of Appendix 1 of this manual. All shapes must be initially measured by an AITL to determine the lowest Solar Reflectance. The shape with the lowest Solar Reflectance will be used for reporting the CRRC initial and aged values and sent to the test farm for weathering.

3.9 Reporting

Reporting of tested Radiative Properties shall be in accordance with S.2.7 of Appendix 1 of this manual, and the following provisions:

(A) Initial Radiative Properties shall be the arithmetic mean of the initial test results of the specimens from Batches A and B.

(B) Aged Radiative Properties shall be the arithmetic mean of the aged test results of each of the nine (9) product specimens that undergo aging exposure.

(C) The AITL shall photograph specimens during initial and aged testing of all products undergoing the process of obtaining a CRRC product rating. The photographs shall be submitted with the initial test results and the aged test results. The AITL must include the following information in the file name of each digital photo:

- Initial or Aged
- Date photo was taken
- Specimen numbers

Example: Initial_YYYY-MM-DD_[specimen #] Multiple specimens can be grouped together in a single photograph as long as the entire surface of each specimen is clearly visible in the photograph. Proper lighting and high-resolution image quality are required.

3.10 Validation Testing of Rated Products

The CRRC reserves the right to conduct periodic testing of actively rated Wall Products through the Validation Testing Program. The purpose of the Validation Testing Program is to verify the product ratings of actively rated products to maintain the credibility of the CRRC Rated Wall Products Directory. All products with an active rating may be selected for Validation Testing.

CHAPTER 4.0 CRITERIA FOR EXTERIOR WALL PRODUCT LICENSEES

4.1 General

To obtain or maintain an active status as a Wall Licensee with rated wall products, the Wall Licensee shall comply with all the conditions and criteria of this chapter and all applicable requirements of the CRRC Wall Rating Program.

A Wall Licensee, as governed by the CRRC Wall Rating Program License Agreement, shall make no representation that it is “approved” or “certified” by the CRRC or that the rated product is approved or certified by the CRRC. The CRRC does not certify or approve products as a part of the Wall Rating Program.

4.2 Compliance with Criteria and Conditions

Compliance by a Wall Licensee with all the criteria and conditions of the CRRC Wall Rating Program shall be subject to review by the CRRC at any time.

4.3 Licensee’s Representative

A Wall Licensee shall designate one or more individuals to be responsible for the proper labeling of CRRC rated products and serve as the primary point of contact for the Wall Rating Program. The Licensee shall notify the CRRC if there are changes to the responsible individual(s).

4.4 Quality Control

The Wall Licensee shall have an appropriate quality control plan in place to ensure its product(s) maintain their Radiative Properties within ±0.05 of those listed for that product(s) on the CRRC Rated Wall Products Directory (i.e., values obtained through testing). A Wall Licensee shall designate at least one employee as the quality control manager at each plant. All quality control records and the quality control plan shall be made available to the CRRC upon written request.

4.5 Initial and Aged Testing Requirements

All products, with the exception of Color Family Additional Elements and Reference Ratings, shall be submitted to an AITL for Initial Radiative Properties testing. Upon completion of initial testing by the AITL, the product specimens shall be sent by the AITL to an Approved Test Farm where they shall undergo weathering exposure for three (3) years, after which they shall be retested by an AITL in order to determine the Aged Radiative Properties. Color Family Additional Elements may be tested by either an AITL or AMTL and do not undergo three-year weathering. For Compound Ratings, only the product with the lowest Solar Reflectance undergoes weathering.

Testing and weathering exposure shall be performed at the expense of the Wall Licensee.

The Wall Licensee shall be responsible for the selection, sampling, and labeling of products that go through testing for a CRRC product rating according to the provisions set forth in Chapter 3.0 and Appendix 1 of this manual.

4.6 Product Rating Applications

With the exception of Color Family Additional Elements and Reference Ratings, each Wall Licensee shall have its products’ Radiative Properties measured by a CRRC-approved Accredited Independent Testing Laboratory as described in Section 4.5 of this manual. The Wall Licensee shall complete the following steps for each product for which it wishes to obtain a CRRC product rating:

1. Submit a product rating application.
2. Submit payment of the application fee.
3. Submit a Safety Data Sheet, product specification sheet, field application instructions, or other supporting documentation, as applicable.
4. Assign a public contact for the CRRC Rated Wall Products Directory.
5. Denote the CRRC-approved Accredited Testing Laboratory and Approved Test Farm that will handle testing and sample exposure for the product, respectively.
6. Provide any other pertinent information relevant to the submission, as applicable or as requested by the CRRC.

4.7 Product Rating Authorization Procedures

(A) Product Rating Authorization: After receiving the required items listed in Section 4.6 above and conducting a review and approval of the test results, the CRRC will notify the Wall Licensee by email regarding the approval of the Rating Authorization.

(B) Reference Ratings (Private-Labeling): A Wall Licensee may apply for a Reference Rating if they are bringing a product to market that contains an existing CRRC-rated component.

For example, the original manufacturer of an exterior wall product, such as a paint producer, may obtain a CRRC product rating for the product, even if they are not the company bringing the product to market. A Wall Licensee that manufactures a final exterior wall product using that CRRC-rated component (e.g., paint formulation) may use the original manufacturer's CRRC rated values for their own CRRC product rating.

Reference Ratings can also be obtained for private labeled products. If one manufacturer sells a CRRC-rated product to another company to be marketed under a different brand name, the marketer of the private labeled product may use the original manufacturer's CRRC rated values for their own CRRC product rating.

Any scenario wherein one product's ratings rely on another product's ratings through a Reference Rating application, identical rating values must be used for both the rated products on the CRRC Rated Wall Products Directory and the CRRC Wall Product Label. If the original manufacturer's product rating is terminated, all product ratings referencing that rating will also be terminated.

(C) Rating Acquisitions Procedures: When a Wall Licensee (e.g., Company A) acquires another Wall Licensee (e.g., Company B) or its products and wishes to retain the product ratings under Company A's name, Company A must submit a new Product Rating Application for each of Company B's actively rated products in accordance with the procedures in Section 4.6 of this manual. Under normal circumstances, Company A will be able to use the existing Test Results Reports originally obtained by Company B. However, the CRRC reserves the right to require Company A to resubmit products for initial testing, weathering, and aged testing, if warranted, such as in the case where the test method originally used to measure the product is no longer current.

The CRRC will work with the Wall Licensee to ensure that the rated values for the new product listings are correct.

4.8 Formula Change

A Formula Change is defined as a change in the Radiative Properties of a rated product by more than ±0.05 of the Initial Radiative Properties. Any CRRC-rated product that undergoes a Formula Change shall obtain a new CRRC product rating and new CRRC Rating Authorization in accordance with the procedures as set forth in Chapter 3.0 and Section 4.6 of this manual.

To rate a new formulation of a rated product, the Wall Licensee shall have an AITL (or AMTL, as applicable) submit new test results and complete the requirements described in Section 4.6 of this manual. The replacement product shall receive a CRRC product ID number that consists of the ID number for the original formulation followed by a suffix. When the test results of the reformulated product are approved by the CRRC, the Radiative Properties of the product shall be listed on the CRRC Rated Wall Products Directory and on the CRRC Wall Product Label. The rating for the previous formulation will be terminated and removed from the CRRC Rated Wall Products Directory. The Wall Licensee shall discontinue the use of the CRRC label for the terminated product.

(A) Reference Ratings: A Wall Licensee with a Reference Rating for a product that undergoes reformulation will be asked to confirm if they wish to transition the Reference Rating to the reformulated product or have their product rating inactivated. If the Reference Rating is transitioned to the reformulated product, the Radiative Properties of the Reference Rating displayed on the CRRC Rated Wall Products Directory will be updated to align with the retested values. The Wall Licensee must also transition to using a new CRRC Wall Product Label that displays the retested values.

4.9 Product Retesting Due to Test Method Changes

The CRRC reserves the right to adopt new test methods or substantively revise existing test methods. When the CRRC Board approves a new or revised test method, the previous test method is withdrawn from the Wall Rating Program, which may require some products with existing CRRC ratings to be retested using new product Specimens in accordance with the new or revised test method. The specific retesting requirements will vary depending on the test method adoption or change.

4.10 CRRC Label Requirements

The Wall Licensee shall only use the CRRC Wall Product Label for CRRC rated products in accordance with Chapter 5.0 of this manual.

4.11 Confidentiality

CRRC product rating applications and test results shall be considered confidential and shall not be disclosed by the CRRC except as set forth in this manual, pursuant to legal proceedings or in the context of appeals.

4.12 Inactive and Terminated Product Ratings

The following requirements shall apply to inactivated and terminated products:

(A) A CRRC rated product shall be removed from the CRRC Rated Wall Products Directory for any of the following reasons:

1. Product has been discontinued by the manufacturer, meaning it is no longer in production or available for purchase.
2. The manufacturer no longer wishes to maintain a CRRC product rating.
3. The manufacturer fails to pay renewals fees for the product.
4. Product has been reformulated or retested by the manufacturer resulting in a variance in solar reflectance or thermal emittance from the initial rating and for which a replacement product has been rated.
5. The product rating has been terminated by the CRRC for any reason, including Validation Testing failure or failure to comply with CRRC requirements.

(B) The Wall Licensee must reapply for a reinstatement of an inactivated product. The Wall Licensee must provide a statement that the product formula has not changed or must have the reformulated product retested in accordance with Chapter 3.0 and Section 4.8 of this manual. Any outstanding fees must be paid to the CRRC before the product will be reinstated.

For inactivated products that have not undergone a Formula Change, previous test data may only be used if the previous testing was conducted in accordance with current CRRC testing and weathering requirements, otherwise the product must restart the rating process.

(C) Terminated products are not eligible for reinstatement.

CHAPTER 5.0 CRRC LABEL USE

5.1 General

Use of the CRRC Wall Product Label, as governed by the CRRC Wall Rating Program License Agreement, is permitted solely for products that meet the CRRC Wall Rating Program requirements and for which a CRRC Rating Authorization has been issued.

5.2 Licensed Use of the CRRC Wall Product Label

The following requirements shall be met when using the CRRC Wall Product Label:

(A) The graphic format shall be as shown in the Wall Rating Program License Agreement.

(B) The CRRC Wall Product Label shall be used only for wall products that have been determined by the CRRC to meet the CRRC Wall Rating Program requirements.

(C) The CRRC Wall Product Label shall be clearly visible when placed on one or more of the following:

1. The rated Wall Product.
2. The packaging, wrapping or container for the rated Wall Product.
3. The bill of lading or other documentation that accompanies the delivery of the Wall Product to the user.
4. Marketing materials for the Wall Product.

(D) When used in product marketing or informational materials for multiple products, the CRRC Wall Product Label shall be placed adjacent to the specific Wall Product that received the CRRC Rating Authorization.

5.3 Reproduction of Label

The CRRC will provide the CRRC Wall Product Label to the Wall Licensee upon request. The label is available in color and in grayscale. Reproduction of the label shall meet the following requirements:

(A) Not be smaller than the CRRC Wall Product Label provided to the Wall Licensee.

(B) Meet the same proportions of the CRRC Wall Product Label provided to the Wall Licensee, if the Wall Licensee wishes to increase the size of the CRRC Wall Product Label.

(C) Include the Radiative Properties as issued by the CRRC.

(D) Not be altered or modified in any way.

CHAPTER 6.0 REVOCATION OR CLOSING FILES

6.1 Scope

The CRRC shall have the authority to revoke or modify for cause (including but not limited to imposition of further conditions) any license and/or product rating granted under the CRRC Wall Rating Program. "Cause" shall include:

(A) Failure of the material to conform to the rating upon which the Rating Authorization was based.

(B) Failure of the material, and/or method of manufacturing, to remain consistent.

(C) Failure to comply with any condition or rule of the CRRC Wall Rating Program.

(D) Any intentional misstatement in the application or any inaccurate data knowingly submitted in support thereof.

(E) Failure to comply with any provision in the Rating Authorization, Wall Rating Program License Agreement, and/or Accredited Manufacturing Testing Laboratory License Agreement.

(F) Any other ground considered as adequate cause in the judgment of the CRRC whether of the same or a different type than listed above.

6.2 Reinstatement

(A) Licensed parties that are terminated as a result of nonpayment of annual CRRC renewal fees may be reinstated if the necessary fees are paid within the same calendar year. At the end of the calendar year, reinstatement is subject to item (B).

(B) The submission for license reinstatement shall be in accordance with the requirements stipulated in Chapter 4.0 (Licensees) or Chapter 2.0 for (accredited test labs) of this manual.

(C) Reinstatement of a product rating is subject to the provisions in Section 4.12 of this manual; terminated products are not eligible for reinstatement. The decision to reinstate an inactivated product may be subject to review by the CRRC Board.

6.3 Consultation

Prior to the CRRC acting on the closing of files, the holder of the CRRC license shall be given reasonable notice and an opportunity to be heard in accordance with Section 7.2 of this manual.

CHAPTER 7.0 COMPLAINTS

7.1 Purpose

These rules establish procedures for complaints regarding CRRC licenses and Wall Product ratings.

7.2 Pre-Action Procedures

Any party shall be afforded the opportunity to discuss, clarify, and resolve disagreements with respect to cited disputes concerning actions by the CRRC or by a licensed party regarding licensure and labeling policies and procedures prior to that party submitting a complaint.

7.3 Submission

Any person may submit a written complaint to the CRRC. Complaints shall be directed to CRRC headquarters, and shall include the following information:

(A) The name(s) and address(es) of the submitter(s), telephone, and email contact information;

(B) description of the complaint;

(C) relevant information to support the complaint; and

(D) a filing fee to be determined by the CRRC Board. In the event of a complaint regarding inaccuracy of a product rating, the complainant shall pay a filling fee that includes the cost of obtaining and testing the product sample.

The CRRC reserves the right to request further information or written clarification.

7.3.1 Notification

Upon receipt of the complaint, the CRRC shall forward a notice indicating receipt of the submission, an action plan that further identifies cost and timeline for resolving the complaint, and shall assign the submission a file number. Any licensed party who is the subject of the complaint shall be provided with a copy of the notice.

7.3.2 Review

The CRRC may take such action as it deems appropriate, in its sole discretion, to address the complaint. In the event of a complaint regarding inaccuracy of a Wall Licensee's product rating, the CRRC will obtain a product sample and shall coordinate product testing with an AITL. In the event the product rating was inaccurate, the Wall Licensee shall pay the CRRC the amount of the filing fee and the complainant shall have its filing fee refunded.

The CRRC shall notify the complainant of the CRRC's decision by certified mail, return receipt requested, or other method, which provides evidence of, and a receipt for, delivery.

CHAPTER 8.0 APPEALS

8.1 General

Any licensed party (appellant) aggrieved by any determination by the CRRC pursuant to Chapter 6.0 of this manual who chooses to appeal shall do so within 20 business days of the date of receipt of said written determination or order.

8.2 Submission

Appeals shall be submitted in writing, directed to the CRRC Board Chairperson, addressed to the CRRC headquarters, and shall include the following information:

(A) The name and address of the appellant, telephone, and email contact information, and the name and address of legal counsel if the appellant desires to have representation;

(B) description of the product under appeal,

(C) description of the issue being appealed;

(D) statement of reasons for appeal; and

(E) relevant evidence and supporting data or information.

The CRRC reserves the right to request further information or a written clarification from the appellant, and shall extend the appeal review if, in the opinion of the CRRC, the content of the additional information or written clarification is of substance to warrant additional time.

8.3 Notification

Upon receipt of the appeal, the CRRC shall assign a file number. All future correspondence to and from the CRRC shall reference the file number. The appellant shall be notified of any associated hearings convened by the CRRC Board.

8.4 Appeal Review

The CRRC shall, upon receipt of a completed submission, evaluate the appeal and render a decision of the matters in dispute within 20 business days of receipt of the completed submission or within 20 business days of a hearing if one is convened. The decision to hold a hearing shall be at the discretion of the CRRC Board. The CRRC reserves the right to extend the time of review if the CRRC determines that there is sufficient cause. The CRRC shall notify the appellant of its decision by certified mail, return receipt requested, or other method, which provides evidence of, and a receipt for, delivery.

CHAPTER 9.0 ARBITRATION

9.1 General

If the appellant disputes the decision of the CRRC under Chapter 8.0 of this manual, the appellant has the right to appeal solely through arbitration. The appellant shall notify the CRRC of a request for arbitration in writing within 20 business days of receipt of the written appeal review decision. The request shall include the following information:

(A) The name(s) and address(es) of the appellant(s), telephone, and email contact information, and name and address of legal counsel if the appellant desires to have said representation;

(B) description of the product subject to the arbitration,

(C) description of the issue being arbitrated;

(D) statement of reason for the arbitration;

(E) relevant evidence and supporting data or information; and

(F) concise statement of its rebuttal position(s).

9.2 Arbitration Method

The arbitration shall consist of one of the following methods:

(A) A single arbitrator selected jointly by the appellant and the CRRC to investigate and resolve the matter, or

(B) The CRRC and the appellant shall use the American Arbitration Association's procedures for the selection of a single arbitrator from a list of seven candidates, with each party having the right to strike three.

9.3 Cost

The appellant shall be responsible for all time and expense costs incidental to the arbitration proceedings.

9.4 Hearing

The hearing may be conducted under the American Arbitration Association procedures for arbitration if requested by either party. Unless otherwise agreed upon by all parties, the arbitrator(s) shall issue a written decision within 15 business days of the hearing or of the final written submission.

APPENDIX 1: WALL RATING PROGRAM TESTING AND WEATHERING REQUIREMENTS

Section S.1 - General

S.1.1 Scope
This appendix covers specimen preparation and test methods for determining and reporting the Initial and Aged Radiative Properties of exterior Wall Products.

S.1.2 Significance and Use
This appendix provides a practice and method for testing and reporting the Radiative Properties of exterior Wall Products before and after a specified test exposure. Product test Specimens are exposed to specific tests and to the exterior environment throughout a specified time period. The tests provide a relative measure of the Wall Product's response to the test conditions. This appendix does not purport to be representative of all conditions that an exterior Wall Product may experience in the field. Variations of the test conditions or Specimen construction also affect the Specimen's response.

S.1.3 Advisory Notes
This appendix contains references to advisory notes that are provided as explanatory material.

Section S.2 - Conduct of Tests

S.2.1 Product Specimens
All product Specimens used for testing the Initial and Aged Radiative Properties shall be chosen by the Wall Licensee. Testing shall be in accordance with this appendix and Chapter 3.0 of this manual.

An Accredited Independent Testing Laboratory (AITL) or Accredited Manufacturing Testing Laboratory (AMTL), if applicable, shall measure the dimensions of each test Specimen. Specimen measurements shall be within 2.54 centimeters (1 inch) of the minimum required specimen size, and specimens shall be measured to an accuracy of 0.64 centimeters (0.25 inches).

The accredited test lab shall note in the initial test results that the Specimens meet the size requirements. If the Specimens do not meet the size requirements, the Laboratory will notify the Wall Licensee to obtain new Specimens.

S.2.2 Solar Reflectance Tests

(A) Solar Reflectance tests shall be conducted based upon one of the following test methods using the air-mass 1.5 global vertical (AM1.5GV) Solar Reflectance of a sun-facing, 90° (vertical) tilted surface, except for Variegated Wall Products, which must be tested using CRRC-1 Test Method #1.

1. ASTM E903, in conjunction with the global solar-spectral irradiance at air mass 1.5 incident on a sun-facing, 90° (vertical) tilted surface, specified as "Global 90°" in ASTM G197.
2. ASTM C1549, using the global Solar Reflectance at air-mass 1.5 for a sun-facing, 90° (vertical) tilted surface, specified as output "1.590" (air mass 1.5; tilt 90°) on version 6 of the Devices & Services Solar Spectrum Reflectometer.
3. CRRC-1 Test Method #1, using the variant of ASTM C1549 specified in item (2).

4. The *Standard Test Method for Determining the Directional Hemispherical Solar Reflectance of Materials Using a Directional-Hemispherical Portable Reflectometer*, using the global Solar Reflectance at air-mass 1.5 for a sun-facing, 90° (vertical) tilted surface, specified as output "G197GT90" on the Surface Optics 410-Solar or 410-Solar-*i.*

Advisory note: The CRRC-1 Test Method #1 can be found in the appendix of ASTM C1549. The *Standard Test Method for Determining the Directional Hemispherical Solar Reflectance of Materials Using a Directional-Hemispherical Portable Reflectometer* can be found in Appendix 3 of this manual.

(B) For Architectural Coating products applied to a Standard Substrate, a bare Standard Substrate must also be tested for Solar Reflectance using the same test method that is used for the prepared Specimens. The Solar Reflectance of the Standard Substrate must meet the requirements of section 3.8 (A) of this Manual in order to proceed with a product rating using the selected Standard Substrate.

S.2.3 Thermal Emittance Tests

Thermal Emittance tests shall comply with the following:

(A) Architectural Coatings applied to an uninsulated metal substrate or Leneta Chart and uninsulated Factory-Coated Metal products shall be tested in accordance with ASTM C1371 or the Slide Method.

(B) There shall be three (3) measurements taken on each Specimen.

(C) Any Wall Product *other than* Architectural Coatings applied to an uninsulated metal substrate or Leneta Chart and uninsulated Factory-Coated Metal products shall be tested using the Slide Method. In the Slide Method, the emissometer head shall be moved, without creating a gap between the specimen and the emissometer, every 15 seconds during the testing procedure. Architectural Coatings applied to an uninsulated metal substrate or Leneta Chart and uninsulated Factory-Coated Metal products are allowed, but not required, to be tested using the Slide Method.

Advisory note: *The Slide Method can be found in Devices and Services (D&S) Technical Note 11-2 at http://devicesandservices.com.* Moore, Charles. *Model AE1 Emittance Measurements using a Port Adapter, Model AE-ADP*. D&S Technical Note 11-2. Dallas, TX: Devices & Services Co., 2011.

S.2.4 Color Family Elements – Instrumentally Measured Color Tests

Color Family Elements shall be tested for L, a, and b coordinates on the Hunter or CIE color scale for Factory-Applied Coating Wall Products (metal) and Architectural Coating Wall Products (paint), respectively. Color measurement equipment specification: 0°/45° (illuminant/observer) geometry with 10° standard observer, D65 illuminant. (Informative Note: See ASTM E805, Section 9 for reference only.)

The color Specimen shall be conditioned to room temperature (24 ± 3 °C) for at least 30 minutes prior to measurement. The color Specimen shall be placed on the instrument and measurements conducted according to the instrument manufacturer's instructions. The L, a, and b coordinates shall be measured at three (3) locations on the Specimen Test Surface and the average of each color coordinate shall be reported. The test results shall be reported in a manner that identifies the specific specimen, the color coordinates (L, a, b) at each location, and the average of the three readings for each coordinate.

S.2.5 Thickness Tests

(A) Architectural Coating Wall Products: Thickness tests shall be conducted in accordance with ASTM D1005 or ASTM D7091. A Thickness measurement shall be taken at five (5) evenly spaced points on each of the nine (9) Specimens. The average of the five (5) measurements shall

be used to determine the Thickness of the coating on each specimen. The average Thickness of the measured coating for a given Specimen shall be within 20% of the manufacturer's recommended minimum dry film Thickness. Any Specimen this is not within this range shall not be used for ratings. The Accredited Testing Laboratory shall notify the Licensee to request a new Specimen.

S.2.6 Requirements for Field Exposure of Wall Products

The following criteria shall be met to determine aged ratings:

(A) Test Farm Qualifications: A Test Farm shall be accredited to ISO/IEC Standard 17025 for the weathering and colorimetry testing of Wall Products, and shall be independent from any AITL or Licensee.

(B) Test Farm Sites: Specimens shall be exposed in the following three (3) locations representing three (3) climate zones:

1. Hot/Humid climate with:
    a. Annual Heating Degree-Day (HDD) @ 18 °C of 72 (Annual HDD @ 65 °F of 130), and
    b. Annual Cooling Degree-Day (CDD) @ 10 °C of 5,447 (Annual CDD @ 50 °F of 9,805), and
    c. An average yearly relative humidity of 83% in the A.M. and 61% in the P.M.
2. Cold/Temperate climate with:
    a. Annual Heating Degree-Day (HDD) @ 18 °C of 3,280 (Annual HDD @ 65 °F of 5,904), and
    b. Annual Cooling Degree-Day (CDD) @ 10 °C of,1,662 (Annual CDD @ 50 °F of 2,992), and
    c. An average yearly relative humidity of 80% in the A.M. and 62% in the P.M.
3. Hot/Dry climate with:
    a. Annual Heating Degree-Day (HDD) @ 18 °C of 523 (Annual HDD @ 65 °F of 941), and
    b. Annual Cooling Degree-Day (CDD) @ 10 °C of 5,067 (Annual CDD @ 50 °F of 9,120), and
    c. An average yearly relative humidity of 50% in the A.M. and 23% in the P.M.

The heating degree-day and cooling degree-day shall be determined in accordance with ANSI/ASHRAE Standard 169. The average yearly relative humidity shall be determined in accordance with NOAA comparative climate data. Test farm location climate values shall be within plus or minus 10% of those values shown above.

Advisory note: *Examples of regions of the United States that comply with Section S.2.6 are, but are not limited to, the following:*

Hot/Humid climate: Miami, Florida.

Cold/Temperate climate: Chicago, Illinois; Cleveland, Ohio; Youngstown, Ohio; Pittsburgh, Pennsylvania.

Hot/Dry climate: Phoenix, AZ.

(C) Specimen Exposure Period: Specimens shall be exposed for a minimum of three (3) continuous years at the locations specified in Section S.2.6(B) above in accordance with specimen preparations described in Section S.3 below. Specimens shall remain untouched for that minimum period, except for removal and reinstallation at the Test Farm Site as a result of weather conditions that have the potential for damaging the Specimens. Said removal and reinstallation shall be in accordance with the Test Farm's policy and procedures for the safe-keeping of Specimens.

(D) Photographic Documentation: The Test Farm shall take photographs of exposed Specimens after each year of exposure (e.g., after 12, 24, and 36 months) and submit the photos to the CRRC.

(E) Specimen Mounting: Exposure shall be in accordance with ASTM G7. Specimens shall be exposed on wood backing at 90° South in an offset rack that horizontally staggers Specimens to minimize cross-contamination induced by dripping.

(F) Exposure Removal: After three years of exposure, the Specimens are removed for the purposes of testing and reporting the Aged Solar Reflectance and Thermal Emittance results.

To ensure the proper handling of specimens, AITLs and Test Farms shall adhere to the procedures in ASTM G147, **except** sections 14.3 through 14.4 involving the washing of specimens. The Test Surface of each specimen **shall not** be washed, cleaned, or wiped in any fashion. Loose dirt, embedded dirt, environmental stains, mold, mildew, and any other material that rests on—or has become incorporated into—the surface of the material shall not be altered.

(G) Testing of Exposed Specimens: The Specimens shall be tested in accordance with Section S.2 above.

(H) Exposure Notification: The Test Farm shall be responsible for notifying the Licensee of exposure start and end dates and any other pertinent information about Specimen damage or unusual appearance. The Test Farm is also responsible for accurately labeling the exposed specimens to coincide with the exposure location (i.e., Test Farm Site).

Section S.3 - Test Specimen Selection

S.3.1 General

Wall Product Specimen selection shall be determined in accordance with one of the following:

(A) Section S.3.2 below for standard Wall Products, when the product is not a Color Family Representative Element, a Color Family Additional Element, or a Variegated Wall Product.

(B) Section S.3.3 below for products that are part of a Color Family Group.

(C) Section S.3.4 below for Variegated Wall Products.

S.3.2 Standard Wall Products

(A) Specimen Selection:

Licensee shall randomly select nine (9) Specimens from routine production to send to an AITL for testing. These Specimens shall be grouped into three (3) sets:

1. Three (3) Specimens from Batch A,

2. Three (3) Specimens from a Batch B, and
3. Three (3) Specimens for which each of the two (2) Batches shall be represented.

This results in a total of four (4) Specimens from one Batch and five (5) from the other.

For Polypropylene Siding Wall Products applying for a compound rating, all shapes with the same formulation must be measured to determine the lowest Solar Reflectance. The profile with the lowest Solar Reflectance will be reported and will be sent to the Test Farm for three-year weathering.

(B) Specimen Preparation (including size, Batch, number of Specimens, identification, substrate, and Thickness):

1. Each Specimen shall be a minimum of 10.2 centimeters by 15.2 centimeters (4 inches by 6 inches) in size.
2. Each Specimen shall be identified with the following:
    a. Licensee name;
    b. product name and/or model number; and
    c. Batch number and individual Specimen number.

Labels shall be adhered to the back of each Specimen and be durable to withstand three-year weathering. The information on the label shall be legible.

(C) Substrate:

Where applicable, the Licensee shall be responsible for ensuring that product Specimens are prepared on the appropriate substrate(s) according to the following provisions:

1. Architectural Coating Wall Products: Color Family Representative Element products shall be applied to a Standard Substrate with a Solar Reflectance less than 0.20. Color Family Additional Element Products shall be applied to the Standard Substrate or a Leneta BK chart or the black portion of a Leneta 2C chart. Specimens shall be applied at the minimum dry film thickness or coverage recommended by the Licensee for use in the field. The dry film thickness shall be within 20% of the manufacturer's recommended minimum thickness and shall be verified upon initial testing by an AITL in accordance with the procedures set forth in Section S.2.5 above.
2. Vinyl Siding Wall Products, Polypropylene Siding Wall Products, and Insulated Vinyl Siding Wall Products: The Licensee shall be responsible for ensuring that Specimens are prepared on the appropriate substrate(s) based on solid or variegated capstock.

(D) Radiative Properties Reporting:

The tested Radiative Properties of the Specimens shall be reported according to the following provisions:

1. Initial tested Radiative Properties shall be reported as the arithmetic mean of the initial test results of the Specimens from Batches A and B.
2. Aged tested Radiative Properties shall be reported as the arithmetic mean of the aged test results for each of the nine (9) Specimens that completed three-year weathering.

3. In the event that a Specimen is uncharacteristically damaged during weathering, the specimen shall be removed from the calculation of the Aged Radiative Properties. As a result of such an occurrence, the Aged Radiative Properties that are reported shall be the arithmetic mean of the measurements made on the remaining Specimens from each Test Farm Site.

   Up to two (2) Specimens per Test Farm Site shall be permitted to be discarded if Uncharacteristically Damaged. Should all three (3) Specimens from one Test Farm Site be Uncharacteristically Damaged, the Licensee shall have the product re-tested.

S.3.3 Color Family Group Products

All elements of a Color Family Group must belong to the same product line. In establishing a Color Family Group, the Licensee will submit data for all products included in the Group. The Representative Element of the group shall be tested for Radiative Properties by an AITL and aged according to section S.2.6 above. Color Family Additional Elements shall be tested by an AITL or an AMTL.

Color shall be established using the average Hunter or CIE L, a, b measurements taken on one Specimen from Batch A and one Specimen from Batch B. The reported values shall establish the color of the product. The measured color coordinates shall fall within the coordinate ranges for the CRRC Color Families. If the color measurements do not fall within the defined coordinate ranges, the product is ineligible to be rated as a part of a Color Family Group, and must be rated as a Standard Product.

Advisory note: Colorimetry measurements may be made by an AITL, AMTL, or Test Farm.

(A) Specimen Selection:

1. Color Family Representative Element: The Licensee shall randomly select nine (9) Specimens from routine production to send to an AITL for testing. These Specimens shall be grouped into three (3) sets: a) three (3) Specimens from one Batch, b) three (3) Specimens from a second Batch, and c) another set of three (3) Specimens for which each of the two Batches must be represented. This results in a total of four (4) Specimens from one Batch and five (5) from the other.
2. Color Family Additional Element: For each Color Family Additional Element to be added to an existing Color Family Group, six (6) Specimens shall be randomly selected and tested by an AITL or AMTL. The Specimens shall be grouped into two (2) sets: a) three (3) Specimens from one Batch and b) three (3) Specimens from a second Batch.

(B) Specimen Preparation:

1. Each Specimen shall be at least 155 square centimeters (24 square inches) in size.
2. Each Specimen shall be identified with the following:
   a. Licensee name;
   b. product name and/or model number; and
   c. Batch number and individual Specimen number.

Specimens shall be legibly labeled on the back of each panel. In the case of Representative Elements, the labeling shall be durable to withstand three-year weathering.

(C) Substrate:

The Licensee shall be responsible for ensuring that Specimens are prepared on the appropriate substrate(s) as described in section S.3.2 (C) above.

(D) Radiative Properties Reporting:

The tested Radiative Properties of the specimens shall be reported as described in section S.3.2 (D) with the following exception: Color Family Additional Elements are not subject to Aged Radiative Properties testing. The Aged tested Radiative Properties reported for the Color Family Additional Element and in the test results shall be identical to what is reported for the Representative Element of the Color Family Group.

S.3.4 Variegated Products

A product is considered Variegated if a series of five (5) Solar Reflectance measurements taken approximately equidistant along a diagonal axis of the Specimen varies by more than 0.05 from the arithmetic mean of all five measurements.

Variegated Wall Products shall be tested using CRRC-1 Test Method #1. When products are tested in accordance with CRRC-1 Test Method #1, the following provisions must be followed:

(A) Specimen Selection:

1. The Licensee shall randomly select Specimens from routine production to send to an AITL for testing. These Specimens shall be grouped into three (3) sets:
    a. Three (3) Specimens from Batch A;
    b. Three (3) Specimens from Batch B;
    c. Three (3) Specimens for which each of the two Batches shall be represented.

(B) Specimen Preparation:

1. The area of each Specimen shall be at least 10.2 by 25.4 centimeters (4 inches by 10 inches).
2. Specimens shall be labeled with the necessary information for identification by Batch and Specimen.
    a. Labels shall be adhered to the back of each Specimen and be durable to withstand three-year weathering.
    b. The information on the label shall be legible.

(C) Radiative Properties Reporting:

1. Initial tested Radiative Properties shall be reported as the arithmetic mean of the average Radiative Property values determined in accordance with CRRC-1 Test Method #1.

    In the event that two (2) Specimens yield radiative property values that differ by more than 0.05 from each other, both specimens shall be deemed to be non-compliant with the requirements stated in this section (Section S.3.4). The Licensee shall then be required to prepare three (3) additional Specimens of sufficiently larger dimensions to ensure that the difference in the Radiative Property values between each of the two (2) new measured Specimens is equal to or less than 0.05.

2. Aged tested Radiative Properties shall be reported as the arithmetic mean of the average Radiative Values for each of the three (3) Test Farm Sites, as determined in accordance with CRRC-1 Test Method #1.

3. In the event that a Specimen is uncharacteristically damaged during weathering, the specimen shall be removed from the calculation of the Aged Radiative Properties. As a result of such an occurrence, the Aged Radiative Properties that are reported shall be no higher than the arithmetic mean of the averaged results from each Test Farm Site. Up to two (2) Specimens per Test Farm Site shall be permitted to be discarded if Uncharacteristically Damaged. Should all three (3) Specimens from one Test Farm Site be Uncharacteristically Damaged, the Licensee shall have the product re-tested.

S.4.0 Quality Assurance

All active rated products are subject to testing under the Wall Program Validation Testing Program (VT Program). On a rolling basis, the CRRC will select active rated products on the Directory for testing to ensure that the values displayed on the Directory still reflect the market-available product. The selection process will incorporate randomness, but will also take into account other factors, such as the amount of time since the product was initially tested, the amount of time since last tested by VT, and other circumstances.

VT will be conducted by an AITL and will comply with the requirements set forth in Appendix 1 of this manual. If the tested values differ from the initial rated values by more than ±0.05, an additional Specimen (i.e., panel) of the product will be obtained and sent to a different AITL for testing. If the results of the second test also differ from the initial rated values by more than ±0.05, the CRRC will notify the Wall Licensee that the product has failed VT. The failed product will be terminated from the Directory.

If a Representative Element of a Color Family Group fails VT, the remainder of products in the Color Family Group shall be temporarily suspended while the below procedure is conducted. The Wall Licensee is responsible for the cost of the subsequent testing described below.

1. The Additional Element with the lowest initial Solar Reflectance in the Color Family Group will be sent to an AITL for testing.
    a. If the product meets the VT passing criteria as described above, the Additional Element can become the new Representative Element, but must undergo three-year aging in accordance with Section 3.7 of this manual. Specimens of the new Representative Element will be prepared, and tested by an AITL. The aged results for all products in the Color Family Group will display as “Pending” on the Directory and CRRC Label until three-year results are available.
    b. If the product does not meet the VT passing criteria, the product and the Color Family Group will be terminated from the Directory. The Wall Licensee may elect to resubmit the Color Family Group with revised test results and a new Representative Element.

S.4.1 AMTL Testing Violations

If an Additional Element that was tested by an AMTL fails VT, the CRRC will note the failure as a violation of the Wall Rating Program requirements. If any Additional Elements from a Color Family Group are selected and fail VT, the AMTL will be placed in an “Under Review” period, during which no new product ratings can be submitted until the laboratory conducts testing on a set of specimens supplied by the CRRC. The test results submitted by the AMTL will be compared with other known test values to ensure the AMTL’s results align with the results provided by other testing entities.

If an additional five (5) products are subsequently selected and fail VT and the Wall Licensee cannot provide sufficient data to support that they should pass VT, the AMTL will be suspended from the CRRC Wall Rating Program and will not be eligible to submit any new product ratings for a period of twelve (12) months. Reinstatement will be subject to the discretion of the CRRC Board. The AMTL may be subject to a reinstatement fee.

APPENDIX 2: COLOR FAMILY POLICIES AND PROCEDURES

1.0 Scope
These procedures describe the process to establish a Color Family Group (also see S.3.3 of Appendix 1 of this manual) for a given Architectural Coating Wall Product or Factory-Applied Coating Wall Product product line through the CRRC Color Family Program and the subsequent inclusion of Color Family Additional Elements to a Color Family Group. This procedure is limited to Architectural Coating Wall Products and Factory-Applied Coating Wall Products, which have thousands of color options available to consumers, making it cost-prohibitive for Wall Licensees to seek standard product ratings on every available color.

A Wall Licensee that manufactures or sells Architectural Coating Wall Products or Factory-Applied Coating Wall Products may also rate products using the Standard Wall Product rating at any time; the Color Family procedures are an optional pathway to streamline the rating process for hundreds or thousands of colors.

2.0 Accredited Manufacturer Test Laboratories
The test results for Color Family Additional Elements may be submitted to the CRRC by an Accredited Manufacturer Testing Laboratory (AMTL) or an Accredited Independent Testing Laboratory (AITL).

All AMTLs are subject to the requirements described in Chapter 2.0 of this manual. The CRRC will not accept test results for Color Family Representative Elements or for Standard Products from an AMTL, only an AITL.

3.0 Establishing a Color Family Group
Multiple Color Families are defined within the L,a,b color space, using CIE or Hunter coordinates, for Architectural Coatings Wall Products and Factory-Applied Coating Wall Products, respectively. The Color Families are defined in Table 1 and Table 2, below. A Wall Licensee may elect to establish one or more Color Family Groups within a Color Family. All members of a Color Family Group must be a part of the same Product Line and fall within the same Color Family parameters shown in Table 1 or Table 2. If a product falls outside the L,a,b ranges provided in Table 1 and Table 2, the product must be rated as a Standard Wall Product. Only one gloss level needs to be submitted for testing for products that are available in multiple gloss levels.

3.1 Rating Process for Establishing a Color Family Group

1. The Wall Licensee will submit product testing data for all products in the Color Family Group, whether tested by an AITL or AMTL. The CRRC will review the product data and select the product that will act as the Color Family Representative Element for the establishment of a Color Family Group. The Color Family Representative Element must have the lowest Solar Reflectance of all of the products that will be included in the Color Family Group. If more than one product has the lowest Solar Reflectance, the product that has the lowest Thermal Emittance will be the Representative Element. If more than one product has the lowest Solar Reflectance and Thermal Emittance, the product with the lowest L value will be the Representative Element.
    a. Note: The product with the lowest Solar Reflectance typically correlates to the product with the lowest Light Reflectance Value (LRV) and highest pigment loading in that Color Family.
2. The Wall Licensee shall prepare the appropriate number of Specimens of the Representative Element, following the requirements described in Section S.3.3 of Appendix 1 of this manual and submit the Specimens to an AITL for testing.

3. The AITL shall conduct Solar Reflectance, Thermal Emittance, and colorimetry testing and report the results in accordance with Appendix 1 of this manual.
4. The CRRC will review the initial test results. As soon as the initial test results are approved by the CRRC, a unique CRRC ID number will be assigned to the product and the product rating will be appear on the Directory. If Color Family Additional Element applications were submitted at the same time as establishing the Color Family Group, the CRRC will review and approve those applications at this time. The Wall Licensee is also eligible to submit additional Color Family Additional Element ratings, as described below.
5. After the AITL submits the test results to the CRRC, the AITL shall send the Specimens to an Approved Test Farm for three-year natural exposure in accordance with Chapter 3.0 and Appendix 1 of this manual.
6. The remainder of the rating process shall follow the process for a Standard Product rating.

4.0 Submitting Color Family Additional Elements

A Wall Licensee may submit Color Family Additional Elements to an established Color Family Group after the CRRC has approved the initial test results for the Color Family Representative Element that has established that Color Family Group.

4.1 Rating Process for Adding Additional Elements to a Color Family Group

1. The Wall Licensee shall prepare the appropriate number of Additional Element specimens in accordance with Section S.3.3 of Appendix 1 of this manual.
2. Either an AMTL or AITL shall conduct colorimetry testing as described in Section S.3.3 of Appendix 1 of this manual. If the product does not fall within the Color Family L,a,b ranges for the established Color Family Group, the product is not eligible for a Color Family rating; it will need to be rated as a Standard Product.
3. Either the AMTL or AITL shall conduct initial Solar Reflectance and Thermal Emittance testing and report the results in accordance with Chapter 3.0 and Appendix 1 of this manual. For Architectural Coating products, thickness testing must also be conducted in accordance with Chapter 3.0 and Appendix 1 of this Manual. The initial tested Solar Reflectance of the Color Family Additional Element shall be equal to or greater than the initial Solar Reflectance of the Color Family Representative Element.
    a. Note: If the Solar Reflectance of the Color Family Additional Element does not meet or exceed the initial Solar Reflectance of the Color Family Representative Element, the Additional Element is not eligible for inclusion in the Color Family Group.
4. If all requirements are met, the Additional Element will be added to the Color Family Group on the Directory. Once approved by the CRRC, the measured initial Solar Reflectance and Thermal Emittance values of the Additional Element will be published on the Directory. The Additional Element will inherit the aged Solar Reflectance and Thermal Emittance values of the Representative Element.

Table 1. Wall Rating Program Color Families for Architectural Coating Wall Products

Color Family Name	Typical LRV Ranges*	CIE L range	CIE a range	CIE b range
Muted Dark Colors	0 to 14.99	0 to 45	-14.99 to 19.99	-15.99 to 24.99
Muted Medium Colors	15 to 35	45.1 to 65	-14.99 to 19.99	-15.99 to 24.99
Blues	4 to 35	25 to 65	-50 to 19.99	-100 to -16
Muted Yellows & Greens	15 to 45	25 to 65	-14.99 to 19.99	25 to 49.99
Bright Yellows & Oranges	25 to 85	55 to 100	-50 to 50	50 to 100
Greens	5 to 35	25 to 65	-100 to -15	-15.99 to 49.99
Reds & Purples	5 to 35	25 to 65	20 to 100	-40 to 50
Pastels (Medium)	33 to 60	65.01 to 79.99	-50 to 49.99	-35 to 49.99
Pastels (Light) and Whites	54 to 100	80 to 100	-35 to 35	-35 to 49.99

*** For Reference Only**

Table 2. Wall Rating Program Color Families for Factory-Applied Coating Wall Products

Color Family Name	Hunter L range	Hunter a range	Hunter b range
Red	17 to 29	7 to 36	0 to 15
Terra Cotta	20 to 38	15 to 30	6 to 16
Bright Red	23 to 38	35 to 49	10 to 48
Beige / Off-White	59 to 86	-5 to 5	-3 to 23
Tan	51 to 65	-2 to 7	6 to 21
Dark Blue	13 to 35	-7 to 6	-25 to -2
Medium To Light Blue	34 to 55	-12 to -3	-25 to -8
Dark Brown	17 to 30	-1 to 9	0 to 10
Medium To Light Brown	25 to 58	-2 to 17	2 to 26
Dark Green	18 to 45	-20 to -3	-25 to 11
Medium To Light Green	24 to 70	-20 to 0	-25 to 11
White	76 to 89	-3 to 2	-3 to 10
Bright White	>85	-3 to 1	-3 to 6
Black	<26	-1.5 to 1.5	-1.5 to 1.5
Dark Grey	24 to 42	-4 to 2	-8 to 4
Medium To Light Grey	40 to 77	-4 to 3	-3 to 8
Pearlescent Colors	25 to 75	-15 to 17	-15 to 24

APPENDIX 3: STANDARD TEST METHOD FOR DETERMINING THE DIRECTIONAL-HEMISPHERICAL SOLAR REFLECTANCE OF MATERIALS USING A DIRECTIONAL-HEMISPHERICAL PORTABLE REFLECTOMETER

1. Scope

1.1. This test method covers a technique for determining the directional-hemispherical Solar Reflectance of materials in a laboratory or in the field using a commercial portable Reflectometer. The purpose of the test method is to evaluate the reflectance properties of surfaces exposed to solar radiation.

1.2. This test method is applicable to Specimens of materials having both specular and diffuse optical properties.

1.3. This technique is supported by comparing Reflectometer measurements with those using ASTM E903-12 test method for Solar Reflectance using integrating spheres.

1.4. This test method refers to applications using standard solar spectral irradiance functions but may be applied using alternative weighting functions if the source and details are reported.

1.5. *This standard does not purport to address the safety concerns, if any, associated with its use. It is the responsibility of the user to establish appropriate safety and health practices and determine the applicability of regulatory limitations.*

2. Referenced Documents

2.1. ASTM Standards:

2.1.1. C1549-16 Standard Test Method for Determination of Solar Reflectance Near Ambient Temperature Using a Portable Solar Reflectometer

2.1.2. C1864-17 Standard Test Method for Determination of Solar Reflectance of Directionally Reflective Material Using Portable Solar Reflectometer

2.1.3. E903-12 Standard Test Method for Solar Absorptance, Reflectance, and Transmittance of Materials Using Integrating Spheres

2.1.4. E490-14 Standard Solar Constant and Zero Air Mass Solar Spectral Irradiance Tables

2.1.5. E891-92 Tables for Terrestrial Direct Normal Solar Spectral Irradiance Tables for Air Mass 1.5

2.1.6. G173-12 Standard Tables for Reference Solar Spectral Irradiances: Direct Normal and Hemispherical on 37° Tilted Surface

2.1.7. G197-14 Standard Table for Reference Solar Spectral Distributions: Direct and Diffuse on 20° Tilted and Vertical Surfaces

2.2. Additional References:

2.2.1. Levinson, R.; Akbari, H.; Berdahl, P.; "Measuring Solar Reflectance-Part I: Defining a metric that accurately predicts solar heat gain," *Solar Energy* **84**, 1717-1744 (2010).

2.2.2. Gueymard, C.; "Simple Model of the Atmospheric Radiative Transfer of Sunshine (SMARTS) 2.9.5." <http://www.nrel.gov/grid/solar-resource/smarts.html>.

3. Terminology

3.1. Definitions – The definitions in ASTM C1549-16, ASTM E903-12, and Levinson *et al.* (2010) are applicable to this method.

3.2. Definitions of terms specific to this standard:

3.2.1. Directional-hemispherical reflectance – ratio of the total energy reflected into the subtending hemisphere to the energy incident on the surface from a given direction.

3.2.2. Directional-hemispherical in-band reflectance – directional-hemispherical reflectance for a given wavelength band (i.e., measured by a given detector).

3.2.3. Solar spectral irradiance – power of electromagnetic radiation received from the Sun per unit area as a function of wavelength.

3.3. Symbols:

3.3.1. λ – Wavelength of light, nm.

3.3.2. R_{solar} – Directional-hemispherical Solar Reflectance, dimensionless.

3.3.3. $R_{in\text{-}band,j}$ – Directional-hemispherical in-band reflectance measured by detector *j*, dimensionless.

3.3.4. $\rho(\lambda)$ – Directional-hemispherical spectral reflectance, dimensionless.

3.3.5. $\imath(\lambda)$ – Solar spectral irradiance, $W/m^2 \cdot nm$.

4. Summary of Test Method

4.1. This test method uses a commercial portable Reflectometer to characterize the directional-hemispherical Solar Reflectance of a material. The test Specimen is illuminated at 20° from normal and the directional-hemispherical reflectance is measured in seven wavelength bands from approximately 335 to 2,500 nm utilizing an integrating sphere equipped with an array of detectors and filters.

4.2. The instrument's software calculates the directional-hemispherical Solar Reflectance or absorptance by taking a weighted average of the directional-hemispherical in-band reflectances using a standard or custom solar spectral irradiance as the weighting function.

5. Significance and Use

5.1. Exposure to solar radiation is primary concern for construction materials, aerospace vehicles, solar power devices, and any application where a surface is exposed to solar radiation. The property called "Solar Reflectance" is defined as the fraction of incident solar radiation reflected by a surface.

5.2. This test method is designed to provide reproducible data in the field or in the lab. Use this method to compare results among laboratory or field facilities, compare results from different times by the same facility, or compare data obtained on different materials. This method can be used to monitor changes in directional-hemispherical Solar Reflectance due to aging, exposure, or other dynamic processes.

5.2. Directional-hemispherical Solar Reflectance affects the heat balance of the building envelope and the performance of solar energy systems, including photovoltaic devices and solar thermal energy collectors.

5.3. Directional-hemispherical Solar Reflectance is critical for the thermal control of spacecraft and the solar power of extraterrestrial systems.

5.4. This test method provides a means for determining directional-hemispherical Solar Reflectance for both terrestrial and extraterrestrial conditions using either standard solar spectral irradiance or alternative weighting functions.

5.6. This test method is appropriate for smooth and rough materials having both specular and diffuse optical properties. Some structured anisotropic materials may require special consideration because of the azimuthal angular dependence of the reflectance. For such cases, an average directional-hemispherical Solar Reflectance can be determined by making measurements at several orientations (refer to ASTM C1864-17).

6. Apparatus

6.1. This test method applies to directional-hemispherical Solar Reflectance determination with a commercial portable Reflectometer. The instrument utilizes the principles of an integrating sphere for performing optical reflectance measurements in the spectral region of 335 to 2,500 nm. The instrument consists of two units, the Measurement Head and the Command Module (Fig. 1).

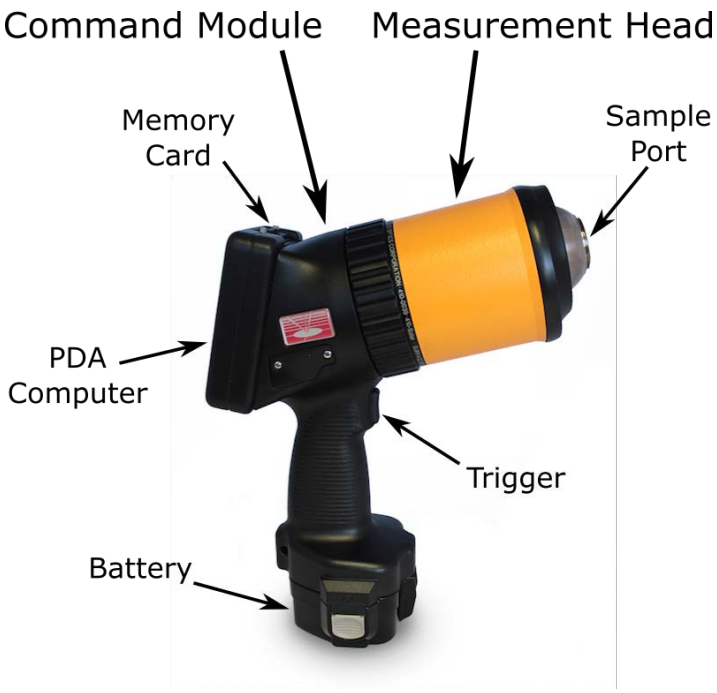

Figure 1. 410-Solar-i Reflectometer by Surface Optics Corporation

6.1.1. Measurement Head – The Measurement Head is constructed around an integrating sphere for measurements of directional-hemispherical reflectance. Light from a tungsten halogen lamp enters the integrating sphere through an internal beam port and illuminates the test Specimen at the sample port at a 20° angle of incidence. The test Specimen scatters light back into the integrating sphere where it is uniformly diffused. A portion of the light reaches the detector arrays which are used to measure the directional-hemispherical in-band reflectance. Optical filters and detector arrays cover seven spectral bands in the wavelength range of 335 to 2,500 nm (335-380, 400-540, 480-600, 590-720, 700-1,100, 1,000-1,700, and 1,700-2,500 nm). A rubber ring protects the measured surface from contact with the metal surface of the integrating sphere and provides a non-skid surface to press against the sample surface.

6.1.2. Command Module – The Command Module provides computer processing, electrical power, and structural support for the Measurement Head. The Command Module housing contains the Trigger, Battery Cartridge, a small Personal Digital Assistant (PDA) type computer, Light Emitting Diode (LED) & Vibrator Motor indicators, Secure Digital (SD) card port, Measurement Head mechanical and electrical connections, Input/Output port, and safety strap. The computer is located at the top of the handle with a

touch screen display that faces the user during operation. The user controls the unit by selecting various software functions from the touch screen interface and pressing the trigger when a measurement is to be made.

6.2. Calibration Coupons – Calibration of the Reflectometer is accomplished with a manufacturer-supplied calibration coupon. The reflectance values of the provided coupon are stored on the supplied SD card. Zero reflectance is measured with no sample present at the sample port of the integrating sphere. The Measurement Head must be pointed away from artificial light sources, such as fluorescent lighting, during the Zero measurement.[i] During the calibration process (and during each sample measurement cycle), the instrument automatically makes an additional measurement of the light beam reflected off a specific location on the wall of the integrating sphere. A ratio of the electrical signal generated by the detector when the beam illuminates the sample to that when the beam illuminates the reference point on the integrating sphere is used in the calculation of sample reflectance values. This normalization process eliminates most of instrument drift that might be caused by thermal or electrical system instabilities.

6.3. Test Specimens – Specimens to be tested can be flat, concave (inner diameter larger than 15 cm), or convex (outer diameter larger than 8 cm), and may have specular or diffuse characteristics. The sample is illuminated with an elliptical spot of about 12 mm at the major axis and 6 mm at the minor axis. The sample port of the integrating sphere is pressed flush against the measured surface, which must have a minimum dimension of 13 mm.

7. Procedure

7.1. Setup – The instrument is powered from a 12 volt battery. The battery must be charged in the manufacturer-supplied battery charger prior to first use. The battery is inserted in the bottom of the Command Module by the user. The instrument is powered up by pressing the trigger located at internal top of the handle. The instrument boots to the Main Operation menu displayed on the computer screen. The user can adjust various parameters through the **Setup** menu. The instrument shall be calibrated after at least 5 min. of warm-up time.

7.1.1. Calibration Setup – The **Calibration Setup** menu contains the known reflectance values of the calibration coupon. These values are provided by the manufacturer and must match the supplied calibration coupon.

7.1.2. Device Setup – The **Device Setup** menu contains various device parameters which alter the performance conditions of the instrument. The factory settings are appropriate for most measurements. Most commonly, the user might adjust Points (number of readings averaged during one measurement), Cal X (number of repetitions during calibration procedure), and Sample X (number of measurements used to generate statistics).

7.2. Calibration – From the main menu, press **Calibration** to display the Calibration screen. The computer screen guides the user through the calibration process using the calibration coupon. The coupon requires a set of calibration values, which are entered under the Calibration Setup menu and are stored in a file on the SD card. The name of the current calibration file is displayed at the top of the calibration screen. To select a different calibration file, press the button with the calibration name, make selection. Remove the sample port cap from the integrating sphere and hold the calibration coupon flat against the sample port and press the trigger. Continue to hold the coupon over the sample port during the measurement. The LED and vibrator motor will indicate that the measurement step is complete. Remove the calibration coupon from in front of the sample port and press the trigger with nothing blocking the sample port (do not aim at fluorescent lights). The LED and vibrator motor will indicate that the calibration is complete. Press the back arrow at the bottom of the screen to return to the Main Menu. Repeat the calibration procedure every time the instrument is turned on and after extreme changes in the environment (e.g. temperature, humidity).

7.3. Measurement – Press the **Measurement** button on the Main Menu screen. All data taken with the 410-Solar-i are saved into a data file (*.ems) and stored on the SD card. The file name is displayed on the grey button under the screen title. The sample name is indicated on the second button. To change the file

name and/or the sample name press the appropriate button. The software keeps a list of the data files on the card. Take the unit to the surface to be tested. Press the sample port tight against the measured object and press the trigger. Continue to hold the sample port against the measured surface while the measurement is taken and the hourglass indicator is shown. To indicate that the measurement is finished, the hourglass will disappear, the LED in the upper left-hand corner of the PDA housing will light, and the handle will vibrate. The measurement results are saved and displayed in a column on the PDA screen. The graphical representation of the data can be viewed by pressing the Graph button. Each reflectance value is plotted at the measured value across the entire spectral band. The instrument can be pre-set to display either directional-hemispherical Solar Reflectance or absorptance, this setting is done in the Device Setup. To view the directional-hemispherical Solar Reflectance value, press the ρ (rho) button at the bottom of the screen. Under that screen the solar spectral irradiance can be selected.

7.4. Calculation – Before a test is performed, press the small button marked "[n]x" to enter the number of readings to be performed and averaged. Upon completion of the first reading, the color of the [n]x button changes from black to red, the number of measurements is lowered by 1, and the reflectance values and directional-hemispherical Solar Reflectance are displayed. Continue taking measurements until the color of the button changes back to black. The screen will then display a column of averaged reflectance values and the standard deviation for each of those values. The averaged directional-hemispherical Solar Reflectance and its standard deviation are also displayed. All values are automatically stored on the SD card.

7.5. Directional-Hemispherical Solar Reflectance – The instrument measures the directional-hemispherical reflectance of a test Specimen in each of the seven spectral bands listed in Section 6.1.1. Directional-hemispherical spectral reflectance ρ(λ) is estimated as a simple step function from the seven directional-hemispherical in-band reflectances. Directional-hemispherical Solar Reflectance R_{solar} is computed as the weighted average of the directional-hemispherical spectral reflectance, where the solar spectral irradiance ı(λ) is the weighting function. That is,

$$R_{solar} = \frac{\int_{\lambda_1}^{\lambda_2} \rho(\lambda) \times i(\lambda)\, d\lambda}{\int_{\lambda_1}^{\lambda_2} i(\lambda)\, d\lambda} \quad (1)$$

where the limits 1 and 2 are 250 and 2,500 nm. Note, the reflectance from 335 nm is linearly extrapolated out to 250 nm for this calculation.

7.5.1. Solar Spectral Irradiance – The user can select one of the standard solar spectral irradiances provided with the instrument or their own custom weighting function via the **Solar Irradiance** drop-down menu located in the **Directional-Hemispherical Solar Reflectance** screen. Standard solar spectral irradiances are denoted using the same initialism as Levinson *et al.* (2010). For terrestrial applications use E891BN (ASTM E891-92), AM1GH (Gueymard, 2006), G173GT (ASTM G173-12), G197GT20 (ASTM G197-14), G197GT90 (ASTM G197-14), or AM1.5GH (Gueymard, 2006). For extraterrestrial applications use AM0 (ASTM E490-14). Custom weighting functions are added as a *.jfn file to the **Program** directory on the SD card.

7.6. Evaluation of a Surface – Quantify the variability of the directional-hemispherical Solar Reflectance with position on a test Specimen by measuring three or more locations on the surface.

8. Report

8.1. Reporting requirements shall be in accordance with ASTM C1549.

9. Precision and Bias

9.1. Precision – Precision statistics were determined for SOC 410-Solar-i portable Reflectometer measurements of the 26 materials shown in Table 1. The samples include roofing materials and paints. Here, "panel" refers to a smooth rectangular metal sheet as the base material and "shingle" refers to a

rough rectangular felt mat as the base material. Based on the standard deviation of those measurements, the precision was found to be within 0.02 reflectance units (scale of 0 to 1).

9.2. Bias – Directional-hemispherical Solar Reflectance values calculated using the air mass 1.5 global tilt solar spectral irradiance specified by ASTM G173-12 were obtained for 26 materials using ASTM E903-12. These measurements were used to assess the bias of the SOC 410-Solar-i from ASTM E903-12 which is shown in Table 1. The 410-Solar-i test method yields directional-hemispherical Solar Reflectance results that are 0.004 higher than those obtained with ASTM E903-12.

Table 1. Comparison of directional-hemispherical Solar Reflectance measurements on 26 samples using the SOC 410-Solar-i portable Reflectometer and a spectrophotometer operated according to E903-12. Directional-hemispherical Solar Reflectance values are calculated using the air mass 1.5 global tilt solar spectral irradiance specified by ASTM G173-12.

Coating	Cary 5000	410-Solar-i
White Knight Plus on Panel	0.82	0.82
White Knight Plus on Shingle	0.80	0.80
Pyramic on Panel	0.82	0.80
Pyramic on Shingle	0.82	0.81
White Coating	0.84	0.84
TPO	0.77	0.76
Beige Acrylic	0.69	0.70
Aluminized Shingle	0.64	0.64
EPDM	0.16	0.15
Shingle	0.17	0.17
Silver Shadow	0.27	0.28
Red Metallic	0.45	0.46
Duke Blue	0.30	0.31
Saffron Metallic	0.49	0.50
Ultra Cool Pewter	0.41	0.43
Russet Metallic	0.29	0.30
Nike Orange	0.51	0.53
Sandstone	0.58	0.58
Copper	0.43	0.44
Aged Copper	0.29	0.30
Zinc Yellow	0.66	0.68
Matte Black	0.09	0.09
Decisive Yellow	0.71	0.73
Seekonk Purple	0.24	0.23

Regal White	0.73	0.73
Weathered Zinc	0.29	0.30

10. Keywords

10.1. portable; handheld; Reflectometer; solar; spectral; reflectance; directional; hemispherical; ultraviolet; visible; near infrared;

11. Suitable Practices

11.1. Do not overreach. Always keep proper footing and balance.

11.2. Be sure that no one is below when using the unit in high locations.

11.3. Use of the lanyard is encouraged but do not carry the unit using only the lanyard.

11.4. Do not drop, shake, or strike the unit.

11.5. Do not remove the two screws in the factory diagnostics port cover. Removal of the screws or cover or accessing the port will void the warranty.

11.6. Be careful not to scratch or physically damage the screen.

11.7. Protect against electrostatic discharge.

11.8. Do not store at temperatures below -25 °C (-13 °F) or above 70 °C (158 °F).

11.9. Warm unit to at least 0 °C (32 °F) for two hours before using if stored below 0 °C (32 °F).

11.10. Do not operate at ambient temperatures below 0 °C (32 °F) or above 50 °C (122 °F).

11.11. The integrating sphere is a critical component of the instrument. Care should be taken to avoid contaminating the integrating sphere. When possible, make measurements pointing the Reflectometer downwards.

11.12. Replace the sampling port cap when not taking measurements to minimize contamination of the integrating sphere.

11.13. Use the storage container or another airtight barrier when not in use.

11.14. Avoid working in heavy fog, snow, or rain, or under conditions of blowing dust.

11.15. Avoid placing the 410 on any surface covered with movable dust or dirt, such as the ground or floor.

11.16. Do not put any objects or solvents inside the integrating sphere. Do not blow air into the integrating sphere including electronics cleaning products.

11.17. The surface of the calibration coupon should be protected from scratches and contamination. Do not touch the surface of the calibration coupon.

11.18. Always cover the calibration coupons and put away immediately after calibration is complete. Replace the calibration coupon if it becomes damaged or contaminated.

[i] A chopper modulates the light source at ~100 Hz. The electrical signals generated by the detector are filtered via lock-in amplification such that the only signals extracted are those modulating at the reference frequency (100 Hz). Artificial light sources, such as fluorescent lighting, can flicker close to this frequency and contribute to the measurement.

P026 - 701.4.3
INSULATION AND AIR SEALING

Stay Away from Foil-Faced Bubble Wrap

This R-1 product can be used to make Halloween costumes, but should never be used as insulation

By Martin Holladay | March 21, 2014

View Gallery 8 images

Most brands of foil-faced bubble wrap are only 3/8 inch thick or less, and have an R-value of only 1.0 or 1.1. Since the product often costs more per square foot than 1-inch thick rigid foam rated at R-5, why would anyone use bubble wrap as insulation?

The R-value of foil-faced bubble wrap is so low that it has few, if any, advantages over rigid foam. Of course, the product's foil facing can be used as a radiant barrier — but if you want a radiant barrier, cheaper products are available. (The bubble wrap layer is unnecessary, since it adds cost to the material without adding any useful thermal performance.)

Exaggerated R-value claims

Since the main benefit from foil-faced bubble wrap is due to its radiant-barrier facing, the product is basically worthless unless it faces an air space. A decade ago, when I was the editor of *Energy Design Update*, I noticed that many manufacturers of foil-faced bubble wrap were promoting their products for use under concrete slabs on grade. In this application, the shiny foil is clearly not facing an air space, so the exaggerated R-value claims made by bubble-wrap manufacturers were particularly outrageous. My article exposing the bubble-wrap scammers appeared in the September 2003 issue of *EDU*.

RELATED ARTICLES

Understanding R-Value

Is Bubble Wrap Duct Insulation a Good Idea?

In that article, I reported that one manufacturer, WE International, made absurd claims about a thin (5/16-inch) product called Concrete Barrier rFoil. The manufacturer's website boasted, "Concrete Barrier can serve three

a Good Idea?

Radiant Barriers: A Solution in Search of a Problem

Are Bubble Wrap R-Value Claims Accurate?

The Foil-Faced Bubble Wrap Sham

purposes underneath concrete: R-10 insulation, a vapor barrier and a radon barrier. ... How does it compare to 2-inch foam board? It works just as well."

Similarly, Insulation Solutions, the manufacturer of a 3/8-inch thick product called Insul-Tarp, claimed that the flexible tarp has an "R-value equivalent" rating of R-5 to R-10.

After these lies were publicized, three manufacturers wrote letters to *EDU* apologizing for the "oversights" and "typographical errors" that appeared on their websites.

Blurring the line between product R-values and assembly R-values

Many of the manufacturers and distributors that publish exaggerated R-values deliberately blur the bright legal line that separates product R-values from assembly R-values.

According to federal law, the R-value of an insulation product — for example, a piece of 1-inch thick polyisocyanurate — is the R-value of the insulation alone. That's the R-value which insulation manufacturers are required to report on their packaging and in their advertising; the requirement is spelled out in the Federal R-Value Rule, a law that applies to manufacturers, retailers, and builders.

The R-value of a *building assembly* is something different. For example, if you build a wall with a layer of interior polyisocyanurate, followed by horizontal 1×4 strapping and drywall, the air space between the polyiso and the drywall has a measurable R-value. If you want to calculate the R-value of the entire wall assembly, you would need to calculate the R-value of the air space and add that R-value to the R-value of all the other layers. Once you've done that, you'll know your wall assembly R-value.

Here's the key point: polyiso manufacturers can't claim the R-value of an air space in their labeling or advertising (unless the advertising makes a very clear distinction between the product R-value and the R-value of a hypothetical

distinction between the product R-value and the R-value of a hypothetical building assembly).

Product distributors are violating federal law

Fortunately, most (but not all) manufacturers of foil-faced bubble wrap have removed the blatant lies from their websites. Instead, manufacturers tempt the unwary with vague promises; for example, they claim that their bubble wrap "has a high R-value" or that it "resists the transfer of heat."

The scoff-law websites with the greatest number of lies about foil-faced bubble wrap are those maintained by distributors — including a few large corporations like Home Depot, Ace Hardware, and Amazon — rather than those maintained by manufacturers.

For example, Amazon claims that a type of foil-faced bubble wrap product manufactured by EcoFoil ("HVAC Duct Wrap Insulation") has an R-value of R-8. But a careful reading of the manufacturer's technical data sheet and the referenced ICC-ES Evaluation Report reveals that the R-8 value claim is based on an assembly that includes the R-value of a 2-inch air space.

Similarly, Ace Hardware is advertising Reflectix, an R-1 foil-faced bubble wrap product, with a blurb that claims that the product has "R-values ranging from R-3.7 to R-21."

That's a little like Starbucks saying that a cup of coffee is a satisfying meal — as long as you remember to accompany the coffee with a 12-inch submarine sandwich (not included).

Yes, a few manufacturers are still lying

Although the major manufacturers of foil-faced bubble wrap have (almost) cleaned up their act, some still include exaggerations on their websites.

FUN QUOTES

"Last September, the editors of Energy Design Update *(EDU) questioned the astounding claims for R-value made by various manufacturers and*

One manufacturer that trumpets exaggerated R-values is EcoFoil (a.k.a. rFoil, a.k.a. Covertech Fabricating). The EcoFoil website describes the company's duct wrap as an R-8 product, even though the R-8 claim is based on an assembly that includes an adjacent air space. The company also claims that

various manufacturers and distributors of foil-faced bubble pack insulation. Curiously, the November issue of EDU was full of qualifications from manufacturers, down-rating their R-value claims. To help resolve these competing claims, Canada Mortgage and Housing Corporation (CMHC) decided to fund a quick study on the actual installed performance of foil bubble pack and competing subslab insulations. ... The foil bubble pack tested was next to useless as subslab insulation."
— Foil Bubble Pack: Subslab Insulation?

"The bubble-pack insulation had a low insulating value compared to the polyurethane panels and the XPS board. Its cost benefit was the poorest of all insulating materials tested."
— Canada Mortgage and Housing Corporation research report

"Manufacturers of reflective bubble pack insulations have claimed R-values for 5/16" thick duct wrap as high as 5.6. Independent testing of some manufacturers' products has shown that the actual R-value is approximately 1.1 when the product is tested in accordance

space. The company also claims that "EcoFoil [foil-faced bubble wrap] under concrete insulation is superior to traditional, outdated forms of concrete floor insulation such as polystyrene or foam sheets." This statement is false.

Elsewhere, EcoFoil claims that its 5/16-inch-thick bubble wrap product, which is called "Under Concrete Insulation," has an R-value of R-3.8. It does not.

Another bad apple is Insulation4less, which retails a thin product called Prodex Total. On its website, the company states, "Prodex Total has a nominal thickness of 5 mm (13/64 inch) closed cell polyethylene foam covered on both sides with .0012 (00.03 mm) aluminum foil facing. ... R-value R-16 unaffected by humidity."

Prodex may be unaffected by humidity — but it is seriously affected by gross exaggeration.

These are not examples of victimless crimes; there are victims. One victim is a blogger who reports using this sub-slab assembly: "In basement, install Insul-Tarp over crushed rock, single layer of wire mesh, and Wirsbro [hydronic] tubing, pour concrete (pump hose will go through stairwell hole)."

Unfortunately, Insul-Tarp has an R-value of R-2 or less. For years, however, the manufacturer of Insul-Tarp claimed that the product was rated at R-7.44.

with ASTM C 518."
— NAIMA: Facts About the Performance of Reflective Bubble Pack Insulations in Duct System Applications

"We found no basis for the manufacturer's claim of 77% reduction in heat loss due to Ultra CBF rFOIL in an under-slab application. This heat loss reduction significantly exceeds even that of 2-inch extruded polystyrene insulation installed under the full slab, while the insulating value of Ultra CBF rFOIL is much less."
— Washington State University Extension Energy Program

that the product was rated at R-7 or more. The blogger who specified Insul-Tarp believed the false claims, which is why he wrote, "This is what the Insul-Tarp looks like. The exterior is some kind of tough fabric, then there are two layers of thin white foam, then a layer of bubble wrap. Hard to believe this can be equivalent of 2 inches of styrofoam."

Indeed, it *is* hard to believe — so hard, in fact, that the Federal Trade Commission initiated court action that forced Meyer Enterprises, the manufacturer of Insul-Tarp, to stop making false claims. According to the FTC complaint, Meyer Enterprises "claimed Insul-Tarp's R-value is 7.54, but in reality Insul-Tarp's R-value could not be more than 2."

Duct insulation scams

These days, most of the remaining confusion about foil-faced bubble wrap concerns duct insulation. As building codes ratchet up — many jurisdictions now require ducts to include R-8 insulation — manufacturers of bubble wrap have switched tactics. Instead of marketing their bubble wrap to concrete contractors, an increasing number of manufacturers are marketing bubble wrap to HVAC contractors as an easy-to-install duct insulation.

Online ads for "R-8 bubble wrap" lure unwary contractors into the marketers' net. Claims that bubble wrap can achieve R-4, R-6, or R-8 when used as duct insulation are based on a rarely attempted installation technique that requires contractors to install a series of spacers to maintain a consistent air space between the duct and the bubble wrap. This type of insulation is fussy and is unlikely to be durable. The manufacturers hardly care whether the assembly works, however, since they are basing their sales on obfuscations and contractors' misunderstandings.

Few contractors bother to learn about the difference between product R-values and assembly R-values. A classic example of what's going on at job sites around the country was described in a Q&A thread here at GBA: "Reflectix is still claiming R-4.2 for its bubble wrap, and my HVAC guy is hooked."

The only remedy to these misunderstandings is the drumbeat of education. To stop these scams, energy experts need to educate building inspectors as well as contractors.

Martin Holladay is a retired editor living in Vermont.

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BUILDING ENVELOPE

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P047 & P079 - 802.5 FAUCETS & 11.802.5 A

Calculating Savings For:

Auto-Diverting Tub Spout System with ShowerStart TSV

Troy Sherman
Evolve Technologies
April 9, 2019

This paper presents considerations and calculations for the water savings potential of the Evolve Technologies' Auto-Diverting Tub Spout System with ShowerStart TSV (ADTS). Please note that the calculations contained herein are modeled for the California and Southwestern US markets. Adjustments should be made, primarily to the behavioral waste variable and the other variables on which it is dependent, when making computations for regions outside of those markets.

ADTS Background

There are two methods for drawing hot water to a shower in a tub/shower combination bathroom. The first method is called a showerhead warm-up. This type of warm-up occurs when bathers activate the water flow and immediately divert water from the tub spout to the showerhead while it is still cold - thereby drawing hot water via the showerhead. After the water exiting the showerhead becomes hot, bathers begin showering. Showerhead warm-ups occur in a tub/shower combo bathroom 60% of the time (Sherman 2014 Appendix B – Question 8).

The second method is called a tub spout warm-up. This type of warm-up occurs when bathers draw hot water by having cold water exit the tub spout until hot water arrives. After the water becomes hot, bathers use the tub spout diverter to send water to the showerhead and begin showering. Tub spout warm-ups occur in a tub/shower combo bathroom 40% of the time (Sherman 2014 Appendix B – Question 8).

It is important to consider the significant difference in flow rates for showerhead warm-ups and tub spout warm ups. The average showerhead flows at 2.2 gpm (REUWS 1999) and the average tub spout flows at approximately 5 gpm (assumption). Thermal losses while hot water is traveling through pipes vary significantly depending on the water's velocity.

At showerhead flow rates (2.2 gpm per REUWS 1999) hot water travels at "long bullet" flow and the volume of water that must be purged prior to hot water arriving is 10% to 50% more that the volume of water being held in the pipe (Koeller 2007 – Page 44-45).

At tub spout flow rates (5 gpm) hot water travels at "plug flow" and the volume of water that must be purged prior to hot water arriving is nearly equal to the volume of water being held in the pipe (Koeller 2007 – Page 44-45).

As a result of these dynamics it is reasonable to conclude that showerhead warm-ups have, approximately, a 30% greater volume of water to purge before hot water arrives.

(10% higher flow rate + 50% higher flow rate)/2 = 30% higher flow rate on average

A considerable volume of water is wasted while users are waiting for hot water to arrive. This waste is called warm-up waste and consists of two distinct components; structural waste and behavioral waste.

Structural waste is the volume of water that is wasted while purging the previously heated, but now cold, water from the hot water line before hot water arrives at the point of use. Behavioral waste is the volume of hot water that is wasted before bathers actually begin showering.

Behavioral waste occurs when bathers use their time comfortably and efficiently while waiting for hot water to reach the shower. As a result, they turn on the water and leave to do something else while waiting. When they return the water is hot, but a meaningful volume of hot water is inadvertently wasted while they are away.

By analyzing papers and data from Lawrence Berkley National Lab, (Sherman 2014 – Page 11) determines that behavioral waste occurs for 47 seconds and is 59% of the warm-up waste. Considering this conclusion, structural waste would comprise 41% of the warm-up waste and occurs for 33 seconds.

[(47 seconds of behavioral waste / 59% behavioral waste) – 47 seconds of behavioral waste] = 33 seconds of structural waste

The total warm-up waste lasts for 80 seconds.

33 seconds structural waste + 47 seconds behavioral waste = 80 seconds of total warm-up waste.

Data from Sherman 2014 (Page 10) also indicates that getting hot water more quickly to the point of use does not reduce behavioral waste. As such, it is reasonable to conclude that the duration of time spent away from the shower for both showerhead warm-ups and tub spout warm-ups is consistent at 80 seconds.

Finally it is important to acknowledge the common presence of leaks emanating from tub spout diverters while bathers are showering in tub/shower combination bathrooms. Leaking diverters allow water to flow out of the tub spout while water is being diverted to the showerhead. The leaking water runs down the drain with no benefit to the bather and is wasted.

Field research of 120 tub/shower combination bathrooms by Taitem Engineering in 2011 revealed that 34% of tub spouts have significant leaks and the average of those leaks is .8 gallons per minute (Taitem 2011 – Page 2).

ADTS Theory Of Operation

Evolve Technologies' Auto-Diverting Tub Spout System with ShowerStart TSV (ADTS) functions by making every shower warm-up a tub spout warm-up. This has the dual benefit of delivering hot water more quickly to the point of use (5 gallons per minute vs. 2.2 gallons per minute) and reducing structural waste.

ShowerStart TSV technology is incorporated into the tub spout portion of the product. As result, cold water exits the tub spout until hot water arrives. Once the water becomes hot the integrated ShowerStart TSV shuts off the tub spout's flow and the hot water is automatically diverted to a specialized showerhead. Incorporating the ShowerStart TSV into the tub spout has the added benefit of positively shutting off the flow thereby eliminating the potential for a leaking tub spout.

The specialized showerhead to which the hot water is automatically diverted is a WaterSense 1.5 gpm model with an integrated NC (normally closed) valve. The NC valve causes the specialized showerhead to trickle by default – thereby eliminating behavioral waste. Pulling the specialized showerhead's integrated lanyard allows the bather to bypass the NC valve to begin normal showerhead flow.

Once the bather is finished showering and water flow has been terminated, the ShowerStart TSV integrated into the tub spout and the NC valve integrated into the specialized showerhead automatically reset for their next use.

The default operation for ADTS assumes a shower will be taken. This default operation can be bypassed to allow for baths and cold showers. If by passed the unit returns to its default mode after the bath or cold shower is taken.

A core functionality diagram is available on the following page.

A thermal imaging video of ADTS functionality can be seen by clicking here.

1. Turn water on.

2. Cold water exits tub spout.

3. Tub spout automatically closes once hot water arrives.

4. Hot water is automatically diverted to specialized showerhead (integrated normally closed valve).

5. Specialized showerhead trickles by default so hot water is not flowing until user is ready to shower.

6. User pulls cord to activate specialized showerhead's normal flow and begins showering.

ADTS Savings Calculations

Please note that the calculations contained herein are modeled for the California and Southwestern US markets. Adjustments should be made, primarily to the behavioral waste variable and the other variables on which it is dependent, when making computations for regions outside of those markets.

Evolve Technologies' Auto-Diverting Tub Spout System with ShowerStart TSV (ADTS) is a showering system that saves water by:

- **REDUCING STRUCTURAL WASTE**
  This is the previously heated, but now cold, water that must be purged before hot water arrives.
- **ELIMINATING BEHAVIORAL WASTE**
  This is the hot water that's inadvertently wasted before the user begins showering.
- **PREVENTING TUB SPOUT DIVERTER LEAKS**
  This is the hot water leaking from tub spout while the user is showering.
- **PROVIDING EFFICIENT SHOWERING**
  It uses a specialized 1.5 gpm WaterSense certified showerhead.

To properly calculate the efficiency of ADTS each element should be examined individually by first determining the water savings. Although this paper does not attempt to determine energy savings, they can easily be derived from the water savings based on regional factors including, but not limited to showers per day, occupancy, water inlet temperatures, heating source types, heating source fuels.

Below are considerations and corresponding calculations for determining the average water savings associated with each unique savings element. Various savings scenarios are explored based on qualifications/feasibility for ADTS installation.

Citations have been made in the prior background information to support the calculations. Additionally, as appropriate, notes regarding the water's energy content are included.

Savings are calculated on a per shower basis. Appropriate multipliers should be used to determine household savings based on factors such as average occupancy and showering days per year.

STRUCTURAL WASTE SAVINGS CALCULATIONS

- Calculate the volume of structural waste for showerhead warm-ups

  (33 sec of structural waste/60 sec. per min.) x 2.2 gpm showerhead flow rate = 1.21 gallons

- Determine structural waste savings achieved by warming up through the tub spout due to reduced thermal loss (Koeller 2007 – Page 44-45)

  1.21 gal structural waste through tub spout x 30% savings vs. showerhead warm-up = .363 gallons saved by warming up through tub spout

- The additional .363 gallons saved by warming up through the tub spout should only be added to showerhead warm-ups. This amount will be called the "structural waste reduction benefit".

BEHAVIORAL WASTE SAVINGS CALCULATIONS

New Condition Approach –
This method should be used if savings projections for behavioral waste have been traditionally calculated using the flow rate of the new measure. An example of this approach would be using a 1.5 gpm flow rate to calculate the behavioral waste savings of a 1.5 gpm showerhead with ShowerStart TSV. Because ADTS automatically converts all shower warm-ups to a tub spout warm-up, savings under the New Condition Approach are calculated using 100% tub spout warm-ups.

- Calculate behavioral waste savings for tub spout warm-ups

  [(80 seconds total warm-up waste/60 seconds) x 5 gallons per minute] – 1.21 gallons of structural waste = 5.46 gallons

Weighted Average Approach –
This method might be used if savings projections for behavioral waste have not been traditionally calculated by using the flow rate of the new measure. It considers a weighted average of tub spout to showerhead warm-ups based on pre-installation behavior.

- Calculate behavioral waste savings for showerhead warm-ups

  [(80 seconds of total warm-up waste/60 seconds per minute) x 2.2 gpm flow] – (1.21 gallons of structural waste + .363 gallons structural waste reduction benefit) = 2.09 gallons of behavioral waste savings for showerhead warm-up

- Calculate behavioral waste savings for tub spout warm-ups

  [(80 seconds total warm-up waste/60 seconds) x 5 gallons per minute] – 1.21 gallons of structural waste = 5.46 gallons

- Calculate the weighted average of behavioral waste savings (this is avg. quantity saved)

  (2.09 gallons of behavioral waste from showerhead warm-up x 60% frequency) + (5.46 gallons of behavioral waste from tub spout warm-up x 40% frequency) = 3.5 gallons saved by eliminating behavioral waste

behavioral waste energy content note: *Behavioral waste is the most energy intensive waste because it occurs when the mixing valve is turned to full hot (Lutz 2004 – Page 2). As a result approximately 80% - 85% of the water exiting the showerhead or tub spout is hot water during the behavioral waste event (estimation based on pressure balanced mixing valve functionality).*

ANTI- LEAK TUB SPOUT SAVINGS CALCULATIONS

Replace Leaking Tub Spout Approach -
This method should be used if ADTS is replacing a leaking tub spout.

- 34% of tub spouts leak an average of .8 gpm during the shower (Taitem 2011 – Page 2)

- Determine the amount of time water is leaking from the tub spout during a shower by subtracting the previously calculated warm-up waste numbers (structural waste + behavioral waste) from the REUWS 1999 total average shower volume and then divide by the REUWS 1999 showerhead flow rate volume of 2.2 gpm.

  [(17.2 total shower gallons) - (1.21 gallons of structural waste + 3.5 gallons of behavioral waste)] /2.2 gallons per minute = 5.68 minutes of actual showering time

- Multiply the actual showering time by the leak rate to determined gallons saved

  (5.68 minutes of actual showering time x .8 gallons per minute) = 4.54 gallons saved

Replace All Tub Spouts Approach -
This method should be used if ADTS is replacing a tub spout without pre-qualifying for the presence of a leak.

- 34% of tub spouts leak an average of .8 gpm during the shower (Taitem 2011 – Page 2)

- Determine the amount of time water is leaking from the tub spout during a shower by subtracting the previously calculated warm-up waste numbers (structural waste + behavioral waste) from the REUWS 1999 total average shower volume and then divide by the REUWS 1999 showerhead flow rate volume of 2.2 gpm.

  [(17.2 total shower gallons) - (1.21 gallons of structural waste + 3.5 gallons of behavioral waste)] /2.2 gallons per minute = 5.68 minutes of actual showering time

- Determine the average tub spout leak volume per shower by multiplying actual showering time by the leak rate and then multiplying by the incidence of tub spout leaks.

  (.8 gallons per minute leaking from tub x 5.68 minutes of actual showering time) x 34% incident of leaking tub spouts = 1.54 gallons saved

EFFICIENT SHOWERHEAD SAVINGS CALCULATIONS

1.5 gpm showerhead savings are likely well defined within existing efficiency program databases or technical resource manuals. However a calculation is made below using data from REUWS 1999 and WaterSense testing for Evolve Technologies' most recently certified 1.5 gpm showerhead product.

- Determine the per minute savings for the evolve 1.5 gpm showerhead by taking the average showerhead flow rate from REUWS 1999 and subtracting the average flow rate from WaterSense testing for the evolve showerhead.

  [(2.2 gallons per minute – (1.3 gallons per minute average flow)] = .9 gallons savings per minute

- Determine the per shower savings by multiplying the per minute savings by the showering duration.

  .9 gallons saved per minute x 5.68 minutes of actual showering time = 5.11 gallons saved per shower

ADTS Savings Scenarios

Please note that the calculations contained herein are modeled for the California and Southwestern US markets. Adjustments should be made, primarily to the behavioral waste variable and the other variables on which it is dependent, when making computations for regions outside of those markets.

The following summation compiles savings for the Evolve Technologies Auto-Diverting Tub Spout with ShowertStart TSV (ADTS) based on two savings scenarios.

1. ADTS is installed without verifying the existence of a tub spout leak or the flow rate of the showerhead being replaced.

5.46 gallons	by eliminating behavioral waste using New Condition Approach
1.54 gallons	by eliminating leaking tub spout using Replace All Tub Spouts Approach
5.11 gallons	by providing efficient showering
12.11 gallons	**total saved per shower by ADTS**

2. ADTS is installed in bathrooms that exhibit a tub spout leak, but the flow rate of the showerhead being replaced is not verified.

5.46 gallons	by eliminating behavioral waste using New Condition Approach
4.54 gallons	by eliminating leaking tub spout using Replace Leaking Tub Spout Approach
5.11 gallons	by providing efficient showering
15.11 gallons	**total saved per shower by ADTS**

References – In Order Of Citation

(Sherman 2014) **Disaggregating Residential Shower Warm-Up Waste**

(REUWS 1999) **Residential End Uses of Water Study**

(Koeller 2007) **Evaluation of Potential Best Management Practices – Residential Hot Water Distribution**

(Taitem 2011) **Taitem Tech Tip – Leaking Shower Diverters**

(Lutz 2004) **Feasibility Study and Roadmap to Improve Residential Hot Water Distribution Systems**

(Lutz 2011) **Water and Energy Wasted During Residential Shower Events**

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TEST REPORT

Report Number: 1052-15022

Report Issued: December 28, 2015 **Project No.:** 25405-002

Client: Evolve Technologies, LLC
15354 North 83rd Way, Suite 102
Scottsdale, AZ 85260 **Contact:** Mr. Jason Swanson

Source of Samples: The samples were sent by Evolve Technologies, LLC and received by IAPMO R&T Lab in good condition on December 1, 2015 and December 21, 2015.

Date of Testing: December 2, 2015 through December 22, 2015

Product Description: Tub spout flow-reduction systems (with auto-diverting diverter and with or without showerhead)

Models: *See Page 2*

Scope of Testing: The purpose of the testing was to determine if the samples tested of the tub spout flow-reduction systems met the applicable requirements of IAPMO IGC 244-2015a, entitled, "Tub and Shower Flow-Reduction Systems" and ASME A112.18.1-2012/CSA B125.1-12, entitled, "Plumbing Supply Fittings".

Conclusion: The samples tested of the tub spout flow-reduction systems, models as listed on Page 2, from Evolve Technologies, LLC COMPLIED with the applicable requirements of IAPMO IGC 244-2015a and ASME A112.18.1-2012/CSA B125.1-12.

By our signatures below, we certify that all the testing and sample preparation for this report was performed under continuous, direct supervision of IAPMO R&T Lab, unless otherwise stated.

Tested by,

Wei Hsia (Sherman), Test Technician

Reviewed by,

Andy Ho, Manager, Fitting Testing

WH: ah

Model List:

Model No.	Description
EV3312-CP150-SB	Tub Spout System with SFNC Showerhead, 1.5 GPM, Chrome, Shipper
EV3312-CP200-SB	Tub Spout System with SFNC Showerhead, 2.0 GPM, Chrome, Shipper
EV3322-CP150-SB	Tub Spout System with MFNC Showerhead, 1.5 GPM, Chrome, Shipper
EV3322-CP200-SB	Tub Spout System with MFNC Showerhead, 2.0 GPM, Chrome, Shipper
EV3302-CP000-SB	Tub Spout with Stand Alone Normally Closed Valve, Chrome, Shipper
EV3302-CP000-BP	Tub Spout with Stand Alone Normally Closed Valve, Chrome, Bulk Pkg

Notes:

- Models EV3302-CP000-SB and EV3302-CP000-BP are the same except for packaging.
- The showerhead used in model EV3312-CP150-SB is the same as the listed model EV3011-CP150-SB *(currently c-UPC® listed in File # 5352 and listed to WaterSense in File # 7638)* but with an integral normally-closed (NC) trickle valve instead of a thermostatic shut-off valve (TSV).
- The showerhead used in model EV3312-CP200-SB is the same as the listed model EV3011-CP200-SB *(currently c-UPC® listed in File # 5352 and listed to WaterSense in File # 7638)* but with an integral normally-closed (NC) trickle valve instead of a thermostatic shut-off valve (TSV).
- The showerhead used in model EV3322-CP150-SB is the same as the listed model EV3021-CP150-SB *(currently c-UPC® listed in File # 5352 and listed to WaterSense in File # 7638)* but with an integral normally-closed (NC) trickle valve instead of a thermostatic shut-off valve (TSV).
- The showerhead used in model EV3322-CP200-SB is the same as the listed model EV3021-CP200-SB *(currently c-UPC® listed in File # 5352 and listed to WaterSense in File # 7638)* but with an integral normally-closed (NC) trickle valve instead of a thermostatic shut-off valve (TSV).
- The normally-closed trickle valve doesn't affect the showerhead performance (including the WaterSense testing portion) comparing to the above mentioned listed showerheads that have a thermostatic shut-off valve (TSV). Therefore, no material test and life cycle test were conducted on the showerhead in this report.

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Primary Standards: IAPMO IGC 244-2015a, sections tested / evaluated:

4.2	General	4.5	Automatic Reset
5.1	Life Cycle Test	5.2	Operating Control Test
6	Markings and Accompanying Literature		

ASME A112.18.1-2012/CSA B125.1-12, clauses tested / evaluated:

4.1	Supply Fittings	4.2	Servicing
4.3	Installation	4.4	Threaded Connections
4.5	Other Connections	4.7	Backflow Prevention
4.8	Cover Plates and Escutcheons	4.9	Toxicity and Lead Content
4.11	Shower Heads	4.12	Cross-Flow
5.1	General	5.2	Coatings
5.3	Pressure and Temperature	5.4	Flow Rate
5.5	Operating Requirements	5.6	Life Cycle
5.7	Resistance to Installation Loading	5.8	Resistance to Use Loading
6.0	Markings		

Sections / Clauses of IAPMO IGC 244-2015a and ASME A112.18.1-2012/CSA B125.1-12 not listed above were considered not applicable to subject product.

Test Results: All tests and evaluations were conducted per the written procedures specified in the standards.

IAPMO IGC 244-2015a

4.2 General – COMPLIED

(a) The tub spout flow-reduction systems complied with the applicable requirements of ASME A112.18.1-2012/CSA B125.1-12. *Refer to the ASME A112.18.1-2012/CSA B125.1-12 portion of this report for details.*

(b) The tub spout flow-reduction systems complied with the applicable performance requirements of ASSE 1062-2006. *Refer to the ASSE 1062-2006 portion of this report for details.*

4.5 Automatic Reset – COMPLIED

The flow-reduction device immediately and automatically reset upon completion of a shower or bathing event. The automatic reset feature

(a) was triggered when the operator terminates flow to the device which the flow reduction system is part of; and

(b) returned the device to trickle flow [i.e., between 0.76 and 0.20 L/min (0.20 and 0.05 gpm)] when water in the supply line immediately upstream of the device is 37 °C (99 °F).

5.1 Life Cycle Test – COMPLIED

When tested in accordance with Section 5.1.2 for 15,000 cycles, the test specimen reduced the flow of water to 0.07 gpm (between 0.20 and 0.05 gpm as required) when the water temperature reached 37 °C (99 °F). In addition, the device reset to its maximum flow when the water supply was shut off and reached a temperature of 29 °C (85 °F) or less.

5.2 Operating Control Test – COMPLIED

The operating control of the normally-closed shower head trickle valve of the tub spout flow-reduction systems did not fracture when applied a torque of 15 lbf-in in the manner requried to operate the control.

6.0 Markings and Identification – COMPLIED

6.1 The tub spout flow-reduction systems were permanently marked with the manufacturer's name "evolve" on the spout and the maximum flow rate on the showerhead.

6.2 The markings were permanent, legible and visible after installation.

Note: The maximum flow rate marking requirement is not applicalbe to models EV3302-CP000-SB and EV3302-CP000-BP since they are not provided with a showerhead and are not intended to be used to limit the flow.

ASME A112.18.1-2012/CSA B125.1-12

4.1 Supply Fittings

4.1.1 Rated Pressure – COMPLIED

4.1.1.1 The tub spout flow-reduction systems were designed for a rated pressure of 100 psi.

4.1.1.2 The tub spout flow-reduction systems were designed to function at a supply pressure between 20 psi and 125 psi.

4.1.2 Rated Temperatures – COMPLIED

The tub spout flow-reduction systems were designed for rated supply temperatures from 40 °F to 160 °F.

4.2 Servicing – COMPLIED

The tub spout flow-reduction systems were designed so that the replacement of wearing parts could be accomplished without removing the fitting from the supply system, without removing the piping from the body, without disturbing the finished wall, and by using standard tools or manufacturer provided tools.

4.3 Installation – COMPLIED

A method of sealing between the fitting and the fixture to which it is fastened was provided.

4.4 Threaded Connections – COMPLIED

4.4.1 The ½" (female inlet and male outlet) and ¾" (female inlet) NPT pipe threads complied with ASME B1.20.1.

4.4.9 The showerheads were capable of being connected to a ½" NPT male thread.

4.5 Other Connections – COMPLIED

4.5.4 The ½" and ¾" slip-fit joints met the performance requirements of this Standard.

4.7 Backflow Prevention – COMPLIED

The tub spout flow-reduction systems were designed to prevent backflow as required by an air gap when evaluated per Clause 5.9. *Refer to Clause 5.9.*

4.8 Cover Plates and Escutcheons – COMPLIED

4.8.2 The minimum diameter of the escutcheon was 3.62". The minimum requirement was 1.73".

4.9 Toxicity and Lead Content

4.9.1 NSF/ANSI 61-9 – NOT APPLICABLE

The NSF/ANSI 61-9 test is not applicable to shower fittings.

4.9.2 Metal Alloys – COMPLIED

All metal alloys in contact with potable water contained less than 8% lead as required.

Findings: The brass spout inlet adapters contained 2.028% lead, spout shaft contained 3.138% lead, spout shaft fitting contained 2.654% lead, sensing element contained 0.170% lead, NC valve body contained 2.023% lead, NC valve ½" NPT inlet fitting contained 2.295% lead, and NC valve inner body fitting contained 3.346% lead. The zinc spout body contained 0.025% lead. The stainless steel sensing element fitting and spring contained 0.000% lead. No solder and flux were used.

4.9.3 NSF/ANSI 372 – NOT APPLICABLE

The NSF/ANSI 372 test is not applicable to shower fittings.

4.11 Shower Heads

4.11.1 General – COMPLIED

The flow-restricting insert of the showerheads was mechanically retained at the point of manufacture to withstand a removal force of not less than 8.0 lbf (36 N).

Note: The flow restrictor which is inserted in the ball joint can't be accessible without disassembling the showerhead.

4.11.2 High-Efficiency Shower Heads – NOT APPLICABLE

The supplied showerheads were not designated as a high-efficiency type.

4.12 Cross-flow – COMPLIED

The flow-control device *[normally-closed (NC) trickle valve]* did not completely shut off the flow of water.

5.1 General – FOLLOWED

Before testing, specimens were conditioned at ambient laboratory conditions for not less than 12 h. All applicable tests were conducted in accordance with Table B.1 of this standard.

5.2 Coatings *(Chrome Finish)*

5.2.1 General – COMPLIED

The significant surfaces of the coated components were free of surface defects and uncoated areas, and were not stained.

5.2.2 Corrosion – COMPLIED

After being subjected to the corrosion test of ASTM B117 (neutral salt) for Service Condition 2 for 24 h as specified in Clause 5.2.2.2.1, the coating did not show more than one surface defect in any 1.0 in^2 area of the significant surface or up to three surface defects on a 1.0 inch length of parting line. The surface defects were not larger than 0.03 inch any dimension.

5.2.3 Adhesion – COMPLIED

5.2.3.2 The coating on metals met the grind-saw test requirements as defined in ASTM B 571.

5.2.3.3 The coating on plastics met the following thermal cycling test requirements when tested per Clause 5.2.3.3.2.

a) No surface defects such as cracks, blisters, peeling, or discoloration on significant surfaces.
b) No cracks longer than 0.25 in with a loss of adhesion between the base material and the coating.
c) No blisters exceeding 0.01 in^2 in area within 0.25 inch of an injection point.
d) No warpage affecting the performance of the fitting or component.

5.3 Pressure and Temperature

5.3.1 Static and Dynamic Seals – COMPLIED

The seals of the tub spout flow-reduction systems did not leak or otherwise fail when tested in accordance with Clauses 5.3.1.3 and 5.3.1.4 of the standard. The test pressure was applied at 20 psi and 125 psi for 5 minutes each with the spout in closed position.

Note: The showerheads of the tub spout flow-reduction systems were tested with flowing pressures as the outlet is difficult to block.

5.3.6 Diverters – COMPLIED

The rate of leakage out of the tub spout of the bath and shower diverter did not exceed 0.1 gpm when tested in accordance with Clause 5.3.6.1.2.

Finding: The rate of leakage out of the spout was 0.0 gpm.

5.4 Flow Rate – COMPLIED

5.4.1 The tub spout flow-reduction systems met the flow rate requirments as specified in Table 1, at the temperatures and flowing pressures specified in Clause 5.4.2.3.

Finding:

Model No.	Measured Flow Rate at 20 psi from Spout *(Min. Required = 2.4 gpm)*	Measured Flow Rate from Showerhead	
		Min. Measured Flow Rate at 45 psi *(For Information Only)*	Max. Measured Flow Rate at 80 psi *(Max. Allowed = 2.5 gpm)*
EV3312-CP150-SB	> 12.0 gpm	1.3 gpm (Single Mode)	1.3 gpm (Single Mode)
EV3312-CP200-SB		1.8 gpm (Single Mode)	1.9 gpm (Single Mode)
EV3322-CP150-SB		1.3 gpm (in Center Spray Mode)	1.3 gpm (in Outer Spray Mode)
EV3322-CP200-SB		1.7 gpm (in Center Spray Mode)	1.9 gpm (in Outer Spray Mode)
EV3302-CP000-SB		N/A	N/A
EV3302-CP000-BP			

Note: The water saving mode designed to flow less than 0.5 gpm at 80 psi (on models EV3322-CP150-SB and EV3322-CP200-SB only) is excluded from the minimum flow requirement at 45 psi per the standard.

5.5 Operating Requirements – COMPLIED

5.5.1 The tub spout flow-reduction systems were operable with a torque not exceeding that in Table 2 when tested at the temperatures and pressures specified in Clause 5.3.1.4.

Finding: The maximum operating torque was 2.0 lbf-in for the normally-closed valve control.

Note: The operating requirement for tub-to-shower diverters is exempted per the standard.

5.6 Life Cycle

5.6.1.5 Diverters – NOT APPLICABLE

The life cycle test for the auto-diverting diverter of the tub spout flow-reduction systems is exempted per Section 4.2 (a) of IAPMO IGC 244-2015a. **Note:** The thermostatic shut-off valve (temperature actuated valve) that is integrated into the tub spout will automatically close and divert water to the showerhead position when the inlet water supply temperature reaches at about 96.0 °F to 97.0 °F.

5.6.3.3 Other Devices (In-line Flow Control Device) – COMPLIED

The in-line flow control device (normally-closed valve) was tested to 15,000 cycles. During and after the test, the control mechanism continued to function as at the beginning of the test and did not develop any defects that could adversely affect its functionality or serviceability.After the test, the operating torque was 1.0 lbf-in when tested in accordance with Clause 5.5 of the standard.

5.7 Resistance to Installation Loading

5.7.2 Thread Torque Strength – COMPLIED

5.7.2.1 The ½" and ¾" NPT metal threaded connections withstood a torque load of 45 lbf-ft and 65 lbf-ft, respectively as specified in Table 4 of the standard without evidence of cracking or separation.

5.7.2.2 The threaded connections intended to seal water did not crack, strip, or leak when tested in accordance with Clause 5.3.1.3 with the threaded connection tightened to (a) the torque required to affect the seal; and (b) 150% of the torque required by Item (a).

5.7.2.3 NOT APPLICABLE – Clause 5.3.2 (Burst Pressure Test) only applies to threaded supply connections intended for use under continuous pressure. The tub spout flow-reduction systems are not intended for use under continuous pressure application.

5.8 Resistance to Use Loading

5.8.1 Operating Controls – COMPLIED

5.8.1.3 The operating controls that can not be grasped withstood an axial load of 10 lbf without pulling off.

5.9 Backflow Prevention – COMPLIED

5.9.2 Fittings with Plain Outlets – COMPLIED

The tub spout flow-reduction systems were designed to prevent backflow from the outlet with an air gap in accordance with ASME A112.1.2. The actual air gap was dependent on field installation.

6.0 Markings

6.1 General – COMPLIED

6.1.1 The tub spout flow-reduction systems were permanently marked with the manufacturer's name "evolve" on the spout body. The marking was visible after installation.

6.1.2 The showerheads were marked with the manufacturer's specified maximum flow rate, in L/min and gpm, in accordance with Clause 5.4.2.3.2(a).

6.3 Packaging – COMPLIED

6.3.1 **NOT EVALUATED** – The packaging shall be marked with the manufacturer's name or trademark as well as the model number.

Finding: No formal production packaging was received for review.

6.3.2 The packaging or other included literature shall be marked with the following:

(a) the manufacturer's specified maximum flow rate determined in accordance with Clause 5.4.2.3.2(a); and

(b) the statement "For use with automatic compensating valves rated at xxx L/min (yyy gpm) or less", where xxx L/min (yyy gpm) is the lowest minimum flow rate recorded in accordance with Clause 5.4.2.3.2(b).

Finding: The user guide was marked with the manufacturer's specified maximum flow rate as specified in Clause 6.3.2(a) and the statement as specified in Clause 6.3.2(b).

3.1 Working Pressure Test – COMPLIED

The device (integrated into tub spout) was installed per Figure 1 and tested per Section 3.1.2 of this standard at the pressure of 125.0 psi for 1.5 minutes.

Finding: No indication of leakage or damage was observed.

Note: Per Section 4.2 (b) of IAPMO IGC 244-2015a, the test was conducted at 125.0 psi as specified in Clause 5.3.1.4.2 of ASME A112.18.1-2012/CSA B125.1-12.

3.2 Deterioration at Extremes of Manufacturer's Temperature and Pressure – COMPLIED

The device (integrated into tub spout) was set up per Figure 1 and tested per Section 3.2.2 of this standard at 125.0 psi and 150.0 °F for 30 minutes.

Finding: No indication of leakage or damage was observed.

Note: Per Section 4.2 (b) of IAPMO IGC 244-2015a, the test was conducted at 125.0 psi and 150.0 °F as specified in Clause 5.3.1.4.2 of ASME A112.18.1-2012/CSA B125.1-12.

3.3 Flow Rate Test – COMPLIED

The device (integrated into tub spout) was set up per Figure 2 and tested per Section 3.3.2 of this standard.

Finding: The flow rate at 20 psi was more than 12.0 gpm, which met the minimum flow rate requirement of 2.4 gpm as specified in ASME A112.18.1-2005/CSA B125.1-05 for tub spouts.

3.4 Flow Reduction and Reset Test – NOT APPLICABLE

The test procedure outlined in Section 3.4.2 indicates to initiate the water flow at 104.0 °F ± 5.0 °F through the device. However, the device that is integrated into the tub spout will fully close and divert water to the showerhead position when the inlet water supply temperature reaches at about 96.0 °F to 97.0 °F. Therefore, this test can not be conducted. Section 4.2 (b) of the primary standard IAPMO IGC 244-2015a requires the device only to comply with the applicable requirements of ASSE 1062. Therefore, this test is considered not applicable.

3.5 Life Cycle Test – NOT APPLICABLE

The life cycle test is exempted per Section 4.2 (b) of IAPMO IGC 244-2015a.

3.6 Hydrostatic Pressure Test – COMPLIED

The device (integrated into tub spout) was pressurized with water at ambient temperature to 125.0 psi for one minute with the outlet blocked and the device fully open.

Finding: No leakage through the device was observed.

Note: Per Section 4.2 (b) of IAPMO IGC 244-2015a, the test was conducted at 125.0 psi as specified in Clause 5.3.1.4.2 of ASME A112.18.1-2012/CSA B125.1-12.

4.1 Materials in Contact with Water – COMPLIED *(For Whole Tub Spout)*

All metal alloys in contact with potable water contained less than 8% lead as required.

Findings: The brass NPT inlet adapters contained 2.028% lead, shaft contained 3.138% lead, shaft fitting contained 2.654% lead, sensing element contained 0.170% lead. The zinc body contained 0.025% lead. The stainless steel sensing element fitting and spring contained 0.000% lead. No solder and flux were used.

Note: The device is intended for shower applications, not intended to be used for dispensing water for human consumption.

4.2 Coatings – COMPLIED *(Chrome Finish)*

The coating complied with the applicable requiremnents specified in Clause 5.2 of ASME A112.18.1-2005/CSA B125.1-05 when tested in accordance with that Clause.

Finding: Clause 5.2 of ASME A112.18.1-2005/CSA B125.1-05

5.2.2 General – COMPLIED

The significant surfaces of the coated components were free of surface defects and uncoated areas, and were not stained.

5.2.2 Corrosion – COMPLIED

After being subjected to the corrosion test of ASTM B117 (neutral salt) for Service Condition 2 for 24 h as specified in Clause 5.2.2.2.1, the coating did not show more than one surface defect in any 1.0 in^2 area of the significant surface or up to three surface defects on a 1.0 inch length of parting line. The surface defects were not larger than 0.03 inch any dimension.

5.2.4 Adhesion – COMPLIED

5.2.3.2 The coating on metals met the grind-saw test requirements as defined in ASTM B 571.

5.2.3.3 The coating on plastics met the following thermal cycling test requirements when tested per Clause 5.2.3.3.2.

a) No surface defects such as cracks, blisters, peeling, or discoloration on significant surfaces.
b) No cracks longer than 0.25 in with a loss of adhesion between the base material and the coating.
c) No blisters exceeding 0.01 in^2 in area within 0.25 inch of an injection point.
d) No warpage affecting the performance of the fitting or component.

4.3 Markings – NOT APPLICABLE

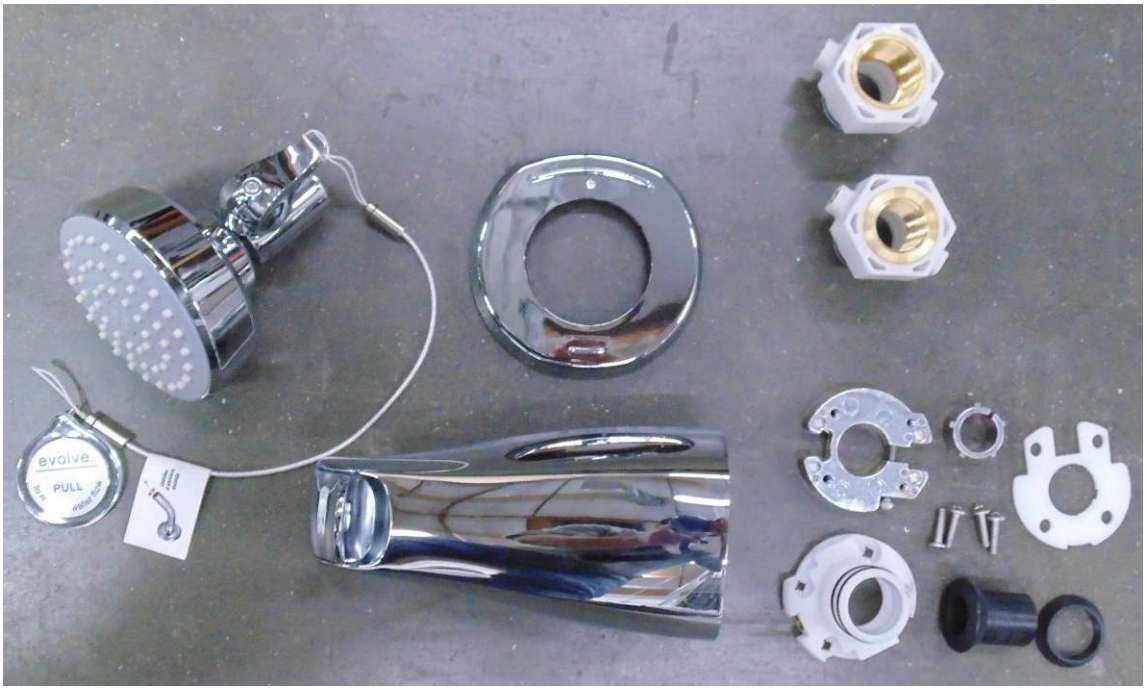
The primary standard used for the testing of the device is IAPMO IGC 244-2015a. The device should be evaluated to the marking requirements of IAPMO IGC 244-2015a.

4.4 Installation Instructions – COMPLIED

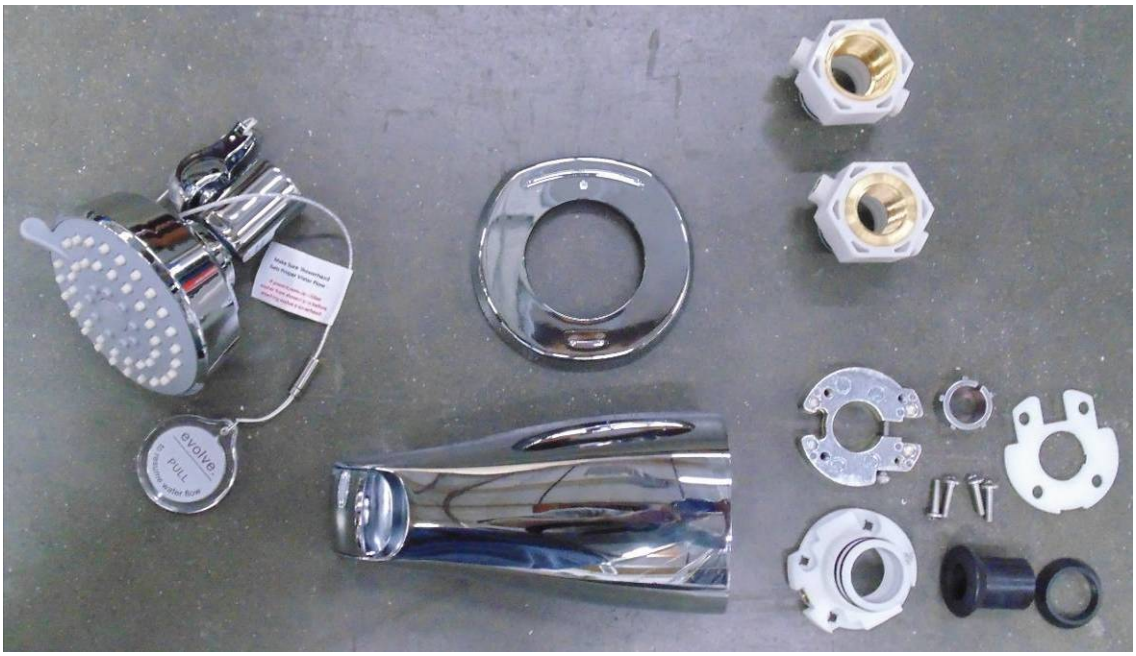
4.4.1 Complete instructions for installation was packaged with the device. Drawings and schematic sketches which would be useful to the installer are part of these instructions. These instructions provide all information necessary for correct installation.

4.4.2 The installation instructions indicate the tested and approved installation position of the device.

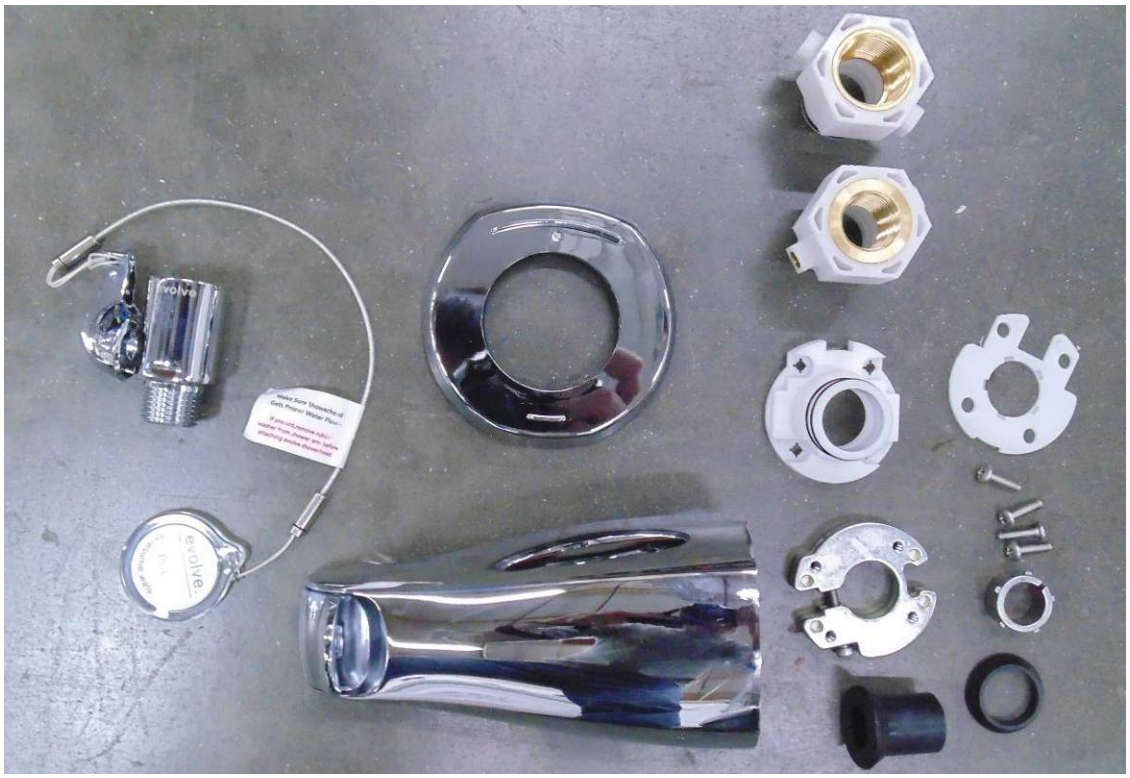
Photographs of Samples Tested:



Model EV3312-CP150-SB / EV3312-CP200-SB

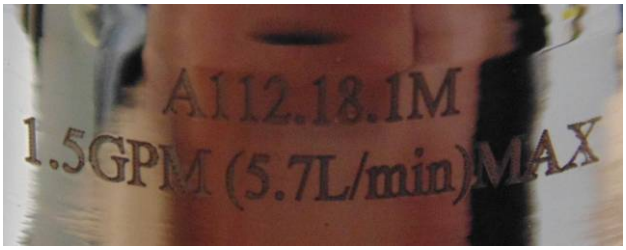


Model EV3322-CP150-SB / EV3322-CP200-SB



Model EV3302-CP000-SB / EV3302-CP000-BP

Name Marking on Product



Flow Rate Marking on Showerhead

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Improving Multifamily Net Operating Income Through Innovative Hot Water Savings:

Field study of the Auto Diverting Tub Spout System within a 156-unit apartment complex in Frederick, MD

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April 8, 2019

THE NET OPERATING INCOME – INNOVATIVE HOT WATER SAVINGS CONNECTION

One of the quickest and easiest ways to increase a multifamily property's Net Operating Income (NOI) while enhancing resident value and improving community quality is through innovative hot water savings. And by creatively conserving hot water, property owners and managers can not only increase an apartment building's value, they can also improve property appeal while adding comfort and convenience to residents' bathing routines.

The key to creating meaningful and sustainable NOI results is to focus on innovative ways to save hot water without taking water away from residents while they're actually showering. In general, low flow shower heads are poorly perceived by many, if not most, residents. For example, the current best-selling shower head on Amazon.com is a 2.5 gpm model actively promoting removal of the unit's flow restrictor. Further evidence of attitudes towards low flow shower heads is demonstrated by a research report conducted by the Department for Environment, Food and Rural Affairs in the UK, a country of where "green" attitudes are more prevalent than in the US (DEFRA 2009). The report concluded:

- Water use is not a consideration for when purchasing shower heads
- Individuals have a general feeling that water efficient showers won't feel good
- When asked to choose their ideal shower, people ignore information on water consumption
- Powerful water flow showers are what most people aspire to owning

Additionally, a review of Google search terms for "low flow shower head" vs. "high pressure shower head" from 2004 to present reveals steady growth in "high pressure shower head" interest over time. In fact, the term "high pressure shower head" began to consistently surpass "low flow shower head" in August 2016 and is projected to be 3x greater than "low flow shower head" in March 2019.

Fortunately, as new technologies become available, low flow shower heads are no longer the only means for conveniently and cost effectively reducing both water and energy use. In fact, when it comes to innovative hot water savings and property management, multifamily owners and managers can improve Net Operating Income and delight residents by targeting the following key hot water savings areas:

- Reducing Structural Waste
  This is the previously heated, but now cold, water that must be purged before hot water can arrive.
- Eliminating Behavioral Waste
  This is the hot water that is inadvertently wasted before residents actually begin showering.
- Preventing Tub Spout Leaks
  This is the hot water that unknowingly leaks past the tub spout diverter while the resident is showering.

Focusing on innovative alternatives to low flow shower heads for generating hot water savings has distinct advantages, not only in terms of resident satisfaction, but also in total gallons of hot water saved. Specifically, reducing Structural Waste eliminating Behavioral Waste and preventing Tub Spout Diverter Leaks can cost effectively save up to 10 gallons of hot water per shower while adding significant comfort and convenience benefits to residents' bathing routines. A matrix illustrating these factors is available in Figure 1.

HOT WATER SAVINGS OPPORTUNITY	RESIDENT COMFORT & CONVENIENCE	EST. HOT WATER SAVED*
Reducing Structural Waste	Faster Hot Water Delivery Times	.4 Gallons Per Shower
Eliminating Behavioral Waste	Freedom to Multitask While Waiting For Hot Water To Arrive	5.1 Gallons Per Shower
Preventing Tub Spout Diverter Leaks	Hot Water Lasts Longer	4.5 Gallons Per Shower

**Detailed calculations available in "Calculating Savings For Auto-Diverting Tub Spout System with ShowerStart TSV". Paper available upon request.*

Figure 1.

AN INNOVATIVE HOT WATER SAVINGS SOLUTION – THE AUTO-DIVERTING TUB SPOUT SYSTEM

Evolve Technologies' Auto-Diverting Tub Spout System with ShowerStart TSV (ADTS), Figure 2., is a complete fixture replacement for tub/shower combination bathrooms.

Figure 2.

The ADTS functions by first purging the cold water in the plumbing lines (Structural Waste) through its tub spout fixture. Because of its design, the tub spout expels Structural Waste more than 2X faster than possible through a shower head. Warming the shower in this manner not only significantly reduces hot water waits, but also reduces the volume of Structural Waste that must be purged before hot water can arrive. Due to its much higher velocity, less thermal loss occurs as the water travels through the plumbing line to the shower. Hot water arrives faster and the volume that must be purged before it does is reduced.

Structural Waste continues exiting the ADTS' tub spout fixture at high volume until hot water arrives. Once it does, the tub spout fixture automatically blocks the tub spout's out-flow and diverts hot water to the unit's shower head fixture. As hot water reaches the shower head, its flow is automatically paused (reduced to a trickle) until the bather is ready to begin showering. The shower head's pause eliminates Behavioral Waste by preventing hot water from inadvertently running down the drain while residents are away from the shower during the warm-up process. By eliminating the potential for Behavioral Waste, residents can gain the freedom to multitask while waiting for their hot water to arrive - without wasting hot water while they do so. Once ready to shower, residents' pull the shower head's lanyard to resume normal flow and shower as usual. After showering is completed, the ADTS automatically resets for its next use.

While showering, the shut-off that automatically diverted hot water to the shower head fixture, remains active. This tight, positively reinforced, thermostatically activated seal stops Tub Spout Diverter Leaks by preventing hot water from sneaking past the diverter and running out of the tub spout while residents are showering. Tub Spout Diverter Leaks are a very common, but often unrecognized contributor to significant hot water waste. In fact, field studies reveal that approximately 34% of all tub spouts exhibit a diverter leak while the shower is running and the average leak for those faulty diverters is .8 gallons per minute (Taitem 2011).

The Auto-Diverting Tub Spout's functionality is illustrated in Figure 3.

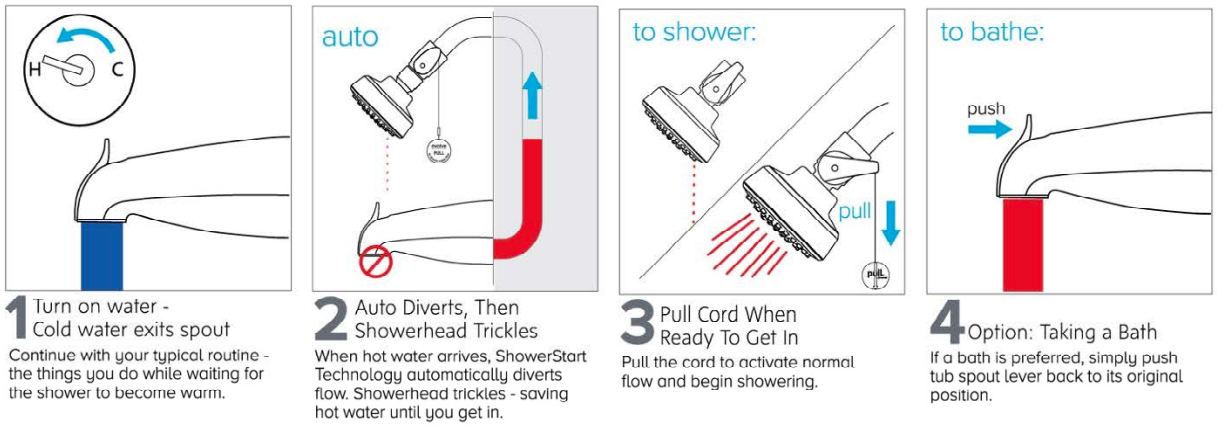


Figure 3.

ADTS FIELD STUDY - RESULTS FROM A 156 UNIT APARTMENT COMPLEX IN FREDERICK, MD

Field Study Background:

Applegate Apartments, owned and operated by Maryland Management, is located in a well-established residential area just outside of historic downtown Frederick, MD. The multifamily property contains two buildings comprising one, two and three bedroom apartments. Rents range from $1074 to $1709 per unit.

The property began installing 156 Auto-Diverting Tub Spout units in the summer of 2016. Installations were performed by the complex's maintenance staff over the course of several months and total water consumption was monitored via meter readings from the billing statements provided by the local water utility.

No other water saving products were installed during the monitoring period. Additionally, no savings were generated from the ADTS' shower head, as the unit's flow rate was identical to the flow rate of the shower head it replaced. A break-out of the key property characteristics are listed in Figure 4.

	PROPERTY PROFILE
Owner/Manager	Maryland Mgmt.
Name	Applegate Apartments
Location	Frederick, MD
Buildings	2
Apartment Units	156
ADTS Installation	Summer 2016
Pre Install SH Flow Rate	1.5 gpm
Post Install SH Flow Rate	1.5 gpm
Additional Water Measures Installed	None

Figure 4.

Predicted Yearly Hot Water Savings:

Prior to completion of the field study, Evolve Technologies endeavored to predict the water savings associated with Applegate's installation of the 156 Auto-Diverting Tub Spout Systems by using the following formula:

[apartment units] x [bathrooms per apartment] x [persons per apartment] x [showers per person per day] x [days per year] x [occupancy rate] x [ADTS predicted gallons saved per shower]

The property's known Occupancy Rate averaged 90% and, based on conversations with the property owner, an average of 2 persons per apartment was assumed. Additionally, is was assumed that residents, on average, showered .75 times per day (approximately 5 times per week) and the ADTS unit would save 10 gallons of hot water per shower by reducing Structural Waste, Eliminating Behavioral Waste and Preventing Tub Spout Diverter Leaks as defined in Figure 1.

Upon calculation of the prediction formula, it was projected that the ADTS would save Applegate Apartments 769,217 gallons of hot water per year as illustrated in Figure 5.

	WATER SAVINGS VARRIABLES
Apartment Units	156
Bathrooms Per Apartment	1
Persons Per Apartment	2
Shower's Per Person Per Day	0.75
Days Per Year	365.25
Occupancy Rate	0.90
ADTS Predicted Gal. Saved/Shower	10

PREDICTION
769,217
GALLONS SAVED PER YEAR

Figure 5.

Actual Yearly Hot Water Savings:

To calculate hot water savings resulting from installation of the Auto-Diverting Tub Spout Systems, Evolve Technologies reviewed quarterly metering and billing statements from Applegate's water utility, The City of Frederick, MD.

Statements for the 4 consecutive quarters prior to installation we're reviewed to determine water use for the Year Prior To Install. Quarterly statements for a period of one year after installation were reviewed to determine water use for the Year After Install. To neutralize the impact of occupancy rate variances within the analysis, water use was adjusted to assume 100% occupancy using the following formula:

[total gallons used] / [average occupancy rate]

Actual monthly occupancy rates during the measurement period ranged from 88% - 96%.

Additional details driving the Actual Yearly Hot Water Savings analysis are available in Figure 6.

	BILLING DATE	PERIOD START DATE	PERIOD END DATE	BLDG. 1 GALLONS USED	BLDG. 2 GALLONS USED	TOTAL GALLONS USED	AVG. OCC. RATE	OCC. ADJUSTED TOTAL GAL USED	OCC. ADJUSTED GALLONS USED
YEAR PRIOR TO INSTALL	12/1/15	7/30/15	10/26/15	1,577,400	883,800	2,461,200	95%	2,590,737	11,234,157
	3/1/16	10/26/15	1/21/16	1,395,300	1,149,500	2,544,800	92%	2,766,087	
	6/1/16	1/21/16	4/20/16	1,309,200	1,150,000	2,459,200	90%	2,732,444	
	9/1/16	4/20/16	7/27/16	1,596,900	1,233,500	2,830,400	90%	3,144,889	
YEAR AFTER INSTALL 	12/1/16	7/27/16	10/26/16	1,307,400	1,140,600	2,448,000	90%	2,720,000	10,448,803
	3/1/17	10/26/16	1/26/17	1,294,600	1,167,500	2,462,100	88%	2,797,841	
	6/1/17	1/26/17	4/27/17	1,208,400	1,039,500	2,247,900	90%	2,497,667	
	9/1/17	4/27/17	8/2/17	1,433,100	708,200	2,141,300	88%	2,433,295	

Figure 6.

Comparing water use from the Year Prior To Install to the Year After Install reveals 785,345 gallons saved. This savings represents a combined 7% reduction in total water use for the Applegate multifamily property (Figure 7). Notably, the Actual Yearly Hot Water Savings came within 2% of the Predicted Yearly Hot Water Savings results.

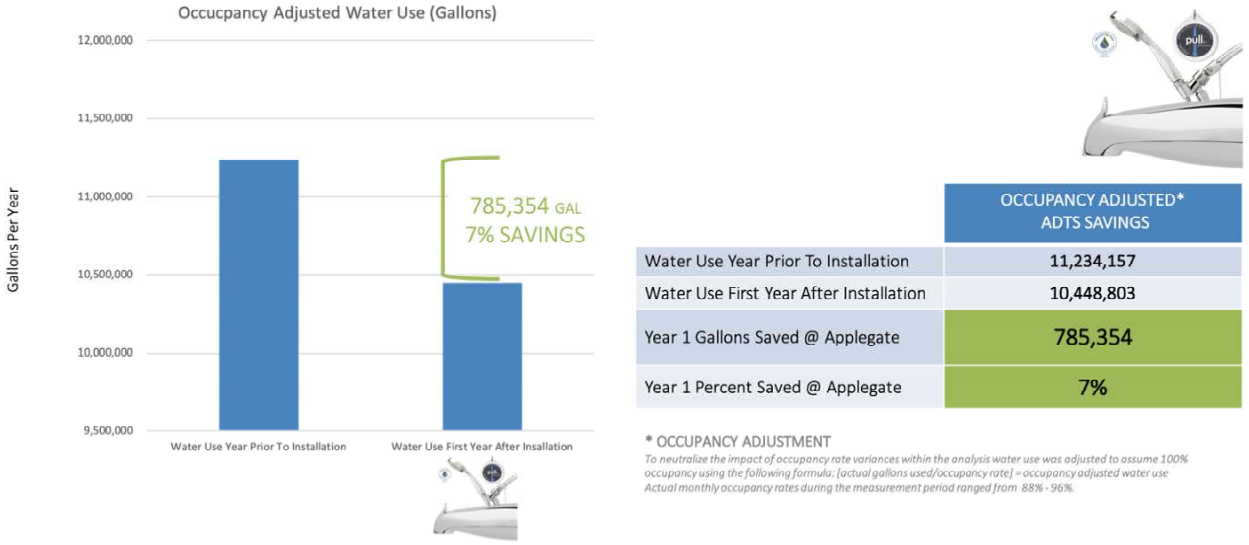


Figure 7.

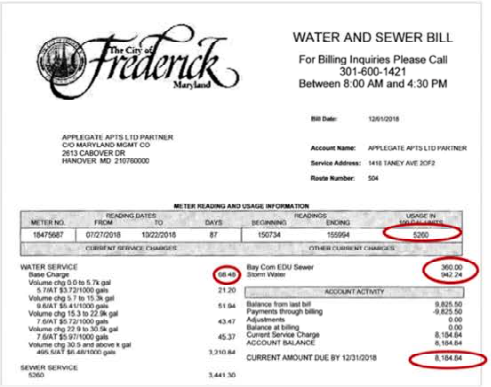
Water & Sewer Savings Payback:

Based on the Occupancy Adjusted water consumption data, payback for purchase of the Auto-Diverting Tub Spout System is 11 months, assuming a $.013 water and sewer cost derived by using the following formula:

[bill total] – [fixed cost*] / [gallons used]

*Water Service Base Charge, Bay Com EDU Sewer and Storm Water

Payback times for purchase of the Auto-Diverting Tub Spout System shrank to just 9 months when conducting a straight comparison, without an occupancy adjustment, of water use for the Year Prior To Installation vs. the First Year After Installation as illustrated in Figure 8.



WATER AND SEWER BILL

For Billing Inquiries Please Call
301-600-1421
Between 8:00 AM and 4:30 PM

Bill Total	$ 8,185.00
Fixed Cost Bay Com EDU Sewer	$ - 360.00
Fixed Cost Storm Water	$ - 942.00
Fixed Cost Base Charge	$ - 68.48
Net Cost For Water & Sewer	$ 6,814.52

PAYBACK IN LESS THAN 1 YEAR
ON WATER SAVINGS ALONE

- does not consider energy savings
- does not consider shower head savings

	PAYBACK CALCULATIONS
Water/Sewer Cost Per Gallon	$.013
ADTS Cost	$60.00*
Gallon Cost Per ADTS	4,631
ASTS Units Installed	156
Gallon Savings Required To Break Even	722,498
Year 1 Gallon Savings – Occupancy Adjusted	785,354
Payback Months – Occupancy Adjusted	**11**
Year 1 Gallon Savings	996,300
Payback Months	**9**

* Typical ADTS costs range from $69 - $79 based on sales channel and purchase volume. Applegate paid $60 to offset internal costs for monitoring and sharing water use information.

Figure 8.

Water & Sewer Savings ROI

The investment for Applegate's purchase of the 156 Auto-Diverting Tub Spout Systems at $60* per unit was $9,360. Installation expenses were not factored into this calculation because the units were installed by the complex's in-house maintenance staff.

Given the previously derived $.013 Water/Sewer Cost Per Gallon and Occupancy Adjusted Water Savings of 785,354 gallons per year, Annual Water & Sewer Bill savings for Applegate are $10,174.31. That's a First Year Return On Investment of 109% (Figure 9.).

	ADTS ROI ANALYSIS
Annual Water/Sewer Bill Savings	$10,174.31
ADTS Cost Per Unit	$60.00
ADTS Units Installed	156
ADTS Cost Of Investment	$9,360
ADTS Est. Useful Life - Years	10
ADTS Gain From From Investment	$101,743.10
ROI (Yr 1)	**109%**

ROI = Gain From Investment / Cost Of Investment. First year's savings only.

Figure 9.

Estimated Annual Energy Savings:

In addition to lowering Applegate's total water consumption by 7% and saving $10,174.31 per year in water and sewer charges, the Auto-Diverting Tub Spout System also reduces the amount of electricity or gas used for water heating. Depending upon the fuel type used, and other environmental and regional factors, operating costs for Applegate could be decreased by an additional $4,305 (gas savings) to $11,147 (electric savings) per year while using the ADTS (Figure 10.).

	Structural & Behavioral Waste Savings	Shower Head Savings	Tub Spout Diverter Leak Savings	Per ADTS Energy Saved	ADTS Units Installed	Occupancy Rate	Total Energy Savings	Total $ Savings
ELECTRIC	323 kWh	0 kWh	281 kWh	604 kWh	156	.91	85,744 kWh	$11,147
GAS	14.2 Therms	0 Therms	12.4 Therms	26.6 Therms	156	.91	3,776 Therms	$4,305

ASSUMPTIONS:

- 2 persons per apartment
- .75 showers per person per day
- 56.8 F avg. water mains temp
- 105F – 101F showering temp range
- $.13 per kWh (chooseenergy.com)
- $1.14 per Therm (energy-models.com)

Figure 10.

Depending upon rent structures and other factors, residents may be directly responsible for the energy costs associated with water heating. In these instances, multifamily properties may still be able to improve Net Operating Income through energy savings by modestly increasing rents. This is achieved by effectively marketing the conservation, comfort and convenience aspects of each apartment's main bathroom as a result of its ADTS.

Combined Water, Sewer & Energy Savings Impact on Net Operating Income:

Assuming water, sewer and estimated energy savings, Maryland Management is increasing its Applegate property's Net Operating Income by $14,479.31 to $21,321.31 per year by innovatively saving hot water without taking water away from residents while they're actually showering.

REFERENCES - IN ORDER OF CITATION

(DEFRA 2009) Public Understanding of Sustainable Water use in the Home

(Taitem 2011) Taitem Tech Tip – Leaking Shower Diverters

P047 & P079 - 802.5 FAUCETS & 11.802.5 D

FES-C15b TubSpout™ with Low Flow Showerhead

Technology Description

TubSpout™ technology monitors the temperature of water exiting the tub spout and as soon as the water temperature reaches 95°F, it is diverted to a specialized, normally-closed showerhead. This unique method will ensure you always have a hot shower and will save a large amount of hot water that runs down the drain that is usually wasted waiting for the shower to warm. Not only is water and energy waste minimized, but it will allow for greater hot water capacity during clustered hot water events (i.e. multiple showers in the morning).

Methodology and Assumptions

The limitation with this technology is that it only saves energy if the user leaves the tub spout running once the water temperature reaches 95°F. If the user gets in the shower immediately once the water temperature reaches 95°F, there will be no savings. Shower water waste has been studied and it is justifiably estimated below.

If this is to be recommended as an incentive, it is recommended that this technology be combined with a specialized normally-closed, low-flow showerhead. The savings for this measure is estimated using the following equations:

$$Water\ Saved_{TSV} = Q_{tub} * \left(\frac{t_{warmup}}{60}\right) - SW * \frac{(SPCD * PPH)}{SPH} * Days$$

Where,

- Flow rate of tub spout, Q_{tub} = 5.0 gpm[1]
- The average warmup duration, t_{warmup} = 80 seconds[2]
- The "structural waste" which represents the water that needs to be purged from the pipes, SW = 1.21 gallons[3]
- The average people per household (single-family), PPH_{SF} = 2.53[4]
- The average people per household (multi-family), PPH_{MF} = 1.83[5]
- The average showerheads per household (single-family), SPH_{SF} = 1.50[6]
- The average showerheads per household (multi-family), SPH_{MF} = 1.11[7]

[1] Estimate from Evolve Technologies, *Calculating Savings For: Auto Diverting Tub Spout System with ShowerStart TSV*, Sherman, Troy. Page 2.
[2] 47 seconds of waste is attributed to behavioral aspects and is estimated to account for 59% of total waste. 80 seconds of total warm-up time is calculated by 47 sec/59% = 80 seconds. *Disaggregating Residential Shower Warm-Up Waste: An Understanding and Quantification of Behavioral Water Based on Data from Lawrence Berkely National Labs.* Sherman, Troy. August 2014. http://thinkevolve.com/wp-content/uploads/2014/09/Disaggregating-Residential-Shower-Warm-Up-Waste.pdf. Pages 6 & 8 Accessed 7/13/15.
[3] Given that 33 of the 80 seconds of waste is attributed to "structural" waste and a showerhead flow rate of 2.2 gpm, the volume of water wasted in the "structural" period is 33/60 * 2.2 gpm = 1.21 gallons. Refer to Reference 1. Page 5.
[4] *Showerhead and Faucet Aerator Metering Study*, Cadmus and Opinion Dynamics. June 2013.
[5] Ibid.
[6] Ibid.
[7] Ibid.

- Showerheads per capita per day, SPCD = 0.6[8]
- Annual days of operation, Days = 365

$$Water\ Saved_{Leaks} = Q_{leaks} * t_{shower} * \frac{(SPCD * PPH)}{SPH} * Days$$

Where,

- Flow rate of leaks, Q_{leaks} = 0.8 gpm[9]
- The average shower duration, t_{shower} = 7.8 minutes[10]

$$Water\ Saved_{Total} = Water\ Saved_{TSV} + Water\ Saved_{leaks}$$

$$Energy\ Saved = Water\ Saved_{Total} * \rho_{H_2O} * \frac{(T_{exit} - T_{in})}{RE * C}$$

Key Assumptions:

- Inlet water temperature, T_{in} = 54.5°F[11]
- Exit water temperature during warm-up, T_{exit} = 105°F[12]
- Existing electric water heater efficiency, $RE_{electric}$ = 0.98[13]
- Existing gas water heater efficiency, RE_{gas} = 0.76[14]
- The density of water, ρ_{H2O} = 8.33 lb/gallon
- Conversion factor, $C_{electric}$ = 3,412 Btu/kWh
- Conversion factor, C_{gas} = 100,000 Btu/therm

Estimated Energy Savings

Annual Energy Savings	Water Heating	Single-Family	Multi-Family
TubSpout with 1.75 gpm Showerhead	Electric Domestic Water Heater	794 kWh	776 kWh
	Gas Domestic Water Heater	29.6 therms	28.9 therms
TubSpout with 1.5 gpm Showerhead	Electric Domestic Water Heater	877 kWh	858 kWh
	Gas Domestic Water Heater	33.2 therms	32.5 therms

Coincident Peak Impact

Electric Demand Savings	Water Heating	Single-Family	Multi-Family
TubSpout with 1.75 gpm Showerhead	Electric Domestic Water Heater	0.063 kW	0.062 kW
TubSpout with 1.5 gpm Showerhead		0.070 kW	0.069 kW

[8] Ibid.
[9] *Tech Tip: Leaking Shower Diverters*. Taitem Engineering. Page 2. http://www.taitem.com/wp-content/uploads/Diverter-Valve-Tech-Tip-2011.7.20.pdf. Accessed 07/13/15.
[10] See Reference 4.
[11] Ibid.
[12] Per email with Jill Steiner of Cadmus.
[13] See Reference 4.
[14] Ibid.

Estimated Water Savings

Water Savings	Single-Family	Multi-Family
TubSpout with 1.75 gpm Showerhead	6,481 gal/yr	6,335 gal/yr
TubSpout with 1.5 gpm Showerhead	7,202 gal/yr	7,039 gal/yr

Measure Life

10 years[15]

Coincidence Factor

CF = 0.7[16]

Initial One-Time Cost

Typical cost is estimated at $42.[17]

Requirements for Application

Equipment must be new.

Tub spout must be equipped with ShowerStart technology (or thermostatic restriction valves) and the showerhead must be a specialized, normally-closed low-flow (1.5 gpm or 1.75 gpm) showerhead.

Attachment

FES-C15b Low Flow Showerheads w TubSpout.xls

[15] The only known product of this type of device, manufactured by ShowerStart™, passed a required IAPMO life-cycle test of a minimum of 10,000 cycles (*See IAPMO R&T Lab Test Report for ShowerStart LLC. Report #1052-07001. October 2007. Pages 1 and 6*). Assuming that one cycle corresponds with one shower, and conservatively estimating 3 persons/household and one shower/household, 10,000 cycles translates to a minimum of 13 years. 10 years is used, so as to be consistent with the measure life of a low-flow showerhead that is installed with. The same thermostatic valve technology is used in the TubSpout product.

[16] Calculated value based on residential domestic hot water usage profiles, Franklin Energy Services.

[17] "It is currently estimated that TubSpout will be made available to IOUs and their installation contractors for a price no greater than $42." *Calculating Savings For: Auto Diverting Tub Spout System with ShowerStart TSV.* Page 5. Sherman, Troy. Page 8.

P098 - D101.5
COMPUTER WATER RATING INDEX

Cindy Wasser
Home Innovation Research Labs

Section: Appendix D

Section Number: D101.5 Compute Water Rating Index

Reason Statement: Appendix D D101.5 states "The WRI shall be computed as a percentage of the combined indoor and outdoor water use in relation to the combined indoor and outdoor water baseline." Appendix D, as written, does not address common areas; however, in most other areas of the NGBS, all residential portions of a multifamily building, including residential common areas, are evaluated for compliance. Add an additional section that addresses Indoor Common Areas. The values water volume and use factors included within the proposal below are derived largely from The Handbook of Water Use and Conservation.

Proposed Change:

Revise D101.5 as follows:

D101.5 Overall Water Rating Index (WRI) Calculation. The WRI is an overall rating for the home on an annual basis. The WRI shall be computed as a percentage of the combined indoor and outdoor water use in relation to the combined indoor and outdoor water baseline.

$$WRI = 100 * (IndoorUseUnits + IndoorUseCommon + OutdoorUse) / (IndoorBaseline + IndoorBaselineCommon + OutdoorBaseline)$$

Add the following:

D101.6(3)-CA Indoor Water of Common Areas – Calculations

Indoor water calculations for annual Baseline and annual Use shall be as follows:

$$\textbf{IndoorBaseline} = [ToiletWater_{(baseline)} + UrinalWater_{(baseline)} + ShowerWater_{(baseline)} + LavatoryWater_{(baseline)} + FaucetWater_{(baseline)} + DishWasherWater_{(baseline)} + ClothesWasherWater_{(baseline)} + StructuralWasteWater_{(baseline)} + OtherWaterUse_{(baseline)}] * 365 \text{ days/year}$$

$$\textbf{IndoorUse} = [ToiletWater_{(verified)} + UrinalWater_{(verified)} + ShowerWater_{(verified)} + LavatoryWater_{(verified)} + FaucetWater_{(verified)} + DishWasherWater_{(verified)} + ClothesWasherWater_{(verified)} + StructuralWasteWater_{(verified)} + OtherWaterUse_{(verified)}] - IndoorWaterReuseCredit_{(verified)} \text{ x } 365 \text{ days/year})$$

D101.6(3)-CA Indoor Water of Common Areas– Baseline Water Use for Devices

Baseline water for each device in Table 1 shall be:

Baseline $_{(device)}$ = Planned Maximum Capacity for Amenity Area(s) x Use Factor x Baseline Water Volume Per Use

Use factors for water devices are as follows:

TABLE D101.6(3)-CA
BASELINE WATER USES & VOLUME FOR COMMON AREA DEVICES

Device	Baseline VolumePerUser (gallons/day/user)	Use Factor(s)
Toilet	3.2	2 uses / day / user
Urinal	1.6	1 use / day / user
Shower	9.01	5.3 minutes / day / user
Lavatory	4	4 minutes / day / user
Faucet	6.8	4 minutes / day / user
Dishwasher	0.45	0.1 loads / day / user
Clothes Washer (residential style)	22.3	0.37 loads / day / user
Clothes Washer (commercial style)	3.256 per cubic foot for Top Loading / 1.517 per CF for Front-Loading (Integrated Water Factors of 8.8 for Top-Loading and 4.1 for Front-Loading)	0.37 loads / day / user

D101.6(4)-CA Indoor Water of Common Areas – Verified Water Use for Devices

Verified use for each device in Table 1 shall be:

Verified $_{(device)}$ = Planned Capacity for Amenity Area(s) x Use Factor x VerifiedFlowRate

D101.6(5)(a)-CA - Indoor Water of Common Areas – Structural Waste (Verified)

Structural waste, which is the water volume in the pipe between the hot water source and the plumbing fixture or appliance plus the extra volume needed to heat the pipe as hot water is delivered to its use.

(a) VerifiedStructuralWaste (gallons), shall be field measured as the water volume collected until the temperature of the water equals 100°F at the furthest fixture for a domestic hot water system.

(i) This test shall be performed before any other tests in order to avoid preheating the pipes. This test shall use an apparatus with a thermometer and water container.

(ii) If there is more than one hot water system serving multifamily amenity areas, all systems shall be tested for structural waste with the worst performing system entered into the calculation.

D101.6(5)(b)-CA Indoor Water of Common Areas – Structural Waste (Baseline)

BaselineStructuralWaste (gallons/day) is approximated based on the amenity area size and configuration. The pipe length is estimated as a horizontal length plus a vertical length.

For Common Areas, the calculation is as follows:

Baseline Structural Waste = Estimated Total Pipe x Pipe Volume (see Table 2)

Estimated Total Pipe is the sum of Estimated Horizontal Pipe and Estimated Vertical Pipe.

Estimated Horizontal Pipe = Total Footprint of All Amenity Areas x 2

Estimated Vertical Pipe = Floor Height of Amenity Areas

P104 - D101.7
WATER CAPTURE FOR POTENTIAL REUSE

Cindy Wasser
Home Innovation Research Labs

Section: Appendix D

Section Number: D101.7 Water Capture for Potential Reuse

Reason Statement:

Appendix D provides incomplete information about the appropriate applications of captured water. Not all indoor and outdoor water uses are identified as potential applications for captured water. As written, the methodology does not allow a building to achieve a score as low as 0; not all water uses can be offset by captured water.

Proposed Change:

Add additional text that clearly identifies the applications for the different captured water types.

Capture Type	***Uses***
Rainwater	*Toilet* *Urinal* *Shower* *Bathtub* *Lavatory Faucet* *Dishwasher* *Clothes Washer* *Pools/Spas* *Irrigation*
Greywater	*Toilet* *Urinal* *Irrigation*
Blackwater	*Irrigation*

Also add the following clarification:

> *For multifamily buildings with common areas, capture water is applied toward in-unit water use first, then to common area uses. Structural waste can be offset as well, when the user identifies that all water is from captured water sources.*