Uniform Test Method for Measuring the Energy Consumption of Dishwashers

AHAM DW-1- 2020

AHAM
ASSOCIATION OF HOME APPLIANCE MANUFACTURERS

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PREFACE

The Association of Home Appliance Manufacturers develops standards in accordance with AHAM's "Policy and Procedures Governing Technical Standards" which states:

> "AHAM Standards shall be in the best interest, mutually, of consumers who use appliances, the industries which provide and service appliances, and other interested parties. They shall relate to actual use conditions and be technically and scientifically sound."

Use or observance of AHAM standards is voluntary.

This standard contains:

> Test procedures that may be applied to any brand or model of household electric dishwashers. Results of tests in accordance with this standard may be publicly stated.
>
> Recommended levels of performance which are considered important to include but which, necessarily, are recommendations only.

With regard to safety, AHAM recommends that all appliance products -- both major and portable -- manufactured or marketed in the United States be submitted to a Nationally Recognized Testing Laboratory (NRTL[1]) for inspection and listing in conformance with the safety standards and procedures followed by such laboratories. The relevant standard for dishwashers is ANSI/UL 749, CAN/CSA C22.2 No. 167 "Standard for Safety, Household Dishwashers," latest edition.

AHAM welcomes comments and suggestions regarding this standard. Any standard may be reviewed and improved as needed. All standards must be updated or reconfirmed at least every five years. Any interested party, at any time, may request a change in an AHAM standard. Such request should be addressed to AHAM's president, and should be accompanied by a statement of reason for the request and a suggested alternate proposal.

[1] The Occupational Safety and Health Administration (OSHA) recognizes laboratories that have the necessary qualifications to perform safety testing and certification of specific products covered within a scope of recognition as Nationally Recognized Testing Laboratories (NRTL).

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This standard establishes uniform, repeatable procedures or standard methods for measuring the energy consumption of household electric dishwashers.

1. DEFINITIONS

1.1 Active mode

A mode in which the dishwasher is connected to a mains power source, has been activated, and is performing one of the main functions of washing, rinsing, or drying (when a drying process is included) dishware, glassware, eating utensils, and most cooking utensils by chemical, mechanical, and/or electrical means, or is involved in functions necessary for these main functions, such as admitting water into the dishwasher, pumping water out of the dishwasher, circulating air, or regenerating an internal water softener.

1.2 AHAM

The Association of Home Appliance Manufacturers.

1.3 Clean out event

An event that occurs in water re-use system dishwashers wherein the dishwasher cleans out the water holding tank and water lines at a predefined interval.

1.4 Combined low-power mode

The aggregate of available modes other than active mode.

1.5 Compact dishwasher

A dishwasher that has a capacity of less than eight place settings plus six serving pieces as specified in AHAM DW-2-2020, using the test load specified in section 2.7.

1.6 Cycle

A sequence of operations of a dishwasher which performs a complete dishwashing function, and may include variations or combinations of washing, rinsing, and drying.

1.7 Cycle finished mode

A standby mode which provides continuous status display following operation in active mode.

1.8 Cycle type

Any complete sequence of operations capable of being preset on the dishwasher prior to the initiation of machine operation.

1.9 Drain out event

An event that occurs in water re-use system dishwashers wherein if the dishwasher is not operated for a defined period of time, the dishwasher drains out the saved water.

1.10 Fan-only mode

An active mode that is not user-selectable, and in which a fan circulates air for a finite period of time after the end of the cycle, where the end of the cycle is indicated to the consumer by means of a display, indicator

light, or audible signal.

1.11 IEC 62301

The standard published by the International Electrotechnical Commission, titled "Household electrical appliances-Measurement of standby power," Publication 62301 (Edition 2.0, 2011-01).

1.12 Inactive mode

A standby mode that facilitates the activation of active mode by remote switch (including remote control), internal sensor, or timer, or that provides continuous status display.

1.13 Non-soil-sensing dishwasher

A dishwasher that does not have the ability to adjust automatically any energy consuming aspect of the normal cycle based on the soil load of the dishes.

1.14 Normal cycle

The cycle type, including washing and drying temperature options, recommended in the manufacturer's instructions for daily, regular, or typical use to completely wash a full load of normally soiled dishes including the power-dry feature. If no cycle or more than one cycle is recommended in the manufacturer's instructions for daily, regular, or typical use to completely wash a full load of normally soiled dishes, the most energy intensive of these cycles shall be considered the normal cycle. In the absence of a manufacturer recommendation on washing and drying temperature options, the highest energy consumption options must be selected.

1.15 Off mode

A mode in which the dishwasher is connected to a mains power source and is not providing any active mode or standby mode function, and where the mode may persist for an indefinite time. An indicator that only shows the user that the product is in the off position is included within the classification of an off mode.

1.16 Power-dry feature

The introduction of electrically-generated heat into the washing chamber for the purpose of improving the drying performance of the dishwasher.

1.17 Preconditioning cycle

A normal cycle run with no test load to ensure that the water lines and sump area of the pump are primed.

1.18 Sensor heavy response

For standard dishwashers, the set of operations in a soil-sensing dishwasher for completely washing a load of dishes, four place settings of which are soiled according to AHAM DW-2-2020 and as additionally specified in section 2.7. For compact dishwashers, this definition is the same, except that two soiled place settings are used instead of four.

1.19 Sensor light response

For both standard and compact dishwashers, the set of operations in a soil-sensing dishwasher for

completely washing a load of dishes, one place setting of which is soiled with half of the gram weight of soils for each item specified in a single place setting according to AHAM DW-2-2020 and as additionally specified in section 2.7.

1.20 Sensor medium response

For standard dishwashers, the set of operations in a soil-sensing dishwasher for completely washing a load of dishes, two place settings of which are soiled according to AHAM DW-2-2020 and as additionally specified in section 2.7. For compact dishwashers, this definition is the same, except that one soiled place setting is used instead of two.

1.21 Soil-sensing dishwasher

A dishwasher that has the ability to adjust any energy-consuming aspect of the normal cycle based on the soil load of the dishes.

1.22 Standard dishwasher

A dishwasher that has a capacity equal to or greater than eight place settings plus six serving pieces as specified in AHAM DW-2-2020, using the test load specified in section 2.7.

1.23 Standby mode

A mode in which the dishwasher is connected to a mains power source and offers one or more of the following user-oriented or protective functions which may persist for an indefinite time: (a) To facilitate the activation of other modes (including activation or deactivation of active mode) by remote switch (including remote control), internal sensor, or timer; (b) continuous functions, including information or status displays (including clocks) or sensor-based functions. A timer is a continuous clock function (which may or may not be associated with a display) that provides regular scheduled tasks (*e.g.*, switching) and that operates on a continuous basis.

1.24 Truncated normal cycle

The normal cycle interrupted to eliminate the power-dry feature after the termination of the last rinse operation.

1.25 Truncated sensor heavy response

The sensor heavy response interrupted to eliminate the power-dry feature after the termination of the last rinse operation.

1.26 Truncated sensor light response

The sensor light response interrupted to eliminate the power-dry feature after the termination of the last rinse operation.

1.27 Truncated sensor medium response

The sensor medium response interrupted to eliminate the power-dry feature after the termination of the last rinse operation.

1.28 Water-heating dishwasher

A dishwasher which, as recommended by the manufacturer, is designed for heating cold inlet water (nominal 50 °F) or designed for heating water with a nominal inlet temperature of 120 °F. Any dishwasher designated as water-heating (50 °F or 120 °F inlet water) must provide internal water heating to above 120 °F in a least one wash phase of the normal cycle.

1.29 Water re-use system dishwasher

A dishwasher that has the capability of saving water from the final rinse of one cycle for use in a subsequent cycle.

1.30 Water-softening dishwasher

A dishwasher which incorporates a water softening system that periodically consumes additional water and energy during the cycle to regenerate.

2. TESTING CONDITIONS

2.1 Installation requirements

Install the dishwasher according to the manufacturer's instructions, including drain height. If the manufacture does not provide instructions for a specific drain height, the drain height shall be 20 in. The racks shall be positioned according to the manufacturer recommendation for washing a full load of normally soiled dishes, or in the absence of a recommendation, the racks shall be maintained in the as-shipped position. The rinse aid container shall remain empty. A standard or compact under-counter or under-sink dishwasher must be tested in a rectangular enclosure constructed of nominal 0.374 in (9.5 mm) plywood painted black. The enclosure must consist of a top, a bottom, a back, and two sides. If the dishwasher includes a counter top as part of the appliance, omit the top of the enclosure. Bring the enclosure into the closest contact with the appliance that the configuration of the dishwasher will allow. For standby mode and off mode testing, these products shall also be installed in accordance with section 5, paragraph 5.2 of IEC 62301, disregarding the provisions regarding batteries and the determination, classification, and testing of relevant modes.

2.2 Electrical energy supply

2.2.1 Dishwashers that operate with an electrical supply of 115 V

Maintain the electrical supply to the dishwasher at 115 V ± 2% and within 1% of the nameplate frequency as specified by the manufacturer. Maintain a continuous electrical supply to the unit throughout testing, including the preconditioning cycles, specified in section 2.9, and in between all test cycles.

2.2.2 Dishwashers that operate with an electrical supply of 208 V

Maintain the electrical supply to the dishwasher at 208 V ± 2% and within 1% of the nameplate frequency as specified by the manufacturer. Maintain a continuous electrical supply to the unit throughout testing, including the preconditioning cycles, specified in section 2.9, and in between all test cycles.

2.2.3 Dishwashers that operate with an electrical supply of 240 V

Maintain the electrical supply to the dishwasher at 240 V ± 2% and within 1% of the nameplate frequency

as specified by the manufacturer. Maintain a continuous electrical supply to the unit throughout testing, including the preconditioning cycles, specified in section 2.9, and in between all test cycles.

2.2.4 Supply voltage waveform

For the standby mode and off mode testing, maintain the electrical supply voltage waveform indicated in Section 4, Paragraph 4.3.2 of IEC 62301.

2.3 Water temperature

Measure the temperature of the water supplied to the dishwasher using a temperature measuring device as specified in section 3.1.

2.3.1 Dishwashers to be tested at a nominal 140 °F inlet water temperature

Maintain the water supply temperature at 140° ± 2 °F.

2.3.2 Dishwashers to be tested at a nominal 120 °F inlet water temperature

Maintain the water supply temperature at 120° ± 2 °F.

2.3.3 Dishwashers to be tested at a nominal 50 °F inlet water temperature

Maintain the water supply temperature at 50° ± 2 °F.

2.4 Water pressure

Using a water pressure gauge as specified in section 3.4, maintain the pressure of the water supply at 35 ± 2.5 pounds per square inch gauge (psig) when the water is flowing. The pressure shall be achieved within 2 seconds of opening the water supply valve.

2.5 Room ambient

2.5.1 Ambient and machine temperature, and relative humidity

Using a temperature measuring device as specified in section 3.1, maintain the room ambient air temperature at 75° ± 5 °F, with 75 °F as the target temperature, and ensure that the dishwasher and the test load are at room ambient temperature at the start of each test cycle. Relative humidity shall be maintained at 35% ± 15% throughout the soiling application and two-hour air dry period.

2.5.2 Standby mode and off mode ambient temperature

For standby mode and off mode testing, maintain room ambient air temperature conditions as specified in section 4, paragraph 4.2 of IEC 62301.

2.6 Test cycle and load

2.6.1 Non-soil-sensing dishwashers to be tested at a nominal inlet temperature of 140 °F.

All non-soil-sensing dishwashers to be tested according to section 4.1 at a nominal inlet temperature of 140 °F must be tested on the normal cycle without a test load if the dishwasher does not heat water in the normal cycle.

2.6.2 Non-soil-sensing dishwashers to be tested at a nominal inlet temperature of 50 °F or 120 °F

All non-soil-sensing dishwashers to be tested according to section 4.1 at a nominal inlet temperature of 50 °F or 120 °F must be tested on the normal cycle with a clean load of eight place settings plus six serving pieces, as specified in section 2.7. If the capacity of the dishwasher, as stated by the manufacturer, is less than eight place settings, then the test load must be the stated capacity.

2.6.3 Soil-sensing dishwashers to be tested at a nominal inlet temperature of 50 °F, 120 °F, or 140 °F

All soil-sensing dishwashers shall be tested according to section 4.1 on the normal cycle. The dishwasher shall be tested first for the sensor heavy response, then tested for the sensor medium response, and finally for the sensor light response with the following combinations of soiled and clean test loads.

2.6.3.1 For tests of the sensor heavy response, as defined in section 1.18:

(A) For standard dishwashers, the test unit is to be loaded with a total of eight place settings plus six serving pieces as specified in section 2.7. Four of the eight place settings, except for the flatware, must be soiled according to sections 5.3 through 5.7 of AHAM DW-2-2020 and as additionally specified in sections 2.7.4 and 2.7.5, while the remaining place settings, serving pieces, and all flatware are not soiled. The test load is to be loaded in the dishwasher according to section 5.8 of AHAM DW-2-2020 and as additionally specified in section 2.6.3.4 of this procedure.

(B) For compact dishwashers, the test unit is to be loaded with four place settings plus six serving pieces as specified in section 2.7. Two of the four place settings, except for the flatware, must be soiled according to sections 5.3 through 5.7 of AHAM DW-2-2020 and as additionally specified in sections 2.7.4 and 2.7.5, while the remaining place settings, serving pieces, and all flatware are not soiled. The test load is to be loaded in the dishwasher according to section 5.8 of AHAM DW-2-2020 and as additionally specified in section 2.6.3.4 of this procedure.

2.6.3.2 For tests of the sensor medium response, as defined in section 1.20:

(A) For standard dishwashers, the test unit is to be loaded with a total of eight place settings plus six serving pieces as specified in section 2.7. Two of the eight place settings, except for the flatware, must be soiled according to sections 5.3 through 5.7 of AHAM DW-2-2020 and as additionally specified in sections 2.7.4 and 2.7.5, while the remaining place settings, serving pieces, and all flatware are not soiled. The test load is to be loaded in the dishwasher according to section 5.8 of AHAM DW-2-2020 and as additionally specified in section 2.6.3.4 of this procedure.

(B) For compact dishwashers, the test unit is to be loaded with four place settings plus six serving pieces as specified in section 2.7. One of the four place settings, except for the flatware, must be soiled according to sections 5.3 through 5.7 of AHAM DW-2-2020 and as additionally specified in sections 2.7.4 and 2.7.5, while the remaining place settings, serving pieces, and all flatware are not soiled. The test load is to be loaded in the dishwasher according to section 5.8 of AHAM DW-2-2020 and as additionally specified in section 2.6.3.4 of this procedure.

2.6.3.3 For tests of the sensor light response, as defined in section 1.19:

(A) For standard dishwashers, the test unit is to be loaded with a total of eight place settings plus six serving pieces as specified in section 2.7. One of the eight place settings, except for the flatware, must be soiled with half of the soil load specified for a single place setting according to sections 5.3 through 5.7 of AHAM DW-2-2020 and as additionally specified in sections 2.7.4 and 2.7.5, while the remaining place settings,

serving pieces, and all flatware are not soiled. The test load is to be loaded in the dishwasher according to section 5.8 of AHAM DW-2-2020 and as additionally specified in section 2.6.3.4 of this procedure.

(B) For compact dishwashers, the test unit is to be loaded with four place settings plus six serving pieces as specified in section 2.7. One of the four place settings, except for the flatware, must be soiled with half of the soil load specified for a single place setting according to sections 5.3 through 5.7 of AHAM DW-2-2020 and as additionally specified in sections 2.7.4 and 2.7.5, while the remaining place settings, serving pieces, and all flatware are not soiled. The test load is to be loaded in the dishwasher according to section 5.8 of AHAM DW-2-2020 and as additionally specified in section 2.6.3.4 of this procedure.

2.6.3.4 Soil Sensing Machine Loading requirements

Where similar items (*e.g.*, all bread and butter plates or all fruit bowls) are loaded adjacent in the racks, there shall not be any empty rack spaces in between. Empty rack spaces between different items (*e.g.*, between the set of bread and butter plates and set of fruit bowls) are acceptable only if one of the following conditions is met:

(A) The capacity of the unit under test is greater than the number of place settings required by section 2.6.

(B) The manufacturer's use and care guide for the unit under test instructs the user to leave empty rack spaces while loading.

Clean items shall be loaded in the unit under test first, followed by the soiled items.

For soil sensing units, the alternating of clean and soiled items for standard dishwashers is explained below. Test load items adjacent to any empty rack spaces shall be clean.

(A) Sensor Heavy Response Test Load: Alternate clean and soiled items. Figure 1 in Appendix A shows an example schematic of the Sensor Heavy Response loading pattern for an example dishwasher.

(B) Sensor Medium Response Test Load: The soiled items shall be evenly distributed throughout each group of dish type (*e.g.*, when all dinner plates are loaded into the dishwasher the soiled dish is repeated after every two clean items). Figure 2 in Appendix A shows an example schematic of the Sensor Medium Response loading pattern for an example dishwasher.

(C) Sensor Light Response Test Load: Load the soiled item towards the middle of each group of each type of dish (*e.g.*, when all dinner plates are loaded into the dishwasher, the soiled dinner plate should be either the fourth or fifth dinner plate). Figure 3 in Appendix A shows an example schematic of the Sensor Light Response loading pattern for an example dishwasher.

For each soil load, the alternating of clean and soiled items for compact dishwashers is explained below. Test load items adjacent to any empty racks spaces shall be clean.

(A) Sensor Heavy Response Test Load: Alternate clean and soiled items.

(B) Sensor Medium Response Test Load and Sensor Light Response Test Load: Load the soiled item towards the middle of each type of dish (*e.g.*, when all dinner plates are loaded into the dishwasher, the soiled dinner plate should be either the second or third dinner plate).

Rinse aid shall not be used in the unit under test.

2.7 Test load

2.7.1 Test load items

Test load items are described in section 3.4 of AHAM DW-2-2020.

2.7.2 Place setting

A place setting shall consist of one cup, one saucer, one dinner plate, one bread and butter plate, one fruit bowl, one iced tea glass, one dinner fork, one salad fork, one knife, and two teaspoons.

2.7.3 Serving pieces

Serving pieces shall consist of two serving bowls, one platter, one serving fork, and two serving spoons.

2.7.4 Soils

The soils shall be as specified in section 5.4 of AHAM DW-2-2020.

2.7.5 Soil Preparation

Soils shall be prepared according to section 5.5 of AHAM DW-2-2020, with the following additional specifications.

2.7.5.1 Milk

The nonfat dry milk shall be reconstituted before mixing with the oatmeal and potatoes. It shall be reconstituted with water by mixing 2/3 cup of nonfat dry milk with 2 cups of water until well mixed. The reconstituted milk may be stored for use over the course of 1 day.

2.7.5.2 Instant mashed potatoes

The potato mixture shall be applied within 30 minutes of preparation according to section 5.5.4 of AHAM DW-2-2020.

2.7.5.3 Ground beef

The 1-pound packages of ground beef shall be stored frozen for no more than 6 months.

2.8 Testing requirements

Provisions in this standard pertaining to dishwashers that operate with a nominal inlet temperature of 50 °F or 120 °F apply only to water-heating dishwashers as defined in section 1.28.

2.9 Preconditioning requirements

Precondition the dishwasher twice by establishing the testing conditions set forth in sections 2.1 through 2.5. For each preconditioning, set the dishwasher to the preconditioning cycle as defined in section 1.17, without using a test load, and initiate the cycle. For dishwashers other than water re-use system dishwashers, during the second preconditioning, measure the prewash fill water volume, V_{pw}, if any, and the main wash fill water volume, V_{mw}.

2.10 Detergent

For dishwashers other than water re-use system dishwashers, determine the amount of detergent (in g) to be added to the prewash compartment and the main wash compartment according to section 2.10.1. For water re-use system dishwashers, determine the amount of detergent (in g) to be added to the dishwasher according to section 2.10.2.

2.10.1 Detergent Dosing for Dishwashers other than Water Re-use System Dishwashers

Use half the quantity of detergent specified according to section 4.1 of AHAM DW-2-2020. Prewash detergent shall be used if recommended by the manufacturer's instructions for conditions consistent within this test procedure. If prewash detergent usage is recommended by the manufacturer's instructions, placement of the prewash detergent shall be as instructed by the manufacturer. If no recommendation for placement is offered by the manufacturer then prewash detergent shall be placed on the inner door near the detergent cup.

2.10.2 Detergent Dosing for Water Re-use System Dishwashers

Determine the quantity of dry wash detergent, D_{rw}, in grams (g) as:

$$D_{rw} = V_{rw} \times \rho \times k \times \frac{0.25}{100}$$

where, V_{rw} = the reported volume of water in gal, representing both saved water fill and house supply water fill, and

ρ = water density = 8.343 lb/gal for dishwashers to be tested at a nominal inlet water temperature of 50 °F (10 °C), 8.250 lb/gal for dishwashers to be tested at a nominal inlet water temperature of 120 °F (49 °C), and 8.205 lb/gal for dishwashers to be tested at a nominal inlet water temperature of 140 °F (60 °C), and

k = conversion factor from lb to g = 453.6 g/lb.

2.11 Water Hardness

Maintain the hardness of the water supply between 0 and 85 parts per million (ppm) of $CaCO_3$. Where necessary a cation exchange water softener may be used to maintain water hardness at this level. Conduct water hardness measurements no less than once a week across a test series.

3. INSTRUMENTATION

Test instruments must be calibrated annually.

3.1 Temperature measuring device

The device must have an error no greater than ± 1 °F over the range being measured.

3.2 Timer

Time measurements for each monitoring period shall be accurate to within 2 seconds.

3.3 Water meter

The water meter must have a resolution of no larger than 0.1 gal and a maximum error no greater than ± 1.5% of the measured flow rate for all water temperatures encountered in the test cycle.

3.4 Water pressure gauge

The water pressure gauge must have a resolution of one pound per square inch (psi) and must have an error no greater than 5% of any measured value over the range of 35 ± 2.5 psig.

3.5 Watt-hour meter

The watt-hour meter must have a resolution of .1 Wh or less and a maximum error of no more than 1% of the measured value for any demand greater than 5 W.

3.6 Standby mode and off mode watt meter

The watt meter used to measure standby mode and off mode power consumption shall meet the requirements specified in section 4, paragraph 4.4 of IEC 62301.

3.7 Relative humidity measuring device

Relative humidity measurement equipment shall have resolution of at least 1% RH, and shall have an accuracy of at least ± 6% RH over the temperature range of 75 ºF ± 5 ºF.

4. TEST CYCLE AND MEASUREMENTS

4.1 Active mode cycle

Perform a test cycle by establishing the testing conditions set forth in section 2, setting the dishwasher to the cycle type to be tested according to section 2.6.1, 2.6.2, or 2.6.3, initiating the cycle, and allowing the cycle to proceed to completion.

4.1.1 Machine electrical energy consumption

Measure the machine electrical energy consumption, M, expressed as the number of kilowatt-hours of electricity consumed by the machine during the entire test cycle, using a water supply temperature as set forth in section 2.3 and using a watt-hour meter as specified in section 3.5.

4.1.2 Fan electrical energy consumption

If the dishwasher is capable of operation in fan-only mode, measure the fan electrical energy consumption, M_F, expressed as the number of kilowatt-hours of electricity consumed by the machine for the duration of fan-only mode, using a watt-hour meter as specified in section 3.5. Alternatively, if the duration of fan-only mode is known, the watt-hours consumed may be measured for a period of 10 minutes in fan-only mode, using a watt-hour meter as specified in section 3.5. Multiply this value by the time in minutes that the dishwasher remains in fan-only mode, L_F, and divide by 10,000 to obtain M_F. The alternative approach may be used only if the resulting M_F is representative of energy use during the entire fan-only mode.

4.1.3 Water re-use system dishwashers

All water re-use system dishwashers must be tested in a reasonable time such that no clean out event occurs during testing. Disconnecting a dishwasher's electrical power supply will result in the occurrence of a clean

out event during the next dishwasher cycle; therefore, all testing must be completed with continuous electrical supply as specified in section 2.2. Avoid long lapses between the start of cycles to prevent a drain out event from occurring during testing.

4.1.3.1 Detection of a drain out event

To detect a drain out event, measure the water volume supplied during the first fill. A cycle shall be considered to have a drain out event if the volume of water during the first fill greatly exceeds the typical volume of the first fill of other tested cycles.

4.1.3.2 Detection of a clean out event

To detect a clean out event, monitor the temperature of the sump water using an additional temperature measuring device as specified in section 3.1. The temperature measuring device shall be placed inside the sump in an area such that it is always submerged in water and does not interfere with the operation of the dishwasher. A cycle shall be considered to have a "clean out" event if the temperature of the sump water during wash and rinse portions of the cycle is significantly higher than the temperature of the sump water of other test cycles.

4.1.3.3 Drain out or clean out event during testing

If a drain out or clean out event occurs during testing, disconnect and reconnect power to the dishwasher, then restart the test. For a clean out event, confirm that the saved water has returned to room ambient temperature by placing a thermocouple on the surface of the saved water tank to measure temperature before restarting the testing of a subsequent cycle. Any results from cycles where a drain out or clean out event occurs shall be disregarded.

4.1.4 Water consumption

Measure the water consumption, V, expressed as the number of gallons of water delivered to the machine during the entire test cycle, using a water meter specified in section 3.3.

4.2 Standby mode and off mode power

Perform standby mode and off mode testing after completion of the last active mode test included as part of the energy test sequence. After opening the door; without changing the control panel settings used for the active mode wash cycle, immediately close the door and without disconnecting the electrical supply to the dishwasher, begin the standby and off mode tests. For units with both standby and off modes, standby mode shall be tested first, followed by off mode.

Ensure the dishwasher is connected to a standby mode and off mode watt meter as specified in section 3.6. Establish the testing conditions set forth in sections 2.1, 2.2, and 2.5.2. For dishwashers that take some time to enter a stable state from a higher power state as discussed in section 5, paragraph 5.1, note 1 of IEC 62301, allow sufficient time for the dishwasher to reach the lower power state before proceeding with the test measurement. Follow the test procedure specified in section 5, paragraph 5.3.2 of IEC 62301 for testing in each possible mode as described in sections 4.2.1 and 4.2.2.

4.2.1 Inactive mode power

If the dishwasher has an inactive mode, as defined in section 1.12, measure and record the average inactive mode power of the dishwasher, P_{IA}, in W.

4.2.2 Off mode power

If the dishwasher has an off mode, as defined in section 1.15, measure and record the average off mode power, P_{OM}, in W.

5. CALCULATION OF DERIVED RESULTS FROM TEST MEASUREMENTS

5.1 Machine energy consumption.

5.1.1 Machine energy consumption for non-soil-sensing electric dishwashers

Take the value recorded in section 4.1.1 as the per-cycle machine electrical energy consumption. Express the value, M, in kWh per cycle.

5.1.2 Machine energy consumption for soil-sensing electric dishwashers

The machine energy consumption for the sensor normal cycle, M, is defined as:

$$M = (M_{hr} \times F_{hr}) + (M_{mr} \times F_{mr}) + (M_{lr} \times F_{lr})$$

where, M_{hr} = the value recorded in section 4.1.1 for the test of the sensor heavy response, expressed in kWh per cycle,
M_{mr} = the value recorded in section 4.1.1 for the test of the sensor medium response, expressed in kWh per cycle,
M_{lr} = the value recorded in section 4.1.1 for the test of the sensor light response, expressed in kWh per cycle,
F_{hr} = the weighting factor based on consumer use of heavy response = 0.05,
F_{mr} = the weighting factor based on consumer use of medium response = 0.33, and
F_{lr} = the weighting factor based on consumer use of light response = 0.62.

5.1.3 Machine energy consumption during water softener regeneration for water-softening dishwashers

The machine energy consumption for water softener regeneration, M_{WS}, is defined as:

$$M_{WS} = M_{WS_{cycle}} \times \frac{N_{WS}}{N}$$

where, $M_{WS_{cycle}}$ = the reported value of the additional machine electrical energy consumption required for water softener regeneration during a cycle including water softener regeneration, expressed in kWh,
N_{WS} = the reported representative average number of water softener regeneration cycles per year, and
N = the representative average dishwasher use of 184 cycles per year.

5.1.4 Machine energy consumption during drain out events for water re-use system dishwashers

The machine energy consumption during drain out events for water re-use system dishwashers, M_{DO}, is defined as:

$$M_{DO} = M_{DO_{cycle}} \times \frac{N_{DO}}{N}$$

where, $M_{DO_{cycle}}$ = the reported value of the additional machine electrical energy consumption required during a drain out event for a water re-use system dishwasher, expressed in kWh,

N_{DO} = the reported representative average number of drain out events per year, and

N = the representative average dishwasher use of 184 cycles per year.

5.1.5 Machine energy consumption during clean out events for water re-use system dishwashers

The machine energy consumption during clean out events for water re-use system dishwashers, M_{CO}, is defined as:

$$M_{CO} = M_{CO_{cycle}} \times \frac{N_{CO}}{N}$$

where, $M_{CO_{cycle}}$ = the reported value of the additional machine electrical energy consumption required during a clean out event for a water re-use system dishwasher, expressed in kWh,

N_{CO} = the reported representative average number of clean out events per year, and

N = the representative average dishwasher use of 184 cycles per year.

5.2 Fan-only mode energy consumption

5.2.1 Electrical energy consumption for fan-only mode for non-soil-sensing electric dishwashers

Take the value recorded in section 4.1.2 as the per-cycle electrical energy consumption for fan-only mode. Express the value, E_F, in kWh per cycle. If the dishwasher is not capable of operation in fan-only mode, $E_F = 0$.

5.2.2 Electrical energy consumption for fan-only mode for soil-sensing electric dishwashers

The fan-only mode electrical energy consumption, E_F, for the sensor normal cycle is defined as:

$$E_F = \frac{E_{F_{hr}} + E_{F_{mr}} + E_{F_{lr}}}{3}$$

where, $E_{F_{hr}}$ = the value recorded in section 4.1.2 for the test of the sensor heavy response, expressed in kWh per cycle,

$E_{F_{mr}}$ = the value recorded in section 4.1.2 for the test of the sensor medium response, expressed in kWh per cycle,

$E_{F_{lr}}$ = the value recorded in section 4.1.2 for the test of the sensor light response, expressed in kWh per cycle,

If the dishwasher is not capable of operation in fan-only mode, $E_F = 0$.

5.3 Drying energy

5.3.1 Drying energy consumption for non-soil-sensing electric dishwashers

Calculate the amount of energy consumed using the power-dry feature after the termination of the last rinse option of the normal cycle. Express the value, E_D, in kWh per cycle.

5.3.2 Drying energy consumption for soil-sensing electric dishwashers

The drying energy consumption, E_D, for the sensor normal cycle is defined as:

$$E_D = \frac{E_{D_{hr}} + E_{D_{mr}} + E_{D_{lr}}}{3}$$

where, $E_{D_{hr}}$ = energy consumed using the power-dry feature after the termination of the last rinse option of the sensor heavy response, expressed in kWh per cycle,
$E_{D_{mr}}$ = energy consumed using the power-dry feature after the termination of the last rinse option of the sensor medium response, expressed in kWh per cycle,
$E_{D_{lr}}$ = energy consumed using the power-dry feature after the termination of the last rinse option of the sensor light response, expressed in kWh per cycle,

5.4 Water consumption

5.4.1 Water consumption for non-soil-sensing electric dishwashers using electrically heated, gas-heated, or oil-heated water

Take the value recorded in section 4.1.3 as the per-cycle water consumption. Express the value, V, in gal per cycle.

5.4.2 Water consumption for soil-sensing electric dishwashers using electrically heated, gas-heated, or oil-heated water

The water consumption for the sensor normal cycle, V, is defined as:

$$V = (V_{hr} \times F_{hr}) + (V_{mr} \times F_{mr}) + (V_{lr} \times F_{lr})$$

where, V_{hr} = the value recorded in section 4.1.3 for the test of the sensor heavy response, expressed in gal per cycle,
V_{mr} = the value recorded in section 4.1.3 for the test of the sensor medium response, expressed in gal per cycle,
V_{lr} = the value recorded in section 4.1.3 for the test of the sensor light response, expressed in gal per cycle,
F_{hr} = the weighting factor based on consumer use of heavy response = 0.05,
F_{mr} = the weighting factor based on consumer use of medium response = 0.33, and
F_{lr} = the weighting factor based on consumer use of light response = 0.62.

5.4.3 Water consumption during water softener regeneration for water-softening dishwashers using electrically heated, gas-heated, or oil-heated water

The water consumption for water softener regeneration, V_{WS}, is defined as:

$$V_{WS} = V_{WS_{cycle}} \times \frac{N_{WS}}{N}$$

where, $V_{WS_{cycle}}$ = the reported value of the additional water consumption required for water softener regeneration during a cycle including water softener regeneration, expressed in gal per cycle,

N_{WS} = the reported representative average number of water softener regeneration cycles per year, and

N = the representative average dishwasher use of 184 cycles per year.

5.4.4 Water consumption during drain out events for water re-use system dishwashers using electrically heated, gas-heated, or oil-heated water

The water consumption during drain out events for water re-use system dishwashers, V_{DO}, is defined as:

$$V_{DO} = V_{DO_{cycle}} \times \frac{N_{DO}}{N}$$

where, $V_{DO_{cycle}}$ = the reported value of the additional water consumption required during a drain out event for a water re-use system dishwasher, expressed in gal per cycle,

N_{DO} = the reported representative average number of drain out events per year, and

N = the representative average dishwasher use of 184 cycles per year.

5.4.5 Water consumption during clean out events for water re-use system dishwashers using electrically heated, gas-heated, or oil-heated water

The water consumption during clean out events for water re-use system dishwashers, V_{CO}, is defined as:

$$V_{CO} = V_{CO_{cycle}} \times \frac{N_{CO}}{N}$$

where, $V_{CO_{cycle}}$ = the reported value of the additional water consumption required during a clean out event for a water re-use system dishwasher, expressed in gal per cycle,

N_{CO} = the reported representative average number of clean out events per year, and

N = the representative average dishwasher use of 184 cycles per year.

5.5 Water energy consumption for non-soil-sensing or soil-sensing dishwashers using electrically heated water

5.5.1 Dishwashers that operate with a nominal 140 °F inlet water temperature, only

5.5.1.1 Calculate the water energy consumption, W, expressed in kWh per cycle and defined as:

$$W = V \times T \times K$$

where, V = water consumption in gal per cycle, as determined in section 5.4.1 for non-soil-sensing dishwashers and section 5.4.2 for soil-sensing dishwashers,

T = nominal water heater temperature rise = 90 °F, and

K = specific heat of water in kWh per gal per °F = 0.0024.

5.5.1.2 For water-softening dishwashers, calculate the water softener regeneration water energy consumption, W_{WS}, expressed in kWh per cycle and defined as:

$$W_{WS} = V_{WS} \times T \times K$$

where, V_{WS} = water consumption during water softener regeneration in gal per cycle which includes regeneration, as determined in section 5.4.3,
T = nominal water heater temperature rise = 90 °F, and
K = specific heat of water in kWh per gal per ºF = 0.0024.

5.5.1.3 For water re-use system dishwashers, calculate the drain out event water energy consumption, W_{DO}, expressed in kWh per cycle and defined as:

$$W_{DO} = V_{DO} \times T \times K$$

where, V_{DO} = water consumption during drain out events for water re-use system dishwashers in gal per cycle, as determined in section 5.4.4,
T = nominal water heater temperature rise = 90 °F, and
K = specific heat of water in kWh per gal per ºF = 0.0024.

5.5.1.4 For water re-use system dishwashers, calculate the clean out event water energy consumption, W_{CO}, expressed in kWh per cycle and defined as:

$$W_{CO} = V_{CO} \times T \times K$$

where, V_{CO} = water consumption during clean out events for water re-use system dishwashers in gal per cycle, as determined in section 5.4.5,
T = nominal water heater temperature rise = 90 °F, and
K = specific heat of water in kWh per gal per ºF = 0.0024.

5.5.2 Dishwashers that operate with a nominal inlet water temperature of 120 °F

5.5.2.1 Calculate the water energy consumption, W, expressed in kWh per cycle and defined as:

$$W = V \times T \times K$$

where, V = water consumption in gal per cycle, as determined in section 5.4.1 for non-soil-sensing dishwashers and section 5.4.2 for soil-sensing dishwashers,
T = nominal water heater temperature rise = 70 °F, and
K = specific heat of water in kWh per gal per ºF = 0.0024,

5.5.2.2 For water-softening dishwashers, calculate the water softener regeneration water energy consumption, W_{WS}, expressed in kWh per cycle and defined as:

$$W_{WS} = V_{WS} \times T \times K$$

where, V_{WS} = water consumption during water softener regeneration in gal per cycle which includes regeneration, as determined in section 5.4.3,

T = nominal water heater temperature rise = 70 °F, and
K = specific heat of water in kWh per gal per ºF = 0.0024.

5.5.2.3 For water re-use system dishwashers, calculate the drain out event water energy consumption, W_{DO}, expressed in kWh per cycle and defined as:

$$W_{DO} = V_{DO} \times T \times K$$

where, V_{DO} = water consumption during drain out events for water re-use system dishwashers in gal per cycle, as determined in section 5.4.4,
T = nominal water heater temperature rise = 70 °F, and
K = specific heat of water in kWh per gal per ºF = 0.0024.

5.5.2.4 For water re-use system dishwashers, calculate the clean out event water energy consumption, W_{CO}, expressed in kWh per cycle and defined as:

$$W_{CO} = V_{CO} \times T \times K$$

where, V_{CO} = water consumption during clean out events for water re-use system dishwashers in gal per cycle, as determined in section 5.4.5,
T = nominal water heater temperature rise = 70 °F, and
K = specific heat of water in kWh per gal per ºF = 0.0024.

5.6 Water energy consumption per cycle using gas-heated or oil-heated water.

5.6.1 Dishwashers that operate with a nominal 140 °F inlet water temperature, only.

5.6.1.1 Calculate the water energy consumption using gas-heated or oil-heated water, W_g, expressed in Btu's per cycle and defined as:

$$W_g = V \times T \times \frac{C}{e}$$

where, V = water consumption in gal per cycle, as determined in section 5.4.1 for non-soil-sensing dishwashers and section 5.4.2 for soil-sensing dishwashers,
T = nominal water heater temperature rise = 90 °F,
C = specific heat of water in Btu's per gal per ºF = 8.2, and
e = nominal gas or oil water heater recovery efficiency = 0.75,

5.6.1.2 For water-softening dishwashers, calculate the water softener regeneration water energy consumption, W_{WS_g}, expressed in kWh per cycle and defined as:

$$W_{WS_g} = V_{WS} \times T \times \frac{C}{e}$$

where, V_{WS} = water consumption during water softener regeneration in gal per cycle which includes regeneration, as determined in section 5.4.3,
T = nominal water heater temperature rise = 90 °F,

C = specific heat of water in Btu's per gal per ºF = 8.2, and
e = nominal gas or oil water heater recovery efficiency = 0.75.

5.6.1.3 For water re-use system dishwashers, calculate the drain out event water energy consumption, W_{DO}, expressed in kWh per cycle and defined as:

$$W_{DO} = V_{DO} \times T \times K$$

where, V_{DO} = water consumption during drain out events for water re-use system dishwashers in gal per cycle, as determined in section 5.4.4,
T = nominal water heater temperature rise = 90 °F, and
C = specific heat of water in Btu's per gal per ºF = 8.2, and
e = nominal gas or oil water heater recovery efficiency = 0.75.

5.6.1.4 For water re-use system dishwashers, calculate the clean out event water energy consumption, W_{CO}, expressed in kWh per cycle and defined as:

$$W_{CO} = V_{CO} \times T \times K$$

where, V_{CO} = water consumption during clean out events for water re-use system dishwashers in gal per cycle, as determined in section 5.4.5,
T = nominal water heater temperature rise = 90 °F, and
C = specific heat of water in Btu's per gal per ºF = 8.2, and
e = nominal gas or oil water heater recovery efficiency = 0.75.

5.6.2 Dishwashers that operate with a nominal 120 °F inlet water temperature, only

5.6.2.1 Calculate the water energy consumption using gas-heated or oil-heated water, W_g, expressed in Btu's per cycle and defined as:

$$W_g = V \times T \times \frac{C}{e}$$

where, V = water consumption in gal per cycle, as determined in section 5.4.1 for non-soil-sensing dishwashers and section 5.4.2 for soil-sensing dishwashers,
T = nominal water heater temperature rise = 70 °F,
C = specific heat of water in Btu's per gal per ºF = 8.2, and
e = nominal gas or oil water heater recovery efficiency = 0.75.

5.6.2.2 For water-softening dishwashers, calculate the water softener regeneration water energy consumption, W_{WS_g}, expressed in kWh per cycle and defined as:

$$W_{WS_g} = V_{WS} \times T \times \frac{C}{e}$$

where, V_{WS} = water consumption during water softener regeneration in gal per cycle which includes regeneration, as determined in section 5.4.3,
T = nominal water heater temperature rise = 70 °F,

C = specific heat of water in Btu's per gal per ºF = 8.2, and
e = nominal gas or oil water heater recovery efficiency = 0.75.

5.6.2.3 For water re-use system dishwashers, calculate the drain out event water energy consumption, W_{DO}, expressed in kWh per cycle and defined as:

$$W_{DO} = V_{DO} \times T \times K$$

where, V_{DO} = water consumption during drain out events for water re-use system dishwashers in gal per cycle, as determined in section 5.4.4,
T = nominal water heater temperature rise = 70 °F, and
C = specific heat of water in Btu's per gal per ºF = 8.2, and
e = nominal gas or oil water heater recovery efficiency = 0.75.

5.6.2.4 For water re-use system dishwashers, calculate the clean out event water energy consumption, W_{CO}, expressed in kWh per cycle and defined as:

$$W_{CO} = V_{CO} \times T \times K$$

where, V_{CO} = water consumption during clean out events for water re-use system dishwashers in gal per cycle, as determined in section 5.4.5,
T = nominal water heater temperature rise = 70 °F, and
C = specific heat of water in Btu's per gal per ºF = 8.2, and
e = nominal gas or oil water heater recovery efficiency = 0.75.

5.7 Annual combined low-power mode energy consumption

Calculate the annual combined low-power mode energy consumption for dishwashers, E_{TLP}, expressed in kWh per year, according to the following:

$$E_{TLP} = \{(P_{IA} \times S_{IA}) + (P_{OM} \times S_{OM})\} \times K$$

where: P_{IA} = dishwasher inactive mode power, in W, as measured in section 4.2.1 for dishwashers capable of operating in inactive mode; otherwise, $P_{IA} = 0$,
P_{OM} = dishwasher off mode power, in W, as measured in section 4.2.2 for dishwashers capable of operating in off mode; otherwise, $P_{OM} = 0$,
S_{IA} = annual hours in inactive mode as defined as S_{LP} if no off mode is possible, $[S_{LP}/2]$ if both inactive mode and off mode are possible, and 0 if no inactive mode is possible,
S_{OM} = annual hours in off mode as defined as S_{LP} if no inactive mode is possible, $[S_{LP}/2]$ if both inactive mode and off mode are possible, and 0 if no off mode is possible,
S_{LP} = combined low-power annual hours for all available modes other than active mode as defined as $[H - \{N \times (L + L_F)\}]$. For dishwashers not capable of operating in fan-only mode, set $L_F = 0$,
H= the total number of hours per year = 8766 h per year,
N = the representative average dishwasher use of 184 cycles per year,
L = the average of the duration of the normal cycle and truncated normal cycle, for non-soil-sensing dishwashers with a truncated normal cycle; the duration of the normal cycle, for non-soil-sensing dishwashers without a truncated normal cycle; the

average duration of the sensor light response, truncated sensor light response, sensor medium response, truncated sensor medium response, sensor heavy response, and truncated sensor heavy response, for soil-sensing dishwashers with a truncated cycle option; the average duration of the sensor light response, sensor medium response, and sensor heavy response, for soil-sensing dishwashers without a truncated cycle option,

L_F = the duration of the fan-only mode for the normal cycle for non-soil-sensing dishwashers; the average duration of the fan-only mode for sensor light response, sensor medium response, and sensor heavy response for soil-sensing dishwashers, and

K = 0.001 kWh/Wh conversion factor for Wh to kWh.

APPENDIX A: SCHEMATIC OF LOADING PATTERN

The figures below show schematics for the loading pattern of an example standard dishwasher for the sensor heavy response, sensor medium response, and sensor light response soil loads. These schematics show examples of potential ways to alternate clean and soiled items, and should be used for reference only. The instructions in section 2.6.3 shall be followed for loading the unit under test, with clean and soiled items alternated as shown in the examples below.

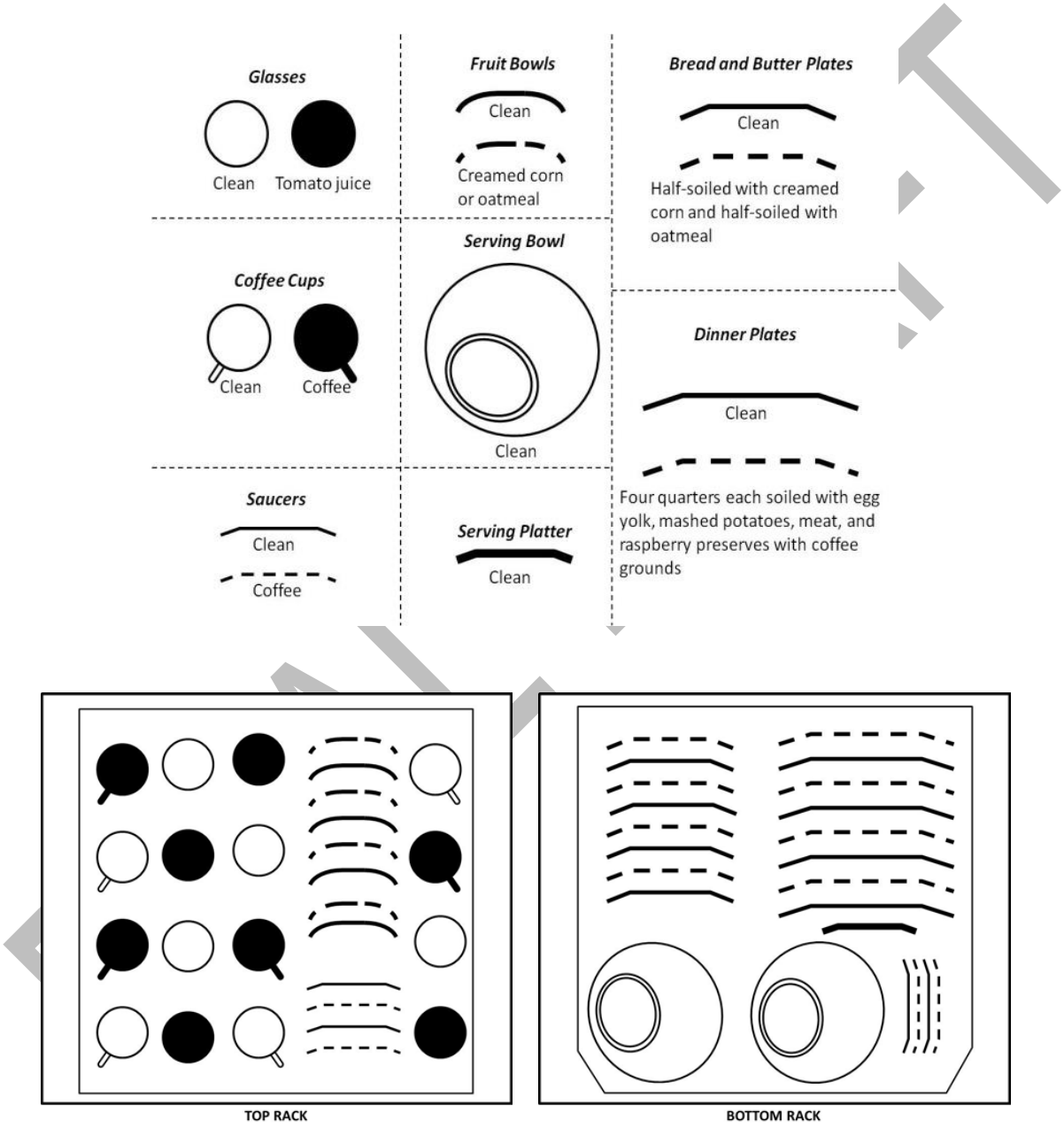

Figure 1 Loading pattern for the sensor heavy response soil load

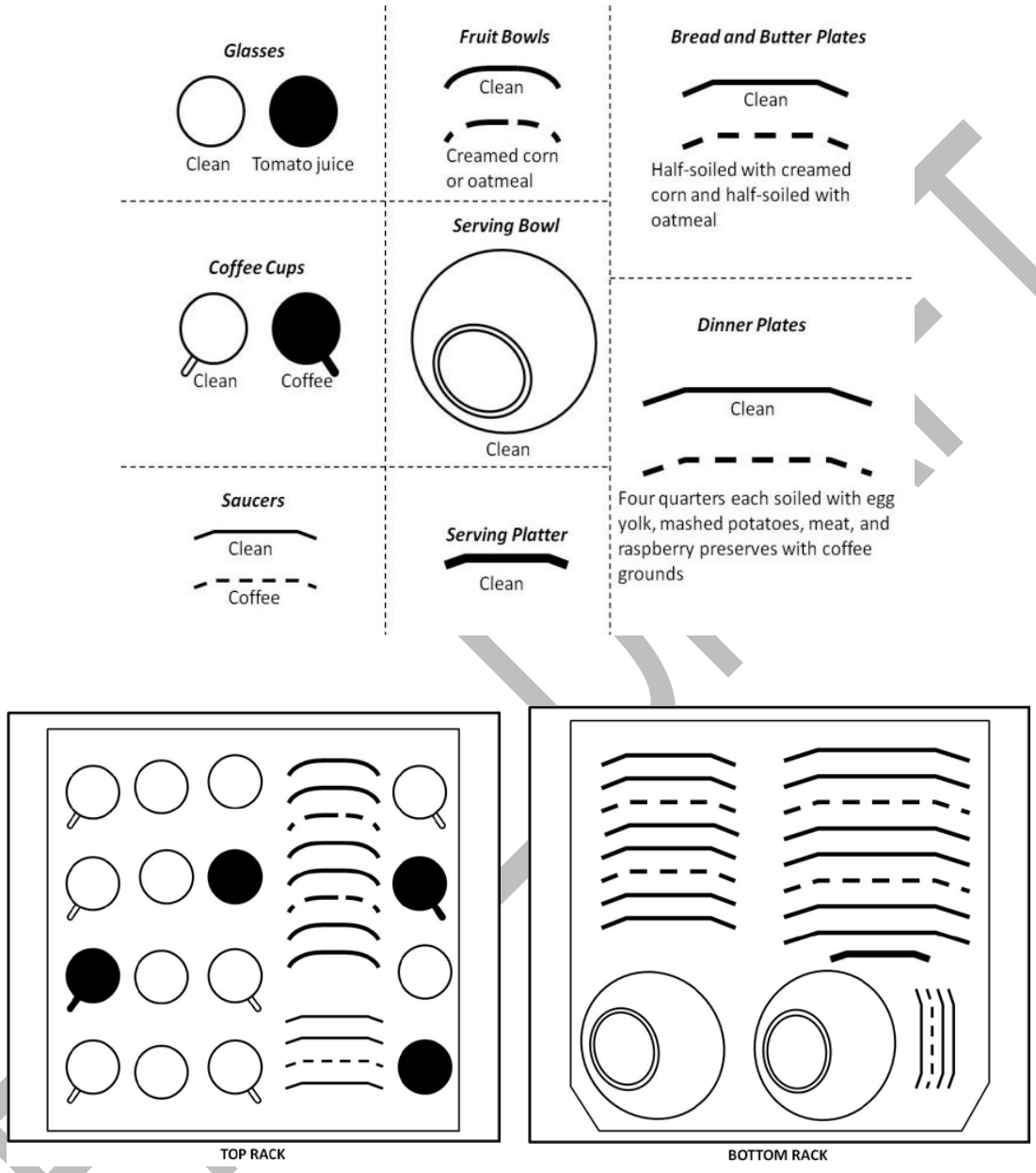

Figure 2 Loading pattern for the sensor medium response soil load

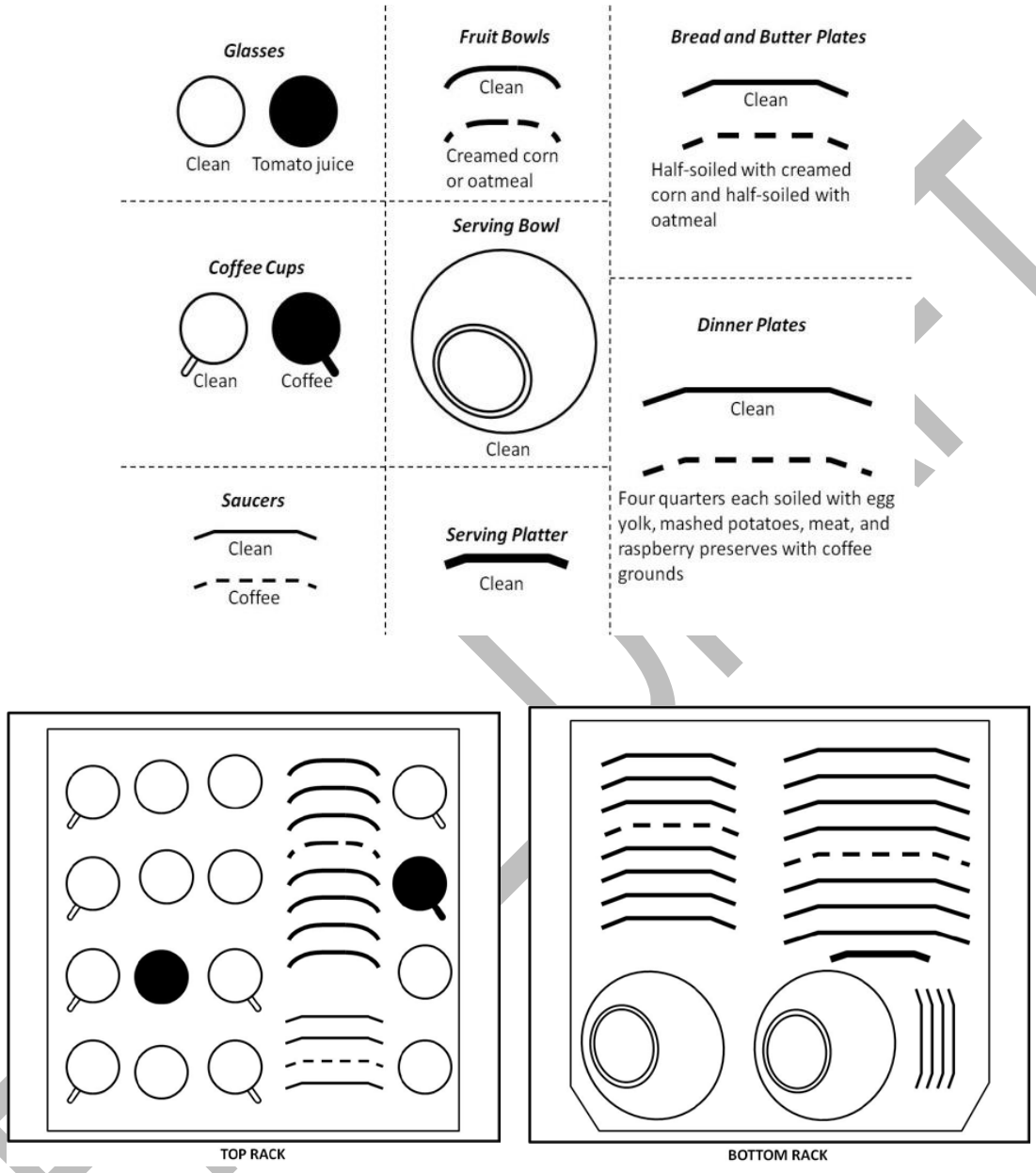

Figure 3 Loading pattern for the sensor light response soil load