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An American National Standard

Standard Test Method for Energy Performance of Rack Conveyor, Hot Water Sanitizing, Commercial Dishwashing Machines[1]

This standard is issued under the fixed designation F 1920; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method evaluates the energy consumption of rack conveyor, hot water sanitizing, commercial dishwashing machines, hereafter referred to as dishwashers. It excludes rack conveyor, chemical sanitizing, commercial dishwashing machines, and dishwashers with multiple tanks and prewashing sections. This test method also excludes single temperature rack conveyor dishwashing machines. Dishwasher tank heaters are evaluated separately from the booster heaters. Dishwashers may have remote or self-contained booster heater. This procedure does not address cleaning or sanitizing performance.

1.2 The following procedures are included in this test method:

1.2.1 *Procedures to Confirm Dishwasher is Operating Properly Prior to Performance Testing*:

1.2.1.1 Maximum energy input rate of the tank heaters (10.2).

1.2.1.2 Maximum energy input rate of the booster heater, if applicable (10.3).

1.2.1.3 Final sanitizing rinse water consumption calibration (10.4).

1.2.1.4 Booster temperature calibration, if applicable (10.5).

1.2.1.5 Wash tank temperature calibration (10.6).

1.2.1.6 Wash tank pump and conveyor motor calibration (10.7).

1.2.2 *Energy Usage and Cycle Rate Performance Tests*:

1.2.2.1 Washing energy performance test (10.8).

1.2.2.2 Tank heater idle energy rate (10.9).

1.2.2.3 Booster idle energy rate, if provided (10.10).

1.3 The values stated in inch-pound units are to be regarded as standard. The SI units given in parentheses are for information only.

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

2. Referenced Documents

2.1 *ASTM Standards:*

D 3588 Practice for Calculating Calorific Heat Value, Compressibility Factor, and Relative Density of Gaseous Fuels[2]

F 858 Specification for Hot Water Sanitizing Commercial Dishwashing Machines, Single Tank, Conveyor Rack Type[3]

F 861 Specification for Commercial Dishwashing Racks[3]

2.2 *NSF Standards:*

ANSI/NSF 3–1996 Commercial Spray-Type Dishwashing and Glasswashing Machines[4]

NSF, Listings-Food Equipment and Related Products, Components and Materials[4]

2.3 *ASHRAE Standard:*

ASHRAE Guideline 2–1986 (RA90) Engineering Analysis of Experimental Data[5]

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *booster heater*, *n*—water heater for taking supply hot water (typically 140°F) up to 180°F+ for sanitizing rinse; the booster heater may be separate from dishwasher or integral.

3.1.2 *cycle rate*, *n*—maximum production rate of a dishwasher when washing dishloads in accordance with the Cycle Rate Performance test.

3.1.3 *dishload*, *n*—a peg-type, polypropylene dishrack of a specified weight, loaded with ten 9-in. plates of a specified weight, used to put a thermal load on the dishwasher during the washing energy test.

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[2] *Annual Book of ASTM Standards*, Vol 05.06.

[3] *Annual Book of ASTM Standards*, Vol 15.08.

[4] Available from NSF International, P.O. Box 130140, 789 N. Dixboro Rd., Ann Arbor, MI 48113-0140.

[5] Available from American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. (ASHRAE), 1791 Tullie Circle, NE, Atlanta, GA 30329.

3.1.4 *dishwasher*, *n*—for this test method, dishwasher is defined as a rack conveyor, hot-water sanitizing, commercial dishwashing machine.

3.1.5 *empty dish rack*, *n*—a dish rack without any dishware placed in the dish rack. Two empty dish racks are run through the dishwasher prior to washing the first dishload to condition the dishwasher for testing as specified in the Washing Energy Test (see 10.8).

3.1.6 *ready temperature*, *n*—the dishwasher tank temperature that is hot enough to start washing the next room temperature dishload and not drop the tank temperature below the required minimum tank temperature.

3.1.7 *recovery time*, *n*—the time from the end of washing a dishload to until the wash tank temperature is back up to a (ready) temperature high enough to start washing the next dishload.

3.1.8 *tank heater idle rate*, *n*—rate of energy consumed by the dishwasher while "holding" or "idling" the wash tank water at the thermostat(s) set point during the time period specified.

3.1.9 *uncertainty*, *n*—measure of systematic and precision errors in specified instrumentation or measure of repeatability of a reported test result.

4. Summary of Test Method

4.1 The maximum energy input rate of the tank heater and the booster heater, if applicable, is measured to confirm that the dishwasher is operating at the manufacturer's rated input. If the measured input rate is not with 5 % of the rated input, all further testing ceases, and the manufacturer shall be contacted. The manufacturer may make appropriate changes or adjustments to the dishwasher.

NOTE 1—It is the intent of the testing procedure herein to evaluate the performance of a dishwasher at its rated gas pressure or electric voltage. If an electrical unit is rated dual voltage, that is, designed to operate at either 208 or 240 V with no change in component, the voltage selected by the manufacturer or the tester, or both, shall be reported. If a dishwasher is designed to operate at two voltages without a change in the resistance of the heating elements, the performance of the unit, for example, cycle rate, may differ at the two voltages.

4.2 Wash tank and booster temperatures are calibrated to manufacturer's recommendations.

4.3 Water consumption is adjusted in accordance with manufacturer's specifications.

4.4 The tank heater energy rate is determine at idle, that is, when the tank temperature is being maintained, but no washing is taking place.

4.5 Booster heater idle energy rate is determined.

4.6 Dishwasher and booster energy consumption per rack of dishes is determined by washing ten racks loaded with a specified quantity of dishes.

4.7 Water consumption (gal/h (L/h)) is monitored during testing to determine the rate of water usage.

5. Significance and Use

5.1 The maximum energy input rate test is used to confirm that the dishwasher is operating at the manufacturer's rated input prior to further testing. This test method also will indicate any problems with the electric power supply, gas service pressure, or steam supply flow or pressure.

5.2 Tank and booster temperatures, as well as water consumption, are adjusted to NSE specifications to insure that the test is applied to a properly functioning dishwasher.

5.3 Because much of a dishwasher's operating period is spent in the idle condition, tank heater and booster idle energy consumption rate(s) are important parts of predicting dishwasher's energy consumption.

5.4 The washing energy test determines energy usage per rack. This is useful both as a measure for comparing the energy performance of one dishwasher to another and as a predictor of the dishwashers energy consumption.

5.5 Water-consumption characterization is useful for estimating water and sewage costs associated with dishwashing machine operation.

6. Apparatus

6.1 *1 or 2 Wh Meters*, for measuring the electrical energy consumption of the tank heaters, pump motor, and booster heater, if applicable, shall have a resolution of at least 10 Wh and a maximum uncertainty no greater than 1.5 % of the measured value for any demand greater than 100 W. For any demand less than 100 W, the meter shall have a resolution of at least 10 Wh and a maximum uncertainty no greater than 10 %.

6.2 *1 or 2 Gas Meters*, for measuring the gas consumption of tank heater, or booster heater, if applicable, or both, shall have a resolution of at least 0.01 ft^3 (0.0003 m^3), and a maximum uncertainty no greater than 1 % of the measured value for any demand greater than 2.2 ft^3/h (0.06 m^3/h). If the meter is used for measuring the gas consumed by pilot lights, it shall have a resolution of a least 0.01 ft^3 (0.0003 m^3) and have a maximum uncertainty of at least 0.01 ft^3 (0.0003 m^3) and have a maximum uncertainty no greater than 2 % of the measured value.

6.3 *1 or 2 Steam Flow Meters*, for measuring the flow of steam to tank heaters and or booster heater, if applicable, shall have a resolution of 0.01 ft^3 (0.0003 m^3), and a maximum uncertainty of 1 % of the measured value.

6.4 *Pressure Gage*, for measuring pressure of steam to steam coils and steam injector, shall have a resolution of 0.5 psig (3.4 kPa), and a maximum uncertainty of 1 % of the measured value.

6.5 *Canopy Exhaust Hood or Vent Cowl Exhaust Ducts*, measured in agreement with manufacturers requirements. Vent cowl exhaust ducts shall operate at a nominal 200 cfm (94.4 L/s) on entrance side of dishwasher and 400 cfm (188.8 L/s) on exit side or in accordance with manufacturer's recommendation, if applicable. Canopy exhaust hood shall use a 3-ft by 6-ft configuration operating at the dishwashing machine manufacturer's specified ventilation rate. Report the ventilation rate and ventilation exhaust type.

6.6 *Pressure Gage*, for monitoring natural gas pressure, shall have a range of 0 to 10 in. H_2O (zero to 2.5 kPa), a resolution of 0.1 in. H_2O (125 Pa), and a maximum uncertainty of 1 % of the measured value.

6.7 *Temperature Sensor*, for measuring natural gas temperature in the range of 50 to 100°F (10 to 40°C), with a resolution of 0.5°F (0.3°C) and an uncertainty of ± 1 °F (0.5°C).

6.8 *Barometer*, for measuring absolute atmospheric pressure, to be used for adjustment of measured natural gas volume to standard conditions, shall have a resolution of 0.2 in. Hg (670 Pa), and an uncertainty of 0.2 in. Hg (670 Pa).

6.9 *Flow Meter*, for measuring water consumption of the dishwasher. Shall have a resolution of 0.01 gal (40 mL), and an uncertainty of 0.01 gal (40 mL), at flow rate as low as 0.2 gpm (13 mL/s).

6.10 *Stop Watch*, with a 0.1-s resolution.

6.11 *Analytical Balance Scale*, or equivalent, for measuring weight of dishes and dish racks used in the dishload energy test. It shall have a resolution of 0.01 lb (5 g) and an uncertainty of 0.01 lb (5 g).

6.12 *Calibrated Exposed Junction Thermocouple Probes*, with a range from -20 to 400°F (-30 to 200°C), with a resolution of 0.2°F (0.1°C) and an uncertainty of 1.0°F (0.5°C), for measuring tank temperature, booster and dishwater inlet temperatures. Calibrated K-type 24-GA thermocouple wire with stainless steel sheath and ceramic insulation is the recommended choice for measuring the booster and dishwater inlet temperatures. The thermocouple probe can be fed through a compression fitting so as to submerge exposed junction in booster and dishwasher inlets.

6.13 *Dishracks*, 12, Metro Mdl P2MO, 20-in. × 20-in., peg-type, commercial or acceptable equivalent. Each shall weigh 4.6 ± 0.1 lb, and used in the Washing Energy Test (see 10.8).

6.14 *Plates*, 100, 9-in., ceramic glazed plates, weighing an average of 1.3 ± 0.05 lb each. If plates meeting this criteria cannot be obtained, then it will be necessary to acquire saucers, as specified in 6.15. See 9.11 prior to obtaining these plates.

NOTE 2—Inter-American® mdl #132 are within the specified weight range and are inexpensive.

6.15 *Saucers*, 20, glazed saucers, weighing less than 0.5 lb each. See 9.11 for an explanation of why these may be required.

6.16 *Surface Temperature Thermocouple Probe*, for measuring dish plates and dishracks temperatures. Resolution and uncertainty shall be the same as in 6.12.

7. Sampling

7.1 *Dishwasher*—A representative production model shall be selected for performance testing.

8. Materials

8.1 As specified in 6.13, the dishracks must be made of polypropylene. This material is required because the test method assumes a specific heat of 0.39 Btu/lb × °F. One verification that a rack is polypropylene is if it has the recycling symbol No. 5 on it (and the letters "PP" below it).

9. Preparation of Apparatus

9.1 Install the dishwasher in accordance with the dishwasher manufacturer's instructions under a 3-ft by 6-ft canopy exhaust hood or connect to vent cowl exhaust ducts. Vent cowl exhaust ducts should operate at a nominal 200 cfm (94.4 L/s) on the entrance side of dishwasher and 400 cfm (188.8 L/s) on exit side or in accordance with manufacturer's recommendations, if applicable. The associated heating or cooling system shall be capable of maintaining an ambient temperature of 75 ± 5°F within the testing environment when the exhaust ventilation system is working and the appliance is being operated.

9.2 Install the booster heater, if it is not integral to the dishwasher, in accordance with the manufacturer's recommendations. The pipe from the booster outlet to the dishwasher inlet shall be minimized and shall be wrapped with ½-in. insulation along its entire length.

9.3 Connect the booster to a supply of water, which is within ±3°F of its input temperatures, not to exceed 140 ± 3°F.

9.4 Connect the dishwasher and booster to calibrated energy test meters. The dishwasher and booster shall not be monitored as one energy load. Separate monitoring will broaden the usefulness of the data and enhance the accuracy of the results.

9.5 For gas installations, install a pressure regulator (downstream from the meter) to maintain a constant (manifold) pressure of gas supplied to the dishwasher and booster heater, if applicable, for all tests. Install instrumentation to record both the pressure and temperature of the gas supplied to the dishwasher and the barometric pressure during each test so that the measured gas flow can be corrected to standard conditions.

9.6 For electric tank heaters and boosters, confirm, while the elements are energized, that the supply voltage is within ±2.5 % of the operating voltage specified by the manufacturer. If it is not, a voltage regulator may be required during the tests. Record the test voltage for each test.

9.7 For gas tank heaters and boosters, during maximum energy input, adjust the gas supply pressure downstream from the appliance's pressure regulator to within ±2.5 % of the operating manifold pressure specified by the manufacturer. Make adjustments to the dishwasher following the manufacturer's recommendations for optimizing combustion, as applicable.

9.8 Install the flow meter (6.9), such that total water flow to the booster and dishwasher is measured.

9.9 Install a temperature sensor(s) (6.12) in the wash tank near the thermostat bulb.

9.10 Install a temperature sensor (6.12) in the dishwasher final rinse water manifold and in the booster inlet. The sensors should be installed with the probe immersed in the water.

NOTE 3—Install the thermocouple probes described in 6.12 into final rinse water manifold for the dishwasher and into the supply water inlet at the booster. The thermocouple probe must be installed so that the thermocouple probe is immersed in the incoming water. A compression fitting should be first installed into the plumbing for both inlets. A junction fitting may need to be installed in the plumbing line that would be compatible with the compression fitting.

9.11 Install dishwashing machine's strip (end) curtains in accordance to manufacturer's recommendations.

9.12 *Preparation of dishloads*:

9.12.1 This section describes preparation of ten dishloads and two empty racks to be used in the washing energy test.

9.12.2 An important feature of the washing energy test is that every dishwasher be subjected to the same thermal load. To accomplish this feature, the tested must control some of the factors that affect the thermal load. These factors are as follows.

9.12.2.1 The total weight of the dishes,

9.12.2.2 The weight of the (empty) racks, and

9.12.2.3 The initial temperature of the dishes and racks.

9.12.3 The weight of the racks is specified in 6.13 as 4.6 lb or greater. If they weigh greater than 4.7 lb, trim away material until they weigh 4.6 ± 0.1 lb. To see what parts of the rack are not needed for the test and may therefore be trimmed, it may be desirable to load the racks as they will be used during the test. The loading is explained in 9.12.4 and 9.12.5.

9.12.4 Prepare ten dishloads as described in this and the following step (9.12.5). The ten dishloads must have 13.0 ± 0.5 lb of plates. Ideally, this simply requires ten 9-in plates. If total weight of the ten 9-in. plates does not fall within the range, then use the saucers to adjust the total weight. A maximum of two saucers can be added per rack.

9.12.5 The plates and saucers should be spaced evenly on the racks.

9.12.6 The bulk temperature of the dishloads before washing must be 75 ± 2°F. This can be accomplished by storing the dishloads in a room with an ambient temperature of 75 ± 2°F. Avoid any circumstances that would result in some dishes being at different temperatures from others, such as being stored in the air path of an HVAC supply register. Determine the bulk temperature using a surface temperature probe (6.16), measuring the temperature of at least three plates (one front, one center, and one rear) of each dishrack. Average these temperatures to determine the bulk temperature.

9.13 Conveyor and wash pump motor operation may be adjustable. If adjustable calibrate as described in 10.7.

10. Procedure

10.1 *General*:

10.1.1 Obtain and record the following for each run of every test (gas and electric).

10.1.1.1 Voltage while elements are energized.

10.1.1.2 Measure peak input rate during or immediately prior to test, which does not include motor starting load.

10.1.2 For dishwashers with a gas powered tank heater or booster the following shall be obtained and recorded for each run of every test.

10.1.2.1 Higher heating value.

10.1.2.2 Standard gas conditions of calculation in 11.3.

10.1.2.3 Measure gas temperature.

10.1.2.4 Measured line gas pressure (before pressure regulator).

10.1.2.5 Barometric pressure.

10.1.2.6 Measured peak input rate according to 10.2.

NOTE 4—For a gas appliance, the quality of heat (energy) generated by the compliance combustion of the fuel is known as the heating value, heat of combustion, or calorific value of that fuel. For natural gas, this heating value varies according to the constituents of the gas. It is measured in Btu/ft^3. The heating value should be obtained during testing and used in the determination of the energy input to the appliance.

NOTE 5—The preferred method for determining the heating value of gas supplied to the dishwasher under testing is by using a calorimeter or gas chromatograph in according with accepted laboratory procedures. It is recommended that all testing be performed with gas with a heating value between 1 000 and 1075 Btu/ft^3 (37300 to 40100 kJ/m^3). The use of "bottle" natural gas with a certified heating value within the specified 1000 to 1075 Btu/ft^3 (37300 to 40100 kJ/m^3) range is an acceptable alternative.

10.1.3 For gas dishwashers, energy calculations shall be in accordance with 11.3.

10.1.4 For dishwashers that use steam coils or steam injectors for tank heat, the supplied steam pressure, steam temperature at dishwasher inlet, steam temperature at dishwasher outlet, and average flow rate shall be recorded for each run of every test.

10.1.5 For each run of every test, confirm that the peak input rate is within ±5 % of rated "nameplate" input. If the difference is greater than 5 %, testing shall be terminated and contact the manufacturer. The manufacturer shall make appropriate changes or adjustments to the dishwasher.

10.2 *Tank Heater Maximum Energy Input Rate*:

10.2.1 *Gas Tank Heaters*—Fill the dishwasher tank with 70 ± 10°F water, initiate the tank heaters, and when the burners cycle off, immediately drain the tank and proceed with 10.2.2.

NOTE 6—For some gas appliances, the energy input rate changes as the burner orifices heat up from room temperature to operational temperature. The step described in 10.2.1 is provided to minimize this effect.

10.2.2 Fill the dishwasher tank with 70 ± 10°F water, and energize the tank heaters. Commence monitoring time and energy consumption. When the heaters cycle off, note the time and total energy consumption. For electric tank heaters, a direct measurement of power may be substituted for the monitoring of time and energy consumption.

10.2.3 In accordance with 11.4, determine the tank heater maximum energy input rate for the dishwasher under test. Report the measured input rate and confirm that it is within 5 % of the nameplate rated input. If the difference is greater than 5 %, testing shall be terminated and the manufacturer contacted. The manufacturer may make appropriate changes or adjustments to the dishwasher.

10.3 *Booster Maximum Energy Input Rate*:

NOTE 7—For some gas appliances, the energy input rate changes as the burner orifices heat up from room temperature to operational temperature. The step described in 10.3.1 is provided to provide a stable test condition. The dishwasher machines final rinse cycle is run continuously to initiate and keep the booster heater's gas burner(s) on during the booster maximum energy input rate test.

10.3.1 Open the dishwasher drain. Close the door(s) and initiate the final rinse. For electric booster heaters, after the booster cycles on, monitor time and energy consumption for 10 min. For gas boosters, commence the 10-min monitoring period 15 min after the burners cycle on (to allow the burners to stabilize). For electric boosters, a direct measurement of power may be substituted for the monitoring of time and energy consumption.

10.3.2 Determine the booster maximum energy input rate for the dishwasher under test, in accordance with 11.4. Report the measured input rate and confirm that it is within 5 % of the nameplate rated input. If the difference is greater than 5 %, testing shall be terminated and the manufacturer contacted. The manufacturer shall make appropriate changes or adjustments to the booster.

10.4 *Dishwasher Final Sanitizing Rinse Water Consumption Calibration*:

10.4.1 Adjust pressure regulator in water supply line for final sanitizing rinse to 20 ± 1 psi while final rinse water is flowing.

10.4.2 Measure water consumption using the flowmeter specified in 6.9. Run final rinse cycle for one minute and record water consumption (gal/min).

10.4.3 Confirm that the water consumption in gallons per minute is within ±5 % of the NSF-rated water consumption or the manufacturer's rating if not listed to NSF standards. If it is not, testing shall be terminated and the manufacturer contacted. The manufacturer shall make appropriate changes or adjustments to the dishwasher.

10.5 *Booster Temperature Calibration*:

10.5.1 While monitoring the water inlet of the booster heater and dishwater (rinse manifold) temperature, initiate a dishwasher cycle. Continue to initiate a new dishwashing cycle 15 sec after the completion of the previous dishwasher cycle. Adjust the booster heater such that the average temperature of water at the dishwasher manifold (measured only during the rinse) is 181 ± 1°F on five consecutive cycles.

10.6 *Wash Tank Temperature Calibration*:

10.6.1 Fill the dishwasher tank and activate the tank heaters. When the tank heaters cycle off, start the wash pump and commence monitoring temperature. Observe the temperature at which the tank heaters cycle on. Allow the tank temperature to recover, cycle off, and again observe the cycle-on temperature. Observe the cycle-on temperature a third time, and confirm that for each run, the cycle-on temperature was 161 ± 1°F or the manufacturer's rated minimum tank temperature if lower than 160°F. If it falls outside of this range on any run, adjust the thermostat accordingly and repeat the three runs.

NOTE 8—The wash tank temperature calibration may need to be changed again during the Washing Energy Test (see 10.8) to achieve the "ready" temperature required for this test. The reasoning for changing the wash tank temperature thermostat setting is explained in Note 9. The "ready" temperature is an approximate starting point for the determination of when to start washing the next dishload. The "ready" temperature is the dishwasher tank temperature that is hot enough to start washing the next room temperature dishload and not drop the tank temperatures below the required 160°F.

10.7 *Wash Tank Pump and Conveyor Motor Calibration*:

10.7.1 Dishwashing machines may be equipped with automatic shut down that stop the wash pump and conveyor motors when no racks are being washed. For wash tank pump and conveyor motors that have automatic or adjustable operation time, set the controls so motors operate continuously during washing energy performance testing.

10.7.2 Some dishwasher machines are equipped with a final rinse catch pan (final rinse water saver) to capture the water from the rinse cycle. Set the catch pan drain to manufacturer's recommended setting. Report final rinse catch pan rain setting.

10.7.3 If conveyor speed is adjustable, set to manufacturer's data plate value and report conveyor speed.

10.8 *Washing Energy Performance Test*:

10.8.1 This test will require ten dishloads and two empty dishracks, as described in Sections 3, 6, and 9. Record the weight of the dishes and the weight of the racks. Record the make and model of the dishracks and dishes.

10.8.2 The bulk temperature of the dishloads must be 75 ± 2°F. Determine the bulk temperature using a surface temperature probe (6.16) and measuring the temperature of at least three plates (one front, one center, and one rear). Average these temperatures to determine the bulk temperature.

10.8.3 Allow the dishwasher to idle (no washing taking place) for 1 h.

10.8.4 Using the surface temperature probe measure the temperature of a dish in the front, middle, and rear of each dishload. Record the average of these temperature and confirm that it is 75 ± 2°F.

10.8.5 After the 1-h idle period, observe the tank heaters and tank temperature. When the tank temperature is on the rise (tank heaters energized), and the temperature reaches "ready" temperature, start washing the first empty dishrack (see Note 8 and Note 9). Immediately after completion of the final rinse cycle (do not remove rack before dishwasher is finished conveying the rack), remove the first empty dishrack.

NOTE 9—The condition required to start washing the first empty dishrack may not occur immediately following the 1-h idle period. For example, when 1-h has elapsed, the tank temperature already may be above the ready temperature, with the tank heaters already energized. In this case, allow the elements or burners to cycle off, then on again, and wait for the temperature to reach the ready temperature.

NOTE 10—If the starting ready temperature is not known, try 166°F. The specification of 166°F as the "ready" temperature is an approximate starting point. It may be different from dishwasher to dishwasher and from dishload to dishload and is precisely determined though an iterative process. The goal of the iteration is to determine the lowest possible "ready" temperature that does not result in any dishload dropping the tank temperature below the NSF required minimum 160°F (that is, 161 ± 1°F). There is one period during the washing energy test where the lowest tank temperature might occur, that is during the washing of the first dishload; therefore, this test requires that the tank temperature falls to within the range of 161 ± 1°F during the first dishload. If it does not, then the "ready" temperature is adjusted (up if it fell below 160°F, down if it fell above 162°F), and the test is rerun. The tank heater thermostat may require adjusting up if element(s) or burner(s) cut out before the tank temperature reaches the "ready" temperature and down if the tank temperature is always above the "ready" temperature. The "ready" temperature may be changed during the test in order to maximize the cycle rate (racks washed/h), provided the minimum tank temperature meets the qualifications that the tank temperature fall to 161 ± 1°F with the first dishload and 160°F or higher with each subsequent dishload.

10.8.6 Commence washing the second empty dishrack as soon as the same "ready" temperature from the previous empty rack has been reached. Immediately after completion of the cycle remove the second empty dishrack. When the tank temperature reaches the "ready" temperature needed to insure that the first dishload will cause the tank temperature to fall to 161 ± 1°F, commence washing the first dishload. Commence monitoring time, energy of the dishwasher and the booster, water consumption, and temperatures of the booster inlet, final rinse and wash tank. Note the minimum tank temperature experienced during the washing period. Confirm that, at some point during this dishload, this tank temperature is 161 ± 1°F. Remove the dishload when the cycle is complete.

10.8.7 If the minimum tank temperature that occurred during the washing of this first dishload does not fall into the range of 161 ± 1°F, adjust the "ready" temperature (up if it fell to below 160°F, down if it feel to above 162°F), and repeat the test, starting at 10.8.2.

10.8.8 If the minimum tank temperature that occurred during the washing of this first dishload does fall into the range of 161± 1°F, record the tank temperature and proceed to washing subsequent dishloads. When the tank temperature reaches the next "ready", commence washing the next dishload. Remove the dishload when the cycle is complete. Repeat this step eight more times (resulting in a total of twelve loads—two with the empty racks and ten with dishloads). Note that the minimum tank temperature that occurs during any of these dishloads does not have to fall in the range of 161 ± 1°F (that requirements only pertains to the washing of the first dishload); however, it does have to remain above the NSF required minimum 160°F at all times. If the temperature does fall below 160°F at any time, increase the "ready" temperature by 1°F and repeat the test starting at 10.8.2.

10.8.9 After removing the last dishload and when the tank temperature reaches (recovers to) the "ready" temperature, turn off the tank heaters. The recovery to the last "ready" temperature signifies the end of the washing energy test and should be the same "ready" temperature as the tenth dishload's "ready" temperature, that is, if the tenth dishload's "ready" temperature is 165°F, after the tenth dishload has been washed, wait till the tank temperature has recovered to 165°F before ending test).

10.8.10 Record final dishwasher and booster energy, elapsed time, from start of washing the first dishload to when the final "ready" temperature is reached in step 10.8.9, average dishwasher inlet temperature, average booster inlet temperature, minimum tank temperature, and total water consumption, and "ready" temperatures. If at anytime the booster supplying the dishwasher does not maintain the average final rinse temperature of 181 ± 1°F during washing energy performance test, the test shall be considered a failure.

10.8.11 In accordance with 11.7, calculate and report the energy consumed per rack.

10.9 *Tank Heater Idle Energy Rate (Doors Closed)*:

10.9.1 Tank heater idle energy rate test is to run using tank heater thermostat set point from washing energy performance test. Allow the dishwasher to fill, and energize the tank heaters.

10.9.2 With the exterior service door(s) closed, allow the dishwasher tank to idle for at least two tank heater "on" cycles. Commence monitoring elapse time, temperature, and energy consumption as the tank heater "on" cycles for the second time. Allow the dishwasher to idle for 3 h. Record final time and energy consumption.

10.9.3 In accordance with 11.5, calculate and report the tank heater idle energy rate.

10.10 *Booster Idle Energy Rate*:

10.10.1 The booster idle energy rate test is run using the booster heater thermostat set point used in the washing energy performance test to deliver average temperature of 181 ± 1°F at the final rinse water manifold. Allow the booster to idle (no water drawn from it) for a minimum of 1 h. Commence monitoring energy consumption and time. Continue for a minimum of 5 h.

10.10.2 In accordance with 11.6, calculate and report the booster heater idle energy rate.

11. Calculation and Report

11.1 *Test Dishwasher*:

11.1.1 Summarize the physical and operating characteristics of the dishwasher using the Specification F 858. Describe the physical and operating characteristics of the booster heater, and if needed, describe other design or operating characteristics of the dishwasher or booster that may facilitate interpretation of the test results. Report final rinse water catch pan drain setting and conveyor speed if adjustable.

11.2 *Apparatus and Procedure*:

11.2.1 Confirm that the testing apparatus conformed to all of the specifications in Section 9. Describe any deviations from those specifications. Report the ventilation rate.

11.2.2 Report the voltage for each test.

11.2.3 Report the higher heating value of the gas used during each test for gas booster or tank heaters.

11.3 *Gas Energy Calculations*:

11.3.1 For gas dishwashers, add electric energy consumption to gas energy for all tests, with the exception of the energy input rate test (10.2).

11.3.2 Calculate the energy consumed based on the following equation.

$$E_{gas} = V \times HV \tag{1}$$

where:

E_{gas} = energy consumed by the appliance,
HV = higher heating value,
= energy content of gas measured at standard conditions, Btu/ft^3
V = actual volume of gas corrected for temperature and pressure at standard conditions, ft^3.

$$V_{measured} \times T_{cf} \times P_{cf} \tag{2}$$

where:

$V_{measured}$ = measured volume of gas, ft^3, and
T_{cf} = temperature correction factor.

$$= \frac{\textit{absolute standard gas temperature}°\,R}{\textit{absolute actual gas temperature}\ °R}$$

$$= \frac{\textit{absolute standard gas temperature}°\,R}{[\textit{gas temp}\ °F + 459.67]\ °R}$$

P_{cf} = pressure correction factor,

$$= \frac{\textit{absolute actual gas pressure}\ \text{psia}}{\textit{absolute standard pressure}\ \text{psia}},$$

$$= \frac{\textit{gas gage pressure}\ \text{psig} + \textit{barometric pressure}\ \text{psia}}{\textit{absolute standard pressure}\ \text{psia}}$$

NOTE 11—Absolute standard gas temperature and pressure used in this calculation should be the same values used for determining the higher heating value. Standard conditions using Method D 3588 are 14.73 psia (101.5 kPa) and 60°F (519.67 °R, (288.71 °K)).

11.4 *Booster and Tank Heater Energy Input Rate*:

11.4.1 Report the manufacturer's nameplate energy input rate in Btu/h for a gas booster or tank heater and in kW for an electric booster or tank heater.

11.4.2 Calculate and report the measured energy input rate (Btu/h or kW) of the booster heater and the tank heaters based on the energy consumed during the period of peak energy input according to the following relationship:

$$E_{input\ rate} = \frac{E \times 60}{t} \quad (3)$$

where:
$E_{input\ rate}$ = measured peak energy input rate, Btu/h or kW,
E = energy consumed during period of peak energy input, Btu or kWh, and
t = period of peak energy input, min.

11.5 *Tank Heater Idle Energy Rate*:

11.5.1 Calculate and report the tank heater idle energy rate (Btu/h or kW) based on the following equation.

$$E_{idle\ rate} = \frac{E \times 60}{t} \quad (4)$$

where:
$E_{idle\ rate}$ = idle energy rate, Btu/h or kW,
E = energy consumed during the test period, Btu or kWh, and
t = test period, min.

11.6 *Booster Heater Idle Energy Rate*:

11.6.1 Calculate and report the booster heater idle energy rate (Btu/h or kW) based on the following equation.

$$E_{idle\ rate} = \frac{E \times 60}{t} \quad (5)$$

where:
$E_{idle\ rate}$ = idle energy rate, Btu/h or kW,
E = energy consumed during the test period, Btu or kWh, and
t = test period, min.

11.7 *Washing Energy Test*:

11.7.1 Calculate and report each of the following:

11.7.1.1 Dishwasher electric energy per rack (kWh),

11.7.1.2 Booster electric energy per rack, if applicable (kWh),

11.7.1.3 Total electric energy per rack (kWh),

11.7.1.4 Dishwasher gas energy per rack, if applicable (Btu),

11.7.1.5 Booster gas energy per rack, if applicable (Btu),

11.7.1.6 Total gas energy per rack, if applicable (Btu), and

11.7.1.7 Cycle rate (racks/h).

11.7.2 Use the following relationship:

$$E_{rack} = \frac{E_{test}}{10} \quad (6)$$

where:
E_{rack} = one of the energy per rack values listed above, and
E_{test} = energy consumed during the ten dishload run test, specific to the parameter being expressed, for example, for dishwasher energy per rack, E_{test} = the total energy consumed by the dishwasher during the ten run test.

11.7.3 Report the elapsed time for the washing energy test. The elapsed time is measured from the time the dishwasher has commenced washing the first dishload, until the dishwasher tank temperature has reached the tenth dishload's ready temperature after the last dishload has been removed. Calculate the cycle rate (racks/h) by dividing ten racks (ten dishloads) by the elapsed time.

12. Precision and Bias

12.1 *Precision*:

12.1.1 *Repeatability (Within Laboratory, Same Operator and Equipment)*—The repeatability of each reported parameter is being determined.

12.1.2 *Reproducibility (Multiple Laboratories)*—The interlaboratory precision of the procedure in this test method for measuring each reported parameter is being determined.

12.2 *Bias*—No statement can be made concerning the bias of the procedures in this test method because there are no accepted reference values for the parameters reported.

13. Keywords

13.1 booster; conveyor; dishload; dishrack; dishwasher; hot-water sanitizing; tank heater; warewasher

ANNEX

(Mandatory Information)

A1. PROCEDURE FOR DETERMINING THE UNCERTAINTY IN REPORTED TEST RESULTS

NOTE A1.1—This procedure is based on the ASHRAE method for determining the confidence interval for the average of several test results (ASHRAE Guideline 2–1986 (RA90)). It only should be applied to test results that have been obtained within the tolerances prescribed in this method, for example, thermocouples calibrated, appliance operating within 5 % of rated input during the test run.

A1.1 For the energy per rack (ER) and cycle rate (CR) results, the uncertainty in the averages of at least three test runs is reported. For each test run, the uncertainty of the energy per rack and cycle rate must be no greater than ±10 % before any of the parameters for that washing energy test run can be reported.

A1.2 The uncertainty in a reported result is a measure of its precision. For example, if the cycle rate for the dishwasher is 30 racks/h, the uncertainty must not be greater than ±3 racks/h; thus, the true cycle rate is between 27 and 33 racks/h. This interval is determined at the 95 % confidence level, which means that there is only a 1 in 20 chance that the true cycle rate could be outside of this interval.

A1.3 Calculating the uncertainty not only guarantees the maximum uncertainty in the reported results, but also is used to determine how many test runs are needed to satisfy this requirement. The uncertainty is calculated from the standard deviation of three or more test results and a factor from Table A1.1, which lists the number of test results used to calculate the average. The percent uncertainty is the ratio of the uncertainty to the average expressed as a percent.

A1.4 *Procedure*:

NOTE A1.2—Section A1.5 shows how to apply this procedure.

A1.4.1 *Step 1*—Calculate the average and the standard deviation for the test results (energy/rack and cycle rate) using the results of the first three test runs, as follows:

A1.4.1.1 The formula for the average (three test runs) is as follows:

$$Xa_3 = (1/3) \times (X_1 + X_2 + X_3) \quad \text{(A1.1)}$$

where:
Xa_3 = average of results for three test runs, and
X_1, X_2, X_3 = results for each test run.

A1.4.1.2 The formula for the sample standard deviation (three test runs) is as follows:

$$S_3 = (1/\sqrt{2}) \times \sqrt{(A_3 - B_3)} \quad \text{(A1.2)}$$

where:
S_3 = standard deviation of results for three test runs,
A_3 = $(X_1)^2 + (X_2)^2 + (X_3)^2$, and
B_3 = $(1/3) \times (X_1 + X_2 + X_3)^2$.

NOTE A1.3—The formulas may be used to calculate the average and sample standard deviation; however, a calculator with statistical function is recommended, in which case be sure to use the sample standard deviation function. The population standard deviation function will result in an error in the uncertainty.

NOTE A1.4—The "*A*" quantity is the sum of the squares of each test result, and the "*B*" quantity is the square of the sum of all test results multiplied by a constant (1/3 in this case).

A1.4.2 *Step 2*—Calculate the absolute uncertainty in the average for each parameter listed in Step 1. Multiply the standard deviation calculated in Step 1 by the Uncertainty Factor corresponding to three test results from Table A1.1.

A1.4.2.1 The formula for the absolute uncertainty (three test runs) is as follows:

$$U_3 = C_3 \times S_3 \quad \text{(A1.3)}$$
$$U_3 = 2.48 \times S_3$$

where:
U_3 = absolute uncertainty in average for three test runs, and
C_3 = uncertainty factor for three test runs (see Table A1.1).

A1.4.3 *Step 3*—Calculate the percent uncertainty in each parameter average using the averages from Step 1 and the absolute uncertainties from Step 2.

TABLE A1.1 Uncertainty Factors

Test Results, *n*	Uncertainty Factor, C_n
3	2.48
4	1.59
5	1.24
6	1.05
7	0.92
8	0.84
9	0.77
10	0.72

A1.4.3.1 The formula for the percent uncertainty (three test runs) is as follows:

$$\%U_3 = (U_3/Xa_3) \times 100\,\% \quad \text{(A1.4)}$$

where:
$\%U_3$ = percent uncertainty in average for three test runs,
U_3 = absolute uncertainty in average for three test runs, and
Xa_3 = average of three test runs.

A1.4.4 *Step 4*—If the percent uncertainty, $\%U_3$, is not greater than ±10 % for energy per rack and cycle rate, report the average for these parameters along with their corresponding absolute uncertainty, U_3, in the following format:

$$Xa_3 + U_3 \quad \text{(A1.5)}$$

If the percent uncertainty is greater than ±10 % for the energy per rack or cycle rate, proceed to Step 5.

A1.4.5 *Step 5*—Run a fourth test or the energy per rack or cycle rate results if the percent uncertainty is greater than ±10 %.

A1.4.6 *Step 6*—When a fourth test is run for a given energy per rack and cycle rate, calculate the average and standard deviation for test results using a calculator or the following formulas:

A1.4.6.1 The formula for the average (four test runs) is as follows:

$$Xa_4 = (1/4) \times (X_1 + X_2 + X_3 + X_4) \quad \text{(A1.6)}$$

where:
Xa_4 = average of results for four test runs, and
X_1, X_2, X_3, X_4 = results for each test run.

A1.4.6.2 The formula for the standard deviation (four test runs) is as follows:

$$S_4 = (1/\sqrt{3}) \times \sqrt{(A_4 - B_4)} \quad \text{(A1.7)}$$

where:
S_4 = standard deviation of results for four test runs,
A_4 = $(X_1)^2 + (X_2)^2 + (X_3)^2 + (X_4)^2$, and
B_4 = $(¼) \times (X_1 + X_2 + X_3 + X_4)^2$.

A1.4.7 *Step 7*—Calculate the absolute uncertainty in the average for each parameter listed in Step 1. Multiply the standard deviation calculated in Step 6 by the Uncertainty Factor for four test results from Table A1.1.

A1.4.7.1 The formula for the absolute uncertainty (four test runs) is as follows:

$$U_4 = C_4 \times S_4, \quad \text{(A1.8)}$$
$$U_4 = 1.59 \times S_4$$

where:
U_4 = absolute uncertainty in average for four test runs, and
C_4 = the uncertainty factor for four test runs (Table A1.1).

A1.4.8 *Step 8*—Calculate the percent uncertainty in the parameter averages using the averages from Step 6 and the absolute uncertainties from Step 7.

A1.4.8.1 The formula for the percent uncertainty (four test runs) is as follows:

$$\%U_4 = (U_4/Xa_4) \times 100\,\% \quad \text{(A1.9)}$$

where:

$\%U_4$ = percent uncertainty in average for four test runs,
U_4 = absolute uncertainty in average for four test runs, and
Xa_4 = average of four test runs.

A1.4.9 *Step 9*—If the percent uncertainty, $\%U_4$, is not greater than ±10 % for energy per rack and cycle rate, report the average for these parameters along with their corresponding absolute uncertainty, U_4, in the following format:

$$Xa_4 \pm U_4 \tag{A1.10}$$

If the percent uncertainty is greater than ±10 % for the energy per rack or cycle rate, proceed to Step 10.

A1.4.10 *Step 10*—The steps required for five or more test runs are the same as those described above. More general formulas are listed below for calculating the average, standard deviation, absolute uncertainty, and percent uncertainty.

A1.4.10.1 The formula for the average (*n* test runs) is as follows:

$$Xa_n = (1/n) \times (X_1 + X_2 + X_3 + X_4 + ... + X_n) \tag{A1.11}$$

where:
n = number of test runs,
Xa_n = average of results of n test runs, and
$X_1, X_2, X_3, X_4, ... X_n$ = results for each test run.

A1.4.10.2 The formula for the standard deviation (*n* test runs) is as follows:

$$S_n = (1/\sqrt{}(n-1)) \times (\sqrt{}(A_n - B_n)) \tag{A1.12}$$

where:
S_n = standard deviation of results for *n* test runs,
A_n = $(X_1)^2 + (X_2)^2 + (X_3)^2 + (X_4)^2 + ... + (X_n)^2$, and
B_n = $(1/n) \times (X_1 + X_2 + X_3 + X_4 + ... + X_n)^2$.

A1.4.10.3 The formula for the absolute uncertainty (*n* test runs) is as follows:

$$U_n = C_n \times S_n \tag{A1.13}$$

where:
U_n = absolute uncertainty in average for *n* test runs, and
C_n = uncertainty factor for *n* test runs (Table A1.1).

A1.4.10.4 The formula for the percent uncertainty (*n* test runs) is as follows:

$$\%U_n = (U_n/Xa_n) \times 100\ \% \tag{A1.14}$$

where:
$\%U_n$ = percent uncertainty in average for *n* test runs,
U_n = absolute uncertainty in average for *n* test runs, and
Xa_n = average of *n* test runs.

When the percent uncertainty, $\%U_n$, is less than or equal to ±10 % for the energy per rack and cycle rate, report the average for these parameters along with their corresponding absolute uncertainty, U_n, in the following format:

$$Xa_n \pm U_n \tag{A1.15}$$

NOTE A1.5—The researcher may compute a test result that deviates significantly from the other test results. Such a result should be discarded only if there is some physical evidence that the test run was not performed according to the conditions specified in this test method. For example, a thermocouple was out of calibration, the dishwasher's input capacity was not within 5 % of the rated input, or the dishrack was not within specification. To assure all results are obtained under approximately the same conditions, it is good practice to monitor those test conditions specified in this test method.

A1.5 *Example of Determining Uncertainty in Average Test Result*:

A1.5.1 Three test runs for the washing energy performance yielded the following cycle rate (CR) results:

Test	CR
Run No. 1	33.8 racks/h
Run No. 2	34.1 racks/h
Run No. 3	31.0 racks/h

A1.5.2 *Step 1*—Calculate the average and standard deviation of the three test results for the CR.

A1.5.2.1 The average of the three test results is as follows:

$$Xa_3 = (1/3) \times (X_1 + X_2 + X_3), \tag{A1.16}$$

$$Xa_3 = (1/3) \times (33.8 + 34.1 + 31.0),$$

$$Xa_3 = 33.0 \text{ racks/h}$$

A1.5.2.2 The standard deviation of the three test results is as follows. First calculate "A_3" and "B_3".

$$A_3 = (X_1)^2 + (X_2)^2 + (X_3)^2, \tag{A1.17}$$

$$A_3 = (33.8)^2 + (34.1)^2 + (31.0)^2,$$

$$A_3 = 3266$$

$$B_3\ (1/3) \times [(X_1 + X_2 + X_3)^2],$$

$$B_3 = (1/3) \times [(33.8 + 34.1 + 31.0)^2],$$

$$B_3 = 3260$$

A1.5.2.3 The new standard deviation for the CR is as follows:

$$S_3 = (1/\sqrt{}2) \times \sqrt{}\ 3266 - 3260), \tag{A1.18}$$

$$S_3 = 1.71 \text{ racks/h}$$

A1.5.3 *Step 2*—Calculate the uncertainty in average.

$$U_3 = 2.48 \times S_3, \tag{A1.19}$$

$$U_3 = 2.48 \times 1.71,$$

$$U_3 = 4.24 \text{ racks/h}$$

A1.5.4 *Step 3*—Calculate percent uncertainty.

$$\%U_3 = (U_3/Xa_3) \times 100\ \%, \tag{A1.20}$$

$$\%U_3 = (4.24/33.0) \times 100\ \%,$$

$$\%U_3 = 12.9\ \%$$

A1.5.5 Run a fourth test. Since the percent uncertainty for the cycle rate is greater than ± 10 %, the precision requirement has not been satisfied. An additional test is run in an attempt to reduce the uncertainty. The CR from the fourth test run is 32.5 racks/h.

A1.5.6 *Step 4*—Recalculate the average and standard deviation for the CR using the fourth test result:

A1.5.6.1 The new average CR is as follows:

$$Xa_4 = (1/4) \times (X_1 + X_2 + X_3 + X_4), \tag{A1.21}$$

$$Xa_4 = (1/4) \times (33.8 + 34.1 + 31.0 + 32.5),$$

$$Xa_4 = 32.9 \text{ racks/h}$$

A1.5.6.2 The new standard deviation is. First calculate "A_4" and "B_4":

$$A_4 = (X_1)^2 + (X_2)^2 + (X_3)^2 + (X_4)^2, \tag{A1.22}$$

$$A_4 = (33.8)^2 + (34.1)^2 + (31.0)^2 + (32.5)^2,$$

$$A_4 = 4323$$

$$B_4 = (1/4) \times [(X_1 + X_2 + X_3 + X_4)^2],$$

$$B_4 = (1/4) \times [(33.8 + 34.1 + 31.0 + 32.5)^2],$$

$$B_4 = 4316$$

A1.5.6.3 The new standard deviation for the CR is as follows:

$$S_4 = (1/\sqrt{3}) \times \sqrt{(4323 - 4316)}, \quad \text{(A1.23)}$$

$$S_4 = 1.42 \text{ racks/h}$$

A1.5.7 *Step 5*—Recalculate the absolute uncertainty using the new standard deviation and uncertainty factor.

$$U_4 \; 1.59 \times S_4, \quad \text{(A1.24)}$$

$$U_4 = 1.59 \times 1.42, \text{ and}$$

$$U_4 = 2.25 \text{ racks/h}$$

A1.5.8 *Step 6*—Recalculate the percent uncertainty using the new average.

$$\%U_4 = (U_4/Xa_4) \times 100\ \%, \quad \text{(A1.25)}$$

$$\%U_4 = (2.25/32.9) \times 100\ \%,$$

$$\%U_4 = 6.8\ \%$$

A1.5.9 *Step 7*—Since the percent uncertainty, $\%U_4$, is less than ± 10 %, the average for the cycle rate is reported along with its corresponding absolute uncertainty, U_4 as follows:

$$\text{CR: } 32.9 \pm 2.25 \text{ racks/h} \quad \text{(A1.26)}$$

A1.5.9.1 The CR can be reported assuming the ±10 % precision requirement has been met for the corresponding washing energy per rack value. The washing energy per rack and its absolute uncertainty can be calculated following the same steps.

APPENDIX

(Nonmandatory Information)

X1. RESULTS REPORTING SHEETS

Manufacturer ______________________________

Model ______________________________

Date ____________

Test Reference Number (optional) __________

Section X.1 Dishwasher (check one for each classification)

ASTM F858-96 Hot Water Sanitizing Commercial Dishwashing Machines, Single Tank, Conveyor Rack Type. Classification. __________

Additional description of operational characteristics:

____

____

____

____

____

____

Report Conveyor Speed ____________ (ft/min)
Final Catch Pan Drain Setting __________

Manufacturer's Nameplate Information

Tank Heater Rated Input __________ (Btu/h, kW or lb_{steam}/h)
Pump Motor Horsepower _________
Voltage _________
Phase _________

Booster:

FIG. X1.1 Sample Results Reporting Sheets

Make ________
Model ________
Temp Rise / GPM ________
Rated Input ________ (Btu/h, kW or lb_{steam}/h)

Section X.2 Apparatus

____ Check if testing apparatus conformed to specifications in section 9.

Deviations ____

____

____

____

____

____

____

Testing Voltage ________Volts

For Gas appliances, if applicable:
Gas Heating Value ________Btu/ft^3
Barometric Pressure ________psia
Gas Temperature ________°F
Gas Pressure ________psia

Section X.3 Maximum Energy Input Rate

Tank Heaters

Measured (Btu/h (kJ/h) or kW) ________

Rated (Btu/h (kJ/h) or kW) ________

Percent Difference between Measured and Rated ________ %

Booster

Measured (Btu/h (kJ/h) or kW) ________

Rated (Btu/h (kJ/h) or kW) ________

FIG. X1.1 *(continued)*

Percent Difference between Measured and Rated ________ %

Section X.4 Tank Heater Idle Energy Rate

(Btu/h (kJ/h) or kW) ________

Average idle temperature (°F) ________

Section X.5 Booster Heater Idle Energy Rate

(Btu/h (kJ/h) or kW) ________

Section X.6 Washing Energy Test

Tank heater thermostat cut-in temperature (°F) ________

	Ready Temperatures (°F)	Rack Temperatures (°F)	Dish Temperatures (°F)	Dish Temperatures (°F)	Dish Temperatures (°F)
First Empty Rack	______	______	______	______	______
Second Empty Rack	______	______	______	______	______
First Dishload	______	______	______	______	______
Second Dishload	______	______	______	______	______
Third Dishload	______	______	______	______	______
Fourth Dishload	______	______	______	______	______
Fifth Dishload	______	______	______	______	______
Sixth Dishload	______	______	______	______	______
Seventh Dishload	______	______	______	______	______
Eighth Dishload	______	______	______	______	______
Ninth Dishload	______	______	______	______	______
Tenth Dishload	______	______	______	______	______

	Dishwasher	Booster	Total
Electric energy per rack (kWh)	________	________	________
Gas energy per rack (Btu)	________	________	________
Cycle rate (Racks per hour)	________		

FIG. X1.1 *(continued)*