Designation: ~~F1521 – 12~~ F1521 – 12 (Reapproved 2018)

An American National Standard

Standard Test Methods for Performance of Range Tops[1]

This standard is issued under the fixed designation F1521; 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 These test methods cover the energy consumption and cooking performance of range tops. The food service operator can use this evaluation to select a range top and understand its energy consumption.

1.2 These test methods are applicable to gas and electric range tops including both discreet burners and elements and hot tops.

1.3 The range top can be evaluated with respect to the following (where applicable):
1.3.1 Energy input rate (see 10.2), and
1.3.2 Pilot energy consumption (see 10.3).
1.3.3 Heat-up temperature response and temperature uniformity at minimum and maximum control settings (see 10.4), and
1.3.4 Cooking energy efficiency and production capacity (see 10.5).

1.4 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.5 *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~~ safety, health, and ~~health~~environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]
A36/A36M Specification for Carbon Structural Steel
D3588 Practice for Calculating Heat Value, Compressibility Factor, and Relative Density of Gaseous Fuels
2.2 *ASHRAE Standard:*
ASHRAE Guideline 2-1986 (RA90) Thermal and Related Properties of Food and Food Materials[3]

3. Terminology

3.1 *Definitions:*
3.1.1 *cooking container*—a vessel used to hold the food product that is being heated by the cooking unit.

3.1.2 *cooking energy*—energy consumed by the cooking unit as it is used to raise the temperature of water in a cooking container under full-input rate.

3.1.3 *cooking energy efficiency*—quantity of energy input to the water expressed as a percentage of the quantity of energy input to the cooking unit during the full-input rate tests.

3.1.4 *cooking unit*—a heating device located on the range top that is powered by a single heat source comprised of either a gas burner or an electrical element that is independently controlled.

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[1] These test methods are under the jurisdiction of ASTM Committee F26 on Food Service Equipment and are the direct responsibility of Subcommittee F26.06 on Productivity and Energy Protocol.
Current edition approved ~~Oct. 1, 2012~~Oct. 1, 2018. Published ~~December 2012~~November 2018. Originally approved in 1994. Last previous edition approved in ~~2008~~2012 as ~~F1521 – 03 (2008).~~F1521 – 12. DOI: ~~10.1520/F1521-12.~~10.1520/F1521-12R18.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] See *ASHRAE Handbook of Fundamentals*, Chapter 30, Table I, 1989, available from American Society of Heating, Refrigeration, and Air-Conditioning Engineers, 1791 Tullie Circle NE, Atlanta, GA 30329.

3.1.5 *energy input rate*—rate (Btu/h) at which an appliance consumes energy.

3.1.6 *heat-up temperature response*—temperature rise on the surface of a steel plate during the test period in accordance with the heat-up temperature-response test.

3.1.7 *production capacity*—maximum rate at which the cooking unit heats water in accordance with the cooking energy-efficiency test.

3.1.8 *production rate*—rate at which the cooking unit heats water in accordance with the cooking energy-efficiency test.

3.1.9 *range*—a device for cooking food by direct or indirect heat transfer from one or more cooking units to one or more cooking containers.

3.1.10 *temperature uniformity*—the comparison of individual temperatures measured on the surface of a steel plate at the end of the test period in accordance with the heat-up temperature-response test.

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

4. Summary of Test Methods

4.1 The range to be tested is connected to the appropriate metered energy source. The energy input rate is determined for each type of cooking unit on the range top and for the entire range top (all cooking units operating at the same time) to confirm that the range top is operating within 5.0 % of the nameplate energy input rate. The pilot energy consumption is also determined when applicable to the range being tested.

4.2 Thermocouples are attached to a circular steel plate which is then placed on the cooking unit to be tested. The heat-up temperature response of the cooking unit at the minimum control setting and at the maximum control setting is determined as well as the temperature uniformity at each control setting.

4.3 Energy consumption and time are monitored as each different type of cooking unit on the range is used to heat water from 70 to 200°F (21 to 93°C) at the full-energy input rate. Cooking energy efficiency and production capacity are calculated from this data.

5. Significance and Use

5.1 The energy input rate test is used to confirm that the range under test is operating at the manufacturer's rated input. This test would also indicate any problems with the electric power supply or gas service pressure.

5.2 The heat transfer characteristics of a cooking unit can be simulated by measuring the temperature uniformity of a steel plate.

5.3 Idle energy rate and pilot energy consumption can be used by food service operators to estimate energy consumption during non-cooking periods.

5.4 The cooking energy efficiency is a direct measurement of range efficiency at the full-energy input rate. This data can be used by food service operators in the selection of ranges, as well as for the management of a restaurant's energy demands.

NOTE 1—The PG&E Food Service Technology Center has determined that the cooking energy efficiency does not significantly change for different input rates. If precise efficiency calculations are desired at lower input rates, the full-input rate test procedure is valid for all input rates (that is, less than full-input).

5.5 Production rate and production capacity can be used to estimate the amount of time required for food preparation and as a measure of range capacity. This helps the food service operator match a range to particular food output requirements.

6. Apparatus

6.1 *Analytical Balance Scale,* for the determination of water and cooking container weight, with a resolution of 0.01 lb (5 g).

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

6.3 *Cooking Container,* 13-in. (330-mm) diameter, 20-qt (19-L), sauce pot with matching lid. The bottom of the pot shall be flat to within 0.0625 in. (1.6 mm) over the diameter.

6.3.1 The recommended cooking container for all testing shall be a professional standard weight Wear Ever Model 4333[4] sauce pot with a Wear Ever Model 4193 lid.[4] If it is not possible to use the recommended cooking container for testing, then a cooking container with a similar capacity may be substituted. The cooking container capacity should be no less than 12-qt and no more than 24-qt. The cooking container may be aluminum or steel. The weight of the substituted cooking container and lid must be noted and included in 11.7.1.

NOTE 2—The recommended aluminum sauce pot may not always be a suitable cooking container. For example, an electric induction range top requires

[4] Available from Lincoln Foodservice Products, Inc., P.O. Box 1229, Fort Wayne, IN 46801.

that the cooking container be magnetic, typically steel or stainless steel plated nickel. For this reason 6.3.1 is included for flexibility.

6.4 *Canopy Exhaust Hood,* 4 ft (1.2 m) in depth, wallmounted with the lower edge of the hood 6½ ft (2.0 m) from the floor and with the capacity to operate at a nominal exhaust ventilation rate of 300 ft^3/min/linear foot (230 L/s/linear metre) of active hood length. This hood shall extend a minimum of 6 in. (150 mm) past both sides of the cooking appliance and shall not incorporate side curtains or partitions.

6.5 *Gas Meter,* for measuring the gas consumption of a range, shall be a positive displacement type with a resolution of at least 0.01 ft^3 (0.0003 m^3) and a maximum error 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 the pilot lights, it shall have a resolution of at least 0.01 ft^3 (0.0003 m^3) and have a maximum error no greater than 2 % of the measured value.

6.6 *Pressure Gage,* for monitoring natural gas pressure, with a range from 0 to 10 in. H_2O (0 to 2.5 kPa), a resolution of 0.5 in. H_2O (125 Pa), and a maximum uncertainty of 1 % of the measured value.

6.7 *Steel Plate,* composed of structural-grade carbon steel in accordance with Specification A36/A36M, free of rust or corrosion, 12-in. (300-mm) diameter, and ¼ in. (6.4 mm) thick. The plate shall be flat to within 0.010 in. (3 mm) over the diameter.

6.8 *Strain Gage Welder,* capable of welding thermocouples to steel.[5]

6.9 *Thermocouple(s),* fiberglass-insulated, 24-gage, Type K thermocouple wire, peened flat at the exposed ends and spot welded to surfaces with a strain gage welder.

6.10 *Thermocouple Probe(s),* capable of immersion with a range from 50 to 200°F (10 to 93°C) and accuracy of ±2°F (±1°C), preferably industry standard Type T or Type K thermocouples.

6.11 *Temperature Sensor,* for measuring natural gas temperature in the range from 50 to 100°F (10 to 38°C), with a resolution of 0.1°F (0.05°C) and an accuracy of ±0.5°F (±0.3°C).

6.12 *Watt-Hour Meter,* for measuring the electrical energy consumption of a range, shall have a resolution of at least 1 Wh and a maximum error no greater than 1.5 % of the measured value for any demand greater than 100 W.

7. Reagents and Materials

7.1 *Water,* having a maximum hardness of three grains per gallon. Distilled water may be used.

8. Sampling and Test Units

8.1 *Range*—A representative production model shall be selected for performance testing.

9. Preparation of Apparatus

9.1 Install the appliance in accordance with the manufacturer's instructions under a 4-ft (1.2-m) deep canopy exhaust hood mounted against a wall with the lower edge of the hood 6½ ft (2.0 m) from the floor. Position the range so that the front edge is 6 in. (150 mm) inside the front edge of the hood. The length of the exhaust hood and active filter area shall extend a minimum of 6 in. (150 mm) beyond both sides of the range. In addition, both sides of the range shall be 3 ft (1.1 m) from any side wall, side partition, or other operating appliance. The exhaust ventilation rate shall be 300 ft^3/min/ linear foot (460 L/s/linear metre) of hood length. The associated heating or cooling system shall be capable of maintaining an ambient temperature of 75 ± 5°F (24 ± 3°C) within the testing environment while the exhaust system is operating.

9.2 Connect the range to a calibrated energy-test meter. For gas installations, a pressure regulator shall be installed downstream from the meter to maintain a constant pressure of gas for all tests. Both the pressure and temperature of the gas supplied to a range, as well as the barometric pressure, shall be recorded during each test so that the measured gas flow can be corrected to standard conditions. For electric installations, a voltage regulatory may be required during tests if the voltage is not within ±2.5 % of the manufacturer's nameplate voltage.

9.3 For a gas range, adjust (while a cooking unit is operating) the gas pressure downstream from the appliance pressure regulator to within ±2.5 % of the operating manifold pressure specified by the manufacturer. Also make adjustments to the appliance following the manufacturer's recommendations for optimizing combustion.

9.4 For an electric range, confirm (while a cooking unit is operating) that the supply voltage is to within ±2.5 % of the operating voltage specified by the manufacturer. The test voltage shall be recorded for each test.

NOTE 3—If an electric range is rated for dual voltage (for example, 208/240), the range should be evaluated as two separate appliances in accordance with these test methods.

[5] Eaton Model W1200 Strain Gage Welder, available from Eaton Corp., 1728 Maplelawn Road, Troy, MI 48084, has been found satisfactory for this purpose.

10. Procedure

10.1 *General:*

NOTE 4—Prior to starting these test methods, the tester should read the operating manual and fully understand the operation of the appliance.

10.1.1 For gas ranges, obtain and record the following for each run of every test:
10.1.1.1 Higher heating value,
10.1.1.2 Standard gas pressure and temperature used to correct measured gas volume to standard conditions,
10.1.1.3 Measured gas temperature,
10.1.1.4 Measured gas pressure,
10.1.1.5 Barometric pressure, and
10.1.1.6 Energy input rate during or immediately prior to test.

NOTE 5—The preferred method for determining the heating value of gas supplied to the range under test is by using a calorimeter or gas chromatograph in accordance with accepted laboratory procedures. It is recommended that all testing be performed with gas with a heating value between 1000 and 1075 Btu/ft^3 (37 300 to 40 000 ~~kJ~~kJ/~~m~~m^3).

10.1.2 For gas ranges, measure and add any electric energy consumption to gas energy for all tests, with the exception of the energy input rate test (see 10.2).

10.1.3 For electric ranges, obtain and record the following for each run of every test:
10.1.3.1 Voltage while elements are energized.
10.1.3.2 Energy input rate during or immediately prior to test run.

10.2 *Energy Input Rate:*

10.2.1 For gas ranges, operate one of the cooking units with the temperature control in the full "on" position. Allow the cooking unit to operate for 15 min.

10.2.2 At the end of the 15-min stabilization period, begin recording the energy consumption of the cooking unit for the next 15 min.

10.2.3 For electric ranges, operate one of the cooking units with the temperature control in the full "on" position, and record the energy consumption of the cooking unit for the next 15 min. If an electric cooking unit begins to cycle, see Note 6.

NOTE 6—If an electric unit cycles within the 15-min time period required for the test, record only the energy used during the noncycling period starting from the instant that the cooking unit was turned on. If more than one cooking unit is operating, stop recording the energy consumption when any unit begins to cycle.

10.2.4 Repeat the procedure in 10.2.1 – 10.2.3 for each cooking unit on the range top and record the energy consumption for the specified time period as well as the position of the cooking unit (for example, left front, left rear, center front, or right rear).

10.2.5 Repeat the procedure in 10.2.1 – 10.2.3, operating all of the range top cooking units at the same time, and record the energy consumption of the entire range top for the specified time period. If an electric cooking unit begins to cycle see Note 7.

10.2.6 In accordance with 11.4, report the measured energy input rate for each separate cooking unit tested and for the entire range (all cooking units operating at the same time). Report the nameplate ratings for each separate cooking unit tested and for the complete range top.

NOTE 7—The nameplate rated input of a range top is generally specified as the sum of the nameplate ratings of each of the individual cooking units located on the range top. For example, a range top with four 20 000-Btu/h burners has a nameplate rating of 80 000 ~~Btu/h.~~Btu/h. Due to this fact, the measured input rate of the entire range top is sometimes different from the nameplate rating. Section 10.2.5 compares the nameplate rating against the measured rating for the entire range top. The remainder of the tests contained in this test method concentrate on individual cooking units; therefore, it is important that the measured input rates of the individual cooking units fall within the specified variance from their nameplate ratings.

10.2.7 Confirm that the measured input rate or power (British thermal units per hour for a gas range top and kilowatts for an electric range top) for each cooking unit tested is within ±5 % of the rated nameplate input or power for that cooking unit. If the difference is greater than ±5 %, terminate testing and contact the manufacture. The manufacturer may make appropriate changes or adjustments to the individual cooking units or the entire range top or choose to supply an alternative range for testing. It is the intent of the testing procedures herein to evaluate the performance of a range at rated gas pressure or electrical voltage.

10.3 *Pilot Energy Consumption (Gas Models with Standing Pilots):*

10.3.1 Where applicable, set the gas valve controlling the gas supply to the range top at the "pilot" position. Otherwise, set the range top temperature controls to the "off" position.

10.3.2 Light and adjust pilots in accordance with the manufacturer's instructions.

10.3.3 Record the gas reading after a minimum of 8 h of pilot operation.

10.3.4 Allow pilots to operate for the remainder of the tests listed in this procedure. Do not extinguish pilots until all testing is complete.

10.4 *Heat-Up Temperature Response and Temperature Uniformity at Minimum and Maximum Control Settings:*

10.4.1 Using a strain gage welder, attach seventeen thermocouples to a 12-in. (300-mm) diameter, ¼-in. (6.4-mm) thick steel plate as detailed in Fig. 1. Thermocouple locations shall be numbered, starting with 1in the center, 2 to 9 on the innermost circle of thermocouples, and 10 to 17 on the outermost circle of thermocouples. For a hot top see Note 8.

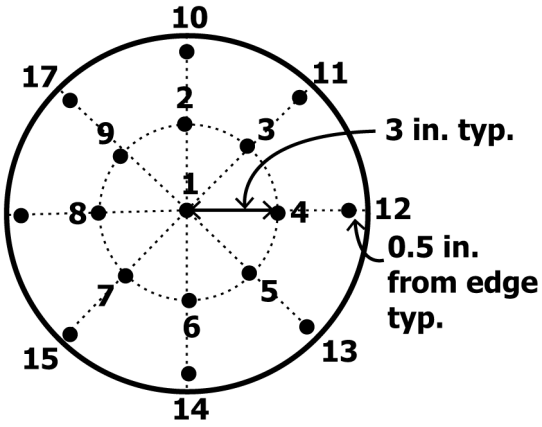

FIG. 1 Thermocouple Placement

NOTE 8—Use one steel plate for each full 1 by 1 ft (305 by 305 mm) of cooking surface on the hot top cooking unit. For example, both a 1 by 2-ft (305 by 610-mm) and a 1½ by 2-ft (457 by 610-mm) cooking unit would require two plates; however, a 2 by 2-ft (610 by 610-mm) cooking surface would require four plates. Alternately, a surface requiring more than one plate can be tested using only one plate by moving the plate to each of the required positions and repeating the test for each position. Many hot tops are designed to have a temperature gradient from front to back; therefore, the temperature data gathered from every plate position should be reported separately.

10.4.2 Place and center the plate, thermocoupled side up, on the first cooking unit to be tested. The cooking unit to be tested shall be the one closest to front and left. Report the position of the tested cooking unit on a diagram of the range top (see Fig. 2). If the cooking unit is an open gas burner, ensure that the plate is situated so that the thermocouple locations on the top of the plate are over the open flame and not over the burner grates. Support the thermocouple wires so that their weight does not affect the contact between any part of the plate and the cooking unit.

10.4.3 Verify that the plate is at 75 ± 5°F (24 ± 3°C). The cooking unit shall not have been operated for at least the preceding 1 h.

10.4.4 Operate the cooking unit at its minimum control setting or lowest level (that is, for gas cooking units operate the cooking unit at the lowest sustainable flame level and for electric cooking units set the control at the lowest position at which the indicator light turns on or at the lowest setting of the control knob) and immediately start recording the temperatures and the time, simultaneously computing the average temperature of the plate (all of the thermocouples combined).

10.4.5 Allow the cooking unit to operate for 1 h. Record the energy consumption of the cooking unit.

NOTE 9—The length of the test is set at 1 h in order to be sure to include the temperature response for all types of ranges.

10.4.6 At the end of 1 h, note the average temperature of the plate (all of the thermocouples combined) and the temperature of each individual point on the plate.

10.4.7 Turn the cooking unit off and allow it to sit and cool for at least 1 h. Remove the plate from the cooking unit and allow it to cool to 75 ± 5°F (24 ± 3°C).

10.4.8 Replace the plate on the cooking unit. Set the cooking unit controls at the maximum control setting or full "on," and immediately start recording the temperatures and the time, simultaneously computing the average temperature of the plate (all of the thermocouples combined).

10.4.9 Allow the cooking unit to operate for 1 h. Record the energy consumption of the cooking unit.

10.4.10 At the end of 1 h, note the average temperature of the plate (all of the thermocouples combined) and the temperature of each individual point on the plate.

10.4.11 Repeat the test for each type of cooking unit on the range top.

10.5 *Cooking Energy Efficiency and Production Capacity:*

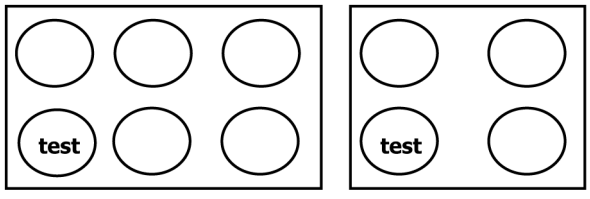

FIG. 2 Selection of Test Cooking Unit

10.5.1 This procedure is comprised of one 30-min stabilization run, followed by a minimum of three separate test runs (in accordance with A1.4.4) at the full-energy input rate. The reported values of cooking energy efficiency and production capacity shall be the average of the three test runs.

10.5.2 Prepare a minimum of three empty 13-in. (330-mm), 20-qt (19-L), sauce pots and lids (in accordance with 6.3). Verify that each sauce pot is at 75 ± 5°F (24 ± 3°C). For a hot top see Note 10.

NOTE 10—Use one sauce pot for each full 1 by 1 ft (305 by 305 mm) of cooking surface on the hot top cooking unit. For example, both a 1 by 2-ft (305 by 610-mm) and a 1½ by 2-ft (457 by 610-mm) cooking unit would require 6 sauce pots (two pots for three tests); however, a 2 by 2-ft (610 by 610-mm) cooking surface would require 12 sauce pots (4 pots for three tests).

10.5.3 Each sauce pot lid shall have a hole located within 2 in. (51 mm) of the center and no larger than 0.25 in. (6 mm) in diameter to allow for a thermocouple probe. The thermocouple shall extend 4 in. (102 mm) below the bottom of the lid.

10.5.4 Pour 20 lb (9091 g) of 70 ± 2°F (21 ± 1°C) water into each sauce pot and record the water temperature. Place a lid on each sauce pot. These are the test pots. Pour 20 lb of 70 ± 2°F water into a fourth similar sauce pot and center the pot on the first cooking unit to be tested (see 10.4.2). Place the lid on this sauce pot. This is the stabilization pot.

10.5.5 Set the cooking unit controls at 50 ± 5 % of the full-energy input rate (including any pilot energy) and allow the unit to operate for 30 min. At the end of 30 min, remove the stabilization pot.

10.5.6 If the cooking unit is a hot top, repeat the stabilization procedure detailed in 10.5.4 and 10.5.5 for two 30-min stabilization periods, totaling 1 h.

10.5.7 Center a test pot on the cooking unit, allowing no more than 15 min between the removal of the previous pot and the placement of this pot.

10.5.8 Record the time and energy (including any electric energy used by a gas range) required to raise the water temperature to 200°F (93°C). If more than one sauce pot is required, end the test when the water temperature of all the sauce pots combined averages 200°F.

10.5.9 Repeat 10.5.7 and 10.5.8 for the two remaining test runs.

10.5.10 Calculate the cooking energy efficiency and production capacity for the cooking unit in accordance with 11.7 and 11.8.

10.5.11 Repeat the procedures detailed in 10.5 until each type of cooking unit has been tested.

11. Calculation and Report

11.1 *Test Range*—Summarize the physical and operating characteristics of the range.

11.2 *Apparatus and Procedure*—Confirm that the testing apparatus conformed to all of the specifications in Section 9. Describe any deviations from those specifications.

11.3 *Gas Calculations:*

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

11.3.2 Calculate the energy consumed based on:

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

where:

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

$$= V_{meas} \times T_{cf} \times P_{cf}$$

where:

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

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

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

P_{cf} = pressure correction factor

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

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

NOTE 11—Absolute standard gas temperature and pressure used in this calculation should be the same values used for determining the higher heating