JUNE 6, 2023

Energy Consumption of Conventional Cooking Products

ASGE Presentation

Agenda / Topics

Background and Overview

Preparation

Test Procedure

Data Analysis and Reporting

Challenges

Q&A

Background

- DOE has published Appendix I1 to Subpart B of Part 430 to establish a standard methodology for measuring energy consumption of both electric and gas ranges and cooktops.
- Starting February 2023, any representation related to energy consumption must be based on the results of this test method.
- The method weaves together several IEC standards by reference
  - IEC 60350-2 Household electric cooking appliances - Part 2: Hobs - Methods for measuring performance
  - IEC 62301 (1st Edition) Household electrical appliances - Measurement of standby power
  - IEC 62301 (2nd Edition) Household electrical appliances - Measurement of standby power

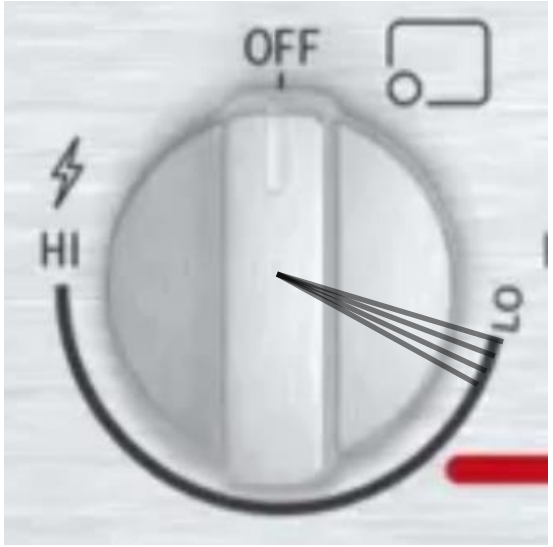
Provides a common procedure to measure energy consumption for each cooktop burner.

The Bottom Line

To identify the power setting which will allow a specific water load to maintain a temperature between 90°C and 91°C over a 20-minute simmer period.

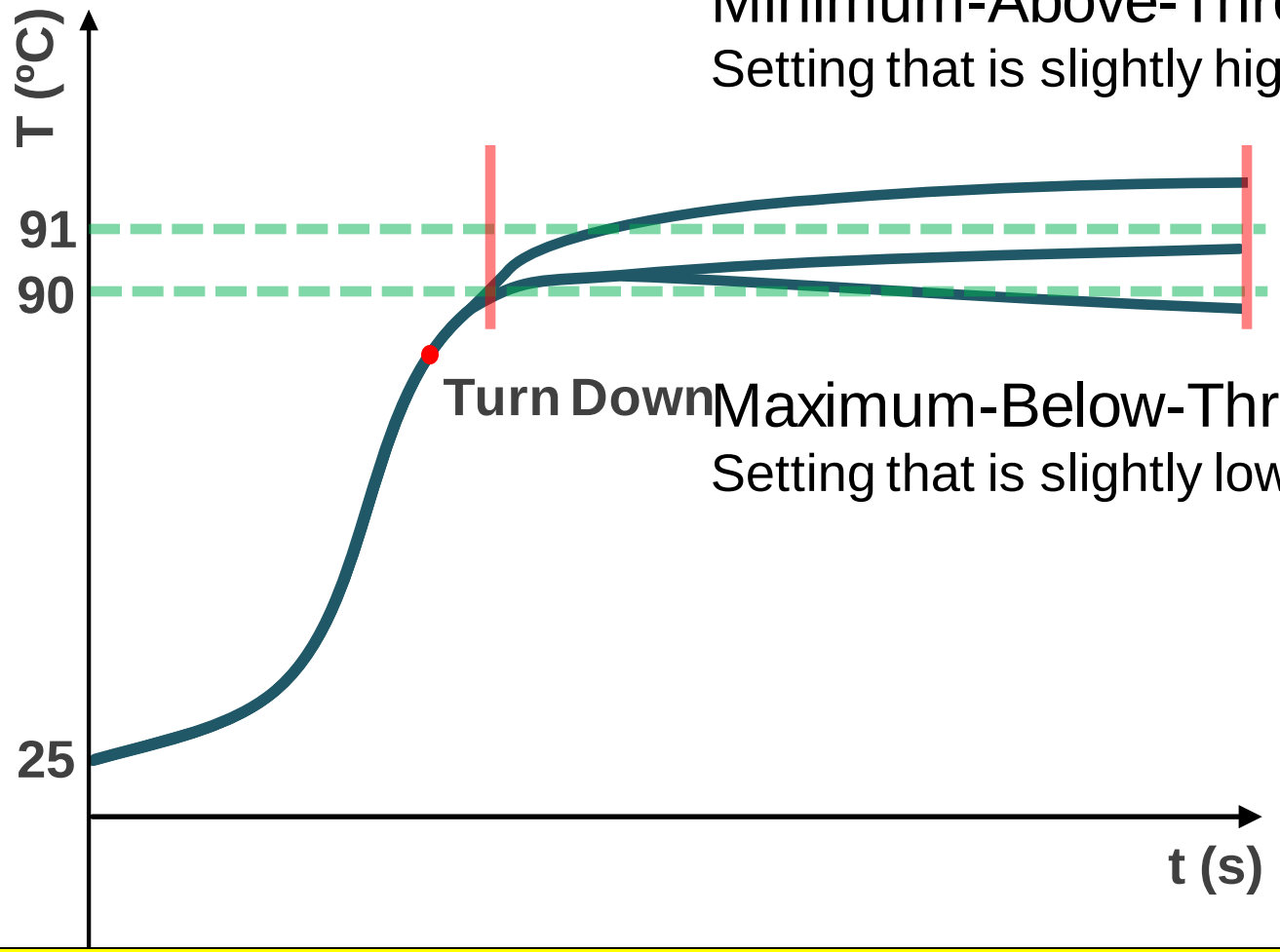
CHALLENGE

"Infinite" Adjustments



In most cases, the optimal setting is impossible to find via measurement.

DOE Test Procedure Overview



Minimum-Above-Threshold (MAT)
Setting that is slightly higher than optimal

Maximum-Below-Threshold (MBT)
Setting that is slightly lower than optimal

Goal is to determine the WHEN and to WHAT lower setting the burner should be adjusted to.

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Test Vessels + Water Loads

- Specialized vessels according to IEC 60350-2
- Water loads defined by cookware type

Diameter of the cookware bottom (outside) mm	Diameter of the lid mm	Lid hole circle diameter mm	Number of holes on the circle	Total cookware height (outside) mm	Flatness of cookware bottom mm	Water load g	Cooking zone size category mm	Standardised cookware categories
120 ± 0,5	130 ± 1	80 ± 1	7	125 ± 0,5	≥ 0 < 0,075	650	≥ 100 < 130	A
150 ± 0,5	165 ± 1	110 ± 1	11	125 ± 0,5	≥ 0 < 0,075	1 030	≥ 130 < 160	
180 ± 0,5	200 ± 1	140 ± 1	16	125 ± 0,5	≥ 0 < 0,075	1 500	≥ 160 < 190	B
210 ± 0,5	230 ± 1	170 ± 1	22	125 ± 0,5	≥ 0 < 0,1	2 050	≥ 190 < 220	C
240 ± 0,5	265 ± 1	200 ± 1	29	125 ± 0,5	≥ 0 < 0,1	2 700	≥ 220 < 250	
270 ± 0,5	300 ± 1	230/210 [a] ± 1	18/18 [a]	125 ± 0,5	≥ 0 < 0,15	3 420	≥ 250 < 280	D
300 ± 0,5	330 ± 1	260/210 [a] ± 1	23/22 [a]	125 ± 0,5	≥ 0 < 0,15	4 240	≥ 280 < 310	
330 ± 0,5	365 ± 1	290/270 [a] ± 1	27/27 [a]	125 ± 0,5	≥ 0 < 0,15	5 140	≥ 310 ≤ 330	

[a] Number of holes are arranged on two hole circles.

Nominal gas burner input rate (Btu/h)		Test Vessel Diameter (mm)	Water Load Mass (g)
Minimum (>)	Maximum (≤)		
	5,600	210	2,050
5,600	8,050	240	2,700
8,050	14,300	270	3,420
14,300		300	4,240

Unit Preparation

- Any UUT incorporating a network function (e.g. Bluetooth, Wi-Fi, etc.) should be disabled if possible or tested in the default / as-shipped condition.
- Freestanding ranges and cooking tops are installed with the back directly against, or as near as possible to a vertical wall that extends at least 1-foot above and 1-foot beyond both sides
- Before the first measurement is taken, all cooking zones must be operated simultaneously for at least 10-minutes at maximum power. This is conducted once.

Burner Power Setting Markings

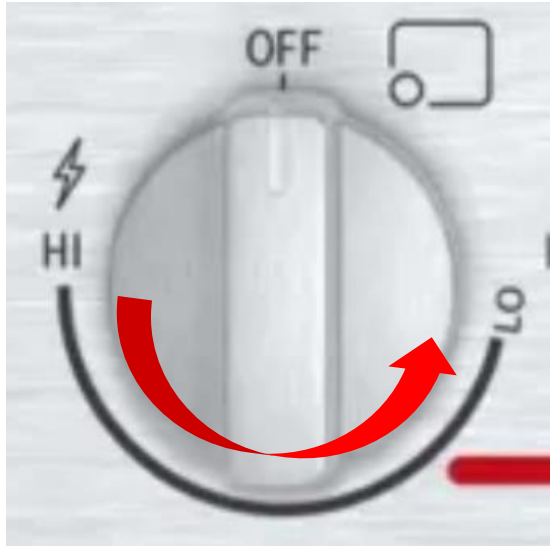
Infinite power setting (dial)

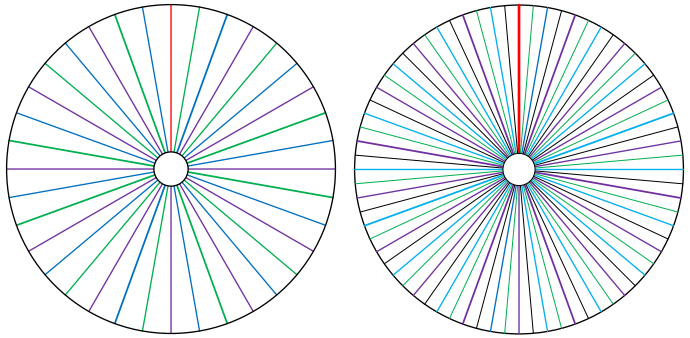
- For rotation from high to low > 150° = increments of 10°
- For rotation from high to low ≤ 150° = increments of 5°

Discrete settings (touch, presets) – mark with tape or paint marker

Hybrid controls (dials with presets)

- Any combination of method to clearly distinguish target setting





Additional Gas Appliance Requirements

INITIAL OPERATION AND GAS UNIT ADJUSTMENTS

Gas supply should have dry-basis heating value of 1025 Btu/ft^3

Challenge – Calorimeters are typically not installed at the meter and are normally placed at the building supply's inlet.

Bottled gas is the only option to achieve consistent measurements but is costly.

Burners are adjusted to ± 2% of nominal heat input rate which is measured 5-minutes after starting ignition.

Challenge #1 – Burners are traditionally rated to a ± 5% tolerance.

Challenge #2 – There are multiple measurements needed for each burner making environmental changes to CF more challenging.

Assume no repeatability.

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Input #1 - Overshoot Test

Input #1 – WHEN do we turn down the burner?

Overshoot Test

1. Heat the water load at full power until 70°C before shutting off burner
2. Check 70°C water temperature (T_{70}) at time, t_{70}

   T_{70} is the average of t_{70} – 10s and t_{70} + 10s

   Valid if the value is within the tolerance of (70 ± 0.5)°C
3. Allow the water temperature to reach a peak value, T_{max}
4. Calculate the turndown temperature, Tc, rounded to the nearest integer, using the formula:

$$Tc_{Target} = 93°C - (T_{max} - T_{70})$$

Input #2 - Potential Simmer Setting

Input #2 – WHAT lower power setting do we use?

Potential Simmer Test

1. Measure energy consumption for each power setting (starting at lowest) for 10-minutes
2. Calculate the energy density:

   Gas Units $Q_{g,j} = \frac{6\times(V_j \times CF \times H + E_{ej} \times K_e)}{a}$

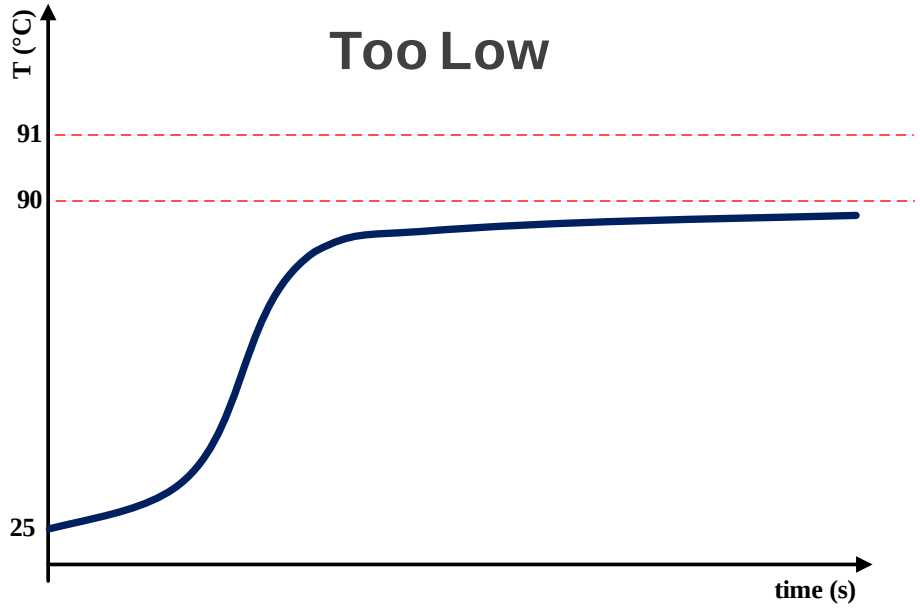
   Electric Units $Q_{e,j} = \frac{6\times E_j}{a}$
3. Repeat measurements for increasing power levels until the energy density exceeds:

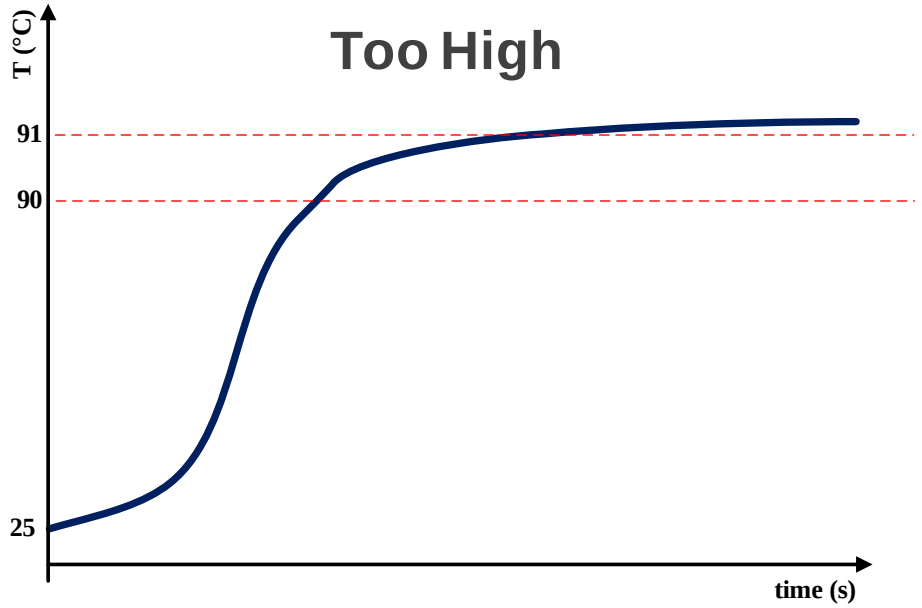
   Gas Units: $4.0\ {}^{Btu}/_{h\cdot cm^2}$

   Electric Units: $0.8\ {}^{W}/_{cm^2}$
4. Of the last two settings tested, the potential simmer setting is the power density closest to the target value.

Simmer Test

1. Note Input #1, target turndown temperature, and Input #2, power setting for upcoming test
2. Start the run at full power and turn down the burner to the lower power setting when the target temperature has been reached.
3. At the conclusion of the test, apply a smoothing function (averaging) to the actual water temperature channel (data).





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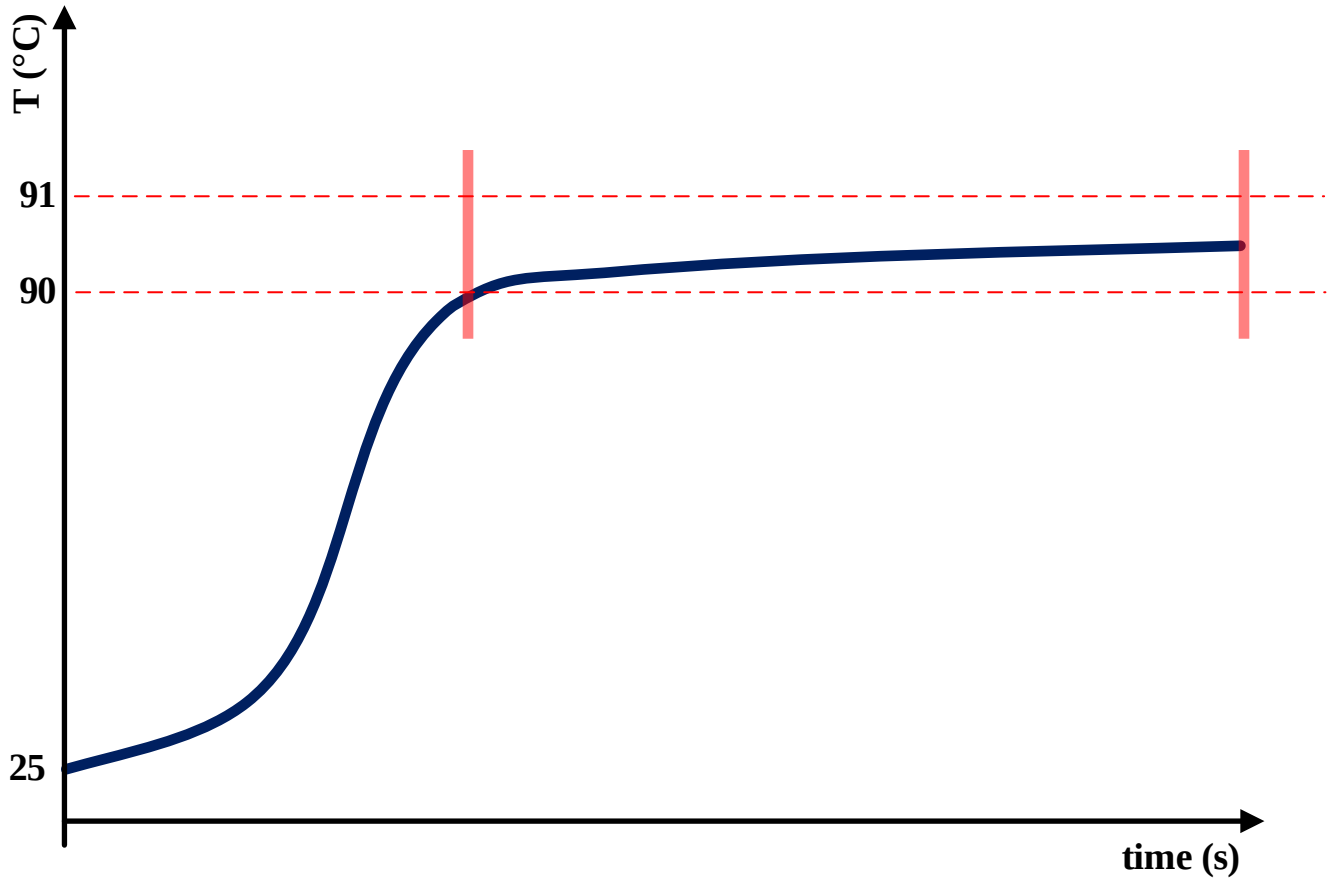
Reporting Results

- Conventional Cooking Top V1 template published in February 2023
- Measurements

Water temperature	Current
Ambient temperature	Gas volume
Ambient barometric pressure	Gas temperature
Voltage	Gas pressure
Frequency	

- Dissection and processing of smoothened data

Smoothened Data



Energy Calculations

$$E_g = E_{gt,MAT} - \frac{E_{gt,MAT} - E_{gt,MBT}}{T_{S,MAT} - T_{S,MBT}} \times (T_{S,MAT} - 90)$$

$E_{gt,\ MAT}$ = As tested gas energy consumption for Minimum Above Threshold (MAT) run

$T_{s,\ MAT}$ = Smoothened water temperature at the end of simmer for MAT run

$E_{gt,\ MBT}$ = As tested gas energy consumption for Maximum Below Threshold (MBT) run

$Ts_{,\ MBT}$ = Smoothened water temperature at the end of simmer for MBT run

DOE Test Procedure

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- Gas rating repeatability
- Variability of turndown across multiple users
- System response on discrete-type controls
- Data acquisition sophistication

Questions?

Thank you.

Nick Asmis
Technical Specialist

8501 E. Pleasant Valley
Independence, OH 44131

1 216-520-8981
nick.asmis@csagroup.org