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Standard Practice for Determining Energy Consumption of Nonimpact Personal Computer Printers[1]

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ε[1] NOTE—Keywords were added editorially in January 2008.

1. Scope

1.1 This practice covers a procedure by which nonimpact personal computer printers, accessories, and similar office imaging devices can be tested for energy consumption.

1.2 *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:* [2]

F 335 Terminology Relating to Electrostatic Imaging

F 757 Test Method for Determining Energy Consumption of Copier and Copier-Duplicating Equipment[3]

F 909 Terminology Relating to Printers

2.2 *ANSI Standard:*

C 12.10 Electromechanical Watthour Meters[4]

3. Terminology

3.1 For definitions of terms used in this practice, see Terminologies F 335 and F 909 and Test Method F 757.

3.2 *cycle out*—the condition which exists when the machine has finished printing a page and has returned to a stand-by mode.

3.3 *energy-saver*—the condition that exists when the machine is not printing, has previously reached operating conditions, but is consuming less power than when the machine is in the stand-by mode.

3.4 *idle time*—the amount of time that the machine is not printing when testing printing energy.

3.5 *job*—printing pages without interruption or delay between pages.

3.6 *machine energy*—the energy consumed by a printer that is plugged in 24 h/day and turned on 10.5 h (see Note 1), but is not printing pages.

NOTE 1—Some users may want to adjust this time if they do not turn off their printers. Therefore, the test should be performed for the plug-in and warm-up modes, but won't be included in the calculations. If the user wants to include these modes in the calculations, the tester should recalculate the numbers used in Section 10.

3.7 *machine speed, first page*—the amount of time the machine takes to produce the first page of a job.

3.8 *machine speed, subsequent pages*—the amount of time the machine takes to produce multiple pages after the first page of a job.

3.9 *printing*—the machine condition that exists from the beginning to the end of the cycle that produces a page or pages.

3.10 *printing energy*—the energy consumed during a designated printing mode exclusive of stand-by and plug-in energy.

3.11 *printing time*—the amount of time that the nominal jobs are run when testing printing energy.

3.12 *standard pages per day*—the number of standard pages produced on a single machine during a standard printing day.

3.13 *stand-by*—the condition that exists when the machine is not printing, has reached operating conditions, but has not yet entered into an energy-saver mode.

3.14 *warm-up*—the condition that exists when the machine is turned on from a plug-in mode and prior to printing pages.

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[1] This practice is under the jurisdiction of ASTM Committee F05 on Business Imaging Products and is the direct responsibility of Subcommittee F05.04 on Electrostatic Imaging Products.

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[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] Withdrawn.

[4] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

4. Summary of Test Method

4.1 The standard energy consumption rating is determined for a printer while the machine is in a simulated customer installation performing one eighth of a typical day's printing jobs (using a watt-hour meter). The typical day's jobs (size and number of pages) are based on a standard volume (see Table 1). The simulated customer installation can be calculated with actual usage data, or can be based on the following assumptions, that the printer will typically:

4.1.1 Be plugged in to a live power line for thirty 24-h days (720 h)/month.

4.1.2 Be turned on or off, or both, each of 22 work days/month.

4.1.3 Go through a warm-up cycle (if required) once for each of 20 work days each month.

4.1.4 Be left on 24 h/day for 2 days of each standard work month.

4.1.5 As a result of items 4.1.2 and 4.1.3, be left on for an average of 10.5 h each of the 22 days.

4.1.6 Be in an energy-saver mode some amount of time depending on the nominal volume and use from Table 1, the printing time from Table 2, and the energy-saver delay time.

4.1.7 Perform a typical day's printing jobs for each of the 22 workdays each month.

4.2 The energy consumption per printed page or the typical month's energy consumption (kilowatt hour (kWh) per month) are determined using calculations based on the test data.

5. Significance and Use

5.1 This practice provides a procedure for measuring the energy consumption of the product and associated accessories in various operating modes. It does not reflect the total energy required to produce a page. It does not, for example, include the energy required to manufacture the paper or the machine. It is intended to determine the energy requirements of products by a method that will permit accurate energy efficiency comparisons with similar products.

TABLE 1 Nominal Parameters for Each Standard Volume

Nominal Monthly Volume, Pages per Month	Nominal Day's Pages	Nominal Jobs (1/8 day)n^A		
		Number of Jobs	Number of Pages per Job	Job Interval
200	8	1	1	60 min
500	24	3	1	20 min
1 000	48	3	2	20 min
2 500	112	7	2	8.6 min
5 000	224	14	2	8.6 min
10 000	432	18	3	3.3 min
25 000	1 152	36	4	1.6 min
40 000	1 824	57	4	65 s
80 000	3 600	90	5	40 s
100 000	4 800	100	6	36 s
280 000	13 200	165	10	22 s

$^A n$ = number of jobs × number of originals × number of pages per original.

TABLE 2 Calculation for Printing Time

Nominal Monthly Volume, Pages per Month	Number of Jobs, j	Number of Pages per Job	Printing Time, min/h (S/R_t)
200	1	1	$1/X^A$
500	3	1	$3/X$
1 000	3	2	$3/X + 3/Y^B$
2 500	7	2	$7/X + 14/Y$
5 000	14	2	$14/X + 14/Y$
10 000	18	3	$18/X + 36/Y$
25 000	36	4	$36/X + 108/Y$
40 000	57	4	$57/X + 171/Y$
80 000	90	5	$90/X + 360/Y$
100 000	100	6	$100/X + 500/Y$
280 000	165	10	$165/X + 1485/Y$

$^A X$ = machine speed, first page.
$^B Y$ = machine speed, subsequent pages.

6. Apparatus and Supplies

6.1 *Watt-Hour Meter*, one per phase, accurate to three figures and compliant with ANSI C 12.10, performance tables 5.1.8.[5]

6.2 *Timer*—A timing device accurate to 1 s and ±0.5 %.

6.3 *Personal Computer*—With the printer attached, used to generate or print, or both, the test targets described in 6.4 and 6.5.

6.4 *Anacom Smartbox Device*—A device that takes the place of a computer and downloads text or graphic images, or both, to a printer with the use of erasable programmable read-only memories (EPROMs) and either serial or parallel ports.[6]

6.5 *Test Target*—The test target with 8 % coverage, option XX in the Anacom Smartbox device should be used.

6.6 *Graphic Test Target*—The test target with 8 % coverage, option XXX in the Anacom Smartbox device should be used.

6.7 *Paper*, 8½ by 11 in. (216 by 280 mm), 20-lb bond or where not applicable use the machine manufacturer's recommended midpoint range of paper weight.

7. Sampling

7.1 The energy rating should be that for a device representative of the commercially available equipment. Any modification of the product or additional configurations that significantly alter energy consumption requires additional testing.

7.2 The printers configured with automatic duplex option should be tested twice, once at 100 % of single-sided and once at 100 % of two-sided pages (each side counts as one page).

[5] The sole source of supply of the series 1000 Kilowatt Hour Meter apparatus known to the committee at this time is National Meter Industries, Inc., P.O. Box 462, Stamford, CT 06907. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

[6] The sole source of supply of the Anacom Device apparatus known to the committee at this time is Laser Supply, Inc., P.O. Box 462, Edgemont, PA 19028. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

7.3 The printer(s) to be evaluated should be set to within the manufacturers operating specifications.

7.4 The printers equipped with more than one resolution setting should be tested at the highest resolution settings, using the manufacturer's recommended contrast settings. Resolution enhancement should be enabled.

8. Preparation of Apparatus

8.1 *Test Conditions*:

8.1.1 The room ambient temperature shall be within a range of 21 ± 3°C; from 40 to 60 % relative humidity.

8.1.2 The working voltage shall be machine-rated voltage ±2 %.

8.1.3 The machine shall be at least 2 ft (610 mm) from any wall, obstacle, or air vent.

8.1.4 All supplies used shall be those specified by the printer manufacturer and preconditioned for a minimum of 24 h at room ambient temperature and humidity prior to evaluating the printer energy consumption.

8.1.5 The alternating current power shall be supplied as a true sine wave with no more than 3 % harmonic distortion.

8.1.6 The power frequency must be rated at ±0.1Hz.

8.1.7 The manufacturer defines the configuration (including accessories) of the machine to be tested and the volume at which it will be tested (Table 1). Normally, each printer will be tested for the volumes for which the manufacture intends to market the product.

NOTE 2—During the test cycle, the machine should be allowed to cycle out after the required number of pages have been completed. This does not apply to machines with features that allow for continuous operation without cycling out.

8.1.8 The test should be discontinued if an unusually high number of machine problems occur. Excess machine stoppages may distort the overall energy rating. A reasonable number of paper misfeeds (for example, >1 misfeed per 1000 pages) that can readily be cleared by the operator should not be considered reason to discontinue the test.

9. Procedure

9.1 Steps 9.1.1-9.1.4 of this procedure should be completed once for each machine. The data from 9.1.1-9.1.4 applies to all standard volumes for which the machine is being tested. The data from 9.1.5 applies only to one configuration, one emulation, and one resolution setting, and must be repeated for all other configurations, emulations, and resolution settings for which the machine is being tested. Prior to the start of this test, the machine should be plugged in to a live power line but turned off and stabilized at ambient conditions for at least 12 h. The personal computer or Anacom device should be connected to the printer at least 12 h prior to the test. An appropriate watt-hour meter should be in line with the machine, ready to give an accurate indication of machine energy consumption without disruption of the energy source. This test should be run at the printer setting that, in the opinion of the evaluator, is the one yielding the best apparent quality.

9.1.1 *Printing Time*—Choose the appropriate formula in Table 2 that matches the monthly volume for the machine under test. Using the manufacturer's values for printer speeds, where X is the number of pages per minute for the first page, and Y is the number of pages per minute for subsequent pages, follow appropriate formulas. Record the printing time in Fig. 1.

9.1.2 *Plug-In Energy*—Read and record the watt-hour meter indication and the time (or start the stopwatch or timer). After 1 h, read and record the watt-hour meter indication again. The difference between the two readings of the watt-hour meter is the test data for plug-in mode energy use. Record the result in Fig. 1, Test Results, Part A. If it is known that the test machine consumes no energy during the plug-in mode, enter a zero for the observed data for plug-in energy use and omit this step.

9.1.3 *Warm-Up Mode Plus Stand-By Mode Energy*—With the machine in a stabilized plug-in condition, read and record the watt-hour meter indication and the time (or start the stopwatch or timer). Turn on the machine and allow it to warm up and stabilize in the ready mode. After 1 h, read and record the watt-hour indication again. The difference between the two readings of the watt-hour meter is the test data for warm-up mode plus stand-by mode energy use. Record the result in Fig. 1, Test Results, Part B. If it is known that the machine uses no energy in the warm-up mode (as defined by this procedure) omit this step and proceed to 9.1.4.

9.1.4 *Stand-by Energy*—For printers with an energy-saver mode, disable the feature. At the conclusion of the previous 1-h measurement (9.1.2) leave the machine turned on. After 1 h, record the watt-hour reading. The difference between the watt-hour reading at the start and finish of the hour is the test data for the stand-by mode energy. Record the result in Fig. 1, Test Results, Part C.

9.1.5 *Energy-Saver Energy*—For printers with an energy-saver mode, enable the feature. If the energy-saver mode is automatic, let the machine enter the energy-saver mode. When it has entered the energy-saver mode, read and record the watt-hour meter and the time. After 1 h, record the watt-hour reading again. The difference between the watt-hour reading at the start and finish of the hour is the test data for energy-saver mode energy. Record the result in Fig. 1, Test Results, Part D. If it is known that the machine does not have an energy-saver mode (as defined by this procedure) record the stand-by energy (results from Part C) in Fig. 1, Test Results, Part D.

9.1.6 *Printing Energy Plus Stand-by Energy*—With the machine in a stand-by mode, read and record the watt-hour indication and the time (or start the stopwatch or timer). Using a standard original (6.5, 6.6) have the Anacom device perform the standard jobs (Table 1) for the standard volume and mode for which the machine is being tested. Equally space the jobs throughout the 1 h allocated for this part of the test (Table 1 for job time interval). The operator should send the original image so that it has minimal impact on job time and energy use. After the jobs have been performed and 1 h has elapsed, read and record the watt-hour meter indication again. The difference between the two readings of the watt-hour meter is the test data for printing energy use. Record the result in Fig. 1, Test Results, Part E.

9.1.7 *Energy-Saver Delay Time*—For printers with an energy-saver mode, if the time to enter the energy-saver mode is adjustable, set the feature to one minute. Print a page. Using the timer, record the amount of time it takes the machine to

Machine Tested	Simplex Prints	Duplex Prints
Monthly volume N [n X 176]	_____	
Number of pages n in test (from Table 1)	_____	
Printing Time P_t (from Table 2)	_____	
Idle Time, I_t [60 minutes - P_t]	_____	
Number of Jobs j in test (from Table 1)	_____	
Test Results (1 - h Test)		
A. Plug-in energy	_____Wh	
B. Warm-up plus stand-by energy	_____Wh	
C. Stand-by energy	_____Wh	
D. Energy-saver energy	_____Wh	
E. Printing energy plus stand-by	_____Wh	_____Wh
F. Energy-saver delay time	_____Wh	
G. Recovery Energy plus Energy-Saver	_____Wh	
Calculations, All Printers		
H. Warm-up energy, [B-C]	_____Wh	
I. Printing energy, E_p [E-C]	_____Wh	_____Wh
J. Recovery Energy E_{rp} [G-D]	_____Wh	
K. Printing energy per page, E_p/n	_____Wh	_____Wh
E_p/n X 0.001 =	_____kWh	_____kWh
L. Energy saver time per hour [I_t - j X F]	____min/hr	
M. Fraction energy-saver time [L/60]	_____min	
Calculations, Printers Without Auto Shut-off		
N. Plug-in energy per standard month [A X 489]	_____kWh	
O. Warm-up plus stand-by energy per standard month [B X 20]	_____Wh	
P. Energy-saver time per month [(M X 176) + 35-(5 X F/60)]	_____min	
Q. Stand-by energy per standard month [C X (211 - P)]	_____Wh	
R. Energy-saver energy per standard month [D X P]	_____Wh	
Calculations, Printers, With Auto Shut off		
S. Plug-in energy per standard month [A X 519]	_____Wh	
T. Warm-up plus stand-by energy standard per month [B X 22]	_____Wh	
U. Energy-saver time per month [(M X 176)+3-(3 X F/60)]	_____min	
V. Stand -by energy per standard month [C X (179-U)]	_____Wh	
W. Energy-saver energy per standard month [D X U]	_____Wh	
Calculations, All Printers		
X. Machine energy per standard month -- Independent at Volume E_m = [N + O + Q + R] or [S + T + V + W]	_____Wh	
Y. Total energy per month $E_t = E_m + (E_p/n + E_{rp})N$	_____Wh	_____Wh
Z. Average total energy per page $E_{tave} = \frac{E_m + (E_p/n + E_{rp})N}{N}$	_____Wh	_____Wh

FIG. 1 Sample Data Sheet

enter an energy-saver mode. If the machine is one which is manually placed in the energy-saver mode, activate the feature when the machine has cycled out, and then record the time it takes to reach the energy saver mode. The printer should stay in the energy-saver mode for 1 h. Using the timer, record the amount of time it takes the machine to come out of the energy-saver mode. Add this time to the amount of time it took the printer to go into an energy-saver mode and record the result in Fig. 1, Test Results, Part F.

9.1.8 *Recovery Energy Plus Energy-Saver Energy*—Repeat the steps in 9.1.4. When the machine enters the energy-saver mode, read and record the watt-hour indication and the time (or start the stopwatch or the timer). At 1 h minus the time needed for the machine to come out of the energy-saver mode, bring the machine out of the energy-saver mode. Record the watt-hour meter reading. The difference between these two readings is the test data for recovery energy plus energy-saver energy. Record this in Fig. 1, Test Results, Part G.

9.2 Repeat the procedure in 9.1.6 with the machine set to duplex.

10. Calculation

10.1 Enter the number of pages n (Table 1, Footnote A) and the monthly volume $N[n \times 176]$ into Fig. 1.

10.2 Calculate the data from the following sections for 100 % single-sided copies and list in the appropriately designated section in Fig. 1.

10.2.1 Enter the data obtained from 9.1.1 under Printing Time, P_t in Fig. 1.

10.2.2 Enter the data obtained from 9.1.2 through 9.1.8 under Test Results, Part A through G.

10.2.3 Calculate warm-up energy [B – C] and record under Part H.

10.2.4 Calculate printing energy E_p[E – C] and record under Part I.

10.2.5 Calculate the recovery energy per month. Subtract the energy-saver energy from the recovery energy plus energy-saver energy and multiply this difference by the number of jobs in the test and by 176. E_{rp} = (G – D) × j × 176. Record this result in Fig. 1, Part J.

10.2.6 Calculate printing energy per page [E_p/n]. Multiply E_p/n by 0.001 to determine kilowatt hours. Record both results under Part K.

10.2.7 Calculate the energy-saver time per hour. Multiply the number of jobs j by the energy-saver delay time, and subtract the total from the idle time I_t = (I_t – j × F). If this value is less than zero, enter zero. Record under Part L.

10.2.8 Calculate the fraction of energy-saver time. Divide the energy-saver time/hour by 60 min/h (L/60). Record under Part M.

10.2.9 For printers without auto shutoff, calculate plug-in energy per standard month [A × 489 h/month]. Record under Part N.

10.2.10 For printers without auto shutoff, calculate warm-up plus stand-by energy per standard month [B × 20 h/month]. Record this result under Part O.

10.2.11 For printers without auto shutoff, calculate the amount of time the printer is in an energy-saver mode per month ((M × 176) + 35 – (5 × F/60)). Record this result under Part P.

10.2.12 For printers without auto shutoff, calculate stand-by energy per standard month (C × (211 – P) h/month). Record under Part Q.

10.2.13 For printers without an auto shutoff and with an energy-saver mode, calculate energy-saver energy per standard month (D × P h/month) and record under Part R.

10.2.14 For printers with auto shutoff, calculate plug-in energy per standard month (A × 519 h/month). Record under Part S.

10.2.15 For printers with auto shutoff, calculate warm-up plus stand-by energy per standard month (B × 22 h/month). Record this result under Part T.

10.2.16 For printers with auto shutoff and with an energysaver mode, calculate the amount of time the copier is an energy-saver mode per month ((M × 176) + 3 – (3 × F/60)). Record this result under Part U.

10.2.17 For printers with auto shutoff, calculate stand-by energy per standard month (C × (179 – U) h/month) and record under Part V.

10.2.18 For printers with auto shutoff and with an energy-saver mode, calculate energy-saver mode energy per standard month (D × U h/month) and record under Part W.

10.2.19 Calculate machine energy per standard month E_m = (N + O + Q + R) or (S + T + V + W). This is the energy consumed by the machine independent of volume. Record this result under Part X.

10.2.20 Calculate the total energy per month E_t. Total energy equals machine energy plus printing energy.

$$E_t = E_m + (E_p/n + E_{rp})N \quad (1)$$

Record the results under Part Y.

10.2.21 Calculate the average total energy per page as follows:

$$E_{tave} = \frac{E_m + (E_p/n + E_{rp})N}{N} \quad (2)$$

Record the results under Part Z.

10.3 Calculate the data for duplexed pages and list in the appropriately designated section in Fig. 1.

11. Report

11.1 If several identical machines are tested, report the average energy rating. If the results for each machine differ by more than 10 %, repeat the test.

11.2 Report all data recorded to a minimum of three significant figures.

12. Keywords

12.1 electrostatic printer; energy usage; nonimpact printer