Designation: F 757 – 01

Standard Test Method for Determining Energy Consumption of Copier and Copier-Duplicating Equipment[1]

This standard is issued under the fixed designation F 757; 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 procedure provides a test method by which copiers, copier-duplicators, accessories, and similar office imaging devices may be rated 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:*

F 335 Terminology Relating to Electrostatic Copying[2]

F 995 Test Method for Estimating Toner Usage in Copiers Utilizing Dry Two-Component Developer[2]

3. Terminology

3.1 *Definitions*—For definitions of terms used in this test method, see Terminology F 335.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *accessories*—any device that expands the capability of the equipment beyond its normal operating mode. An accessory for purposes of energy tests shall be defined as one that is under the control of the operator.

3.2.2 *automatic shut-off mode*—variable energy state into which the machine can be programmed to place itself after a period of time of non-use or at a specified time.

3.2.3 *copier speed, first copy*—one of the convenient levels for which the copier's speed is measured. This is the amount of time the copier takes to make the first copy of a job.

3.2.4 *copier speed, multi copy*—one of the convenient levels for which the copier's speed is measured. This is the amount of time the copier takes to make multiple copies after the first copy of a job.

3.2.5 *copying*—the machine condition that exists from the beginning to the end of the cycle that produces a copy or copies.

3.2.6 *copying energy*—the amount of energy needed in excess of stand-by mode energy during a designated copying mode exclusive of plug-in and warm-up mode.

3.2.7 *copying time*—the amount of time that the nominal jobs are run when testing copying energy.

3.2.8 *cycle out*—the condition which exists when the machine has finished copying, and has returned to a stand-by mode.

3.2.9 *energy-saver recovery time*—the amount of time that the machine takes to come out of the energy-saver mode.

3.2.10 *energy-saver mode*—the condition that exists when the machine is not making copies and is consuming less power than when the machine is in stand-by mode. The machine goes into this mode a period of time after it finishes copying. Widely-used International Energy Star Program contributed to refer to this mode as low–power mode. It specifies that the machine starts passing to the energy-saver mode from the stand-by mode within 15 min. In compliance with the Energy Star Program, this document provides that the machine stays in the stand-by mode for 15 min until the start of passing to the energy-saver mode.

3.2.11 *energy-saver time*—the amount of time that the machine is in an energy-saver mode.

3.2.12 *job*—making copies from one or more originals without interruption or delay between originals.

3.2.13 *machine energy*—the energy consumed by a copier that is plugged-in 24 h/day and turned on 9 h but that is not making copies.

3.2.14 *nominal copies per day*—the number of nominal copies produced on a single machine during a nominal copying day.

3.2.15 *nominal volume*—one of the convenient levels into which the entire range of monthly volumes have been divided.

3.2.16 *plug-in mode*—the condition that exists when the machine is connected to an appropriate electrical source and is not turned on.

3.2.17 *recovery energy*—the amount of energy needed in excess of energy-saver mode energy to pass from the energy-saver mode to the stand-by mode.

3.2.18 *run mode*—a particular combination of originals per job and copies per original.

3.2.19 *standard copy*—a sheet imaged on one side that measures 8 ½ by 11 in. (216 by 280 mm).

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

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[2] *Annual Book of ASTM Standards*, Vol 15.09.

3.2.20 *standard month*—thirty 24-h days.

3.2.21 *standard work day*—9 h.

3.2.21.1 *Discussion*—Since the International Energy Star Program is widely used nowadays, standard copiers have an automatic shut-off. The standard work day was changed from 10.5 to 9 h.

3.2.22 *standard work month*—22 standard work days.

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

3.2.24 *warm-up mode*—the condition that exists when the machine is turned on from a plug-in mode and prior to reaching the stand-by mode.

4. Summary of Test Method

4.1 The standard energy consumption rating is determined (using a watt-hour meter) for a copier while the machine is in a simulated customer installation performing one eighth of a typical day's copying jobs. The typical day's jobs are based (size, number of originals, and copies per original) on the standard volume (see Table 1).

4.2 The simulated customer installation may be calculated with actual usage data (see 4.4), or based on the following assumptions, that the copier will typically:

4.2.1 Be connected to a live power line for thirty 24 h days (720 h) per month.

4.2.2 Be turned on or off or both each of 22 work days per month.

4.2.3 Go through a warm-up cycle once each of 22 work days each month, since the copier has an automatic shut off.

4.2.4 As a result of 4.2.2 and 3.2.22, be left on for an average of 9 h each of the 22 days, since the copier has an automatic shut-off.

4.2.5 As a result of 3.2.10, in the case where the number of jobs under the nominal jobs (⅛day) is 4 or more from Table 1, the machine does not go into the energy-saver mode in the copying cycle (8 h a day), because the job interval is 15 min or less. Also as a result of 3.2.10, the machine is basically left in the energy-saver mode for 1 h during the lunch break out of the 9 h when the machine is on each standard work day.

4.2.5.1 *Discussion*—In actual use, the higher the monthly copying volume is, the larger the number of jobs is. Besides, it is less likely to go into the energy-saver mode. Considering these, Table 1 was changed and the nominal monthly copying volume of 7500 was added on assumption that the monthly copying volume of 7500 or less results in the number of jobs of 3 or less under the nominal job (⅛ day); and the monthly copying volume of 10 000 or more results in the number of jobs of 4 or more under the nominal job (⅛ day).

4.2.6 Perform a typical day's copying jobs each of the 22 work days each month.

4.3 The energy consumption per copy or the typical month's energy consumption rating (kW/h per month) are determined using calculations based on the test data.

4.4 As an alternative you can use actual usage data for estimated hours of use in these formulas, and in Section 10. When making comparisons of like machines, it is recommended to use the same usage data.

5. Significance and Use

5.1 This test method provides a procedure for measuring the energy consumption of the product and associated accessories in various operating modes. It is intended to permit rating the energy requirements of products by a method that will permit accurate energy efficiency comparisons of each product with all other similar products.

6. Apparatus and Supplies

6.1 *Watt-Hour Meter*, one per phase, accurate to three figures.[3]

6.2 *Timer*, a timing device accurate to 1 s.

6.3 *Test Target*—A ten pitch, pica, 45 lines of lower case "k" character, 65 characters per line (2925 total characters), with a 1-in. (25-mm) clear border around the typed area, and on white paper. This target is prepared by the user. Alternately, the test target with 8 % coverage (PCN 12-609950-11) from Test Method F 995, can be used.

6.4 *Paper*—8½ by 11 in. (216 by 280 mm), 20-lb bond or

[3] For certain low-volume copiers that consume little energy, the Duncan model EM-10 which reads to 0.1 watt hour per count, or equivalent, has been found suitable for use (12.2). Duncan models are available from Duncan Electric Co., Lafayette, IN, and the General Electric model is available from General Electric, Schenectady, NY.

TABLE 1 Nominal Parameters for Each Nominal Volume

Nominal Monthly Volume, Copies/Month	Nominal Copies/Day	Nominal Jobs (1/8 day)n^A			
		Number of Jobs	Number of Originals	Number of Copies/Original	Job Interval, min
200	8	1	1	1	60.0
500	24	1	1	3	60.0
1 000	48	2	1	3	30.0
2 500	120	3	1	5	20.0
5 000	216	3	1	9	20.0
7 500	336	3	2	7	20.0
10 000	432	6	3	3	10.0
25 000	1 152	6	3	8	10.0
40 000	1 824	6	2	19	10.0
80 000	3 600	6	5	15	10.0
100 000	4 800	4	10	15	15.0
280 000	13 200	5	10	33	12.0
500 000	22 800	5	15	38	12.0
1 000 000	45 600	4	20	71	15.0

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

where not applicable, use machine manufacturer's recommended mid-point 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 will require re-ratings or additional ratings.

7.2 Those copiers configured with automatic duplex option should be rated twice, once at 100 % single-sided copy and once at 100 % of two-sided copies (each side counted as one copy).

7.3 The copier(s) to be evaluated should be set to within the manufacturer's operating specifications.

8. Preparation of Apparatus

8.1 *Test Conditions*:

8.1.1 The room ambient shall be within a range of 21± 3°C; 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 or air obstacle.

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

8.1.5 The AC 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 frequency ±0.1 Hz.

8.1.7 The manufacturer will define the configuration (including accessories) of the machine to be tested, the volume at which it will be rated (Table 1), and both the first copy copier speed and multi copy copier speed (Table 2). Normally, each copier will be rated for the nominal volumes and copier speeds for which the manufacturer intends to market the product.

8.1.8 When operator speed is a variable affecting energy use the manufacturer should use and specify a normal operating time.

TABLE 2 Calculation for Copying Time

Nominal Montly Volume, Copies/ Month	Number of Jobs, *j*	Number of Originals	Number of Copies/Original	Copying Time, min/h (C_t)
200	1	1	1	$1/X^A$
500	1	1	3	$1/X + 2/Y^B$
1 000	2	1	3	2/X + 4/Y
2 500	3	1	5	3/X + 12/Y
5 000	3	1	9	3/X + 24/Y
7 500	3	2	7	3/X + 39/Y
10 000	6	3	3	6/X + 48/Y
25 000	6	3	8	6/X + 138/Y
40 000	6	2	19	6/X + 222/Y
80 000	6	5	15	6/X + 444/Y
100 000	4	10	15	4/X + 596/Y
280 000	5	10	33	5/X + 1645/Y
500 000	5	15	38	5/X + 2845/Y
1 000 000	4	20	71	4/X + 5676/Y

[A] *X* = copier speed, first copy.
[B] *Y* = copier speed, multi copy.

NOTE 1—During the test cycle, the machine should be allowed to cycle out after the required number of copies per original have been completed. This aspect does not apply to those machines having automatic document feeders or other features that allow for continuous operation without cycling out.

Example: Document change time used—3.0 s

8.1.9 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 jams that can be readily cleared by the operator should not be considered reason to discontinue the test.

9. Procedure

9.1 Steps 9.1.1, 9.1.2, 9.1.3, 9.1.4, 9.1.5 and 9.1.7 of this procedure should be completed once for each test machine. The data from 9.1.1, 9.1.2, 9.1.3, 9.1.4, 9.1.5 and 9.1.7 will apply to all nominal volumes for which the machine is being rated. The data from 9.1.6 will only apply to one configuration and must be repeated for all other configurations for which the machine is being rated. Prior to the start of this test, the machine should be plugged in to a live power line but turned off and stabilized at room ambient conditions for at least 12 h. 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 copier setting that, in the opinion of the evaluator, is the one yielding the best appearing copy.

9.1.1 *Copying Time*— Choose the appropriate formula in Table 2 that matches the monthly volume for which the machine is being rated. Using the manufacturer's values for copier speeds, where *X* is the number of copies per minute for the first copy, and *Y* is the number of copies per minute for multiple copies, follow the appropriate formulas. Record the copying time in Fig. 1.

9.1.2 *Plug-In Mode Energy*—Read and record the watt-hour meter indication and the time (or start the stop watch or timer). After 1 h, read and record the watt-hour indication again. The difference between the two readings of the watt-hour meter is the observed 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 Plus Stand-By Energy*—With the machine in a stabilized plug-in mode, read and record the watt-hour meter indication and the time (or start the stopwatch or timer). Turn the machine on and allow the machine to warm up and stabilize in the ready mode. Record the warm-up time in Fig. 1. After 1 h, read and record the watt-hour indication again. The difference between the two readings of the watt-hour meter is the observed 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 9.1.3.

9.1.4 *Stand-by Mode Energy*—For copiers having an energy-saver mode feature, disable the energy-saver mode. 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.

Machine Tested

	Single-sided Copies	Duplexed Copies
Monthly volume, N ($n \times 176$)	_____	
Number of copies, n, in test (from Table 1)	_____	
Copying time, C_t(from Table 2)	_____min	
Warm-up time, T_w	_____min	
Number of Jobs, j, in test (from Table 1)	_____	
Test Results (1-h test):		
A. Plug-in energy	_____Wh	
B. Warm-up plus standby energy	_____Wh	
C. Standby energy	_____Wh	
D. Energy-saver energy	_____Wh	
E. Copying energy plus standby	_____Wh	_____Wh
F. Energy-saver recovery time	_____min	
G. Recovery energy plus energy-saver energy	_____Wh	
Calculations, All Copiers:		
H. Warm-up energy, $E_t[B - C]$	_____Wh	
I. Copying energy, $E_c[E - C]$	_____Wh	_____Wh
J. Recovery energy, $E_{rc}(G - D)$	_____Wh	
K. Copying energy per copy, E_c/n	_____Wh	_____Wh
$E_c/n \times 0.001$ =	_____kWh	_____kWh
L. Stand–by energy time per month	_____min/h	
[No. of jobs <= 3: $(T_w) \times 22 + (Ct/n) \times N + 0.25\ (j) \times 176$]		
[No. of jobs >= 4: 176 h]		
M. Energy-saver time per month [$198 - L$]	_____	
N. Plug-in energy per standard month [$A \times 522$]	_____Wh	
O. Warm-up energy per standard month [$(B - C) \times 22$]	_____Wh	
P. Standby energy per standard month ($C \times L$)]	_____Wh	
[No. of jobs (j) < = 3: $C \times \{(T_w) \times 22 + (Ct/n) \times N + 0.25 \times (j) \times 176\}$]		
[No. of jobs (j) > = 4: $C \times 176$]		
Q. Energy-saver energy per standard month [$D \times M$]	_____Wh	
[No. of jobs (j) < = 3: $D \times [198 - \{(T_w) \times 22 + (Ct/n) \times N + 0.25 \times (j) \times 176\}]$]		
[No. of jobs (j) > = 4: $D \times 22$]		
R. Machine energy per standard month $E_m = [N + O + P + Q + J]$	_____Wh	
S. Total energy per month $E_t = E_m + (E_c/n)N$	_____Wh	_____Wh
T. Average total energy per copy	_____Wh	_____Wh

$$E_{tave} = \frac{\{E_m + (E_c/n)N\}}{N}$$

FIG. 1 Sample Data Sheet

The difference between the watt-hour reading at the start and finish of the hour is the observed data for stand-by mode energy. Record the result in Fig. 1, Test Results, Part C.

9.1.5 *Energy-Saver Mode Energy*—Since the International Energy Star Program recently has been in wide use, standard copiers have an automatic shut-off. When the machine has automatically entered 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 observed data for energy-saver mode energy. Record the result in Fig. 1, Test Results Part D. Some machines go into auto shut-off mode from the energy-saver mode within 1 h, since the Energy Star Program specifies so for the copying speed of 44 cpm or less, and this hinders the measurement. In this case, the energy-saver mode time should be extended to prevent the auto shut-off from working during the measurement.

9.1.6 *Copying 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 nominal original or originals (6.2) perform the nominal jobs (Table 1) for the nominal volume and configuration for which the machine is being rated. Equally space the jobs throughout the 1 h allocated for this part of the test (Table 1 for job time interval). The operator should change the original or originals in such a manner as to have a minimal impact on job time and energy use (see 8.1.8 for exceptions). 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 observed data for copying energy use. Record the result in Fig. 1, Test Results Part E.

9.1.7 *Energy-Saver Recovery Time*—Using the stopwatch, record the amount of time it takes the machine to come out of the energy-saver mode, in minutes and seconds. Record the result in Fig. 1, Test Results Part F.

9.1.8 *Recovery Energy Plus Energy-Saver Energy*—Repeat the steps in 9.1.5. When the machine enters the energy-saver mode, read and record the watt-hour indication and the time (or start the stopwatch or timer). At one hour minus the time needed for the machine to come out of the energy-saver mode, bring the machine out of the energy-saver mode. When the machine reaches the stand-by mode, the time should show one hour. Record the watt-hour meter reading. The difference between these two readings is the Recovery Energy plus Energy-Saver Energy. Record this in Fig. 1, Part G.

9.1.9 Repeat the procedure in 9.1.6 with the machine set to duplex and enter in the appropriate sections in Fig. 1.

10. Calculation

10.1 Enter the number of copies, n (Table 1, Footnote A), the monthly volume N ($n \times 176$), copying time C_t (Table 2), warm-up time (T_w) and the number of jobs, j, 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. Also, see 4.3.

10.2.1 Enter the data obtained from 9.1.1 under Copying Time, C_t in Fig. 1.

10.2.2 Enter the data obtained from steps 9.1.2, 9.1.3, 9.1.4, 9.1.5, 9.1.6, 9.1.7 and 9.1.8 under Test Results, Parts A, B, C, D, E, F and G.

10.2.3 Calculate warm-up energy ($B - C$) and record under Part H.

10.2.4 Calculate copying energy E_c using ($E - C$) and record under Part I.

10.2.5 Calculate the recovery energy per month (E_{rc}). Subtract the energy-saver energy from the recovery energy plus energy-saver energy ($G - D$). If the number of jobs (j) is 4 or more, the machine does not go into the energy-saver mode in the copying cycle, that means the energy-saver mode time is only based on 22 lunch breaks per month. The recovery energy per month is obtained from $(G - D) \times 22$. If the number of jobs (j) is 3 or less, the machine goes into the energy-saver mode "the number of jobs (j) × 8 h" times in the copying cycle of each day in addition to the lunch break energy-saver mode time. In this case, the recovery energy per month is obtained from $(G - D) \times \{(j) \times 176 + 22\}$. Record this result in Fig. 1, Part J.

10.2.6 Calculate energy per copy (E_c/n). Multiply E_c/n by 0.001 to determine kilowatt hours. Record both results under Part K.

10.2.7 Calculate the stand-by energy time per month. If the number of jobs (j) is 3 or less, the stand-by energy exists in: (*1*) the warm-up time (Tw); (*2*) copying time (Ct); and (*3*) the time ($0.25 \times (j)$ h) obtained by multiplying the predetermined time up until passing to the energy-saver mode (15 min = 0.25 h) by the number of jobs (j). Calculate the stand-by energy time per month from $(Tw) \times 22 + (Ct/n) \times N + 0.25\ (j) \times 176$. If the number of jobs (j) is 4 or more, the machine does not enter the energy-saver mode in the copying cycle and the 8-h long copying cycle each of 22 work days per month is regarded as the stand-by energy time. Calculate the stand-by energy time from $8 \times 22 = 176$. Record under Part L.

10.2.8 Calculate the energy-saver energy time per month. The power-on time per month is 198 h as a result of calculation, 9 h × 22 days. The energy-saver time per month is expressed as "198-L". If the number of jobs (j) is 3 or less, the stand-by energy time per month is given by: $L = (Tw) \times 22 + (Ct/n) \times N + 0.25 \times (j) \times 176$. Calculate the energy-saver energy time per month from: $198 - \{(Tw) \times 22 + (Ct/n) \times N + 0.25 \times (j) \times 176\}$. If the number of jobs (j) is 4 or more, the stand-by energy time per month is 176 h. This leads to 198 − 176 = 22 h corresponding to the lunch hours per month obtained by multiplying 1 h by 22 days. Record under Part M.

10.2.9 Calculate plug-in energy per standard month ($A \times$ 522 h/month). Record this result under Part N.

10.2.10 Calculate warm-up energy per standard month [$(B - C) \times$ 22 h/month)]. Record this result under Part O.

10.2.11 Calculate the stand-by energy per standard month ($C \times L$). The number of jobs (j) < = 3: $C \times \{(Tw) \times 22 + (Ct/n) \times N + 0.25 \times (j) \times 176\}$. The number of jobs ($j$) > = 4: $C \times 176$. Record this result under Part P.

10.2.12 Calculate energy-saver energy per standard month ($D \times M$). The number of jobs (j) < = 3: $D \times [198 - \{(Tw) \times 22 + (Ct/n) \times N + 0.25 \times (j) \times 176\}$. The number of jobs ($j$) > = 4: $D \times 22$. Record under Part Q.

10.2.13 Calculate machine energy per standard month $E_m = [N + O + P + Q + J]$. Record this result under Part R.

10.2.14 Calculate the total energy per month, E_t. Total energy equals machine energy plus copying energy, as follows:

$$E_t = E_m + (E_c/n)N \tag{1}$$

Record the result under Part S.

10.2.15 Calculate the average total energy per copy as follows:

$$\frac{\{E_m + (E_c/n)N\}}{N} \tag{2}$$

Record the result under Part T.

10.3 Calculate the data from 10.2.1 to 10.2.15 for 100 % duplexed copies and list in the appropriately designated section in Fig. 1.

11. Report

11.1 If several identical machines are rated, the average energy rating should be reported. If the results for each machine differ by more than 10 %, the test should be repeated.

11.2 All data recorded should be reported to a minimum of three significant figures.

12. Precision and Bias

12.1 Precision and bias of the energy rating may be determined with calculations, projections, extrapolations or all three, as long as the overall accuracy is not significantly affected. However, the resulting energy rating must be based upon the conditions specified in this procedure.

12.2 All time-measuring devices shall have an accuracy of ±0.5 %. All other measuring devices should provide a ±2 % accuracy.

12.3 It is not practicable to specify the precision and bias of the procedure in this test method for measuring the energy consumption of copier and copier duplicating equipment, because there is no standard report.