Revision of the ENERGY STAR® Specifications for Imaging Equipment
Update and Clarifications to the Draft Typical Electricity Consumption and Operational Mode Test Procedures

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Introduction

Status of Revision Process

On June 30, 2004, EPA distributed materials concerning a July 14 industry meeting to all stakeholders who had expressed an interest in the revision of the ENERGY STAR specifications for imaging equipment. These documents included a draft test procedure to measure and calculate the Typical Electricity Consumption (TEC) of imaging equipment products, as well as the existing Operational Mode test procedure. In the July 14 industry meeting, EPA invited stakeholders to provide initial comments and requests for clarification on these test procedures by August 18, and more robust comments by September 30. Please note that the September deadline has been extended to **October 25.** As you review this clarifications document and the draft test procedures, please consider how these methods are successful or unsuccessful in prescribing a means to measure the energy consumption across the variety of imaging equipment products.

After October 25, once all stakeholders who are interested in doing so have shared comments with EPA on how to improve the draft TEC test procedure, EPA will distribute a revised version for stakeholders to begin to collect data. This data collection will serve two primary purposes:

1. Allow for a more thorough evaluation of the TEC test procedure; and
2. Generate preliminary data for EPA to analyze to determine if the TEC approach will achieve energy savings.

Please note that a revised operational mode test procedure will not be distributed at this time, as EPA already has access to operational mode data.

EPA will schedule another stakeholder meeting in November/December 2004 to discuss all comments on the test procedure received by October 25. Detailed instructions and timeframes for testing products to the TEC test procedure to collect preliminary data will be discussed in this meeting.

Response to Clarification Comments

EPA is very appreciative of the initial feedback industry has shared on these test procedures. These interim comments have helped EPA understand where portions of the test procedures may require clarification and correction. This document constitutes EPA's response to the initial comments and requests for clarification from industry. Rather than waiting until all comments have been received after October 25, EPA would like to take this opportunity to share some rationale, clarifications, and additional discussion questions, all of which respond to the feedback EPA received before August 18. This additional documentation may assist industry in undertaking a more complete review of the test procedures.

Please note that very few comments were received about the existing Operational Mode test procedure, which has been in effect for some time. For this reason, the draft TEC test procedure receives the majority of the focus in this document. EPA continues to welcome comments on both test procedures as both may be used in the future revised specification, depending on product type and segment.

Following this introduction, this document contains two main sections and two appendices:

- **Section 1: Clarifications** – In this section, EPA summarizes comments received on the test procedures by August 18, and provides direct responses to those elements that are appropriate to address at this time. Several comments concern the larger concept of the fitness of using TEC

to address the energy efficiency of a product, and will need to be resolved only once test data is available. The attempt in this section is to respond to questions and to clarify what was intended by the draft TEC test procedure. In cases where stakeholders noted specific errors, this section explains what has changed in the revised test procedures that accompany this document. Please note that this document does not cover every comment received, but just those that could be answered through clarifications to the original test procedure.

- **Section 2: Discussion Questions and Thoughts** – As always, stakeholders are encouraged to comment on any portion of the test procedures and should not feel limited by the specific questions presented in this section. These discussion questions are offered to give stakeholders food for thought, and to help target potential comments to specific areas where EPA requires assistance from industry.

- **Appendix A: Background and Rationale** – In this appendix, EPA presents some of the rationale and logic used to develop specific components of the draft TEC test procedure. It is hoped that this section anticipates and addresses questions industry may have about the reasons for including or excluding elements of the draft TEC test procedure.

- **Appendix B: References**

To reiterate, industry is asked to provide comments on the draft TEC test procedure and existing Operational Mode test procedure by October 25, 2004. Please note, however, that EPA is **not** requesting that industry begin to gather data by testing products at this time.

The input that stakeholders provide by October 25 will allow EPA to modify the test procedures, and in particular, to generate a revised version of the TEC test procedure that can be used to gather data for analysis. It should be stressed that additional discussions with industry will take place throughout this process, and that this is **not** your final opportunity to comment on ENERGY STAR test procedures for imaging equipment. Your thoughtful consideration of this document at this time is greatly appreciated.

1. Clarifications

As mentioned in the Introduction, the following questions and statements have been abstracted from comments received from stakeholders through August 18. It is hoped that the clarifications provided below will assist in your formulation of detailed comments by the October 25 deadline.

1.1 General

1.1.1 The test procedure says nothing about scanners. What is planned for them?
EPA did not have sufficient information at hand to produce a draft TEC test procedure for scanners or large format devices. EPA welcomes comments on what a test procedure should look like, or whether scanners and large format devices are best covered by the TEC or operational mode approach.

1.1.2 The test procedure and spreadsheet are oriented more to copiers than printers and MFDs.
For the next version of the TEC test procedure, separate procedures and spreadsheets will be produced as needed to maximize clarity and simplicity of each procedure and spreadsheet. The accompanying spreadsheet, which was crafted for copiers, is included in the test procedure materials as an illustration of how the test procedure would function.

1.1.3 Did you consider using comprehensive product test procedures, such as the ASTM procedures or the updates of them being done by JBMIA? How about the Japan Energy Saving Law (JESL) procedure?
These procedures produce more results than does the TEC test procedure, but require a more controlled test environment and take significantly longer to perform. These tests are useful for many purposes;

however, at this time, EPA believes that the benefits of a much simpler procedure merit creating a new test. The JESL procedure is closer to ENERGY STAR's needs, but does not include energy consumed at night.

1.2 Job Table

1.2.1 Why does the formula for non-Ink-jet monochrome printers in the Job Table (Table 2) result in negative images per job for certain speeds?
This is due to a typographical error. The speed transition should be 25 for this product type, not 15 as shown. **This change has been made to the Draft 2 TEC test procedure you are receiving with this document.**

1.2.2 Isn't there a problem if the number of jobs used in the test procedure is different from what a customer actually uses, or what is typical in different countries?
EPA believes that this test procedure is not intended to inform end users of their likely energy consumption. Rather, it is hoped that this test procedure provides a fair means by which to differentiate the most energy- efficient -products on the market that should earn the ENERGY STAR.

1.2.3 What is the basis for the numbers in the Job Table? Who is Buyer's Laboratory, Inc. (BLI)?
BLI is a private testing laboratory in the United States that tests imaging equipment products (http://www.buyerslab.com/bli/). The Job Table numbers in the draft TEC test procedure are based on regressions of manufacturers' monthly rated volumes. EPA obtained these figures from BLI publications of characteristics of recent models, and took 20% of these figures to be closer to typical usage.

1.2.4 Why use different imaging rates in the Job Table for copiers and copier-based MFDs when in many cases, the copiers can be readily converted to be MFDs?
The initial Job Table was based on manufacturer's ratings, where monthly rated volumes were different. EPA continues to welcome comments on more appropriate content for the Job Table.

1.3 Procedures

1.3.1 The specification for meter accuracy in combination with the relatively short metering periods results in excessive errors.
This was a typographical error. The accuracy listed as 0.1 Wh should be 0.01 Wh. **This change has been made to the Draft 2 TEC test procedure you are receiving with this document.**

1.3.2 Can copy functions be used to generate images to print for MFDs?
Under the draft TEC test procedure, MFDs are to be tested in their print mode. It is believed that end users employ the print function on an MFD more often than the copy function, and that testing both the print and copy functions of an MFD would complicate and lengthen the testing. In addition, in the July 14 industry meeting, manufacturers confirmed that the energy values for printing and copying are very similar. If stakeholders disagree with testing MFDs in print mode, they are encouraged to provide specific examples of cases where the printing and copying energy differ substantially.

1.3.3 Did you deliberately not include monochrome modes on color-capable products and copying modes on MFDs?
Yes, it was intentional to suggest that the TEC test procedure for MFDs only be performed in monochrome mode. The goal of the TEC test procedure is not to be comprehensive of all modes, but only to serve as the basis for a fair comparison. EPA does not believe that testing a product multiple times in multiple modes, i.e., color vs. monochrome, is necessary, and it is believed that testing in monochrome makes the testing more consistent across all products.

1.3.4 Why does the Operational Mode procedure use hour long measurement periods while the draft TEC test procedure uses much shorter periods? And why does it only cover the sleep mode?
The Operational Mode test procedure provided comes from the existing ENERGY STAR specification, and was derived from the ASTM test method. Using a series of hour-long measurement periods for the

TEC test procedure would make it quite lengthy. The intention is to use the shortest periods that provide reliable results. Ultimately, if the Operational Mode approach is used for any product categories, the Operational Mode test procedure will need to be updated to reflect the requirements of the new specification.

1.3.5 Why does the Operational Mode procedure use much more restrictive environmental conditions than does the draft TEC procedure?
EPA assumes the conditions each manufacturer will select for testing will be suitable enough to produce consistent results across industry. However, if any stakeholders feel that some conditions will favor certain products over others, then these concerns should be brought to EPA's attention. In the end, if an operational mode and TEC test procedure are required by the new specification, EPA will strive to make the environmental conditions consistent.

1.3.6 Why does the procedure not specify paper sources or output bins?
Since the manufacturer does the testing, EPA assumes that all will choose combinations that do not adversely affect the results. EPA also assumes that the paper sources/output bins do not change the energy consumption of the devices significantly. If any stakeholders feel that the selection of paper source or output bin does affect the results, they should bring this to EPA's attention for consideration.

1.3.7 Does EPA assume that delay timers operate in serial or in parallel? That is, with a Sleep delay time of 20 minutes and an Auto-off delay time of 40 minutes, does the machine turn itself off after 40 minutes (parallel) or 60 minutes (series) from the last use?
The draft TEC test procedure assumes that it is most common in industry for timers to operate in series. EPA welcomes comments on this practice.

1.3.8 Might the measurement of Auto-off for copiers actually result in the Manual-Off power instead?
This is possible, considering that the test, in its present form, asks the user to begin the test procedure by testing the unit while in Off. If so, the procedure order will need to be adjusted to assure that the Auto-off power is measured, possibly by asking the user to measure the Auto-Off energy last.

1.4 Calculations

1.4.1 To more closely reflect actual energy consumption, shouldn't the TEC test procedure use weekly or monthly consumption rather than daily?
To reiterate, the TEC number generated from the test procedure should provide a means for **comparing** products' energy consumption, rather than providing the actual energy consumption of the tested model. EPA suspects that the comparison of machines would not change much if the key figure was changed to weekly or monthly. This issue will be best addressed when there are some results from a future version of the test procedure. If those results show that weekly or monthly values produce substantially different results, then the calculation could be easily adjusted.

1.4.2 Are you sure that imaging products are rarely in low-power modes during typical workdays? Why isn't Recovery from Sleep used in the copier calculation?
EPA welcomes comments on actual time spent in Sleep mode for different product types and speed ranges. EPA lacked sufficient data at the time this test procedure was drafted to propose an alternative. Recovery from Sleep is not used in the copier calculation due to the lack of Sleep time during the day in the assumed usage pattern. If the operating pattern should change to include Sleep time, then this energy would be incorporated into the calculation as needed. If altering the calculation to include Recovery from Sleep does not meaningfully alter the overall TEC value of the product, EPA feels it is preferable to retain a simpler calculation rather than add this complexity.

1.4.3 Is the energy to transition from Off to Ready included in the calculation?
For copiers, this energy is included as the "Recovery from Auto-off energy." For printers and MFDs, this energy is not part of the calculation since the transition is assumed to occur rarely.

1.5 Spreadsheet

1.5.1 The test procedure refers to the possibility of multiple Ready and multiple low-power modes but the spreadsheet only allows for one.
Any revised spreadsheets will provide for multiple modes.

1.5.2 The spreadsheet seems specific to copiers. Will there be separate spreadsheets for printers and MFDs?
After the TEC test procedure is revised, additional spreadsheets will be created as needed.

1.5.3 Why is the rated monthly volume on the spreadsheet when it doesn't enter into the calculations?
The monthly rated volume is requested to understand more about the capacity of these products as data is gathered initially. EPA will consider if this field should be deleted from further drafts of the TEC test procedure.

1.5.4 The spreadsheet (cell G25) doesn't allow for Sleep times greater than 10 minutes as the test procedure does.
This cell has been corrected on the accompanying draft TEC test procedure.

1.6 Speed Measurement

1.6.1 Won't it be confusing for consumers to test energy consumption while duplexing, since that will be a different speed on many products than the manufacturer's nominal speed, which is usually the simplex speed?
This question suggests that there may have been misunderstanding regarding how speed is treated in the draft TEC test procedure. First, consumers do not test the products; only manufacturers test their products. Secondly, the draft TEC test procedure never uses the speed of a product in the actual calculations. Rather, manufacturers use the product's rated speed when referencing the Job Table for determining the appropriate number of images per job for performing the test. Third, the manufacturer is asked to perform the test in the product's duplex mode for the following two reasons: a.) product duplex speed should not be very different from the product's simplex speed; and b.) if some products do have very different simplex and duplex speeds, EPA wants to provide an incentive for those products that have faster duplex speeds to encourage the use of duplexing in the field. Using the draft TEC test procedure, manufacturers would never need to know or report the duplexing speed of their products to EPA.

Section 2 – Discussion Questions and Thoughts

Following are some discussion questions and thoughts from EPA on areas of the draft TEC test procedure that require further improvement. Stakeholders should feel free to comment on any component of either test procedure, and EPA is particularly interested in feedback on the following questions.

2.1 What should EPA use as the standard test image?
EPA does not believe that the choice of standard test image is likely to change the TEC ranking results significantly, and would prefer to identify an existing test image (page) rather than create a new one for the TEC procedure.

2.2 Does electricity consumption by this procedure change much between A4 and 8.5x11" ?
Conducting all tests with the same paper size removes that variation, but it may be that the standard paper size should be treated like the voltage and tested for all markets in which the product is marketed.

2.3 Does using the monochrome speed on color copiers introduce any problems?
Using monochrome speed for all products seems to account for the actual capability of a product's engine, in terms of speed. This should be acceptable as long as it does not introduce any unfair

advantages or disadvantages for certain products. However, EPA is interested in better understanding how the operation of serial versus parallel machines would affect the color speed of these machines, and whether this difference, if it exists, should be captured in the testing.

2.4 Any other criteria that should be specified for the procedure?
In general, it seems products should be tested at their default settings. Additional criteria could be added if it is necessary to assure a fair comparison. For simplicity, EPA would like to specify only parameters that industry believes could affect the TEC result significantly.

2.5 What situations would cause a stabilization period of only one hour to lead to unreliable results? What stabilization period(s) are needed for different product types?
The draft TEC test procedure should specify a stabilization period only as long as necessary to produce results that are not affected significantly by the previous state.

2.6 What "job table" should be used for each product type?
The proposed method for determining the length (in minutes) and number of images made for each imaging job attempts to approximate broadly the typical annual imaging rates for each speed of product, and complexity of the procedure. Please suggest any formulas that will serve the needs of the TEC test procedure better, along with an explanation of why they better balance accuracy and simplicity than do the formulas shown in Table 2 in the draft TEC test procedure.

2.7 What job tables should be used for large format products, color products, and mailing machines?
EPA has not proposed job tables for many product types, and seeks input from stakeholders. Of course, it is not certain that these products fit with the TEC method, and discussion is still open on this topic.

2.8 What standard page sizes and test pages should be used for large format product?
EPA assumes that large format products would need a large standard test page, possibly created by tiling the basic standard test pages. For standard page sizes, EPA welcomes suggestions.

2.9 Are there MFDs sold that lack print capability?
If there are, then the test procedure would need to specify that these should be tested as copiers, and perhaps grouped with copiers for energy consumption criteria levels.

2.10 Is there anything about the calculation method and underlying model that introduces significant distortion in comparing products by relative TEC (i.e., adaptive controls, multiple low-power modes, etc.)?
If so, please provide quantitative data to illustrate the problem.

2.11 For product speed ranges in which some products can make duplex copies and some cannot, should the testing be allowed to be done simplex for all products?
As stated in 1.6.1, EPA believes that energy consumption does not differ significantly between simplex and duplex mode. As a result, the TEC test procedure could be conducted in either simplex or duplex, and comparable results would still be produced. In the draft TEC test procedure, duplex mode was suggested for testing, as it is hoped that the end user will make use of this mode if available on a product. However, EPA raises this question here to address products in speed ranges where duplexing may or may not be offered. EPA does not want to create a disincentive for duplexing by establishing a procedure where products without duplex capability are treated more favorably in the TEC test procedure.

2.12 How should recovery time be defined? (Specifically, what actions should start and what should end the recovery time measurement?)
The recovery time measurement needs to be fair and accurate. EPA welcomes stakeholder input on how recovery should be defined.

2.13 Is the assignment of the following characteristics to product-types in Table A.2 correct and/or preferred?

a. Parameters
b. Units
c. Source of parameter
d. Comments

EPA realizes that products vary widely, therefore the assessment of parameters by product type may not be correct in Table A.2. EPA welcomes stakeholder feedback.

2.14 For MFDs, is it ever necessary to measure printing and copying separately?
As stated in 1.3.2, EPA has assumed that the energy required for general printing and copying on MFDs is similar enough that measuring printing only is sufficient. They need not be the same so long as the difference is similar across products.

2.15 For MFDs, is there any need to measure faxing or scanning electricity consumption?
EPA assumes that the annual energy consumption attributable to use of fax or scan features on MFDs is small enough not to merit their measurement in the TEC procedure.

2.16 What needs to be done to assure that the test procedure does not capture service and/or maintenance modes?
EPA does not intend for the TEC test procedure to reflect product behavior that is infrequent enough not to contribute appreciably to annual consumption. Thus, the TEC test procedure should not measure consumption of these modes unintentionally.

2.17 Do you have any existing products that use adaptive controls, or any plans to introduce them that can be shared with EPA?
Reasonably capturing the effect of adaptive controls seems infeasible for the TEC test procedure. For this reason, the draft test procedure specifies that any adaptive controls must be disabled before beginning the procedure. Does this seem like the most fair and feasible approach? Note that this does not preclude products being shipped with the adaptive controls enabled, as long as ordinary usage patterns do not result in significantly greater energy consumption with the adaptive controls enabled than would occur with them disabled.

Appendix A – Background and Rationale

This appendix is provided for general information only. The following describes logic and rationale used to create the draft TEC test procedure. The intent of this section is to provide some background to help stakeholders understand why the TEC test procedure has taken its current shape.

Purpose of the TEC Test Procedure

The primary purpose of the TEC test procedure is to provide a **reliable comparison of the relative energy efficiency of products**. The future ENERGY STAR specification, not the test procedure, will identify the specific criteria that products must meet to be considered ENERGY STAR qualified. EPA understands that changes to this test procedure may be necessary to better capture the energy performance of imaging equipment. Many possible changes to the procedure would vary the quantitative result for each product, but not appreciably change the relative comparison with other products. For example, whether the standard work day has eight or ten hours of use does not change appreciably the comparison of products by their TEC.

It is important to emphasize what the TEC test procedure is **not** intended to do. It is not intended to provide a best estimate of average consumption of a product in actual use — in part since this will vary by country and actual usage patterns. However, the TEC results can be employed to approximate typical usage by applying particular assumptions about usage patterns. The procedure is not intended to cover all aspects of product usage, but only those which substantially affect the TEC result.

Suggestions from Stakeholders

When drafting the TEC test procedure, EPA considered and agreed with the following suggestions made by stakeholders throughout the specification revision process. These suggestions were used as guidelines while crafting the test procedure:

Use formulas rather than bins/steps.
Many comments on the Directional Draft[1] (DD) expressed this preference, in particular, to avoid sharp jumps from small changes in product speed. EPA concurs that these sharp jumps should be avoided wherever possible. In the draft TEC test procedure, this suggestion is implemented in certain segments of the Job Table, as well as the proposed TEC formula. EPA is interested in furthering the use of formulas in the Job Table where feasible.

Keep the test procedure as simple as possible.
EPA agrees with this popular comment. Simplicity in the test procedure makes it less onerous and expensive to conduct and increases the transparency of the process and results.

Assume the manufacturer does the testing.
ENERGY STAR qualified office equipment products have always been tested by the manufacturer, and EPA hopes that this practice will continue for imaging equipment products under a revised specification. Test procedures conducted by third parties need strict specifications of many parameters such as climate and voltage, to ensure that a product is not disadvantaged by adverse conditions. With the manufacturer conducting the test, EPA expects that it will be performed in conditions that support good product performance. This avoids the need for expensive equipment such as test chambers and controlled power supplies. Parameters of concern can be reported in the test results rather than being closely regulated.

Try to keep the total test time under two hours.
There seems to be a consensus among industry that two hours should be sufficient to gather the needed data for a single product, at least for the majority of product types.

[1] ENERGY STAR Qualified Imaging Equipment, Specification Revision, Directional Draft, February 10, 2004.

Be consistent with existing test procedures when feasible.
EPA will strive for consistency with existing test procedures. The draft TEC test procedure draws significantly on the ASTM copier test procedure. Consistency among test procedures has many readily apparent benefits.

Use default delay times.
EPA assumes that manufacturers set default delay times for low power modes to values that they recommend will balance energy efficiency with customer expectations of product responsiveness. Thus, the draft TEC test procedure uses these values in calculating the TEC result.

Do not measure output speed.
In the draft TEC test procedure, EPA permits manufacturers to reference a products "claimed speed," rather than performing a test to measure product speed. As with the existing ENERGY STAR specification, it is assumed that manufacturers report speeds for their products that are correct and reasonable – subject to the basic assumptions outlined in the existing MOUs.

Detailed Rationales

The remainder of this section addresses details and background for the draft TEC test procedure. For many products, the draft TEC test procedure produces intermediate results for specific modes which match those from the current ENERGY STAR procedures, and for active power, it is based on the ASTM copier procedure, which some manufacturers routinely apply to their products. This discussion uses copiers as the example product, with others simple adaptations of the copier procedure.

Existing Test Procedures

At least as far back as 1987, there has been an ASTM test procedure for the electricity consumption of copiers, and it was subsequently adapted to printers and fax machines. The copier procedure was updated in 1994 to include electricity consumption while duplexing. The current version is dated 2001.

The existing ENERGY STAR specifications for imaging equipment contain test procedures for producing the off and low-power power-level results to compare product performance against the ENERGY STAR criteria. This data is subsequently reported in the ENERGY STAR products database. Assessing energy efficiency on the basis of TEC requires additional data and methods for obtaining the data. .

The existing ENERGY STAR specifications for imaging equipment contain test procedures for producing the Off and low-power power-level results to compare product performance against the ENERGY STAR criteria. This data is subsequently reported in the ENERGY STAR products database. Assessing energy efficiency on the basis of TEC requires additional data and methods for obtaining the data.

The current draft ENERGY STAR imaging equipment test procedures were abstracted from the copier and printer ASTM test procedures. The results from applying the ENERGY STAR procedure to a given product should closely match the comparable value from applying the ASTM procedure, though the ENERGY STAR procedure is less demanding in terms of total time required and complexity. Specifically, the Off and low-power values from the current ENERGY STAR copier test should match the plug-in Off and energy-saver power from the ASTM test.

The current draft of IEC 62301 specifies how to measure standby power, the minimum power mode of a product. In general, power levels are to be measured by obtaining the average over a period of five minutes. This is used to measure Auto-off.

Terminology

Terminology used to describe various power modes and activities, though defined very differently across product categories and throughout industry, needs to be expressed clearly and consistently in any future ENERGY STAR test procedure. Table A.1 below lists key terms that differ among the procedures

discussed in this document. Additional terms used here are “job” and “job interval” from the ASTM procedure.

Table A.1 Equivalent terms from the TEC, ENERGY STAR, and ASTM test procedures for Copiers

TEC	**ENERGY STAR** (Existing MOU)	**ASTM**
*Active [Mode]	not applicable	run mode
Job Energy	not applicable	copying energy
Ready [Mode]	not applicable	stand-by mode
Sleep [Mode]	Low-Power Mode	energy saver mode
Auto–Off [Mode]	Off Mode	automatic shut–off mode
Sleep Delay Time	Low-Power Default Time	not addressed
Auto-off Delay Time	Off Mode Default Time	energy saver time
Recovery Time from Sleep	Recovery Time	energy saver recovery time
Recovery Time from Auto-off	not addressed	not measured

Notes: The Directional Draft refers to “Plug-in Off/Standby” which is different from the Auto-off/Off mode on some products that have separate Manual Off and Auto-off modes. *”Active” is not formally used in the TEC test procedure, but it is useful in discussion; Job Energy includes both Active and Ready modes (and possibly Sleep).

This document uses Images per Minute (ipm) as the throughput speed of any imaging product, including copiers and printers for which Copies per Minute (cpm) and Pages per Minute (ppm) are commonly used, respectively.

Overall Operating Pattern

Figure A.1 shows a schematic of the assumed operating pattern used as the basis for the draft TEC test procedure. Note that neither axis is to any scale. About two-thirds of the day is actually spent in the Auto-off mode. Final Ready Time and Final Sleep Time are net of any time of each that is incorporated into the eighth hour (in the final 15-minute Job Interval).

Figure A.1 Schematic representation of the TEC operating pattern (copier example)

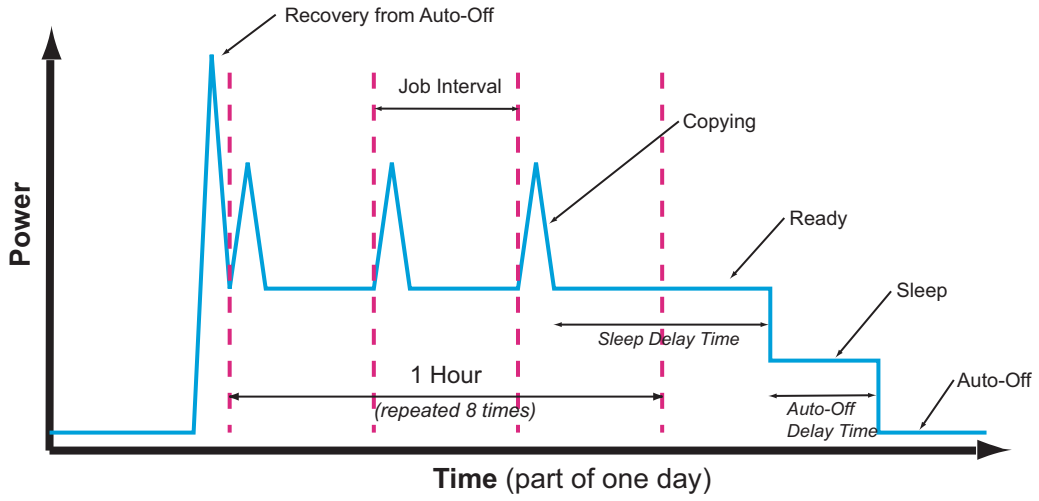
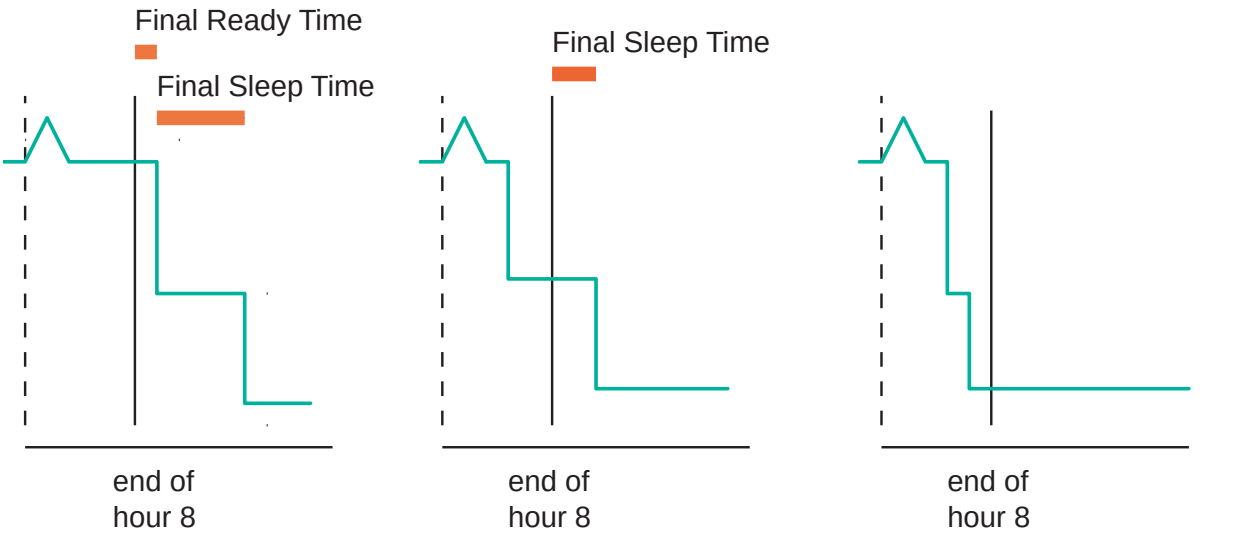


Figure A.2 shows the three possible scenarios for how the day ends, showing the final job interval and the time after the eighth imaging hour at the end of the work day. In Example 1, the product is still in its Ready mode at the end of the eighth hour, so there is some Final Ready Time and all of the Sleep delay time is Final Sleep Time. In Example 2, the product has gone to Sleep when the eighth hour ends and so there is no Final Ready time and only some of the Sleep time is Final Sleep Time. In Example 3, the product has turned itself off by the time the eighth hour finishes so that there is no Final Time (Ready or Sleep). Note that the actual length of the imaging time is ignored for deciding when the Sleep timer engages for purposes of calculating Final Sleep Time and Final Ready Time.

The TEC calculation uses the ASTM figure of eight hours per day of active use with identical imaging patterns. The test and calculations use the default (as-shipped) delay times for each transition to a lower power mode. On many copiers, this will be a time in Ready before it goes to Sleep, and a time in Sleep before the Auto-off feature engages. For printers, MFDs, and fax machines, there is no Auto-off feature in the test. Products may have more than one Ready mode or more than one Sleep mode. Products may have a manual-off mode different from the Auto-off mode, but the calculation does not include any manual-off time. Some printers have no Sleep mode, and some have no Off mode. In a final TEC test procedure, measurement of these modes will be omitted as appropriate for each product type.

Figure A.2 Three end-of-day conditions (copier example)



Example 1: Both Final Ready and Final Sleep Time

Example 2: Only Final Sleep Time

Example 3: Neither Final Ready Nor Final Sleep Time

Simplifications

Aspects of typical product usage that have a negligible effect on the final results are ignored in the calculation. For example, the Recovery from Auto-off time is not used in the electricity calculations, which in effect, adds the Auto-off power to this period of time; however, with small Auto-off power levels and short recovery times, this amounts to an exceedingly small amount of electricity. Also, imaging time for each job is not measured or accounted for in the TEC calculation. This shortens the final Ready time (or Sleep time) of the day on many products by the minute or less of imaging time typical of the jobs. Again, this amounts to very little electricity. No benefit, and much complexity, would result from including these two times in the electricity calculations. By definition, imaging time will be similar among products of similar speed.

The draft TEC test procedure stabilizes the unit in Auto-off for one rather than 12 hours (as the ASTM test specifies); this should not make a significant difference. The test period length of five minutes is taken from the IEC test procedure for standby power (IEC 62301).

Duplexing

The draft TEC test procedure only considers imaging in duplex mode when this mode is available. For many products, the difference in Active time and in TEC between simplex and duplex imaging is small. Thus, using only duplex imaging has little effect on relative comparisons. Products with substantial difference between simplex and duplex imaging times will dissuade users from using duplex imaging as much as they would otherwise and therefore, use more energy embodied in the extra paper. It does not make sense to "reward" these less efficient products by using the simplex speed. In summary, the difference often doesn't matter, and when it does, using duplex imaging is more appropriate. For products that do not have a duplex unit even as an option, the test is done single-sided.

Imaging Rates and Job Structure

The most difficult part of creating a TEC test procedure is the choice of imaging "job" — how many originals are presented, how many images of each are made, and how often a job is performed. An example job is three images (duplexed) of five originals, every 15 minutes. This amounts to 15 images per job, 60 per hour, 480 per day, 9,600 per month, and 115,200 per year (based on eight hours per day of active use, and 20 days of use per month). The number of images made over a period of time is the "imaging rate."

The imaging job choice results in images per month or year; however, ENERGY STAR and manufacturers typically categorize products by speed. Imaging rates could be derived from the manufacturers' maximum rated imaging capacity for each model; however, this would result in different imaging rates for products of the same speed. The ASTM procedure suggests using actual usage instead of rated capacity as well as applying the same rate to all products being compared. However, this only applies to individual applications, not generic evaluations.

Another option is to compile all manufacturer-maximum-rated capacities to create a standard correspondence with speed, yet this would result in imaging rates much higher than are typical in actual use. EPA research in the mid-1990s found that copiers used approximately 15% of the rated capacity on average. Although this figure may have changed over time; and different factors may apply to printers, MFDs, and fax machines; it is clear that products are used typically at rates well under rated capacity.

The draft TEC test procedure is built on an assumption that products are used today, on average, for about 20% of their rated capacity. This 20% is based on the assumption that the percentage of use has increased over time since the aforementioned 15% was determined. EPA welcomes more recent data if it is available. A relationship between maximum capacity and speed was derived from products currently available in the U.S. and the 20% figure was applied to this. To provide consistency across all products, the job interval is held constant at 15 minutes.

To easily accommodate odd numbers of pages of originals per job, the test may be conducted with single-sided or double-sided originals.

The ASTM test procedure has a job table outlining 14 copying job combinations. This is believed to be overly complex and has several other drawbacks: it is copyrighted; some of the jobs take an entire hour; and no table exists for MFDs. For these reasons, EPA has developed the formulas in Table 2 in the draft TEC test procedure.

The draft TEC test procedure allows for each job to be accomplished by a succession of smaller jobs to address the limited capacity of document feeders, e.g., if the test calls for 75 copies while the document feeder only can hold 50 originals. An alternative is to make multiple copies of each original. The

following language could replace the paragraph immediately before Table 2 in the draft TEC test procedure:

> "The number of originals is not to exceed 25, so that for images per job above two, the figure should be truncated to an even number, and two sets of half as many originals should be made, e.g., for 30 images per job, two copies of 15 originals. This is extrapolated to images above 50, 75, etc."

Recovery Times

Another aspect of product performance that may be reflected in a TEC specification is the product "recovery time" that customers usually experience. There are a variety of ways to measure this. The draft TEC test procedure specifies measuring the time between waking the product and when it indicates that it has reached a Ready state.

An alternative method is to measure the first copy time for all three modes — from Ready, from Sleep, and from Auto-off — and then focus on the increment between Ready and Sleep times and between Ready and Auto-off times. For example, if the first copy time of a product is five seconds, and it takes 25 seconds from Sleep to produce a copy, then the recovery time is 20 seconds.

Summary of Key Parameters

The procedure results in up to eight measurements that feed into subsequent calculations for obtaining the overall TEC. The parameters important to the measurements and calculations in the draft TEC test procedure are listed in Table A.2 below, showing which are assumed applicable to the four product types, based on available data EPA welcomes industry feedback on whether these parameters are correct and complete for each product.

Table A.2 Summary of Key Parameters

C	P	M	F	Parameter	Units	Source	Comments
A	A	A	A	Job Power	Wh/h	TEC	Usually only includes power consumed during Active and Ready modes
A	A	A	A	Ready Power	Wh/h	TEC	
A	+	+	+	Sleep Power	Wh/h	TEC (or ENERGY STAR)	
A	A	A	A	Auto-off or Off Power	Wh/h	TEC (or ENERGY STAR)	Off power is not used in calculations for printers, MFDs, or fax machines
A	+	+	+	Sleep Delay Time	minutes	Manufacturer	Delay used in test must be the default
A	U	U	U	Auto-off Delay Time	minutes	Manufacturer	For printers, MFDs, and fax machines, report if present but do not use in calculations
A	—	+	+	Recovery Time From Sleep	seconds	TEC	
A	—	U	U	Recovery Time From Auto-off or Off	seconds	TEC	

Notes: "ENERGY STAR" in this table is the existing ENERGY STAR test procedure. C, P, M, and F represent Copiers, Printers, MFDs, and Fax Machines, respectively. "A" = always; "—" = not applicable; "+" = usually; U = unlikely, but possible. A few imaging products lack an Off mode, and not all have a Sleep mode.

Printers, MFDs, and Fax Machines

Printers, MFDs, and fax machines are assumed not to utilize an Auto-off function (although there is no prohibition on them having one), so the Auto-off parameters in Table A.2 above do not usually apply. Because it is assumed that users are less conscious of recovery times when printing, there is no need to report these parameters for print functions.

Notable differences among the ENERGY STAR, ASTM, and TEC Test Procedures

To measure Sleep power, the existing ENERGY STAR test procedure specifies that the technician wait 15 minutes after the last image is made and then record the power used in the subsequent hour, which implies that the Auto-off delay time is 75 minutes or more. The draft TEC test procedure specifies that this measurement period should be reduced if the default Sleep delay time is less than 15 minutes, and that the measurement period should be the Auto-off delay time, which will usually be less than one hour. The two procedures produce different results for products with Auto-off delay times less than 60 minutes. It seems likely that the intent was the same, but that the existing procedure presumed that all Auto-off delay times would be in excess of 75 minutes.

The existing ENERGY STAR test procedure specifies the Auto-Off delay times. The draft TEC test procedure specifies that the time used in the test should equal the product's default delay time as-shipped.

For the Auto-Off and Off power measurements, the draft TEC test procedure assumes that these modes are stable, so that (per IEC 62301) a measurement period of five minutes is sufficient. Both the existing ENERGY STAR and ASTM procedures measure it for a full hour.

For the electricity calculation, the draft TEC test procedure deviates from ASTM by assuming no manual turn-off and the end of the day and by measuring the recovery from Auto-off energy separately from the imaging time. Also, the ASTM procedure includes one hour of non-use at lunch which the draft TEC test procedure does not.

The ASTM procedure measures both simplex and duplex copying energy. The draft TEC test procedure measures only duplex copying.

Other Issues

EPA is aware that some products have modes that occur infrequently enough to not contribute appreciably to TEC.

EPA is also aware that at least a few products have adaptive controls for changing power management behavior based on past experience of usage patterns. Adaptive controls are power controls, other than those with fixed delay times, which lower power modes or daily or weekly timers. Adaptive controls include those that "learn" from past usage patterns to turn themselves on or off at appropriate times, or automatically change delay timer settings.

Appendix B – References

ASTM Standards

F757-01 Standard Test Method for Determining Energy Consumption of Copier and Copier-Duplicating Equipment

F1706-96(2002) Standard Practice for Determining Energy Consumption of Nonimpact Personal Computer Printers

F1707-96(2002) Standard Practice for Determining Energy Consumption of Facsimile Machines

F335-03 Standard Terminology Relating to Electrostatic Copying

EPA/DOE ENERGY STAR website: www.energystar.gov

Products: Office Equipment: Copiers: Copier of the Future.

Copiers, Multifunction Devices, Printer & Fax Machines, Scanners:

Key Product Criteria and Test Procedures

Hershberg, Craig. 2004, Jan 12. ENERGY STAR Qualified Imaging Equipment Specification

Revision: Directional Draft. EPA ENERGY STAR Office Equipment program, Washington DC.

International Electrotechnical Commission, IEC 62301 Ed 1: Measurement of Standby Power, IEC TC 59, TC59, Working Group 9 59/297/CD Household Electrical Appliances.

Nordman, Bruce, M.A. Piette, B. Pon, K. Kinney. 1998. It's Midnight … Is Your Copier On?:

ENERGY STAR Copier Performance. LBNL-41332. Lawrence Berkeley National Lab, Berkeley CA.

Buyer's Laboratory, Inc. Multifunction Device Specification Guide, Fall 2003.

Buyer's Laboratory, Inc. Printer (non-impact) Specification Guide, Winter 2004.