ENERGY STAR® Qualified Imaging Equipment

Final Draft Test Procedure Rationale

Typical Electricity Consumption (TEC)

April 15, 2005

This document provides details and rationale regarding the contents of the final draft TEC test procedure, dated April 15, 2005, and provides an account of what has changed in this version from the revised draft procedure distributed on February 16, 2005.

Introduction

The TEC test procedure and corresponding materials present a method to measure and compare the relative energy consumption of imaging equipment products in a precise and repeatable manner.

The methodology and content of the final draft test procedure, dated April 15, 2005, are the culmination of careful consideration of all stakeholder feedback received to date. This document is intended to provide background on key aspects of the procedure, respond to feedback, and explain why each revision to the previous version was made.

It should be emphasized again that **the TEC method is not meant to precisely replicate real-life operating patterns**. EPA has structured the method to resemble a typical working week. However, due to the wide variation of imaging equipment, both in usage and functionality, it is impossible to mimic real usage in all cases. Rather, the TEC test procedure, which results in a TEC value, is a consistent method of measuring imaging equipment and comparing the energy performance of similar products. The TEC procedure does not replace the usefulness or need for more sophisticated measurements such as the ASTM test procedures.

Product Categorization

The TEC test procedure is designed for use as a method of measurement for the following standard-size products, regardless of color capability, which use the below designated marking technologies:

Table 1. Products and Marking Technologies Evaluated with TEC

Products Covered by TEC	Marking Technologies Covered by TEC
Digital duplicators[t]	Direct Thermal
Stand-alone copiers^	Dye Sublimation
Stand-alone printers	Electrophotographic (laser, LED, LCD) **
Stand-alone fax machines	Solid Ink
Multifunction devices (MFDs)*	Thermal Transfer

[t] Digital duplicators use a marking technology not reflected in the list of technologies covered by TEC; however, these products are still treated by TEC

^Includes standard and upgradeable

* Includes printer/fax combination units

** Includes both serial and parallel color

EPA determined that the above products and marking technologies are best suited to the TEC approach for product comparison based on careful consideration of stakeholder feedback. These marking technologies use heat-intensive processes in transferring images to the media, which causes active and ready modes to dominate energy consumption and potential savings. Additionally, data collected in the field by Lawrence Berkeley National Laboratory (LBNL)* shows that products using these technologies are more subject to power-management disabling due to longer recovery times. EPA considers user-disabling a reason to consider the TEC of a product.

The product areas listed in Table 1 are products that commonly utilize the listed marking technologies, with the exception of digital duplicators. Digital duplicators have been selected for consideration under the TEC approach based on high productivity and functional similarities to traditional copiers and printers.

Treating Non-Ink Jet Printers under TEC

EPA has decided to test non-Ink Jet types of printers under the TEC approach based on several factors. As stakeholders will note, printers were not included in the original February 2004 Directional Draft where EPA initially proposed the TEC concept. As today's imaging-equipment market moves increasingly towards multifunctionality, EPA feels it makes sense to address related imaging equipment together, based on both functionality and marking technology. Several stakeholders have commented that since non-Ink Jet printers are often the basis for non-Ink Jet MFDs, it does not make sense at this time to treat printers differently from their MFD counterparts; EPA agrees with this assessment. Stakeholder feedback also supports this conclusion.

MFDs without Print Capability

MFDs without print capability are treated as copiers in all aspects of this procedure. This is because these products cannot be tested with print jobs and so must be tested while copying, and because the lack of a network connection makes the use of an auto-off mode more practical. EPA has not yet determined how these products will be categorized in the future specification.

Operational Mode Categorization

The majority of comments received support considering the products and marking technologies listed in Table 1 under the TEC approach. Similarly, most stakeholders also agreed that Ink Jet and Impact continue to be treated under the Operational Mode (OM) approach. Based on this feedback, for the time-being, EPA plans to address remaining imaging equipment not covered by this final draft TEC test procedure under the traditional OM approach, including Ink Jet and Impact products, such as printers, faxes, and MFDs, as well as scanners and mailing machines. Additionally, based on operating patterns and duty cycle considerations, EPA plans to address all large/wide-format imaging equipment using the OM approach. EPA may decide at a later time to treat these products under TEC, but for the time-being, stakeholder feedback and other considerations such as energy-savings potential support the OM path.

Test Conditions and Parameters

Color vs. Monochrome

Color-capable products shall be tested in monochrome.

Some stakeholders have suggested that testing of color machines should incorporate both monochrome and color images to better assess the energy usage of various types of color-production processes. The February 16, 2005 draft TEC test procedure specified that all testing be performed in monochrome, however, EPA will consider additional targeted test data in the coming weeks to make a final

* Roberson, Judy, Carrie Webber, et al. 2004. After-hours Power Status of Office Equipment and Inventory of Miscellaneous Plug-Load Equipment. LBNL-53729. Lawrence Berkeley Lab, Berkeley CA.

determination on whether color images need to be incorporated into the TEC test procedure, and if so, how these images should be incorporated.

Environmental Conditions

The environmental conditions and equipment specifications for testing imaging equipment can be found in the document, **Test Conditions for Determining the ENERGY STAR Qualification Status of Imaging Equipment Products**. This document also includes the rationale behind the creation of this document and response to stakeholder comments on environmental conditions.

Media Input and Output Configurations

Paper source and finishing hardware shall be present and configured as-shipped.
A single imaging equipment product is often sold in a variety of configurations. Throughout the specification, where "as-shipped" is specified, EPA assumes partners will test the product in the base configuration available to consumers. For example, if a copier is offered with or without an automatic stapler, this copier may be tested in its base state, e.g., without the automatic stapler installed. Partners who are concerned that they might be penalized for offering more complex base machines should provide TEC test data to EPA supporting this concern.

Anti-humidity features may be turned off if user controllable.
Since these devices are used only in limited geographic locations, EPA does not want to penalize partners who offer these devices on certain units for certain customers.

Digital duplicators are eligible for testing under this version of the TEC test procedure, and shall be set up and used in accordance with their use and capabilities.
Since these products are designed for large print/copy jobs of a single pattern, which is dissimilar from standard printers or copiers, EPA has modified the testing as appropriate to these machines, e.g., a single original image per job. Further direction is provided in the test procedure text.

Media

A specific test pattern shall be used for each image original.
EPA has not seen data to suggest that the content of the test image affects the TEC result, but the burden of specifying a simple standard test image is low and it removes a possible source of variation in the TEC result. Based on this, the procedure now specifies a standard monochrome text-only test pattern from ISO/IEC Standard 10561:1999.

Testing shall be performed on paper of size and basis weight appropriate to the intended market.
There is variation in standard paper among international markets, and the size and basis weight used during testing may affect the TEC result. Since typical paper used in each market varies, along with the voltage/frequency combination of that market, the procedure now specifies these two factors in the document **Test Conditions for Determining the ENERGY STAR Qualification Status of Imaging Equipment Products**.

Networking

Printers and MFDs shall be connected to a network if capable of being network-connected as-shipped.
It has been suggested to EPA that the presence of the network connection may change a product's power levels or behavior. For consistency, all products that are network-capable shall be connected to a network during testing. However, this does not mean that network-capable products must have the job sent via the network (e.g., jobs may be sent via a USB connection from a personal computer).

Images shall be sent to the product in a page description language (e.g., PCL or Postscript) if the product is capable.
Using a page description language when it is available on a product reflects typical usage patterns and should not be overly burdensome.

***The type of network connection used shall be reported on the TEC data collection spreadsheet*.**
EPA does not feel it is necessary to specify the type of network connection used during testing since a variety are sold on the market for different purposes and customers. The revised TEC test procedure calls for the manufacturer to test using any available network connection for which the product may be configured; however, it also asks that the person performing the test procedure note which connection this is.

Simplex vs. Duplex

Originals for copying shall be simplex images.
For greater consistency across all products tested under the TEC approach, EPA has decided that products shall be tested using simplex original images.

Testing shall be performed in simplex mode.
In the February 16, 2005 draft of the TEC test procedure, it was specified that the test procedure be performed in duplex mode for machines that are duplex-capable. Several stakeholders expressed concern that performing the test procedure in duplex mode could be problematic since not all products that fall under the TEC approach are designed to have duplex capability, particularly products designed for residential or small office application. Allowing simplex output alleviates these concerns and provides for greater consistency across all products tested under the TEC approach.

Voltage/Frequency

Testing voltage and frequency shall be appropriate for the market where the product is sold.
Product testing should be performed at the relevant voltage/frequency combination(s) for where the product is sold since energy consumption values may vary according to the input voltage/frequency combination. This has been the general procedure for ENERGY STAR testing across product categories in the U.S., and as the ENERGY STAR program develops an increasingly international scope, EPA has determined that it is important to confirm that products meet the new specification at the representative market conditions where the products are sold. For markets where there is more than one relevant voltage/frequency combination, manufacturers should test at that market's primary voltage/frequency combination, unless the product is designed to operate at a specific voltage/frequency combination other than the primary (e.g., if a copier is designed to operate at 230 Volts AC, 60 Hz rather than at 115 Volts AC, 60 Hz in the U.S.).

Job Structure

Speed

Maximum claimed simplex speed shall be used to determine job size.
The TEC test procedure now clarifies that manufacturers shall use the product's maximum claimed simplex speed to determine job size for performing the TEC test procedure. The TEC test itself continues to be performed at the product's default speed setting, which may or may not be the same as the maximum claimed speed. Speed itself is not measured by the TEC test procedure. When the speed varies with market, the highest speed across all markets where the product is sold is used for determining job size.

Jobs/Day Calculation

The number of images per job is determined by two calculations.
The calculation method for obtaining the number of images per job relies on two separate calculations of jobs per day and images per day. The result reflects the assumption that products with greater imaging speeds typically produce greater numbers of jobs per day. The calculation of jobs per day was developed in response to stakeholder comments, which called for the calculated number of jobs per day to increase according to product speed, consistent with the proposed new ASTM test for copiers and MFDs.

Job Table (Images per Day)

A single images-per-day formula is used for all imaging equipment covered by the TEC method, except for stand-alone fax machines.
This single formula is more consistent to reflect the limited and similar marking technologies covered by TEC, and responds to stakeholders who suggested that there is no need to differentiate between copier- and printer-based MFDs.

The formula for images per day was approximated from the proposed new ASTM test procedures developed by JBMIA for copiers and MFDs.
These procedures use monthly volumes of 10 x ipm^2 for copiers and 15 x ipm^2 for MFDs with copying capability, which results in daily volumes (at 22 days per month) of 0.455 x ipm^2 for copiers and 0.682 x ipm^2 for MFDs with copying capability. One stakeholder proposed 0.32 x ipm^2. EPA does not believe that the exact formula will change the ranking of products significantly.

Measurement Procedure

The Measurement Procedure section of the TEC Test Procedure contains two versions of the test procedure—one for printers, digital duplicators and MFDs with print capability, and fax Machines, which are assumed not to utilize an auto-off, and one for copiers, digital duplicators, and MFDs without print capability, which are assumed to have an auto-off mode.

Figure 1. TEC Measurement Procedure

Figure 1 shows a graphic form of the measurement procedure. Note that products with short default-delay times may include periods of sleep within the four job measurements, or auto-off within the sleep measurement in Step 4. Also, non-copier products with just one sleep mode will not have a sleep mode in the final period. Step 10 only applies to copiers, digital duplicators, and MFDs without print-capability.

General

Test procedure measurements record energy values not power values.
Several stakeholders had commented that measuring the accumulated energy used in various power modes and converting this value into power may lead to significant error, particularly with short measurement periods and low power levels in sleep and off. It should be noted that for sleep, there is a full hour allotted for that mode in the test procedure, the purpose of which is to allow the fuser to partially cool down; this period is used to obtain a more accurate measurement. For devices tested under Table 3 that have an auto-off time of less than 60 minutes, a shorter time period may be used to measure the sleep power level. For off, manufacturers are allowed to extend the measurement period past the minimum of five minutes to obtain a more accurate reading if desired.

The test procedure remains brief but thorough.
Some stakeholders have cautioned EPA to avoid making the TEC test procedure too short. They note that though shortening the procedure makes it simpler to test products, it also introduces possible error and inaccuracies. EPA believes that the TEC test procedure strikes the appropriate balance between testing burden and validity of the result.

Active

The job measurement is repeated four times.
Repeating the job measurement addresses the fact that that some units consume a notably different amount of energy in the first job than in successive ones, and that there is some natural variation from job to job even with identical imaging. If sufficient data is gathered that shows fewer than four jobs are needed for certain speed ranges or product types, EPA will consider abbreviating this portion of the procedure.

The test procedure specifies that jobs be printed on MFDs rather than copied.
EPA believes that more images are produced on MFDs by printing than by copying. If the page rendering process increases consumption, then the procedure should take that into account. EPA has not seen evidence showing that measuring both printing and copying would change the results enough to merit the added complexity of the procedure and calculations. The majority of stakeholders support printing the jobs on MFDs instead of copying them due to simplicity, and also because some argue that MFDs with print capability are more often used for printing than for copying.

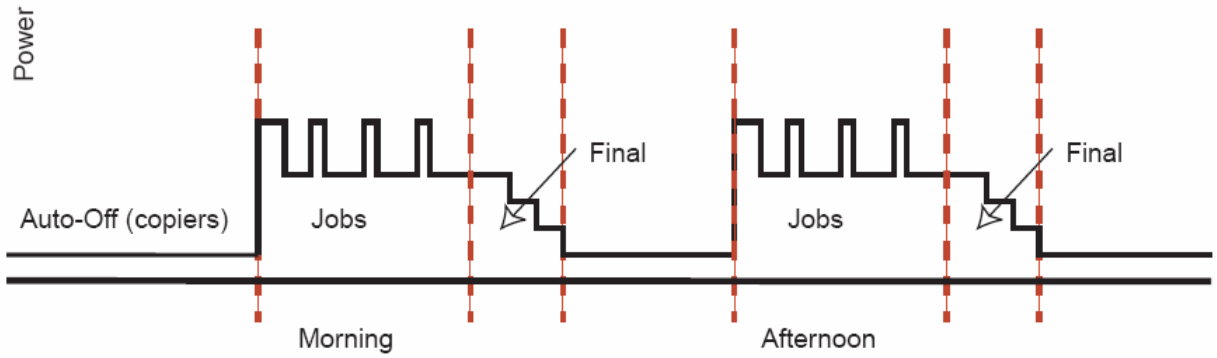
Jobs performed on an MFD or printer may be sent via network or via direct connection.
For MFDs or printers, the job may be sent to the product either via a network connection or via a direct connection to a computer, e.g., USB.

The job interval is 15 minutes for all products tested under TEC.
Some stakeholders have suggested to EPA that the standard 15-minute job interval should be expanded to a greater duration of time, e.g., 30 minutes, depending on the type of product. Some have commented that some manufacturers' products will enter sleep during the measurement of job energy, whereas others will not. In an office environment, these latter models would certainly enter sleep during a typical work day, not just at night. By not entering sleep during the measurement of job energy, the TEC test makes it appear as if these products are in active and ready for eight hours each day. Other stakeholders support the static 15-minute job interval, claiming it benefits EP products by allowing residual heat from one job to be incorporated into successive jobs. EPA continues to use the 15-minute job interval in this revised TEC procedure because it seems to be the best single interval to use across the full range of imaging products. However, the number of jobs per day has been reduced and an effective lunch period

has been incorporated into the calculations to increase the amount of time during the day that products spend in sleep or in off.

Figure 2 shows a schematic example of an eight-ipm copier that performs four jobs in morning, four jobs in afternoon, has two "final" periods and an auto-off mode for the remainder of the workday and all of the weekend. An assumed “lunchtime” period is implied but not explicit. The figure is **not** drawn to scale. As shown, jobs are always 15 minutes apart and in two clusters. There are always two full “final” periods regardless of the length of these periods. Printers, digital duplicators and MFDs with print capability, and fax machines use sleep rather than auto-off as the base mode but are otherwise treated the same as copiers.

Figure 2. A Typical Day



Off and Auto-off

The measurement of off for copiers, as used in the calculations, is performed at the end of the procedure rather than at the beginning.
On some models, the manual-off and auto-off power levels are different, meaning that measuring off at the beginning could provide an incorrect result.

The revised TEC test procedure maintains the measurements of off and auto-off at the minimum of five minutes.
Many stakeholders have commented that these modes are very stable for imaging equipment, and longer measurement durations are not necessary. However, a few stakeholders expressed concern over accuracy with these short periods; therefore the procedure allows for longer measurement periods if desired.

Manual off energy and time measurements are now included for copiers, digital duplicators, and MFDs without print-capability.
For these products, the off-power measurements are not used in the calculations since auto-off values are used for this purpose; however, off power data is necessary for EPA to understand if the product meets Federal Energy Management Program (FEMP) standby power levels. As such, Step 1 in Table 3 of the TEC test procedure has been modified to match Step 1 in Table 2.

Ready

Multiple ready or sleep modes are accounted for in the revised TEC test procedure, but are not measured separately.
Stakeholders have suggested that EPA revise the procedure to create multiple ready or sleep measurements to provide for products that may have multiple modes, e.g., secondary ready modes that

consume less energy, or additional sleep modes such as the "Low Power" mode from the existing MFD specification. EPA believes that the revised procedure accurately accounts for multiple levels of energy consumption so that there is no need to create additional measurements within the TEC procedure to capture these additional levels. For products with such lower-energy-consuming mode, EPA believes this lower energy consumption will be reflected in the product's overall TEC value.

Recovery and Default Times

Recovery times are no longer captured in the TEC test procedure.
The February 16, 2005 version of TEC test procedure included two distinct recovery time measurements which resulted in a calculated value for the product's incremental recovery time. These measurements collected the time from job initiation to paper output for one job initiated from ready mode and for another job initiated from sleep. Based on stakeholder input, EPA decided not to create requirements in the IE specification for recovery time, and therefore, these measurements have been dropped from the procedure. EPA remains attentive, however, to whether excessively long recovery times could encourage consumers to disable power management.

Service/Maintenance Modes

Service and/or maintenance modes are not included in the TEC test.
Language is included in the TEC test procedure to provide direction on how to treat service and/or maintenance modes during testing. In general, EPA asks that partners do not include data from these instances if they occur during testing.

Sleep

Steps 3 and 4 ensure that all units have been asleep for one hour after having been previously active.
The measurement of sleep in previous drafts of the TEC test procedure had been specified for the duration of the product's sleep delay time; this extended sleep period addresses stakeholder comments suggesting that longer periods of measurement might prevent avoidable inaccuracies, which are more common with shorter measurement periods.

The "final" energy and time measurement includes any ready time that occurs after the 15 minute job period as well as possibly some sleep time.
For printers, it includes higher sleep modes if there is more than one, and for copiers it includes all sleep modes. The method does not require separate measurements of each ready and each sleep mode within the procedure.

Multiple Mode Data

The test procedure now includes a measurement of off mode power for devices that are not print-capable.
In the February 16, 2005 draft of the TEC test procedure, EPA had included a request for additional, separate measurements of the various power modes, include ready, sleep, and off. To reduce the burden on manufacturers, this request has been removed. However, EPA considers it important to collect data for confirming whether products meet Federal Energy Management Program (FEMP) power levels for standby (usually off mode). For this reason, the measurement for off mode included in Table 3, Step 1 of the TEC test procedure has been modified from the version distributed to stakeholders in February to match the direction provided in Table 2. It is important to note that EPA has not yet determined whether FEMP guidelines will be incorporated into the ENERGY STAR IE specification.

Print Controllers or Digital Front Ends (DFEs)

A new measurement has been added to collect the ready-mode power of print controllers. High-capacity imaging equipment can require high-capacity controllers; these controllers are often called DFEs. Some of these controllers are physically incorporated in the imaging products with which they operate and some are external but functionally integrated. Some have their own AC power cord. Some are essential to the product's functioning and others simply enhance its speed and/or capability. The TEC test procedure captures the total, typical electricity consumption of imaging equipment, including any print controllers shipped with them. However, since the contribution of high-end controllers to the weekly TEC value can be high, it is critical for EPA to understand the role that these controllers play in the TEC value. For this reason, a short separate measurement of the controller alone has been incorporated into this latest version of the TEC test procedure for controllers with their own AC power cords. This "ready" value is expected to capture the majority of controller electricity consumption.

Calculation Method

***The TEC calculation is different for copiers, digital duplicators, and MFDs without print-capability*.** The calculation is different to reflect the auto-off difference assumed for these products, as described in the **Measurement Procedures** section.

***The revised test procedure addresses potential error*.** Language has been included in the TEC Data Collection Worksheet to provide direction on the calculation of total potential error of the TEC measurement process.

The weekly TEC value is based on five individual formulas. For illustration purposes, the five formulas for printers, digital duplicators and MFDs with print-capability, and fax machines can be combined as follows:

$$TEC = [(Job1 \times 2) + ((Jobs\ Per\ Day - 2) \times (Job2 + Job3 + Job4) / 3)] + (2 \times Final\ Energy) + [24\ hours - ((Jobs\ per\ day / 4) + (Final\ Time \times 2)) \times Sleep\ Power] \times 5 + (Sleep\ Power \times 48)$$

And can be rearranged as shown below:

$$TEC = (Job1 \times 10) + [(Jobs\ Per\ Day - 2) \times ((Job2 + Job3 + Job4) / 3) \times 5] + (10 \times Final\ Energy) + [Sleep\ Power \times (168\ hours - (Final\ Time \times 10) - (Jobs\ per\ Day\ x\ 1.25))].$$

Accuracy

Meter accuracy details are requested for each measurement to calculate total potential error. These accuracy details will be used to quantitatively assess the effect of meter accuracy on the results. Since the accuracy rating usually depends on the meter range(s) used, and on the reading itself (i.e., percent of full scale and percent of reading), this will be unique to each product.

Each of the accuracy assessments can be expressed as an absolute Watt-hour figure or as a percentage of the reading using the spaces provided in the TEC Data Collection Spreadsheet. These are then automatically aggregated through the same formula used to calculate the TEC to determine the potential error of that value.

Manufacturers are not required to do the accuracy calculations provided for in the spreadsheet so long as they are confident that the result will be equal to or less than 5% total potential error of the TEC value. Recording meter specifications and ranges used in the various measurements allows for the calculation of error to be done at any future time. The concept of "Adjusted TEC" has been dropped from the TEC test procedure since the February 16, 2005 distribution and replaced with a calculation of Percent TEC Error.