October 20, 2014

MEMORANDUM

To: **Jeremy Dommu**
From: **Jason Friedrich and Jennifer Sanford**
Re: Department of Energy, Notice of Data Availability for Energy Conservation Standards and Test Procedure for Battery Chargers, 79 Fed. Reg. 27774 (May 15, 2014), Docket No. EERE-2014-BT-NOA-0012; Additional Information for DOE Consideration

Introduction

We are following up on our meeting with DOE on August 7, 2014. During the meeting, several topics were identified as warranting further investigation as related to battery chargers, including test procedures and standards. This document provides additional information relating to these topics. We request that this document be placed in the record of this proceeding.

Defining Continuous Use Products Containing Batteries for Backup Use

There are several categories of products that are intended for continuous use and also contain battery charging circuits in order to provide backup power in case of AC mains power loss. The following list shows some examples:

- Modems or gateways[1]
- Home security systems, including cameras[2]
- Smoke and carbon monoxide alarms[3]
- Sump pump controllers[4]

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[1] For example, ARRIS TG862 (http://www.arris.com/products/product.asp?id=79) or Cisco DPC3212 (http://www.cisco.com/web/consumer/support/modem_DPC3212.html)
[2] For example, http://www.newegg.com/Product/Product.aspx?Item=9SIA1NV0TB9833
[3] For example, Kidde i12010SCO (http://www.kidde.com/Documents/Data-Sheet-i12010SCO.pdf).
[4] For example, Basement Watchdog (http://www.basementwatchdog.com/Basement_Watchdog_battery_back-up_sump_pump.php).

- Smart light fixtures[5]
- Alarm clocks[6]
- Plug-in timers[7]

Continuous use products are not intended to be turned off and lack a power switch. In some cases, as with alarm clocks or timers, the backup battery is provided for user convenience. However, in many other cases the backup battery is provided for emergency use. Products such as security systems, security cameras, smoke alarms, emergency lighting, and sump pump controllers contain batteries for protection of the home and occupants during a power failure. In addition, modems and gateways with VoIP functionality provide battery backup to provide continued telephone service for emergency use.[8]

As a result of the wide diversity of uses for products containing battery chargers, a set of criteria is needed to clearly define continuous use products containing batteries for backup use. When defining these products, the following characteristics should be considered:

Product feature marketing

There are many reasons why a product may use a battery. Many products contain batteries for mobile or portable use. Examples of these products may include cellular phones, tablets, camcorders, and MP3 players. Some products may contain batteries in order to provide the convenience of wireless use. Examples of these products may include a wireless computer mouse or wireless headphones. In contrast to the above, continuous use products containing a battery for backup use will only use the battery to preserve the product's primary function through a power outage. In all cases, the intended use of the battery should be determinable from product marketing or support documentation.

Many mobile, portable, or wireless products may continue to be used during a power outage. However, this would not be considered "backup use" since the batteries contained in mobile, portable, and wireless products are intended to provide regular use without regard to the availability of AC power. Continuous use products containing batteries for backup use are marketed as having the added feature of continuous operation through a power outage. Therefore, product marketing or support

[5] For example, eSenlite EE809WMC (http://www.eesgi.com/index.php?option=com_content&view=category&layout=blog&id=5&Itemid=17).

[6] For example, Electrohome EAAC475W Clock Radio (http://www.electrohome.com/products/display.php?id=148).

[7] For example, Stanley 38424 Timer (http://thenccusa.com/stanley/?page_id=23&prod_id=477).

[8] Many other battery powered products, such as smart phones and tablets, may be designed for continuous use, but use their battery for primary power, rather than backup power. In addition, there are several products that contain batteries that are only used occasionally. For example, power tools or rechargeable flashlights are not continuously used.

documentation should be consulted to determine if the battery is intended for backup use only.

Direct operation from the main power supply

Continuous use products may use an external power supply or have an integrated power supply. In either case, products containing a battery for backup use will continue to operate independent of the battery state. The battery charging system is an ancillary function, and is not a prerequisite for the primary function. In the case of main power loss, these products often incorporate circuitry to automatically switch to battery power until the main power is restored. In many cases, the battery is user replaceable. In some cases, the battery may even be marketed as an optional add-on accessory, so the product can actually be purchased and used without a battery installed.

The definition for "direct operation" in the Energy Conservation Standards for External Power Supplies (79 Fed. Reg. 7865) could be used to determine if the product can operate as intended without dependence on the battery charge status. If the battery is removable, the product should turn on and perform the primary function(s) with the battery removed. If the battery is not removable, the product should turn on and perform the primary function(s) with a completely depleted battery.

Lacks a power switch

Continuous use products lack a power switch to turn off the product's primary function(s). As indicated by the use of the word "continuous," these products are intended to operate without ceasing. Adding a power switch would change the fundamental nature of the product. Also, a power switch would likely cause consumer confusion as to whether or not the battery backup should be running when the switch is set to "off." In addition, as explained further below, adding a power switch is often not possible due to the integrated nature of the product.

In the typical usage scenario, a continuous use product containing a battery for backup use will automatically switch over to the battery when the main power is lost. The only way to turn off the product is to disconnect both the main supply and the battery. These products will often be delivered to the consumer with the battery pack removed or with some kind of insulator to keep the battery disconnected until the product is unpackaged.

Not a portable or mobile product

Products that contain batteries for backup use only are not intended to be routinely carried by the user or held by the user while in use. These products may be movable, meaning they are small enough to be carried by the consumer. However, they are intended to be stationary while in use. In some cases these products are even intended to be built-in prior to use. As mentioned above, product feature lists and support documentation may be consulted to determine that a product is not intended to be portable or mobile.

Primary function uses wired connections

The primary function for many continuous use products involves connection to other devices, networks, or infrastructure through wired connections. For example, modems and gateways require an upstream connection to a service provider network and a downstream connection to telephones. A home security system often depends on hardwired sensors on doors and windows. Plug-in timers are used to connect and disconnect power to a load such as a lamp. A sump pump is often connected to drainage pipes or hoses. It should be noted that while this is a defining characteristic for many continuous use products, it is not a requirement for all such products. For example alarm clocks and carbon monoxide detectors typically do not have any wired connections beyond the AC mains supply.

Product Class Criteria Should Include Product Function

Most product classes covered by DOE test procedures and standards have narrowly focused primary functions. For example, refrigerator models may have significantly diverse features from one model to another, but they all share the same primary function of refrigeration. In comparison, battery chargers are found in a vast array of consumer products with significantly diverse primary functions. Currently, the DOE battery charger product classes are broken down by product input and output voltage types (i.e., AC vs. DC), battery energy, and battery voltage. This type of classification is helpful when considering different battery chemistries and charging techniques. However, it does not take into account the vast differences in primary function of the products, which does influence the function of battery charger system. The following product characteristics need to be factored into battery charger product classifications and the associated test procedures.

Charge rate may be dependent on primary functions

Battery charge rate can vary significantly regardless of battery chemistry. For all battery chemistries, fast charging requires a lot of energy and typically results in lower battery charger efficiency due to losses in the form of heat in the battery cells. The charge rate of a battery charger is often based on usage profile or consumer preference.

It may be critically important or strongly desired by the consumer to have the backup battery charged as fast as possible. While power outages typically have a very low occurrence, events such as severe weather may cause unstable power grid conditions that result in several short outages over a period of several days. Depending on the application, a product may be required to charge the battery as fast as possible in order to be prepared for possible successive outages. Modem and gateway products that provide telephony services may intentionally use a rapid charge technique, at the expense of reduced energy efficiency, in order to ensure that consumers can use emergency telephone services during multiple successive power outages.

Charge rate may be offered as differentiation between product models or battery pack models, so the consumer may choose the options that best fit its needs or desired price point. For example, battery packs designed for some ARRIS modems and gateways are offered with different charge current capabilities. A customer who does not need fast charging, can select a "standard" battery pack with a slower charge rate. However, a customer who desires fast charging may choose to pay a little more for a battery pack that is specially design to accept a higher charging current. Many ARRIS modems and gateways have multiple options for battery capacity. In some cases, higher capacity batteries support higher charging currents in order to recharge the battery within a desired period of time.

Ancillary functions may not have access to full power when primary functions are in use

The current carrying capacity of a product's power supply is a significant design decision when considering product size and efficiency. Often for products that have many functions, it is not practical to design the power supply to support simultaneous use of all functions. Instead a smaller, lighter, more efficient supply may be used that supports only a minimum set of simultaneous functions. In that case, power management circuits or processor algorithms may be used to manage how power is allocated to different functions of the product.

When the battery charger is an ancillary function for backup use only, it may not have access to full power supply current if other primary functions are in use. For example, it can take a considerable amount of energy to cause telephones to ring. Therefore, in order to ensure there is adequate power available for telephony service, a modem or gateway may throttle back the charging current or even completely disable the battery charger when there is an incoming call.

Similar conditional charging algorithms or power throttling options bay be available in other consumer products. Such user configurable options can have significant impacts on the energy efficiency of the battery charger system, and in-turn result in significant variation in battery charger efficiency test results.

Smart battery charging systems may not be operable when the product is not fully functional

Of the many different battery chemistry options available, lithium based batteries require the most sophisticated and carefully controlled charging regime. If a product has a replaceable battery, before charging can even begin, the battery charger system must identify and validate the battery. A product may be design to accept battery packs with a variety of charge capacities and/or charge rates. In some cases batteries may even have memory devices used for unique identification, tracking, and security. For modems and gateways, the customer is often given a choice of battery capacity and charge rate so they can choose the battery that best meets their needs.

Once the product identifies and validates the installed battery, the appropriate charge rate is determined. Especially for lithium-ion batteries, before charging can begin, the battery voltage must be measured to determine if it is within the safe charging range. If the battery voltage is too low (i.e., over-depleted), applying full charge current can cause thermal runaway and create a serious safety issue. Instead, the battery must first be charged with a very small conditioning current until it is within the predetermined safe voltage range. Once the battery is above the minimum voltage threshold, full charging current may be applied until it reaches an upper voltage threshold. Overcharging a lithium-ion battery can cause permanent cell damage, and possibly even instability resulting in safety issues. During active charging, lithium-ion battery chargers use a constant current/constant voltage regime. The constant current mode is used to bring the battery to a voltage just below the maximum cell voltage. During this constant current mode, the battery cell temperature must be carefully monitored to prevent overheating that could result from a defective battery or other environmental factor. Overheating the battery is not only a significant loss of energy in the form of heat, but it also can cause a serious safety issue. Once the battery voltage reaches the predetermined upper voltage threshold, the charger switches to a constant voltage mode to slowly and carefully bring the battery to the optimum cell voltage without exceeding the maximum voltage limit. The transition from the constant current mode to constant voltage mode is very important for both safety and efficiency of the battery charger system. Many battery charger systems use carefully controlled circuitry or silicon devices optimized for providing a smooth transition. All of the individual battery charger modes listed above typically have associated safety timers. If any of the modes run longer than expected, the battery charging function is terminated and the battery is determined to be defective.[9]

In addition to all of the battery identification, charge control, and safety monitoring functions mentioned above, batteries used for backup purposes must be checked to ensure they are "healthy" and have adequate energy storage capacity. Products with backup batteries carefully monitor and log all of the battery charger functions in order to calculate the actual battery capacity and overall battery health. This is important for lithium-ion batteries since a known physical property of the battery chemistry includes loss of available capacity over time. Typically lithium-ion batteries lose 18-20% of their capacity per year, regardless of use and charge cycles. Since modems and gateways are often design for an operational lifespan of at least 5 years, the battery will likely need to be replaced at least once during the product's life. Since modems and gateways use backup batteries to support emergency telephone use, it is important that they monitor battery "health" (i.e., capacity) and be able to provide notification when the battery can no longer meet the minimum required capacity. While this notification may be through a simple indicator to the user, these products often also include telemetry functions to notify the service provider that their customer needs a battery replacement.

There are many "off-the-shelf" semiconductor products that a manufacturer may use to safely charge a lithium-ion battery.[10] However, the sophisticated measuring and processing functions needed to calculate battery "health" and perform

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[9] The timers implemented in lithium-ion battery chargers are primarily for safety reasons. They also provide the added benefit of preventing the battery charger from wasting energy by continuously driving current into a battery.

[10] For example, Texas Instruments bq24296M (http://www.ti.com/product/bq24296m) or Linear Technology LTC4110 (http://www.linear.com/product/LTC4110).

alerting/telemetry functions exceeds the capabilities of "off-the-shelf" battery charger circuits. For modem and gateway products, carefully controlled charging algorithms, conditional charging modes, battery health management, and telemetry functions need to be incorporated into the main processor of the product. Consolidating all of these functions into the main processor is consistent with consumer product design trends fueled by increasingly powerful processors and the desire for reduced product size. As has been repeated stressed, continuous use products containing a battery for backup use are increasingly more integrated, with more functionality being performed by a system chip or chip set. As a result, there is no ability to "turn off" the rest of the product or chip and leave only the battery charging function for battery charger testing.

DOE's test procedure can and should be modified to work with continuous use products

As discussed above, continuous use products lack a power switch to turn off other functions during battery charger testing. Also, for products that contain batteries for backup use only, the battery charger function is an ancillary function that often cannot be isolated from the primary function. In order for the battery charger test procedure to be applicable independent of product functions, it should be modified to include a normalization process to extract the battery charger energy from the total product energy. This normalization process has been described in previous communications in this proceeding. We have included much of that same information in the following sections along with additional information to answer questions raised during our meeting with DOE.

Using normalization to measure battery charger active mode energy

Normalization is a measurement technique commonly used in electronics. This type of measurement may also be known as a reference or baseline measurement. The basic principle involves establishing a reference or baseline energy level before measuring the increased energy associated with a particular function. The reference energy value can be subtracted from the total combined energy value to calculate the individual energy value for the particular feature of interest.

For continuous use products containing a battery for backup use, the first step is to determine a stable operating condition that can be used to make the reference or baseline measurement. As discussed above, the primary functions of the device may have many configuration options and will likely have a significantly higher current draw than the battery charger system alone. The particular settings or operational modes used for the reference measurement may not be important. However, it is critical that the product is operating with a stable and/or predictable current draw. The recommended approach is to use the product in an "as-shipped" mode or "typical use" mode. The as-shipped mode is commonly understood in the industry and used in other test procedures. The typical use mode may be defined based on product marketing materials or the user manual.[11] It is important to note that some products require external connections in order to operate properly or in a stable condition. For example, modems and gateways are conditional access devices that are intended to be connected and provisioned on a service provider network. Without a properly established service provider network connection, the device may continually re-boot in attempt to establish a link on the network. Therefore, section 4.4 of the current test procedure should be modified to ensure that a test lab establishes external connections necessary to establish a stable or typical use operating state. As noted above, the exact settings for user configurable options likely do not matter as long as the product current draw is stable and/or predictable.

If the product has a removable battery, the battery should be removed while making the reference or baseline energy measurement. If the battery is not removable or cannot otherwise be disconnected, the reference energy measurement should be performed with a fully charged battery.

It is important to note that many products with backup batteries perform a battery integrity test soon after the first battery charge cycle. The battery integrity test is intended to ensure the battery is "healthy" and ready for emergency use. During the battery integrity test, the product may temporarily switch from the main power supply to the back-up battery, or it may run a subset of the product functions from the backup battery. Therefore, it is important that the reference or baseline measurement is taken when the battery is fully charged and idle (no load). Product documentation should be consulted to determine if and when a battery load test is performed, and how to avoid performing measurements during a battery load test.

After the reference or baseline measurement is obtained, the measurement should be repeated with a fully depleted battery. This second measurement will be a combination of the reference energy and the battery charger energy. Subtracting the reference energy from the combined energy will result in the energy associated with the battery charger system.

As discussed above, since the battery charger is not the primary function, there are several scenarios where primary functions may temporarily disable the battery charger or limit the energy available to the battery charger. Therefore, it is also important to ensure that the functional state chosen for the baseline measurement does not negatively impact the battery charger function. Again, product documentation should be consulted to determine what functional modes are appropriate to allow for full battery charging.

May not be able to measure battery charger maintenance mode current

For the reasons discussed below, the test procedure for maintenance mode should be eliminated. If DOE declines to do so, that test procedure should be modified.

For most, if not all battery chargers, the maintenance mode current is significantly lower than the active mode current. For continuous use products containing a battery for backup

[11] For a regulatory example of defining typical use, it may be helpful to consider the FCC Rule and Order for Implementation of the CVAA, CG docket 10-213, Document # 11-151, paragraphs 179-200.

use, the maintenance mode is likely too small for a normalization process to be effective. The difference between the primary functional current and the maintenance mode current may be different by several orders of magnitude. As a result, typical test equipment will not have enough resolution to accurately distinguish the added current from the battery charger maintenance mode. Hence, the test procedure for maintenance mode should be eliminated. If DOE declines to do so, in the case discussed above the maintenance mode current value should be set to zero. Therefore, in such eventuality, the test procedure should be modified to allow for the maintenance mode current value to be zero for continuous use products containing a battery for backup use.

There is a further reason to eliminate the test procedure for maintenance mode. Many continuous use products containing a battery for backup use are designed with lithium-ion batteries in order to maintain a small product size and low product weight. One of the distinguishing characteristics of lithium-ion batteries is that they have a very low self-discharge rate. In fact, many lithium-ion battery packs used in continuous use products have a self-discharge rate that is many orders of magnitude less than the rated battery current. Therefore, once a lithium-ion battery is fully charged, it can sit in an unloaded state for a long period of time (weeks, months, or years depending on capacity) before it needs to be recharged. For modems and gateways, the combination of a very low self-discharge rate and a relatively high battery capacity result in the battery charger circuit rarely needing to "top-up" the battery. In most parts of the country, power outages are a rare event. Due to the ~18% capacity loss per year described above, the battery integrity test is programmed to run on a periodic basis. As a result, these products do not actually need or have a maintenance mode as defined in the test procedure. Instead, once the battery is fully charged, the battery charger system will remain inactive until triggered by a power failure or the periodic battery integrity test. Therefore, continuous use products containing a battery for backup use do actually have zero maintenance current.

See also pages 13-14 herein for discussion on unwarranted burden related to testing, including maintenance mode, as well as related to standards.

Battery end-of-discharge voltage needs to be based on actual product functional characteristics

The end-of-discharge voltages shown in table 5.2 of the existing test procedure do not represent common industry practices for lithium-ion cells. Specifically, the end-of-discharge voltage of 2.5 V is below the typical used value of 3 V. [12] [13] Section 5.3 in the existing procedure defines a process where the product can be used to characterize the actual end-of-discharge voltage. However, this section current states that it is not applicable to lithium-ion batteries. It is critical that the product itself should be used to determine the

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[12] S. Dearborn, "Charging Li-ion Batteries for Maximum Run Times," *Power Electronics Mag.*, pp. 40-49, Apr. 2005. http://powerelectronics.com/site-files/powerelectronics.com/files/archive/powerelectronics.com/mag/504PET23.pdf.

[13] S. Keeping, "A Designer's Guide to Lithium Battery Charging," Digikey, Sept. 25, 2012. http://www.digikey.com/en/articles/techzone/2012/sep/a-designers-guide-to-lithium-battery-charging.

end-of-discharge voltage so that battery charger will function as expected in subsequent parts of the test procedure.

As discussed above, the battery charger system will not perform active mode charging when the battery voltage is below the minimum threshold programmed for the product. If the battery voltage is below the programmed minimum threshold, the battery charger will perform a pre-conditioning charge in attempt to bring the battery voltage up to the minimum threshold. There are safety timers that limit how long the charger will apply the pre-conditioning charge. If the battery is discharged too low or the pre-conditioning charge runs too long, the product may decide the battery is defective and the test technician will not be able to perform the rest of the test procedure.

The battery packs used in ARRIS modems and gateways are designed with a minimum voltage threshold of 3 V. The value of 2.5 V shown in table 5.2 of the existing test procedure is considerably lower than this programmed value of 3 V. Therefore, if a test technician follows the existing procedure and discharges the battery to 2.5 V they will likely not be able to proceed with the rest of the procedure.

Battery discharge rate needs to be based on actual product functional characteristics

The battery discharge rate shown in table 5.2 of the existing test procedure will likely exceed maximum discharge current for higher capacity batteries. For products that contain batteries for backup use, the battery capacity is based on needed run-time rather than expected discharge current. For example, a cable modem or gateway may have several options for battery capacity. Each battery pack is designed for the same maximum load current even though they have different battery capacity values. Since the current test procedures use a discharge rate based on battery capacity, larger battery capacities require a larger discharge current. The larger discharge current may exceed the maximum current supported by the battery.

To give a specific example, the battery packs designed for use with ARRIS Touchstone modems and gateways have a maximum output current rating of 1.6 A. Battery packs are available with capacity ratings ranging from 2200 mAH to 8800 mAH. Applying the 0.2C discharge rate to the 2200 mAH battery pack requires a 440 mA load. However, the same 0.2C discharge rate applied to the 8800 mAH battery pack requires a 1.76 A load. This will exceed the maximum output current rating of 1.6 A. Applying a load that exceeds the maximum output current will result in significant battery pack heating, which will reduce the overall measured battery energy. In addition, exceeding the maximum output current of the battery pack may cause the internal safety protection circuits to disable the battery pack.

For the above scenario, the battery discharge test procedure should be modified to determine the discharge rate based on the actual product functional characteristics. The proposed method would be to use the product itself to discharge the battery, and record the amount of time it takes for the product to cease operation. The battery discharge current can be calculated by simply dividing the battery capacity by the product run time.

It is important to note that product run time may be dependent on what product features are in use. If few features are in use, it could take over 24 hours to deplete a large capacity battery. Therefore, the test technician could be allowed to enable additional features in order to shorten this step of the test procedure. For example, a gateway or modem will discharge the battery faster if the connected phone(s) are in use.

It should also be noted that some gateways and modems may include functions to disable product functions after a set period of battery run time or when the battery falls below a set capacity level. For example, the Wi-Fi radio may be powered by the battery for a certain period of time and then disabled in order to ensure enough remaining battery capacity to provide emergency telephony service. Therefore, the actual product discharge current may not be a constant over time. Using the process above of dividing the battery capacity by the total run time will effectively result in an “average” load current. This is reasonable since the key point is to ensure that the discharge rate does not exceed the rated value for the battery pack.

Need to exclude power supply conversion energy

As DOE has clearly explained, the goal of this proceeding is to create measurement procedures that focus specifically on the efficiency of the battery charging function. The existing battery charger test procedure measures energy consumed during battery charger functions from the perspective of the primary power source. For continuous use products, the primary power source will usually be AC mains. In order to focus on battery charger efficiency measurement for continuous use products with a battery for backup use, the test procedures need to be modified to exclude the energy consumed in power supply conversion for product functions not related to the battery charger. For example, a product utilizing a power supply with multiple simultaneous voltage outputs will have higher overhead energy consumption. The battery charger function may only use a subset of the voltage outputs. The additional power supply overhead should be excluded from the battery charger efficiency measurements. The normalization process described above would also allow this additional power supply overhead to be excluded.

Continuous use products with a battery for backup use may be designed with an external power supply or an internal power supply. The power supply architecture employed in continuous use products will largely depend on the primary function(s) of the product. DOE has established test procedures and energy efficiency standards for external power supplies. As a result, products containing a battery charger system that use an external power supply will be subject to two sets of testing and potentially two sets of efficiency standards: First for the external power supply and second for the battery charger system. Allowing measurements to be performed at the connection point between the external power supply and the product would create a disadvantage and bias against products that incorporate an internal power supply. The normalization process described above would be an effective and universally applicable method for focusing measurement results on the battery charger system regardless of power supply design. The baseline power measurement would include the energy consumed by all functional modes and the conversion losses of the power supply. Subsequently, subtracting the baseline measurement from the combined measurement will would result in the desired and focused efficiency measurement for the battery charge function.

As previously explained, since the battery is for backup use only, the battery charger system is an ancillary function. Therefore, the power supply will be optimized to support the primary function of the product. The power for ancillary functions may be sourced through additional power supply capacity or carefully controlled power management systems. As DOE explains in the Technical Support Document for Battery Chargers and External Power Supplies (March 2012), power supply efficiency varies with the amount of output power. According to the current battery charger test procedures, the primary functions should be minimized when measuring the battery charger system. If this were possible in some products, minimizing or disabling primary functions will likely create a condition in which the power supply is operating in a low efficiency state, and cause an inaccurate battery charger efficiency measurement. If instead the product is operated according to typical use, then the power supply will be operating in the range of optimized efficiency. Once again, using a normalization method, as described above, would enable the product to be operated as intended while still enabling a narrowly focused efficiency measurement of the battery charger system.

Group products to reduce manufacturer test burden.

During our meeting, DOE asked if products could be grouped in order to reduce test burden for manufacturers. The need of communications equipment to support several options for connections and protocols leads to a large number of product models. When the communications equipment is designed for continuous use and contains a battery for backup use, it results in several product models with a common battery charger implementation, only differing by variations in the primary purpose. Using the normalization process described above would exclude the variation in communications ports and focus on the common battery charger implementation. Excluding the differences in communications ports to focus on the common battery charger implementation would also allow these products to meet the current definition of basic model (10 C.F.R. § 430.2):

> *Basic model* means all units of a given type of covered product (or class thereof) manufactured by one manufacturer, having the same primary energy source, and which have essentially identical electrical, physical, and functional characteristics that affect energy consumption, energy efficiency….

To give a specific example based on ARRIS products, battery pack BPB044S[14] can be used in Touchstone product families TM8, TG8, and TG16 (in addition to some older discontinued product families). Product families are differentiated by differences in network protocols or user features. For example, the TM8 family provides 1 Ethernet port and 2 VoIP ports. The TG8 family adds a built-in router with 3 more Ethernet ports and a Wi-Fi radio. Each product family is further broken down into several models based on consumer options. For example, the TG16 family is broken down into TG1662 and TG1672, where the latter adds support for MoCA in-home network protocol. Regardless of the differences between

[14] ARRIS battery pack model BPB044S is shown online as P/N: 790512 at http://www.arrismodemsite.com/.

families and models, the battery charger circuit is identical across the TM8, TG8, and TG16 product families. From a battery perspective, the only difference between product families and models is the load current due communications protocol differences and/or consumer options. Since the normalization process described above is able to isolate the battery charger current from the rest of the product functions, the battery charger efficiency measurements would be identical across the TM8, TG8, and TG16 product families. Therefore, it would definitely be possible and reasonable to group products based on common charger circuit design.

It is a common practice in industry to group products by common design implementations in order to reduce test burden. Product safety standards, such as UL 60950, require many design considerations and extensive safety testing for battery chargers. As a result, it is common to maintain a consistent battery charger design across product models and families so the safety testing only needs to be performed on one representative model. This saves both time and money for a manufacturer throughout design, manufacture, and support of products. DOE could use this same strategy to reduce test burden and costs for manufacturers.

A preemptive determination on efficiency standards is needed.

In the Notice of Data Availability, DOE asked if its analysis of battery charger energy efficiency standards needs to be revised. We strongly urge DOE to quickly move forward with establishing preemptive energy efficiency standards to prevent a patchwork of differing State regulations. This would include a preemptive determination that no standard is warranted in the case of continuous use products containing batteries for backup use. See 42 U.S.C. §§ 6295(o)(3)(B), 6295(u)(1)(E)(II).

Efficiency standards need to consider product function.

Further in this regard, when establishing efficiency standards, DOE needs to include consideration for product function. DOE has explained that its goal is to establish rules that focus exclusively on the efficiency of the battery charger function. The Technical Support Document for Battery Chargers and External Power Supplies explains how DOE developed an approach in which it makes UEC a function of battery energy. This approach can only work when battery charging is the sole function of the product, or when battery charging can truly be isolated from all other functions. In the case of continuous use products containing a battery for backup use, this approach will not work since the battery charger function cannot be isolated from the primary function(s). As described above, the primary function(s) of the product can have a significant impact on battery charger control, charge rate, and other characteristics, which can all affect the battery charger efficiency metric. Therefore, battery charger efficiency standards cannot be based on battery energy alone.

Backup battery systems have a very low number of charge cycles

As discussed above, continuous use products containing lithium-ion batteries for backup use typically have a very low number of charge cycles per year. For modems and gateways, the battery charger enters the active mode only after a power outage or a periodic battery capacity test. In some cases, products may only enter the active charge mode twice over the course of a year[15]. Since the maintenance mode and standby mode currents are zero, the annual energy consumption of the battery charger system is as low as two active charge cycles per year. This number is so low it should not warrant the extra burden and cost of regulatory testing and standards. See pages 8-9 above for further discussion.

Charging efficiency is already important for devices that use batteries for backup power

As discussed above, the battery charger system is not the primary function of products containing batteries for backup use. In these products, the battery charger system is an ancillary function and is limited in how much energy it can use. Therefore, the battery charger system must be designed to operate efficiently in order to ensure sufficient energy is available for the primary functions. This inherent efficiency supports a preemptive determination that no standard is warranted in the case of continuous use products containing a battery for backup use.

Products such as modems and gateways are often operated in areas with little to no air circulation. In addition, it is often important to the consumer that these devices have a relatively small physical size. This combination of low airflow and small size require that the electronics function as efficient as possible in order to limit the generation of heat. Again, since the battery charging system is an ancillary function it must operate efficiently to avoid wasted energy in the form of heat.

Including a backup battery in some consumer products not only provides consumer convenience and emergency readiness, but it also provides greater efficiency when compared to the alternative of using an external UPS. For an example, consider a VoIP modem powered by an external AC-to-DC power supply. If the modem did not have an internal backup battery, then an external UPS would be required. In the event of a power loss, the UPS functions by converting DC battery power to AC power. Then the power supply for the VoIP modem would convert that AC power back to DC power. Each of those conversions suffers from efficiency losses. Instead, by building the battery into the VoIP modem, the DC battery power is used directly by the modem circuits without the additional power conversion losses. This further supports a preemptive determination that no standard is justified in relation to continuous use products containing a battery for backup use.

[15] If there are no power outages and a product is configured to perform the battery integrity test every 6 months, there will only be two charge cycles in the course of the year.