Summary of Battery Charger Test Procedure Comments:

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This is a list of all comments received by Ecos Consulting and EPRI Solutions on draft 1 of the battery charger energy efficiency test procedure dated September 30, 2005. These comments were received between October 2005 and March 2006, including all comments received at the battery charger workshop held in California on November 17, 2005. These comments were compiled with funding from the California Energy Commission, contract # 500-04-030. For more information about the test procedure and other battery charger research conducted with California Public Interest Energy Research funds, please see www.efficientproducts.org.

1. Policy Landscape – Relationship of Existing Standards and Specifications to Energy Commission Plans for Future Battery Charger Standards

A. Stringency

Immediate concerns were raised about the consideration of the concerns of manufacturers in the development of a specification and whether the Energy Commission would adopt the voluntary ENERGY STAR battery charger specifications which are designed such that only 25% of devices qualify into a mandatory Commission, the result of which would prevent 75% of the market from sales in California.

A question was raised about how the scope of CEC battery charging efforts will differ from those of the EPA and ENERGY STAR.

B. Input not heard by the Commission when creating External Power Supply (EPS) standard

Some attendees were concerned that industry does not have enough input into policy creation for the External Power Supply Standard. “The last time we gave our input, our concerns were not heard.” (

2. Safety Considerations

Concern was raised that consideration might not be given to various types of devices that are bound by certain safety requirements (i.e. devices that, for safety reasons, do not currently qualify for EPS standard). Safety issues need to be considered. 60% to 70% of the products that are currently have on the shelves would not qualify with the new standards, in particular items requiring 4000-volt dielectric strength isolation from the mains. Switching power supplies cannot be used to meet this standard, we must use iron (transformer isolation). (Attendee) concurred with (Company) comments. Thinks it is representative of concerns of the industry.)

In testing items such as phones, secondary lines (phone line) should be connected to analyze for safety concerns.

Questions were raised about whether testing would go outside the bounds of UL specifications and whether the testing procedure would include testing batteries not designed to be tested with the battery charger in question. (See also Consistency with Existing Standards)

One attendee suggested an additional step in which the technician must confirm that the battery under test is recommended for use with the unit under test.

Questions arose regarding the dismantling of a device. It was suggested to include safety procedures regarding taking apart the batteries and to add a specific reference to existing safety procedure. Additionally there were questions specifically about dismantling devices with Li-Ion batteries.

3. Consistency with Existing Standards

Concerns were raised about the lack of reference to IEEE 1625 Livium Standards. The commenter suggested that Ecos Consulting research/ refer to the 2004 Livium Safety standards for concerns about how to declare to the safety issues that are delineated in their research. Manufacturers can "self" declare versus having "third party" testing. The ability of a manufacturer to self-declare is preferable to third party testing.

A commenter noted that there is a huge difference between the size and shape of batteries in how long the rest time should be between tests (USABC Procedures/BCI Procedures). It was noted that rather than specify resting periods, standard IEC recommended temperatures for discharge should be specified.

Questions were raised about whether testing would go outside the bounds of UL specifications and whether the testing procedure would include testing batteries not designed to be tested with the battery charger in question. (See also Safety Considerations)

It was noted that Ecos Consulting should ensure that the test procedure is consistent with existing test procedures developed by the Battery Council International and the United States Advanced Battery Consortium. Additionally, attendees advised that the test procedure should pursue approval of and use exact language from the IEC.

The testing should be specific to where it takes place and include global standards, based on where the product is shipped. Within IEC 62301, technicians should know what elements of testing are unnecessary.

A number of attendees supported the need to condition batteries as described in IEC standards. (See also General Battery Health/Battery Conditioning)

The test procedure should include consideration of the EMC/EMI/FCC standards as well as ANSI (perhaps it's ANSI 22, the commenter was not sure?)

"An example of a procedure for testing a traction battery with consideration of the vehicle operating cycle, charger algorithm, maintenance energy and standby energy for an on road electric vehicle can be found on the Idaho National Engineering Laboratory website at http://avt.inl.gov/fsev.shtml. A copy of the procedure is attached. Section 7 'Charging Efficiency' is similar in intent to the proposed approach. The procedure is part of a suite of tests run under the US Department of Energy's EVAmerica program for evaluation of advanced vehicles."

"How does the Draft Test Procedure relate to the California Energy Commission Title 20, Sections 1601 – 1608? Since Section Title 20, Section 1602 defines a 'single-voltage external AC to DC or AC to AC power supply' as a device that does not have a battery chemistry or type selector switch and an indicator light; or, does not have a battery chemistry or type selector switch and a state of charge meter, does this test procedure complement Title 20?"

"Section IV E (Lines 237 – 250) Industrial chargers operate at 480V 60Hz three-phase supply A reference to the standard industrial mains for each country should be added, example the USA of 240V, 208V – 3P,480 – 3P 60Hz."

"There is no reference to existing flooded-lead acid battery charger system standards. These standards have been developed and evolving as lead acid battery chemistries and charging technologies have changed. This history and experience should not be ignored. We suggest the CEC investigate the following existing standards:

1. Battery Council International (BCI) is the industry standards organization that publishes standards for Industrial Batteries and Chargers used in for Electric forklifts.

2. BCI-I-B-2, 'Determination of Capacity of Lead-Acid Industrial Storage Batteries for Motive Power Service' is the industries standard for measuring capacity and rating forklift truck batteries. The US industry uses the 6-hour rate to 1.70 volts per cell at 25°C.
3. BCI-I-B-4, 'Standard for Deep Cycle Batteries and Chargers' is the industry standard for forklift battery chargers and has a formula and requirement for calculating the charger cycle efficiency.
4. BCI also publishes standards for testing automotive and golf cart batteries.
5. There are other BCI standards that cover life testing and tests for battery components.
6. W-B-133E, Federal Specification Battery, Storage, Lead-Acid (Industrial Motive Power Service) is the Federal Specification for Forklift batteries. It recognizes BCI-IB-2 and other BCI standards as and part of the specification.
7. IEC 60254-1, 'Lead-Acid Traction Batteries – Part 1' is the general requirements and methods of tests for traction batteries. This is the international standard for forklift batteries and uses the 5-hour rate to 1.75 volts per cell at 30°C."

"Line 188, Section IV, Table A, Step 2 should refer to manufactures' recommendation or BCI standards for forklift truck batteries. Established industry standards for forklift truck batteries allow nameplate capacities to be established on or before cycle 10. We recommend documentation of the battery conditioning in this step."

4. Concerns about the Broadness of the Battery Charger Test Procedure

<u>A. General</u>

One attendee wondered if the test procedure had been developed such that it can be generalized for application on any device with battery chargers? (Is Ecos trying to develop it such that it could be used with UPSs, emergency egress lighting, electric vehicle charging, etc.?)

Concerns were raised about developing a test procedure, and possibly standards, that bind future products because they are based on current technology. The commenter suggested that the test procedure should be different for different products. Perhaps, the commenter suggested, there are some so different that they deserve different test procedures. He said that if the intent is to allow consumers to decide between products in the same category that it may not make sense to utilize a test procedure that groups all categories together.

Because this will likely lead to mandatory standards, an attendee said it should be more specific to products and cannot generalize. The commenter wondered what the point is of trying to use one test procedure for devices that are not compared to one another.

"It is understood that this standard does not set any performance limits at this time, but it is expected that California will establish mandatory requirements based on the standard. For this reason, the standard should make a clear distinction between a simple battery charging system (e.g. power drill) and a laptop computer."

"The scope indicates that the standard is intended to be used by policy makers to set regulatory limits. To reduce the chance of unintended consequences of policymakers setting 'one size fits all' limits, the scope of the standard should be restricted to simple charging systems. If this suggestion is unacceptable, at the very least the text of the standard should inform and educate policy makers of the limitations of a 'one size fits all' approach when applied to complex multifunction devices."

"I do not believe that industrial battery chargers intended to charge large lead acid batteries (for forklifts as an example) should be included in this test procedure. The test procedures are clearly set out in BCI standards covering chargers and batteries. These BCI standards are adhered to by the industry. Typical industrial battery chargers are designed to recharge 100% discharged batteries (discharged at the six hour rate) in eight hours. This is not always the case though. There are 80% rated chargers, there are chargers designed to fully charge in 10 hours, 12 hours etc. The industry has multiple input voltage chargers as well as multiple cell output chargers. It is my opinion that these industrial battery chargers are so different and diverse that they not be included in this standard."

"As (Trade Organization) has stated on several occasions, we believe it is extremely important, if not crucial to our industry, that there be a separate test procedure and standard within California Title 20 to deal with battery chargers. We do not believe these products should be tested to the External Power Supply test procedure nor be required to meet the standards applied to constant voltage power supplies. The appliance battery chargers are different, and should be tested in a different manner. Comments such as the one found on Line 267-268 of the Draft Test Procedure seem to indicate that there is such a thing as a separate battery charger and external power supply. This is not the case with appliance battery chargers. There is one battery charger.

While we appreciate that the scope of the CEC Battery Charger project may be larger than the one for EPA Energy Star program for appliance battery chargers, we believe it is important to not lose sight of the unique qualities of appliance battery chargers. These devices are mostly low power output (often less than 10 watts, with many less than 3 watts), constant current devices that are completely linked to the product they serve. It is not possible to look at the 'box' on the end of the power cord with the receptacle plug blades as a power supply and separate it for testing from the appliance. In our design world, these are all part of the total battery charging system. For this reason, we believe Ecos should consider having a general part of the test procedure with basic measuring techniques, but separate sections that are devoted to the measurement of appliance battery chargers, which may be distinct from those battery chargers serving emergency lighting, fork lifts, or golf carts. To use one test procedure for all different types of battery chargers is not appropriate.

It is important to recognize that certain types of appliance battery chargers have unique characteristics.

1. One example of this would be the so-called 'cord-cordless' appliances. These appliances use a battery charger for powering the product directly from the power cord if the battery is completely drained, or if the consumer wishes. This measurement has no relationship to a battery charger and this energy usage should not be measured. At other times the battery charger is used to recharge batteries. Because of the wide variety of these products, their usage, and time in both applications, we urge CEC and Ecos to exempt these products from the test procedure until an appropriate test procedure applicable to these products is written.
2. Another example of unique construction would be the inductive charge appliances. These appliances, because of the need to maintain safety near wet environments and cleanliness, need to charge without using metal contacts. These products charge by inductive current through the plastic appliance housing and should be exempt from regulations.
3. I know that the CEC wants to encompass all things, which have rechargeable batteries into one procedure, but due to the vast differences of products I do not think this is feasible. Except for our cord/cordless products (when running the product) all have a power output less than 2 watts. The circuit boards in these units are specifically designed to go with their charging adaptors. The trimmer/clipper and the adaptor are all part of a charging system. This is why we need to have a general section of the test procedure with basic measuring techniques, and separate sections for appliance battery chargers, forklifts, and golf carts, which are all different. To use one test procedure for all different types of battery chargers is not appropriate."

"(Company Name) continues to stress our view that industrial lead acid battery chargers should not be included in a 'one size fits all' testing procedure that covers charger output ranges from milliampere-hour to 2000 ampere hour and higher.

The draft procedure seems to be directed at consumer (residential & commercial) battery/charger systems and seems to have added industrial batteries/charger systems as an afterthought. This makes it very difficult to write a comprehensive procedure that adequately covers the details needed for such a broad spectrum of systems, applications, chemistries, and ratings. Cell phones, cordless phones, cordless power tools, laptop computers, cordless shavers, & rechargeable toys are similar consumer type applications and scale. The list expands to include emergency egress lighting and golf carts, which gets larger and starts to get into commercial. The scope then makes a dramatic jump in scale and complexity to include battery-powered forklifts. We see this as three distinct areas that require consideration of the applications, chemistries and existing standards to be included in the procedure."

B. Low Voltage Concerns

"As stated above all of our battery chargers operate at less than 2 watts of output power when charging the battery. I think we should exempt these low wattage appliances from the test procedure and regulations. Unfortunately, as the wattage becomes smaller, the amount of power consumed by rectification circuits (changing AC to DC) makes up a larger percentage of the overall power. In present configurations, and to meet consumer expectations, we cannot reduce this rectification energy significantly. In addition, I have spoken with manufacturers of 'switch mode' type chargers and they do not have chargers available for many of these low wattage products that we manufacture. If you look at catalogs with the switch mode supplies you will see that they all begin at 3 volts. This is because of the design it is hard to make less than 3 volts. Most of our products are 1.2 volts as they only have one battery. Therefore, we have a problem with too much voltage and as of this date we have not been able to properly size a switch mode supply for one battery so that it is efficient. If we are able to size one up we believe there will be little or no opportunity for energy savings and believe they should be exempt.

Many of the appliance battery chargers operate at less than 2 watts of output power. We suggest that Ecos and CEC exempt these low wattage appliances from the test procedure and regulations. Unfortunately, as the wattage becomes smaller, the amount of power consumed by rectification circuits (changing AC to DC) make up a large percentage of the overall power, but cannot be reduced significantly. In addition, the so-called 'switch mode' type chargers are not available for many of these low wattage products. The opportunity for savings is not present and these products should be exempt."

5. Multi-function Devices

There were discussions about chargers imbedded with other functions, i.e., radio/charger or phone with a base containing a clock, etc. One commenter sought clarification on how the battery-charging circuitry is separate from the functionality of the device. He said that when charging the battery, you're not using the devices as functional.

Functionality of the device. Concern was expressed that in multi-function devices that the on/off switch on the base unit does not disable additional functions of the unit.

Consideration should be given to the type of product the battery eventually powers.

"Another troubling element of the product scope is the inclusion of those products that may have a battery charger imbedded in them, but use utility power for other functions while charging. While the obvious example is cordless telephones, (Trade Organization) members produce a limited number of products where a convenience battery charger is incorporated into a larger product such that mains supplies both charging and the primary function. To assess this product as a charger is clearly inappropriate and these products should be excluded from coverage here in covered under methods intended to evaluate the efficiency of the primary function."

"Lines 289 to 291 located in Section V. Battery Charger System Requirements of your test procedure specifically states: 'Any optional functions controlled by the user and not associated with the battery charging process shall be turned off. If it is not possible to turn them off, they should be set to their lowest power-consuming mode during the test.' (Name of Company) believes that the basic function and the safety of the product would be penalized by this test requirement. Our test findings show that about 40% of the wattage is consumed from the battery charger alone. There is a separate transformer and power supply to power the digital radio, CD player, clock, 12 VDC auxiliary output, LCD screen and the ground fault circuit interrupter (GFI). There also is an energized relay coil that disconnects the radio from the battery pack when the ac plug is connected."

6. General Battery Health/Battery Conditioning

A number of attendees supported the need to condition batteries as described in IEC standards. (See also comments on standards consistency)

In addition to conditioning the battery, many felt it was important to determine how close the battery was to its rated capacity. Some had suggested that the battery not be more than 1% less than its rated capacity. This raised the question about whether a battery that tests at less than its full capacity is suffering from "bad health" or "bad marketing" and some wondered if one can still use capacity as denominator in an efficiency metric. Determining the overall health of a battery is especially important in lead acid batteries and in battery charging systems that do not come with batteries.

Questions arose as to *requirements* of the condition of the battery before testing. It was expressed that one should not simply assume that a battery is in good health and ideal condition before testing and that the test procedure should call out the need to ensure that the battery included as part of the system is as close as possible to its rated capacity.

One attendee suggested that the battery should be stable within 2% of previous discharge.

"Line 390, Section VII: US standards for forklift batteries allow up to 10 cycles for conditioning. See BCI-IB-2 and Federal Standard WB-133E. Since that is the standard that US manufacturers use. This protocol needs to consider this standard."

7. Test Procedure Details

<u>A. Test Procedure Overall</u>

An attendee wanted clarification on the general nature of the test as to whether it was more of a snapshot in time, or whether the intent is to represent cumulative consumption over a period of time.

Someone asked what the procedure would be if the capacity of the battery is not available. He then suggested that the test procedure should include language about what to do if the rated capacity of the batter is unavailable. Specifically he suggested stating "if available" in step 1 of #8.

Steps 1-10 in the section on reporting requirements should be connected or reference with step 1 of Table A.

Attendees wanted to know how the people making the standards would be measuring the devices? At one second intervals versus one minute? How it was measured should be documented.

One attendee commented that there seemed to be three features, each of which might be tested separately:

1. Stand by power and maintenance test
2. Battery charger interaction (check functionality)
3. Power conversion efficiency test

Another attendee stated that not all would agree that dividing out these three features would be best for all applications. The commenter replied that he did not want to include power conversion efficiency in the test and that manufacturers should be allowed to choose where they want to save energy.

Someone raised the question as to whether it was important to include power factor on devices that are prevalent in the residential sector.

"For the equipment listed in the proposed approach, many different batteries are used. Flooded lead acid, valve regulated lead acid and more recently lithium polymer. The round trip (charge/discharge) energy efficiency for these various battery types will vary significantly and, for all but the most inefficient battery chargers, dwarf the energy loss from the battery charger power electronics. Therefore, much more consideration must be given to the battery tested with the battery charger. It will not be sufficient, as specified in 'Battery Charger System Setup Requirements,' to select a battery that is 'most closely associated with the product.'"

"With ferroresonant traction battery chargers and with many SCR traction battery chargers with unsophisticated charge algorithms, each charge is provided with a full overcharge. For example whether 100 ampere-hours or 300 ampere-hours are returned on charge, at 15% overcharge will be delivered. For a 500 ampere-hour battery, this would result in 75 ampere-hours being lost to overcharge (no energy stored in the battery). If the battery is routinely discharged only 100 ampere-hours, then the charge efficiency is only 57% (100/175). If the battery is routinely discharged 300 ampere-hours, the charge efficiency is 80% (300/375). Therefore, the depth of discharge and rate of discharge for the "Battery Discharge Energy Test" should be specified to reflect the typical usage of the battery in the specific application being evaluated for the UUT."

"Line 188, Section IV, Table A includes a table that describes a test sequence, but the rest of the document does not follow this sequence. Procedures are not included in the rest of the document for some of the steps. The Equipment Needed column includes some equipment but does not include all the equipment and meters needed to collect the data described in the test procedures.

Line 188, section IV, Table A, Step 1: does this include any reading form the battery or is this time just to record the General information listed in line 456 to 465, section IX, General? If it requires readings, we could not find a procedure.

Line 202, Section IV, Paragraph B: A resolution of 1 watt is unrealistic for 1 to 30 KW chargers. If the test is going to include Industrial chargers it needs to have requirements for them.

Lines 194-209, Section IV, paragraph B: recommend including an AC watt-hour or Kilowatt-hour meter so the Work (Stored Energy) can be directly measured. These meters can also measure the consumed energy during the Maintenance and No battery test modes.

Lines 212-226, Section IV, paragraph C: I do not believe that the referenced IEC documents apply to testing high power equipment. The Energy Efficiency will depend on both the AC charger measurements and DC battery measurements yet the protocol allows a higher tolerance for the AC measurements than the DC measurements.

Line 231, Section IV, paragraph D calls for a room ambient of 23±5°C, while line 380 and 407 call for 20±5°C. US Industrial forklift batteries are usually rated at 25°C and are frequently used in ambient conditions between –25 and 45°C. Efficiency will vary significantly with temperature, but it is not practical to test all ranges.

Line 239, Section IV, Paragraph E: A 10 to 30 Kilowatt AC reference source that can maintain ±1% is extremely expensive. This is another example that shows it is not practical for one standard to cover this range of electrical equipment.

Line 248 & 249, Section IV, Table B: Here is another example where the procedure does not cover the requirements for industrial batteries and chargers. More than 60% of industrial forklift chargers operate on 3 phase high voltage sources. They are almost all multi-voltage units that can be connected to 208V, 240V, 277V, or 480V 3 phase sources. They frequently can charge different voltage batteries. In fact, some can even detect the voltage and size of the battery so that they can be used with many different size batteries in a facility. This flexibility feature is very desirable to the user. It is impractical to test all possible conditions."

B. Battery Charger System Setup Requirements

"Line 260, Section V: We do not recommend ignoring the manufacturer's instructions for charger system setup and preparation.

Line 266, Section V: New batteries will give the best efficiency and may be significantly different at end of life. I agree that this is the only practical way to control the testing, but manufactures are going to be running the test on different chargers using the same battery when ever possible. There are to many combinations to make the use of new batteries practical due to the expense of industrial batteries.

Line 289, Section V: Some optional functions are specifically designed to improve efficiency, power quality, and peek power to reduce energy cost. These functions should be used if normal default settings."

C. Standby/No Battery Mode

A question was raised about how exactly no battery mode is different from standby mode and might they be the same in some products.

One commenter requested that we add to the definitions the differences for Standby versus No- Battery modes.

A commenter was concerned about testing a battery charger in "no battery mode" because in separating the power supply from battery charging system, it would no longer represents a battery charging system.

There was a question about why power factor in no battery mode was important?

"(Trade Organization) members believe that all non-active modes of energy use (both stand-by mode and maintenance mode) should be collected and reported as a non-active power measurement for purposes of the test procedure, reporting or regulation. This approach will give manufacturers the ability to be flexible with solutions that meet their individual needs. The only important fact for consumers is the overall energy used/saved. Whether that comes in stand-by mode or maintenance mode is immaterial."

"We ask Ecos to consider using appropriate terms in some applications. A 'no-battery' mode is not the same as 'stand-by' mode."

"Test Procedure Line 305, contains an error. It would be inaccurate to state that all electric razors/shavers do not have a 'no-battery' condition. The test procedure needs to be re-configured to better approximate the full measurement of a both the no-load and battery maintenance conditions."

"(Company) supports the comments provided by (Trade Organization). We are writing to further emphasize our concerns regarding the procedure in line 305 of the test procedure. This line suggests that a 'No-battery mode test' should not always be used. We disagree. Our products are used in a variety of circumstances and conditions. At one time or another virtually all will have a 'no battery mode.' The test should be run but should reflect the time in such condition rather than establish arbitrary time periods for different modes. Usage of golf carts is entirely different than usage of shavers.

We manufacture trimmers and clippers and I can tell you that, the way our products are used, many do not have a 'no battery' situation. The test procedure needs to be re-drafted to better match the full measurement of both the no-load and battery maintenance conditions. I believe we need to have both of these measurements in case it is required for determining % efficiency of the battery charger. It is important to recognize that certain types of appliance battery chargers have unique applications.

One example of this would be 'cord-cordless' appliances. We manufacture these products and have tremendous experience with them. These appliances use a battery charger for recharging the battery or powering the product directly from the power cord/transformer if the battery is completely drained. The energy that is being used when it is powering the product (when the battery is dead) should not be used, as it has nothing to do with charging the battery. We need to make sure we address these situations in the test procedure and in some cases I think some should be exempt because there is not going to be any savings.

The procedure points out that the user should consider the energy use in no-battery and maintenance modes. We agree that these are useful factors and should be available to the user so they can be balanced against other factors. We believe that it is very important that customers are provided this information as independent factors instead of including them as a single, all-encompassing energy efficiency rating. Individual ratings will allow the user to balance the relative importance of these factors to their specific applications and needs. Also, this will give the user the ability to control the charger's use to address one, two, or all three of these efficiency factors based on the energy savings vs. operational effectiveness decision. Finally, we believe that these independent factors should be measured and reported as Power, not Energy, because the time period can often be controlled as needed which will allow the user to evaluate performance based on their specific application.

We recommend that your procedure have 4 separate outputs:

1. Recharge Energy Efficiency (%)
2. Average Power Factor (%)
3. Power draw in No-battery mode (appropriate unit of Watts)
4. Power draw in maintenance Mode (appropriate unit of Watts)

Section VI: We recommend that you add a requirement to check the manufacturer's instructions before running this test. This could be a safety issue."

D. Active Mode

"The test procedure attempts to assess active mode charging and runs into a variety of practical issues associated with measuring this energy separately from maintenance energy. For example, it is not always clear when active mode (along with equalization, etc.) has concluded. Combining active mode and maintenance mode into one measurement requires that the test procedure incorporate the appropriate use patterns into the measurement period. Theses and other issues can introduce an absolute error into the measurement that overwhelms the true efficiency. It should also be mentioned that chargers are generally most efficient during active mode charging. Active mode also lasts for much shorter periods than other modes for power tool chargers. Due to these reasons, we believe that the risk of inaccurate or inappropriate measurement is great and the benefit of including active mode is small. This analysis was corroborated by (attendee's) presentation during the workshop. Based upon this, the (Company) believes that active power should not be covered by the test procedure."

"The proposed Ecos test procedure calls for measurement of active mode, stand-by mode, and maintenance mode charging. We do not believe it is necessary to measure energy consumption of appliance battery chargers during active mode. For most types of appliance battery chargers, the active mode amount of energy is only 17-22% of the overall energy used in a 48 hour time period. For longer time periods, such as by week or month, the percentage is even smaller. The percentage of time spent in active mode is very dependent on the usage patterns and product category. For example, in a cordless vacuum cleaner, some use it for a few seconds to remove a few grains of sand or cereal, and others use it to clean a kitchen floor. The time spent in active mode varies widely with product type, usage patterns, type of home, presence of children or pets, whether there are one or more devices, etc. The active mode time intervals are widely varied. Measurement of this is unnecessary and would necessitate making judgments of the usage patterns and factors to equate the measurements."

E. Battery Discharge Energy Test

"I. General

Line 384, Section VII, number 4: What device or calculation method listed in this procedure provides the total 'energy extracted'? Is this the battery Analyzer listed in section IV, paragraph C?

II. Rates

There was a discussion about the use of the 0.2 C discharge rated for all devices and battery types instead of using industry standards that vary by device. Some thought it should vary by device, various battery manufacturers said that 0.2 C for a discharge rate is fine and that the standard focuses more importance on the end-of-discharge cutoff voltages.

After reviewing a few more VRLA battery specifications it appears there is flexibility in what specific discharge rate is selected. The British specifications, BS6290:4 calls out a C3 rate, or a 3-hour rate to 1.75 VPC. IEEE Std 1188 (Recommended Practice for Maintenance, Testing and Replacement of VRLA Batteries for Stationary Applications) does not specify a rate; rather, it recommends choosing a rate that is close to the rate the battery will actually see in the application. However, it does standardize on 1.75 VPC as the cutoff, as you guys have done. The bottom line is that the rate you folks chose (C2) is an acceptable rate and so far I've not seen anything that specifically argues against this rate.

Section VII (Lines 366 – 399). The proposed method is fine unless otherwise specified by the battery manufacturer for example: Industrial lead-acid batteries should be discharged at per the battery manufactures specification at a 6-hour rate with the end-of-discharge voltage of 1.7 V/cell as per BCI – I – 2 Standard.

III. Temperature

Line 379, Section VII: There appears to be inconsistency throughout this document regarding temperature parameters as evidenced by the temperature of 20°C in this paragraph and 23°. To make this more confusing, 25°C is specified in BCI-IB-2 (US forklift industry standard) and 30°C is specified in IEC forklift the standard. Again, existing industry standards need to be considered in this procedure. These are reasons why it is difficult to have one procedure for this diverse a spread of applications, chemistries and sizes.

IV. Discharge Rates and End of Discharge

Table C in the Battery Discharge Energy Test specifies 'end-of-discharge' for Lithium – Ion (Li-Ion) as 3.0 volts per cell. Can this be modified to read: 'Since the end-of-discharge varies, according to material, this value is left blank.'

The Battery Discharge Energy Test (Section VII.) requires a significant amount of measurements, bordering on unrealistic. Can the amount of measurements be decreased? Perhaps discharge capacity can be reported, instead of the large amount of measurements.

Line 388, Section VII, Table C: We are not aware of a 'battery chemistry' called Lead Acid (SLA). As stated previously, all batteries are vented to allow for gas ventilation. VRLA stands for Valve Regulated Lead Acid. US Forklift batteries are rated at the C6 rate to 1.70 volts per cell not the C5 rate to 1.75 volts per cell. Recommend a discharge rate of C6/6 (0.1667C6)."

F. Rest Period

Manufacturer should be allowed to determine how long the battery rests in between each test.

A commenter noted that there is a huge difference between the size and shape of batteries in how long the rest time should be between tests (USABC Procedures/ BCI Procedures). It was noted that rather than specify resting periods, standard IEC-recommended temperatures for discharge should be specified. (See also comments on standards consistency)

There were questions about how long a battery should be allowed to rest as well as the impact of the resting period after discharge.

"Line 188 Section IV, Table A, Step 4: It is important that the tests start at standard conditions so they are repeatable and comparable. Starting at different temperatures will drastically affect the out come of the test. Industry practice usually calls for 8 to 16 hours of cooling after a recharge before using the battery. Industry test procedures require that the battery to be cooled to room temperature before starting the test. The discharge capacity will also be affected if you do not allow the battery to cool to room temperature since you have not included a temperature correction factor.

Line 188, Section IV, Table A, step 6: This step can affect the charger test. A long rest will improve efficiency because of acid diffusion. A short rest will allow the battery to cool so that results can be compared to other results. A very long stand can damage the battery especially since the battery was fully discharged (100%). Industry practice is to immediately recharge the battery after discharge."

G. Charge Mode and Battery Maintenance Mode Test

"I. General

Line 419, Section VIII, number 5: The final power (Watts) draw might be interesting in evaluating the maintenance mode, but is not a unit of energy consumed (work) so it can not be directly related to efficiency. We suggest the protocol request a calculation or reading of energy consumed (Work) so that Energy efficiency can be determined."

A question was raised as to the inclusion of charging elements that may be part of the maintenance mode.

One attendee asked if one of the objectives of the test procedure development was to shorten the time compared to the EPA test procedure.

One attendee suggested that the initial charge times and the 'tested' charge times should be mirrored, i.e., 16 hours or 24 hours.

One attendee noted that there might be a skew based on how much time a device spends in each mode. He said that one could always extend the maintenance ratio and you've captured the charge time. These numbers, he noted, can then be used with duty cycle estimates.

One attendee asked if the objective was to get 4 hours of maintenance to highlight devices that are the 'losers' with respect to maintenance. He suggested that we might want a separate maintenance mode measurement of 4 hours.

"A significant energy loss is associated with battery overcharge during both normal and equalization charging. Based on (company's) experience with typical traction battery chargers (and their associated charge algorithm) typical overcharge for a flooded lead acid traction battery will be 6% to as much as 15% of nominal capacity. During equalization, the overcharge may be as much a 20% to 40% of nominal capacity. Batteries are typically equalized once per week. Therefore, with a 30% equalization overcharge, the average energy loss per charge cycle just for equalization is over 4%. Ignoring this as specified in the 'Charge Mode and Battery Maintenance Test' section will result in erroneously optimistic efficiency results."

"Is the related humidity requirement contained in standards and best practices in the Reference Section (II.)?"

"In the Charge Mode and Battery Maintenance Mode Test (Section VIII.), line 415, the term 'energy' should be described as 'power factor.' Section VIII requires a significant amount of measurements, bordering on unrealistic. Can the amount of measurements be decreased? Also, the length of the measurement period causes a unit under test (UUT) charge time to be short. A more suitable total charge would be over five hours. For example, a UUT with a reported charge time of one hour would actually be tested for six hours.

For the Reporting Requirements (Section IX.), lines 475 – 478, cause confusion due to the inconsistent use of the terms: battery voltage and cell voltage. Please rewrite consistently. Additionally, details on marking battery chargers and submitting the related data are needed to complete this section."

"Line 422 to 449, Section VIII, Charge Mode and Battery Maintenance Mode Test: We are unclear on why the protocol sets artificial time periods and tries to combine recharge and maintenance mode into one measurement. The power consumed in both periods is meaningful information that could be beneficial for users in making application or purchasing decisions."

II. Charge Time Too Short

There were a number of concerns about only performing the test over a 16 hour time period. Some devices, some suggested, would likely not have completed a charging cycle in that amount of time. Some attendees suggested increasing the test period to 24 hours.

A number of attendees suggested that to ensure a fully charged battery, it must be charged for a minimum of 24 hours. One suggested that the 'bulk charge' test be avoided entirely. He suggested that the test start with a fully charged battery to measure mostly the maintenance and no-battery tests.

One attendee commented that the procedure could suggest 24 hours but if the manufacturer agrees to a time that is less then it could be changed.

An attendee commented that the intent is to make sure the battery is fully charged

An attendee commented that the test procedure assumes an anticipated use pattern by setting a 16-hour charge period. He asked why shorter periods could not be used. Could they use EPA time period but include charge?

An attendee commented that you couldn't be sure that the battery reached its rated capacity within 16 hours. Some types of batteries require longer periods to actually reach full charge, so that maintenance mode would be underrepresented or not present at all in the energy calculation. He suggested either a 24-hour period or some way to separate the maintenance mode measurement.

"During the measurement of both no-load and maintenance power there are assumptions made regarding the ability to evaluate average power measured over short periods to the average power in actual use. We believe that these assumptions are generally inappropriate for power tool battery chargers. This may be even more of an issue when one considers that design innovations intended to reduce energy consumption are the likely outcome of the recent focus on battery charger efficiency and that these may employ long maintenance duty cycles to reduce consumption. A test procedure should not be insensitive to these innovations if they can benefit California's energy usage.

The test period for charging needs to be at least 24 hours. Again, this may be different for different types of battery charging products, but for appliance battery chargers, a time period of 24 hours will ensure that the battery is fully charged, and has stabilized and equalized all cells. Any less and it may be that you would be measuring other factors than maintenance or stand-by mode energy."

"Line 185, section IV, paragraph A indicates that the test can easily be completed in a 24 hour period, but the table that it refers to has the total test time as 40 hours. It is unlikely that you can run this test on a large industrial forklift battery in 40 hours and still have the battery at room temperature when the discharge step starts. If the Discharge test does not start at room temperature the results will not be useful in comparing to other tests. Forklift batteries have a very high thermal mass and do not cool to room temperature as fast as small cell phone batteries. It is important that the tests start at standard conditions so they are repeatable and comparable. This paragraph implies that the test is simple and does not require a lot of labor or expense. We disagree in the case of industrial forklift batteries and chargers. The equipment is very expensive because of the scale and power ratings needed, even if you do not include handling equipment. The test requires trained technicians and a lot of lab space and time. There are many different size batteries and chargers used in forklifts in California. EnerSys has over 8000 different batteries in 20 major types and over 200 different chargers using different technologies. We have most of the equipment needed for this test, but it is in all most constant use to develop new products, check the quality of existing products, investigate warranty claims, and pursuing customer requirements."

H. Testing at multiple voltages

An attendee commented that the description of how to test battery-charging systems that can charge multiple batteries of various types was confusing. He suggested that it be described electrically.

A number of attendees were concerned that if devices worked at more than one frequency and voltage, that efficiency testing would be required at all those frequencies and voltages – even those that would not be used in California.

One attendee asked, if the test included a variety of multi-voltage permutations, could one use the measurements to generate a weighted average? The attendee noted that the EPA test procedure allows for an option to use a weighted average of the products. He suggested that perhaps general-purpose batteries should be separated out from specific battery packs.

"As I pointed out along with others at the meeting the task that has been handed Ecos has been made very difficult due to the CEC's charge to develop only one test methodology to accommodate a very large range of product types. This large range of products all function very differently and have varying power in their charge, maintenance and standby operations. Just one example of a special charger design that is not properly addressed in the current test proposal would be a cordless power tool charger designed for one of our very popular 18 volt drills. This charger is designed to charge batteries at 7.2, 9.6, 12, 14.4 and 18 volts. This charger is purchased with an 18 volt drill and two 18 volt batteries. It can be argued that the charger would for the most part be used in the 18 volt charge mode. It could also be argued that the charger would be used in the 14.4 volt mode, the second most popular battery voltage design sold. Finally it could be concluded that the charger would only be used in the 7.2 volt charge mode a very small fraction of the time if at all. The 7.2 volt charging option is mainly offered as a convenience to our customers who have been using (company) products for a long time and still have some of the older 7.2 volt products in use. It is also true that in general our multi-voltage chargers are more efficient in the higher voltage battery range (18V) than in the lower voltage battery ranges (7.2 & 9.6). The current proposed test methodology takes the highest voltage battery and the lowest voltage battery and will calculate the energy efficiency and allow them to have equal weighting in determining the overall charger's efficiency. The equal weighting applied to the 7.2 volt battery is just not accurate because the charger will only be used in this mode about 1 to 2% of the time when compared to the 18 and 14.4 volt charging modes. As a manufacture, in order to pass the proposed testing, we may be forced to eliminate the" one charger design for all battery voltage types" by removing the ability to charge the lower voltage batteries such as 7.2 and 9.6 V. This change would then result in the development of an additional charger designed for the lower voltage batteries so that compliance to the CEC testing can be accomplished. Ultimately this would mean in the locations where the 18 volt batteries and the 7.2 or 9.6 batteries are still being used, there would now be 2 charger unites used instead of the one designed for all battery voltages."

I. Cooling

One attendee sought clarification about the use of external cooling of the unit under test.

J. Maximum and Minimum Capacity Tests

An attendee wanted to know what difference one hoped to capture by testing maximum and minimum batteries, instead of just maximum.

“Line 143, Section III, paragraph L is missing the time function defining the capacity. Capacity is the product of the discharge current and discharge length of time (hours). It is expressed in terms of ampere-hours (AH) or milliampere-hours (mAH) depending on the units of current. Even if you are defining the capacity in terms of work (released stored energy) you need to include the time period in the equation. In this case Measured Capacity would be the product of the discharge current (mA or Ampere), discharge period (hours), and the average battery voltage (volts) during the discharge. The units of work (stored energy) would be milliwatt hours (mWH) or Watt-Hours (WH) for small batteries. Forklift batteries are usually in Killowatt-hours (kWh). “

8. Field Conditions vs. Lab Conditions

<u>A. Considerations of consumer behavior</u>

A comment was made that a statement about how consumers treat batteries should be included to address the effects of consumer behavior, if only to acknowledge that they exist. The commenter suggested that Ecos Consulting include factors that might better represent real world scenarios.

<u>B. Duty Cycles and Loads</u>

An attendee questioned how well the test procedure would capture product differences that require different loads based on assumptions about the way the battery will ultimately be used by the product it is intended to power.

Concerns were expressed about how well the test procedure will include considerations for devices that may never reach a fully charged state, such as cordless phones; how will it take into consideration standby and maintenance modes?

Concerns were expressed about the ramifications of not considering the load of the devices. These loads may influence the design of the battery charging system, i.e. the charger-battery system may not operating under conditions for which it was designed, and the measured efficiency may therefore be significantly lower (or higher) than the system operating at the conditions for which it was designed.

“The proposed approach indicates applicability to electric vehicles, including golf carts and forklifts. In traction applications such as these, the energy lost (decreased efficiency) associated with the battery is typically many times the energy lost in the charger. Therefore, battery system efficiency testing should consider the method by which the battery is used and the algorithm by which it is charged. The efficiency test is more a test of the battery and charge algorithm efficiency than it is a test of the charger power conversion efficiency.”

“While (Trade Organization) members believe that the time period for most appliance battery chargers to remain in stand-by mode (also sometimes called no-load, or battery uncoupled mode) is very small. Nevertheless, because there is concern about the “stand-by energy” of these products, our industry agrees that it is proper to measure this amount of energy. However, it is extremely important to note that because there are significant differences in the amount of time that different products within CEC/PIER battery charger products, there should be a table assigned with values for the amount of time per week or per month that various products spend in stand-by mode, and apply this against any measurement to arrive at overall energy usage for regulatory purposes. If a cordless rechargeable vacuum has stand-by time of 3-4 minutes per month, it would seem unreasonable to equate this in regulations to a golf cart charger, which may see hours of stand-by time each day. “

9. EPA-California Energy Commission coordination

<u>A. Sharing data</u>

A question was raised about how Ecos Consulting will partner with Cadmus Group to share data to avoid duplication of efforts.

B. Consistency with EPA ENERGY STAR specification

"In general, (Name of Company) believes that the EPA approach represents an important method for assessing the energy efficiency of Battery Charging Systems for power tools and would hope that CEC would adopt this method. This would allow consistency in measurement between two closely related programs and avoid having manufacturers pursuing possibly conflicting objectives. While the Ecos test procedure was clearly written with an awareness of the EPA method, it is not clear why Ecos chose not to adopt the pre-existing EPA method.

For power tools it is highly recommended that the current test methodology that has already been developed by the EPA (Energy Star Battery Charging Systems (BCSs)) for appliances be considered. There have already been a large number of tests conducted and many of the problems identified during the research have been addressed. Using the BCS testing methodology would allow the CEC to address the appliance energy usage and set limits in a more expedient manner without additional testing. This would also free up Ecos to focus on the proper testing that would need to be developed and set limits for the many other categories being addressed by the CEC for efficient operation.

We feel that you should follow the Energy Star test procedure which excludes:

1. Inductively coupled devices used to transfer energy between two enclosures
2. Chargers with nameplate input power less than two watts and greater than 150 watts
3. Charging systems that draw additional power to support added functionality such as radios, CD players, and GFI AC outlets, e.g., (company) Power Box."

10. Application of Data within a Energy Commission Standard

"The current draft test procedure from Ecos Consulting does not explain how the data gathered in this test procedure would be used by the California Energy Commission to set regulatory requirements for battery chargers. It is difficult to react to a test procedure without understanding the outcome.

The test procedure makes no mention of how the resulting data is to be used in assessing the energy efficiency of products. It is difficult to assess the appropriateness of this or any test procedure when it not known how the data generated by that procedure is to be employed. It is also difficult to see how a procedure could be written without an intended purpose for the data. During the workshop it was mentioned that the data might be used along with field surveys to develop models for energy consumption of various products in residential environments. These surveys would be conducted over a long enough period of time (a week perhaps) to reflect consumers use patterns. Given this objective, there are shortcomings in how the data is collected and reported, most notably the relatively short collection periods and the clear differentiation between active mode energy and maintenance mode power. If the procedure is intended to produce a figure of merit by which various battery chargers may be compared, particularly for the purposes of regulation, then that figure of merit should be part of the procedure so that readers may assess how well the method supports this value. In any case, stakeholders are at a disadvantage when the purpose of the method is not revealed and the procedure does not benefit from their assessment of how well the method achieves its goals."

"The test procedure does not explain how the data gathered would be used by the California Energy Commission to set regulatory requirements for battery chargers. It would benefit us all to have this information while we are working on the procedure so that we include the right measurements and gather all the data needed to apply it."

"This test procedure provides a method to collect data that could be used to determine energy efficiency, but does not include a definition of energy efficiency or provide a method to calculate energy efficiency from the data. Without knowing how the data will be used to determine efficiency levels, it is impossible to comment on whether the data or methods of collecting the data are reasonable. Most of the data asked for in Section IX, lines 450-492 should be available as data, but would not be appropriate as stand alone measurements of efficiency."

11. General Comments/Questions

Some attendees expressed appreciation for the inclusion of industry concerns in the development of the test procedure.

Attendees asked if they could have access to data on their specific product and that any other product specific data not otherwise be shared.

Ecos Consulting was encouraged to consider the marketing rationale that supports decisions on which batteries to sell with a device.

An attendee asked that manufacturer names be removed from charts before any become publicly available.

Different sized batteries are offered as accessories. How would accessory batteries be covered under a battery charging test procedure and possible specification?

An attendee asked if the test was measuring *efficiencies* at one-minute intervals (rather than voltage and current or power levels). They were concerned that the efficiency might bounce around a lot and wondered whether one would take the optimal efficiency measurement over a one-minute interval.

Comparing the products on the basis of battery voltage instead of battery capacity is preferable once this process moves to a standard.

Does the Draft Test Procedure apply to certified manufacturers and certified (third party, or other) test facilities?

Line 106: Delete the “sealed” and just say “Lead Acid” so that both flooded and the valve-regulated batteries are covered.

Line 203: Add a resolution for instruments in 10kW+ power measurement range (e.g., 0.1kW or better).

Line 405: If equalization is user selectable then it should be switched on.

The Ecos Draft Test Procedure contains many definitions that are not used in the Test Procedure. We question why these terms are defined if not used.

We believe that the outcome of the test procedure should be an energy ratio.

Our goal as a manufacturer of forklift batteries and chargers is to develop and supply a broad line of products so that users can select the products that best meet their needs. Users of our batteries and chargers balance many factors when making purchasing decisions, such as the effectiveness of the charger to recharge the battery and extend battery life, service life of the battery and charger, system purchase and lifetime costs, speed of the recharge, “flexibility” of the charger not only to accommodate differing battery types but also differing charging environments, ease of use and automation of process, heating of battery, battery gassing and water usage, maintenance and reliability, AC input requirements, physical size and shape, power factor, power quality (THD), energy efficiency and costs. Energy efficiency is certainly one of these factors and should be available to guide the purchasing decision. The forklift industry has recognized this for many years and has a requirement to calculate efficiency as defined in the industrial charger standard (BCI-I-B-4).

Line 106, Section III, paragraph E refers to “Sealed Lead Acid” batteries as battery chemistry. All lead-acid batteries, including your referral to “Sealed Lead Acid” batteries have a pressure relief value so that gas is vented if the pressure is too high. The industry uses the term Valve Regulated Lead Acid (VRLA) so that users are not misled.

The use of a total of 16 hours of charging time or 5 hours longer than recommend charging time seems reasonable enough to capture both recharge efficiency and maintenance mode data when the charging algorithm is unknown or the charger does not automatically terminate. Averaging the power usage during the last 4 hours also seems reasonable to capture maintenance mode power usage if the power usage is stable, but would not work for some forklift chargers since they turn back on every periodically to refresh the battery. This procedure should be flexible enough to allow the recharge efficiency to be measured independently when the charger is automatic and then continued to measure average power usage in maintenance mode. In both cases the tests should be long enough to capture any normally programmed algorithms if the algorithms are known. An artificial time limit would not be needed in this case as long as the test time is adjusted to provide the total average, and the charging times for both tests are documented.

We suggest you include in your Test Output the following:

1. % Recharge Energy Efficiency= (DC Energy returned to the battery * 100)/AC Energy used by the charger during the recharge).
2. Total recharge time in hours.
3. Average Power consumed in Watts during maintenance mode
4. Length of maintenance mode test in hours.