Response to Battery Charger Test Procedure Comments Received for 45-Day Language

Submitted to:
California Energy Commission
In consideration for the 2008 Rulemaking Proceeding on Appliance Efficiency Regulations, Docket number 08- AAER-1B

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1 Response to ETEC's Kevin Morrow's Comments October 15, 2008

Enumerated below are comments from ETEC on part 2 of the California battery charger test procedure. Below each comment is a response and recommended action (*in italics*). The changes recommended below will be included in version 2.2 of the test procedure.

1.1 Standard Test Conditions & Measuring Equipment

The note should be more specific about state-of-health determination. The USABC procedures require a test plan development and series of extensive tests to determine battery performance and state-of-health. This seems unnecessarily complex to simply validate battery performance to support a charger test.

***RESPONSE**: State of health procedures found in BCIS-14 are relatively simple to perform. We agree that USABC procedure is overly burdensome for this test.*

***RECOMMENDED ACTION**: We suggest changing the test procedure to eliminate the reference to USABC and instead reference only BCIS-14 for state of health determination. We may need to specify within the test procedure electrolyte temperature and discharge rate specific for golf-cart applications not provided in BCIS-14.*

1.2 Charger/Battery Selection and Qualifications

Selection of the battery for charger testing should be at the discretion of the agency requesting the test, with test documentation clearly identifying the test configuration.

***RESPONSE**: The test procedure is not meant to evaluate the performance of the charger with a specific battery, but rather to evaluate the performance of the charger with a range of batteries that could be employed with the charger. The current approach, to specify that the highest and lowest capacity battery be tested for each charger sufficiently binds the range of efficiencies that the charger could experience in the field without overburdening the manufacturer with tests with each battery.*

***RECOMMENDED ACTION**: No change*

As most charging inefficiency results from equalization, simply verifying that [equalization] meets "manufacturer requirements" is not adequate to ensure representative results.

***RESPONSE**: Our testing and research indicate that the most important opportunity to improve efficiency is during the charge cycle. Many chargers do not ensure that the charge cycle efficiency is consistent regardless of the depth of discharge of the battery. We acknowledge that energy used for equalization does not produce useful work in the device it is intended to power, however equalization is required for battery health.*

This procedure does not evaluate the efficiency of the equalization cycle because it is generally a small component of the battery charger's duty cycle. In addition, there is a market driver to minimize the energy used during this operation. Excessive equalization not only wastes energy, it also reduces battery life, forcing industrial managers to replace batteries more frequently.

***RECOMMENDED ACTION**: No change*

1.3 Test Procedure: Battery Discharge/Recharge Sequence

It is not clear what "fully discharged" means. Is this 100% DOD? If so, this is not appropriate for VRLA batteries. Additionally, only 40% DOD and 80% DOD are discussed in Section 1, Battery Discharge.

***RESPONSE**: Fully discharged means that the battery is discharged to 100% DOD. As indicated in the procedure, 100% DOD is defined as the end-of-discharge cell voltage as given in Table D, Section III, F, which contains the appropriate voltage for VRLA cells.*
Section 1 requires discharges down to 40% DOD, 80% DOD and 100% DOD.

We agree that repeatedly discharging a VRLA battery to 100% DOD will shorten its life, but the few cycles that are applied throughout this procedure will not have measurable impact on battery life. This 100% DOD is necessary in the procedure because it is the only accurate method to determine its actual energy capacity.

***RECOMMENDED ACTION**: We suggest providing some clarification by inserting "(100% DOD)" after "fully discharged" in the procedure.*

This procedure requires that equalization be disabled. As equalization is the greatest contributor to charging inefficiency it is not appropriate to ignore this. Further, it is very easy for manufacturers to under equalize for purposes of testing in order to document a greater efficiency than is achievable on a sustainable basis in the field. To be accurate and realistic, testing should involve the equivalent of one week of battery charge/discharge to include full charges and equalization.

***RESPONSE**: The test procedure does not measure or characterize the performance of the equalization cycle of the battery charger. The procedure*

requires that equalization be performed on the battery used in the test during the conditioning cycles. The equalization of the battery helps to ensure the battery is in its best health and minimizes the effects of the battery on the measured performance of the charger under test. Under equalization or not properly equalizing the battery during the conditioning cycles of the test procedure will have detrimental effects if any on the observed battery charger efficiency; thus, under equalizing the battery during the conditioning cycles is not in the manufacture's best interest. For additional information on this topic see second response to 1.2 above.

***RECOMMENDED ACTION**: No change*

1.4 Reporting Requirements

Several parameters that precisely define the charge algorithm should be included in the required documentation. It is far too easy to test with an algorithm that sacrifices battery life for efficiency, then switch back to a more realistic algorithm for actual field use.

***RESPONSE**: Tested chargers should be production models – not tweaked engineering samples where the algorithms are easily modified. Nevertheless, we agree clarity on this issue in the test set up section of the procedure is appropriate to avoid testing fraud. In addition, there are some products that enable the user to select a charge profile based on the battery chemistry that is employed in the field. We realize that it is important to ensure that the charger is efficient during all these charge profiles.*

***RECOMMENDED ACTION**: We suggest changing the battery selection protocol to require that each charge profile be tested with the highest and lowest capacity batteries. This would mean that a charger with 2 charge chemistry profiles meant for a range battery capacities would be tested in 4 different configurations.*

2 Response to EnerSys' Stephen Spaar's Comments September 15, 2008

Enumerated below are comments from EnerSys on part 2 of the California battery charger test procedure. Below each comment is a response and recommended action (*in italics*). The changes recommended below will be included in version 2.2 of the test procedure.

2.1 References

Battery Council International, Standard for Deep Cycle Fast/Battery Chargers, BCIS-18 Rev. 2006-04 was not sited as a reference. We recommend reviewing this document which includes industry accepted standards on industrial charger efficiency.

***RESPONSE**: BCIS-18 is a comprehensive document and good reference for charger manufacturers. The document does not actually have standards for charger efficiency, but the mathematical method for calculating power conversion efficiency is the same as in our Part 2.*

***RECOMMENDED ACTION**: We suggest modifying the test procedure references list to include this method.*

2.2 Definitions

The definition refers to the "rated charge capacity of the battery". Charge capacity of batteries is not an accurate description of the battery's capacity rating and will lead to confusion due to the use of Charge in many different contexts in the document. A battery is rated according to the amount of amperes over a standard number of hours. We suggest the term "charge capacity" be replaced with "rated capacity". This change should be implemented throughout the document wherever "charge capacity" is referred to in relation to the battery's rated capacity.

***RESPONSE**: The term "Rated Charge Capacity" is used to differentiate the rated capacity of the battery expressed in ampere-hours with the "Rated Energy Capacity" expressed in watt-hours. Both "Rated Charge Capacity" and "Rated Energy Capacity" are contained in the definitions section of the document to avoid confusion.*

***RECOMMENDED ACTION**: We understand that these terms are not normally employed and may be unfamiliar to technicians. We suggest changing the test procedure to format these terms in a way that draws the attention to the reader and reminds them to refer to the definitions list.*

We are concerned that the example used to explain how to determine C rate may lead the reader to conclude that "one -C" is the accepted or common discharge batteries. Also, the definition given in the Definitions section conflict with the use of the C rate under III Test Procedure Part 2, C, 1), which includes references to discharge rates of "C_6/6 for lift truck batteries and C_5/5 for golf cart-type batteries".

We recommend using the industry accepted standard for depicting the charge and discharge rates of batteries by placing the charge, rating before the "C"

and indicating the discharge rating by using a subscript after the "C". thus a charge rate of 20% with a discharge rating of 6 hours would be written "0.2C6". We also recommend using this example and not the "one-C" currently used to explain the determination of C rate in the Definitions.

***RESPONSE**: There are a variety of methods used to express discharge rates, with advantages to each. Because we specifiy discharge rates other than "one-C," for the tests themselves, we believe there is little risk that the technician conducting the test could potentially use the incorrect discharge rate. We chose the method shown because the standard discharge rate for a lift truck battery is 6 hours. The discharge current is commonly expressed as a fraction of the capacity at a particular rate (as in $C_6/6$). Using a decimal number in place of a fraction would be impractical for that discharge rate (0.1666666C6).*

***RECOMMENDED ACTION**: No change*

2.3 Equalization

The use of the word "optimum" can imply many different conditions. We suggest the word "optimum" be replaced by "normal" or "full".

***RESPONSE**: We agree.*

***RECOMMENDED ACTION**: "Optimum" should be replaced by "normal" in the procedure.*

2.4 Equalization

Please include the acronym Ah to refer to ampere-hours. This is an industry accepted acronym and should be used throughout this document.

***RESPONSE**: Agreed.*

***RECOMMENDED ACTION**: We suggest inserting "Ah" in the document where appropriate.*

2.5 Rated Energy Capacity

The definition indicates the use of a "rated battery voltage". Using the rated battery voltage will give an inflated energy capacity rating for the battery because over the course of battery discharge, the voltage can range from 2.11 volts per cell to 1.7 volts per cell when fully discharged. The rated voltage for a Lead Acid battery is 2 volts per cell. Since the voltage is below the rated voltage for most of a discharge and varies greatly depending on discharge rate

and time duration the rated capacity is usually given in terms of average discharge voltage for the rate.

***RESPONSE**: The term “rated energy capacity” is not used for any efficiency calculations or determinations in the procedure. Its purpose is to provide a “rule of thumb” for the technician to estimate the expected energy capacity of the battery during the discharge test in the procedure. We agree that the nomenclature on this is inappropriate because the “energy capacity” is not provided by the manufacturer.*

***RECOMMENDED ACTION**: We suggest the definition remain, but should be called “Calculated Energy Capacity” instead of “rated energy capacity”.*

2.6 Standard Test Conditions

Please clarify the term "cycle" used in this reference. Does this mean 128 samples per frequency cycle or a charging cycle?

***RESPONSE**: For AC power measuring, the term “cycle” refers to one 60 Hz sine wave.*

***RECOMMENDED ACTION**: Clarification should be provided in the test procedure.*

2.7 Battery Data

We recommend taking specific gravity readings at start and finish of discharge. This will confirm the state of charge of the battery prior to beginning the recharge cycle.

***RESPONSE**: We agree this is necessary and these data points are already included. Specific gravity readings are taken after the discharge (Section II-D) and after the charge (Section III-C-2). This confirms the state of charge at both positions.*

***RECOMMENDED ACTION**: No change*

2.8 Battery Discharge/Recharge Sequence

A fully discharged (100% DOD) is not a recommended practice by any battery manufacturer and is not a common practice. Discharging a battery to 100% DOD on a consistent basis will quickly cause irreversible damage to the battery and significantly shorten the cycle life of the battery.

Discharging to final voltage will also add inconsistency to the results because the battery condition will be more of a factor on the results since the Ah's removed during the discharge will be different. In order to provide practical results from this test standard, we recommend using 20%, 50% and 80% for the three levels of battery discharge. Using these levels will assure that every test has the same Ah's removed prior to recharge also significantly reduce the testing time required to recharge the battery, and preserve the test battery in good condition throughout the entire testing tenn.

***RESPONSE**: The conditioning cycles required by the test procedure help to ensure that the battery used in the test is in good condition. A battery that is in good health can be expected to perform in a predicable way during the test procedure, thus providing consistency. We have carefully considered the impacts of the battery used in the test on the measured battery charger performance during the development of the test procedure, and that is why we included a requirement for battery conditioning. With a properly conditioned battery, including an equalization cycle, the 100% DOD test is a usable and useful in characterizing battery charger performance. The procedure also requires that the charge test being with 24 hours of the last conditioning cycle concluding, which helps ensure the battery is healthy when the charge test are performed.*

The procedure requires that a battery be discharged to 100% DOD only one time during the test procedure. This 100% DOD is necessary in the procedure because it is the only accurate method to determine its actual energy capacity, which is a critical metric for characterizing battery charger performance. For additional information see response in section 1.3.

***RECOMMENDED ACTION**: No change*

The use of the terminology "measured battery capacity" is inconsistent with the terminology used in the definitions section of this document and incorrect. It should be 40% of rated capacity since it should be based on rating not measured. We recommend for both bullets within this section, "measured charge capacity" should be replaced with the previously defined "Rated capacity". Also, the bullets indicate the battery voltage readings can be determined by "voltage reading on the vehicle gauge". Since the test procedures under C{l) Battery Discharge indicate the use of a battery cycler or load bank, the use of a vehicle gauge is not practical or consistent.

***RESPONSE**: We agree there is inconsistent nomenclature regarding the definition of "measured capacity", but believe the discharge should be based on measured, not rated. Since the actual (measured in the qualification test) battery capacity might be as low as 80% of the rated capacity (The battery must be in a state of condition to provide a minimum of 80% of nameplate capacity at*

the nominal rate in order to be used in this test) it is required to use the measured battery capacity to perform the battery discharge sequence (Section III-C-1). Otherwise, the discharge state would be inconsistent from battery to battery, depending on its health.

We agree the use of a vehicle gauge should not be allowed. This was an artifact of previously removed drive test provisions.

***RECOMMENDED ACTION**: The definitions should be changed to indicate "measured charge capacity" as this is more consistent with "rated charge capacity" used elsewhere. The reference to vehicle gauge as an appropriate measuring mechanism should be removed.*

By defining the precise intervals of 5 minutes, one hour, three hours and five hours for recording the AC and DC power, power factor, current THD, and voltage THD, a manufacturer could develop charge firmware that could change the charge power during these intervals and artificially improve the results for their charge. Also, some chargers will emit a higher DC charge pulse lasting milliseconds throughout the charge cycle. These pulses are used for diagnostic purposes and improve the charger's energy efficiency by limiting the overcharging of batteries. If a reading is taken coincident with this DC pulse, a high DC KW data point will be measured which will result in a poor power conversion efficiency based on the given definition of Power Conversion Efficiency provided earlier In this document. We recommend taking these readings at one minute intervals during the entire charge cycle. This will allow for a more relevant "average" power conversion efficiency, power factor, and THD, which has much more impact on the end-users electric bill.

***RESPONSE**: We agree with your concerns raised in this comment, and originally proposed the current solution to easily enable data recording in a template. It is clear that the drawbacks of the current approach outweigh the benefits.*

***RECOMMENDED ACTION**: Most of the equipment will actually be monitoring the circuit continuously and automatically recording these data at one minute intervals. We suggest modifying this data recording process so that the specific intervals recorded in the data sheet will be based on the maximum power drawn over the course of the test. So, the technician will have the equipment automatically record the data at one-minute intervals and then retrospectively identify which data points to record based on a set of criteria that ensures power stability and is based on the maximum power recorded during the testing period.*

The updated procedure to ensure power stability, prior to reporting a performance point, will be explicitly detailed to enable the technician to distinguish between pulse phenomena and a point representative of the

charger's operational power. The updated procedure requires that the data point selected for reporting be within 4% of the adjacent data points. This will eliminate the possibility of a pulse phenomena being reported as the maximum operational power during charging.

2.9 Measurement of DC Current

Measurement of DC current below 2% of the battery's rated capacity to verify a complete recharge is not realistic. Many charge algorithms will stop charging prior to this level of DC current output.

***RESPONSE**: If the charger has stopped, the monitored current should be around zero and is therefore below 2% of the battery's rated capacity. Going to zero current enables the technician to verify complete recharge.*

***RECOMMENDED ACTION**: No change*

2.10 Reporting requirements

For reasons provided in our comments under Part 2, Section III, 2) above, we recommend using average conversion efficiency.

***RESPONSE**: This section needs clarification. The updated test procedure will require reporting of the charger's conversion efficiency performance at three different levels: minimum power, median power, and maximum power. A charger's conversion efficiency is likely to fluctuate throughout it's charge cycle, and with the updated test procedure the reported conversion efficiency will provide better resolution of the performance of the battery charger than the average conversion efficiency is able to provide.*

***RECOMMENDED ACTION**: We suggest revisiting the wording in this section to clarify the measurement and reporting of the benchmark performance values.*

2.11 Power conversion efficiency

The statement "In general, the power conversion efficiency should be relatively constant throughout the charge" is incorrect. We have demonstrated in all technologies used in industrial applications that conversion efficiencies across the charge cycle can vary by 10 points or more.

***RESPONSE**: We agree.*

***RECOMMENDED ACTION**: This statement should be removed.*

2.12 Power factor

Power Factor definition is inconsistent with definition of Power Factor under Definitions.

***RESPONSE**: Power factor is the ratio of total active power to the apparent power. This definition is redundant*

***RECOMMENDED ACTION**: The definition of power factor in this section should be removed.*

3 Response to Jonathan Wexler's Comments October 30, 2008

Enumerated below are comments from Jonathan Wexler on part 2 of version 2.1.4 of the California battery charger test procedure. Below each comment is a response and recommended action (*in italics*). The changes recommended below will be included in **version 2.2** of the test procedure.

3.1 General Structure

1. Test procedure is difficult to follow. Provide outline of TP at the beginning of the preparation section rather than afterwards.

***RESPONSE**: Good suggestion – it would make Part 2 easier to follow.*

***RECOMMENDED ACTION**: We suggest placing an outline of the test procedure at the beginning of the preparation section.*

2. Minimum "recommended" test data is in conflict with what is reported under section IV and what is actually required to be measured through inline instructions in section III.C, III.D, and III.E. Remove section II.B,

"Test Data" or revise section II.B using sections III.C, III.D, III.E, and IV as guides.

***RESPONSE**: Good suggestion – it would make Part 2 easier to follow.*

***RECOMMENDED ACTION**: This should be clarified by explicitly listing what is required in each section of the procedure, eliminating the word recommended, and just listing the required data.*

3. Not always clear why optional items are not required, or how they help in the testing.

Overall, too many optional clauses are included in the testing, giving the impression that much of the testing is optional. E.g., “the ambient environment should be maintained between 18^{o}C and 27^{o}C” (emphasis added).

Clearly differentiate between required procedures, equipment, conditions, measurements and reported data and recommended procedures, equipment and measurements. Clearly indicate the value or function of the recommended additions.

RESPONSE*: Agreed – recommended procedure and test data will be eliminated from the test procedure.*

RECOMMENDED ACTION*: The procedure should be modified to include only required procedures and data acquisition protocols.*

3.2 Measurement Equipment

I. List of measurement equipment is vague. Provide minimum list of required equipment, not recommended equipment. If additional equipment is recommended, clearly indicate the function of the equipment.

RESPONSE*: Agreed – only the required list of equipment will be listed.*

RECOMMENDED ACTION*: The procedure should be modified to only list required equipment.*

2. Unclear whether barometer and hygrometer are used. Include equipment in list only if explicitly used in test procedure. Test procedure requires measurement—but not reporting—of “ambient conditions”, but does not specify how the results of these measurements are to be used.

Furthermore, it is unclear what impact atmospheric conditions have on efficiency. It would be sufficient to record the altitude of the test site, which would determine the typical air density and the cooling effectiveness.

RESPONSE*: Having recorded the ambient conditions during the test procedure may help identify the cause of any anomalies in the test results. The updated test procedure requires temperature to be reported.*

RECOMMENDED ACTION*: The procedure should be modified to only list required equipment. The procedure should be modified to state that temperature is required to be recorded and reported.*

3. What does “AC current measurement (for verification only)” mean?

Remove from list of measurement equipment or replace with an associated measurement device. Clearly indicate in the test procedure when and where the measurement must be taken and how it is to be reported.

***RESPONSE**: Agreed*

***RECOMMENDED ACTION**: The "AC current measurement (for verification only)" item should be removed from the test procedure. The procedure should be clarified and reorganized to clearly identify what measurements are required to be made, how, and where they shall be reported.*

4. "It is recommended that equipment be calibrated…"

Require that equipment be calibrated.

***RESPONSE**: Agreed*

***RECOMMENDED ACTION**: We suggest making the requisite change requiring equipment to be calibrated.*

5. "…associated uncertainty less than or equal to 1%"

Insert confidence level for uncertainty requirement (e.g., one or two std. dev.)

***RESPONSE**: The wording needs some clarification. The intent of this section of the test procedure is to state the required parameters for calibrated measuring equipment. The references to uncertainty requirements pertain to the equipments' ability to precisely and accurately measure data. The reference to confidence level can be confusing, because this metric is often associated with quantifying statistical significance of a relatively small sample size of a much larger set of data. In the case of electrical measurements uncertainty is a more useful metric for specifying the performance of a piece of equipment.*

***RECOMMENDED ACTION**: We suggest eliminating the confidence level statement in Part 1 of the test procedure to harmonize with the approach taken in Part 2. We suggest clarifying the language in this section to make it more clear that these requirements are for equipment not the test procedure*

6. "Total measurement uncertainty should be calculated according to standard methods."

Explicitly list method (i.e., root sum square of uncertainty).

***RESPONSE**: Uncertainty in the sense that it is being used in this test procedure pertains to the equipment used to take measurements and is a function of the equipment's calibration. It is not necessary for the technician*

performing the test to calculate the uncertainty of the measurements made by the test equipment rather, it is the technician's responsibility to verify that the equipment is calibrated to operate within the required limits of uncertainty

***RECOMMENDED ACTION**: We suggest eliminating the reference to a preferred method of calculating uncertainty.*

7. Total uncertainty requirement is absent.

Uncertainty requirement only applies to individual pieces of measurement equipment—add requirement for uncertainty of entire test setup (e.g., ≤ 2%, as on p. 11 of Part 1 of TP)

***RESPONSE**: Agreed.*

***RECOMMENDED ACTION**: We suggest making the requisite change to procedure stating uncertainty requirement for total test setup be ≤ 2%.*

8. Recommended ambient temperature for Part 1 differs from that for Part 2.

Consider harmonizing ambient temperature with that specified in Part 1.

***RESPONSE**: The ambient conditions in Part 2 are developed from standards for industrial equipment and do not necessarily pertain to conditions associated with consumer electronics. It is highly unlikely that entities performing Part 2 of the test procedure will also be performing tests under Part 1.*

***RECOMMENDED ACTION**: No change*

3.3 Test Conditions and Setup

1. Unclear where to measure AC source THD, voltage, and frequency.

Require that these measurements be taken after the input (AC) power meter and before the UUT (unit under test).

***RESPONSE**: This is the intent of the wording.*

***RECOMMENDED ACTION**: We suggest that the wording be reviewed and clarified.*

2. AC source voltage and frequency values disagree with Part 1 of TP.

Harmonize with Part 1 of test procedure.

***RESPONSE**: The power sources from Part 1 and Part 2 differ. Equipment tested under Part 2 of the test procedure requires higher power and much higher voltages than equipment under Part 1. For Part 2 of the test procedure it could be cost prohibitive to provide input voltage precision to the degree of Part 1's input voltage precision requirement. Frequency precision is not nearly as difficult and the requirements for Part 1 & 2 can be harmonized. The range of input voltages and frequency requirements are not demarcated in Part 2 of the test procedure, like in Part 1, because there is such a wide variety of possible input power combinations associated with equipment covered in Part 2.*

***RECOMMENDED ACTION**: We suggest no change to the input voltage precision requirements, but the input frequency requirements should be harmonized with Part 1, to ± 1 % of the specified frequency.*

3. Sampling requirements do not belong in TP.

Remove.

***RESPONSE**: Agreed. Sampling size is up to the implementation agency enforcing the standard.*

***RECOMMENDED ACTION**: We suggest making the requisite change to procedure, removing sampling requirement.*

4. Nameplate data collection requirement is repeated from section I.C.

Remove.

***RESPONSE**: Section I.C refers to test equipment, while II.A refers to battery and charger under test. This could be a factor if you are testing multiple products with the same set up.*

***RECOMMENDED ACTION**: We suggest that the wording be reviewed and clarified.*

5. Depth of discharge is undefined.

Define depth of discharge relative to start and end voltage or specific gravity of cell; repeat relevant rows of Table D (p. 19 of Part 1 of TP) for reference.

***RESPONSE**: This is not necessary for conditioning and only adds complexity. The procedure requires that the battery used in the test be qualified with respect to a BCIS-14; this measure is in place to help ensure the battery used in the test will not detrimentally affect the measured performance of the battery charger under test. The conditioning cycles are an additional measure to ensure battery health for the test, and we wanted to limit the burden of the test*

procedure on those performing the test where possible. Excluding measurement requirements and additional detail in the battery conditioning portion of the test helps to alleviate the burden of performing the test.

***RECOMMENDED ACTION**: No change*

6. Discharge rate for conditioning unspecified.

Specify rate.

***RESPONSE**: This is not necessary for conditioning and only adds complexity. Please see the response to comment 3.3 #5 above for additional information.*

***RECOMMENDED ACTION**: No change*

7. Ambient conditions required for valid measurement are unspecified.

Harmonize ambient test conditions with Part 1 of TP.

***RESPONSE**: The conditions pertinent to the successful execution of Part 2 of the test procedure are developed from standards for industrial equipment, concern battery temperature, and do not necessarily pertain to conditions associated with consumer electronics.*

***RECOMMENDED ACTION**: No change*

3.4 Measurement Procedure

1. Unclear how peak AC power is to be measured.

Test procedure only specifies measuring AC power at 5 minutes and 1, 3, and 5 hours after start of recharge. Clarify that peak AC power is the maximum of those AC power measurements.

***RESPONSE**: We agree with your concerns raised in this comment, and originally proposed the current solution to easily enable data recording in a template. It is clear that the drawbacks of the current approach outweigh the benefits.*

***RECOMMENDED ACTION**: Most of the equipment will actually be monitoring the circuit continuously and automatically recording these data at one minute intervals. We suggest modifying this data recording process so that the specific intervals recorded in the data sheet will be based on the maximum power drawn over the course of the test. So, the technician will have the equipment automatically record the data at one-minute intervals and then retrospectively identify which data points to record based on a set of criteria that ensures*

power stability and is based on the maximum power recorded during the testing period.

The updated procedure to ensure power stability, prior to reporting a performance point, will be explicitly detailed to enable the technician to distinguish between pulse phenomena and a point representative of the charger's operational power. The updated procedure requires that the data point selected for reporting be within 4% of the adjacent data points. This will eliminate the possibility of a pulse phenomena being reported as the maximum operational power during charging.

2. Two battery discharge rates specified and manufacturer allowed to choose discharge rate, opening a potential loophole.

Specify one battery discharge rate that all manufacturers would have to obey, as discharge rate influences the measured capacity of the battery.

RESPONSE*: Part 2 of the test procedure covers a broad range of large battery chargers, and these battery chargers often have different usage pattern in the field. It is the intent of the test procedure to provide allowance for these differences, where the discharge rates can be especially important in terms of battery efficiency. Allowing forklift batteries to be discharge at over 6 hours helps to ensure the battery has as little effect as possible on the measured performance of the battery charger. Discharge rate should agree with published capacity values for the vocational application. We believe this section could benefit from some additional clarification with respect to designating discharge rates for the chargers under test.*

RECOMMENDED ACTION*: We suggest revisiting the wording designating the discharge rates for certain types of battery products to ensure that the procedure provides a clear method for selecting a discharge rate.*

3. Battery can be discharged through driving, but vehicle is not a controlled testing environment.

Require that battery energy be measured during discharge at a precise rate under specified conditions.

RESPONSE*: Agreed.*

RECOMMENDED ACTION*: Vehicle references should be removed, and recording requirements clarified.*

4. Battery recharge rate unspecified.

Specify the rate at which the battery is to be recharged for chargers with multiple user-selectable charge rates.

***RESPONSE**: We agree, there are some products that enable the user to select a charge profile based on the battery chemistry that is employed in the field. We realize that it is important to ensure that the charger is efficient during all these charge profiles.*

***RECOMMENDED ACTION**: We recommend the battery selection protocol be changed to require that each charge profile be tested with the highest and lowest capacity batteries. This would mean that a charger with 2 charge chemistry profiles meant for a range battery capacities would be tested in 4 different configurations.*

In addition, we will change to the test instructions to indicate that the charge profile should be the same as the one employed in the field during each test.

5. "For a valid test, the battery temperature during charging (as measured in Part 2, Section II. D.) must be . .. " However, section II.D deals with the discharge test, so it is unclear at which point during the charge test (III.C.2) the temperature measurement should be taken.

Specify exactly at what intervals the temperature of the battery needs to be measured to maintain the validity of the charge test.

***RESPONSE**: Battery heating occurs linearly with respect to time during charging, meaning the battery will be the hottest at the end of the charge test period. BCIS-14 specifies a procedure, as well as acceptable battery temperatures for charging, to measure battery temperature. We are going to align the test procedure to harmonize with the requirements of BCIS-14 on this matter.*

***RECOMMENDED ACTION**: The wording should be revisited to clarify measurements to be taken at over the last 30 minutes of the test, subject to BCIS-14, as well as procedures to handle batteries that over-heat during the testing period.*

6. How to treat equalization.

Clarify what to do if charger performs equalization procedure during testing. Indicate under which section results will be saved.

***RESPONSE**: In Section III.C 2 it states: "If the equalization phase is carried out, this will be noted, but the results will not be saved under this section." The wording can be clarified to repeat test.*

***RECOMMENDED ACTION**: The wording should be clarified to state the need to repeat test.*

7. Verification of full charge unclear. Four methods of verification provided: charger indicator, current measurement, temperature, specific gravity.

Prioritize which verification method takes precedence if others disagree. Also, voltage was used previously in section II.D—add here in case of VRLA batteries. Finally, clarify language—can't directly compare charger DC current (in amperes) to battery capacity (in ampere-hours).

***RESPONSE:** All four of the methods are required to be recorded on the data sheet to enable further analysis if needed. This will be clarified in the test procedure.*

***RECOMMENDED ACTION**: Wording be added to prioritize the charge state determination methodologies for analysis. The wording will be added: "when charging current reaches ≤ 2 % of charging current capacity the charge is complete".*

8. Maintenance power test too long (72 hours).

Shorten the maintenance test to < 1 hour and calculate the AC and DC average power. A
72 hour test conducted for maximum and minimum battery voltage and capacity will tie up valuable equipment for weeks, just to test one charger.

***RESPONSE**: This suggestion will not capture industrial charger maintenance events. Maintenance events occur periodically and could take 48 hours in between maintenance events. The 72 hour period, although inconvenient, is necessary.*

***RECOMMENDED ACTION**: No change*

9. Explanation of maintenance power in relation to no-battery losses is confusing.

Remove sentence starting with " 'No Battery losses,' if any . . ."

***RESPONSE**: Explanation needs clarification.*

***RECOMMENDED ACTION**: The wording should be revisited and clarified.*

10. Unclear when no battery power is considered steady and what to do when it is not.

Provide explicit instructions as to when measured power is steady and what to do if not (e.g., measure average power).

***RESPONSE**: Steady is meant to imply not significantly changing. Wording could be clarified to determine exact definition of "steady"*

***RECOMMENDED ACTION**: The wording should be clarified to explicitly detail measurement and recording of no battery power.*

3.5 Data Reporting

1. Certain parameters such as "charging profile", "character of maintenance mode", "full power, mid- and low power levels" are undefined.

Define all parameters to be reported and specify how they are to be measured in the body of the TP, or calculated from other parameters measured in the TP.

RESPONSE: These parameters are called out in the data template, which will be integrated into the next version of the test procedure. The data reporting section is going to be revised with respect to the new organization of the test procedure and some of the parameters will be eliminated.

***RECOMMENDED ACTION**: Make requisite changes to test procedure by defining terms, specifying how they are found, eliminating parameters no longer needed, and restructuring data reporting section to reflect reorganization of Part 2 of the test procedure.*

2. Optional data in reporting requirements.

Remove optional data from reporting requirement, e.g., the charge return factor at low, medium, and high starting state of charge.

***RESPONSE**: Agreed. This data should not be optional.*

***RECOMMENDED ACTION**: We suggest that the data be defined as required.*

3. 24-hour calculated energy loss for no-load power unnecessary.

Reporting of this parameter is redundant since no-battery power is reported as well. Remove.

***RESPONSE**: Agreed. These calculations can be made from data in the template*

***RECOMMENDED ACTION**: We suggest removing the requirement to calculate 24-hour energy loss.*

4. Unclear exactly which parameters are to be reported.

Certain items are simply definitions or explanations, e.g., “Battery Charging Profile” or “Power Factor”. Reorganize section so it is clear exactly which parameters are to be reported and how to obtain them from the numerous parameters measured in the body of the test procedure.

RESPONSE*: Agreed.*

RECOMMENDED ACTION*: This section should be reorganized to clearly outline which parameters are reported and how to obtain them.*

5. Test procedure requires more measurements than are reported or necessary to ensure the repeatability of the test.

Remove all extraneous measurements from the body of the test procedure, e.g., DC power measured occasionally during recharge, ambient conditions.

RESPONSE*: Agreed*

RECOMMENDED ACTION*: This section should be reorganized to clearly outline which parameters are reported and how to obtain them. The test procedure will eliminate measurements that are not reported.*