

1 **Working Draft to Solicit Comment From Stakeholders**
2
3 **Energy Efficiency Battery Charger System Test Procedure**

4
5 **May 21, 2007**

6
7 **Suzanne Foster Porter and Paul Bendt, Ph.D. Ecos Consulting**
8 **Haresh Kamath and Tom Geist, EPRI Solutions**

9
10 **Development funded by: Pacific Gas and Electric and**
11 **Public Interest Energy Research (PIER) program**
12 **California Energy Commission**
13

This is the working draft of the Energy Efficiency Battery Charger System Test Procedure, completed for Pacific Gas and Electric. This is an edited version of Draft 2 published 2/28/2007. Changes to Draft 2 appear in red underlined text. Future updates and developments related to this document will be available at www.efficientproducts.org.

14
15 **I. Scope**

16
17 The purpose of the test procedure is to measure the energy efficiency of chargers
18 coupled with their batteries, which we refer to collectively as **battery charger systems**.
19 Battery charger systems include those electronic devices with a battery that are normally
20 charged from ac line voltage through an internal or external power supply and a
21 dedicated battery charger. This includes devices that are designed to run on battery
22 power during part or all of their duty cycle (such as many portable appliances and
23 commercial material handling equipment) as well as dedicated battery systems primarily
24 designed for electrical or emergency backup (such as emergency egress lighting and
25 small-scale uninterruptible power supply (UPS) systems).

26
27 The charging circuitry of battery charger systems may or may not be located within the
28 housing of the functional device itself. In many cases, the battery may be charged with a
29 dedicated external charger and power supply combination that is separate from the
30 device that runs on power from the battery. Examples of battery charger systems
31 included in this scope are: cellular and cordless telephones, cordless power tools, laptop
32 computers, cordless shavers, emergency egress lighting, golf carts, portable lawn tools,
33 and rechargeable toys.

34
35 The scope of this document also includes those devices whose primary function is to
36 charge batteries. These units include replacement chargers for power tools and
37 chargers for automotive, AA, AAA, C, D, and 9 V rechargeable batteries.
38

39 This scope is meant to cover those battery charger systems found in the residential and
40 commercial sectors that operate on single-phase voltage and have a nameplate ac
41 rating of less than 2 kW. For the purposes of this procedure, the commercial sector is
42 generally defined as businesses; federal, state, and local governments; and other private
43 and public organizations, such as religious, social, or fraternal groups; institutional living
44 quarters; and sewage treatment facilities.¹ Some battery charger systems may be used
45 in both industrial and commercial sectors (e.g., commercial floor scrubbers); such
46 battery charger systems are included under this scope. This test procedure may also be
47 used for battery charger systems which use a dc input power source.
48

49 This test procedure is not intended to cover laboratory test equipment used to test and
50 analyze batteries. This test procedure applies only to whole battery charger systems,
51 not components of that system. In other words, this test procedure does not specify how
52 to test a charger in the absence of a battery, nor a battery in the absence of a charger.
53 Furthermore, this document does not specify safety requirements, nor does it specify
54 limits on energy consumption or efficiency, though policy-making bodies may choose to
55 reference this test procedure in proposing such limits.
56

Authors' comment on scope: *In response to stakeholder comment in November of 2005, the scope of the test procedure is, limited to single-phase battery chargers with nameplate rating less than 2kW. The scope no longer includes large battery charging systems that operate on three-phase input voltage, which we believe to be significantly different than the other products under consideration in this scope.*

57

58 II. References

59 The following list includes documents used and/or referenced in the development of this
60 test method:

61

- 62 1) Battery Council International, *BCI Specifications for Electric Vehicle Batteries*,
63 BCIS-05 Rev. DEC02.
- 64 2) Battery Council International, *Determination of Capacity of Lead-Acid Industrial*
65 *Storage Batteries for Motive Power Service*, BCIS-14 Rev. DEC02.
- 66 3) Battery Council International, *Standard for Deep Cycle Battery Chargers*, BCIS-
67 16 Rev. DEC02.
- 68 4) International Electrotechnical Commission, *Direct Acting Indicating Analogue*
69 *Electrical Measuring Instruments and their Accessories*, IEC 60051, parts 1-9.
- 70 5) International Electrotechnical Commission, *Household Electrical Appliances -*
71 *Measurement of Standby Power*, IEC 62301, 2005.

¹ For a more complete definition of energy sectors, as defined by DOE, please see
<http://www.eia.doe.gov/neic/datadefinitions/sectors25B1.htm>

- 72 6) International Electrotechnical Commission, *International Electrotechnical*
73 *Vocabulary- Electrical and Electronic Measurements and Measuring Instruments*,
74 IEC 60050-300, Edition 1.0, 2005.
75 7) International Electrotechnical Commission, *Primary batteries – Part 1: General*,
76 IEC 60086-1. Edition 9.0.
77 8) International Electrotechnical Commission, *Lead-acid traction batteries – Part 1:*
78 *General requirements and methods of tests*, IEC 60254-1, Edition 4.0, 2005.
79 9) International Electrotechnical Commission, *General Purpose Lead-Acid Batteries*
80 *(Valve Regulated Types) – Part 1: General Requirements, Functional*
81 *Characteristics – Methods of Test*, IEC 61056-1, Edition 2.0, 2002.
82 10) International Electrotechnical Commission, *Secondary cells and batteries*
83 *containing alkaline or other non-acid electrolytes – Portable sealed rechargeable*
84 *single cells – Part 1: Nickel-cadmium*, IEC 61951-1. Edition 2.0, 2003-2004.
85 11) International Electrotechnical Commission, *Secondary cells and batteries*
86 *containing alkaline or other non-acid electrolytes – Portable sealed rechargeable*
87 *single cells – Part 2: Nickel-metal hydride*, IEC 61951-2, Edition 2.0, 2003.
88 12) International Electrotechnical Commission, *Secondary cells and batteries*
89 *containing alkaline or other non-acid electrolytes – Secondary lithium cells and*
90 *batteries for portable applications*, IEC 61960, Edition 1.0, 2003.
91 13) International Electrotechnical Commission, *Secondary cells and batteries*
92 *containing alkaline or other non-acid electrolytes – Safety requirements for*
93 *portable sealed secondary cells, and for batteries made from them, for use in*
94 *portable applications*, IEC 62133, Edition 1.0, 2002.
95 14) Institute of Electrical and Electronics Engineers, *The Authoritative Dictionary of*
96 *IEEE Standards Terms*, IEEE 100, Edition 7.0, 2006.
97 15) Institute of Electrical and Electronics Engineer Power Engineering Society,
98 *Livium: IEEE Standard for Rechargeable Batteries for Portable Computing*, IEEE
99 1625-2004.
100 16) Buchmann, Isidor, *Batteries in a Portable World: A Handbook on Rechargeable*
101 *Batteries for Non-Engineers*, Cadex Electronics Inc., 2001.

Authors' comment on references: *To ensure that test requirements are understood in their full context, and in the interest of brevity, this test procedure references the relevant test protocols listed above by document and section number rather than including exact wording from those documents.*

102

103 III. Definitions

104

105 A. Active Power (P)

106 The rms value, taken over one **sampling** period, of the instantaneous **ac or dc** power.
107 Most measuring instruments average active power over a number of **sampling** periods
108 (ac cycles); readings from such instruments are equally valid for this measurement.

109

110 B. Ambient Temperature

111 Ambient temperature is the temperature of the ambient air immediately surrounding the
112 UUT.

113

114 C. Apparent Power (S)

115 The total or *apparent power* (S) is the product of rms voltage and rms current (VA).

116

117 **D. Battery Chemistry**

118 The chemistry of the rechargeable battery, usually nickel cadmium, nickel metal hydride,
119 lithium ion, rechargeable alkaline, or lead acid. The chemistry of the battery is typically
120 printed on the label of the battery itself, can be found in product literature, or can be
121 obtained from the manufacturer of the battery system.

122
123 **E. Battery Conditioning**

124 A special procedure performed on a battery to ensure optimal performance. Nickel
125 cadmium and nickel metal hydride batteries, for instance, must occasionally be fully
126 discharged and then charged to deliver maximum energy output.

127
128 **F. Battery Discharge Energy**

129 The energy delivered by a fully charged battery when it is discharged at a constant
130 current to a specified end of discharge voltage value.

131
132 **G. Battery Maintenance Mode**

133 Refers to the state in which the battery charger system is connected to input power, and
134 the battery charger may be delivering current to the battery in order to counteract or
135 compensate for self-discharge of the battery. The battery is, in this state, at or near
136 100% capacity.

137
138 **H. Battery Rest Period**

139 A period of time between discharge and charge or between charge and discharge,
140 during which the battery is resting in an open-circuit state in ambient air. The rest period
141 is intended to allow the battery to cool and to return to electrochemical equilibrium
142 Battery rest periods are required as part of this test procedure.

143
144 **I. Charge Mode**

145 Refers to the state in which the battery charger system is connected to input power, and
146 the battery charger is delivering current in order to bring the battery from a state of
147 discharge to a state at or near 100% capacity.

148
149 **J. C-Rate**

150 C-rate (in amperes) refers to the rate of charge or discharge. A discharge rate of one C
151 draws a current equal to the rated capacity of the battery (in ampere-hours or
152 milliampere-hours) for one hour.

153
154 **K. External Power Supply**

155 External power supplies are designed to convert ac line voltage into low voltage output
156 (either ac or dc) and are contained in a separate housing from the product they are
157 powering. For further clarification, see *Test Method for Calculating the Energy Efficiency*
158 *of Single-Voltage External Ac-Dc and Ac-Ac Power Supplies*, August 11, 2004, at
159 www.efficientpowersupplies.org.

160
161 **L. End-of-Discharge Voltage**

162 Specified closed circuit battery voltage at which discharge of a battery is terminated.

163
164 **M. No-Battery Mode**

165 Refers to the state in which the battery charger system is connected to input power, is
166 configured to charge a battery, but there is no battery connected to the dc output.
167 Ideally, the charger has just finished charging a battery, the battery (or the portable

168 device which contains the battery) is removed from the charger (or the charging cradle),
169 and no other adjustment is made to the charger.

170

171 **N. Measured Energy Capacity**

172 The amount of storable energy in a battery measured with the test procedure detailed in
173 section VI of this document. It is equal to the product of the measured current during
174 constant current discharge (in amperes or milliamperes), the total time (in hours) of
175 discharge, and the average battery voltage during discharge. Measured battery capacity
176 is in units of energy (watt-hours (Wh)), and should be distinguished from rated charge
177 capacity, defined in this document below.

178

179 **O. Power Factor (True)**

180 The *true power factor* is the ratio of the active, or real, power (P) consumed in watts to
181 the apparent power (S), drawn in volt-amperes (VA).

182

$$183 \quad PF = \frac{P}{S}$$

184

185 This definition of power factor includes the effect of both distortion and displacement.

186

187 **P. Rated Charge Capacity**

188 The capacity, usually given in ampere-hours (Ah) or milliamperes-hours (mAh), specified
189 by the manufacturer and typically printed on the label of the battery itself. In general, it is
190 the quantity of electric charge the manufacturer declares the battery can store under
191 particular pre-specified test conditions.

192

193 **Q. Rated Battery Voltage**

194 The battery voltage specified by the manufacturer and typically printed on the label of
195 the battery itself. If not printed on the battery, it can be derived from the electrical
196 configuration and chemistry of the battery.

197

198 **R. Rated Input Frequency**

199 Range of ac input frequencies designed to operate the UUT; assigned by the
200 manufacturer and usually printed on the housing of the charging device.

201

202 **S. Rated Input Voltage**

203 Range of ac or dc input voltage designed to operate the UUT; assigned by the
204 manufacturer and usually printed on the housing of the charging device.

205

206 **T. Standby Mode**

207 Refers to the state in which the battery charger system is connected to input power, but
208 there are no batteries connected to the dc output. It is the lowest power mode that
209 normally cannot be switched off (influenced) by the user and may persist for an indefinite
210 time when the battery charger is connected to input power and used in accordance with
211 the manufacturer's instructions. This may be different from no-battery mode in that a
212 "hard-off" switch on the charger may be available to put the UUT in a power state lower
213 than no-battery mode.

214

215

Authors' comment on operational modes: The operational modes considered by this test procedure (charging, maintenance, no-battery, and standby) are meant to be comprehensive, reflecting all of the ways in which a battery charger system may be used. The authors recognize that some battery charger systems are charged and discharged infrequently and spend the majority of their lifecycle in battery maintenance mode. The purpose of this procedure is to measure all ways in which a battery charger system may be used to provide manufacturers and policymakers with comprehensive data. Particular policymakers may not reference all battery charger tests outlined in this document, especially for devices that rarely enter certain modes of operation. At this stage of data gathering, the test procedure does not include exceptions for certain battery charger systems.

216
217
218
219
220
221
222
223

U. Total Harmonic Distortion (THD)

Total harmonic distortion is a measure of the degree to which a waveform departs from a pure sinusoidal waveform. It is defined as the ratio of the vector sum of all harmonic components (greater than 1) to the magnitude of the fundamental. For instance, for a voltage waveform, THD is defined by the equation:

$$\text{THD} = \frac{\sqrt{V_2^2 + V_3^2 + V_4^2 + \dots + V_n^2}}{V_1}$$

224
225
226
227
228
229
230

where V_n is the rms voltage of harmonic n .

V. UUT

UUT is an acronym for "unit under test," which in this case refers to the battery charger and battery being tested.

Authors' comment on definitions: Several definitions have been added or clarified in response to stakeholder comment in November 2005. In particular, definitions for battery conditioning, battery discharge energy, battery rest period, and total harmonic distortion have been added; definitions for capacity have been corrected and clarified to distinguish between charge capacity and energy capacity; and definitions for rated input voltage and rated input frequency have been clarified and made consistent throughout the document.

231
232
233
234
235
236
237
238

IV. Standard Test Conditions

A. General

The test sequence outlined in this document is summarized in the table below. Although not required, the test sequence in Table A is suggested for efficient use of technician and lab equipment time, and to ensure that the measured charge/discharge cycle returns the battery to its beginning state:

Table A: Suggested Test Sequence

Step	Description	Data Taken?	Approx. Technician Time	Equipment Needed	Approx. Lab Equip. Time	Approx. Total Test Time
1	Record general data on UUT	Yes	15 min	battery(ies) and charger	0	15 min
2	<i>Battery conditioning (optional)</i>	No	variable	battery(ies) and battery analyzer	variable	variable
3	<u>Discharge the batteries according to section VI (Battery Discharge Energy Test). The energy does not need to be recorded, but discharge must be at the proper rate and end at the proper voltage.</u>	No	<u>10 min</u>	Battery(ies), <u>battery analyzer</u>	<u>variable</u>	<u>variable</u>
<u>4</u>	<u>Store battery(ies) between discharge and charge, according to section IV,G</u>	<u>No</u>	<u>5 min</u>	<u>Battery(ies)</u>	<u>0</u>	<u>1 h</u>
<u>5</u>	<u>Conduct Charge Mode and Battery Maintenance Mode Test as Specified in section VII.</u>	<u>Yes</u>	<u>15 min</u>	<u>Batteries, Charger, AC power meter</u>	<u>24 h (test runs overnight)</u>	<u>24 h</u>
<u>6</u>	Store battery(ies) between charge and Battery Discharge Energy Test, according to section IV, G*	No	5 min	battery(ies)	0	1 h
<u>7</u>	Discharge battery(ies) according to section VI (Battery Discharge Energy Test)	Yes	15 min	battery(ies), battery analyzer	5.25 h	5.25 h
<u>8</u>	Remove battery(ies) and conduct No-Battery Mode Test detailed in section VIII	Yes	10 min	charger, ac power meter	5 min	10 min
9	Compile data into report	No	25 min	none	0	25 min
Approximate Test Times:			2 h		29 h	56 h

241 * Larger batteries may require longer rest periods, as provided in the standards referenced in
242 Section IV G.

Authors' comment on test sequence. For some battery types, the test procedure may not fit readily into 8-hour workdays. Previous comments from stakeholders were that having an accurate test procedure was more important.

243
244
245
246
247
248
249
250
251
252

Unless otherwise specified, measurements shall be made under the test conditions and with the equipment specified below.

B. Ac Measuring Equipment

All input power measurements shall be made with a suitably calibrated power analyzer, per the requirements of section 4.5 of IEC 62301, with consideration of the provisions in Annex B and Annex D of the same document.

253 **C. Battery Measurement Equipment**

254 The overall accuracy of controlled or measured values associated with discharging the
255 battery, relative to the specified or actual values, shall be within the tolerances specified
256 in the applicable industry standard for batteries of this chemistry, as listed below:

- 257 • Flooded Lead Acid Batteries: IEC 60254-1, Section 4.1.
- 258 • VRLA Batteries: IEC 61056-1, Section 5.2.1
- 259 • Nickel Cadmium Batteries: IEC 61951-1, Section 4
- 260 • Nickel Metal Hydride Batteries: IEC 61951-2, Section 4
- 261 • Lithium Ion Batteries: IEC 61960, Section 4

262

263 If the chemistry under test is not listed above, then the applicable procedure should be
264 referenced and documented on the test report.

265

266 For assistance in selecting instrumentation, see the IEC 60051 series. The details
267 (make, model, and calibration schedule) of the instrumentation used shall be provided in
268 each report of results.

269

270 **D. Test Room**

271 All tests shall be carried out in a room with ambient conditions in accordance to Section
272 4.2 of IEC 62301. There shall be no intentional cooling of the UUT by use of separately
273 powered fans, air conditioners, or heat sinks. The UUT shall be tested on a thermally
274 non-conductive surface. Products intended for conditions outside of this specified range
275 may be tested at additional temperatures, provided those are in addition to the
276 conditions specified above and are noted in a separate section on the test report. When
277 not undergoing active testing, batteries shall be stored under per the requirements of
278 Section IV, G below.

279

***Authors' comment on test room temperature:** This range was chosen as coinciding with the various IEEE, IEC, and other industry test standards examined in the course of test procedure development, as listed in the Section II References.*

280

281 **E. Input Reference Source: Input Voltage and Input Frequency**

282 An input power reference source shall be used to provide input power to the UUT, as
283 specified in IEC 62301, Section 4.3.

284

***Authors' comment on UUT input voltage:** Although U.S. units are likely be tested at 115 V and 60 Hz, the reference to other voltages above is meant to address the needs of international stakeholders who could potentially reference this test method in their own battery charger programs and policies.*

285

286 **F. Ac Input Reference Source: Other Specifications**

287 The total harmonic distortion (THD) of an ac supply voltage when supplying the UUT in
288 the specified mode shall conform to Section 4.4 of IEC 62301.

289

290 **G. Battery Rest Periods**

291 The battery shall be rested between charge and discharge, and between discharge and
292 charge, according to the applicable industry test standard for batteries of certain
293 chemistries, as listed:

- 294 ○ Flooded Lead Acid Batteries: IEC 60254-1, Section 5.2.3
- 295 ○ VRLA Batteries: IEC 61056-1, Section 6.2.1
- 296 ○ Nickel Cadmium Batteries: IEC 61951-1, Section 7.2.1
- 297 ○ Nickel Metal Hydride Batteries: IEC 61951-2, Section 7.2.1
- 298 ○ Lithium Ion Batteries: IEC 61960, Section 7.2.2, Step 2
- 299

300 In addition for flooded lead acid batteries, battery electrolyte temperatures shall be
301 measured per IEC 60254-1 Section 4.1.2. Charging or discharging activities shall not be
302 conducted unless battery electrolyte temperatures are less than 30°C.

303
304 Ambient conditions during rest periods shall be the same as those prescribed in Section
305 IV, D of this document.

306
307 If the chemistry under test is not listed above, then the applicable procedure for resting
308 the battery should be referenced or described on the test report.

Authors' comment on rest periods and battery electrolyte temperature: Rest periods between charge and discharge operations, and between discharge and charge operations allow the battery to reach electrochemical equilibrium and cool to ambient temperature. In November 2006, stakeholders suggested that for flooded lead acid batteries, electrolyte temperature should be used as a second measure of equilibrium. We have included that additional criterion in this draft.

309 310 **V. Battery Charger System Setup Requirements**

311 312 **A. General Setup Guidance**

313 The battery charger system should be prepared and set up in accordance with the
314 manufacturer's instructions. If no instructions are given, then factory or "default" settings
315 shall be used, or where there are no indications of such settings, the UUT shall be tested
316 as supplied. In all cases, the battery charger unit shall be used with the exact external
317 power supply packaged with the unit, if any.

318 319 **B. Age of Battery Charger System**

320 The UUT, including the battery charger and its associated battery, shall be new products
321 of the type and condition that would be sold to a customer. For lead acid batteries,
322 "new" shall be defined as IEC 60254-1, Section 4.2.1.

323 324 **C. Guidance on Battery to Use for Test**

325 The battery charger unit shall be tested with the batteries that are commercially
326 packaged or most commonly sold with the unit. If the unit is not packaged or sold with
327 batteries, then the charger should be tested using suitable batteries made by the same
328 manufacturer, if available. If batteries from the same manufacturer are not available,
329 then charger shall be tested with batteries that are recommended by the manufacturer.
330 The recommendation can be either packaged with the charger or as a separate
331 communication to the testing laboratory.

- 332
- 333 • If multiple types of batteries or batteries of different capacities are commonly used
334 with the product, then the tests specified in sections VII, and VIII of this document
335 (Battery Discharge Test, and Charge/Maintenance Mode Test) shall all be conducted
336 twice, once with the highest capacity battery that is sold or associated with the

- 337 charger, and once with the lowest capacity battery that is sold with or associated with
338 the charger. Measurements from both tests shall be recorded.
- 339 • For chargers with multiple charging ports, the tests specified in sections VI, and VII
340 of this document (Battery Discharge Test, and Charge/Maintenance Mode Test) shall
341 all be conducted twice with battery configurations list below:
 - 342 ○ The maximum number of identical batteries of maximum capacity that the
343 charger is meant to accommodate shall be used
 - 344 ○ The minimum number of identical batteries of minimum capacity that the
345 charger is meant to accommodate shall be used
- 346 Measurements from both tests shall be recorded.

347 **D. Battery Conditioning/Preparation**

348 If specified by the manufacturer, a battery conditioning/preparation procedure shall be
349 conducted according to procedures recommended by the battery manufacturer.

350 **E. Other Non-Battery Charger Functions**

351 Any optional functions controlled by the user and not associated with the battery
352 charging process (i.e., a radio integrated into a cordless tool charger) shall be turned off.
353 If it is not possible to turn such functions off, they should be set to their lowest power-
354 consuming mode during the test. The operations that are available to the user shall be
355 recorded.

- 356 • Example 1: If there is a radio in the same housing as a tool battery charger, the radio
357 shall be turned off for all the tests. The user is no longer able to listen to the radio, so
358 the only functionality available to the user (and what should be recorded on the
359 report) is the “On-Off switch for the radio.”
- 360 • Example 2: A cordless phone battery charger also contains the circuitry for
361 monitoring the phone line for a call. This functionality cannot be disabled and so shall
362 be recorded on the test procedure report as “monitoring phone line for incoming call.”

363 If the battery charger unit has other electrical connections associated with its
364 functionality (such as phone lines, serial or USB connections, Ethernet, cable TV lines,
365 etc.) these connections shall be left disconnected during the testing. A connection shall
366 be made if that the connection is required for the battery charger function to operate
367 properly. In this case, the requirements and the steps taken to comply with them shall
368 be included in the final report.

369 **F. Safety Considerations**

370 In no case shall the test procedure conflict with general safety standards or safety
371 provisions in the manufacturer’s instructions for set up.

372 **G. Access to the Battery for Discharge Test**

373 The manufacturer shall provide the testing laboratory with any instructions, special tools,
374 connectors, or test jigs which are required to safely access the battery(ies) for the
375 Battery Discharge Energy Test. If the batteries are not designed to be replaceable by
376 the consumer, the manufacturer shall provide instructions and necessary tools to access
377 the dc terminals of the battery. If the battery is not clearly labeled with a positive and
378 negative terminal, it shall include pin-outs and connection descriptions. If a smart
379 battery requires any activation codes for discharge, the codes shall be described or a
380 test jig which supplies the codes shall be provided.

Authors' comment on Section V: A number of modifications were made to section V in response to November 2006 stakeholder comment including adding a section detailing safety considerations; providing more detailed guidance on non-battery charger functions; and more detailed guidance on the required age of the battery charger system.

Section V.C may require a more detailed description of the batteries to be chosen for testing a charger.

386
387

VI. Battery Discharge Energy Test

389

390 The purpose of this test is to measure the extractable energy from the battery associated
391 with the battery charger system. The battery used in this test shall be the same battery
392 used for tests specified in section VII, Charge/Maintenance Mode Test. If multiple
393 batteries are being used in this test (see section V, Battery Charger System Setup
394 Requirements), then each battery should separately undergo this discharge test to
395 determine its capacity. Identical batteries that have been charged in a series connection
396 may also be discharged using the same series connection.

397

398 For this test, the following steps apply:

399

- 400 1) The battery is charged with its associated battery charger (not with a battery
401 analyzer).
- 402 2) The cell or battery shall be rested per provisions of the applicable industry test
403 standard as listed in Section IV, G above.
- 404 3) The battery shall be discharged at a constant current of 0.2 C, until its voltage is
405 equal to the specified end-of discharge voltage (in Table B below).
- 406 4) The total energy extracted during the period of discharge should be recorded as
407 well as the battery voltage and current values as a function of time. Voltage and
408 current shall be sampled at least once per minute. For guidance on calculating
409 energy extracted during discharge, please see IEC 62301, Annex C.

410

411

Table B: Required Battery Discharge Rates and End-of-Discharge Battery Voltage

Battery Chemistry	Discharge Rate	End-of-Discharge
Valve-Regulated Lead Acid (VRLA)	0.2 C	1.75 volts per cell
Flooded Lead Acid	0.2 C	1.70 volts per cell
Nickel Cadmium (NiCd)	0.2 C	1.0 volts per cell
Nickel Metal Hydride (NiMH)	0.2 C	1.0 volts per cell
Lithium Ion (Li-Ion)	0.2 C	3.0 volts per cell
Rechargeable Alkaline	0.2 C	0.9 volts per cell
<u>Other Chemistries</u>	<u>As per manufacturer's recommendation or appropriate standard</u>	

412

Authors' comment on end-of-discharge voltages: The end-of-discharge voltage for flooded lead-acid batteries has been changed to 1.70 volts per cell to conform to IEC 60254-1.

413

Authors' comment on discharge rates chosen: 0.2 C was chosen because it is referenced in the IEC and BCI test procedures reviewed and because it provides a favorable representation of battery capacity without placing an undue time burden on testing organizations. (One discharge can easily be performed in a workday.)

While standards for some chemistries, such as VRLA, cite discharge rates as low as 0.05C, we believe that a common discharge rate is important to enable fair comparisons between charger-battery systems based on different battery chemistries.

414
415

416 VII. Charge Mode and Battery Maintenance Mode Test

417

418 The Charge/Battery Maintenance mode test measures the energy consumed during one
419 charge and a significant portion of the maintenance cycle of the UUT. Functions
420 required for battery conditioning that happen only with some user selected switch or
421 other control should **not** be included this measurement. Regularly occurring battery
422 conditioning/maintenance functions that are not controlled by the user will, by default, be
423 incorporated into this measurement.

424

425

426 The following steps apply:

427

- 428 1) Ensure that the battery(ies) used in this test were rested per provisions of the
- 429 applicable industry test standard as listed in Section IV, G above.
- 430 2) Connect the metering equipment to the battery charger.
- 431 3) Ensure that user-controllable device functionality not associated with battery
- 432 charging is turned off.
- 433 4) Record the start time of the measurement period, and begin recording the
- 434 energy, power, and power factor (if applicable) values associated with the
- 435 measurement period.
- 436 5) Connect battery(ies), which have been fully discharged according to section VI of
- 437 this method, to the battery charger.
- 438 6) After the battery(ies) are inserted, record initial time, power (W), power factor,
439 and total harmonic distortion of the input current. These measurements should
440 be taken within the first 10 minutes of active charging.
- 441 7) At the end of the measurement period, record the final time, power (W), power
442 factor, and total harmonic distortion of the input current. These measurements
443 should be taken within the last 10 minutes the maintenance mode test.

444

445 The measurement period shall be at least 24 hours for all battery-charger systems. The
446 test period shall be longer than 24 hours in the following circumstances:

447

- 448 • If the manufacturer indicates or the technician observes that the battery is not
449 fully charged in 20 hours, then the test time may be extended to allow the battery
450 to receive a full charge. The total energy consumed during the charging process
451 is to be reported, regardless of the duration of the test.
- 452 • If the manufacturer indicates or the technician observes that the maintenance
453 mode (see below) is cyclic and the maintenance mode average power cannot be
454 adequately observed in a 24-hour charging period, then the maintenance mode

455 portion of the test shall be extended sufficiently to include an integer number of
456 maintenance cycles.

457
458 During the measurement period, power values shall be recorded at least every minute.
459 After the measurement period is complete, the average power over the last 4 hours (or
460 longer, see above) of the test shall be computed to give the average battery
461 maintenance mode power. This average battery maintenance mode power shall be
462 recorded on the test report.

463
464 Also, the total energy consumed from the time that the battery is installed to the end of
465 the test shall be calculated and recorded. For guidance on energy accumulation
466 methods of measurement and calculation, see IEC 62301 Section 5.3.2, b and Annex C.
467

Authors' comment on 24-hour test length: *This length was chosen in response to November 2006 stakeholder comment that suggested some battery chargers do not fully charge and enter 4 hours of battery maintenance mode in 16 hours. To maintain consistency among the products tested, 24 hours was chosen for all battery charger types.*

In order to accommodate products with charge periods longer than 19 hours, such as emergency egress lighting products, we have inserted the option of extending the charge test.

468

469 **VIII. No-Battery Mode Test**

470

471 This test should be made on devices that contain battery charger systems from which
472 the battery itself or a component housing the battery can be readily removed from the
473 charger during normal operation while the charger remains connected to ac line voltage.

474

475 Examples include:

476

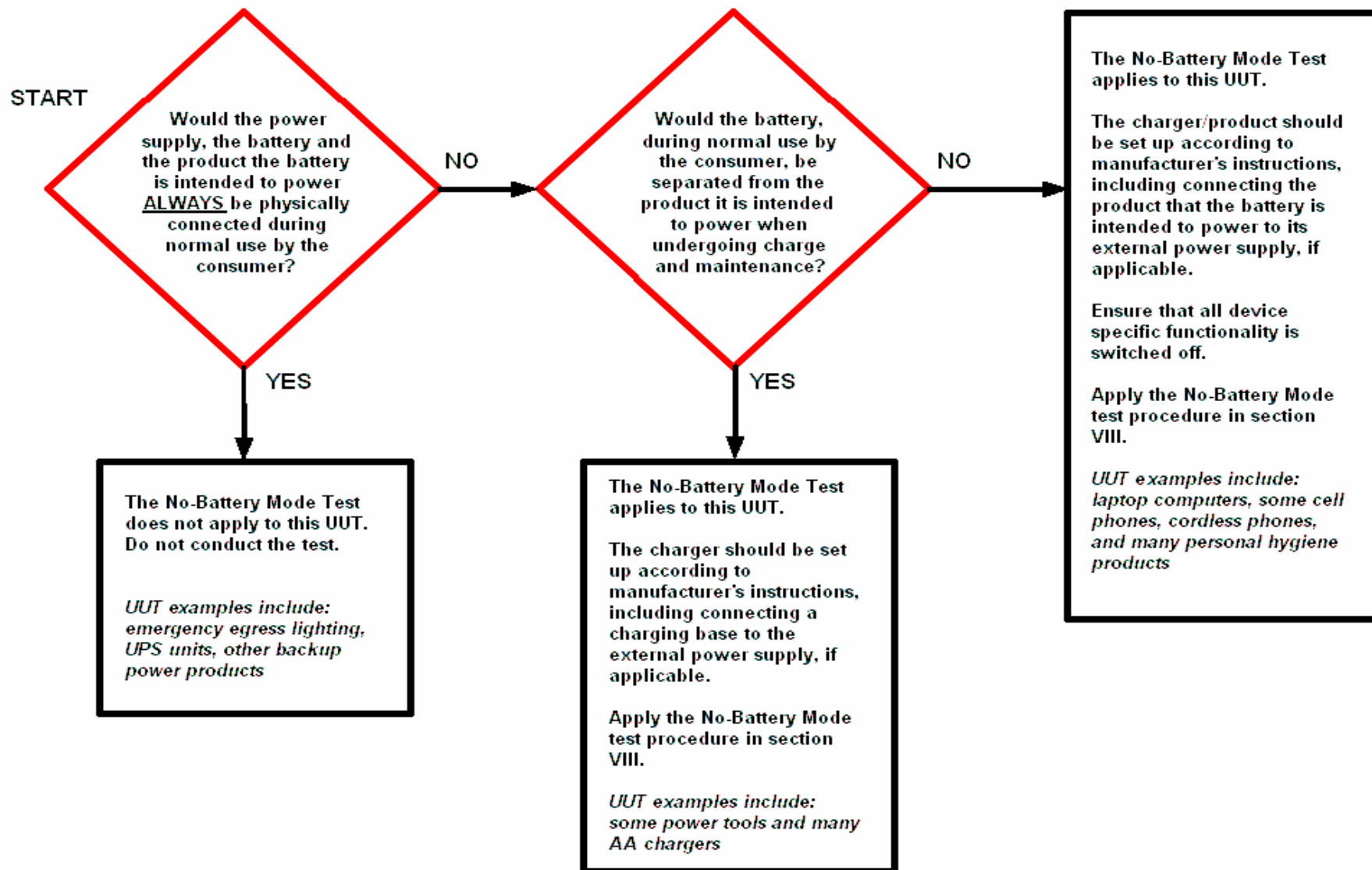
477 1) A cordless phone with the handset off of the base unit. The base unit (charger)
478 remains connected to ac line voltage. In this case, the battery itself is in the
479 phone handset, which should be removed from the base station for the no battery
480 mode test.

481 2) A cordless power tool battery charger. The batteries are removed from the
482 charger (and connected to the tool), while the charger remains connected to ac
483 line voltage for the no-battery test.

484

485 The flowchart on the following page shall be used to determine whether or not the
486 product should be tested in no battery mode, and if so, how the product should be
487 configured.

488



Authors' comment on flowchart: *This flowchart was created to simplify the decision of what no-battery mode test, if any, would be appropriate for a particular product.*

490
491 The No-Battery Mode power may be measured in two ways, depending on the stability
492 of the power measurement.

493
494 **A. Where the selected mode is stable**

495 This method may only be used where the mode and measured power are stable, as
496 defined in IEC 62301, Section 5.3.1. The following steps apply:

- 497
498 1) Configure the charger according to the flow chart.
499 2) Conduct testing per IEC 62301, Section 5.3.1.

500
501 **B. All other cases**

502 This method shall be used where either the no-battery mode or measured power is not
503 stable, as defined in IEC 62301, Section 5.3.2. This mode is acceptable for use with
504 stable modes as well, however, and is recommended when the stability of the mode
505 cannot be clearly determined. The following steps apply:

- 506
507 1) Configure the charger according to the flow chart.
508 2) Conduct testing per IEC 62301, Section 5.3.2.

509
510
511 **C. Standby power**

512 If there are user controls to adjust which will turn the charger off or put it in a reduced
513 power state, these adjustments should be made and then the standby power measured.
514 If there are no such controls, then standby mode is the same as no-battery mode and
515 need not be tested separately. If the standby mode has a stable power consumption, it
516 can be measured per IEC 63201, Section 5.3.1. If it is not stable, the standby power
517 should be measured per IEC 63201, Section 5.3.2.

518
519
520 **IX. Reporting Requirements**

521
522 The following information shall be recorded about each UUT:

523
524 **A. General:**

- 525
526 1) Name of technician performing the test
527 2) Organization performing the test
528 3) Time and date of each test
529 4) Manufacturer and model number of battery charger
530 5) Manufacturer and model number of battery
531 6) Standard size or type of battery (AA, C, D, etc.) if applicable
532 7) Dual functionality of battery charger, if any (see section V for more details)
533 8) Battery chemistry
534 9) Make and model of measurement equipment
535 10) Rated battery voltage (volts)

- 536 11) Rated battery capacity (milliamperere-hours or amp-hours)
537 12) Input power voltage (volts)
538 13) Input frequency (hertz), if ac
539 14) Record of battery conditioning procedure with reference to specific document (if
540 performed)
541 15) Any information provided by the manufacturer regarding access to the battery,
542 particular safety requirements, etc.

543
544 **B. Battery Discharge Test:**

- 545
546 1) Energy delivered during discharge (watt-hours)
547 2) Starting battery voltage (volts)
548 3) Ending battery voltage (volts)
549 4) The length of the rest period before discharge and, if applicable, the electrolyte
550 temperature.
551 5) Sample rate used during test
552

553 **C. Charge /Maintenance Mode Test:**

- 554
555 1) Total accumulated energy over the course of the test (watt-hours)
556 2) The total time duration of the charging test (at least 24 hours)
557 3) Average power during maintenance mode (watts)
558 4) The time duration of the maintenance mode portion (at least 4 hours)
559 5) True power factor at beginning and end of the charge test (expressed as a
560 percent)
561 6) The total harmonic distortion of the input current at the beginning and end of
562 the charge test, (expressed as a percentage).
563 7) The length of the rest period before charging and, if applicable, the electrolyte
564 temperature
565 8) Sample rate used during test
566

567 **D. No-Battery Mode Test:**

- 568
569 1) Average no-battery mode power (watts)
570 2) Average standby mode power (watts) if different from no-battery mode
571 3) Sample rate used during test
572 4) Methodology used for test (accumulated energy or average power as per IEC
573 62301 Section 5.3.1 and 5.3.2)
574

575 **E. General**

- 576
577 1) Charging efficiency, which is the battery discharge energy (item B1) divided by
578 the accumulated charging energy (item C1), expressed as a percentage.
579 2) Any observations, notes or comments by the lab technician.
580

Authors' comment on test report information: We made efforts in this draft to reduce the number of items required on the test report. For example, in the Charge/Maintenance Mode Test, rather than requiring every power and time measurement be reported, we required only that the sample rate, total Charge/Maintenance mode energy, and average Battery Maintenance Mode power be recorded.

A few items have been added, THD and standby power. These do not take any significant additional time and will provide additional information on the energy consumption patterns of charger.

581