

CONTINUOUS FLOAT OPERATION OF
LEAD-ACID-TYPE BATTERIES

1. GENERAL

1.01 This section describes the continuous float operation of lead-acid-type storage batteries in telephone and telegraph power plants.

1.02 This section is reissued:

- (a) To base operation on float voltage and specific gravity readings instead of raised voltage readings.
- (b) To amplify special routines for special applications.
- (c) To amplify recommendations on methods of taking voltage readings.
- (d) To list new model 931 voltmeters to replace the models 280 and 281.
- (e) To give boost charge data in tabular instead of graphic form.
- (f) To bring up to date generally in connection with 2.17 volts per cell float and experience with lead-calcium cells and plastic containers.

1.03 Except where special corrective action has been recommended for a particular battery, these routines apply at all room temperatures normally encountered in battery installations and for any cell whose full charge corrected specific gravity does not exceed 1.225.

1.04 Unless otherwise specified, all recommendations apply to both lead-antimony and lead-calcium cells. At present, only KS-5553-01 and KS-15544 cells are lead-calcium. See Section A801.002 for general battery theory.

1.05 It is the general aim of these routines to maintain all cells healthy by having no cell floated lower than 2.13 volts per cell while avoiding the positive plate abuse to be expected at excessively high voltages. 2.17 volts per cell float seems the best compromise to produce these results. Emphasis in the immediate past on cell-voltage variations was necessary as part of a study of the behavior of lead-calcium cells. Raised-voltage readings, previously used as a basis for maintenance because they tended to magnify float-voltage variations, are replaced by float readings. Raised-voltage readings are inconvenient and not always feasible. Also, they cannot always be correlated with float readings so may give erroneous indications. It is con-

ditions on float with which we are actually interested. Some voltage variations which may be present at installation are expected to disappear after several months of operation by recommended routines. A drop in voltage of one or a few cells during the latter part of anticipated life is an indication of deterioration justifying special attention and reference to the supervisor. See 1.06.

1.06 Unusual performance or unexplained irregularities are of interest to the supervisor who may wish to try special tests or procedures or to obtain additional advice. Diagnosis and prescription for subnormal or irregularly performing cells depend on experience, knowledge of past history of the cells, and possibly some experimenting. If the trouble is lack of charge, a boost on the entire string or on certain cells is desirable. See 4.01. In any case, the accuracy of the average battery float voltage over the day or week, setting of control equipment, and calibrations of float voltmeters should be checked. In some cases, lack of charge may be due to frequent or extended power failures. Where this is chronic, more frequent boost charges should be scheduled. Battery records should help to determine the trouble. If the trouble appeared gradually, there is probably sulfation, and additional charging should be tried. In older cells of the lead-antimony type, it may be due to antimony transfer in which case condition can usually be improved by extra charging. Failure of some cells to gas as freely as other cells on charge indicates sulfation. If the trouble appears suddenly, faults such as internal shorts or contaminated electrolyte are indicated. An increase in water loss for the entire string at constant temperature, an increase in the electrolyte temperature not explained by a change in other conditions, or a sudden and large increase in the trickle current at the same float voltage and temperature are indications of battery deterioration. Less water loss in one cell than in the others in the same string may be due to an internal short. Appreciably more water loss in one cell is probably due to overflow, creepage, or leaks in the cell container. If the water loss in the emergency cells is appreciably different from that in the main battery, incorrect float or other abuse of the emergency cells should be suspected. Where there is appreciable swing of the battery voltage, a subnormal cell usually has less swing than the healthy cells. Other indications of impending failure are cover rise on cells with bottom supported positive plates (see Section A401.001) and

Cracked or broken plates which can be detected usually only on cells in open or transparent containers. In some cases, a discharge capacity test of the string or of the low cells may be justified to see how serious the trouble really is and how much reserve is available in the office. When efforts to find and correct trouble are unsuccessful, it may be desirable to consult the local representative of the battery manufacturer. See 5.09.

2.01 Float at an average battery voltage of 2.17 volts per cell. See Part 3.

2.02 Check average battery float voltage annually and oftener if required. See Part 3. For exception, see 2.09. Record of average battery float voltage and data on which it is based should be made on spare or remarks space on forms used for other battery records.

1.07 Avoid making tests or adjustments at a time when they would interfere with service or cause service reaction. Example: Switching of emergency or counter-cells may interfere with the operation of some critical circuits such as teletype, telephoto, or television.

2.03 Check battery voltage or pilot-cell voltage on float frequently, possibly daily at attended offices and at every visit to unattended offices. Record the results of this check, weekly at attended offices and as near weekly as visits permit at unattended offices. Recheck average battery float voltage if this voltage is outside the limits established in average battery float-voltage determinations. See Part 3. For exceptions, see 2.09. Use of form E-3592 is suggested.

1.08 In any case where unusual conditions are reported to the supervisor, the routines outlined herein, including all periodic readings and special charges if called for by irregular conditions or readings, shall be continued until or unless special instructions are given by the supervisor.

2.04 Check and record individual-cell voltage on float every 3 months. If it is noted during these readings that one or a few cells swing over a much shorter voltage range than the other cells, notify the supervisor. See 1.06. If any cell voltage corrected for temperature is below 2.13 volts with float presumably at 2.17 volts per cell, give a boost charge to the battery. Temperature correction per Section A401.001 need be applied only when uncorrected voltage is 2.13 or below. If voltage is still low at next quarterly readings, repeat the boost to the battery or give to affected cells only. If still low at the next (third in succession) quarterly readings, give a battery boost charge and notify the supervisor. See 1.06. Some voltage variation is likely early in cell life, but three low quarterly readings on the same cell during the first year of life with average float voltage at 2.17 volts per cell is cause for official complaint. Three low readings later in life, particularly in the last quarter of anticipated life, indicates possible trouble and need for special consideration. See 1.06. For exception, see 2.10. Use of form E-3593 is suggested for the records, but form E-2003 may be found more convenient in some offices.

1.09 See Section A401.001 for general information such as anticipated life, normal charging rates, maximum and minimum levels, ampere-hour rated capacity, electrolyte specific gravity and voltage requirements, method of reading hydrometers, method of correcting specific gravity and voltage readings for temperature, method of giving capacity discharge tests, containers for handling electrolyte and water, approved water, precautions against explosions, spilled electrolyte, etc.

Caution: Avoid creation of sparks including those from static electricity or the use of an open flame near batteries, since the gas given off by the battery is explosive.

+ .01 Vts. for 3°F above lowest temp cell

2. ROUTINES

INTERVAL CHART

| | <u>Max Interval</u> | <u>See Par.</u> |
|-----------------------|---------------------|-----------------|
| Voltage | | |
| Battery average float | Year | 2.02 |
| Bat. or pilot cell | Week | 2.03 |
| Individual cell | 3 months | 2.04 |
| Specific gravity | | |
| Pilot cell | 1-1/2 months | 2.05 |
| Individual cell | 3 months | 2.05 |
| Boost charge | Year | 2.06 |
| Clean and inspect | 3 months | 2.07 |
| Calibrate voltmeter | 6 months | 2.08 |
| Exceptions | - | 2.09 to 2.11 |

2.05 Check individual-cell corrected specific gravity every 3 months and pilot-cell corrected specific gravity every one to 1-1/2 months. If a drop for any cell of more than 4 points (0.004) in three months cannot be explained by recent addition of water, low electrolyte level at previous reading, or an emergency discharge, give a boost charge to the cell or the battery. Recheck average battery float voltage. A drop of more than 6 points (0.006) in a year should be reported to the supervisor. See 1.06. For exceptions see 2.09, 2.10, and 2.11. Use of form E-2003 is suggested.

2.06 Give a boost charge annually and when otherwise required. See 1.06, 2.04, and 2.05. Use of form E-2003 is suggested.

2.07 At least every 3 months and oftener if necessary, clean and inspect cells and connections, check electrolyte level, and check general condition of the cells, all in accordance with A401.001. If a cell requires appreciably more or less water than other cells, note in blank space on battery forms. If it occurs at two consecutive quarterly inspections, notify the supervisor. See 1.06. Any irregularities noted in connection with these checks should be noted in battery records.

2.08 Check the accuracy of battery or cell voltmeter at or near the float value every 6 months and oftener if necessary to assure accuracy at float, regardless of accuracy at other points. Set voltmeter having external adjuster as accurately as possible at or near float voltage. The head of the adjusting screw may be covered with tape to avoid both accidental and unauthorized changes. Inking of adjustment date on the tape is suggested. On voltmeters having no external adjuster, mark or tag the instrument or prominently note in office records, the correction to be applied to the readings and the date of calibration. Careful battery maintenance is of little avail if based on inaccurate instruments.

2.09 With some installation such as 301C power plants in No. 5 crossbar offices, load changes are too large and too frequent to be absorbed promptly by the charger and battery. In such a case, all voltage readings are difficult and some are impractical. The following changes from usual routine are suggested:

(a) Maintaining correct average float voltage (2.02) depends on accurate adjustment of plant voltage regulators using a steady voltage such as that from dry cells, some other battery, or a spare charger. With such method a rheostat or potentiometer near the regulator to control the voltage applied to the regulator will be of advantage. A reasonably accurate check of setting and a substitute for the usual battery voltage readings (2.03) is as follows: Take a set of ten consecutive battery voltage readings at 5-second intervals. Do this four times during the same day with at least an hour between each set of readings. The average of the 40 readings is a good practical estimate of the voltage at which the battery is actually floating. If remaining at the office for four hours plus is a real hardship, a slightly less accurate estimate can be obtained from the average of two sets of ten 5-second readings, one set taken as the office load is building up and one as it is dropping off. Frequency of plant voltage regulator checks may be based on these 5-second readings, if desired. Note that whether the 5-second interval is actually timed with a watch or estimated by a count of five, the important requirement is that the voltage be read or estimated exactly at the end of the interval regardless of how

fast or in which direction the voltmeter needle is moving. Following the natural tendency to wait for the needle to stop will destroy the accuracy of the results.

(b) The period between individual-cell corrected specific gravity (2.05) readings should be reduced to between one and 1-1/2 months.

(c) Individual-cell voltage (2.04) readings should be taken at the instant the battery on the upswing reaches specified float value (50 volts on 23-cell battery). These readings are dependable only if the average battery float voltage, see (a) above, is at 2.17 volts per cell. See 2.13(a).

Use of form E-2003 is suggested for all readings at this type of office.

2.10 Where, as at a 250-volt battery in a TD-2 station, charge and float voltage are disconnected when the cabinet is opened, cell-voltage readings are impracticable. The following changes from usual routine are suggested:

(a) Individual-cell voltage (2.04) readings are omitted.

(b) The period between individual-cell corrected specific gravity (2.07) readings should be reduced to between one and 1-1/2 months or as near these values as visits to the office for other reasons permits.

(c) Special attention to accuracy of voltage regulators is necessary. Occasional discharge tests, particularly during the last quarter of anticipated life, may be desirable.

Use of form E-2003 is suggested for all readings at this type of office.

2.11 On emergency cells having manually controlled chargers, individual-cell corrected specific gravities should be taken and recorded weekly at attended offices and as near weekly as visits permit at unattended offices. If corrected specific gravity drops 8 to 14 per cent of the gravity range for full discharge, charge the emergency cells until they start gassing freely or until 15 per cent of the cell capacity has been returned. Rate should not exceed nominal charging rate except on charge by load in which case the time of day of the charge should be selected so that the nominal charging rate will be exceeded as little as possible and temperature should be watched to be sure maximum temperature is not exceeded. Note that a 15 per cent or larger discharge would have made necessary a boost charge per 4.01. Example: Assume a KS-15544, List 405 battery whose corrected specific gravity had dropped 7 points (0.007). From A401.001, these cells are rated at 420 ampere-hours and have a gravity range of 75 points. Seven points is 9-1/3 per cent of 75 points, so a charge is required. It may be until free gassing or until 63 ampere-hours (15 per cent of 420) has been replaced.

2.12 Specific gravity and voltage readings should be taken before rather than after water additions or charging. The best time to add water is during the last quarter of a charge, to take advantage of mixing but avoid overflow. After charging and adding water, specific gravity readings may not stabilize for 6 weeks or more. After charging of the entire string, voltage may not stabilize for 2 or 3 days where the entire string has received the same treatment or for 2 or 3 months where one or a few cells have received different treatment from the rest of the string.

2.13 Where battery voltage is apparently constant or is drifting slowly, that is, does not stand still but is not swinging back and forth over a range within the time available for each cell reading, record for record only the battery voltage before and after taking the individual cell voltages. Complete the individual cell readings as promptly as possible. The individual-cell voltages so read may be used as a basis for maintenance in accordance with this practice. While not as definite and comparable as might be desired, they are reasonably accurate for routine maintenance and they can be corrected, partially at least, to an average battery voltage later if a special study of the cell behavior ever becomes necessary. Where battery voltage is swinging regularly over an appreciable range, the individual cell readings should be taken by one of the following methods which are listed in order of preference.

(a) Read each cell voltage at the instant the battery voltage on the upswing reaches the voltage at which the battery is actually floating at the time of the readings. This requires one man to watch individual-cell voltmeter and take the readings when notified by a second man who is watching the battery voltmeter. Facilities to avoid the need for two men on these readings are under development.

(b) Take individual-cell voltage readings at top and bottom of the swing and record these two readings and their calculated average.

3. AVERAGE BATTERY FLOAT VOLTAGE

3.01 Set voltage regulation so that the battery average float voltage over the day or week is as near 2.17 volts per cell as feasible. Use accurate voltmeter.

3.02 With regulation at the battery, the voltage at which the battery floats does not tend to vary appreciably with office load. This class includes constant-load plants, many plants with commercial charging sets, or regulated rectifiers where regulating leads are run direct to the battery and to plants with common charge and discharge leads if the regulating leads are connected at the battery control board. Where regulation is at the

battery, check annually as follows. Where the battery voltage is constant or drifting slowly, that is, does not swing back and forth within the time available for readings, take ten readings of battery voltage at 5-minute intervals and assume that the average battery float voltage is the average of these ten readings. Where the battery voltage is swinging regularly over an appreciable range, note the high and low for each of five consecutive swings and record the average of these ten readings as the average battery float voltage. If average battery float voltage is outside of 2.16 to 2.18 volts per cell, recheck voltage regulator. If voltage regulator is correctly set and average battery float voltage is outside of 2.15 to 2.19, refer to supervisor for special instructions.

Note: In some constant-load plants, there is no regulating equipment and float-voltage adjustment is made by changing charger setting. With some installations, for example, 301C plants in No. 5 crossbar offices, the usual voltage observations are impracticable. See 2.09.

3.03 With variable-load plants having regulation at the charger, battery voltage is highest at no load and drops with increased load. This class includes diverter pole plants, plants with rectifiers having no separate regulating leads, and plants with centrifugal voltage regulators connected at the charger. It also applies where there are separate charge and discharge leads and the regulator is connected at the control board to the charge leads. With variable-load plants having separate charge and discharge leads and regulation at load bus on the battery control board, the battery voltage is lowest at no load and increases with load. This class includes all plants with M-type generators, some plants with commercial machines, and some with rectifiers.

3.04 With regulation at either the machine or the load bus, annually, during a 5-minute interval of the busy hour, record the highest and lowest office load in amperes as well as the corresponding battery voltage. Repeat these readings for a 5-minute interval during lightest load period of the 24-hour day. Reset regulation if the average of the highest and lowest of these four voltage readings (average battery float voltage) does not equal 2.17 times number of cells. The highest and lowest of these readings establish the voltage range for the particular load range. Frequently note the battery voltage and load current. If they are not both within their established range or if when current is in the upper or lower quarter of its range the voltage is not in the expected half of its range (see below), recheck the average battery voltage and reset regulating equipment as necessary. From 3.03, when regulation is at the charger, the battery voltage would be expected to be in the upper half of its range when the current was in the lower quarter of its range

and in the lower half when current was in upper quarter. When regulation is at the load bus, the battery voltage would be expected to be in the lower half of its range when current was in the lower quarter of its range and in the upper half when current was in the upper quarter.

Note: The above setting based on an average of the high and low for the day should be satisfactory. Where local supervision feels that a particular office operates for long intervals at one end of the range and only short intervals at the other end, a possibly more accurate average can be obtained by averaging hourly or even half-hourly readings over a full 24-hour day or over a longer period if daily loads are not uniform.

3.05 With manually floated emergency cells and engine starting batteries, the battery voltage tends to vary with ac line voltage, but the dc response to the ac changes is so slow that it is usually satisfactory to disregard ac line voltage when checking float voltage. Initially, set rectifier so that the trickle current soon after the initial charge is about 1/2 of 1 per cent of the 8-hour discharge rate for a lead-antimony cell and about 1/8 of 1 per cent for a lead-calcium cell. During the first three months, the battery voltage should be checked about once a week and charger setting changed if battery is not at recommended float value. After satisfactory setting is obtained, the checks should be as often as necessary to assure accurate float at 2.17 volts per cell. See 2.11. Charger setting to provide desired float-voltage is a cut and try procedure. With rectifiers having adjusting steps, the final adjustment during the 3-month initial period and changes made at periodic checks of battery voltage thereafter will usually be smallest change possible with the particular rectifier. With rectifiers such as J86220 and J86230 having continuous adjustment, trimming changes of about 5 per cent of the charger output current before the adjustment are suggested until experience at a particular installation indicates a better value. Voltage readings on engine starting batteries should be made before the engine is started.

3.06 With parallel strings separated by a choke coil, the float shall be based on the low-voltage string, that is, the string separated from the charging equipment by the choke coil. Where, as with 48-volt battery tapped for 24 volts, one section of the battery is subjected to different conditions than the other section, more frequent checks of floating voltage may be necessary to avoid unbalance.

3.07 The most important single precaution in battery maintenance is keeping accurate float voltage and this is possible only if float voltmeters are accurate or in accurate

calibration at float voltage and voltage regulating equipment is in accurate adjustment. The Weston model 931 voltmeter is suitable for voltage readings. Where it is not yet available, dependence must be made on the old model 280 or model 281 voltmeters, used very carefully and supplemented by frequent checks with a better instrument such as the model 931 or model 622 voltmeters. See 2.08.

4. BOOST CHARGE

4.01 A boost charge shall be given annually, when otherwise required (see Part 2), and when ordered by the supervisor. In addition, a boost charge should be given to the main battery and to the emergency cells if they have had any appreciable discharge or if it is known that there has been one emergency discharge or a series of short discharges which (a) were the equivalent of 1/2 hour or more during the heavy-load period of the day; or (b) caused the corrected specific gravity to drop 15 per cent or more of the cell's gravity range for full discharge. Be sure low specific gravity is due to discharge and not to recent addition of water. Pilot-cell specific gravity readings should be taken to determine extent of emergency discharge when the length of the emergency discharge is unknown.

Caution: Watch the first group of emergency cells carefully. A series of emergency discharges may discharge this group much more than the main battery or the second group of emergency cells.

4.02 Periodic boost charges, as well as boost charges after power failure, are given per Table 1 to the entire string. Special boost charges may be given to the string or to certain selected cells only. See Section A301.340.

4.03 Where a boost charge is given to a few cells only, the charge may be per Table 1 but it may be more convenient to give it on an ampere-hour basis. In such cases, the length of the charge shall be 100 per cent of the 8-hour rated capacity of the cells, unless other length of charge is approved by the supervisor. The charge is held at any desired rate not exceeding the nominal charging rate for the cell by frequent adjustments of the charger output. Higher rates are permissible only on discharged batteries (see A301.340) and then only early in the recharge period. Single cell charger J86264 is rated at 210 amperes and KS-15687 at 20 amperes. Either may be used on one or two adjacent cells and at slightly reduced rates on three adjacent cells.

4.04 To give a boost charge per Table 1, first raise the voltage to charge value provided for in the particular plant. This may take only a few minutes for charged battery which has been floated accurately or an

appreciable time if battery is partially discharged. After charge voltage is reached, charge for a period within the maximum and minimum shown for that voltage in Table 1.

Example: At 2.20 volts per cell, the length of charge could be any length of time from 147 to 180 hours, which is approximately one week. With electrolyte temperatures above 95F, the minimum length of boost charge is preferable while at temperatures below 65F, the maximum is preferable. If charge voltage is greater than 2.31 volts per cell, watch pilot-cell temperature, interrupt the charge before 110F is exceeded, and complete later or at reduced voltage.

Table 1 - Boost Charge Time

| Volts per Cell | Hours | |
|----------------|--------|--------|
| | Max | Min |
| 2.60 to 2.53 | 1.50 | 1.50 |
| 2.52 | 1.75 | 1.50 |
| 2.51 | 2.00 | 1.50 |
| 2.50 | 2.25 | 1.75 |
| 2.49 | 2.75 | 2.00 |
| 2.48 | 3.00 | 2.25 |
| 2.47 | 3.50 | 2.75 |
| 2.46 | 4.00 | 3.00 |
| 2.45 | 4.75 | 3.50 |
| 2.44 | 5.50 | 4.25 |
| 2.43 | 6.25 | 4.75 |
| 2.42 | 7.25 | 5.50 |
| 2.41 | 8.50 | 6.50 |
| 2.40 | 9.75 | 7.50 |
| 2.39 | 11.25 | 8.75 |
| 2.38 | 13.00 | 10.00 |
| 2.37 | 15.00 | 11.75 |
| 2.36 | 17.25 | 13.75 |
| 2.35 | 20.00 | 16.00 |
| 2.34 | 23.00 | 18.50 |
| 2.33 | 26.75 | 21.50 |
| 2.32 | 31.00 | 24.75 |
| 2.31 | 36.00 | 28.75 |
| 2.30 | 41.00 | 33.00 |
| 2.29 | 48.00 | 38.75 |
| 2.28 | 56.00 | 45.00 |
| 2.27 | 64.50 | 51.00 |
| 2.26 | 75.00 | 60.25 |
| 2.25 | 86.50 | 70.00 |
| 2.24 | 102.00 | 80.75 |
| 2.23 | 117.00 | 94.00 |
| 2.22 | 135.00 | 110.00 |
| 2.21 | 156.00 | 127.00 |
| 2.20 | 180.00 | 147.00 |

trollyte and interrupt charge, if necessary, to prevent temperatures from exceeding 110F. Complete charge later or at reduced rate.

5. RECORDS

5.01 Record the date and time of all readings or date and time of starting a series of readings such as individual-cell volts or specific gravities.

5.02 Record the temperature whenever a hydrometer reading is taken, since only corrected specific gravity values are of value in determining the condition of the battery. Temperatures are also of interest in connection with voltage readings, but since voltage and specific gravity readings are usually taken at the same time, one set of temperature readings is sufficient.

5.03 Temperature readings should be to the nearest degree, for example, 75F; specific gravities to the thousandths, for example, 1.212; battery voltage to tenths, for example, 49.6 volts; calculated battery average voltage, that is, average of high and low for the day, to hundredths, for example, 49.52 volts; individual cell voltage to hundredths, for example, 2.17 volts; and calculated average cell voltage to thousandths, for example, 2.172 volts.

5.04 When individual-cell specific gravity readings are taken, note on unused space on the forms, the approximate electrolyte level in quarters of an inch from maximum or minimum for average cells and amount if more than 1/4 inch that the level of particular cells vary from this average. When pilot- or emergency-cell specific gravity readings are taken, note approximate electrolyte level in quarters of an inch from maximum or minimum. These are gauge by eye items and are to assist in interpretation of irregular specific gravity readings.

5.05 On unused space on forms, record irregularities noted in conditions or operation of the battery, including irregularities in amount of water required.

5.06 It is suggested, subject to wishes of the supervisor, that individual-cell corrected specific gravity readings for 24- and 48-volt batteries of more than 100-ampere-hours capacity be plotted quarterly on form E-956. On small cells as well as on higher-voltage batteries, particularly where there are duplicate strings, this work does not seem to be justified since the charts can still be made up later from office records if a special study of the behavior of the battery becomes necessary.

5.07 Forms E-3592, E-3593, and E-2003 are suggested in Part 2 for recording various readings. Modifications of these forms

4.05 On a boost charge of emergency cells by load, note cell voltage at 15-minute intervals and terminate charge when the

length of time of charge is within the maximum and minimum shown in Table 1 for voltage which is the average of these 15-minute readings or when the ampere-hours (average current times elapsed time) equals 100 per cent of the 8-hour rated capacity of the cells. In either case watch the temperature of the elec-

to use the space more efficiently in accordance with present routines and to omit space for obsolete readings will be considered a little later when the new routines are in general use. Local forms, the equivalent of the above, are acceptable.

5.08 Compare individual-cell readings with each other and compare present readings with previous records. Correct adverse con-

ditions if cause of irregularities is known, otherwise report to supervisor. See 1.06.

5.09 In case of battery complaints, conclusions satisfactory to all are less likely where records are incomplete and float is found to be incorrect, possibly due to inaccurate voltmeters. It is recommended that a copy of all battery records, including the initial charge report, be maintained at the battery for the life of the battery.