STORAGE BATTERIES

CYCLE CHARGE - MANUAL OPERATION

1. GENERAL

1.01 This section describes the cycle charge, manual operation of open and sealed storage batteries in telephone and telegraph power plants.

1.02 It is reissued to:

(a) omit data or descriptions now considered unnecessary or covered in 157-601-101 or 157-601-701.

(b) restate the conditions under which charge rates above normal are permitted.

(c) add Table 1 to simplify the selection of operating method.

(d) raise trickle voltage of emergency cells from 2.15 to 2.17 volts per cell and omit periodic equalizing charges on such cells.

(e) call for voltage readings on emergency cells at trickle voltage instead of raised voltage.

(f) omit individual cell voltage and specific gravity readings on all cells but trickled emergency cells.

(g) widen the float-voltage range on charge-float-discharge operation from 2.10-2.15 to 2.05-2.17 volts per cell.

(h) simplify the statement on loads above which a float period after charge is usually desirable.

(i) change the suggested end of charge voltage from 2.20 to 2.22 volts per cell where length of charge is based on end of charge voltage.

(j) permit basing end of equalizing charge on either maximum specific gravity or constant power instead of the former only.

(k) increase slightly stabile time in Table 4.

(l) revise Part 5, Records, to agree with other text.

1.03 Except where special corrective action has been recommended for a particular battery, these routines apply at all room temperatures between electrolyte freezing temperature and 100F and for any cell whose full charge corrected specific gravity does not exceed 1.225. Temperatures below 80F are preferred and where average temperature for the 24-hour day exceeds 100F special operating methods may be necessary.

1.04 Satisfactory operation, particularly on constant voltage charges, trickle of emergency cells, and equalizing charges, depends to a large extent on careful maintenance, adjustment, and calibration of instruments and control equipment.

1.05 Charging current should not exceed the charger rating and should not exceed the nominal charging rate of the battery except during the first half hour of the charge when rates up to 150 per cent of the nominal charging rate are satisfactory and on charge by load of emergency cells where averages up to 130 per cent and peaks up to 150 per cent of the nominal charging rate are to be accepted.

1.06 See 157-601-701 for nominal charging rates, 8-hour gravity ranges, maximum and minimum levels, ampere-hour rated capacities, electrolyte specific gravity and voltage requirements, method of reading hydrometers, method of correcting specific gravity readings for temperature, 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.

2. SCHEDULES

2.01 Scheduled attention to the battery shall be in accordance with Table 1. Where frequency is per Table 2, 70 per cent charge should be maintained unless otherwise specified locally.

TABLE 1 - BATTERY SCHEDULE

Charging Method See Note 1	Frequency of Regular Charge	Individual Cell Sp. Gr. and Voltage Readings. See Note 4.	Frequency of Equalizing Charge. See Note 2 and Part 4
Main Battery	See 2.02 to 2.04		
Variable Current	Table 2 - See 3.01	-	Quarterly
Constant Voltage	Table 2 - See 3.04	-	Annually
Small Duplicate Batteries			
Variable Current	Table 2 - See 3.01	-	Quarterly
End of Charge Voltage	1-14 days - See 3.02	-	-
Emergency Cells			
Trickle at 2.17 Volts	- See 2.05	5-7 Wks.	-
Open Circuit	-	-	Monthly
Stored Cells			
Open Circuit	-	-	Quarterly

Notes:

1. Select the option most satisfactory for the particular installation. In case of doubt, use the first listed method.

2. Unscheduled equalizing charge should be given in case of sulfation or other indication of undercharge. For constant voltage method, end of charge voltage method, or trickle of emergency cells, it should be given whenever pilot cell end of charge corrected specific gravity is more than 15 per cent of the 8-hour gravity range, below the corrected specific gravity at the last initial or equalizing charge.

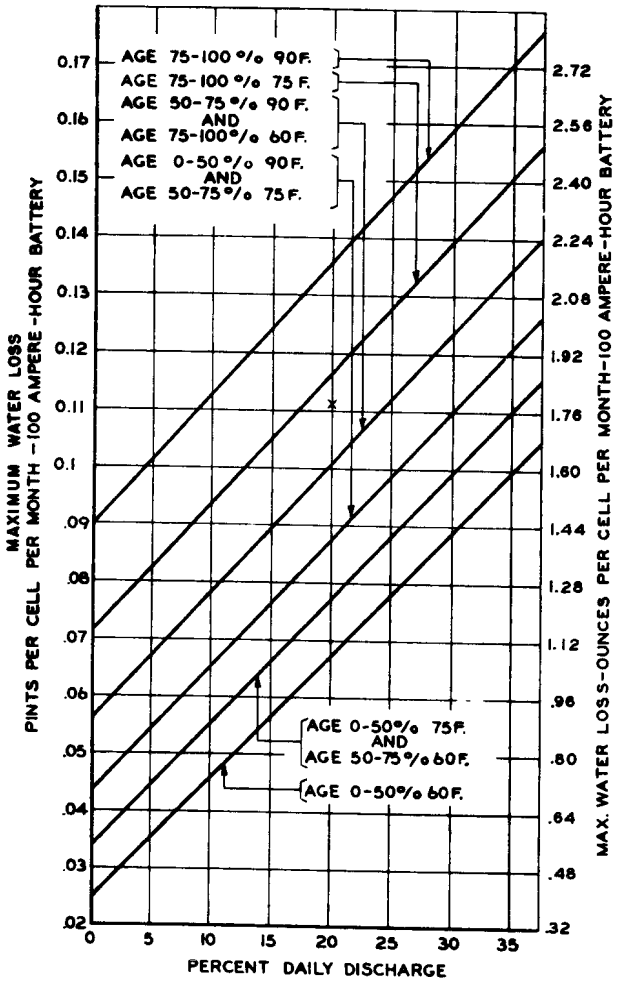
3. Add water periodically to maintain level above minimum. Once a month will probably be often enough. Clean batteries on same schedule.

4. Except as indicated for emergency cells, individual cell voltage and specific gravity readings need be taken only when required locally, in which case action and interpretation of readings should be in accordance with local instructions.

TABLE 2 - CHARGE FREQUENCY

Average Daily Discharge in % of 8 Hr. rated Capacity or % of 8 Hr. Gravity Range	Charging Frequency to Maintain 70%	60%	50%
0 to 1%	Monthly	Monthly	Monthly
1-1/2%	Every 3 Weeks	Every 3 Weeks	Monthly
2%	Every 2 Weeks	Every 3 Weeks	Every 3 Weeks
2-1/2%	Weekly	Every 2 Weeks	Every 3 Weeks
3%	Weekly	Every 2 Weeks	Every 2 Weeks
4%	Weekly	Weekly	Weekly
5%	Weekly	Weekly	Weekly
7%	Every 5 Days	Every 6 Days	Weekly
10%	Every 3 Days	Every 4 Days	Every 4 Days
15%	Every 2 Days	Every 3 Days	Every 4 Days
20%	Every 2 Days	Every 2 Days	Every 3 Days
25%	Daily	Every 2 Days	Every 2 Days
30%	Daily	Daily	Every 2 Days
Over 30%	Daily	Daily	Daily

Note: The percentages in the first column are for a typical 24-hour day having no charge or float period. From the table, the charge should be every other day if a minimum state of charge of 70% is to be maintained and the average daily discharge is 20% of the battery capacity. This assumes that the charge, or float, will extend over enough of the second or charge day to hold its discharge to 10% while 20% was expended on the first or noncharge day.



NOTES:
1. PINTS (OR OUNCES)-ARE PER CELL PER MONTH AND SHOULD BE MULTIPLIED BY THE NUMBER OF MONTHS AND NUMBER OF CELLS. VALUES ARE FOR A 100 AMP.-HOUR BATTERY. DIVIDE BY 100 AND MULTIPLY BY RATED 8 HOUR CAPACITY OF THE BATTERY FOR OTHER SIZES.
2. PERCENT DAILY DISCHARGE-IS IN PERCENT OF 8 HOUR CAPACITY.
3. TEMPERATURES-ARE OF ELECTROLYTE AND ARE THOSE AVERAGING OVER THE PERIOD FOR WHICH WATER LOSS WAS MEASURED.
4. AGE-IS IN PERCENT OF THE ANTICIPATED LIFE GIVEN IN THE REQUIREMENT SECTION.
5. EXAMPLE-IF LOSS FOR 3 MONTHS AT 75F. ON A 12 CELL KS-5361 L.150 BATTERY IS 4 PINTS, THE LOSS PER CELL PER MONTH IS 4 ÷ 36 = 0.111 PINTS. SINCE THIS FALLS BELOW THE 75-100°/o 75F. DIAGONAL IT IS SATISFACTORY. ASSUMING 20°/o DISCHARGE AND 80°/o AGE.

Fig. 1 - Maximum Water Loss for Sealed Type Batteries with Specific Gravity Below 1.225

2.02 With duplicate main batteries, the newly charged battery, after an hour or more on open circuit, should be placed in parallel with the other battery on the load.

2.03 With single main batteries, the charger not only charges the battery but also carries the load during the charging period. Arranging to charge over as much of the working day as feasible reduces the working of the battery and improves the power efficiency. However, where maximum demand or peak load power factor affects power rates, it may not be economical to charge during telephone company or power company peak load periods.

2.04 Where practicable, it is recommended that either single or duplicate main batteries, after completion of the charge, be floated at from 2.05 to 2.17 volts per cell until it is necessary to shut down charging equipment for a low load or unattended period. It is suggested, in absence of contrary experience with a particular charger, that loads in excess of 20 per cent of charger rating be floated. With manual regulation, set voltage slightly high if office load is increasing and slightly low if it is decreasing. This reduces frequency of adjustments.

2.05 Where practicable, the emergency cells should be trickled at a charger setting such that the average of the high and the low voltage for the 24-hour day is as near to 2.17 volts per cell as feasible. Emergency cell voltage and specific gravity readings should be taken at trickle voltage instead of at the raised voltage usually used for such readings. See 157-601-701 for requirements. Check voltage often enough to be sure that it is at correct value. Water loss in excess of the values in Fig. 1 would indicate excess charge and suggest that average voltage and voltmeters be rechecked.

3. REGULAR CHARGES

3.01 The variable current regular charge is applied at any convenient setting or settings of the charger output. See 1.05. It is continued until the corrected specific gravity of the electrolyte of the pilot cell has risen to a value 10 to 15 per cent of the 8-hour gravity range below the corrected specific gravity at the last initial or equalizing charge. See 157-601-701 for method of taking hydrometer readings.

Example: The gravity range of KS-5562, List 04, cell is given as 65 (.065) in 157-601-701. Ten per cent of .065 = .007 and 15 per cent of .065 = .010. If the corrected specific gravity at the last equalizing charge were 1.208, the regular charge would be stopped when the corrected specific gravity was between 1.198 and 1.201.

Due to gassing and slow diffusion, the hydrometer readings may not indicate the true state of charge for some time after the end of the charge. Experience should soon indicate the end of charge hydrometer reading corresponding to the desired specific gravity. Actual corrected specific gravities should be checked several hours, say 2 to 5, after end of charge. The final readings should be scheduled so that there will be no appreciable discharge between the end of the charge and the readings.

3.02 Where the charge of small duplicate batteries is based on end of charge voltage, one battery is charged for a locally determined period with a fixed setting of the nonregulated charger after which it carries the load while the other battery is charged for the same length of time and usually with the same charger setting. The charger should be set by trial so that the battery will have reached full charge or received a slight overcharge by the end of each period. This would be indicated by little loss of full charge corrected specific gravity occurring over several weeks and possibly some gassing at the end of the charge period. End of charge voltage should not exceed 2.40 volts per cell. In the absence of local instructions or experience as to proper charger setting, attempt to reach 2.22 volts per cell at end of charge.

3.03 The length of charge to end of charge voltage can be from a day to 2 weeks based on convenience, load, battery size, and charger capacity. A short schedule gives more frequent overcharges while a longer schedule with its lower rate gives more complete charge for the same end of charge voltage so that either short or long schedules should be satisfactory. A week is suggested unless other period offers advantage. The end of charge voltage should be increased if there is evidence of sulfation, or other undercharge conditions. Water loss in excess of the values in Fig. 1 would point to excess charging and the need for lower end of charge voltage. However, water loss would be expected to run a little high due to the slight overcharge and gassing at end of each period.

3.04 With a regular charge by constant voltage, the battery is charged until a voltage of 2.27 volts per cell is reached, after which voltage should be held constant for the time shown in Table 3. The current, prior to reaching 2.27 volts per cell, should be between 50 per cent and 150 per cent of the current at time 2.27 is reached. The current for the last quarter of the time prior to 2.27 should be between 90 per cent and 110 per cent of the current when 2.27 is reached. Experience will soon indicate generator settings necessary to maintain current between these limits. In determining the extent of the discharge, the pilot cell corrected specific gravity at the end of the preceding regular charge should be used as the full charge value. The equalizing charge specific gravity would not be used in this connection except on the first regular charge after an equalizing charge. The charging periods given in Table 3 apply when last equalizing charge corrected specific gravities were 1.200 or above. For values below 1.200, reduce time of Table 3 by 1-1/2 per cent for each point (.001) the corrected specific gravity at the last equalizing charge is below 1.200 and figure to the nearest quarter hour.

Example: An equalizing charge specific gravity of 1.175 is (.025) 25 points below 1.200. If Table 3 called for 5 hours of charge, it should be reduced 25 x 1-1/2 or 37 per cent which would be 1-3/4 hours. The correct charging time after reaching 2.27 volts per cell would then be 3-1/4 hours.

Note: The constant voltage method is not recommended where the time between charges exceeds one week.

TABLE 3 - REGULAR CHARGE BY CONSTANT VOLTAGE

Current to Battery at Time 2.27 Volts per Cell Is Reached (% of 8 Hr. Discharge Rate)	Electrolyte Temperature At Start Of Charge	Hours Charge After Reaching 2.27 Volts per Cell: 10 to 20% Discharged At Start Of Charge	21 to 30% Discharged At Start Of Charge	31 to 50% Discharged At Start Of Charge	51 to 80% Discharged At Start Of Charge	81 to 100% Discharged At Start Of Charge
100 - 125%	81-100F	1 Hour	2 Hour	4 Hours	6 Hours	7 Hours
	60-80F	2 Hours	3 Hours	5 Hours	8 Hours	10 Hours
	40-50F	3 Hours	4 Hours	6 Hours	10 Hours	12 Hours
75 - 99%	81-100F	1 Hour	2 Hours	3 Hours	5 Hours	6 Hours
	60-80F	2 Hours	3 Hours	4 Hours	7 Hours	8 Hours
	40-59F	2 Hours	3 Hours	5 Hours	8 Hours	10 Hours
50 - 74%	81-100F	1 Hour	1 Hour	2 Hours	4 Hours	5 Hours
	60-80F	1 Hour	2 Hours	3 Hours	5 Hours	7 Hours
	40-59F	2 Hours	3 Hours	4 Hours	7 Hours	8 Hours
25 - 49%	81-100F	3/4 Hr.	1 Hour	2 Hours	3 Hours	4 Hours
	60-80F	1 Hour	1 Hour	2 Hours	4 Hours	5 Hours
	40-59F	1 Hour	2 Hours	3 Hours	5 Hours	6 Hours

4. EQUALIZING CHARGE

4.01 An equalizing charge is an overcharge that is continued to a measured end. See 4.02. It is required periodically under some operating routines (see Table 1) and unscheduled equalizing charges are sometimes necessary. (See Table 1, Note 2). It may be by either the constant voltage (4.03) or the constant current (4.04) method.

4.02 On equalizing charge, the battery should be charged until stabile as evidenced by reaching maximum specific gravity or constant power, that is, current and voltage both constant. As a factor of safety, the charge should then be continued for a period, the length of which depends on the voltage or current used during the charge. Maximum gravity period may be based on hydrometer readings without correcting for temperature unless it becomes necessary to interrupt the charge during the maximum gravity period.

Note: One hydrometer reading that is 1 point (0.001) high during the latter half of the stabile period may be disregarded.

4.03 Where charge is at <u>constant voltage</u>, continue charge after current stabilizes or pilot cell specific gravity has reached its maximum for the number of hours shown in Table 4.

TABLE 4 - CONSTANT VOLTAGE EQUALIZING CHARGE

Volts Per Cell	Stabile Time Hours
Above 2.46	1
2.46	1-1/3
2.42	2
2.38	3
2.34	5-1/2
2.30	9
2.26	15

4.04 Where equalizing charge is by <u>constant current</u>, continue charge after voltage stabilizes or pilot cell specific gravity has reached its maximum for the number of hours shown in Fig. 2, for the used current in per cent of the 8-hour discharge rate. Example, if charge is at 60 per cent of the 8-hour discharge rate, the stabile period is 1 hour and 40 minutes.

4.05 On an equalizing charge of emergency calls by load, the current or voltage to be used in applying Fig. 2 or Table 4 is the estimated average for the stabile period. Watch electrolyte temperature. Interrupt charge before 110F is exceeded.

4.06 Where an <u>unscheduled equalizing charge</u> is given on small cells not arranged for equalizing, it may be necessary to insert a counter emf cell into the circuit temporarily to avoid exceeding circuit voltage limits. If counter emf cells of the alkaline type are not available, a lead-acid storage cell connected to oppose the cells being charged is satisfactory. It may also be necessary to supply additional charging equipment during the charge. Charges involving special equipment should be made only when approved by the supervisor.

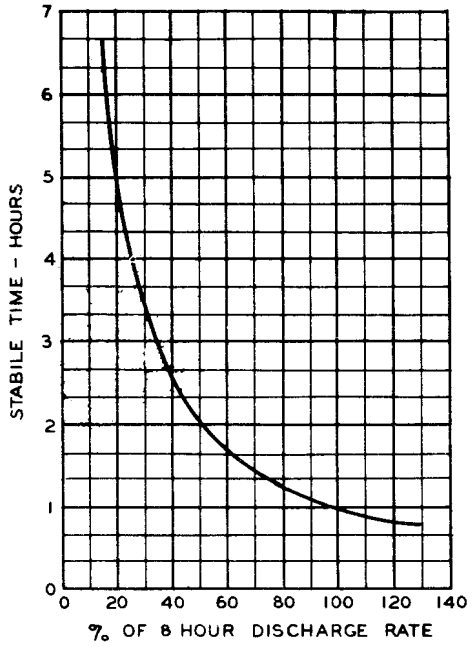


Fig. 2 - Constant Current-equalizing Charge

5. RECORDS

5.01 It is suggested that records be kept on forms E-2004 and E-3591. See Fig. 3. Always record date and time just before a charge starts, just before a charge stops, and when starting any other readings which are recorded. Forms still listing 70F as reference temperature should be changed to read 77F in offices where correction is to 77F.

5.02 Record when water is added and, for enclosed cells, the amount in pints for the entire battery. Water loss in excess of the values given in Fig. 1 indicates excess charge calling for a restudy of charging methods and equipment.

5.03 Every 5 to 7 weeks on trickled emergency cells, record individual cell voltage at high and low line voltage and individual cell corrected specific gravity.

5.04 At each regular charge, record

(a) Before charge starts pilot cell corrected specific gravity and battery or pilot cell voltage.

(b) Start of charge amperes into the battery.

(c) For constant voltage charge only, the time and amperes into the battery when 2.27 volts per cell is reached.

(d) End of charge amperes into the battery and pilot cell or battery voltage.

(e) Several hours, say 2 to 5 hours after charge, pilot cell corrected specific gravity.

(f) For variable current charge only, either the average ampere into the battery or the average amperes output of the charger as convenient.

(g) Time float, if any, is discontinued.

5.05 At each equalizing charge, record constant voltage or constant current during the charge and all current, voltage, or hydrometer readings taken to determine stability.

5.06 Compare readings with previous records. Correct adverse conditions, if cause of irregularities is known; otherwise report to supervisor.

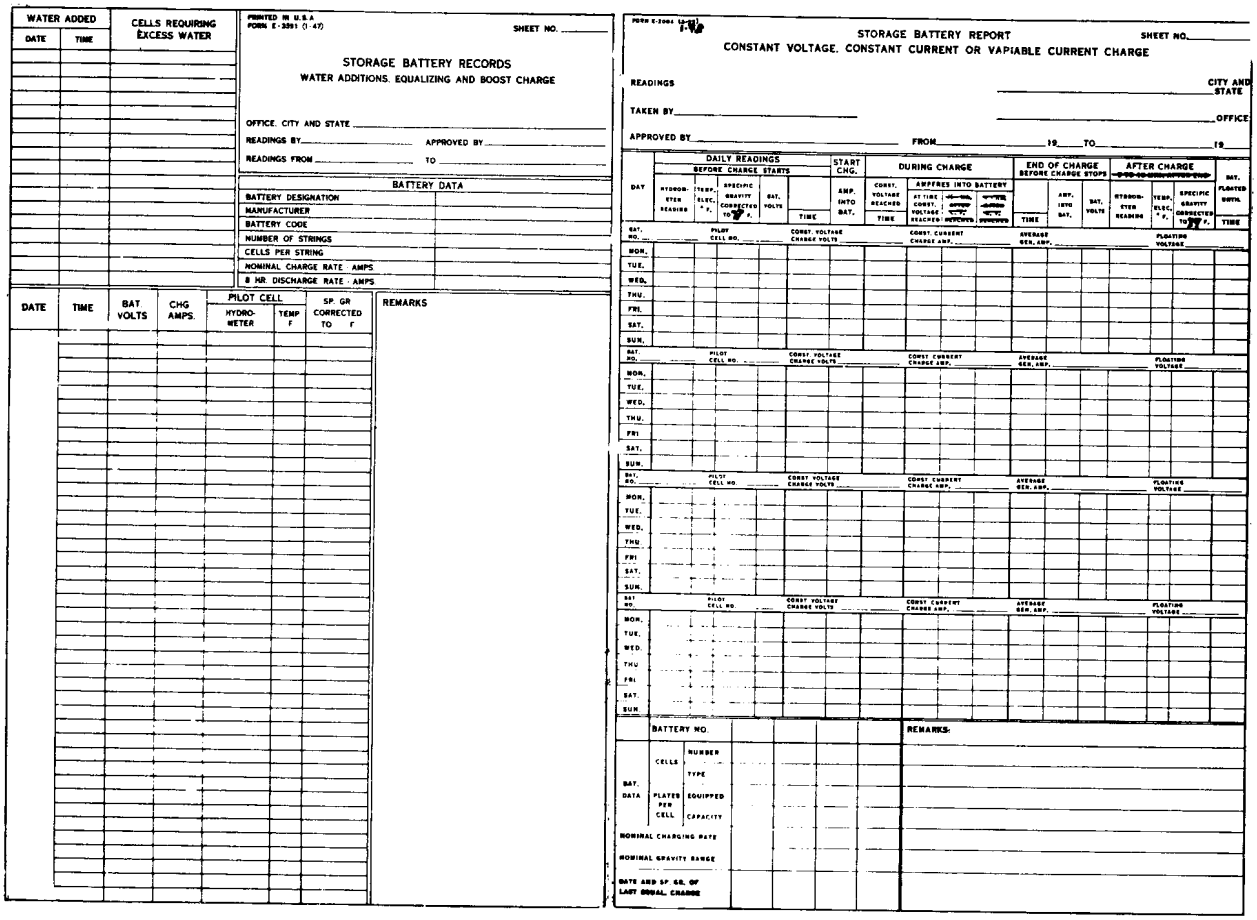


Fig. 3 - Forms