LEAD-ACID TYPE STORAGE BATTERIES
VOLTAGE RELAY 2-RATE CHARGE OPERATION

1. GENERAL

1.01 This section describes the voltage relay controlled 2-rate charge operation of lead-acid type storage batteries. With this system, the charger is switched between relatively high and low charging rates as the battery reaches the low and high settings of the relay contacts. Both rates change somewhat as line voltage, battery voltage, and load change.

1.02 Excessive charging increases the water loss and shortens the life of positive plates and separators. On the other hand, insufficient charging results in rundown (over-sulfated) negative plates and impaired battery capacity.

1.03 The state of charge of a battery is indicated by the relation of the corrected specific gravity of the electrolyte to the full charge corrected specific gravity, assuming the level of the electrolyte to be the same at both readings. In other words, a drop of 10 per cent of the gravity range indicates approximately 10 per cent discharge and 90 per cent remaining capacity. Height of the electrolyte in eights of an inch below maximum level should be recorded whenever hydrometer readings are recorded. Do not discharge beyond the gravity range and do not allow cells to remain fully or nearly discharged.

1.04 Water should be added after rather than before taking specific gravity readings. The electrolyte level in the pilot cell should be maintained in the upper quarter of allowed range so that specific gravity readings will be comparable.

1.05 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 30F are preferred and where average temperature for the 24 hour day exceeds 100F, special operating methods may be necessary.

1.06 This type of operation is not generally applicable to plants having emergency cells. If, however, there are emergency cells, they shall be operated as outlined in 157-601-302 for emergency cells.

1.07 See 157-601-701 for nominal charging rates, gravity ranges, maximum and minimum levels, 8-hour discharge rates, 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 the 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.

1.08 Information in this section is arranged under the following headings:

1. GENERAL
2. OPERATION
3. EQUALIZING CHARGE
4. RECORDS

2. OPERATION

2.01 In the absence of specific recommendations for the office or local instructions to the contrary, set the two rates initially as nearly as practicable in accordance with Table 1.

2.02 When a battery is charged from another battery, there are two charging rheostats, one for setting each charging rate. In plants having a charger and two charging rheostats, part of the adjustment can be made by changing the charger output and the final adjustment made with the rheostats. In plants having only one charging rheostat, the adjustment of the higher rate is made by changing the charger output and the adjustment of the lower rate is then made with the rheostat.

2.03 At the lower rate, the charging equipment should carry as much of the load as practicable but

(a) On plants having no high voltage alarm, the high voltage contact of the control relay would not be expected to make when only the lower charging rate is on.

(b) On plants having a high voltage alarm, the alarm should never operate when only the lower rate is on.

Type of Plant	Initial Setting of Higher Rate (Approximate)	Initial Setting of Lower Rate (Approximate)
Repeater Plate (fixed load)	110% of load	90% of load
Teletype (two fixed constant loads)	110% of higher load	90% of lower load
Telegraph (fluctuating)	110% of busy hour load	10% of busy hour load
Testing (light intermittent)	110% of busy hour load or 100% of normal maximum load	5% busy hour load or normal maximum load but not less than 1% of 8-hour discharge rate of battery
Ringing (AC-DC or Superimposed)	12-13% of 8-hour discharge rate of battery	4% of 8-hour discharge rate of battery
Manual Message Register	30 milliamperes for each 1000 daily registrations plus 1% of 8-hour discharge rate of battery plus 120 milliamperes	5 milliamperes for each 1000 daily registrations plus 1% of 8-hour discharge rate of battery plus 120 milliamperes
Step-by-Step Message Register	3 milliamperes for each 1000 daily registrations plus 70 milliamperes	1/2 milliampere for each 1000 daily registrations plus 70 milliamperes

Note: These batteries should be approximately fully charged when making the initial settings. The central office battery should be approximately fully charged when setting Manual M.R. battery charging rate.

Table 1
Initial Settings of Charging Rates

2.04 The higher rate should be slightly greater than the busy hour load so that the higher charging rate coming on will tend to increase the voltage if the low-voltage limit is reached during the busy hour period. It should be as low as practicable and meet this condition in order that the battery voltage will not build up too rapidly and so prevent internal losses from being replaced.

2.05 With the above conditions met, the length of the complete cycle of low and high charging rate will be a maximum; therefore, adjusting the rates for a maximum length of cycle will generally result in the above requirements being met. See 2.06.

2.06 Because the volts per cell at which the control relay operates are not the same for the various plants and because of the different load characteristics, the maximum length of cycle will vary with different plants. However, it is essential that the system shall cycle. There should be at least one cycle each 24 hours or at most each 36 hours. The majority of plants, particularly those of the ringing battery type, will have considerably shorter cycles, some being as frequent as once an hour. Some of the message register plants have registers to count the number of cycles. On these plants, 10 to 20 cycles per day is suggested. At plants having no register to count cycles, the length of cycle can be determined by observing the charging ammeters, if any, or otherwise the operation of the transfer relay.

2.07 Settings should be rechecked on <u>signs of faulty setting</u> listed below.

(a) If the specific gravity is decreasing at a rate faster than the 3 to 5 points per year to be expected as the battery ages, the lower rate is probably too low or the higher rate too high. On batteries such as those of the ringing battery plant where there is an extended idle period such as a week-end with load much below the average for the other days, the specific gravity would be expected to reach the maximum value only after the idle period if relay setting is satisfactory.

(b) Noncycling indicates that the higher rate is too low or the

lower rate is too high. Whichever rate is on at time of noncycling should be changed accordingly.

(c) High voltage, i.e., above relay cut-off point, indicates that the lower rate is too high.

(d) Water loss in excess of values in Fig. 1 or excess gassing indicate too much charging, possibly due to faulty relay setting.

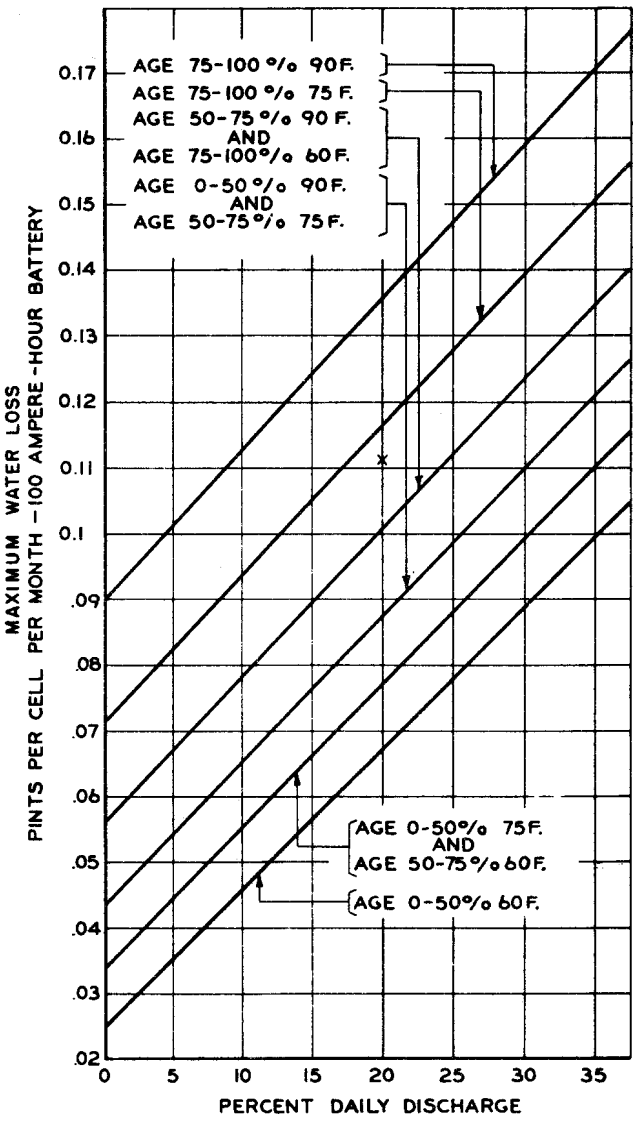
2.08 On plants arranged for equalizing charge, that is, having counter emf cells or resistance which can be inserted between the battery and the fuse board and having sufficient charger capacity, an equalizing charge shall be given annually and whenever the corrected specific gravity of the pilot cell falls 15 per cent or more of the full gravity range below that at the last equalizing (or initial) charge.

2.09 On many plants, provision for convenient equalizing charge was not considered justifiable, particularly where the battery gets extra charge periodically because of a light-load period such as a week-end. If, however, the full charge corrected specific gravity falls more than 30 per cent of the full gravity range below that at the initial (or last equalizing) charge, the supervisor should be notified. If an equalizing charge is ordered, counter emf cells will usually have to be connected temporarily in the discharge circuit. If alkaline-type counter emf cells are not available, cells of the storage battery type, connected to oppose the battery being charged, may be used as counter emf cells. In some cases, it may also be necessary to supply additional charging equipment for use during the charge.

3. EQUALIZING CHARGE

3.01 The equalizing charge, when required by 2.08 and 2.09, may be by the constant voltage (3.03) or the constant current (3.04) method as convenient. In either case, the voltage or current will have to be average rather than actual constant value. Where charge is given at other than a no-load period, note that the current into the battery and not the charger output must be used in computing the average value as the basis of the "constant" current charge or indication of stability on "constant" voltage charge. Water should be added to all cells, if required, at the start of any equalizing charge.

3.02 On equalizing charge, the battery should be charged until stabile as evidenced by reaching maximum specific gravity or constant power input, that is,



NOTES:
1. PINTS-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% 75F. DIAGONAL IT IS SATISFACTORY. ASSUMING 20% DISCHARGE AND 80% AGE.

Fig. 1 - Maximum Water Loss For Sealed Type Cells With Specific Gravity Below 1.225

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

3.03 Where charge is at constant voltage, continue charge after current stabilizes or pilot cell specific gravity has reached its maximum for the number of hours shown in Table 2. 2.30 to 2.34 volts per cell shall be used, if convenient. Voltages above are more effective than those below these values.

Table 2 - Constant Voltage Equalizing Charge

Volts Per Cell	Stabile Time Hours
2.42	2
2.38	3
2.34	5-1/2
2.30	9
2.26	15
2.22	26
2.20	32

3.04 Where equalizing charge is by constant current, 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 20 per cent of the 8-hour discharge rate, the stabile period is 4 hours and 40 minutes.

4. RECORDS (Form E-2006)

4.01 Record the date and time of taking any recorded readings.

4.02 When water is added to all cells, record the amount of water added to the battery and which cell, if any, required appreciably more water than other cells. The water added at more frequent intervals to the pilot cell to maintain its level in the upper quarter of the range need not be recorded.

4.03 Monthly record the pilot cell corrected specific gravity, pilot cell electrolyte level in eighths of an inch

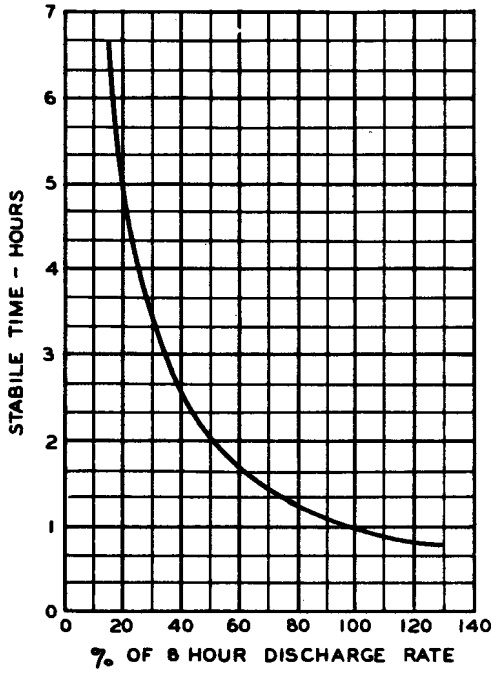


Fig. 2 - Constant Current Equalizing Charge

below maximum level, and the battery voltage as near the time of transfer from high rate to low rate as convenient. Record charger output at both high and low rate. Record the average number of cycles per day where there is a register to count cycles. Where there is no register and the attendant is present during an entire cycle, record length of time charger output is at each rate during the cycle. Note position of charge indicators, if any, but this need be recorded only for cells with red indicators down. These "monthly" readings should be taken weekly until settings are satisfactory after which they may be scheduled for any period from 1 to 6 weeks. After a major change in office load or indications of unsatisfactory operation, the readings should return to the weekly basis until setting is satisfactory.

4.04 During equalizing charge, record the current, voltage, and hydrometer readings taken to determine stability.

4.05 Record at any time irregularities in gassing, charger operation, etc. as well as local conditions affecting cell temperatures and too frequent high or low voltage alarms.

FORM T-1000
(1-48)

SHEET NO._____

STORAGE BATTERY REPORT
AUTOMATICALLY CONTROLLED BY_____
CONTINUOUS VARIABLE CURRENT
PILOT CELL READINGS

_____ CITY AND STATE

READINGS TAKEN BY_____ _____ OFFICE

APPROVED BY_____ FROM_____ 19____ TO_____ 19____

DATE	TIME	HYDROMETER READING	TEMP ELEC. F.	SP. GR. CORRECTED TO F.	METER PERCENT DISCHARGE	70 OR 77 F. SP. GR. CORRECTED TO FULL CHARGE	BAT. VOLTS	CHARGE EQUIP. OUTPUT AMP.	
BATTERY NO. _____ PILOT CELL NO. _____ AMP. HR. METER CAP. _____ AMP. _____ AMP. HRS. COR. FACTOR _____ PER 1%									
BATTERY NO. _____ PILOT CELL NO. _____ AMP. HR. METER CAP. _____ AMP. _____ AMP. HRS. COR. FACTOR _____ PER 1%									

	BATTERY NO.			REMARKS
BAT. DATA	CELLS — NUMBER			
	CELLS — TYPE			
	PLATES PER CELL — EQUIPPED			
	PLATES PER CELL — CAPACITY			
NOMINAL CHARGING RATE				
NOMINAL GRAVITY RANGE				
DATE AND SP. GR. OF LAST EQUAL. CHARGE				

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