LEAD-ACID TYPE STORAGE BATTERIES
AMPERE-HOUR METER CHARGE-DISCHARGE OPERATION

1. GENERAL

1.01 This section describes the ampere-hour meter controlled charge-discharge operation of lead-acid type storage batteries.

1.02 This section is reissued to provide correct references to other Plant Series sections.

1.03 Starting at FULL, the battery discharges and the amount of discharge in per cent of meter rating (not battery rating) registers on the ampere-hour meter. After discharge to 10 per cent of meter rating, contact ST operates to start the charge which is continued until FULL is again reached and the SP contact operates to stop it. If charger output were less than the load, the meter pointer would continue to register discharge and on reaching the AL contact at 35 per cent of meter rating would operate an alarm. An adjustable feedback resistor calibrated in per cent of excess of charge over discharge permits battery losses to be replaced on each discharge-charge cycle. For further information on the ampere-hour meter, see 100-505-701.

1.04 Too much feed back increases the water loss and reduces the life of positive plates and separators. On the other hand, insufficient feed back which may be due either to incorrect resistor setting or too long a charge cycle, will cause sulfation of the negative plates and reduced battery capacity.

1.05 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 electrolyte in eighths of an inch below the maximum level should be recorded whenever hydrometer readings are recorded so that allowance can be made for specific gravities determined at different levels. Do not discharge beyond the gravity range and do not allow cells to remain fully or nearly discharged.

1.06 To obtain the correction factor for use in correcting specific gravity to full charge, obtain immediately after the initial (or an equalizing) charge the temperature corrected specific gravity when the ampere-hour meter pointer reaches the 10 per cent discharge ST mark. The difference in the temperature corrected specific gravities at this point and after the initial (or equalizing) charge is the range for 10 per cent discharge shown on the meter and can be used in correcting subsequent readings to full charge, for example:

Full charge temperature corrected sp. gr. = 1.213 when meter reads 0

Partial discharge temperature corrected sp. gr. = 1.207 when meter reads 10

Difference in sp. gr. = 0.006 (6 points) for 10 per cent discharge on meter

Correction factor = .0006 6/10 of one point sp. gr. for each per cent discharge shown on meter

When a subsequent reading of the temperature corrected specific gravity is 1.213 with 2 per cent discharge shown on the meter, specific gravity corrected to full charge will be

$$1.213 + .0006 \times 2 = 1.213 + .0012 = 1.214$$

1.07 After a satisfactory setting of the meter has been obtained, the temperature corrected specific gravity recorded at FULL charge, or corrected to full charge when taken at other times, will give evidence as to whether the battery operation is successful. Increase in corrected specific gravity above the initial (or equalizing) charge maximum may occur due to evaporation of water, or decrease below this reference point may occur due to change in load conditions, slowing up of the meter or failure of the battery to meet requirements.

1.08 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 the allowed range so that specific gravity readings will be comparable.

1.09 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. Where average temperature for the 24-hour day exceeds 100F special operating methods may be necessary.

1.10 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.

1.11 See 157-601-701 for nominal charging rates, 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 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.

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

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

2. OPERATION

2.01 Unless otherwise specified locally it is suggested that the feed back resistor be set initially at 20 per cent and the charger output at approximately full busy hour load. However, the charger output current should be no greater than the charger rating, the ampere-hour meter ampere rating or the nominal charging rate of the battery.

2.02 By increasing charger output to decrease length of cycle or decreasing it to increase length of cycle, set average length of cycle from 14 to 22 hours, if practicable. 20 hours is the optimum value. In some cases it may be necessary to reduce charging rate to avoid high voltage at end of charge.

2.03 After charger output has been set (2.01 and 2.02) reduce the feed back resistor 5 per cent weekly until the full charge specific gravity corrected for both temperature and state of charge (1.06) shows a downward trend (2.04). Then raise the feed back resister setting 5 per cent and leave at this value until changes in load or other office conditions make a new setting necessary. Recheck length of cycle (2.02). If maximum feed back setting of the resistor results in a downward trend increase the rectifier output to give more frequent cycles. See note under 2.07.

2.04 A downward trend shall be three weekly specific gravity readings corrected for temperature and to full charge, each lower than the previous when there has been no appreciable change in pilot cell electrolyte level. Reducing feed back resister setting should be discontinued when the first lower specific gravity is observed. This is to see if the drop is really part of a downward trend.

2.05 If the battery discharge during a 24-hour day amounts to less than 15 per cent of battery rating, give a boost charge per 2.06. The formula for translating meter data into battery per cent daily discharge is

$$\frac{24 \times 10}{\text{Hrs. for Meter Cycle}} \times \frac{\text{Meter Capacity}}{\text{Battery Capacity}}$$

Example 1. With a 10 per cent meter cycle every 17 hours when meter capacity is 400 and battery capacity is 368 ampere hours, then the battery per cent daily discharge is

$$\frac{240}{17} \times \frac{400}{368} = 15.3 \text{ per cent}$$

and a monthly boost is not required.

2.06 When required by 2.05, a boost charge shall be given by moving the meter pointer by hand 10 per cent lower. For example, if meter is reading 5 per cent, it should be moved to 15 per cent. Unauthorized boost charges are objectionable not only because they may cause excess charging but also because they interfere with proper analysis of battery records.

2.07 Increase feed back resistor 5 per cent on signs of inadequate charge as listed below. In some cases, it may also be desirable to increase charger output 5 per cent to further increase the total charge. If with unchanged load conditions, one change in feed back and one change in charger output does not correct condition, notify the supervisor.

(a) Evidence of sulfation. See 157-601-701. Also report to supervisor.

(b) Any red charge indicator down at any time except after a power failure.

(c) Pilot cell specific gravity corrected for temperature and corrected to full charge more than 10 per cent of the gravity range below that at last equalizing (or initial) charge.

Note: With some combinations of ampere-hour meter size, battery size and load, a downward trend in specific gravity readings or other signs of inadequate

charge may be present even with maximum feed back resistor setting and shortest cycle that is practicable. In such cases, more frequent boost or equalizing charges are necessary or equipment changes such as the connection of a small supplementary rectifier across the battery, may be desirable.

2.08 Decrease feed back resistor setting 5 per cent on signs of excessive charge such as water loss in excess of values in Fig. 1 or excess gassing. In some cases it may also be desirable to reduce charger output 5 per cent to further decrease the total charge. If with unchanged load conditions one change in resistor setting and one change in charger output does not correct the condition, notify the supervisor.

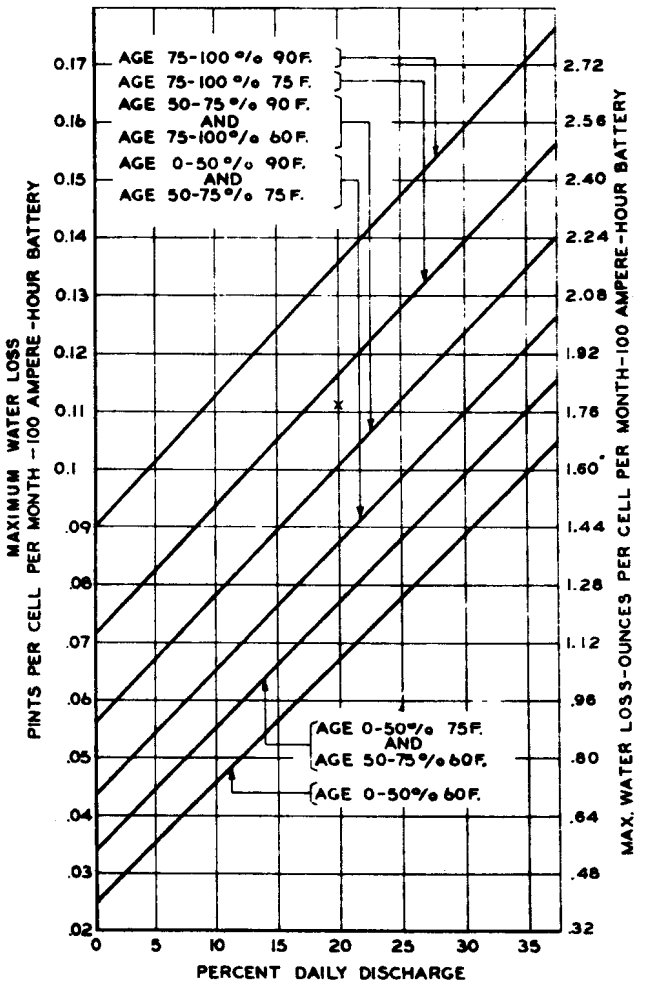
2.09 Give an equalizing charge at least once a year and when ever the pilot cell specific gravity corrected both for temperature and to full charge is 15 per cent of the gravity range below that at the last equalizing (or initial) charge.

3. EQUALIZING CHARGE

3.01 When required by 2.09, the equalizing charge should be given by the constant current method except that an average value of current rather than an actually constant value is used as the basis of the charge. Where equalizing charge can not be given at a no load period, note that current into the battery and not charger output must be used in computing the average value. Water should be added to all cells, if required, before the start of an equalizing charge.

3.02 On equalizing charge it may be more convenient to obtain charging current by moving the ampere-hour meter pointer by hand to the 10 per cent discharged ST mark to start the charging equipment and then to a position just short of the alarm AL mark. Repeat, if necessary. After completion of the equalizing charge, the pointer should be returned by hand to the FULL charge mark. The charging rate regularly employed may be used during this charge, but to save time it may be convenient to increase the rate (2.01 and 2.02) temporarily. If the charger output is increased, restore to the original setting after the equalizing charge has been completed.

3.03 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 average 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 per-



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-5381 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

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

3.04 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 average 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.

3.05 Where an equalizing charge 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.

4. RECORDS (Form 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 for the pilot cell specific gravity corrected both for temperature and to full charge, the charger output in amperes and the length of a cycle. Also monthly, note position of all charge indicators, but this information need be recorded only for cells with red indicators down. These "monthly" readings are required weekly until charger output (See 2.01 and 2.02) and feed back resistor settings have been determined. They may then 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.

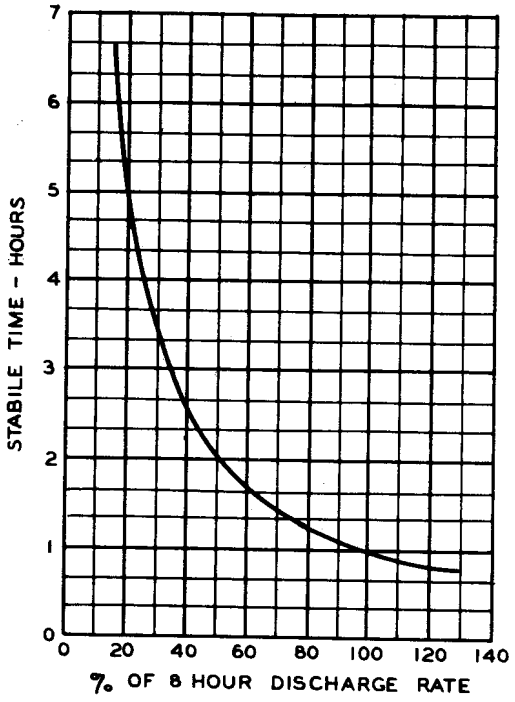


Fig. 2 - Constant Current-equalizing Charge

4.04 During the equalizing charge, record the "constant" (average) current during the charge and all voltage or 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 E-2006 (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%									

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

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