STORAGE BATTERIES

LEAD-ACID TYPE

REQUIREMENTS AND PROCEDURES

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1. GENERAL

A. Introduction

1.01 This practice covers the apparatus requirements and adjusting procedures common to rectangular type lead-acid cells used in battery power plants. ▶The requirements and procedures in this practice also apply generally to lead-acid batteries used for engine-starting applications.◀

1.02 Revision arrows are used to emphasize the more significant changes. This practice is reissued for the following reasons:

(a) To rate the KS-5361, L100, KS-5553, L503 and L505; KS-5562, and KS-15544, L503 and L505; and KS-15577 as Mfr Disc. in Table A

(b) To update the manufacturers' location identification information in subparagraph (a) of paragraph 1.06

(c) To add safety admonishments and information to paragraph 1.10

(d) To rate the KS-21527, L1, eyewash kit and KS-21527, L2, eyewash solution as Mfr Disc.; and to add the KS-21527, L3, eyewash kit and KS-21527, L4, eyewash solution to paragraph 1.11

(e) To add new safety admonishments, information, and procedures to paragraphs 1.13 through 1.16

(f) To add safety admonishments and information concerning battery charging to paragraphs 1.17 and 1.18

(g) To add an index of requirements and procedures in paragraph 1.21

(h) To add an index of requirements and procedures in paragraphs 2.02 and 2.03

(i) To add lead-sulfate crystals (plastic cases) requirements in paragraphs 2.04 through 2.06

(j) To add safety admonishments, information, and procedures concerning battery charging and handling to paragraph 2.08

(k) To add admonishment and information concerning connecting, disconnecting, and overtighting battery connections to paragraph 2.15

(l) To add the KS-22861, L1, digital multimeter to the list of gauges

(m) To add Form E-3591 to subparagraph (a) of paragraph 4.01

(n) To change procedures to measure specific gravity of cells with electrolyte withdrawal tubes to subparagraph (c) of paragraph 4.03

(o) To add lead-sulfate crystals (plastic cases) identification procedures in paragraphs 4.04 through 4.06

(p) To add safety admonishment and information concerning battery charging and handling to subparagraph (a) of paragraph 4.08

(q) To correct the percentage of allowable Manganese impurities in battery water in subparagraphs (a) and (c) of paragraph 4.12 and Table K

(r) To change the discharge capacity tests and replacement criteria in paragraph 4.14.

1.03 For a listing of practices dealing with lead-acid batteries, refer to Practice 157-000-000, Numerical Index Division 157 and to Practice 169-000-000, Numerical Index Division 169 for Rectifiers and Filament Supplies.

Note 1: Installation requirements and procedures for lead-acid storage batteries are contained in Practice 157-601-201.

Note 2: Replacement parts and procedures for lead-acid enclose-type storage batteries are covered in Practice 157-621-801.

Note 3: Description, requirements, and procedures for the KS-20472 ♦LINEAGE[*] 2000 round cell♦ are covered in Practice 157-629-701.

Note 4: ♦Visual inspection procedures for the KS-20472 LINEAGE 2000 round cells are covered in Practice 157-629-702.

Note 5: High-voltage application for the KS-20472 LINEAGE 2000 round cells are covered in Practice 157-629-703.♦

Note 6: Description, requirements, and procedures for KS-15578 nickel-cadmium engine starting and control batteries are covered in Practice 157-631-101.

Note 7: Description, requirements, and procedures for KS-15577 lead-acid engine starting and control batteries are covered in Practice 157-633-101.

Note 8: ♦The KS-15577 lead-acid engine starting battery has been rated Mfr Disc. and replaced by the KS-15578 nickel-cadmium flooded battery.

1.04 ***Hardened-Site and Other KS-Spec Batteries:*** Batteries may be selected as either hardened-site or nonhardened-site construction. The difference between the two types are outlined as follows.♦

(a) See Table A for ♦a listing of battery 5- and 8-hour♦ discharge rates and specific gravity ranges.

(b) There are two KS-numbered ***hardened-site cells.*** The cells are reinforced ('hardened') to enable them to better withstand the shocks of earthquakes or nuclear blasts. They are both manufactured by GOULD[†] . See Tables A, B, C, and D. These cells are:

(1) ***KS-20048, L1, Cells:*** This cell contains the same element as the GOULD KS-5562, L07, tank cell. The element is inserted in a fiberglass reinforced jar with an acid-resistant liner. The KS-20048, L1, cell is designed to be shock resistant. The cell has a capacity rating of 6000-ampere hours at the 5-hour rate or 7000-ampere hours at the 8-hour rate. These ratings are identical to the GOULD KS-5562, L07, cell.

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[*] Trademark of AT&T Technologies.

[†] Trademark of GNB (GOULD).

♦TABLE A♦

BATTERY DISCHARGE RATE AND SPECIFIC GRAVITY RANGE

CELLS	5-HR DISCHG RATE IN AMPERES	8-HR DISCHG RATE IN AMPERES	APPROXIMATE DROP IN SPECIFIC GRAVITY FOR COMPLETE DISCHG IN 5 HRS
KS-5361			
L100*	0.70	0.50	-0.035
L116B & C	1.80	1.25	-0.038
L120B & C	2.60	1.875	-0.059
L130B & C	5.30	3.75	-0.062
L140D & E	8.80	6.25	-0.088
L141D & E	8.80	6.25	-0.088
L150D & E	17.60	12.50	-0.090
L151D & E	17.60	12.50	-0.090
L151HD & HE	22.90	16.60	-0.094
KS-5538			
L1, L3, L10, L18	1.80	1.25	-0.038
L2, L4 thru L6, L8	2.60	1.875	-0.059
L10, L12, L14, L15	2.60	1.875	-0.059
L7, L9, L11, L13	5.30	3.75	-0.062
L19†	5.30	3.75	-0.062
KS-5553			
L310 & L311	31.1	22.5	-0.070
L402	41.4	30.0	-0.083

See footnotes at end of table.

▶TABLE A◀(Contd)

BATTERY DISCHARGE RATE AND SPECIFIC GRAVITY RANGE

CELLS	5-HR DISCHG RATE IN AMPERES	8-HR DISCHG RATE IN AMPERES	APPROXIMATE DROP IN SPECIFIC GRAVITY FOR COMPLETE DISCHG IN 5 HRS
L403	51.8	37.5	-0.083
L405	72.5	52.5	-0.083
L407	93.2	67.5	-0.092
L409	113.9	82.5	-0.088
L501	145.0	105.0	-0.075
L503*	186.4	135.0	-0.079
L505*	227.9	165.0	-0.083
L508	290.0	210.0	-0.083
KS-5562 L04*	685.0	500.0	-0.075
L05*	856.0	625.0	-0.080
L06*	1028.0	750.0	-0.080
L07*	1200.0	875.0	-0.080
KS-15544 L310 & L311	31.1	22.5	-0.070
L310H & L311H	39.7	28.75	-0.075
L402	41.4	30.0	-0.083
L402H	51.8	37.5	-0.085

See footnotes at end of table.

♦TABLE A♦(Contd)

BATTERY DISCHARGE RATE AND SPECIFIC GRAVITY RANGE

CELLS	5-HR DISCHG RATE IN AMPERES	8-HR DISCHG RATE IN AMPERES	APPROXIMATE DROP IN SPECIFIC GRAVITY FOR COMPLETE DISCHG IN 5 HRS
L403	51.8	37.5	-0.083
L403H	65.6	47.5	-0.085
L405	72.5	52.5	-0.083
L407	93.2	67.5	-0.092
L409	113.9	82.5	-0.088
L501	145.0	105.0	-0.075
L503*	186.4	135.0	-0.079
L505*	227.9	165.0	-0.083
L508	290.0	210.0	-0.083
KS-15577*	-	-	-
KS-15754 L1 & L2*	1.05	0.75	-0.044
KS-15886 L100*	0.70	0.50	-0.035
L116B & C	1.80	1.25	-0.038
L120B & C	2.60	1.875	-0.059
L130B & C	5.30	3.75	-0.062
L140D & E	8.80	6.25	-0.088
L141D & E	8.80	6.25	-0.088

See footnotes at end of table.

▶TABLE A◀(Contd)

BATTERY DISCHARGE RATE AND SPECIFIC GRAVITY RANGE

CELLS	5-HR DISCHG RATE IN AMPERES	8-HR DISCHG RATE IN AMPERES	APPROXIMATE DROP IN SPECIFIC GRAVITY FOR COMPLETE DISCHG IN 5 HRS
L150D & E	17.60	12.50	-0.090
L151D & E	17.60	12.50	-0.090
L151HD & HE	22.90	16.60	-0.094
KS-20048 (hardened-site cell) L1*	1200.0	875	-0.140
KS-20106 (hardened-site cell) L101*	147.0	105.0	-0.075
L108*	290.0	210.0	-0.083

* Manufacture discontinued.

† One KS-5538, L19, cell replaces four KS-5361, L116C, cells.

▶TABLE B◀

GRID MATERIAL AND NOMIAL SPECIFIC GRAVITY FOR KS-CODED LEAD-ACID CELLS

CODE OF CELL	TYPE OF GRID MATERIAL		NOMIAL SPECIFIC GRAVITY	
	LEAD-ANTIMONY	LEAD-CALCIUM	1.210	1.300
KS-5361 L115-L151E	X		X	
L151H, 151HD, and 151HE	X			X
KS-5538 (KS-4361, with connectors)	X		X	
KS-5553	X		X	
KS-5562*	X		X	
KS-15544 L310, L311, L402		X	X	
L403, L405, L407		X	X	
L409, L501, L503*,		X	X	
L505*, and L508		X	X	
KS-15544 L310H, L311H,		X		X
L402H, and L403H		X		X
KS-15754*		X		X
KS-15886* L140D, L141D, L150D,		X	X	
L151D and L151E		X	X	
KS-15886* L151H and L151HE		X		X
KS-20048, L1* (hardened-site cell)	X		X	
KS-20106, L101* and L108* (hardened-site cell)		X	X	

* Manufacture discontinued.

♦TABLE C♦

BATTERY ANTICIPATED LIFE ON FLOAT CHARGE AT 77°F

BATTERY KS-NUMBER	LIST NUMBER	ANTICIPATED LIFE IN YEARS WHEN FLOATED
KS-5361, KS-15886*, and KS-5538	110-116 120-151D or 151E 151HD and 151HE	5 8 6 2
KS-5538	All	5-8
KS-5553	All	14
KS-5562*	All	14
KS-15544	All except List No. 310H, 311H, 402H, 403H	15
KS-15544	310H, 311H, 402H, and 403H	10
KS-15754	All	7
KS-20048* (hardened-site cell)	All	14
KS-20106* (hardened-site cell)	All	15

* Manufacture discontinued.

(2) ***KS-20106, L101, and KS-20106, L108, Cells:*** The ***KS-20106, L101,*** cell is a hardened KS-15544, L501, cell, while the ***KS-20106, L108,*** cell is a hardened KS-15544, L508, cell. These cells use the special KS-5499, L5200, terminal connector. These cells are hardened by means of the KS-20054 accessories which include a fiberglass base, top retainer, side plates, and rubber cushions. The accessories enclose the cell and provide a means for mounting to the battery rack.

Note 1: Both KS-20048 and KS-20106 batteries are rated Mfr Disc. and are to be replaced by the KS-20472 ♦LINEAGE 2000 round♦ cell.

Note 2: ♦The KS-20472 LINEAGE 2000 round cell is NOT a one-for-one replacement for the KS-20048 cell. Therefore, standard drawings should be checked to ascertain the number of KS-20472 LINEAGE 2000 round cells required.♦

1.05 ***Cell Grid Material and Specific Gravity:*** Grid material and nominal specific gravity of KS-coded lead-acid cells are shown in Table B. Unless

▶TABLE D◀

BATTERY ELECTROLYTE LEVEL

CODE OF CELL	TYPE OF CONTAINER	ELECTROLYTE LEVEL	
		MAXIMUM	MINIMUM
KS-5361 L116 to L151HE KS-5538 KS-5553 KS-15544 KS-15754 KS-15886 KS-20106* (hardened-site cell)	Plastic jar (transparent)	Bottom of high line	Top of low line
KS-5553 KS-5562 KS-20048* (hardened-site cell)	Nontransparent with float covers		
KS-5553 KS-5562 KS-15544	Nontransparent without float covers	Second color of float stem just visible (usually red)	Top of float stem is flush (or level) with top of float guide
KS-5361 L100 to L114	Plastic jar (transparent)	Level with target aperture (usually triangular) located approximately midway between separators and bottom of cover	

* Manufacture discontinued.

otherwise specified, all requirements and recommended procedures for lead-antimony cells also apply to lead-calcium cells.

B. Manufacturers' Identification and Serial Numbers

1.06 ***Cell Identification Information Location:*** Manufacturers identified the factory where a cell was manufactured by a letter or number stamped on one of the terminal posts, usually the ▶negative post and/or a sticker on the battery jar cover. Both◀ the factory location and date of manufacture should be mentioned on records and correspondence. Serial numbering indicates ▶the date cell(s) were shipped (date of manufacture) and the AT&T Technologies individual cell(s) number(s) by manufacturer.◀

(a) ***Manufacturers' Location Identification:*** ▶The manufacturing location identification is outlined as follows: ◀

(1) GOULD* battery cells manufacturing location identification codes follow:

- ▶D—designates the Depew factory (discontinued manufacturing location).◀

- K—designates the Kankakee factory.
- ▶S—designates the Fort Smith, Arkansas factory.◀
- T—designates the Trenton factory (discontinued manufacturing location).

(2) C&D[*] battery cells manufacturing location identification codes follow:

- A—designates the Attica factory.
- C—designates the Conshohocken factory.
- J—designates the Conyers, Georgia factory.
- ▶W—designates the Santa Rosa, California (West Coast) factory (discontinued manufacturing location).◀

(3) EXIDE[†] battery cells manufacturing location identification codes follow:

- ▶1—designates the Philadelphia, Pennsylvania factory (discontinued manufacturing location).
- 8—designates the Richmond, Kentucky factory.◀
- 9—designates the Chicago, Illinois factory (discontinued manufacturing location).
- 25—designates the San Francisco, California factory (discontinued manufacturing location).

(4) ▶GLOBE[‡] battery cells manufacturing location is as follows:

- Milwaukee, Wisconsin factory.

(b) ▶***Serial Numbering:*** The serial numbering practice for the different manufacturers is outlined as follows:◀

(1) The serial number consists of nine digits. The first four digits indicate the year and month of shipment (manufacturing date). The remaining five digits indicate the individual AT&T Technologies 5-digit cell identification number.

(2) Serial number blocks of 20,000 serial numbers are assigned to each supplier as follows:

GOULD 00001 through 20000

C&D 20001 through 40000

EXIDE 40001 through 60000

▶GLOBE 60001 through 80000.◀

(3) The entire serial number may be on one line or may be separated after the date portion. The 5-digit manufacturers' serial number block portion is usually recycled every month.

Example: 840140024

Where:

84 = 1984 (Shipment Year)

01 = January (Shipment Month)

40024 = Battery No. 40024 shipped by EXIDE in January 1984.

1.07 ***Rules for Good Battery Maintenance:*** The following rules should be adhered to.

(a) Maintain battery in a healthy state of charge with as little excess charge as possible. Maintain correct float charge voltage values. (See Table E and Practice 157-601-301.)

(b) Maintain electrolyte level between maximum and minimum by the addition of approved water. (See Table D.)

(c) Keep temperature of electrolyte within limits.

(d) Keep the battery clean.

(e) Replace cells where bulging, cracking, leaking, or other physical defects require replacement

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[*] Trademark of C&D Batteries.

[†] Trademark of ESB Brands Incorporated.

[‡] Trademark of GLOBE Battery Division, Johnson Control.

♦TABLE E♦

CELL FLOAT VOLTAGE AND SPECIFIC GRAVITY REQUIREMENT CHART

DESCRIPTION OF OPERATION	LOW-GRAVITY CELLS, LIMITS	HIGH-GRAVITY CELLS, LIMITS
Pilot-cell and emergency cell float voltage reading	2.17 ±0.05 volts/cell	Lead-calcium (2.30 ±0.05 volts/cell) Lead-antimony (2.25 ±0.05 volts/cell)
Battery float voltage reading	2.17 ±0.01 volts/cell	Lead-calcium (2.30 ±0.01 volts/cell) Lead-antimony (2.25 ±0.01 volts/cell)
Emergency cell specific gravity	(See paragraphs 2.03, 2.07, and 4.07)	(See paragraphs 2.03, 2.07, and 4.07)
Pilot-cell specific gravity reading (corrected)	1.210 ±0.010	1.300 ±0.010
Individual cell voltage readings	2.17 ±0.05 volts/cell	Lead-calcium (2.30 ±0.05 volts/cell) Lead-antimony (2.25 ±0.05 volts/cell)
Clean and inspect		
Individual cell specific gravity readings	1.210±0.010	1.300 ±0.010
Average battery float voltage (under varying voltage and load conditions)	2.17 ±0.01 volts/cell	Lead-calcium (2.30 ±0.01 volts/cell) Lead-antimony (2.25 ±0.01 volts/cell)
Water analysis		
Electrolyte level		

and insure proper spacing between batteries. (See Practice 157-601-703.)

(f) Avoid using an open flame or creating sparks, including those from static electricity, near batteries. Do not permit excessive gas formation or electrolyte leakage.

1.08 *Anticipated Cell Life:* Table C shows the anticipated life in years of lead-acid cells maintained in accordance with this practice. These figures are based on best available data but are given for planning purposes only. These life figures are average figures only.

C. Safety

1.09 *Electrolyte Corrosion and Bodily Protection:* ▶Battery electrolyte is extremely corrosive to most material and human tissue. Therefore, exercise extreme care whenever handling battery electrolyte or working around batteries.◀

1.10 ▶***DANGER: Wear protective equipment such as rubber gloves, rubber aprons, full face mask and splash-proof goggles when performing any activity involving handling of electrolyte, cells containing electrolyte, or maintenance activities requiring exposure to shock or electrolyte contact from these cells. All lead-acid storage cells/batteries have enormous short circuit capability. Extreme care should be exercised to avoid shorting out cell and/or battery terminals. Shorting a cell or battery with an noninsulated tool can vaporize or throw the tool. The use of INSULATED wrenches is mandatory.***◀ ***Personnel permitted access to battery areas should be fully briefed on the hazards of handling lead-acid batteries.***

(a) *Corrosion:* Most metal, vegetable, and animal products are corroded by electrolyte, unless it is promptly neutralized.

(b) ***Electrolyte Burn Protection: DANGER: Wear protective equipment such as rubber gloves, rubber aprons, and splash-proof goggles when performing any activity that involves handling of electrolyte, cells containing electrolyte, or maintenance activities requiring exposure to shock or electrolyte contact from these cells.*** Bodily protection from electrolyte burns is provided by wearing full face mask, splash-proof goggles, rubber gloves, and rubber apron when working with lead-acid batteries. Rubber gloves protects the hands from electrolyte when working with lead-acid batteries.

(c) ***Electrical Shock and Burns Protection:*** ▶***DANGER: Whenever working around battery strings, any conducting articles on wrists, legs, waist, neck, or head should always be removed. A flashlight having a plastic or rubber housing should be used.***◀ Body protection is provided by wearing rubber gloves, rubber apron, full face mask, splash-proof goggles, and the use of ***insulated tools.*** When it is necessary to work on a rack of batteries that cannot be reached from the floor, the use of a wooden ladder is advised. ▶Whenever it is necessary to work around any string of batteries; rings, wrist watches, metal bracelets, necklaces, belt buckles, etc., should ***always*** be removed.◀

D. First Aid

1.11 *First Aid for Electrolyte in Eyes or on Skin:* ▶Electrolyte in the eyes or on the skin is a ***very*** serious matter, and ***immediate action*** is necessary. Whenever working around batteries or handling battery electrolyte, the following procedures should be observed.

> *Note:* The KS-21527, L1, eyewash kit and the KS-21527, L2, eyewash solution have been Mfr Disc. The replacements are the KS-21527, L3, eyewash kit and the KS-21527, L4, eyewash solution.◀

(a) *Electrolyte Splashes and Burns:* In case of electrolyte splashes, use of the ▶KS-21527, L3, eyewash kit and KS-21527, L4, eyewash solution◀ are recommended. However, if the KS-21527, ▶L3,◀ eyewash kit is not available, use the following procedure.

(1) Remove electrolyte splashed on the skin or in the eyes ***immediately*** by flushing the affected area with large amounts of plain tap water.

(2) In case of electrolyte in the eye, pour water into the inner corner of the eye and allow at least 1 quart of water to run over the eye and under the eyelid. A drinking fountain near at hand may be utilized for this purpose.

(3) Place eye injuries under the treatment of a physician, preferably an eye specialist, as soon as possible.

(b) ***Mounting Eyewash Kits:*** In areas where the ▶KS-21527, L3, eyewash kit and KS-21257, L4, eyewash solution◀ are used, containers may be mounted on building columns, along walls, or at the end of battery stands. ▶A KS-21527, L3, eyewash kit must◀ be within reach in approximately ***12 feet*** at any point in the battery area. ▶The KS-21527, L3, eyewash kits◀ should be mounted where they can be reached without opening doors, climbing ladders, or using stools.

Note 1: The ▶KS-21527, L3,◀ eyewash kit must be separated from other containers in the battery area to minimize the selection of the wrong container in an emergency.

▶*Note 2:* Under federal regulation, expiration dates have appeared on the pint bottles since February 1977. The pint and quart bottles with expiration dates should be disposed of at the time of expiration. The pint bottles with no expiration date may be kept indefinitely.◀

(c) ***Areas Not Equipped with Flame-Arrestor Vents:*** In battery areas containing engine-start batteries ▶***not*** equipped with flame-arrestor vents, the KS-21527, L3, eyewash kit alone is ***not*** considered satisfactory protection. In such areas, consider replacing existing batteries with batteries equipped with ***explosion-proof vents.***◀

Note: ▶Flame-arrestor vents may be ordered from the supplier for cell(s) not originally equipped with them.◀

E. Neutralizing Agents

1.12 *Agents for Neutralizing Lead-Acid Battery Electrolyte:* ***DANGER: Both electrolyte leakage and neutralizing solutions used for cleanup of electrolyte spills may result in conducting paths with attendant voltage hazards.*** ▶Whenever lead-acid battery electrolyte is spilled, it should ***immediately*** be neutralized. The following can be used for electrolyte neutralization purposes:◀

(a) ***Soda Solutions:*** Soda solutions are used for general neutralization of electrolyte.

(1) ***Strong Soda Solution:*** A strong soda solution, used primarily to neutralize spilling or dripping of electrolyte, is made by combining either 2 pounds of baking soda (sodium bicarbonate), or 1 pound of washing soda (sal soda) with 1 gallon of water. One gallon of strong soda solution should neutralize approximately 3/4 pint of low-specific gravity ▶(1.210)◀ electrolyte or 1/2 pint of high-specific gravity ▶(1.300)◀ electrolyte.

(2) ***Weak Soda Solution:*** A weak soda solution for neutralizing traces of electrolyte should be 1/8 the strength of the strong soda solution. A weak soda solution is made by combining either 2 pounds of baking soda (sodium bicarbonate), or 1 pound of washing soda (sal soda) with 8 gallons of water.

Note: After using a soda solution, always wipe the neutralized surface with a cloth dampened in clean water.

(b) ***Tetrasodium Pyrophosphate:*** The use of tetrasodium pyrophosphate (also known as ***pyro***) for general electrolyte neutralization has been discontinued for ecological reasons. However, the existing stock may be used up but not reordered. (Pyrophosphate may continue to be used, on an emergency basis, where immediate neutralization of large quantities of electrolyte is mandatory, such as might occur in underground installations. Use a concentration of 1/2 pound to 1 gallon of water.) An acceptable nonpolluting neutralizing agent is available ▶under the name of 'C-39 Hard Surface Cleaner.' This general purpose cleaner is available from AT&T Technologies Service Center, Item No. 5127-1 COMCODE 401753959.◀

(c) ***Agricultural or Industrial Lime: DANGER: Wear eye protection and rubber gloves when using lime on battery electrolyte spills. Wash hands and face thoroughly after use.*** When it is necessary to neutralize very large quantities of electrolyte, as in the event of a large spillage, agricultural or industrial lime may be used for this purpose as it is a more economical neutralizer. A 25-pound bag of lime should neutralize the acid in a KS-15544 cell.

(d) ***Ammonia Solution:*** A household ammonia solution consisting of 1 part ammonia to 2 parts water, should be used for neutralizing electrolyte on clothing. This solution will not cause fabric spotting as readily as a soda solution. Use caution when opening ammonia bottles because of pressure build up within the bottle. Ammonia liquid in vapor form is harmful to the eyes and nose. Also, do not use ammonia near rotating charging equipment.

Note: Do not use IGEPAL* CO-630 detergent for cleaning. A mild soap solution may be used as described in paragraph 4.17.

F. Explosion and Fire Prevention

1.13 *Explosion and Fire Prevention:* ***DANGER: All lead-acid batteries generate hydrogen gas, even under open circuit conditions. If not permitted to escape, this gas can build up to explosive concentrations in approximately 1 week for pure lead or lead-calcium cells, and in as little as 2 days for lead-antimony cells. NEVER seal lead-acid cells under any circumstances! When handling, storing, or shipping lead-acid cells, the appropriate vented orange shipping plug MUST be inserted into the open vent hole to allow safe venting of gases and to minimize acid spillage.*** The mixture of hydrogen and oxygen gases given off during charge, due to electrolysis of the water, is ***explosive*** if in sufficient concentration. A mixture of hydrogen and air is ***explosive*** if the hydrogen concentration exceeds ▶4◀ percent by volume. ▶The following admonishments, precautions, and procedures should always be followed.◀

(a) *Static Electricity Sparks:* ***DANGER: Avoid creating sparks, including those from static electricity, or the use of an open flame near batteries since the gas generated by batteries is highly explosive. Before performing each individual work operation, firmly touch a ground to discharge the static electricity from your body. Electrolyte level should NEVER be allowed to drop below the end of the antiexplosion funnel.*** Take precautions against static sparks at all times and especially while taking hydrometer or thermometer readings or when installing new vents of any type ▶while cells are◀ in service. These precautions should be observed when working on cells with or without antiexplosion features because of the possibility of cover seal leaks, post seal leaks, or containers, which would bypass the antiexplosion feature. ▶Where static electricity is a problem, the wearing of leather-soled shoes is recommended. Also, a slightly damp cloth, rather than a dry cloth, should be used to wipe plastic containers. To discharge static electricity from body, touch any grounded rack or frame.◀

(b) ***Charge and Discharge Explosion Safety:*** Under normal float charge, discharge, and recharge conditions, no explosion hazard exists with properly vented KS-15544 lead-calcium batteries. ***All lead-antimony batteries may contain an explosive atmosphere even under normal float charge conditions. Regardless of the type of battery, it is prudent to always take precautions against static sparks. During boost charge (2.3 volts or greater), all the batteries covered in this practice contain explosive atmospheres.◀ If a spark (as from a static discharge) enters the cell(s) under these conditions, an explosion may occur. For maximum safety, ▶DO NOT handle (avoid all contact with) cells on boost charge and for 24 hours after completion of boost charge.◀***

(c) ***Explosion Precautions:*** Special precautions should be used while taking hydrometer or thermometer measurements or when installing a new vent or funnel while cells are in service. Battery rooms and enclosures should be ventilated. Flames, arcs, sparks, etc., should be avoided in the vicinity of the battery. At no time should electrolyte level be allowed to drop below the minimum. The supervisor should ensure that all antiexplosion admonishments and precautions of this practice and local instructions are followed. (See Practice 157-601-101.)

(d) ***Battery Connections:*** Do ***not*** loosen or remove battery connections while cells are gassing or discharging unless it is absolutely necessary. If removal of connection is necessary during this period, follow procedures specified in subparagraphs (a), (b), (c), and in paragraph 4.15.

(e) ***Battery Electrolyte Leakage or Spillage:*** Leakage or spillage of battery electrolyte should ***not*** be allowed, especially where such leakage or spillage might form a low resistance arc path to ground or between different potentials.

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* Trademark of GAF Corporation.

Avoid electrolyte leakage or spillage which, in addition to the electrical path hazard, will cause corrosion.

(f) ▶***Battery Electrolyte Level:*** ◀Electrolyte level should ***NOT*** be allowed to fall below minimum since this allows the flame-arrester vents to be bypassed.

(g) ***Electrolyte Overflow:*** Electrolyte overflow from the vent funnel indicates clogged vents, which constitutes an explosion hazard.

(h) ***Battery Terminal Ends:*** The positive (+) and negative (−) ends of battery strings shall not be adjacent. (See Practice 157-601-201.) Adjacent cells in a string must ***not*** be allowed to touch each other.

1.14 ▶***Test Leads:*** Whenever making voltage measurements, observe the following precautions:

- Use extreme caution when making voltage measurements to prevent accidental grounding of the leads during the test operations.
- Secure connections at the meter end.
- The test leads should never touch each other or become grounded.◀
- In no case should connections at the meter end be removed without first disconnecting the test leads from the battery.
- The test lead connections at the battery should be removed immediately after each voltage measurement is taken.

1.15 ***DANGER: Avoid creating sparks, including those from static electricity, or the use of an open flame near batteries since the gas is explosive when sufficiently concentrated. Before performing each individual work operation, firmly touch a grounded rack, or an intercell connector near the grounded end of the battery, to discharge the static electricity from the body.***

1.16 ***DANGER: Do not allow flame-arrestor vents to become clogged as explosion due to internal pressure may result. Such an explosion may short circuit other cells and lead to a fire.***

G. Battery Charging

1.17 ▶***Boost Charge: DANGER: During boost charge and for approximately 24 hours after end of boost charge, an explosive concentration of hydrogen gas exists inside the cell. Therefore, to prevent an explosion, cells must NOT be handled either during the boost charge or during the 24-hour period following a boost charge.*** A boost charge is an overcharge of arbitrary length, the overall time for each voltage being specified. On float charged batteries, it may be given after an emergency discharge and on the first evidence of irregularity or undercharge.

> ***Note:*** Some battery power plants are not capable of boost charging and the cells are float charged continuously.

1.18 ***Equalizing Charge: DANGER: During an equalizing charge and for approximately 24 hours after the end of an equalizing charge, an explosive concentration of hydrogen gas exists inside the cell. Therefore, to prevent an explosion, cells must NOT be handled either during the equalizing charge or during the 24-hour period following an equalizing charge.*** An equalizing charge is a charge that is continued to a measured end; that is, until current and voltage or specific gravity have been stabilized for a specified time. It is a form of overcharge given periodically under some operating routines and in cases of sulfation or other evidence of chronic undercharge.

1.19 ***Initial Charge:*** An initial charge is the first charge given the batteries after receipt from the manufacturer. It is quite important that this charge be given as soon as possible after shipment from the battery company to avoid excessive sulfate formation.◀

H. Field Repairs

1.20 Repairable defects should be reported by way of Engineering Complaints. Field repairs, in many cases, are such that they can only be performed by the battery manufacturer. These repair procedures must have prior approval of the ▶AT&T Technologies Supplies, Marketing, and Engineering (SM&E) Organization. Consequently, request for approved field repair should be made directly to the battery supplier with a copy to AT&T SM&E for 'Information Only.'◀

I. Index of Lead-Acid Battery Requirements and Procedures

1.21 ▶Information in both Part 2 and Part 4 has been arranged under the headings shown in Table F.

J. Recommended Maintenance Intervals

1.22 Recommended maintenance procedures and intervals for the batteries covered by this practice are found in Table G. ◀

2. REQUIREMENTS

A. Battery Records

2.01 ***Battery Records and Readings (Proc 4.01):*** ▶Battery record forms should be filed and maintained for the life of the battery. Records which provide a history of the battery may prove helpful in clearing problems with the battery.◀

(a) Maintain complete battery records for each string of cells. Engineering complaints on battery performance cannot be accurately analyzed and satisfactorily settled unless they are accompanied by records which provide a thorough history of the cells in question.

(b) Any particular set of measurements and readings for a battery, including all measurements and readings within a string, should be taken by the same person using the same instruments. All test meters shall be calibrated by using the same voltage standard.

B. Battery Measurements

2.02 ***Float Voltage Measurements and Readings (Proc 4.02):*** See ▶Table E for the individual float voltage requirements.◀ Suggested intervals between float voltage measurements and readings are given in Table G. Refer to Practice 157-601-301 for special float voltage conditions.

(a) ▶These voltage requirements provide an operating range which is consistent with maximum battery life and reliability. However, cells outside these requirements will not necessarily fail prematurely or catastrophically. Whether or not cells operating outside the required voltage range will affect system reliability depends upon the cause of abnormal voltage conditions as explained in paragraph 4.02.

(b) Voltage values used in operating routines are not corrected for cell temperature. Record electrolyte temperature at time of voltage readings so cell behavior can be accurately analyzed.◀

(c) Calibrate power panel voltmeter in accordance with Practice 100-510-701. Set voltmeter having external adjuster as accurately as possible at or near float charge voltage. The head of the adjusting screw may be covered with tape to avoid accidental and unauthorized changes. ▶Ink the adjustment date on the tape. On voltmeters having no external adjuster, mark or tag the instrument or note in records◀ the correction to be applied to the measurements and readings and the date of calibration. This should be done on an annual basis.

2.03 ***Specific Gravity, Reference Temperature, and Floating Ball Charge Indicators (Proc 4.03):*** The specific gravity of low-gravity and high-gravity cells at electrolyte temperature of 77°F shall be as follows:

(a) ***Low-Gravity Cells:*** For low-gravity cells—1.210, with a tolerance range between ▶1.200 and 1.220◀

(b) ***High-Gravity Cells:*** For high-gravity cells—1.300, with a tolerance range between ▶1.290 and 1.310.◀

Take specific gravity readings before, rather than after water additions or charging. After adding water or charging, lead-antimony cells will regain their full charge specific gravity in about 2 weeks while lead-calcium cells take about 10 weeks. See Table E for specific gravity readings of standard, pilot, and emergency cells. ▶Suggested intervals between specific gravity readings of standard, pilot, and emergency cells are given in Table G.

C. Lead-Sulfate Crystals

2.04 ***Identification of Lead-Sulfate Crystals (Plastic Cases) (Proc 4.04):*** Under normal

♦TABLE F♦

INDEX OF LEAD-ACID BATTERY REQUIREMENTS AND PROCEDURES

SUBJECT HEADING	PART 2 REQUIREMENT PARAGRAPH NUMBER	PART 4 PROCEDURE PARAGRAPH NUMBER
A. Battery Records		
Battery Records and Readings	2.01	4.01
B. Battery Measurements		
Float Voltage Readings	2.02	4.02
Specific Gravity, Reference Temperature, and Floating Ball Charge Indicators	2.03	4.03
C. Lead-Sulfate Crystals		
Identification of Lead-Sulfate Crystals (Plastic Cases)	2.04	4.04
D. Battery Charging		
Emergency Cell Specific Gravity and Charging	2.07	4.07
Boost Charge Rate	2.08	4.08
E. Cell Reversals		
Cell Reversal	2.09	4.09
F. Battery Electrolyte		
Temperature of Electrolyte	2.10	4.10
Freezing of Electrolyte	2.11	4.11
Water Addition and Level of Electrolyte	2.12	4.12
Electrlyte Level Indicator Floats	2.13	4.13
G. Battery Discharge Capacity Tests and Replacement Criteria		
Discharge Capacity Tests and Replacement Criteria	2.14	4.14
H. Battery Connections and General Maintenance		
Battery Connections and Use of NO-OX-ID A*	2.15	4.15
Containers and Covers	2.16	4.16
Use of Tape to Temporarily Seal Plastic Jar Cracks	2.17	4.17
Seals	2.18	4.18
Spacing Between Containers	2.19	4.19
Flame-Arrestor Features	2.20	4.20
Spray Caps and Vent Holes	2.21	4.21
Battery Racks, Stands, Cabinets, and Miscellaneous Equipment	2.22	4.22
* Trademark of Sanchem Incorporated.		

TABLE G

RECOMMENDED MAINTENANCE INTERVALS

TASK	INTERVAL	PARAGRAPH
Calibrate voltmeter	12M	2.02
Check battery float voltage (or each visit to unattended sites)	W	2.02
Check emergency cell float voltage (or each visit to unattended sites)		2.02
Check individual cell float voltage	4M	2.02
Check pilot cell float voltage (lead-antimony) (or each visit to unattended sites)	2W	2.02
Check emergency cell specific gravity		2.03
Check pilot cell specific gravity (lead antimony)	4M	2.03
Check pilot cell temperature	4M	2.10
Check individual cell specific gravity	8M	2.03
Inspect for lead-sulfate crystals	4M	2.04
Check electrolyte level (lead antimony)	6M	2.12
Check electrolyte level (lead calcium)	6M	2.12
Perform water analysis w/o kit	12M	2.12
Inspect level indicator floats (hard rubber case)	12M	2.13
Check connections for corrosion	4M	2.15
Inspect containers for cracks and leaks	4M	2.16
Check battery jar for cracks and electrolyte leakage	4M	2.16

▶TABLE G◀(Contd)

RECOMMENDED MAINTENANCE INTERVALS

TASK	INTERVAL	PARAGRAPH
Inspect battery jars for cracks and electrolyte leakage (battery over 8 years old and in battery strings greater than 48 volts)	2M	2.16
Clean and inspect battery seals	4M	2.18
Check spacing between containers (or each time maintenance is performed)	4M	2.19
Clean and inspect flame-arrestor features	4M	2.20
Clean and inspect spray caps	4M	2.21
Clean and inspect battery racks and stands	4M	2.22

float conditions, all cells should be free of lead-sulfate crystals. The absence of lead-sulfate crystals throughout the life of a battery plant indicates that the cells are float charging properly and maintaining a full state of charge. Cells shall be inspected for lead-sulfate crystals to insure that cells are maintaining their charge.

2.05 The disappearance of lead-sulfate crystals or gray coloration occurs from top to bottom during recharge. To insure total absence of lead-sulfate crystals or gray coloration, where possible, inspection for lead-sulfate crystals should be concentrated at the bottom of the positive plate. The flashlight is held close to the jar wall at an angle of approximately 45 degrees. The lead-sulfate crystals will appear as sparkling diamond-like reflecting particles or as gray coloration. Record presence or absence of lead-sulfate crystals on battery maintenance records in place of cell-voltage measurements and readings.

2.06 If lead-sulfate crystals appear on all cells in a battery string, the following should be checked as possible causes for the abnormal condition. ♦The presence of lead-sulfate crystals is not normally an indication that the battery or cell is incapable of providing adequate capacity; therefore, corrective action for crystalline cells is not an urgent item. A crystalline cell will suffer an immediate loss of 2 to 5 percent of its rated capacity. Any further decay in capacity will depend upon the precise cause for the crystalline condition. The best way to assess the ability of a crystalline cell to deliver capacity is to make a specific gravity reading. If the specific gravity is in the normal range of 1.200 to 1.220 for low gravity cells and 1.290 to 1.310 for high gravity cells; then the deration in cell capacity will be minimal. Concern for the ability of a crystalline cell to deliver reasonable capacity should begin when the specific gravity is less than the normal minimum.♦

(a) ***Rectifier Voltage:*** The appearance of lead-sulfate crystals may indicate a low battery float voltage. Check to see if the individual cell float voltage is correct according to Table E. Make appropriate rectifier adjustments if necessary. (See paragraphs 2.02 and 4.02.)

(b) ***Plant Discharge:*** A battery discharge resulting from a power failure, testing, or other reasons may produce lead-sulfate crystals on the cell(s). This is normal with all lead-acid cells since lead-sulfate is the material produced when a lead-acid cell is discharged. If the cause of the lead-sulfate crystals is a recent discharge, the crystals will disappear when the cells have been fully recharged on float (usually within 2 weeks). It is mandatory to log all ac input power failure alarms in battery maintenance records.

D. Battery Charging

2.07 ***Emergency Cell Specific Gravity and Charging (Proc 4.07):*** Emergency cell specific gravity shall fall no lower than 1.180. Watch the first group of emergency cells carefully. A series of emergency discharges may discharge the first group of emergency cells much more than the main battery or the second group of emergency cells, making cell reversal a possibility.

2.08 ***Boost Charge Rate (Proc 4.08):*** ♦***DANGER: During boost charge and for approximately 24 hours after the end of boost charge, an explosive concentration of hydrogen gas exists inside the cell. Therefore, to prevent an explosion, cells must NOT be handled either during the boost charge or during the 24-hour period following a boost charge.***♦ A boost charge should be given, where possible, to the main battery and for 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 percent or more of the cell's gravity range for full discharge. See Table A for specific gravity ranges of lead-acid cells. ***Be sure low specific gravity is due to discharge and not to recent addition of water.*** Pilot-cell specific gravity measurements and readings should be taken to determine the extent of emergency discharge when the length of the emergency discharge is unknown. Boost charge accelerates return to a full charge condition. In plants where boost charge facilities or capabilities are not available, full charge will eventually return to a discharged battery on normal float charge. ♦The full charge will return♦ at a slower rate than with boost charging. ♦(See Fig. 1 and Practice 157-601-101.)♦

E. Cell Reversals

2.09 ***Cell Reversal (Proc 4.09):*** If one or more cells in series become fully discharged while the remainder of the cells are still discharging, there

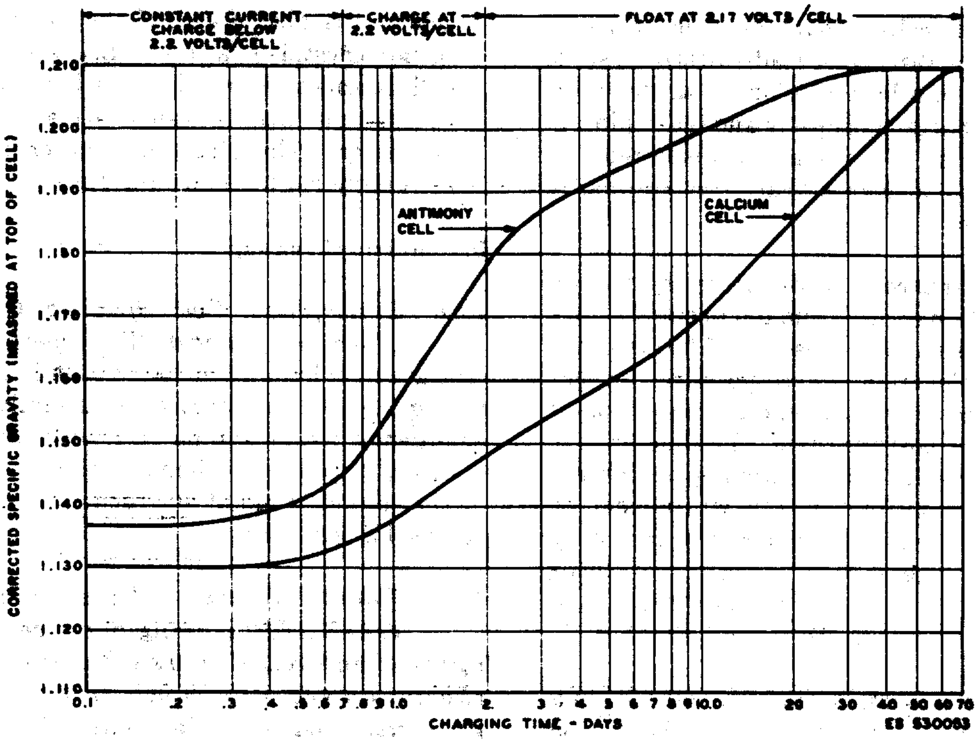

Fig. 1—Typical Charge Curves for a Fully Discharged Lead-Calcium Battery

will be a cell reversal, that is, change of polarity on the discharged cells. ➧If repeated several times, there is adverse effects on the plates of the reversed cell.➧

F. Battery Electrolyte

2.10 ***Temperature of Electrolyte (Proc 4.10):*** The best cell temperature, considering both life and capacity, is from 65 to 80°F. Temperatures lower than 65°F are objectionable only because of lowered battery capacity. High temperatures are objectionable because of increased positive plate corrosion and the resulting decrease in battery life. If operated at electrolyte temperature above 90°F for over 2 months per year, battery life expectancy must be reduced by 20 percent. For lead-calcium cells, the life at 90°F is only half that at 77°F; and at 100°F, the life is 1/3 that at 77°F. The life of lead-antimony cells at 90°F is 3/5 that at 77°F; and at 100°F, the life is 1/3 that at 77°F. Therefore, operation at elevated temperatures is not advisable and, except on initial charge, 110°F should not be exceeded. (See Practice 157-601-201.) For effect of temperature on specific gravity, [see subparagraph (b) of paragraph 4.03]; and for effect on capacity and voltage, see Practice 157-601-101.

2.11 ***Freezing of Electrolyte (Proc 4.11):*** The electrolyte in any cell shall be maintained above the freezing temperature respective to its specific gravity as shown in Table H. Freezing will cause damage not immediately apparent. (See Practice 157-601-101.)

2.12 ***Water Addition and Level of Electrolyte (Proc 4.12): Warning: Overfilling the cell can lead to plugging of the gas vents.*** At all times after initial charge, the level of electrolyte in any cell shall be maintained as indicated in Table D. The drop rate of electrolyte level will vary considerably depending upon cell design and upon operating and atmospheric conditions. The addition of water must, therefore, be at intervals as required at a specific location.

2.13 ***Electrolyte Level Indicator Floats (Proc 4.13):*** Electrolyte level of rubber jar cells is indicated by electrolyte level float indicators. The indicator consists of a float and a float guide (Fig. 2). The electrolyte indicator for the EXIDE KS-5562 cells are fitted with a transparent cover over the exposed stem part of the float. The cover is etched with lines to indicate the high and low level of the electro-

▶TABLE H◀

FREEZING TEMPERATURE OF LEAD-ACID BATTERY ELECTROLYTE

SPECIFIC GRAVITY AT 25.0°C (77°F)	FREEZING TEMPERATURE	
	°C	°F
1.030	-1.11°	+30°
1.060	-3.33°	+26°
1.090	-6.6°	+20°
1.120	-8.8°	+16°
1.150	-13.3°	+8°
1.180	-19.9°	-4°
1.210	-30.6°	-23°
1.240	-46.7°	-52°
1.270	-65.0°	-85°
1.283	-72.8°	-99°
1.300	-73.3°	-100°
1.330	-53.3°	-64°

lyte. The electrolyte level indicator for the GOULD cells without a cover has the float stem colored to indicate the electrolyte level. The minimum level of electrolyte is indicated when the top of the float stem is flush (or level) with the top of the float guide. Floats shall be free to move with electrolyte level changes. To check float indicators equipped without cover, depress the float indicator and observe that the float does not stick when released.

G. Battery Discharge Capacity Tests and Replacement Criteria

2.14 ***Discharge Capacity Tests and Replacement Criteria (Proc 4.14):*** The rated capacity or ampere-hour capacity of all cells is based on the 8-hour discharge rate except for KS-20048 (hardened site) cells where it is based on the 5-hour discharge rate. In practice, the 5-hour discharge rate is used to determine the reserve capacity of all cells because a 5-hour discharge test can be completed during a normal 8-hour work day. Table A gives the 5- and 8-hour discharge rates in amperes of lead-acid cells presently used in telecommunication offices and other power plants. Table I is used for the KS-5562, L04, L05, L06, and L07, tank cells.

H. Battery Connections and General Maintenance

2.15 ***Battery Connections and Use of NO-OX-ID A (Proc 4.15):*** ***▶Caution: Overtighting of the intercell connectors could strip the bolt and/or nut threads resulting in loose connections.◀*** Connections shall be tight and free from dirt and corrosion. ▶Connections should be checked according to the suggested intervals in Table G◀ or per local practices. (See Practice 157-601-702.) Do not loosen or change connections without first referring to subparagraph ▶(d)◀ of paragraph 1.13 and paragraph 4.15.

2.16 ***Containers and Covers (Proc 4.16):*** ***DANGER: Acid leakage can cause short circuits, corrosion of terminals and intercell connectors, and is a potential fire hazard.*** Containers and covers shall be free from cracks and leakage or spillage of electrolyte.

2.17 ***Use of Tape to Temporarily Seal Plastic Jar Cracks (Proc 4.17):*** Leaky jars shall be replaced. Cracks in plastic jars that are leaking shall be temporarily sealed ▶with acid-resistant tape,◀ when possible, while awaiting cell replacement.

2.18 ***Seals (Proc 4.18):*** Post seals and any seals between covers and containers shall be intact and free from electrolyte or residue.

2.19 ***Spacing Between Containers (Proc 4.19):*** ***DANGER: Cells or batteries, especially those with flexible connectors, should be checked for spacing every time maintenance work is performed. Proper spacing of cells prevent the possibility of fire which can occur if the cells are in contact with each other. Where connector terminals and terminal details extend beyond the battery cover, use extreme care to avoid shorts when moving the cells.*** Spacing between containers shall be as specified in Practice 157-601-201. The KS-5562 tank cells may bulge with age

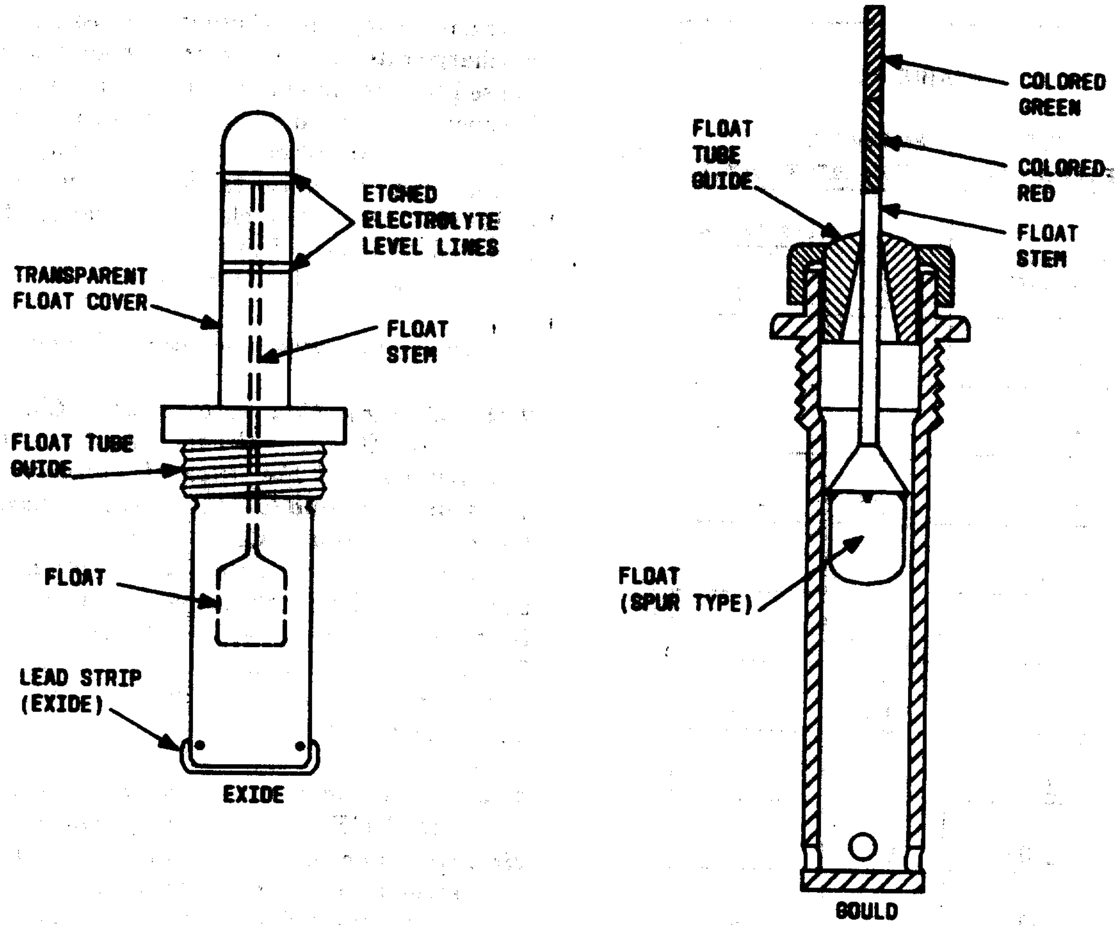

Fig. 2—Rubber Battery Jar Electrolyte Level Indicator Floats

as plate growth occurs. Total bulge (both sides combined) shall not exceed 3/4 inch.

2.20 ***Flame-Arrestor Features (Proc 4.20):*** ***DANGER: Do not allow gas vents to become clogged as spraying or overflow due to internal pressure may result.*** Flame-arrestor features shall be dry, clean, and undamaged. Vents of the screw type shall be screwed down to a snug fit with no leakage through the seal. Vents which are permanently cemented in place shall be firmly seated and sealed at the base. ▶Inspect and gauge antiexplosion features by eye.◀

2.21 ***Spray Caps and Vent Holes (Proc 4.21):*** Spray caps shall be clean and in place. (See Practice 157-601-201.) The vent holes shall be open and free of residue. ▶Inspect and gauge spray caps and vent holes by eye.◀

2.22 ***Battery Racks, Stands, Cabinets, and Miscellaneous Equipment (Proc 4.22):*** Battery racks, stands, cabinets, and miscellaneous equipment shall be clean and free from corrosion. Racks, stands, and cabinets shall be level and properly grounded. (See references in paragraph 4.22.) ▶Inspect and gauge corrosion and grounding by eye.◀

Note: Peeling paint or corrosion may indicate a leaking cell.

▶TABLE H◀

EXPECTED RESERVE OF KS-5562* TANK CELLS AT 600 AMPERES DISCHARGE

CELLS	HOURS	M (MINUTES)
L04	6	360
L05	8.2	492
L06	11	660
L07	13	780

* Manufacture discontinued.

3. APPARATUS

3.01 ***List of Tools and Test Equipment: DANGER: The use of insulated wrenches does not change the requirements for protecting exposed adjacent metal with fiberboard, canvas, or rubber sheeting as may be appropriate.*** The following tools and test equipment are used in this practice. Equivalents may be substituted for those listed.

> *Note:* The wrench sizes are included for information only and do not have to be included with the ordering information.

TOOLS	DESCRIPTION
W1AF	Test Cord
R1060	Putty Knife
R2969	Typewriter Brush
—	KS-5499, L1401, Syringe Type Cell Filler
	Orange Stick
R-4810 DET 1	1/2-Inch Wrench, Box, Insulated
R-4810 DET 2	9/16-Inch Wrench, Box, Insulated
R-4810 DET 3	5/8-Inch Wrench, Box, Insulated
R-4810 DET 4	3/4-Inch Wrench, Box, Insulated
R-4810 DET 5	13/16-Inch Wrench, Box, Insulated
R-4810 DET 6	7/8-Inch Wrench, Box, Insulated
R-4810 DET 7	15/16-Inch Wrench, Box, Insulated
R-4810 DET 8	1-Inch Wrench, Box, Insulated
R-4810 DET 9	1-1/16 Inch Wrench, Box, Insulated
R-4810 DET 10	1-1/8 Inch Wrench, Box, Insulated.
—	Test Cords, WESTON* No. 254761-901 and No. 168023
—	3-Inch C Screwdriver
—	Battery Filler, E. Edelman & Company No. 74C
—	Small Paint Brush (obtain locally)
—	Soldering Copper, Pyramid Point, 1 or 2 pounds
—	Flashlight, regular or angular, having plastic or rubber housing
R-4501	Goggles, Coverall, Clear Lenses

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* Trademark of WESTON Instruments, a Divison of Sangamo, Inc.

TOOLS	DESCRIPTION
—	Glass or Plastic Tube, approx. 1/4-inch O.D. (obtain locally — for checking electrolyte level in special locations)
	Adjustable or Open-end Wrench, as required for bolt-connectors. (Special wrenches will be furnished with connections.) Insulate wrenches with one wrapping of plastic or rubber tape or tubing, and then overwrap with three wrappings of friction tape. Each wrapping shall be applied with half a lap. The entire unused portion of wrenches shall be thoroughly insulated.

GAUGES	DESCRIPTION
—	▶6-Inch Plastic Ruler◀
KS-5499	Thermometer, ▶L1352, L1353, and L1354◀
KS-5499	Hydrometer, ▶L1305 (old) or L1306 (new)◀ (for low-gravity cells) (for checking electrolyte level)
KS-5499	Hydrometer, ▶L1307 (old), or L1308 (new)◀ (for high-gravity cells) (for checking electrolyte level)
—	Thermometer, Fisher Scientific Company No. 14-990, 0 to 230°F.
—	Discharger-Recharger ▶KS-20142, L1, or KS-20770, L1 and L2◀
—	▶KS-22861, L1, Digital Multimeter◀

MATERIALS	DESCRIPTION
R-3034	Rubber Acid Gloves (for heavy duty)
R-3043	Rubber Apron
R-3126	Silicone Compound (2-oz tube for countercells)
KS-14666	Cloth
▶KS-21527, L3	Eyewash Kit
KS-21527, L4	Eyewash Solution◀
—	Household Ammonia
—	Wire brush (Obtain locally. For racks and stands—do not use on connectors)
—	Battery Sealing Compound (battery manufacturers' type)
—	Container (glass, glazed porcelain, plastic, rubber, earthenware, or lead—for handling electrolyte or water)
—	Electrolyte, Specific Gravity not to exceed 1.300 at 60°F (manufacturers' type)
—	Glass or Plastic Funnel (obtain locally)
—	▶Neoprene Gloves◀
R-3266	NO-OX-ID A Compound (for batteries)
—	Round Nipple Brush (obtained locally)
—	4/0 Sandpaper
—	▶Baking Soda (sodium bicarbonate)
—	Washing Soda (sal soda)◀
—	Water, distilled or approved for use in storage cells

MATERIALS	DESCRIPTION
—	Wiper, Paper, SCOTT* No. 58, 59, or ♦59R♦
—	Wax, Battery Jar Black, No. 5300 (from EXIDE) (1 quart)
C-39	Hard Surface Cleaner—(Available from ♦AT&T Technologies♦ Service Center, Item No. 5127-1 COMCODE 401753959)
—	♦Approved Mild Soap Solutions: JOY† Dish Washing Liquid (Mfr—Procter and Gamble); LUX‡ Dish Washing Liquid (Mfr—Lever Brothers); DOVE‡ Dish Washing Liquid (Mfr—Lever Brothers); IVORY LIQUID† Dish Washing Liquid (Mfr—Procter and Gamble); PALMOLIVE§ Dish Washing Liquid (Mfr—Colgate-Palmolive Company)
—	Acid-Resistant Tape (2-inch wide)
—	Electrical Plastic or Rubber Tape (3/4-inch wide)
—	Friction Tape (3/4-inch wide).♦

4. PROCEDURES

A. Battery Records

4.01 ***Battery Records and Readings (Reqt 2.01):*** ♦Battery record forms should be filed and maintained for the life of the battery. Records which provide a history of the battery may prove helpful in clearing problems with the battery.♦

(a) ♦Forms E-2003 (Fig. 3), E-3591 (Fig. 4), E-3592 and E-3593 (Fig. 5),♦ are typical forms suggested for recording various measurements and readings.

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

(c) Record the temperature whenever specific gravity readings and voltage measurements are taken. It is not necessary to take the temperature of each individual cell. The temperature of one cell on each tier will be sufficient.

Note: Unused space on forms may be used to record irregularities such as excessive amount of water required.

B. Battery Measurements

4.02 ***Float Voltage Measurements and Readings (Reqt 2.02):*** ♦***DANGER:*** Accidental grounding of battery connected test leads, while making individual cell voltage readings or average battery float voltage readings, can result in serious interruption to service. In order to avoid this possibility, extreme caution should be observed when taking these readings. Connections at the meter end should be secure and free of any possibility of touching or becoming grounded. In no case should connections at the meter end be removed without first disconnecting the test leads from the battery. The test lead connections at the battery should be removed immediately after each voltage measurement and reading is taken. Always observe polarity and proper scale (if applicable) when measuring cell or battery voltage to avoid possible damage to the meter. Use the 3-volt scale of an approved digital voltmeter for measuring voltages of both low-gravity and high-gravity cells. Voltage measurements and readings should always be taken with the voltmeter leads connected directly to the battery terminals and ***not*** to the intercell connectors.♦

(a) If the voltage requirement is not met, the following should be checked as possible causes of the abnormal condition:

(1) ***Rectifier Voltage:*** Low- or high-voltage cells may be due to incorrect average battery float charge voltage. Check to see if the average battery float charge voltage conforms to the requirements in Table E, i.e., 2.17 ±0.01

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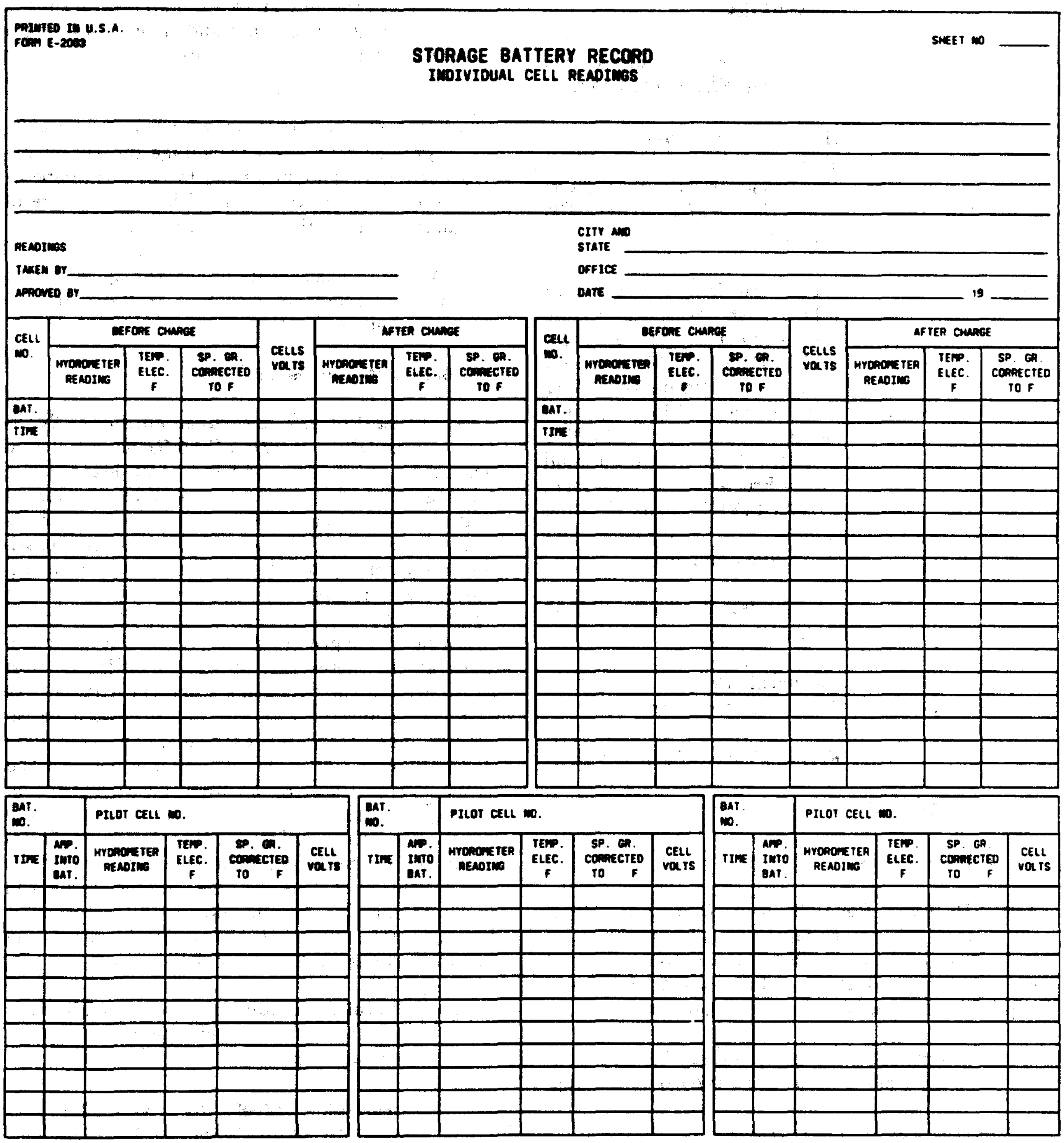
* Trademark of SCOTT Paper Company.

† Trademark of Proctor & Gamble Company.

‡ Trademark of Lever Brothers Company.

§ Trademark of Colgate-Palmolive Company.



PRINTED IN U.S.A.
FORM E-2003

SHEET NO ______

STORAGE BATTERY RECORD
INDIVIDUAL CELL READINGS

____
____
____
____

READINGS
TAKEN BY ______________________

APROVED BY ______________________

CITY AND
STATE ______________________

OFFICE ______________________

DATE ______________________ 19 ______

CELL NO.	BEFORE CHARGE			CELLS VOLTS	AFTER CHARGE		
	HYDROMETER READING	TEMP. ELEC. F	SP. GR. CORRECTED TO F		HYDROMETER READING	TEMP. ELEC. F	SP. GR. CORRECTED TO F
BAT.							
TIME							

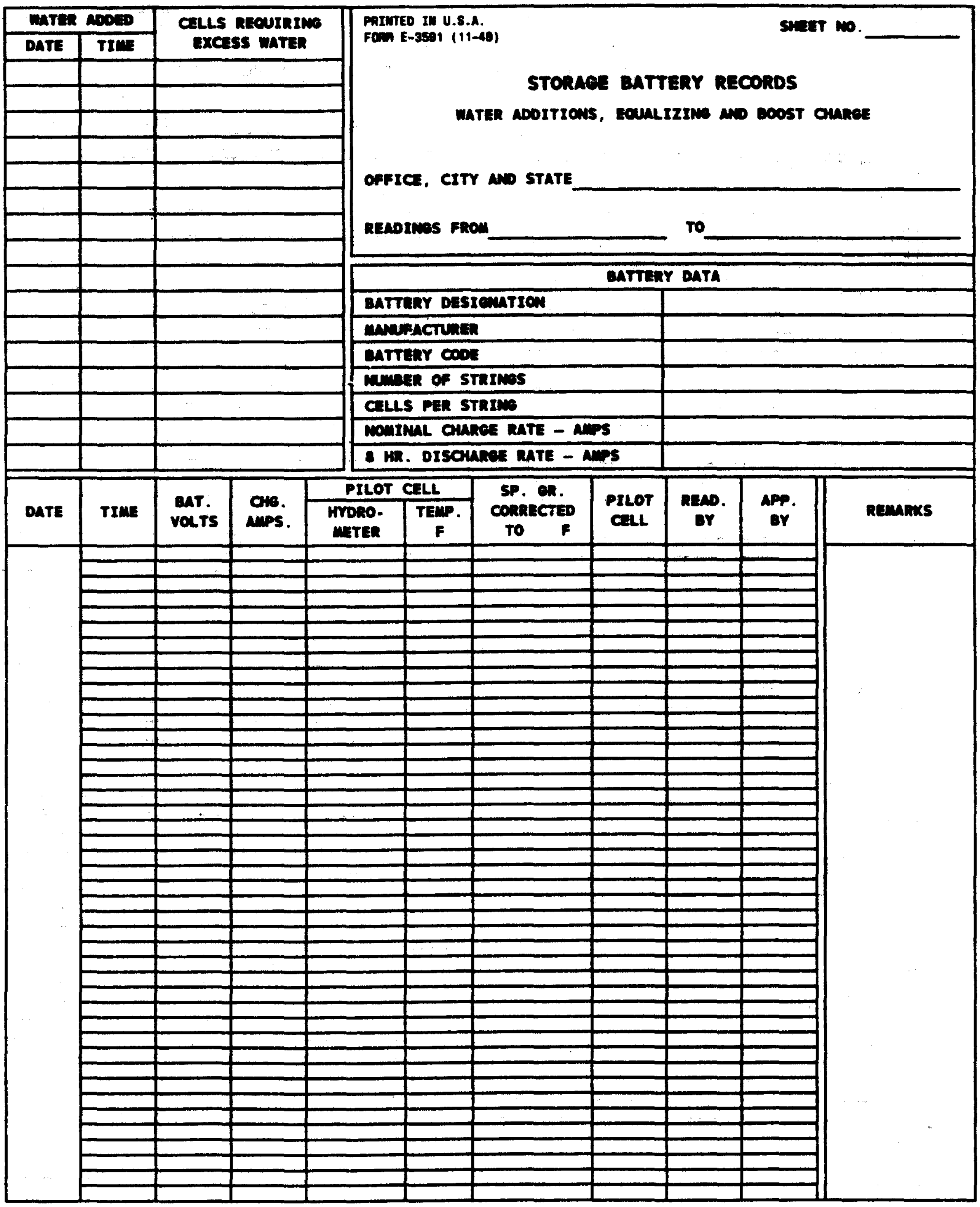
CELL NO.	BEFORE CHARGE			CELLS VOLTS	AFTER CHARGE		
	HYDROMETER READING	TEMP. ELEC. F	SP. GR. CORRECTED TO F		HYDROMETER READING	TEMP. ELEC. F	SP. GR. CORRECTED TO F
BAT.							
TIME							

BAT. NO.		PILOT CELL NO.			
TIME	AMP. INTO BAT.	HYDROMETER READING	TEMP. ELEC. F	SP. GR. CORRECTED TO F	CELL VOLTS

BAT. NO.		PILOT CELL NO.			
TIME	AMP. INTO BAT.	HYDROMETER READING	TEMP. ELEC. F	SP. GR. CORRECTED TO F	CELL VOLTS

BAT. NO.		PILOT CELL NO.			
TIME	AMP. INTO BAT.	HYDROMETER READING	TEMP. ELEC. F	SP. GR. CORRECTED TO F	CELL VOLTS

Fig. 3—Form E-2003 Storage Battery Record



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FORM E-3591 (11-48)

SHEET NO. ____________

STORAGE BATTERY RECORDS

WATER ADDITIONS, EQUALIZING AND BOOST CHARGE

OFFICE, CITY AND STATE ______________________________

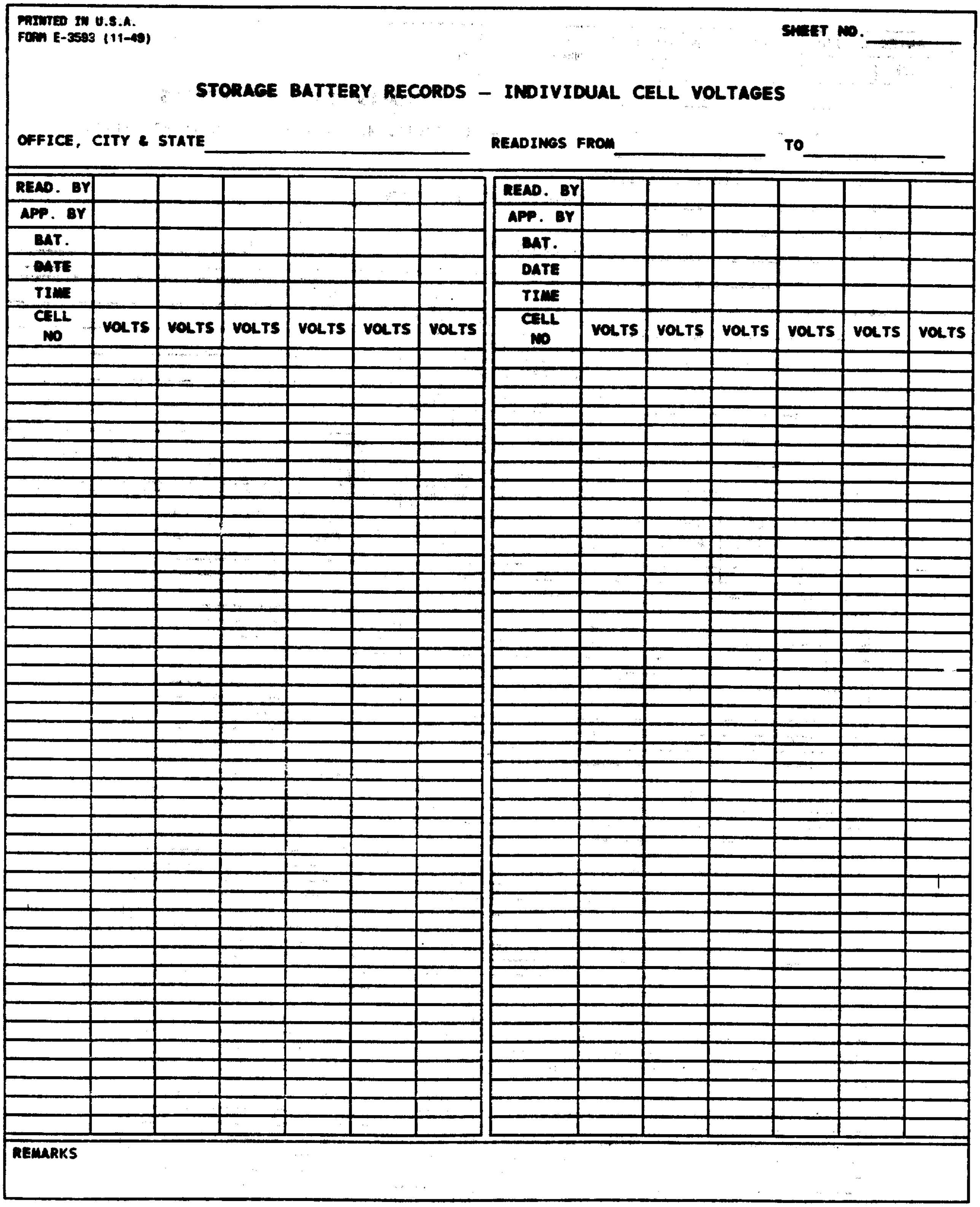
READINGS FROM ______________ TO ______________

WATER ADDED		CELLS REQUIRING EXCESS WATER
DATE	TIME	

BATTERY DATA	
BATTERY DESIGNATION	
MANUFACTURER	
BATTERY CODE	
NUMBER OF STRINGS	
CELLS PER STRING	
NOMINAL CHARGE RATE – AMPS	
8 HR. DISCHARGE RATE – AMPS	

DATE	TIME	BAT. VOLTS	CHG. AMPS.	PILOT CELL		SP. GR. CORRECTED TO F	PILOT CELL	READ. BY	APP. BY	REMARKS
				HYDRO-METER	TEMP. F					

Fig. 4—Form E-3591 Storage Battery Record



PRINTED IN U.S.A.
FORM E-3593 (11-49)

SHEET NO. ______

STORAGE BATTERY RECORDS – INDIVIDUAL CELL VOLTAGES

OFFICE, CITY & STATE ______ READINGS FROM ______ TO ______

READ. BY							READ. BY						
APP. BY							APP. BY						
BAT.							BAT.						
DATE							DATE						
TIME							TIME						
CELL NO	VOLTS	VOLTS	VOLTS	VOLTS	VOLTS	VOLTS	CELL NO	VOLTS	VOLTS	VOLTS	VOLTS	VOLTS	VOLTS

REMARKS

Fig. 5—Form E-3593 Storage Battery Record—Individual Cell Voltages

volts per cell for low-gravity cells, and 2.25 ±0.01 volts per cell for high-gravity, lead-antimony cells, and 2.30 ±0.01 volts per cell for high-gravity, lead-calcium cells, respectively. Make appropriate rectifier adjustments if necessary.

(2) *Cell Temperature Variations:* Improper cell voltage conditions may result from temperature variations between cells in the same string. This is most likely to occur in multitier arrangements where, because of natural air convection, the temperature of the top tier cells may be significantly higher than the lower tier cells. The warmer cells (top tier) would have lower float voltages than the cooler cells (bottom tier). If the difference between the warmest and coolest cell in any string is more than 5°F, appropriate ventilation should be provided to correct the situation.

(3) *Cell Manufacturers:* Cells made by the different manufacturers, even though they have the same capacity rating, have different float charge characteristics. Check to be sure that all cells are from the same manufacturer.

(4) *Cell Types:* Lead-calcium and lead-antimony cells have different float characteristics. A lead-calcium cell mixed in with a string of lead-antimony cells will have a float voltage much higher than the lead-antimony cells. Conversely, a lead-antimony cell mixed in with a string of lead-calcium cells will have a float voltage much lower than the lead-calcium cells. Check cell identification labels to be sure that all cells are of the same lead-alloy (KS-number).

(b) If the above conditions are not met or cannot be identified as the cause of deviation from the float charge voltage requirements, take the following steps:

(1) *Cell Voltage High:* In general, cells operating slightly above the required voltage limit do not indicate a trouble condition and no action need be taken. However, cells float charging at voltages significantly higher than the upper voltage limit must be examined closely since such a condition indicates that possibly one or more of the plates are no longer in the cell circuit. Any cells floating at a voltage higher than the upper voltage requirements, i.e., greater than 2.22 volts for low-gravity cells; greater than 2.30 volts for high-gravity, lead-antimony cells; and greater than 2.35 volts for high-gravity, lead-calcium cells, should be inspected closely for evidence of loss of one or more plates from the cell circuit. Replace any cells which show loss of plates from the cell circuit. If visual inspection does not reveal anything, a discharge test should be run on the cell in question. If the capacity is low (see paragraph 4.14), the cell should be replaced. If both visual inspection and the capacity test do not indicate a trouble condition, no action needs to be taken. However, special attention should be given to the regular voltage measurements and readings. Replace the cell if the float voltage of the cell in question continues to increase.

(2) *Cell Voltage low:* For cells that were float charging within the required range at the previous quarterly voltage reading, float voltages less than ▶2.07◀ volts for low-gravity cells and less than 2.14 volts for high-gravity cells indicate a severe abnormality—possibly a short circuit—and should be replaced. Low-gravity cells between ▶2.07◀ and 2.09 volts; high-gravity, lead-antimony cells between 2.14 and 2.17 volts; and high-gravity, lead-calcium cells between 2.14 and 2.22 volts also indicate an abnormal condition. These cells should be boost charged as soon as possible. If boost charging permanently corrects the abnormally low-voltage condition, no other action needs to be taken.

(c) If the cells voltage is still abnormally low after boost charge or if the cells return to abnormally low float voltage within a year after boost charge, the cells should be replaced. If the cells return to abnormally low-voltage conditions at any time exceeding 1 year after boost charge, boost charge again and follow the procedures given in this paragraph.

(d) Other low-voltage conditions, i.e., below the required minimum float voltage but greater than 2.09 volts for low-gravity cells; greater than 2.17 volts for high-gravity, lead-antimony cells; and greater than 2.22 volts for high-gravity, lead-calcium cells, are more difficult to analyze and disposition of these cells can only be decided after further tests.

(e) If the voltage is still low at the next quarterly reading, the cell should be given a boost charge, and if this corrects the low-voltage condition, no further action needs to be taken. If boost charging does not correct the low-voltage condition, the low-voltage cells should be given a discharge capacity test 6 months after boost charging. Replace cells only if discharge tests show low capacity.

(f) If a single-cell charger is not readily available and the power plant is capable of ▶an equalizing or boost◀ charge, operate the float/charge key ▶to charge position◀ when the battery voltage drops below the minimum requirements [see subparagraph (c) of paragraph 4.08]. A single-cell charger may still be required for individual cells if the ▶equalizing or boost◀ charge does not bring the cells within minimum voltage requirements.

4.03 ***Specific Gravity, Reference Temperature and Floating Ball Charge Indicators (Reqt 2.03): DANGER: When taking specific gravity readings, the open end of the hydrometer shall be covered with ▶a paper towel◀ while moving it from cell to cell to avoid splashing or throwing the electrolyte.*** To check these requirements, proceed as follows.

(a) ▶***Hydrometer Types:*** Use the KS-5499, L1305 (old) or L1306 (new) syringe-type hydrometer for low-gravity cells and the KS-5499, L1307 (old) or L1308 (new) syringe-type hydrometer for high-gravity cells. (See Table E for specific gravity requirements.)◀

(b) ***Reference Temperature and Effect of Temperture on Specific Gravity: Warning: Never insert a thermometer into the electrolyte withdrawal tube or use a mercury-filled thermometer to take temperature measurements and readings.*** Use the KS-5499, L1352, thermometer for cells of 100-ampere hours or less and the KS-5499, L1353, thermometer for cells over 100-ampere hours. Specific gravity readings and electrolyte temperature readings must be taken within a few minutes of each other. The thermometers now being supplied have scales for correcting to the proper reference temperature of 77°F. If a thermometer with correction scale is not available, calculate the correct specific gravity by adding 1 point (0.001) for each 3°F that the electrolyte temperature is above 77°F or by subtracting 1 point (0.001) for each 3°F that the electrolyte temperature is below 77°F.

Note: Thermometers in which the indicating liquid has separated shall not be used ▶and should be discarded.◀

(c) ***Specific Gravity Readings of Cells With Electrolyte Withdrawal Tubes:*** ▶Specific gravity measurements and readings of lead-acid cells with electrolyte withdrawal tubes are taken by first exhausting the hydrometer bulb with the flexible tube inserted in the battery water filler funnel. Then, with the bulb still held depressed, insert the flexible tube into the battery withdrawal tube located in the corner of the battery cover. Releasing the bulb will draw battery electrolyte into the hydrometer, which must then be carefully removed to facilitate reading the specific gravity number on the hydrometer float at the surface of the electrolyte. The hydrometer must be exhausted in the water filler funnel (not the small withdrawal tube) of the cell from which the electrolyte was removed. This procedure should prevent battery electrolyte from splattering from the hydrometer flexible tube during handling.◀

(d) ***Specific Gravity Readings of Cells Without Electrolyte Withdrawal Tubes: Warning:*** ▶***Hydrometers***◀ ***used in lead-antimony, lead-calcium, and KS-20472 LINEAGE 2000 round cell batteries shall not be interchanged since they will contaminate the electrolyte.*** Specific gravity measurements and reading of cells without electrolyte withdrawal tubes are taken by inserting the hydrometer through the opening which is used for the addition of water. However, readings must not be considered accurate unless 10 weeks have elapsed since charging or adding water for lead-calcium cells or 2 weeks for lead-antimony cells. Slowly fill and empty the hydrometer several times before recording readings in order to wet the float, mix the electrolyte, and equalize the temperature of the hydrometer and electrolyte. Exercise care to ensure that the top of the hydrometer does not touch the stop in the hydrometer bulb since this would cause an erroneous reading. Exercise care to avoid dripping or spraying electrolyte from the hydrometer tube.

(e) ***Assembling Hydrometer Syringe: DANGER: In order to avoid possible serious cuts from broken glass, extreme care should***

be used in assembling the hydrometer syringe. If the hydrometer has previously been used, it may possibly contain some electrolyte clinging to the wall of the glass barrel or rubber hose. Goggles should be used in assembly operations to protect the eyes. [See Steps (1) through (4).]

(1) Remove any mold seam fins from those surfaces of the rubber parts which in assembly fit against the glass barrel.

(2) Before assembling any rubber parts to the glass barrel, wrap several thicknesses of heavy cloth around the barrel to protect the hands.

(3) Always wet the rubber parts and that portion of the glass barrel where the fitting is to take place prior to assembly operations.

(4) After performing Steps (1), (2), and (3), fit the rubber parts to the glass barrel.

(f) ***Floating Ball Charge Indicators:*** Charge indicators are furnished on some smaller cells. The indicators are wax balls of selected specific gravity. The three colored ball indicators (blue-green, white, and red) provide the following specific gravity indications:

(1) The blue-green ball drops when the specific gravity falls to 1.195 ±0.002. This ball drops first on discharge.

(2) The red ball drops when the specific gravity decreases by an amount representing between 63- and 69-percent discharge from the full charge value.

(3) The white ball drops when the specific gravity is approximately half-way between the gravity requirements of the blue-green and red indicators.

Note: The indicators in Steps (1), (2), and (3) assume a well mixed electrolyte, at the high level, with a temperature of 77°F.

(g) ***Specific Gravity Out of Range:*** Specific gravity measurements below the required range are rare and indicates that the cell is self-discharging and consequently losing capacity. Boost charge a cell when specific gravity is below the required minimum. If boost charging permanently corrects the condition, no action needs to be taken. If the specific gravity is still low after boost charging, or if the condition reappears within a year of boost charging, replace the cell.

C. Lead-Sulfate Crystals

4.04 ***Identification of Lead-Sulfate Crystals (Plastic Cases) (Reqt 2.04):*** There should be no lead-sulfate crystals or gray coloration present on the positive plates or straps when examined with a flashlight. Normally, only the positive strap will be accessible for examination. In some arrangements the edges of the positive plates will also be visible (Fig. 6). The visible positive elements shall be black or dark brown and totally free of any diamond-like lead-sulfate crystals or gray coloration. The disappearance of lead-sulfate crystals normally occurs in three distinct phases:

Phase 1: Black and crystalline

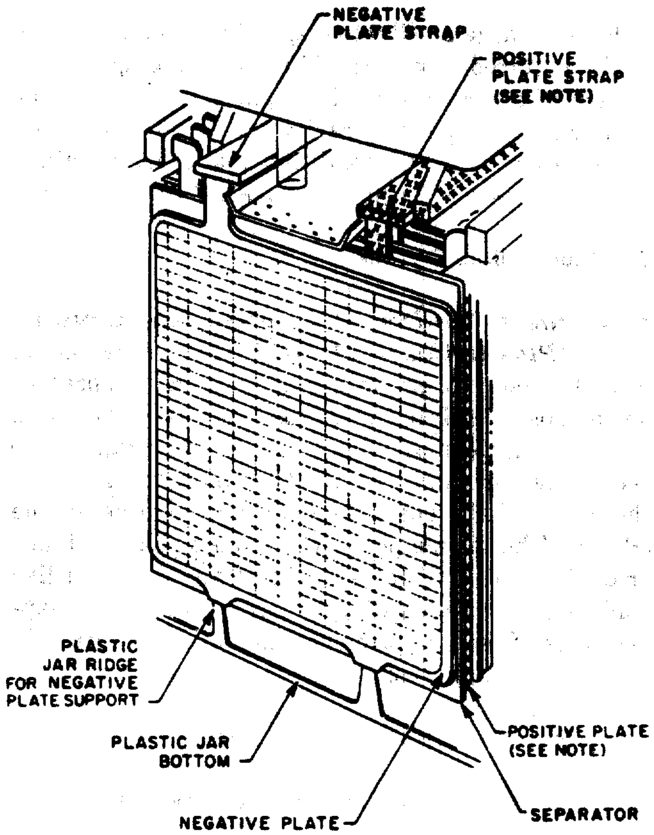
Phase 2: Gray and lightly crystalline

Phase 3: Black or dark brown and crystal free.

4.05 The disappearance of lead-sulfate crystals or gray coloration occurs from top to bottom during recharge. To insure total absence of lead-sulfate crystals or gray coloration, where possible, inspection for lead-sulfate crystals should be concentrated at the bottom of the positive plate. The flashlight is held close to the jar wall at an angle of approximately 45 degrees. The lead-sulfate crystals will appear as sparkling diamond-like reflecting particles or as gray coloration. Record presence or absence of lead-sulfate crystals on battery maintenance records in place of cell-voltage readings.

4.06 If lead-sulfate crystals appear on one or a few cells in a string, the following actions should be taken.

Note: A battery discharge resulting from power failure, testing, or other reasons may produce lead-acid crystals on the cells. This is normal with all lead-acid cells since lead-sulfate is the material produced when a lead-acid cell is discharged. If the cause of the lead-acid crystals is a recent discharge, the crystals will disappear when the cells have been fully



NOTE:
CHECK FOR LEAD-SULFATE CRYSTALS ON AREAS MARKED WITH XXX'S.

Fig. 6—Typical Rectangular Cell Showing Possible Location of Lead-Sulfate Crystals on Positive Elements

recharged on float (usually within 2 weeks). ***It is mandatory to log all ac input power failure alarms in battery maintenance records.***

(a) ***Plant Discharge:*** Check to see if a plant discharge has occurred.

(b) ***Cell Shorted:*** Measure the cell voltage. If the crystalline cell(s) indicates 2.09 volts or less and the cell visible positive elements are black and heavily crystalline (Phase 1), the cell is shorted and should be reported in an engineering complaint.

(c) ***Cell Temperature Variation:*** Measure temperatures of cells in each tier of the string(s) to determine the extremes of temperature differences. Temperature differences of 5°F or more between cells in a string can result in a float problem with the warmer cells which would result in the appearance of crystals. If temperature differences in excess of 5°F are found, appropriate ventilation should be provided to correct the condition.

(d) ***Single-Cell is Crystalline:*** If the problem is ***not*** attributed to a ***shorted cell*** [see subparagraph (b)], or to a ***cell temperature variation*** [see subparagraph (c)], the cell(s) should be boost charged at ♦2.5 to 2.55♦ volts with a single-cell charger. The boost charge should be continued for at least 24 hours after the lead-sulfate crystals have disappeared. Upon completion of the boost charge, the cell should be allowed to float charge in the string.

(1) ♦***DANGER: During boost charge and for approximately 24 hours after end of boost charge, an explosive concentration of hydrogen gas exists. Therefore, to prevent an explosion, cells must NOT be handled either during the boost charge or during the 24-hour period following a boost charge.***♦ If lead-sulfate crystals ***do not*** reappear on float charge, no action needs to be taken.

(2) If lead-sulfate crystals ***do*** reappear, the cell should be reported as an engineering complaint. Copies of the battery record should also accompany the complaint.

(e) ***Multiple Cells Are Crystalline:*** If the problem is ***not*** attributed to ***shorted cells*** [see subparagraph (b)], or to a ***cell temperature variation*** [see subparagraph (c)], it is recommended that the battery string be boost charged at 2.5 to 2.55 volts per cell. The boost charge should be continued for at least 24 hours after the lead-sulfate crystals have disappeared from all cells. Upon completion of the boost charge, the cells should be allowed to float charge in the string.

(1) If lead-sulfate crystals ***do not*** reappear on float charge, no action needs to be taken.

(2) If lead-sulfate crystals ***do*** reappear, the cells should be reported as an engineering complaint. Copies of the battery record should also accompany the complaint.

D. Battery Charging

4.07 ***Emergency Cell Specific Gravity and Charging (Reqt 2.07):*** If corrected specific gravity is low (see paragraphs 2.03 and 2.07), boost charge as described in paragraph 4.08.

4.08 ***Boost Charge Rate (Reqt 2.08):*** Use the following procedures when boost charging the battery.

(a) ♦***DANGER: During boost charge and for approximately 24 hours after end of boost charge, an explosive concentration of hydrogen gas exists. Therefore, to prevent an explosion, cells must NOT be handled either during the boost charge or during the 24-hour period following a boost charge.***♦ Boost charges after power failures are given where possible to the entire string for durations depending upon charging voltage as shown in Table J. Special boost charges, including those made necessary by low voltage or low specific gravity on one or a few cells, may be given to the string or to certain selected cells only. See Practice 169-621-301. ***Bring battery to full charge or nearly so before start of boost charge.*** Cells are close to full charge when the current through them at charge voltage is too low to be read on plant ammeters or when the difference between charger output and load as read on the plant ammeters has been nearly the same value for 10 minutes.

(b) Where it is necessary to ***boost charge*** only a few cells, it may be more convenient to use a single-cell charger ♦at 2.50 to 2.55 volts.♦

(c) The following action should be taken for ***boost charge*** in 50- or 52-volt, 120- or 400-ampere plants only:

(1) ***Plant in Offices Where the Maximum Allowable Voltage Is 50 Volts:*** In these plants, an equalizing or boost charge should not be applied by means of the TST-NOR-CHG key. In the event one or more cells fail to meet the voltage requirements, the cell or cells should be given a boost charge on an individual cell basis.

(2) ***Plant in Offices Where 52-Volt Operation Is Permitted:*** In these plants, operate the TST-NOR-CHG key to CHG. After charging is completed, operate the TST-NOR-

♦TABLE J♦

BATTERY BOOST CHARGE TIME

VOLTS PER CELL	TIME IN HOURS BATTERY IS ON BOOST CHARGE	
	MAXIMUM	MINIMUM
2.50	2.7	2.1
2.49	3.3	2.4
2.48	3.6	2.7
2.47	4.2	3.3
2.46	4.8	3.6
2.45	5.7	4.2
2.44	6.6	5.1
2.43	7.5	5.7
2.42	8.7	6.6
2.41	10.2	7.8
2.40	11.7	9.0
2.39	13.5	10.5
2.38	15.6	12.0
2.37	18.0	14.1
2.36	20.7	16.5
2.35	24.0	19.2
2.34	27.6	22.2
2.33	32.1	25.8
2.32*	37.2	29.7
2.31*	43.2	34.5
2.30*	49.2	39.6
2.29*	57.5	46.5
2.28*	67.2	54.0
2.27*	77.4	61.2
2.26*	90.0	72.3
2.25*	104.0	84.0
2.24*	122.0	97.0
2.23*	141.0	113.0
2.22*	162.0	132.0
2.21*	187.0	152.0
2.20*	216.0	176.0

* The lower voltage values (voltages less than 2.33), are for use with low-gravity cells only. The minimum volts per cell shall be 2.33 for high-gravity cells.

CHG key to NOR for 52-volt operation or to TST for 50-volt operation.

(3) ***Power Failure Procedure:*** No action is required. If the countercell is in the circuit, the countercell will automatically switch out of the circuit and, upon restoration of power, automatically switch into circuit when the battery reaches float voltage. In 52-volt plants only, the TST-NOR-CHG key may be operated to CHG to restore battery voltage more quickly after power failure.

(d) To give a ***boost charge*** as shown in Table J, first raise the voltage to the charge value provided for in the particular plant. This may take only a few minutes for a charged battery which has been float charged accurately or it may take an appreciable amount of time if the battery is partially discharged. After charge voltage is reached and the battery is thought to be fully charged or nearly so [see subparagraph (a)], charge for a time within the maximum and minimum shown for that voltage in Table J.

Example: At 2.20 volts per cell, the charge time shall be from 176 to 216 hours. With electrolyte temperatures above 95°F, the minimum length of boost charge is preferable while at temperatures below 65°F, the maximum is preferable. If charge voltage is greater than 2.30 volts per cell, watch the ***pilot-cell*** temperature and interrupt the charge before 110°F is exceeded, and complete later or at reduced voltage.

(e) On a boost charge of ***emergency cells*** by load, the charge may be terminated when:

(1) The length of time of charge is within the maximum and minimum shown in Table J, and the cell voltage (average of 15-minute interval readings) is within limits.

(2) The ampere-hours (average current times elapsed time) equals 100 percent of the 8-hour rated capacity of the cells.

(3) ➧***Warning: Temperatures exceeding 110°F may damage lead-acid cells.***➧ In either case, watch the temperature of the battery electrolyte and interrupt the charge, if necessary, to prevent temperatures from exceeding 110°F. Complete charge later or at a reduced rate.

E. Cell Reversal

4.09 ***Cell Reversal (Reqt 2.09):*** Cell reversal may occur when a battery plant is allowed to discharge in excess of its rated capacity. Since stationary lead-acid cells are generally designed with excessive negative plate capacity, the positive plates in a cell can undergo reversal without the cell showing an actual reversal of cell polarity. The possibility of reversing a cell(s) should be suspected whenever a battery plant is discharged below an average of 1.75 volts per cell. If any cell reads 1.0 volt or less toward the end of discharge, the positive plates of that cell have probably been reversed, and the cell may present a problem on recharge. A reversed cell typically has a high resistance because the acid specific gravity is very low, and the voltage will be extremely high if the cell is recharged at normal rates. For severely reversed cells, it is not unusual to obtain voltages in excess of 4 volts when the cell is being recharged in series with nonreversed cells at 2.17 volts per cell average. At such high voltages, cell temperature increases rapidly and irreparable damage can be caused. Consequently, reversed cells must be recharged slowly and with caution in order to avoid high temperatures.

(a) ***Identification of a Reversed Cell(s):*** ➧If a cell is suspected to be reversed, perform the following steps to identify the reversed cell(s).➧

(1) If cell reversal is suspected, measure and record the battery voltage and plant load prior to restoring the rectifiers. Also record the dates and times for the start of the battery discharge and when the rectifiers were restored.

(2) Immediately after restoring the rectifiers, measure individual cell voltages.

(3) Thereafter, measure individual cell voltages hourly for a period of 5 hours.

(4) If at any time a cell(s) reads more than 2.5 volts, that cell(s) has been reversed and corrective action is required.

(b) ***Corrective Action—Battery Plant Is a Single String and Cannot Be Disassociated From the Power Plant:*** For reversed cell(s) in a single-string battery which cannot be disassociated from the battery power plant, perform the following corrective action.

(1) Control the rectifier(s) output voltage so that the highest cell does not exceed 3.0 volts.

(2) The voltage of the highest cell(s) should begin to decrease as this cell(s) begins to accept a charge. The time required for this to occur can vary from several minutes to weeks, depending upon the degree of reversal. As the voltage of the high cell(s) gradually decreases, gradually increase the rectifier(s) output voltage (not exceeding 2.17 volts per cell) while still maintaining the high-voltage cell(s) below 3.0 volts.

(3) When all cells are reasonably uniform in voltage; i.e., all in the range of 2.07 to 2.27 volts, and the recharge current is less than 5 amperes, the string shall be given an ***equalizing charge.*** The equalizing charge shall consist of a standard measured end initial charge at 2.5 volts per cell as described in Practice 157-601-201. For this charge, stability has been reached if corrected specific gravity based on hydrometer readings at top of cell is 1.180 or higher for a low-gravity cell, or 1.270 or higher for a high-gravity cell. After this charge, the cell capacity may be even higher than before the reversal, but there may also be internal damage such as cracked plates and loosened active material. Cells that have been reversed should be watched more ***carefully*** during the remainder of their service life. The above equalizing charge will require bringing in an auxiliary string of cells so that the string to be charged can be disassociated from the working plant. If this is not possible, the equalizing charge can be performed on an individual cell basis using a single cell charger.

(c) ***Corrective Action—Battery Plant Has Parallel Strings:*** For reversed cell(s) in a parallel string battery, perform the following corrective action.

(1) If all battery strings have reversed cells, follow the procedures outlined in subparagraph (a).

(2) If all battery strings do not have reversed cells, disconnect the string(s) with reversed cells from the power plant and follow the procedures outlined in subparagraph (a).

(d) ***Contingencies for Reversed Cell(s):*** If the reversed cell(s) fails to respond to the above procedures, any of the following may be attempted.

(1) ***Shunting Around Reversed Cell(s):*** Shunt around the high-voltage cell(s) which will allow maximum recharge current to flow through the nonreversed cells. This may be done by paralleling the high-voltage cell with a suitably sized resistor or with a single cell discharge unit in order to maintain the high-voltage cell(s) between 2.0 and 3.0 volts. Once the nonreversed cells have been recharged, the shunt can be removed from the reversed cell(s) and the reversed cell(s) can then be charged with a single cell charger at 2.5 volts at the highest available current. The above shunting procedures become impractical if more than two cells have reversed in a string.

(2) ***Disconnecting Reversed Cell(s) From String:*** Disconnect the reversed cell(s) from the string and charge these individually or in parallel at 2.5 volts. Meanwhile, charge the nonreversed cells in series at 2.5 volts per cell.

(3) After Steps (1) and (2) have been successfully applied, an equalizing charge must be applied as described in subparagraph (b), Step (3).

(4) Contact the regional ♦AT&T Bell Laboratories field representative and/or the area AT&T Technologies♦ Quality Service Engineer if further assistance is required.

F. Battery Electrolyte

4.10 ***Temperature of Electrolyte (Reqt 2.10):*** Use the KS-5499, L1352, thermometer for cells of 100-ampere hours or less and the KS-5499, L1353, thermometer for cells over 100-ampere hours.

> ***Note:*** Thermometers in which the indicating liquid have separated shall not be used ♦and should be discarded.♦

(a) ***Warning: Never insert the thermometer into the electrolyte withdrawal tubes or use a mercury-filled thermometer to take temperature readings.*** To check the temperature of electrolyte, insert the thermometer into the cell through the same opening that is used for the addition of water. Completely submerge the bulb of the thermometer in the electrolyte for at least 2 minutes before the reading is taken. If there is insufficient clearance to insert the thermometer without removing the cell from the rack or cabinet, an approximation of the cell temperature may be obtained by laying the thermometer on top of the cell for at least 10 minutes before reading. However, pilot cells shall always be accessible for the insertion of the thermometer into the electrolyte.

(b) Prevent excessive temperatures by adequate ventilation, blinds on windows, heat shields between cells and radiators, etc. Where possible, electrolyte temperature of cells within the same string should be within 5°F of each other. The top row of 3-tier racks is particularly apt to have higher temperatures than the bottom row. Where necessary, use fans and other forms of ventilation to lower the temperature of the top row as nearly as possible to that of the bottom row. A pilot cell temperature reading must be taken and recorded from one cell on each tier of a 3-tier string.

4.11 *Freezing of Electrolyte (Reqt 2.11):* When there is danger of electrolyte freezing, immediate steps should be taken to provide special enclosures, insulation, or heaters as necessary.

4.12 *Water Addition and Level of Electrolyte (Reqt 2.12):* ***▶DANGER: Wear protective equipment such as rubber gloves, rubber aprons, and splash-proof goggles when performing any activity involving handling of electrolyte, cells containing electrolyte, or maintenance activities requiring exposure to shock, or electrolyte contact from these cells. The use of insulated wrenches is mandatory.*** To maintain the battery electrolyte level, proceed as follows.◀

(a) Use only distilled water, deionized water, or other water approved for storage battery use to bring electrolyte up to the required level. Maximum allowable impurities are given in Table K. ▶Electrolyte checking interval is dependent upon local conditions.◀ When the actual electrolyte temperature is below 50°F, do not raise the electrolyte level appreciably above the minimum level. This helps to prevent an overflow on charge and electrolyte creepage difficulties.

▶TABLE K◀

MAXIMUM ALLOWABLE IMPURITIES IN BATTERY WATER

TYPE OF IMPURITY	PPM OR MG/LITER (BY WEIGHT)	PERCENT
Total Solids	500	0.0500
Fixed Solids	350	0.0350
Organic and Volatile Matter	50	0.0050
Chloride	25	0.0025
Iron	4	0.0004
Nitrates and Nitrites	15	0.0015
Ammonia	5	0.0005
Manganese	0.07	0.000007

(b) ***▶Warning: Interchanging hydrometers, funnels, and other battery tools between battery types will result in contamination of the electrolyte.*** Hydrometers, funnels, and other battery tools used in lead-antimony, lead-calcium, and KS-20472 LINEAGE 2000 round cell batteries shall not be interchanged. Acid or electrolyte shall not be added to any cell as a substitute for adequate charging. Do not contaminate the electrolyte of lead-antimony cells with electrolyte from lead-calcium cells and vice versa. EXIDE lead-calcium funnels have a green or blue distinguishing band to indicate that they are of lead-calcium composition. Funnels of other manufacturers may not be so marked. Do not use these funnels interchangeably. Plastic funnels will not contaminate but must be rinsed with clean water before using to fill different types of cells. Under no circumstances shall electrolyte be disposed of in such a manner that may result in environmental pollution or damage to equipment. The electrolyte should be neutralized where the possibility of damage might occur.

(c) *Approval of Local Water:* To obtain approval for local water, have it analyzed by either a local laboratory or one of the battery companies.

(1) Each sample should be 1 quart of local water in a clean polyethylene or glass container with a nonmetallic closure.

Note: Current U.S. Post Office regulations concerning the shipment of liquid filled glass containers should be observed. The label on each sample should give the following data:

- Name of company
- Town and state
- Date sample was taken
- Source of water supply such as reservoirs fed by streams, or from wells, a local well, cistern, etc.

(2) Before a particular water source can be accepted, one sample should be taken during the wet season and one during the dry season. If either sample is not satisfactory, the water should not be used for batteries. It is necessary to have the water reanalyzed annually. Any formerly unsatisfactory water source can be reanalyzed whenever it is believed that excessive impurities are no longer present.

(3) Deionized water which meets the requirements in Table K is satisfactory for battery use. Deionizing systems should be equipped with a filter to remove sediment and with an organic removal resin to remove soluble organic materials from the water.

4.13 ***Electrolyte Level Indicator Floats (Reqt 2.13):*** Floats that do not operate properly and floats on which the paint is badly chipped should be replaced.

G. Battery Discharge Capacity Tests and Replacement Criteria

4.14 ***Discharge Capacity Tests and Replacement Criteria (Reqt. 2.14): Warning: Do not discharge emergency cells. If the electrolyte level of the cell to be discharged is at or near the high-level mark on the jar, the electrolyte may overflow on recharge.*** It is recommended that, prior to start of the test, electrolyte be removed to adjust the level approximately midway between the high- and low-level marks. The removed electrolyte can be replaced at the conclusion of the test. ♦If a cell does not seem to take or hold a charge [see subparagraph (b) of paragraph 4.02], a 5-hour discharge test to an end point of 1.75 volts per cell is the best way to determine if sufficient reserve power is available. Practices 157-601-501 through 157-601-505 deal with equipment used for discharge capacity tests. Practices 157-601-503, 157-601-504, and 157-601-505 contain operating instructions for test equipment which may be used on larger capacity cells (180 to 1680-ampere hours). Discharge tests should be run DIRECTLY OFF FLOAT WITHOUT PRIOR BOOST CHARGE. Cells to be tested shall have been on float for at least 3 months without a boost charge and where a power failure exceeding 30 minutes has not occurred within 6 weeks.♦

Note 1: The KS-20142, L1, and KS-20770, L1, and ♦L2♦ dischargers-rechargers are designed to automatically boost charge cells prior to discharge. The boost charge mode for these units must be bypassed when they are used for the discharge capacity test. See Practices 157-601-504 (LORAIN Products) and 157-601-505 (FANTRON) for instructions for bypassing boost charge when using the KS-20142, L1, discharger-recharger. See Practice 157-601-506 (LORAIN Products) when using the KS-20770, L1 ♦and L2, discharger-recharger.♦

Note 2: To ensure that the standard discharge end point of 1.75 volts is reached, discharger-recharger equipment usually will continue the discharge to a value of 1.70 volts.

Note 3: Do not boost charge cells prior to a discharge capacity test.

(a) ♦***Discharge Capacity Test Procedure:*** To perform discharge capacity test to determine if replacement is indicated, proceed as follows.♦

(1) Refer to Table A , as applicable, for the 5-hour discharge rate of the cells to be tested. See Fig. 7 or 8 for suggested record form. ♦If a discharge capacity test is to be performed on a KS-5562, L04, L05, L06, or L07 tank cell, contact the Power Maintenance Engineer for requirements and procedures to make a complete battery string discharge capacity test.♦

(2) Just prior to the single-cell discharge capacity test, record the following for the cell under test:

- ♦String Voltage♦
- Cell float voltage
- Electrolyte temperature
- Corrected specific gravity.

(3) Record the time (in minutes) required to discharge the cell at the 5-hour rate to an end point of both 1.90 and 1.75 volts. Refer to Fig. 7 or 8 for suggested data collection sheet.

Note: One cell at a time may be discharged without disconnecting the cell from the string, changing control equipment, or interfering with service. Observe admonishments and precautions in paragraph 4.15 when making battery connections.

(4) Determine percent of 5-hour rated capacity at 77°F by multiplying the recorded discharge time to 1.75 volts by the correction factor K [see Fig. 9—use the temperature recorded in Step (2)] per the following formula:

Percent of 5-hour rated capacity at 77°F = discharge time (minutes) X K ÷ 300.

Example: Assume electrolyte temperature of 60°F at the start of discharge and 259 minutes of discharge to 1.75 volts. From Fig. 9; K (the correction factor) equals approximately 110 at 60°F. Therefore, percent of 5-hour rated capacity equals 259 ÷ 300 X 110 = 95.

(5) ***Recharge*** or ***boost charge*** cells in accordance with paragraph 4.08 as soon as possible after discharge. The dischargers-rechargers covered in Practices 157-601-504, 157-601-505, and 157-601-506 automatically recharge the cell after discharge. See Practice 169-621-301 for cell recharge after discharge. Continue with subparagraph (b).

(6) Connect ***two*** automatic dischargers-rechargers in parallel to the L04, L05, L06, or L07 cell, one unit to each set of positive and negative terminals.

Note: This procedure allows the tank cell to be discharged at 600 amperes (2 X 300 amperes). The capacity results can be compared to the expected reserve of the KS-5562 tank cell to 1.75 volts per Table I.

(7) After the single-cell discharge capacity test, record the following for the cell under test. See Fig. 7 or 8 for suggested record form.

- ♦String Voltage♦
- Cell float voltage
- Electrolyte temperature
- Corrected specific gravity.

(8) Record the time (in minutes) required to discharge the KS-5562 tank cell at the Table I rate to an end point of both 1.90 and 1.75 volts. Refer to ♦Fig. 7 and 8 ♦ for suggested data collection sheet.

Note: One cell at a time may be discharged without disconnecting the cell from the string, changing control equipment, or interfering with service. Observe admonishments and precautions in paragraph 4.15 when making battery connections.

(9) Determine percent of Table I KS-5562 tank cell rated capacity at 77°F by multiplying the recorded discharge time to 1.75 volts by the correction factor K [see Fig. 9—use temperature recorded in Step (2)] per the following formula:

Percent of 14-hour rated capacity at 77°F = discharge time (minutes) X K ÷ M.

Example: For an KS-5562, L07, tank cell assume electrolyte temperature of 60°F at the

5-HOUR RATE BATTERY DISCHARGE CAPACITY TEST RECORD FORM

OFFICE ________ DIV. ________ POWER PLANT CODE________ TESTER________ DATE________

BATTERY DATA:

K.S. NO.	LIST NO.	MFG. NAME	TYPE BATT.	CASE MTL. RUB – PLASTIC	AGE		VOLTAGE & GROUP	NO. CELLS REG. + EMG.	TYPE OF DISCHARGER
			LEAD		YRS.	MOS.			

CELL SAMPLE
(EXCLUDE PILOT CELLS)

INDIVIDUAL CELL NO. TESTED	DATE CELL WAS TESTED	SPEC. GRAV. BEFORE START OF TEST	CELL VOLTAGE BEFORE START OF TEST	CELL TEMP. BEFORE START OF TEST	TIME TO 190V – MINS.	TIME TO 175V – MINS.	5 HOUR RATE – % (TEMP. CORR.)

GENERAL CONDITIONS NOTES ________

APPROVAL ________

Fig. 7—Suggested 5-Hour Rate Battery Discharge Capacity Test Record Form

SINGLE-CELL DISCHARGE CAPACITY RECORD

P 528 (3-70)

NAME OF BATTERY MANUFACTURER	DATE BATTERY MANUFACTURED (YEAR)	DATE BATTERY INSTALLED (YEAR)	KS AND LIST NUMBER	STRING NUMBER AND NUMBER OF CELLS	CODE OF PLANT AND VOLTAGE	NUMBER OF CELL DISCHARGED	TEMPERATURE OF CELL	CORRECTED SPECIFIC GRAVITY	MAXIMUM COVER RISE	MAXIMUM JAR BULGE	PLATE GROWTH	STRAP GROWTH	CRAZES	CRACKS	POSITIVE POST CORROSION	NEGATIVE POST CORROSION	DISCHARGE TIME IN MINUTES FROM START TO:						DATE TESTED			PER CENT CAPACITY OF CELL (TOTAL DISCHARGE MIN. ÷ 3)	RECHARGE TIME-TOTAL AMPERE-HOURS
																	1.90V	1.86V	1.84V	1.82V	1.80V	1.75V	MONTH	DAY	YEAR		

REMARKS:

OFFICE	PARCEL NUMBER	DIVISION	
CITY		NAME	SUPV. TITLE
DISTRICT		DATE	

Fig. 8—Suggested Single-Cell Discharge Capacity Record Form

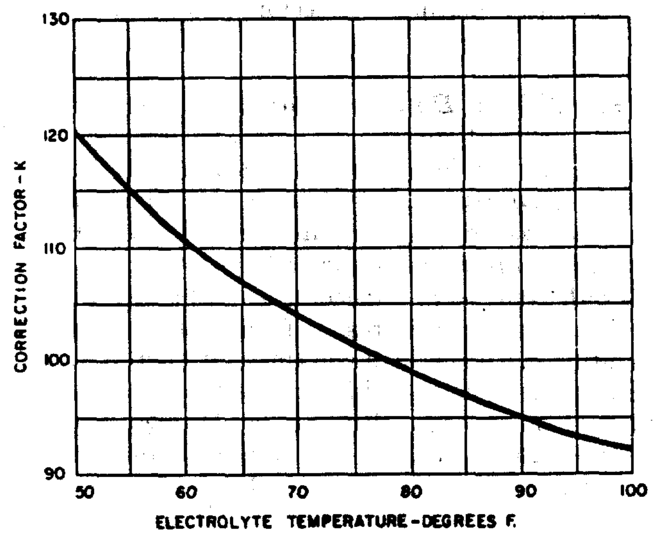


Fig. 9—Correcting Capacity for Temperature (Based on 5-Hour Discharge Rate)

start of discharge and 725 minutes of discharge to 1.75 volts. From Fig. 9; K (the correction factor) equals approximately 110 at 60°F. Therefore, percent of 13-hour rated capacity equals 725 ÷ 780 X 110 = 102.5.

Note: The temperature correction factor (K) from Fig. 9 is to be used.

(10) Recharge or boost charge cells in accordance with paragraph 4.08 as soon as possible after discharge. The dischargers-rechargers covered in Practices 157-601-504, 157-601-505, and 157-601-506 automatically recharge the cell after discharge.

(b) ♦***Cell Replacement Criteria:*** The following outlines the criteria and procedure for replacement of failed cells.♦

Note: In general, cells are considered to have capacity failed if the capacity test gives less than 75 percent of rated capacity.

Refer to Practice 157-601-201 for installation procedures when replacing cells or batteries.

H. Battery Connections and General Maintenance

4.15 ***Battery Connections and Use of NO-OX-ID A (Reqt 2.15): ♦DANGER: Observe the admonishments and precautions in this paragraph before loosening or removing battery connections while cells are gassing or discharging as sparks may occur and a potential fire hazard exists.*** To connect or disconnect battery connections, proceed as follows.♦

(a) ***Connecting or Disconnecting Battery Connections: ♦Caution: Overtighting of the intercell connectors could strip the bolt and/or nut threads resulting in loose connections.♦*** When opening or replacing connections on battery cells with only two terminals, it is recommended that a procedure be employed similar to that illustrated by Fig. 10 in which a temporary switch is connected from terminal to terminal across the intercell connector which is to be removed. The main purpose of the switch connection is to eliminate a potential arcing hazard. A secondary purpose of the switch is to prevent possible loss of service in case power fails while the intercell connector is disconnected. The switch is to be closed before opening or replacing the battery connections. The size of the switch strap and temporary wiring must be sufficient to carry the load under power failure conditions.

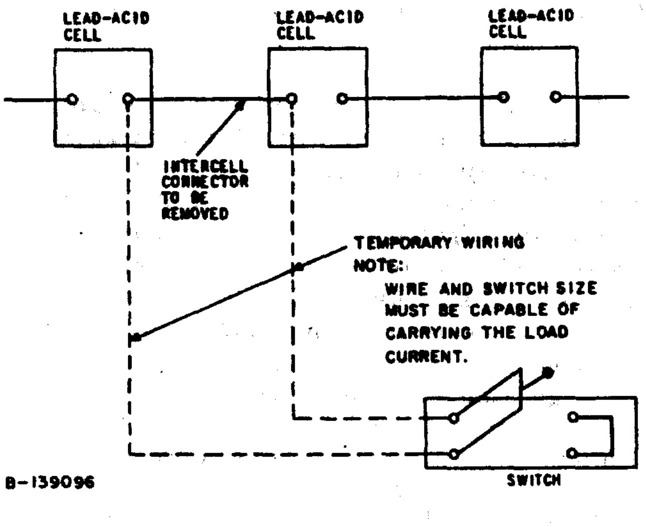


Fig. 10—Typical Temporary Switch Connected to Remove Arc Hazard

(b) ▶*Caution: It is recommended that the temporary knife switch be used, and that the switch contacts be kept closed at all times while working on single-string battery plants. This procedure is recommended even when parallel intercell connectors are used to guard against possible broken posts, connection corrosion, or loose connections on the mate (parallel) intercell connector and posts. Use of the switch is mandatory in all plants powering office equipment which may be adversely affected by rectifier noise or transients which are likely to be present when the battery is not solidly connected as a filter across the rectifier.* The switch illustrated in Fig. 10 is not absolutely required with cells having four terminals. On batteries with four terminals, remove the connector(s) from one terminal at a time, without loosening the parallel connectors on the other terminal. Clean and replace the connector(s) on one terminal before proceeding to the parallel terminal. If it is necessary to break all connectors to a 4-terminal cell simultaneously, the use of a temporary switch is mandatory.◀

(c) ***General Maintenance:*** If a connection appears corroded or damaged (see Practice 157-601-702), open the connection after first observing the admonishments and precautions in subparagraphs (a) and (b), and clean the corroded posts, intercell connector, contact surfaces, and terminal details using a cloth dampened in a ***strong soda solution*** followed by wiping with a cloth dampened in clear water.

(d) *DANGER: Keep the temporary switch closed at all times while working on a connector. Always use insulated tools. Do not allow neutralizing solutions to enter the cell. Sandpaper, stiff wire brushes, or other abrasive tools should not be used on intercell connectors or fastening hardware as this will remove the protective lead coating.* The four sides of each terminal post should be sandpapered to a bright finish without abrading the intercell connectors or the fastening hardware and coated with NO-OX-ID A compound. The ***contact*** areas of intercell connectors and terminal details from which corrosion has been removed should be cleaned by wiping or brushing with a soft brush and then coated with a thin coating of NO-OX-ID A compound. If copper surface on connector shows through lead plating, connector should be replaced.

(e) ▶*DANGER: Do not use an open flame or direct heat on the can of NO-OX-ID A compound. Avoid bodily contact with the hot liquid. Sandpaper, stiff wire brushes, or other abrasive tools should not be used on intercell connectors or fastening hardware as this will remove the protective lead coating.*◀ Clean and remove corrosion from the terminal mounting bolt holes of the battery terminal posts using a round, nonmetallic, bristle brush similar to a baby nipple brush (brush to be obtained locally). Dip the brush in a ***strong soda solution*** [See subparagraph (a) of paragraph 1.12], bump excess solution from the brush, and scrub bolt holes thoroughly, being careful to avoid contact with the adjacent cell connector. Rinse solution from brush in clear water, scrub any soda solution from the bolt holes; again, exercise care to avoid contact with the adjacent cell connector. Wipe the bolt hole with a clean lint-free cloth and apply a light coating of NO-OX-ID A compound to the entire inside of the cleaned bolt hole.

> ***Note 1:*** The NO-OX-ID A compound can be heated by placing the can of compound in hot water of 160°F or more. Heat the compound until it can be easily applied with a brush.

> ***Note 2:*** The NO-OX-ID A compound is now supplied in tube containers which greatly improves application and is normally applied at room temperature. If using compound supplied in the old containers, ***the DANGER and Note 1 still apply.***

> ***Note 3:*** An open flame or direct heat should ***not*** be applied to the container of NO-OX-ID A compound.

> ▶***Note 4:*** Neutralizing solution shall ***not*** be allowed to enter the cell, as this would weaken the electrolyte.◀

(f) If a temporary switch was used, open the switch only after reconnecting the intercell connector; then remove the switch and wiring. If a temporary switch was not used, close the opened connections. Tighten all connections securely and wipe off excess compound. ▶Two insulated wrenches◀ should always be used to tighten a connection in order to avoid the possible breakage of the lead posts or damage to nuts, and to insure a tight connection.

(g) ***Electrolyte Creepage:*** Green or blue copper-sulfate on a part, usually an intercell connector or a terminal detail, indicates that electrolyte has penetrated its lead coating and is reacting with the copper. Any such part, other than a post, should be replaced and all associated surfaces treated in accordance with subparagraphs (a), (b), (c), (d), (e), and (f). Cracked seal nuts should be replaced as recommended in Practice 157-621-801.

4.16 ***Containers and Covers (Reqt 2.16):*** ▶Cell containers and covers should be kept clean, and efforts should be made to prevent damage of containers. Use the following outline for care and maintenance of containers.◀

(a) Replace cells having cracked or leaking containers. Such cells present a fire hazard. Cells should be replaced by like cells (see Practice 157-601-101). See Practice 157-601-201 for allowable limits on scratches at installation. Refer to Practice 157-601-703 and PEL 7367 for more detailed information and photographs on container and cover cracks. See paragraph 4.17 for instructions on temporarily sealing cracks in plastic jars with acid-resistant tape.

(b) Sprayed or dripped electrolyte on containers or covers should be neutralized with a weak soda solution followed by a plain water rinse.

(c) ▶***Warning: Plastic battery containers can be damaged by cleaning with solvents or petroleum based cleaners.***◀ Do not expose or clean plastic containers with petrolatum or solvents such as kerosene, gasoline, or petroleum spirits which is the solvent in most cleaning compounds as well as the thinner in most waxes and polishes. Petroleum spirits and solvents seek out points of residual stress, causing cracks, crazing, and eventual failure. Do not use commercial detergents such as IGEPAL CO-630 on plastic jars as this can lead to crazing or cracking of the jars. A mild soap may be used. (See paragraph 4.17.)

(d) Discolored rubber containers may be refinished by washing with a weak soda solution, followed by a water rinse.

4.17 ***Use of Tape to Temporarily Seal Plastic Jar Cracks (Req t 2.17):*** ▶Plastic battery containers can ***temporarily*** be repaired until the cell(s) are replaced. The container surface should be cleaned and neutralized before the temporary repair is made. An acid-resistant tape is recommended to temporarily seal cracks in plastic battery jars until the cells can be replaced. Minnesota Mining and Manufacturing Company Tape No. 472 has been approved for this purpose. Use the following procedures when temporarily sealing plastic jar cracks.◀

(1) Cover open cracks temporarily with a narrow strip of ▶acid-resistant◀ tape prior to cleaning to eliminate accidental contamination of the electrolyte by cleaning or neutralizing solutions.

(2) Wipe the surface carefully with soft, clean absorbent materials, such as ▶SCOTT paper wiper,◀ No. 590, to remove any accumulations of grease or other foreign materials. Care must be taken not to spread any greasy material over the surface to be coated.

(3) Clean the surface carefully, using a clean material, such as ▶SCOTT paper wiper, No. 590, dampened with a mild soap solution. The soap solution should contain 1 to 5 percent soap by volume. Immediately wipe dry with a SCOTT paper wiper, No. 590, to remove excess soap. Only the following mild soaps should be used for this purpose.

- DOVE dish washing liquid
- IVORY LIQUID dish washing liquid
- JOY dish washing liquid
- LUX dish washing liquid
- PALMOLIVE dish washing liquid.

(4) Rinse with SCOTT paper wiper, No. 590, dampened with tap water and dry with SCOTT paper wiper, No 590.◀

(5) Repeat Step (4) using distilled water or approved water of the type used for battery makeup, until all evidence (foaming) of residual soap has disappeared.

(6) Neutralize with a weak soda solution as specified in subparagraph (a) of paragraph 1.12.

(7) Rinse and dry as in Step (4) using distilled water or the available battery makeup water.

(8) Remove protection strip applied in Step (1).

(9) After cutting ▶acid-resistant◀ tape to appropriate size, allowing a small portion of each end for handling so as to prevent finger contact with the adhesive, apply tape to the cracked area assuring that the tape extends beyond the crack in all directions with a minimum overlap of 1/2 inch. A backup piece of tape for extra support can be used to cover the initial piece, especially where compound angles demand tape stretching.

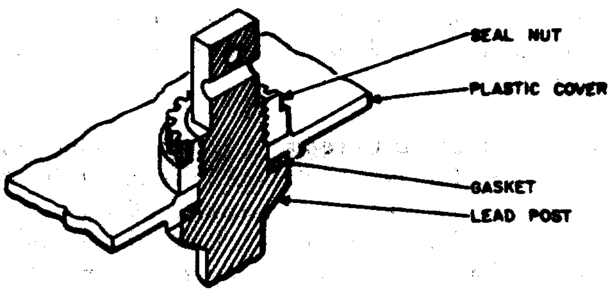
4.18 *Seals (Reqt 2.18):* ▶Cell seals are important to prevent the leakage of electrolyte and the escape of gasses. See Fig. 11 for post seal illustrations for each vender. The following outlines the procedure for cleaning, inspecting, and repairing cell seals.◀

(a) Covers of enclosed cells should be neutralized with a ***soda*** solution [see subparagraph (a) of paragraph 1.12.] Neutralization should be preceded and followed by wiping with a damp cloth.

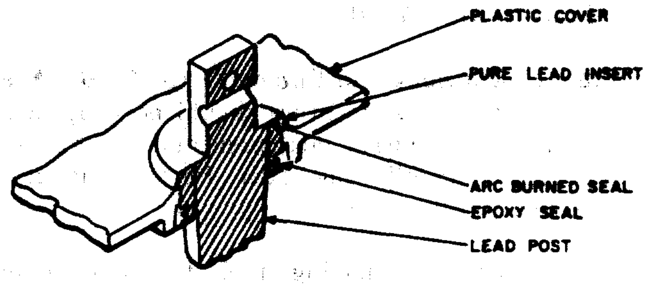
Note: Electrolyte on the top of some cells may be due to the absence of spray caps rather than to a defective seal.

(b) ***DANGER: Leaky cover seals can present a fire hazard. (See Practice 157-601-703.)*** Minor defects in the cover seal of hard rubber cell containers can sometimes be corrected by using a hot soldering copper ***(do not use an open flame)*** to soften and reform the sealing compound at the leak. Larger defects require that the old compound be scraped away at the point of leakage, and the scraped area washed with water. Heat-softened compound can then be added and worked into the crevice with a putty knife or similar tool.

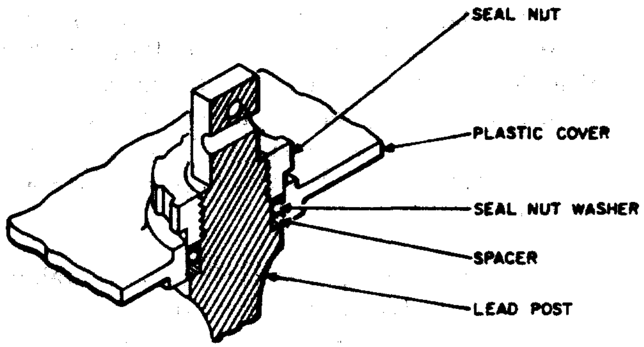
(c) Cover seals suspected of leaking should be clean and neutralized per the instructions contained in paragraph 1.12 and then checked closely for signs of electrolyte seepage for a period of 4 weeks. At the end of the 4-week observation period, recheck the seal(s) for signs of electrolyte seepage. If there are no signs of seepage, no further action is necessary. If, however, there are signs of seepage, reclean the seal(s) as stated above and proceed as follows:



TYPE 1 (EXIDE)



TYPE 2 (C & D)



TYPE (GOULD)

Fig. 11—Battery Post Seals (Typical)

(1) Using the ▶KS-22861, L1, digital multimeter, set to 2 volts dc scale, place one probe of the digital multimeter◀ on the positive post of the cell being checked while probing the jar-to-cover seal area at the gap between the jar and the cover with the other probe. Any voltage reading indicates a jar-to-cover seal leak.

(2) When a jar-to-cover leak is detected, using the ▶millivolt drop◀ technique, an Engineering Complaint should be originated and forwarded to the area Quality Service Engineer.

Note: Field repairs shall not be attempted on plastic covers. The area Quality Service Engineer should be contacted to determine if repair is possible.

(d) Post seals suspected of leaking should be cleaned and neutralized per the instructions contained in paragraph 1.12 and then checked closely for signs of electrolyte seepage for a period of 4 weeks. At the end of the 4-week observation period, recheck the seal(s) for signs of electrolyte seepage. If there are no signs of seepage, no further action is necessary. If, however, there are signs of seepage, reclean the seal(s) as stated above and proceed as follows.

- **Checking Positive Post Seal:** Using the ▶KS-22861, L1, digital multimeter, set to the 3 volts dc scale, hold the negative probe of the KS-22861, L1, digital multimeter◀ on the negative post of the cell being checked. The positive probe is used to check the positive post seal. Any voltage reading indicates a post seal leak.
- **Checking Negative Post Seals:** Using the ▶KS-22861, L1, digital multimeter,◀ set to the 3 volts dc scale, hold the positive probe of the ▶KS-22861, L1, digital multimeter◀ on the positive post of the cell being checked. The negative probe is used to check the negative post seal. Any voltage reading indicates a post seal leak.

Note: GOULD and EXIDE cells use plastic post seal nuts around terminal posts to produce a post seal. When checking for post seal leaks on batteries manufactured by these vendors, the probe checking the seal shall be moved along the junction of the post seal nut and the jar cover. C&D cells use a lead insert around terminal post to effect a post seal. When testing for post seal leaks on these cells, care must be exercised to avoid touching the lead insert with the probe, the probe should be moved around the post seal area just below the junction of the lead insert and jar cover. If the probe touches the lead insert, a voltage reading will be obtained. ▶See Fig. 11 for post seal illustrations for each vendor.◀

4.19 *Spacing Between Containers (Reqt 2.19):* Cells or batteries should be checked for spacing at initial installation (see Practice 157-601-201) and rechecked in event of earthquakes or other severe shocks. Spacers of nonporous, nonconducting material (rubber or plastic) can be placed between adjacent cells and between the cells and the steel rack or uprights so as to limit battery movement to a safe amount and thus prevent the possibility of fire by shorting between cells or to ground. Cells must be kept from touching each other and from touching the framework. Spacers must be free of electrolyte. See Practice 157-601-703 for measuring tank cell bulge.

4.20 *Flame-Arrestor Features (Reqt 2.20):* ***DANGER: Do not allow gas vents to become clogged as explosion due to internal pressure may result.*** Flame-arrestor features, which include ceramic vents and domes and plastic vents, should ***not*** be painted, varnished, or greased and should be free of dirt. If the flame-arrestor features become clogged, the electrolyte may overflow through the filling funnel or electrolyte withdrawal tubes (if so equipped). Vents of the bayonet type or screw type can be removed by turning counterclockwise. Neutralize vents in a ***weak soda solution*** [see subparagraph (a) of paragraph 1.12] and clean with water and brush if they become clogged. For ceramic vents which are cemented to the cell cover, the area Quality Service Engineer should be contacted to arrange removal of these vents.

4.21 *Spray Caps and Vent Holes (Reqt 2.21):* Small cells not having ceramic vents are equipped with spray caps for vents. If filling funnels are supplied for cells with spray caps, the spray caps should be removed to permit mounting of the funnels and then relocated in the top of the filling funnels.

4.22 *Battery Racks, Stands, Cabinets, and Miscellaneous Equipment (Reqt 2.22):* ***DANGER: When using a wire brush to remove corrosion, do NOT allow the wire brush to be brought in close proximity to cell terminals and intercell connectors.*** Battery racks, stands, cabinets, etc., should be wiped at regular intervals with a cloth dampened in a ***weak soda solution*** [see subparagraph (a) of paragraph 1.12] and then with a cloth dampened in water. Paint on bolts, woodwork, cable, conduit, and bus bars should be in good condition. Corrosion should be removed with a wire brush. The area should then be wiped with a cloth dampened with a weak soda solution followed by a cloth dampened with water. Dry with a clean cloth before repainting. The wire brush may also be used to remove old paint prior to repainting. Since corrosion may be due to battery leakage, all cells near such corrosion should be inspected for electrolyte leakage. Refer to Practice 157-601-703 for method of detecting electrolyte leakage using a voltmeter. Battery racks and stands shall be grounded in accordance with Practice 802-001-193. For more detailed information on battery stands in various types of power plants, refer to Practices 802-125-150 through 802-125-152 and 802-126-150 through 802-126-154.