STORAGE BATTERY

LEAD-ACID TYPE

REQUIREMENTS AND PROCEDURES

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1. GENERAL

1.01 This section covers the apparatus requirements and adjusting procedures common to all lead-acid cells used in telephone power plants. The requirements and procedures in this section also apply generally to lead-acid batteries used for engine-starting applications.

1.02 Since this reissue is a general revision, arrows ordinarily used to indicate changes have been omitted. This section has been expanded to include much data formerly contained in other battery sections but which is more relevant to the ***Requirements*** and ***Procedures*** of this section. Some irrelevant or obsolete data has been deleted. An expanded Table of Contents has been added to enable ready reference to specific subjects. Major changes in this reissue are listed as follows:

(1) "Hardened Site" battery information has been added.

(2) Table A has been added showing grid material type (lead-antimony or lead-calcium) and nominal specific gravities (low or high) for major battery types.

(3) Manufacturer's new identification data and new serial numbering method has been explained.

(4) Table B, showing anticipated cell life, has been expanded and brought up to date.

(5) First aid information for electrolyte splashed into eyes has been added.

(6) Cell replacement criteria, based on Discharge Capacity Tests, has been added together with the procedure for performing the Discharge Capacity Tests. A table has also been added to facilitate determination of cells to be replaced due to low capacity.

(7) Float voltage readings and intervals have been revised.

(8) Floating ball charge indicator information is added.

(9) Emergency cell specific gravity reading and charging data has been added.

(10) Boost charge interval requirements have been changed to a "trouble-test" basis. A table showing boost charge durations per different charge voltages has been added.

(11) Cell reversal information has been added.

(12) Information on use of NO-OX-ID A compound and avoidance of harmful cleaning agents has been added.

(13) Fire hazard cautions have been added in the appropriate areas.

(14) Use of tape to temporarily seal plastic jar cracks has been added.

(15) Information on spacing between containers has been added.

(16) A table has been added showing freezing temperatures of electrolyte.

(17) A table has been added showing reading and work intervals together with voltage and specific gravity requirements.

(18) A diagram has been added showing how to temporarily connect a switch to remove arcing hazard when opening or replacing battery connections.

(19) Approval of deionized water for addition to electrolyte is added and the frequency for having tap water analyzed has been increased.

This reissue affects the Equipment Test List.

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

1.04 ***Hardened Site and Other KS-spec Batteries***

(a) See Tables H, I, and J for listings of KS-specifications, 5- and 8-hour discharge rates, finish rates, and specific gravity range for cells of the principal manufacturers.

(b) Two KS-numbered ***hardened site cells*** are available. The cells are reinforced ("hardened") to enable them to better withstand the shocks of earthquakes or nuclear blasts. They are both manufactured by Gould National (see Tables A, B, E, and I). These cells are:

(1) ***KS-20048 L1:*** 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 and is constrained in such a manner as to be shock resistant. The cell has a capacity rating of 6000 ampere hours at the 5-hour rate (7000 ampere hours at the 8-hour rate) which is identical to the Gould KS-5562 L07 cell.

(2) ***The KS-20106 L101*** is a hardened KS-15544 L501, while the ***KS-20106 L108*** is a hardened KS-15544 L508. 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 means for mounting it to the battery rack.

(c) For lead-acid engine starting and control battery types, refer to Section 157-633-101.

1.05 ***Grid material and nominal specific gravity*** of KS-coded lead-acid cells used in central offices and PBX installations are shown in Table A. Unless otherwise specified, all requirements and recommended procedures for lead-antimony cells shall also apply to lead-calcium cells.

TABLE A — GRID MATERIAL AND NOMINAL SPECIFIC GRAVITY FOR KS-CODED LEAD-ACID CELLS

CODE OF CELL	TYPE OF GRID MATERIAL		NOMINAL SPECIFIC GRAVITY	
	LEAD-ANTIMONY	LEAD-CALCIUM	1.210	1.300
KS-5269-01	X		X	
KS-5361				
L100-L151E,	X		X	
L151H, 151HD,	X			X
and 151HE				
KS-5538	X		X	
KS-5553	X		X	
KS-5553-01		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	X		X	
KS-20106				
L101 and L108		X	X	

1.06 ***Manufacturer's Identification and Serial Numbering:*** The manufacturer's identification identifies the factory where a cell is manufactured by a letter or number stamped on one of the terminal posts, usually the negative. This form of identification is being replaced by serial numbering. Both the factory location and date of manufacture should be mentioned on records and correspondence. Serial numbering indicates both factory location and date of manufacture.

(a) ***Manufacturer's New Identification:***

(1) Gould Cells—D designates Depew factory; T, Trenton; and K, Kankakee.

(2) C&D Cells—C designates Conshohocken; A, Attica; W (West Coast); Santa Rosa; and J, Conyers, Ga.

(3) Exide Cells—1 designates Philadelphia; 9, Chicago; and 25, San Francisco.

(b) ***New Serial Numbering:***

(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 battery. The entire serial number may be on one line or may be separated after the date portion. The five-digit portion is usually recycled every month.

Example:

6601 = 1966 January

40024 = Battery No. 40024 for that month or 660140024

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

Gould	00001 through 20000
C & D	20001 through 40000
Exide	40001 through 60000
Globe Union	60001 through 80000

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 voltage values (see Table C and Section 157-601-301).

(b) Maintain electrolyte level between max. and min. by the addition of approved water.

(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 (see Section 157-601-703) and insure proper spacing between batteries.

(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 B shows the anticipated life in years of lead-acid cells maintained in accordance with this section. These figures are based on best available data but are given for planning purposes only. These figures are not to be construed as providing any guarantee that the anticipated life will be reached.

1.09 ***Electrolyte Corrosion and Bodily Protection***

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

(b) ***Protection:*** Rubber gloves will protect the hands from electrolyte when working with lead-acid batteries.

Warning: Wear protective equipment such as rubber golves, rubber aprons, and coverall goggles when handling electrolyte and cells containing electrolyte.

1.10 ***First Aid for Electrolyte in Eyes or on Skin:*** Remove electrolyte splashed on the skin or in the eyes immediately by flushing the

TABLE B — ANTICIPATED LIFE ON FLOAT AT 77°F

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

affected area with large amounts or plain tap water. In case of electrolyte in the eye, pour water into the inner corner of the eye and allow at least one quart of water to run over the eye and under the eyelid. A drinking fountain near at hand may be utilized for this purpose. Eye injuries should be placed under the treatment of a physician, preferably an eye specialist, as soon as possible.

1.11 ***Neutralizing Agents***

(a) ***Soda solutions*** are used for general neutralization of electrolyte. A ***strong soda solution,*** used primarily to neutralize spilling or dripping of electrolyte, is made by combining either 2 pounds of table soda (bicarbonate), or 1 pound of washing soda with one gallon of water. An equally acceptable strong neutralizing solution may be made by mixing 1/2 pound of Bell System pyrophosphate cleaner in 1 gallon of water (see Section 157-601-702). One gallon of strong soda solution should neutralize approximately 3/4 pint of low specific gravity electrolyte or 1/2 pint of high specific gravity electrolyte. A ***weak soda solution*** for neutralizing traces of electrolyte should be 1/8 the strength of the strong solution. After using a soda solution, always wipe the neutralized surface with a cloth dampened in clean water.

Note: Pyrophosphate cleaner does not bubble when it contacts electrolyte.

(b) A ***household ammonia solution*** consisting of 1 part ammonia to 2 parts water, should be used for neutralizing electrolyte on clothing since this solution will not cause fabric spotting as readily as a soda solution. Use caution when opening ammonia bottles because pressure tends to build within them, and 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 3.14.

1.12 ***Explosion and Fire Prevention:*** (See "Gas Explosion Hazard" in Section 157-601-101.)

(a) Take precautions against static sparks at all times and especially while taking hydrometer or thermometer readings or when installing new vents of any type in cells in service. These precautions should be observed when working on cells with or without antiexplosion features (see 2.17 and 3.17) because of the possibility of cover seal leaks, post seal leaks or containers which would by-pass the antiexplosion feature (see Section 157-601-703). To discharge static electricity from body, touch any grounded rack or frame. Remove plugs, if any, and allow the cell to stand for 2 or 3 minutes. Again ground self before inserting the hydrometer or thermometer into cell. In offices 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.

(b) Do not loosen or remove battery connections while cells are gassing or discharging except as specified in (c) and in 3.12(a).

(c) If an enclosed cell does not have an antiexplosion feature or the antiexplosion feature is temporarily inoperative (see 3.17) and if it is necessary to open the circuit at the battery without the disconnect switch described in 3.12(a), observe the following precautions.

(1) Provide maximum ventilation.

(2) Use an insulated tool which will not draw arcs or sparks. Follow procedure in 3.12(a) when opening or closing connections.

(3) Allow the cell to stand at least 1/2 hour on open circuit or, as a second choice, on float voltage. If the cell has vent plugs, remove them.

(4) Cover the aisle side and the space between cells in the same row with several layers of wet cloth.

(d) Leakage of electrolyte should not be allowed, especially where such leakage might form a low resistance arc path to ground or between different potentials.

(e) Electrolyte level should not be allowed to fall below minimum as this promotes gassing.

(f) The positive (+) and negative (−) ends of battery strings shall not be adjacent (see Section 157-601-201).

***Caution 1:* 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.**

***Caution 2:* Do not allow gas 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.**

2. REQUIREMENTS

2.01 ***Battery Records and Readings (Proc 3.01)***

(a) Maintain complete battery records for each string within an office. 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 readings for a battery, including all readings within a string, should be taken by the same person using the same instruments. All meters shall be calibrated by using the same voltage standard.

2.02 ***Float Voltage Readings (Proc 3.02):*** See Table C for both the individual cell and the battery float voltage requirements and for allowable intervals between readings. Refer to Section 157-601-301 for special float voltage conditions. 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 3.02.

Note 1: 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.

Note 2: For special instructions on float voltage and voltage readings where the voltage does not remain constant, refer to Section 157-601-301.

(c) Calibrate power panel voltmeter in accordance with the appropriate Bell System Practice. Set voltmeter having external adjuster as accurately as possible at or near float voltage. The head of the adjusting screw may be covered with tape to avoid accidental and unauthorized changes. Inking of adjustment date on the tape is suggested. On voltmeters having no external adjuster, mark or tag the instrument or prominently note in office records, the correction to be applied to the readings and the date of calibration.

TABLE C — READING AND WORK INTERVALS — VOLTAGE AND SPECIFIC GRAVITY REQUIREMENT CHART

MAXIMUM INTERVAL	DESCRIPTION OF OPERATION	LOW-GRAVITY CELLS, LIMITS	HIGH-GRAVITY CELLS, LIMITS	REFERENCE INFORMATION
Week	Pilot-cell and emergency cell float voltage reading	$2.17^{+0.05}_{-0.04}$ volts/cell	Lead-calcium — 2.30 ±0.05 volts/cell Lead-antimony — 2.25 ±0.05 volts/cell	Par. 3.02 Section 157-601-301
Week	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	Par. 3.02 Section 157-601-301
Week	Emergency cell specific gravity	(See par. 2.04 and 3.04)	—	Par. 2.04 & 3.04
1-1/2 Months	Pilot-cell specific gravity reading (corrected)	$1.210^{+0.015}_{-0.030}$	$1.300^{+0.015}_{-0.025}$	Par. 2.03
3 Months	Individual cell voltage readings	$2.17^{+0.05}_{-0.04}$ volts/cell	Lead-calcium 2.30 ±0.05 volts/cell Lead-antimony 2.25 ± 0.05V	Par. 2.02 & 3.03
3 Months	Clean and inspect	—	—	Par. 2.10 & 2.12 thru 2.17 Section 157-601-703
6 Months	Individual cell specific gravity readings (corrected) & electrolyte level	$1.210^{+0.015}_{-0.030}$	$1.300^{+0.015}_{-0.025}$	Par. 2.03 & 3.03
Year	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 ±0.01V	Section 157-601-301

2.03 ***Specific Gravity, Reference Temperature, and Floating Ball Charge Indicators (Proc. 3.03):*** The ***specific gravity*** of low-gravity and high-gravity cells at electrolyte temperature of 77°F shall be:

(a) For low-gravity cells—1.210±0.015

(b) For high-gravity cells—1.300±0.015

Specific gravity readings shall be taken 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 C for allowable intervals between specific gravity readings of standard, pilot, and emergency cells.

2.04 ***Emergency Cell Specific Gravity and Charging (Proc. 3.04):*** Emergency cell specific gravity shall fall no lower than 8 to 14 percent of the gravity range (see Table H, I, or J as applicable) below the fully charged specific gravity.

> ***Caution: Watch the first group of emergency cells carefully. A series of emergency discharges may discharge the group much more than the main battery or the second group of emergency cells, making cell reversal a possibility (see 2.06).***

2.05 ***Boost Charge and Finish Rate (Proc. 3.05):*** 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 Tables H, I, and J, for specific gravity ranges and finish rates of lead-acid cells. Be sure low specific gravity is due to discharge and not to recent addition of water. Pilot-cell specific gravity readings should be taken to determine extent of emergency discharge when the length of the emergency discharge is unknown. Boost charge accelerates return to a full charge condition. In plants were boost charge facilities or capabilities are not available, full charge will eventually return to a discharged battery on normal float at a slower rate than with boost charging (see Fig. 2 in Section 157-601-101).

2.06 ***Cell Reversal (Proc. 3.06):*** If one or more cells in series become fully discharged while the remainder of the cells are still discharging, there will be a reversal, that is, change of polarity on the discharged cells with adverse effect on the plates, if repeated several times.

2.07 ***Temperature of Electrolyte (Proc. 3.07):*** Except on initial charge (see Section 157-601-201), the temperature of the electrolyte in any cell shall not exceed 110°F at any time. The recommended operating range is 65 to 80°F. If operated at electrolyte temperature above 90°F for over 2 months per year, battery life expectancy must be reduced by 20 percent. Continuous operation above 80°F reduces life by 50 percent for each 15 degrees above 80°F. Electrolyte temperatures from 65°F down to freezing are objectionable only because of lowered battery capacity. For effect of temperature on specific gravity, see 3.03(b); and for effect on capacity and voltage, see Section 157-601-101.

2.08 ***Freezing of Electrolyte (Proc. 3.08):*** The electrolyte in any cell shall be maintained above the freezing temperature respective to its specific gravity as shown in Table D. Freezing will cause damage not immediately apparent (see Section 157-601-101).

TABLE D — FREEZING TEMPERATURES OF ELECTROLYTE

SPECIFIC GRAVITY AT 77°F	FREEZING TEMP. (°F)
1.030	+30
1.060	+26
1.090	+20
1.120	+16
1.150	+ 8
1.180	— 4
1.210	—23
1.240	—52
1.270	—85
1.283	—99
1.300	—100
1.330	—64

2.09 ***Water and Level of Electrolyte (Proc 3.09):*** At all times after initial charge, the level of electrolyte in any cell shall be maintained as indicated in Table E.

TABLE E — 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	Transparent	Bottom of High Line	Top of Low Line
KS-5553 KS-5562 KS-20048 (hardened)	Nontransparent with float covers		
KS-5553 KS-5553-01 KS-5562 KS-15544	Nontransparent without floats uncovered	Second color just visible (usually red)	Top of float just shows
KS-5269-01 KS-5361 L100 to L115C	Transparent	Level with target aperture (usually triangular) located approximately midway between separators and bottom of cover	

Caution: Overfilling can lead to plugging of gas vents.

2.10 *Level Indicator Floats (Proc. 3.10):* Floats shall be free to move with electrolyte level changes. To check, depress the float indicator and observe that the float does not stick when released.

2.11 *Discharge Capacity Tests (Proc. 3.11):* 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. Tables H, I, and J give the 5- and 8-hour discharge rates in amperes of lead-acid cells presently used in telephone offices and other power plants.

2.12 *Battery Connections and Use of NO-OX-ID A (Proc. 3.12):* Connections shall be tight and free from dirt and corrosion. Connections should be checked usually every 3 months (see Section 157-601-702). Do not loosen or change connections without first referring to 3.12(a).

2.13 *Containers and Covers (Proc. 3.13):* Containers and covers shall be free from cracks and leakage or spillage of electrolyte (see Section 157-601-703). ***Acid leakage can cause short circuits, corrosion of terminals and intercell connectors, and is a potential fire hazard.***

2.14 *Use of Tape to Temporarily Seal Plastic Jar Cracks (Proc. 3.14):* Leaky jars shall be replaced. Cracks in plastic jars that are leaking shall be temporarily sealed, when possible, while awaiting cell replacement.

2.15 *Seals (Proc. 3.15):* Post seals and any seals between covers and containers shall be intact and free from electrolyte or residue.

2.16 *Spacing Between Containers (Proc. 3.16):* Spacing between containers shall be as specified in Section 157-601-201 and in any case not less than 3/8 inch after the allowable bulging of 3/4 inch on larger cells (see Section 157-601-703). There shall also be a minimum clearance of 3/8 inch between containers and sides of racks or metal cabinets.

> ***Caution:*** ***Cells or batteries, especially those with flexible connectors, should be checked for spacing every time maintenance work is done in order to prevent the possibility of fire which can occur when 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.***

2.17 ***Antiexplosion Features (Proc. 3.17):*** Antiexplosion 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.

> ***Caution:*** ***Do not allow gas vents to become clogged as spraying of electrolyte or explosion due to internal pressure may result.***

Gauge by eye.

2.18 ***Spray Caps (Proc. 3.18):*** Spray caps shall be clean and in place (see Section 157-601-201). The vent hole shall be open and free of residue (see Caution in 2.17).

Gauge by eye.

2.19 ***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 Section 157-601-201).

> ***Note:*** Peeling paint or corrosion may indicate a battery leak.

Gauge by eye.

3. PROCEDURES

3.001 ***List of Tools, Gauges, and Materials:***

CODE OR SPEC NO.	DESCRIPTION
TOOLS	
W1AF	Test Cord
R-1060	Putty Knife
R-2969	Typewriter Brush
KS-5499, L1401	Syringe type Cell Filler
KS-6320	Orange Stick
—	Test Cords, Weston D-79650 D-79651 and No. 168023
—	3-inch C Screwdriver
—	Battery Filler, E. Edelman & Co. No. 74C
—	Small Paint Brush (obtain locally)
—	Soldering Copper, Pyramid Point, 1 or 2 pounds
—	Flashlight, regular or angular, having plastic or rubber housing
—	Goggles, Coverall, Clear Lenses
—	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 plastic or rubber tape or tubing. The entire unused end of double-end wrenches must be thoroughly insulated.
GAUGES	
R-8550	6-inch Steel Scale
KS-5499, L1352, or L1353	Thermometer
KS-5499, L1305	Hydrometer (for low-gravity cells)
KS-5499, L1307	Hydrometer (for high-gravity cells)
—	Thermometer, Fisher Scientific Co. No. 14-990, 0 to 230°F.
—	Voltmeter, dc, Weston Model 931, 3-V.
KS-20142 L1 or KS-20770 L1	Discharger-Recharger

CODE OR SPEC NO.	DESCRIPTION
GAUGES (Cont)	
—	Voltmeter, dc, Weston Model 931 300/150/75/30
—	Differential Millivoltmeter, Sensitive Research Inst. Corp., Model BELLUD (Optional)
—	Millivoltmeter, DC, Weston Model 281 — Range 100 Millivolts
MATERIALS	
R-3034	Rubber Acid Gloves (for heavy duty)
R-3043	Rubber Apron
R-3126	Silicone Compound (2-oz tube for counter cells)
KS-14666	Cloth
—	Household Ammonia
—	Wire brush (obtain locally. For racks and stands — do not use on connectors) (see 3.19)
—	Battery Sealing Compound (battery Manufacturer's 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 (manufacturer's type)
—	Glass or Plastic Funnel (obtain locally)
—	Neoprene Gloves, Charleston Rubber Co., N140-R (size 9), or N141-R (size 10), for lighter work
R-3266	NO-OX-ID A Compound (for batteries)
—	4/0 Sandpaper
—	Table Soda (bicarbonate)
—	Water, distilled or approved for use in storage cells.
—	Wiper, Paper, Scott No. 58 or 59
—	Wax, Black, Johnson's No. W-5016 (from Exide or C&D) 1 pint or 1 quart)
—	Pyrophosphate Cleaner (Bell System)

Note: Equivalents may be substituted.

3.01 ***Battery Records and Readings (Reqt 2.01)***

(a) In addition to the Equipment Test List (see Section 157-001-013), Forms E-3592, E-3593, E-3595 and E-2003, or equivalent, are suggested for recording various readings.

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

(c) Record the temperature whenever specific gravity readings and voltage readings 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.

3.02 ***Float Voltage Readings (Reqt 2.02):*** Use the Weston Model 931, 3-volt scale, DC Voltmeter for measuring voltages of both low-gravity and high-gravity cells. Where battery voltage swings are large and frequent, a differential voltmeter could be used for individual cell readings (see Section 157-601-301 for special instructions on methods of reading and reading intervals under such conditions). Voltage readings should always be taken with the voltmeter leads connected directly to the battery terminals and ***not*** to the intercell connectors.

Caution 1: Always observe polarity and proper scale (if applicable) when measuring cell or battery voltage to avoid possible damage to the meter.

Caution 2: Accidential 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 reading is taken.

(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 voltage. Check to see if the average battery float voltage conforms to the requirements in Table C, ie, 2.17 ± 0.01 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) ***Temperature Variations:*** Improper cell voltage conditions may result from temperature variations between cells in the same string. This is most likely to occur in multi-tier arrangements where, because of natural air convection, the temperature of the top tier cells may be significantly higher 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) ***Unlike Cells in the Same String:*** Cells made by the different manufacturers, even though they have the same capacity rating, have different float characteristics. Check to be sure that all cells are from the same manufacturer. (See note for exceptions.) In addition, 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.

Note: Manufacture discontinued KS-15544 L503 and L505 cells are no longer available from Exide and Gould. For replacement purposes, C & D KS-15544 cells of the same capacity can be used provided they do not constitute more than 15 percent of the cells in the battery.

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

(1) ***High Voltage Cells:*** In general, cells operating slightly above the required voltage limit do not indicate a trouble condition and no action need be taken. However, cells floating at voltages significantly higher than the upper voltage limit must be examined closely since such a condition indicates that 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, ie, 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 3.11), the cell should be replaced. If both visual inspection and the capacity test do not indicate a trouble condition, no action need be taken. However, special attention should be given to the regular voltage readings. Replace the cell if the float voltage of the cell in question continues to increase.

(2) ***Low Voltage Condition:*** For cells that were floating within the required range at the previous quarterly reading, float voltages less than 2.06 for low gravity cells and less than 2.14 for high gravity cells indicate a severe abnormality—possibly a short circuit—and should be replaced. Low gravity cells between 2.06 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 need be taken.

If the cells are 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 returned to abnormally low voltage conditions at any time exceeding one year after boost charge, boost charge again and follow the procedure given in this paragraph.

Other low voltage conditions, ie, 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.

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 need 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.

(c) If a single-cell charger is not readily available and the power plant is capable of a float charge operate the float charge key when the battery voltage drops below the minimum requirements [see 3.05(c)]. A single cell charger may still be required for individual cells if the float charge does not bring the cells within minimum voltage requirements.

3.03 ***Specific Gravity Readings, Reference Temperature, and Floating Ball Charge Indicators (Reqt 2.03):***

(a) Use the KS-5499 L1305 syringe-type hydrometer for low-gravity cells and the KS-5499 L1307 syringe-type hydrometer for high-gravity cells. (See Table C for reading requirements.)

(b) ***Reference Temperature:*** 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. See Section 157-601-101 also.

Caution: Never insert a thermometer into the electrolyte withdrawal tube or use a mercury-filled thermometer to take temperature readings.

(c) ***Specific gravity readings of cells with electrolyte withdrawal tubes*** are taken by inserting the hydrometer into one of the withdrawal tubes. Hydrometers used in withdrawal tubes should be equipped with flexible tips rather than rigid nozzles. The rubber bumper should be held flush against the top of the tube to prevent spraying the electrolyte.

(d) ***Specific gravity readings 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 hyrdrometer 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.

Caution: A hydrometer used in lead-antimony cells should not be used in lead-calcium cells and vice versa since this would contaminate the electrolyte. Also see Caution 2 under 3.09.

(e) ***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 $\pm$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 (1), (2), and (3) assume a well mixed electrolyte, at the high level, with a temperature of 77°F.

(f) The occurrence of specific gravities below the required range is rare and indicates that the cell is self-discharging and consequently losing capacity. Boost charge a cell whose specific gravity is below the required minimum. If boost charging permanently corrects the condition, no action need be taken. If the specific gravity is still low after boost charging, of if the condition reappears within a year of boost charging, replace the cell.

3.04 ***Emergency Cell Specific Gravity and Charging (Reqt 2.04):*** Make specific gravity readings weekly, or as close to weekly as possible at unattended offices. If corrected specific gravity is low (see 2.03), charge the emergency cells until they start gassing freely or until 15 percent of the cell capacity has been returned. The charge rate should not exceed the finish rate except on charge by load (see Section 157-601-101), in which case the time of day of charge should be selected so that the finish rate [see 3.05(d) and (f)] will be exceeded as little as possible. Maximum allowable temperature should not be exceeded.

Example: Assume the specific gravity of a KS-15544 L405 battery has dropped 7 points (0.007). These cells are rated at 420 ampere hours, with a gravity range of 83 points (see Table H). Seven points is 8.4 percent of 83 points, so a charge is required per 2.04. The charge may be continued until gassing occurs or until 63 ampere hours (15 percent of 420) has been replaced.

3.05 ***Boost Charge and Finish Rate (Reqt 2.05)***

(a) Boost charges after power failure are given where possible, to the entire string for durations depending upon charging voltage as shown in Table F. 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 Section 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 constant for 10 minutes.

TABLE F — BOOST CHARGE TIME

	VOLTS PER CELL	HOURS MAX	HOURS MIN
	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
See	2.25	104.0	84.0
Note	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

Note: The lower voltage values are for use with low-gravity cells only. The minimum volts per cell shall be 2.33 for high-gravity cells.

(b) Where it is necessary to boost charge only a few cells, it may be more convenient to use a single-cell charger. In such cases, the charge shall be 100 percent of the 8-hour rated capacity of the cells. The charge is held at any desired rate not exceeding the finish rate for the cell, except as specified under (d), by frequent adjustments for the charger output. Higher rates are permissible only on discharged batteries (see Section 169-621-301) and then only early in the recharge period. See (d). Single-cell charger J86264A is rated at 210 amperes and KS-15687 at 20 amperes. Either may be used on one or two adjacent cells and at slightly reduced rates on three adjacent cells. The KS-20142 and KS-20770 Discharger-Rechargers may also be used, where applicable, for boost charge of single cells.

(c) The following action should be taken for boost charge in 50-/52-volt, 120- and 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 all Other Offices Where 52-Volt Operation is Permitted:*** Operate the TST-NOR-CHG key to CHG. After charging is completed, operate the TST-NOR-CHG key to NOR for 52-volt operation or to TST for 50-volt.

(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) The ***finish rate*** is a current value that can be absorbed by the cell throughout the charge without overheating or harmful gassing. See Tables H, I, and J for the finish rates of various types of batteries. The finish rate can, in some cases, be exceeded early in the charge to save time. However, lead-antimony cells in the last quarter of their anticipated life should be watched for excessive temperature or excessive gassing any time the finish rate is exceeded. The finish rate should not be exceeded toward the end of charge if the cell is gassing actively. Any of the following rules, as convenient, may be used to avoid rates that are too high and detrimental to the battery.

(1) Hold charging current in amperes to a value less than the capacity in ampere-hours yet required to return to full charge. This is referred to as the ***ampere-hour rule.*** It probably is the quickest safe recharge, but it is not always easy to apply even when data for its application is available.

(2) Current may start at 150 percent of the 8-hour discharge rate and taper to the finish rate providing voltage per cell does not exceed 2.3 volts for low-gravity cells, or 2.4 volts for high-gravity cells while current exceeds the finish rate.

(3) If voltage does not exceed 2.3 volts per cell for low-gravity cells or 2.4 volts per cell for high-gravity cells, there is no restriction on current value. This method takes the longest time, but requires the least attention.

(e) To give a boost charge as shown in Table F, 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 floated 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 (a)], charge for a time within the maximum and minimum shown for that voltage in Table F.

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 ***pilot-cell*** temperature, interrupt the charge before 110°F is exceeded, and complete later or at reduced voltage.

(f) 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 F, 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.

Caution: In either case, watch the temperature of the electrolyte and interrupt charge, if necessary, to prevent temperatures from exceeding 110°F. Complete charge later or at a reduced rate.

3.06 ***Cell Reversal (Reqt 2.06):*** The recharge of reversed cells should be done in the following order and at no time should cell temperatures be above 95°F.

(a) Discharge the reversed cells to zero through resistance as required to limit current to not more than the 8-hour rate of the battery and not more than the capacity of the shunting wire and resistor.

Note: Cells that have been completely or nearly discharged may also be recharged as described in (b) and (c).

(b) Charge in the proper direction at 10 to 15 percent of the 8-hour rate until cell voltage is 2 volts or higher. Where the cells do not accept charge easily and it is difficult to get the 10 to 15 percent current, be careful that they do not suddenly start to accept charge resulting in rates higher than desired.

(c) Apply a standard initial charge to the measured end as described in Section 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.

3.07 ***Temperature of Electrolyte (Reqt 2.07):*** 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.

(a) 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.

Caution: Never insert the thermometer into the electrolyte withdrawal tubes or use a mercury-filled thermometer to take temperature readings.

(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.

3.08 ***Freezing of Electrolyte (Reqt 2.08):*** When there is danger of electrolyte freezing, immediate steps should be taken to provide special enclosures, insulation, or heaters as necessary.

3.09 ***Water and Level of Electrolyte (Reqt 2.09):***

(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 G. Electrolyte checking interval is given in Table C. 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. Observe caution in 1.09.

TABLE G — MAXIMUM ALLOWABLE IMPURITIES IN BATTERY WATER

TYPE OF IMPURITY	PPM (BY WEIGHT)	PERCENT
Total solids	500	0.0500
Fixed solids	350	0.0350
Organic & Volatile Matter	50	0.0050
Chloride	25	0.0025
Iron	4	0.0004
Nitrates & Nitrites	15	0.0015
Ammonia	5	0.0005
Manganese	0.007	0.0000007

Caution 1: Acid or electrolyte shall not be added to any cell as a substitute for adequate charging.

Caution 2: Do not contaminate the electrolyte of lead-antimony cells with electrolyte from lead-calcium cells and vice versa [see Caution in 3.03(d)]. 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.

Caution 3: Under no circumstances shall electrolyte be dumped in a manner that may result in environmental pollution, damage to equipment or hazard.

(b) ***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 one 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 telephone 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 spring season and one during the dry autumn 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 G 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.

3.10 ***Level Indicator Floats (Reqt 2.10):*** Floats that do not operate properly and floats on which the paint is badly chipped should be replaced.

3.11 ***Discharge Capacity Tests (Reqt 2.11):***

Caution: Do not discharge emergency cells.

If a cell does not seem to take or hold a charge [see 3.02(b)], a 5-hour discharge test (on fully charged cells) to an end point of 1.75 volts per cell is the best way to determine if sufficient reserve power is available. Sections 157-601-501 through -506 deal with equipment used for discharge capacity tests. Sections 157-601-503, -504, -505, -506 contain operating instructions for test equipment which may be used on larger capacity cells (180 to 1680 ampere-hour).

(a) ***Discharge Capacity Test Procedure:*** Refer to Tables H, I, and J, as applicable, for the 5-hour discharge rate of the cells to be tested. Record this value. See Table K for suggested record form.

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

(1) Cell float voltage

(2) Electrolyte temperature

(3) Corrected specific gravity

(c) 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 Table K 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 provided that battery finish rates (see Tables H, I, and J) are not exceeded on recharge. Observe precautions in 3.12 when making battery connections.

(d) Determine percent of 5-hour rated capacity at 77°F multiplying the recorded discharge time to 1.75 volts by the correction factor K [see Fig. 1—use temperature recorded in (b)] per the following formula:

Percent of 5-hour rated capacity at 77°F = discharge time (minutes) × 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. 1; K equals approximately 110 at 60°F. Therefore percent of 5-hour rated capacity equals 259/300 × 110 = 95.

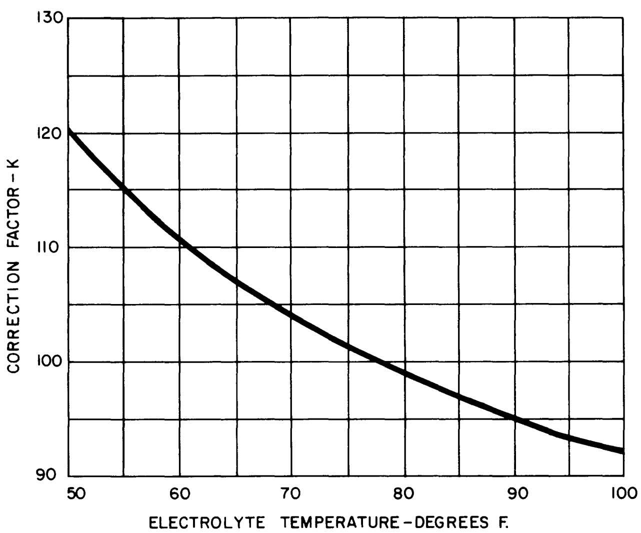

Fig. 1—Correcting Capacity for Temperature(Based on 5-hour Discharge Rate)

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

(f) Refer to EL 114 for cell replacement criteria. Section 157-601-703 should be referred to for trouble conditions other than low capacity which may require cell replacement. Cells should be replaced with like cells of the same manufacturer (see Section 157-601-701). Certain exceptions are authorized however. For example, Exide and Gould KS-15544 List 503 and 505 cells have been rated "Manufacture Discontinued" and when these cells are no longer available C&D KS-15544 List 503 or 505 cells, as applicable, may be substituted for up to 15 percent of the total number of cells in the string. In such case, orders should be worded as follows: (quantity) Battery, Storage, KS-15544 (List 503 or 505), C&D. Orders should include the following:

1. Supplier of the original cell.

2. Date of the string.

3. Number of cells in the string.

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

(g) Recharge or boost charge cells in accordance with 3.05, as soon as possible after discharge. The discharger-rechargers covered in Sections 157-601-504, -505, and -506 automatically recharge the cell after discharge. See Section 169-621-301 for cell recharge after discharge with the J87116A L1 discharger.

(h) Discharge tests on large capacity cells (180-1680 ampere hour) should be run DIRECTLY OFF FLOAT WITHOUT PRIOR BOOST CHARGE. Cells to be tested shall have been on float for at least 6 months without a boost charge and where a power failure exceeding 30 minutes has not occurred within 6 weeks.

Note: The KS-20142 L1 and KS-20770 L1 discharger-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 Sections 157-601-504 (Lorain) and 157-601-505 (Fan-tron) for instructions

TABLE H — C & D BATTERIES

CELLS	5-HR DISCHG RATE IN AMPS	8-HR DISCHG RATE IN AMPS	FINISH RATE IN AMPS	SP GR RANGE FOR COMPLETE DISCHG IN 5-HRS
KS-5361				
L100	0.70	0.50	0.20	35
L116	1.80	1.25	0.50	38
L120	2.60	1.875	0.75	59
L130B	5.30	3.75	1.50	62
L140D & E	8.80	6.25	2.50	88
L141D & E	8.80	6.25	2.50	88
L150D & E	17.60	12.50	5.0	90
L151D & E	17.60	12.50	5.0	90
L151HD & HE	22.90	16.60	6.5	94
KS-15754	1.05	0.75	0.30	44
KS-5553				
L310 & L311	31.4	22.5	9.0	70
L402	42.0	30.0	12.0	83
L403	52.4	37.5	15.0	83
L405	73.4	52.5	21.0	83
L407	94.2	67.5	27.0	92
L409	115.4	82.5	33.0	88
L501	147.0	105.0	42.0	75
L503	189.0	135.0	54.0	79
L505	231.0	165.0	66.0	83
L508	294.0	210.0	84.0	83
KS-15544				
L310 & L311	31.4	22.5	9.0	70
L310H & L311H	30.3	28.75	11.5	75
L402	42.0	30.0	12.0	83
L402H	52.4	37.5	15.0	85
L403	52.4	37.5	15.0	83
L403H	66.6	47.5	19.0	85
L405	73.4	52.5	21.0	83
L407	94.2	67.5	27.0	92
L409	115.4	82.5	33.0	88
L501	147.0	105.0	42.0	75
L503	189.0	135.0	54.0	79
L505	231.0	165.0	66.0	83
L508	294.0	210.0	84.0	83
KS-5562				
L04	684.0	500.0	150.0	75
L05	856.0	625.0	180.0	80
L06	1028.0	750.0	210.0	80
L07	1200.0	875.0	255.0	80

TABLE I — GOULD-NATIONAL BATTERIES

CELLS	5-HR DISCHG RATE IN AMPS	8-HR DISCHG RATE IN AMPS	FINISH RATE IN AMPS	SP GR RANGE FOR COMPLETE DISCHG IN 5-HRS
*KS-5269-01	1.80	1.25	0.50	40-50
KS-5361 (Glass Jars)				
L110	1.80	1.25	0.50	40-50
L120	2.70	1.875	0.75	50-60
L130	5.30	3.75	1.50	55-65
L140	8.80	6.25	2.50	65-75
L150	17.60	12.50	5.00	65-75
KS-5361 (Plastic Jars)				
L116, L116B & C	1.80	1.25	0.50	40-50
L120B & C	2.70	1.875	0.75	50-60
L130B & C	5.30	3.75	1.50	55-65
L140D & L141D	8.80	6.25	2.50	65-75
L140E & L141E	9.20	6.25	2.50	55-65
L150D & L151D	17.60	12.50	5.00	65-75
L150E & L151E	18.30	12.50	5.00	55-65
L151HD	23.00	16.25	6.50	65-75
L151HE	23.10	16.25	6.50	60-70
*KS-15886	Same as corresponding list number under KS-5361			
KS-5538				
L1, L3, L10, L18	See data on KS-5361 L116			
L2 thru L6, L8, L10, L12, L14, L15	See data on KS-5361, L120			
L7, L9, L11, L13	See data on KS-5361, L130			
KS-5553, KS-15544, & KS-20106 (hard site)				
L310 & L311	31.80	22.5	9.0	55-65
L402	42.40	30.0	12.0	55-65
L403	53.10	37.5	15.0	55-65
L405	74.20	52.5	21.0	55-65
L407	95.40	67.5	27.0	55-65
L409	116.60	82.5	33.0	55-65
L501 & L101 (hard site)	147.00	105.0	42.0	80-85
**L503	189.00	135.0	54.0	80-85
**L505	230.10	165.0	66.0	80-85
L508 & L108 (hard site)	294.00	210.0	84.0	80-85
KS-20048 L1 (hard site)	1200.00		350.0	140 max.

TABLE I — GOULD-NATIONAL BATTERIES (Cont)

CELLS	5-HR DISCHG RATE IN AMPS	8-HR DISCHG RATE IN AMPS	FINISH RATE IN AMPS	SP GR RANGE FOR COMPLETE DISCHG IN 5-HRS
KS-5562				
Gould-Trenton Prior to 1952				
L04	690	500	200	70
L05	835	625	250	70
L06	1000	750	300	70
L07	1200	875	350	70
Gould-Depew Prior to 1952 and Gould-Trenton 1952 thru July 1953				
L04	690	560	200	130
L05	835	625	250	130
L06	1000	750	300	130
L07	1200	875	350	130
Gould-Trenton Since July 1953				
L04	690	500	200	70-75
L05	835	625	250	70-75
L06	1000	750	300	70-75
L07	1200	875	350	70-80

* Manufacture Discontinued

** Manufacture Discontinued in KS-15544 [see 3.11(f)]

TABLE J — EXIDE BATTERIES

CELLS	5-HR DISCHG RATE IN AMPS	8-HR DISCHG RATE IN AMPS	FINISH RATE IN AMPS	SP GR RANGE FOR COMPLETE DISCHG IN 5-HRS
KS-5361 (Glass Jars)				
L110	1.75	1.25	1.00	45
L120	2.60	1.875	1.50	73
L130	5.25	3.75	3.00	82
L140	8.75	6.25	5.25	92
L150	17.50	12.5	10.50	115
KS-5361 (Plastic Jars)				
L116	1.75	1.25	1.00	39
L120B & C	2.60	1.875	1.50	73
L130	5.25	3.75	3.00	82
L140	8.75	6.25	5.25	92
L150	17.50	12.5	10.50	92
L151D & E	17.50	12.5	10.50	115
L151HD & HE	22.00	16.25	10.50	115
KS-5553				
L310 & L311	31.0	22.5	18.0	72
L402	43.0	30.0	24.0	83
L403	52.0	37.5	30.0	88
L405	74.0	52.5	42.0	83
L407	93.0	67.5	54.0	80
L409	120.0	82.5	66.0	90
L501	145.0	105.0	70.0	72
L503	180.0	135.0	90.0	78
L505	230.0	165.0	110.0	78
L508	290.0	210.0	140.0	82
KS-15544				
L310 & L311	31.0	22.5	18.0	69
L402	43.0	30.0	24.0	74
L403	52.0	37.5	30.0	82
L405	74.0	52.5	42.0	85
L407	93.0	67.5	54.0	82
L409	120.0	82.5	66.0	90
L501	145.0	105.0	70.0	69
*L503	180.0	135.0	90.0	94
*L505	230.0	165.0	110.0	88
L508	290.0	210.0	140.0	97

TABLE J — EXIDE BATTERIES (Cont)

CELLS	5-HR DISCHG RATE IN AMPS	8-HR DISCHG RATE IN AMPS	FINISH RATE IN AMPS	SP GR RANGE FOR COMPLETE DISCHG IN 5-HRS
KS-5562				
Exide Prior to 1952				
L04	680	500	200	40
L05	830	625	250	50
L06	1010	750	300	50
L07	1180	875	350	70
Exide Since 1953				
L04	680	500	210	40
L05	830	625	250	50
L06	1010	750	290	50
L07	1180	875	350	70

* Manufacture Discontinued [See 3.11 (f)]

for bypassing boost charge when using the KS-20142 L1. See Section 157-601-506 (Lorain) when using the KS-20770 L1.

3.12 ***Battery Connections and use of NO-OX-ID A Compound (Reqt 2.12):***

Caution: Observe the precautions in this paragraph and 1.12(c) before loosening or removing battery connections while cells are gassing or discharging as sparks may occur.

(a) When opening or replacing connections at the battery, it is recommended that a temporary switch be strapped in as shown in Fig. 2. Provide sufficient temporary wiring to locate the switch a safe distance from any point where arcing would be a hazard. Close the knife switch before opening or replacing the battery connections. This procedure is particularly useful when working with larger cells. The size of the switch strap, and temporary wiring in Fig. 2 should be selected to carry the load current under power failure conditions.

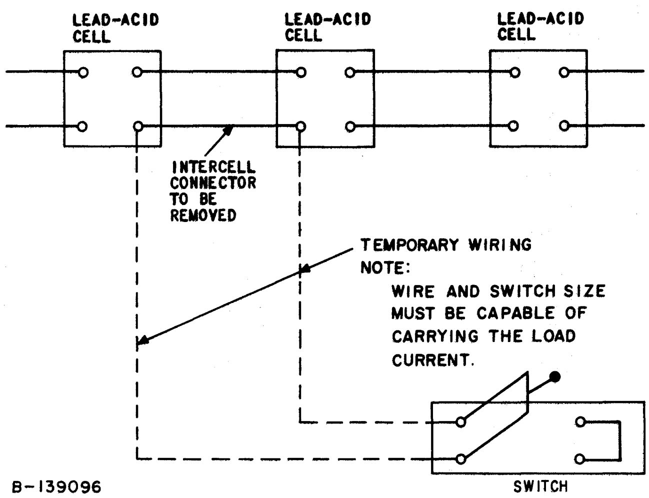

Fig. 2—Typical Temporary Switch Connected to Remove Arc Hazard

(b) ***General Maintenance:*** If a connection appears corroded or damaged (see Section 157-601-702), open the connection observing the precautions in (a) above for large cells, and clean the corroded posts, intercell connectors, and terminal details using a cloth dampened in a strong soda solution [see 1.11 (a)] followed by wiping with a cloth dampened in clear water.

Caution: Do not allow neutralizing solutions to enter the cell.

The four sides of each terminal post should be sandpapered to a bright finish without abrading the intercell connectors or fastening hardware, and coated with heated 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 heated NO-OX-ID A compound.

Note: 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.

Caution 1: 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.

Caution 2: 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.

If a temporary switch was used, close the switch and reconnect the intercell connector. Then open and remove the switch and wiring. If a temporary switch was not used, close the opened connections. Tighten all connections securely and wipe off excess grease.

Note: Two wrenches should always be used to tighten a connection in order to avoid the possible breakage of the lead posts.

(c) ***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 (b). Cracked seal nuts should be replaced as recommended in Section 157-621-801.

3.13 ***Containers and Covers (Reqt 2.13)***

(a) Replace cells having cracked or leaking containers. Such cells present a fire hazard. Cells should be replaced by like cells (see "Excessive Voltage Variation Between Unlike Cells" in Section 157-601-101). See Section 157-601-201 for allowable limits on scratches at installation. Refer to Section 157-601-703 and PEL 7367 for more detailed information and photographs on container and cover cracks. See 3.14 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 [see 1.11(a)].

Caution: 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 the aforementioned 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 3.14).

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

3.14 ***Use of Tape to Temporarily Seal Plastic Jar Cracks (Reqt 2.14)***

(a) ***List of Materials***

CODE OR SPEC NO.	DESCRIPTION
—	Table soda (bicarbonate)
—	"Scott Wipers" No. 590
—	Mild Soap (Mfr. Proctor and Gamble) or equivalent
—	3M Tape, No. 472, black, 2-inch width by 36 yards (Mfr. Minnesota Mining & Mfr. Co.)

(b) 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 procedure when applying the tape.

(1) Cover open cracks temporarily with a narrow strip of recommended 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 Wipers" 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 Wipers" No. 590, dampened with a mild soap solution. Immediately wipe dry with "Scott Wipers" to remove excess soap.

(4) Rinse with "Scott Wiper" dampened with tap water and dry with "Scott Wiper."

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

(6) Neutralize with a weak soda solution as specified in Section 157-601-701.

(7) Rinse and dry as in (4) using distilled water or the available battery make-up water.

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

(9) After cutting 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 back-up piece of tape for extra support can be used to cover the initial piece especially where compound angles demand tape stretching.

3.15 ***Seals (Reqt 2.15)***

(a) Covers of enclosed cells should be neutralized with a weak soda solution. 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) 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.

Caution: Leaky cover seals can present a fire hazard (see Section 157-601-703).

Note: This technique is not applicable to cover seals on plastic jars. Field repairs shall not be attempted on plastic covers. A representative of the battery manufacturer may be contacted to determine whether repair is possible.

3.16 ***Spacing Between Containers (Reqt 2.16):*** Cells or batteries should be checked for spacing at initial installation (see Section 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.

3.17 ***Antiexplosion Features (Reqt 2.17):*** Antiexplosion 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 antiexplosion features becomes 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 and clean with water and brush if they become clogged. The battery manufacturer's area representative should be requested to remove ceramic vents which are cemented to the cover of the cell. If antiexplosion features are damaged, they shall be replaced.

Caution: Do not allow gas vents to become clogged as explosion due to internal pressure may result.

3.18 ***Spray Caps (Reqt 2.18):*** 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 be relocated in the top of the filling funnels.

3.19 ***Battery Racks, Stands, Cabinets, and Miscellaneous Equipment (Reqt 2.19):*** Battery racks, stands, cabinets, etc, should be wiped at regular intervals with a cloth dampened in a weak soda solution 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 (see following Caution). 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 Section 157-601-703 "Leaking Jar Cover Seals" for method of detecting electrolyte leakage using a voltmeter. For detailed information on new battery stand equipment arrangements for 24- and 48-volt power plants which supply loads of 10 to 800 amperes, see Section 802-125-151 (J87122), Issue 3, Addendum 1. Refer to Section 802-125-150, Issue 4 for information on battery stand equipment for the 702C and 708A Power Plants.

Caution: At no time shall the wire brush be brought in close proximity to cell terminals and intercell connectors.

TABLE K — SUGGESTED 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 CONDITION NOTES ______

APPROVAL ______