

CONRAIL



**SPECIAL INSTRUCTIONS
GOVERNING
CONSTRUCTION AND MAINTENANCE
OF SIGNALS AND
INTERLOCKINGS**

**C. & S. 23
(7-76)**

CONSOLIDATED RAIL CORPORATION

SPECIAL INSTRUCTIONS GOVERNING CONSTRUCTION AND MAINTENANCE OF SIGNALS AND INTERLOCKINGS

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GENERAL INSTRUCTIONS

1. Employees whose duties are prescribed by these instructions must have a copy.

2. Employees engaged in the construction and/or maintenance of signals and interlockings must familiarize themselves with the current issue of the following, including all supplements:

(a) Time Table.

(b) C. T. 400 Rules for Conducting Transportation for Employees in the United States. Uniform Code of Operating Rules for Employees in Canada.

(c) S7-C—Safety Rules—Maintenance of Way and Structure Employees.

(d) C. & S. 23—Special Instructions Governing Construction and Maintenance of Signals and Interlockings.

(e) C. & S. 27—Instructions for Making Tests of Signal Apparatus.

(f) C. & S. 33—Rules, Standards and Instructions for Signal Systems.

(g) C. & S. 34—Specifications for Signal and Interlocking Systems.

(h) C. T. 290—(Electrified territory) Electrical Operating Instructions.

3. Communications and Signal Department Employees, except Helpers, will be examined and record maintained by Supervisor C. & S. on Form C. & S. 12 as follows:

(a) C. & S. 23—Special Instructions Governing Construction and Maintenance of Signals and Interlockings—at least once in 2 years.

(b) C. & S. 27—Instructions for Making Tests of Signal Apparatus—at least once in 2 years.

(c) S7-C—Safety Rules for Maintenance of Way and Structures Employees—at least once in 3 years.

(d) C. T. 290—(Electrified territory) Electrical Operating Instructions*—at least once in 3 years.

(e) C. & S.—Employees, except Helpers, will be examined by Rules Examiner on C. T. 400—Rules for Conducting Transportation and/or Uniform Code of Operating Rules for Employees in Canada and Time Table* annually and record maintained on Form CT 1515.

* For those employees to which it applies.

4. Employees are responsible for the inspection, adjustment and proper maintenance of all communications, signal, and interlocking apparatus assigned to their care. They must promptly report to their superior any condition requiring his attention.

5. Employees must cooperate with each other and with the employees of other Departments to keep signal systems, devices and appliances in good working order.

6. Employees must observe and instruct their subordinates as to the necessity for safety, efficiency and economy, and that all work must be done in accordance with authorized practices.

7. Alterations or additions must not be made to any individual components or systems involving signal apparatus or circuits unless properly authorized.

8. Installation of experimental devices, or use of unapproved material, must not be made unless specifically authorized.

9. In these instructions, Supervisor, Assistant Supervisor, Inspector, Foreman, Retarder Technician, Electronic Tech-

nician, Electronic Specialist and Maintainer refers to employees assigned to Communications and/or Signals.

10. Supervisors report to, receive instructions from and are responsible to the Regional Engineer C. & S. in all technical matters relating to construction, maintenance, and performance of signal systems, devices and appliances assigned to them. They report to and receive their instructions from the Division Engineer and must cooperate with the Division Superintendent in all matters relating to Division operation insofar as the Communications and Signal Department function applies.

11. Unless otherwise directed, the Supervisor shall have charge of communications and signal maintenance and construction on his assigned territory. In electrified territory, he may also have charge of transmission, catenary, substation and third rail maintenance and construction.

12. The Supervisor must see that employees assigned to his jurisdiction qualify for the duties to which they are assigned and perform the work in a safe and efficient manner. He must see that these employees are provided with the required rules, plans, specifications and instructions and that they fully understand and comply with them.

13. The Assistant Supervisor reports to, receives instructions from, and is responsible to the Supervisor. The Assistant Supervisor, in the district assigned to him, has the same authority and performs the same functions as the Supervisor.

14. Unless otherwise directed, Inspectors, Foremen, Retarder Technicians, Electronic Technicians, Electronic Specialists and Maintainers report to and receive instructions from the Supervisor.

15. Inspectors, Foremen, Retarder Technicians, Electronic Technicians, Electronic Specialists and Maintainers are responsible for the construction, maintenance, and inspection of communications and/or signal apparatus assigned to them. They shall see that work is performed efficiently, economically, and in compliance with System Plans, Specifications and Standards.

16. Employees must report to their superior any situation or condition which may prevent completion of an assignment on schedule or within authorization.

17. Insofar as possible, material and tools shall be ordered on monthly requisition. In no event will requisitions be placed for material and tools in excess of immediate requirements. A surplus must not be allowed to accumulate. Employees shall exercise proper care of tools, equipment and material assigned to them.

18. The Supervisor or his representative must make frequent examinations of tools to ascertain that they are in proper order, of proper quality and condition. Tools, keys, standard plans and instructions, catalogs and technical literature must be issued to those who require their use.

19. Buildings and surroundings, the care of which is assigned to the C. & S. Department, must be kept in good order. Scrap material must not be allowed to accumulate around headquarters or other facilities. Scrap must be handled in accordance with current instructions.

20. The Supervisor must keep the Division Superintendent advised of any operating changes at interlocking and/or block stations. C. & S. Department Employees shall keep the Operator or Dispatcher informed of any activity in which

they are engaged that has any bearing or effect on the facilities in charge of the Operator or Dispatcher.

21. Malicious damage to signal facilities must be reported promptly to the Supervisor and Railroad Police.

22. Information regarding material or apparatus must not be given except when authorized by proper authority.

23. The Supervisor must report promptly any unusual occurrence which may require special investigation.

24. When special conditions exist that are not covered by these instructions, local instructions shall be issued by the Supervisor.

25. When any changes are made, sufficient tests shall be performed promptly to assure signal system is functioning as intended. All such modifications shall be recorded on C. & S. 4 by the responsible man making the changes.

26. Department of Transportation Rules, Standards and Instructions for Installation, Inspection, Maintenance and Repair of Automatic Block Signal Systems, Interlockings, Traffic Control Systems, Automatic Train Stop, Train Control and Cab Signal Systems and Other Similar Appliances, Methods and Systems have been reprinted and identified as C. & S. 33.

These Rules, Standards and Instructions will govern except where ConRail's requirements are more restrictive. In such case, ConRail's Rules, Standards and Instructions shall govern.

GENERAL — ALL SYSTEMS

50. Signal apparatus must be kept in proper working order and be maintained in accordance with current instructions and standard practice.

51. The normal functioning of any device shall not be interfered with in testing or otherwise without first taking measures for insuring safety of train operation or highway traffic which depends on normal functioning of such device.

52. Defective apparatus that may endanger train or highway traffic movements must be immediately repaired or replaced if practicable. If it cannot be immediately repaired or replaced, its operation must be discontinued, the train and highway movements affected must be protected, and condition reported to the Division Superintendent and Supervisor by telephone.

53. When any function of a signal system is to be taken out of service, Operator or Dispatcher must be notified and Form C. & S. 39 completed.

1. Permission must be obtained from Operator or Dispatcher and a full understanding had when apparatus affecting train operation is to be removed or disconnected. When necessary to remove or disconnect such apparatus for replacement, repairs, inspection, testing or cleaning, train or engine movement must not be permitted over routes involved, unless levers and operating units affected are properly secured or until the apparatus has been restored and operational check made to insure proper working order after repairs have been completed.

55. In case of changes in, failure of or damage to, signal or interlocking apparatus or highway crossing apparatus, the employee in charge must give the Operator, or Dis-

patcher, or Crossing Watchman involved, full information concerning the apparatus affected and arrange for the safe movement of traffic until repairs are completed.

56. Should a failure of switch, signal, highway crossing protection, or device used in connection therewith be reported, and no cause found, the apparatus must be observed for a sufficient period to insure that it is operating properly. If the condition reported is of such a nature that the safety of operation is affected, precautions must be taken as outlined in Paragraph 57. Tests and reports must be made under the direction of the Supervisor.

57. In case of train accident, immediate action must be taken as follows:

(a) Secure all signals including distant signals governing movements into that portion of tracks, which is or may be occupied or fouled by derailed or damaged equipment, so as to display their most restrictive aspects, by disconnecting local controls at each signal. Supervisor must be notified promptly.

(b) If accident is at an interlocking, the position of interlocking levers and controlled functions must be recorded. If at a remotely controlled signal facility, the positions of switches, signals and control relays for such switches and signals must be recorded.

(c) If accident is at a highway crossing protected by automatic devices, an operational test of the installation must be made to check that apparatus is functioning properly. Where apparatus has been damaged, the crossing must be protected until repairs have been made.

(d) If accident involves personal injury or fatality, or if signals are found or suspected of having given false indication, or if switches or other apparatus have not functioned properly the housings enclosing the apparatus which may be involved in the accident must be sealed without change or repair until inspected or otherwise directed by the Regional Engineer C. & S. or his representative. If the proper sealing iron and seals are not immediately available, a competent person must be assigned to see that the apparatus, wiring or wires are not tampered with until seals are applied.

(e) Procedure towards restoration of facilities to service, including tests and inspection, records and reports of same will be made as prescribed by the Regional Engineer C. & S., or his representative.

58. Whenever electrical storm occurs, Maintainer must immediately, if on duty, or as soon as possible after coming on duty, check ground meter readings and, on extended sections, make a general survey of his territory by telephone to operators or other employees to determine general condition of interlockings or section. In case of severe storm, an inspection should be made as soon as practicable and corrective action taken as necessary.

59. If track is found unsafe due to broken rail, wide gage, obstruction, or other conditions, signals (wayside and cab) governing movements over the unsafe track must be secured to display their most restrictive aspects, and immediate action taken to protect trains, notifying proper authorities. After corrections have been completed, signals may be restored to normal operation.

60. When oil pots or any other heating means for melting snow is in operation, Maintainer must look for possible damage to apparatus, wire-ways, wires and insulation at switches and action taken to prevent irregular operation of switches and signals.

61. Doors in housings containing signal and interlocking devices, must fit tightly when closed to prevent water, dust, foreign matter or snow from entering; all unused openings must be filled to prevent the entrance of rodents or insects. Ventilators must be kept in good condition and clean to allow free circulation of air.

62. Extreme care must be used when drilling, filing or chipping metal parts in or near spring combination or other exposed electrical connections, and suitable safeguards provided to prevent particles lodging in apparatus and producing an unsafe condition. Care must also be used to prevent tools or other metal articles coming in contact with adjacent electrical connections. Broom straw or other non-conducting material must be used for the purpose of tracing or locating contacts in spring combinations or other electrical apparatus. When drilling or driving nails in walls or partitions, care should be exercised to avoid damage to wire.

63. Interlocking or control machine, switch movements, and other appurtenances, shall be kept in good condition, free from excessive lost motion, rust, grease and dirt. Levers and locking shall be kept clean. All bearing parts shall be kept lubricated but excessive lubrication should be avoided. Bolts and dowel pins shall be kept tight, cotter pins properly spread and sufficient tension maintained in latch springs. Contacts shall be kept clean and properly adjusted. Lubricants used shall be in accordance with C. & S. 40 or manufacturer's instructions.

64. Bolts, nuts, dowels, screws, binding posts, rivets, nut locks, jam nuts, etc., must be kept in place, in good condition and tight. Care must be used to avoid unnecessary strain or damage to threads on binding posts, small machine screws and bolts.

65. When a slide protection fence is actuated, before signals protecting the movements are restored to normal operation, the tracks throughout the entire length of the fence must be patrolled and necessary corrective action taken.

66. Placing any object in instrument cases or on interlocking machines, which is not an essential part of signal or interlocking equipment, is prohibited.

67. Joints and rivets in signal pipe lines must be kept tight. Pipes shall be fully screwed into coupling and both ends of each pipe shall be riveted to pipe plug with two rivets. Not more than one joint may be made in the same pipe between any two supports. With the lever in center position, the coupling must be located not less than 12 inches from pipe carriers.

68. Pipe casing through which pipes are run must be free from water and kept filled with non-freezing oil, per C. & S. 40. Stuffing boxes must be properly adjusted.

69. Cranks, compensators, and other mechanical connections shall work freely, but shall not have excessive lost motion in moving parts. They shall be kept clean, properly centered, lubricated and in alignment.

70. Maintenance of apparatus not specifically covered in these instructions shall be in accordance with specific instructions issued for such apparatus. When not so covered, the manufacturer's instructions shall be followed.

71. Communications and Signal Department employees must not line hand operated switches or operate bolt lock levers for trainmen or switch tenders.

72. When in the course of construction, switch points are installed in signalled track prior to placing such switches in service, the switch points must be secured in accordance with Paragraph 406. In addition, a switch circuit controller must be installed and wired to shunt the track circuit or circuits or open the signal control circuit when the switch points are open $\frac{1}{4}$ inch or more. Circuit controllers on crossover switches shall shunt track circuits on both tracks in which switches are located, or open the signal control circuits for these tracks when either or both switches are open $\frac{1}{4}$ inch or more.

73. Extreme care must be taken when painting to prevent paint from settling where it will affect the electrical and mechanical characteristics of apparatus or equipment of the signal system.

74. The use of resistors in circuits to provide current limiting protection for relay ribbons in case of an inadvertent short circuit is discontinued. Hereafter, resistors will be installed only for adjustment purposes and where required by circuit plans. A ten (10) ohm resistor will be used on crossing XR circuits at locations where the test switch shunts the relay.

Ten (10) ohm resistors will not be used in the energy supply of any overlay equipment where the supply battery is 8 cells of nickel iron or nickel cadmium or 5 cells of lead acid.

SIGNALS

100. Signal blade, lens, roundels, glass, marker, letter and number plates and lamps shall be cleaned as often as necessary to insure good aspects. Lamps should not be removed except for replacement or testing.

101. Broken or cracked lenses of color-light signals must be replaced as soon as practicable. If a red or yellow lens is broken so that the color is not plainly distinguishable, the signal must be arranged to display its most restrictive aspect by opening the control relay circuit. If lens for the most restrictive aspect is broken, lamp or lamps must be extinguished and Division Superintendent notified.

102. Broken or cracked roundels in semaphore signals must be replaced as soon as practicable. If roundel is broken so that color for most restrictive aspect is not plainly distinguishable, the light must be extinguished and Division Superintendent notified.

103. Broken or cracked lenses of searchlight type signals must be replaced as soon as practicable. If mechanism cover glass, lens, or color discs are damaged, signal must be arranged to display its most restrictive aspect by opening the control relay circuit and mechanism replaced as soon as practicable. If signal's most restrictive aspect is not plainly distinguishable, or hood is not in place, condition must be promptly corrected, or the light must be extinguished, and Division Superintendent notified.

104. Broken or cracked lenses of position light signals must be replaced as soon as practicable. If signal's most restrictive aspect is not plainly distinguishable, condition must be promptly corrected, and if not possible to do so, the Division Superintendent must be notified.

105. Ladder, hand railing, platform, foundation and/or fastenings shall be kept in good condition and securely fastened. Bolts, nuts, dowel pins, screws, binding posts, rivets, lock nuts, etc., must be kept tight and in good condition. The signal must be maintained in erect position.

106. Signals shall be aligned to give the best aspects warranted for approaching trains. Conditions which may affect the reading of a signal aspect must be promptly corrected or reported to the Division Superintendent.

107. Prescribed lamp bulbs must be used and maintained at the specified voltage and replaced in accordance with instructions.

108. Semaphore spectacle casting shall rest against the stop provided allowing verticle connections to be free from downward pressure when in the most restrictive position.

109. Bearings for semaphore signals and smashboard mechanisms shall be lubricated and kept free from grit and dirt.

110. Mechanism shall be kept in proper adjustment. Excessively worn or defective parts shall be replaced.

111. Tooth disc on motor armature or pawl in retain-mechanism which has become worn or burred shall be replaced.

112. Where spreadlight type lenses or deflecting prisms are used, they must be assembled, mounted, and maintained so that the beam spread is in the proper direction. All lamp units of the same signal head must have identical lens, deflecting prism or phankill arrangement. When necessary to replace such lenses, replacements shall be of the same kind.

113. Frequent inspection shall be made to avoid materials, snow, other surrounding lights, etc. interfering with view of signals. Tree limbs and foliage obstructing view of signals should be kept properly trimmed.

114. Signals must be painted periodically. Adjusting bolts and door fastenings must be lubricated to prevent rusting. Doors must be kept well gasketed and tightly closed to prevent water, dust or snow from entering. Where screened air vents are provided, they must be maintained so as to provide air circulation. Wire openings in signal units and masts must be sealed to prevent entrance of rodents, insects, etc.

115. Socket surfaces must be clean and bright. Lamp must be pressed into socket far enough to be turned clockwise to end of slot so that contact spring may force lamp into proper place. Lamp receptacles may be changed or reset only where proper provisions are available for refocusing.

116. Doors or cover of lamp unit must be kept closed when trains are closely approaching. If practicable, doors on same head of color light signals shall be fastened together so that all must be opened at the same time.

117. Search-light mechanisms must be maintained in accordance with Instructions. Mechanisms must not be opened in the field, defective mechanisms must be replaced promptly, and emergency mechanisms kept ready for immediate use.

118. To secure an electrical signal so as to display its most restrictive aspect, control wires must be disconnected from control relays, and, in addition, if signal is of the relay or mechanism type, positive and negative operating wires must be disconnected from the relay or mechanism.

119. Automatic Signals shall be equipped with number plates showing digits for the mile Post to the nearest even tenth of a mile for eastward or northward governing signals and to the nearest odd tenth of a mile for westward or southward governing signals. The number plate will not indicate the track designation. Controlled Signals will be numbered only on panel diagrams and on plans by digits and letter indicating direction such as 2E, 2W.

TRACK CIRCUITS

150. For new work or rail renewals in track circuit territory, insulating rail joints shall be located as follows:

(a) Stagger:

1. The permissible stagger of insulating joints at interlockings and at all locations in cab signal territory, electrified territory and in territory where stray currents are prevalent shall not be more than 56 inches nor less than 32 inches.

2. The permissible stagger of insulating joints at other locations where track circuits adjoin shall not be more than 120 inches nor less than 32 inches.

3. The permissible stagger of insulating joints at locations other than listed in 150 (a) 1 or (a) 2, where track circuits do not adjoin, may be extended to utilize existing rail joints.

(b) Location of Insulating Joints at Signal Locations:

1. To provide for effective locking, insulating joints at interlocked high signals staggered in accordance with paragraph (a) shall not be more than 13 feet nor less than 0 feet in advance of signals.

2. Insulating joints at interlocked dwarf signals staggered in accordance with paragraph (a) shall not be more than 56 inches nor less than 0 inches in advance of signals.

3. Where opposing signals are mounted on the same mast, the insulating joints shall be located so as to span the signal location as far as practicable.

4. Insulating rail joints which had been installed in accordance with Carrier's previous specifications need not be relocated until the rail is renewed or to comply with U. S. Department of Transportation Rules, Standards and Instructions.

151. When the head of rail in track circuit territory is covered with rust, sand, coal, or other material which may interfere with the proper shunting of the track circuits and which cannot be immediately cleared, the Maintainer must notify the Operator or Dispatcher, by completing Form CT 405-11 in quadruplicate, secure acknowledgement as provided on the Form, conspicuously post the original copy at control office and distribute the remaining acknowledged copies as specified on the Form.

The Maintainer must apply approved blocking devices to the affected levers and attach "Rusty Rail" signs.

No alteration is permitted on the effective CT 405-11 Form. A new Form CT 405-11 shall be prepared for subsequent changes in rusted rail conditions as required, and handled in accordance with instructions.

Rule 11 of current issue of CT 405, governs operation under these conditions.

Note: When questionable shunting condition exists at remote location outside the territory of Maintainer having control machine, Maintainer in field and Maintainer of control location shall each complete Form CT 405-11 in quadruplicate and handle as specified on the Form.

152. When rails, switch points, or frogs are removed, the Maintainer must secure all signals governing movements over them, so that they will display their most restrictive aspects. When rails, switch points, or frogs are removed within limits of the approach circuits at automatic highway crossing protection, the Maintainer must take action to prevent unnecessary operation of such devices and provide for safe movement of highway traffic.

Except for minor replacements (one or two rails, frogs, or switch point), signal system must not be restored to normal service after rail renewal until it is known that the track is safe and that rust or other foreign material does not prevent shunting of track circuits. This requirement will be met if the Maintainer, after track is ready for service and after assuring himself that block is clear, connects the track relay and carefully observes its performance when trains are running through the block. The control wire should be held on the relay binding post so that relay can be quickly opened on the passage of train should rust, or foreign matter, prevent the relay from operating properly. The relay must be observed a sufficient number of times to positively in-

sure that it opens properly and remains open while the train is passing through the block.

Where turnouts are being constructed or renewed in signalled main track, signal governing movements over turnout must display its most restrictive aspect until the main track guard rail is correctly placed and spiked, all switch plates on the turnout side are fully spiked in correct position, the main track switch rail is spiked against its stock rail and the free end of the stock rail fastened to prevent movement. On completion of the above work, signal system can be restored to normal operation.

153. Track circuits shall be adjusted and maintained in accordance with C. & S. 34, or appropriate manufacturer's instructions for Audio Frequency Overlay Circuits and/or proximity type detectors as applicable. A check must be made of relay current, and cab signal axle current (in cab signal territory) when tracks are raised, cleaned, or welded rail is installed, to prevent over energized condition, loss of shunting sensitivity and decrease in broken rail protection.

154. In electric traction territory, before disconnecting leads of impedance bonds or removing rails, frogs, etc., care should be exercised to insure at least one return path for traction current is maintained. When making rail renewals etc., before rail is disconnected, a return path for traction current shall be provided by using a temporary bond, Plan E-413610 across the track each side of the rail section to be removed, making sure that no insulating rail joints interfere with this cross bonding circuit. Connections for electric traction return current shall not be made from one rail of a track to the rail of an adjacent track except between propulsion return rails where single rail propulsion return is employed.

155. (a) When cars are stored on a track protected by automatic block signals, the Operator or Dispatcher handling the movement must notify the Maintainer promptly advising him of the limits of the track on which traffic will be suspended as a result of the stored cars. When cars have been stored for 24 hours, the Maintainer will on normal tour of duty disconnect the wires to track at both the relay and feed ends of each track circuit within the limits of the stored cars.

(b) When the cars have been removed, the Maintainer must assure himself that the track circuits properly shunt and that signals function as intended, before restoring normal operation.

156. (a) When cars are stored within the limits of an interlocking or a control point, the Operator or Dispatcher will secure the affected switches and signals with approved blocking devices in accordance with Paragraph 12 of CT405. The Operator or Dispatcher must notify the Maintainer promptly advising him of the limits of the track on which traffic will be suspended because of the stored cars. When cars have been stored for 24 hours, the Maintainer will on normal tour of duty disconnect the wires to track at both the relay and feed ends of each track circuit within the limits of the stored cars.

(b) After cars have been removed, the Operator or Dispatcher must arrange for sufficient movement over the track circuit section to insure proper shunting of the circuits. When Maintainer has assured himself that normal conditions have been restored, he must so notify the Operator or Dispatcher, who may then remove the blocking devices. If normal conditions cannot be restored, Maintainer must comply with rusty rail instructions, Paragraph 151.

157. When stored cars will affect the circuits for highway crossing protection, approach locking, annunciators, etc., the Maintainer must take all necessary precautions to insure safe operations and to safeguard the highway crossings affected. When the cars are removed, the Maintainer must restore circuits to normal operation and protect crossing until he has assured himself the crossing protection is working as intended.

158. When stored cars are being removed from a storage track and the switch at the exit end of this track is interlocked or located near an interlocking, the levers in the route involved must be secured by blocking devices until movement is completed, to prevent improper operation that could result from rusty wheels failing to shunt track circuits

159. Bonding, including track circuit connections, shall be applied and maintained in condition to insure minimum resistance. Where bonds cross under rails of opposite polarity, they should be secured from movement by ballast or frost which would result in an inadvertent short circuit. Bonds and track connections should be arranged to minimize hazard to damage by track work. Care should be exercised in use of staples, nails, or equivalent fastenings employed to track connections or bonds to prevent possible short circuit to a rail anchor, rail spike, or opposite the hole in a tie plate where inserting a future rail spike is possible. As far as possible, track connections and cross bonding shall be installed and maintained so as to remain visible and clear of ballast when necessary to cross under a rail.

160. Both track wires employed for A.C. track circuits, cab signals, and overlay circuits shall be installed in the same conduit or cable to avoid excessive voltage drop or improper energization through inductive coupling. Track wires in cab signal territory should be paired and arranged so as not to provide a foreign or stray field to a cab signal pick up coil. Track wires shall be installed and maintained in such a manner as to protect them from mechanical injury.

161. Track leads for overlay type track circuits shall be paired and twisted with not less than one twist per foot. Track wire pairs with same frequency should be arranged to provide optimum separation, both in ground and in instrument case.

162. Audio-frequency track transmitters and receivers, or equivalent systems of like frequencies, must be separated by length of case, or be in separate housings, like frequencies on the same track should be separated preferably by two sets of insulated joints, but in all cases by at least one set. On the same track, a receiver of less than 8 khz must be separated from unrelated transmitters of the same frequency by a distance of at least 10 miles or by two sets of insulated joints.

163. Pipe lines under rail should be installed and maintained so as to provide at least one inch clearance under base of rail which forms part of a track circuit. Ballast shall be kept clear of signal pipe line to prevent mechanical interference with the free movement of pipe line and possible freezing of pipe line in the inter-tie space during winter weather (where welded rail is installed, care must be exercised to avoid skeletonizing the ballast support for ties).

164. When electric arc welding is to be performed on rails in track circuited territory or where arc welding is to be used in the vicinity of the track where welding currents may enter the rails, signals must be protected against

improper operation. Cable leads from each welding generator where used in vicinity of the track structure must be laid in pairs close together to prevent interference with track circuits through induction. Both cables (electrode and ground) must be completely and properly insulated throughout their length. Ground clamps employed for welding track structure must have full copper face for bearing against the web or base of rail to insure full and proper contact. The ground clamp must be applied to the rail being welded as reasonably close to the work as possible.

WIRES AND CABLES

200. In order to avoid the possibility of damage to insulation, wires must not be crowded or jammed. Wires must be protected from sharp edges. Wires must not be pulled around sharp corners or across sharp edges.

201. Wires and cables without metal sheath, in trunking and other open conduits, must be examined to detect physical damage, semi-annually in territory where trouble due to rodents has been experienced, and annually at other points.

202. Wires and cables shall be without splices as far as practicable. Splices, where necessary, shall be in accordance with approved instructions for the specific type of cable to which they are to be applied. Splices may be made in man-holes, junction boxes or in aerial cable.

203. Cable conductors shall be numbered from core outward. When making splices, conductor number one shall be joined to conductor number one, etc. When reading cables, face the conductors at each end, conductors at central instrument house end shall be read clockwise and conductors at function end, counterclockwise. Cables outside interlocking limits shall be read clockwise at the east or north end and counterclockwise at the west or south end.

204. Half splices of wires or cables are prohibited at any point for permanent construction. Branch connections shall be made in instrument cases, instrument houses, or terminal boxes.

205. Wires or cables entering interlocking buildings, instrument houses, or instrument cases shall be connected to terminals. Cables shall be terminated on a terminal board in conductor order, including spares. Conductor number one shall be placed at top or left-hand side of terminal board. All local wiring shall be installed on mating terminals and test links or straps employed to connect the cable conductors to the local wiring.

206. Jam nuts shall be used on threaded binding posts. Care must be used to avoid undue strain or damage to threads on binding posts, small machine screws and bolts.

207. Wire conduits or chase-ways must be installed and maintained to prevent mechanical injury to the insulated wires and cables. Vacant spaces in wire openings of instrument cases, etc., must be packed tightly with approved sealing material. Wire and cable openings through floors, and other wire ways which would act as a flue to spread any fire which might occur, must be sealed with approved asbestos cement.

208. Conduits and ducts between manholes or similar openings underground and junction boxes, instrument cases or similar housings above ground shall be sealed with an approved sealing compound to prevent cool damp air from entering housing and causing condensation.

209. Broken insulators supporting open wire signal circuits on pole line shall be replaced.

210. Guys shall be adjusted for tension annually, preferably in the fall of the year.

211. When poles are replaced, wires shall be transferred to the new poles promptly and old poles removed and disposed of.

212. Not more than two (2) wires shall be installed on an AAR terminal post. Two wires are permitted to be installed on relay posts of shelf or wall mounted relays.

213. The following cable make-ups will be standard for the uses indicated:

Stock Ref.	Make-Up	Use
02-089211	1 Cond. #9	Track connection wire for D.C. circuits.
02-089187	1 Cond. #6	Track connection wire for cab signals, coded track circuits, overlay track circuits.
02-090326	2 Cond. #6	Signal power distribution.
02-090359	2 Cond. #12	Marker lamp and switch lamp lighting.
02-090557	4 Cond. #9	Flashing light signals, color light signals.
02-090631	5 Cond. #9	Position light signals — automatic.
02-090680	7 Cond. #12	Searchlight signals, circuit controllers, snow melter.
02-090649	7 Cond. #9	Position light signals — interlocking.
02-090730	12 Cond. #14	Pneumatic switch machines.
02-090813	15 Cond. 3 #8 12 #14	Electric switch machines.
02-090748	17 Cond. 10 #9 7 #14	Short arm gates and flashers.
02-090763	19 Cond. #14	Express cable.
02-090920	27 Cond. #14	Express cable.
02-090953	37 Cond. #14	Express cable.
02-090110	#16	Wire, 19 strand, case and instrument wiring 2/64 insulation in accordance with C&S 83 covered by nylon braid.
02-090128	#10	Wire, 37 strand, case and instrument wiring for power and lighting circuits.

INSTRUCTIONS TO FOREMEN IN CHARGE OF LINE WORK

220. The prime responsibility for safe conduct of line work lies with the Foreman. He will also make sufficient inspection of the work site and sufficient observations of the men performing the work to insure that it is being carried out in a safe manner.

221. He shall determine when it is necessary to inspect an entire area before permitting men to commence work.

222. In addition to the Safety Rule for the day, he will discuss the work that is assigned for the day and what hazards may be encountered. At this time he will check his men for proper clothing for the work to be performed.

223. The Foreman will conduct periodic drills in bringing an injured man off a pole and the administering of artificial respiration.

INSTRUCTIONS TO ALL PERSONNEL ENGAGED IN LINE WORK

230. All linemen shall inspect the condition of poles and line, the location of power wires on the line and the location of wire line crossings before ascending the pole. Such inspection for potential hazards shall include a minimum of four poles, each side of the pole to be climbed and what precautionary steps are required to carry out the work safely.

231. After ascending the pole, a second inspection shall be made from this height advantage before work is started.

232. Groundmen shall not handle wires that are down until inspections are made and precautions have been taken so that work may be done safely.

233. Such precautionary measures may include:

- (a) Shutting off railroad power.
- (b) Installing protective barriers.
- (c) Requesting power company to shut off commercial power or to install protective barriers.
- (d) Using electrical protective gloves.

234. When working as a member of a group, each man will observe and protect against hazards for himself and other members in the group.

CHANGES AND TESTS INCIDENT THERETO

250. Alterations must not be made to any apparatus or circuits without proper authority. Plans for such changes must be obtained through the Regional Engineer—Communications and Signals.

251. All changes must be made under the supervision of a designated competent employee, who is personally responsible for work under Paragraphs 253, 255 and 257, and must know that the employees making wire changes and connections are thoroughly qualified for and have full understanding of the work assigned them. The man in charge must be responsible for the preparation of local wiring diagrams when required, on which must be clearly indicated the apparatus wiring, etc., that is in service and that which is to be added. Points at which new circuits tie in with those in service must be plainly marked.

252. At interlockings when changes are made that may interfere with the normal operation of the signal and interlocking system, the distant signals must be arranged so that they will not display an aspect more favorable than Approach and the switches spiked and wedged for all train movements until the changes are completed and checked. In cab signal territory, the cab signal aspect between the home and distant signal must not be more favorable than Approach.

253. Any necessary relocation of apparatus and wiring in service, either permanent or temporary, must be made under the personal direction of the man in charge, and all circuits interfered with in any way must be thoroughly tested immediately after relocation and before circuits are allowed to function for normal operation.

254. New apparatus must be located and new wiring placed and connected to the new apparatus, without disturbing work in service where possible.

255. Connections to wiring in service must be handled under the personal direction of the man in charge. All wiring tied in to existing apparatus and circuits must be tested before tying in, to insure no interference with work in service.

256. The man in charge must make necessary notations on wiring diagram or circuit plans to show any new wiring which is connected to working circuits or apparatus, and must clearly mark on his diagrams or circuit plans, connections required for final arrangement which cannot be made prior to cut-over without interfering with work in service. Wires which are to be connected at cut-over must be marked with yellow tags. Wires which are to be removed at cut-over must be marked with red tags. Wires which, for any particular reason, cannot be hooked up without special arrangement, must be marked with green tags. Wires bearing green tags must be connected only by the man in charge or under his specific instructions which

shall definitely state that "green tag wires" are to be connected. On completion of changes, all colored tags must be removed. Wires taken out of service shall be removed or ends cut back to a safe position.

257. Before final cut-over, all circuits changed must be thoroughly tested as far as possible, and final arrangement must be tested in entirety by a supervisory employee other than the man in charge.

258. When a revision involves additional levers or levers taken out of service in a machine, such levers must be secured against improper or unintentional operation.

259. The men engaged in making or testing circuit changes must have full understanding with Operator or Dispatcher as to any interference with working units, must obtain permission for necessary use of switches or signals, and must secure switches in accordance with Paragraph 407. The man in charge of changes must cooperate with Maintainer so that the latter may be posted at all times as to the condition of the plant. All signal testing and circuit changes must be in accordance with the other provisions of C. & S. 23 and C. & S. 27 insofar as they apply.

260. To provide a check against misunderstanding, when the man in charge directs another to close or open wire connections to wiring or apparatus in service, he must state specifically what is required, using wire number or other definite description, and when possible, must indicate on the circuit plan or the wiring diagram the connection that is to be closed or opened. If the open circuit is protected by a green tag, the man in charge must so state. The one who is to carry out the instruction must repeat the order exactly as received, must not attach wires protected by green tag unless specifically directed, and after carrying out the order must advise in detail, using wire numbers, or other definite description, etc.

261. When circuits are to be closed only for test, the one assigned to this work should preferably remain at that point until the test is completed and then again open the circuit, reporting to the man in charge the exact conditions. The man in charge must, at the earliest opportunity, and before leaving the work, verify the conditions as reported.

262. New wiring to working apparatus, relays or circuits must be secured or insulated from making inadvertent contact with circuits in service.

RELAYS AND CIRCUIT CONTROLLERS

300. The inverting of relays or otherwise tilting them in order to close the contacts is prohibited.

301. The bridging of contacts on relays, indicators or any circuit controlling device, or energizing relays or indicators direct from any source, which will in any way impair the protection of such circuit controlling device, must be done in accordance with the following instructions:

(a) The use of jumpers for the bridging of contacts is restricted to cases of absolute necessity, as when a switch and signal wire or apparatus is damaged, resulting from a wreck, dragging equipment, or similar occurrence; when necessary in connection with tests specified in C. & S. 27 and when renewal of track structure cannot be taken care of otherwise and then only to avoid unnecessary delay to trains. Generally, jumpers must not be used in connection with ordinary maintenance.

(b) When a condition arises which necessitates the use of jumpers, their use must be authorized by the Supervisor or Assistant Supervisor after receiving authority from the Division Superintendent.

(c) Before jumpers are applied to bridge any contacts or to energize a relay or indicator by power direct, from any source, either within or outside of interlocking limits, the Communications and Signal employee authorizing the placing of the jumpers must obtain the approval of the Division Superintendent. Whenever authority is received from the Division Superintendent for the application of jumpers, the Train Dispatcher or Train Director must make notation on the train sheet and the Operator on the block sheet, and a blocking device placed on each interlocking switch and signal lever affected. Before jumpers are placed in territory outside of interlocking limits, the Operator on each side of the location affected by the use of jumpers must in addition to the Train Dispatcher or Train Director, have full knowledge that jumpers are to be applied and notations on the block sheet of their application must be made. When jumpers are used, either within or outside of interlocking limits, the Operator must make a message memorandum of the condition, explaining it to the Leverman, and post the memorandum in a conspicuous place. If going off duty while the abnormal condition exists, he must bring it to the attention of the Operator and Leverman who relieve him, fully explaining the condition to them. The memorandum sheet must not be filed until the Communications and Signal employee authorized to use jumpers has reported that normal conditions have been restored.

(d) When a Communications and Signal employee is instructed to place jumpers, he must remove jumpers immediately after the emergency ceases, and then he must report to the party giving the authority for the application of the jumpers that they have been removed, advising that normal conditions have been restored. The employee securing authority from the Superintendent for the application of jumpers must advise the Train Dispatcher or Train Director, and any other interested employee, that the jumpers have been removed and the switch and signal circuits restored to normal condition. Notation must be made by the Train Dispatcher or Train Director on the train sheet, and by the Operator on the block sheet, of the removal of the jumpers.

(e) The Communications and Signal employee securing authority for the use of jumpers must make sure that

they are not used for a longer period than necessary. The Communications and Signal employee authorized to apply the jumpers will be held personally responsible for their proper application and removal and must know that the switch and signal circuits have been restored to normal condition.

302. When applying jumpers for testing power line in A.C. automatic signal territory two or more qualified employees must cooperate in their application and all must know that they have been removed.

303. Jumpers must not be less than eight (8) feet in length, of flexible wire not smaller than No. 16 A.W.G. and must not be coiled when applied.

304. The greatest possible care must be used in applying a jumper to keep to a minimum the amount of protection cut out by its use.

NOTE: The intention of these instructions is twofold; first, to guard against improper use of jumpers; second, to insure their removal, even though precautions have been taken to render conditions entirely safe during their use. These instructions, therefore apply regardless of whatever else may be done; such as disconnecting circuits, setting signals at "Stop," securing switches and levers, or other precautionary measures.

305. The insertion of insulating material between the contacts of circuit controllers to prevent shunting of track circuit, or the insertion of similar material in other contacts, which would in any way impair any protective feature of any circuit, is prohibited.

306. The seals on relays and other similar apparatus must in no case be broken except by an authorized person. Relays or similar apparatus removed from service, due to defect, must have a tag (C. & S. 46) attached, stating defect, if known, and marked "not fit for service." They must not be used again until a tag (C. & S. 45) is attached by Testman or Inspector stating "O.K. for service."

307. Where contacts are visible, contact openings must be observed frequently and if found more or less than normal, or otherwise defective, apparatus must be replaced.

308. The following relays must operate as indicated for the normal position—where signals are controlled, the normal position must control the "clear" position of the signal.

(a) Model 15 Vane Relay—Vane must be up.

(b) Style TV-30 Relays—Vane must rotate counterclockwise.

(c) D.C. Polar Relay:

1. With polar armature operating in a horizontal plane—contacts must rotate counterclockwise, viewed from above.

2. With polar armature operating in a vertical plane—contacts must rotate clockwise, viewed from the front.

309. All circuit controllers must be kept clean and properly adjusted, and the original sets or bends of contact springs must, as far as possible, be maintained, and any excessive setting or bending which may produce an unsafe condition is prohibited.

310. When work is being done on polarized circuits, only one wire must be off the binding posts at a time, or wires

and posts must be clearly marked to avoid any possibility of reversing the polarity of the circuit.

After wires are restored, necessary checks must be made immediately to determine that all affected facilities are working properly.

MOVABLE BRIDGES

350. Rail locks must be adjusted so that they cannot be locked unless the track rails on the movable span are within three-eighths inch of correct surface and alignment with the rail seating device on bridge abutment or fixed span.

351. Circuit Controllers, operated by track rails on movable span, must be kept so adjusted that the circuit will not be completed unless the track rails on the movable span are within three-eighths inch of correct surface and alignment with rail seating device on bridge abutment or fixed span.

INTERLOCKING, TRAFFIC CONTROL SYSTEMS, AND SWITCHES

400. Communications and Signal Department employees must not operate controls of an interlocking or remotely controlled signal facility except for test and inspection purposes or in an emergency and then only after a definite understanding is had with the Operator on duty in the interlocking or control station.

401. When parts of switch layouts, which may affect the adjustment and locking of the switch, are repaired or replaced, or when adjustments are made in accordance therewith, obstruction test in accordance with Test 13, C. & S. 27, must be made before switch is restored to normal service.

402. Plungers and locking dogs must be full size at locking end. Corners at the ends of plungers and locking dogs, and the edges of openings in lock rods, must be kept sufficiently square to meet the requirements of Form M.W. 41, Switch Inspection and Test Report. The small openings in lock rods must not exceed the width of the rectangular locking dog or plunger by more than three-eighths inch.

403. Where it is required that switches or derails be mechanically locked in one position only, the lock rod must be arranged with one locking opening only.

404. Holes in lock rod shall have square edges and be not more than one-eighth inch larger than round plunger.

405. When for the purposes of maintenance or repair, or when notified a unit is inoperative or disconnected, the Maintainer must determine that approved blocking devices have been applied to the controlling lever or levers. When necessary to apply Blocking Devices on levers of electro-mechanical machines, they must be applied to both large and small levers.

406. When necessary to disconnect a switch, movable-point frog or derail (hereinafter called switch) from its operating mechanism, or to disconnect No. 1 switch rod, the following, as part of providing complete protection for trains, must be done:

(a) The closed point must be held securely against the stock or knuckle rail, by a spike driven in each of the first two ties back of the point, and on 45 ft. switches at the midpoint, and where possible the spikes must pass through the tie plates.

(b) A standard wooden wedge, Plan C. & S.-521, must be driven between the open point and the stock or knuckle rail and be secured by, (1) a lag screw or heavy nail through one of the clip bolt holes, or (2) a piece of wood spiked to the first and second ties ahead of the point, or (3) a light flat headed bolt through a hole in the wedge adjacent to the side of the first tie under the point and between this tie and No. 1 or head rod. The bolt must be secured in place by a cotter pin or split key below the bottom of wedge.

(c) If necessary to disconnect both No. 1 and No. 2 switch rods, train movements must not be made over the switch until one or both rods are properly connected to the switch points and the switch has been secured in accordance with Paragraph 406(a) and (b). If the open point is removed, trailing movement may be made after the closed point has been secured in accordance with Paragraph 406(a). For facing movements, end of lead rail must be moved away from the running rail to provide at least five inches clearance and be provided with a riser wedge fastened to the tie and movements made at restricted speed.

(d) If necessary to disconnect the Track Department switch rods of a switch in an interlocking, or if switch is in automatic territory, or is connected with a distant switch signal, the work must be done under the direction of the Track Foreman in cooperation with the Maintainer.

(e) If switch is in an interlocking, the following must also be done:

1. The locking dog or plunger must be inserted through lock rod if possible.
2. The controlling lever of an interlocking machine, or the lever in a Traffic Control System Machine, must be placed in the position corresponding to that of the switch. Interlocking or TCS Machine levers must be secured by lever blocking devices which must not be removed nor levers operated until instructions to do so are received from the man in charge.
3. The power for power-operated switches must be cut off.
4. At a pneumatic switch a blow-off cock or union must be opened to prevent possible accumulation of pressure through leaky valves.
5. Power-operated switches must be kept spiked and wedged until the power is again turned on so that an accidental change in the position of the valves or controlling apparatus or connections cannot cause the switch to go to the wrong position.

(f) When necessary to disconnect switch, derail, or other unit, it should be done at the crank nearest the unit.

407. When necessary to disconnect or impair function of locks, circuits, or other safeguards in an interlocking, all switches affected must be safely secured before any train or engine is permitted to pass over them, as follows:

(a) The closed point must be held against the stock or knuckle rail by a spike in the head tie, and on 45 ft. switches, at the mid-point; where possible, the spike must pass through the tie plate.

(b) A standard wooden wedge, Plan C. & S.-521, must be driven between the open point and the stock or knuckle rail.

(c) No movements are to be made over switches affected without the consent of the man in charge, and he must, upon completion of repairs, test levers by manipulation before surrendering jurisdiction over the machine.

408. Should any of the apparatus referred to in Paragraphs 406 and 407 fail to function properly, Operator shall restore any power operated switch lever, which, after several trials, has failed to go to the desired position, as far as possible toward the original position where it shall remain until instructions are received from the Maintainer. If no Maintainer is available, Operator shall notify the Superintendent and be governed by local Divisional instructions. If, on electric switches the ammeter indicates excessively heavy current the lever shall be placed and left in the center position, except at electric interlockings where master controllers are used.

Unless the failure is very clearly of such a nature that repairs can be made by the Maintainer in less time than necessary to secure the switches in accordance with Paragraph 407, the units involved must be secured in accordance with these instructions except that where, due to excessive distance from the switch to the control point, it is impracticable to get the lever to correspond with the position of the switch, the lever must be put as far as possible toward the desired position and lever blocking device applied.

409. Electric locks on conventional type interlocking machines shall not be released manually nor lock circuits on relay type interlockings or traffic control points nullified, except in cases of emergency, or when necessary on account of repairs and then only upon authority of the Supervisor. Whenever an electric lock is released manually or an electric lock circuit nullified, notation must be made by the Train Dispatcher on the train sheet and by the Operator on the block sheet. Maintainer must make a detailed report on Form C. & S. 4. After authority has been received to release an electric lock or nullify a lock circuit, the following precautions must be taken:

Signal Indication Locking

(a) If a signal lever cannot be restored to its normal position on account of the signal indication lock or relay holding, the lock or relay must not be released until the Maintainer or Operator knows that all signals directly controlled by the lever are in "Stop" position and all signals governing the approach to these signals are in their normal or a more restrictive position, except where the following precautions are taken:

1. If the Maintainer or Operator knows that the home signals controlling the affected lock or relay are in the "Stop" position, an arrangement may be made by the Superintendent to notify all trains governed by the distant signal controlling the lock or relay affected that the signals are out of order, and to proceed as though the most restrictive aspects were displayed, until examination has been made. Lock or relay may then be released.
2. Examination must be made as soon as possible to determine whether the lock or relay failed to release on account of signal failing at more favorable than its normal position or because of a defect in the indication circuit.

Switch Indication Locking

(b) Indication locking for a switch, derail, or movable point frog must not be manually released until the switch,

derail or movable point frog has been safely secured and checked as per Paragraphs 406 or 407.

Switch Lever Locking

(c) Electric (detector) locks on switch levers or switch locking relays must not be released until it is known that the signal displays its most restrictive aspect and that a train or engine has not accepted the signal and that the route is not occupied or fouled by a train, engine or car. Signal more favorable than Restricting (Rule 290) must not be displayed until the track has been inspected, unless the switch lever or track occupancy lights show that the track is clear.

Traffic Lever Locks or Traffic Relay Circuits

(d) Traffic lever locks or traffic relay circuits may be released manually only after arrangements have been made with the Division Superintendent to safeguard the movement of trains in the territory affected.

Electric Locks on Hand Operated Switches

(e) Electric locks on hand operated switches may be released by hand after permission is obtained from the Division Superintendent.

410. Machine parts, connections and devices affecting the operation of mechanical locking must be renewed as frequently as necessary to insure reliable operation.

411. Quick switches must not be operated by hand for the purpose of permitting lever to be restored to previous position in the event of failure.

412. Quick switches must be regularly inspected for proper clearance and so maintained as to insure that the toggle springs are intact and have proper tension and that there is no binding to prevent free operation.

413. Quick switches must operate after the lever is moved beyond the indicating point and before it reaches a point $\frac{3}{16}$ " from full normal or reverse position, measured by inserting a $\frac{3}{16}$ " gauge between lever and quadrant stop.

414. The spring combination on electro-pneumatic, electric and similar machines and the adjustment of contact springs and bands with relation to indication and electric locking must be carefully maintained as follows where applicable:

(a) Only contact springs with a sharp (V-shape) bend instead of a gradual curve at contact point must be used, and the main stem of the spring must be straight so that any accidental bending during cleaning, or otherwise, will draw back rather than push forward the point of contact. All springs must be secured to the insulating bed plates by bolts that pass through the bed plate, and not more than two wires are to be connected to the same spring combination terminal post.

(b) Contact bands and springs must be cleaned periodically by wiping thoroughly with a clean dry cloth free from lint. Approved commercial cleaning cloths or chamois, moistened with oil, must be used as necessary to maintain clean contacts. Oil must be used very sparingly at relatively long intervals on the roller shaft bearings and must never be used on the bevel gears.

(c) Contact and roller surfaces which inadvertently become covered with an oil film must be cleaned by wiping with a clean cloth free from lint, to which a small amount of approved cleaning fluid has been added. These surfaces must then be rubbed carefully with a clean dry

cloth, free from lint, to remove all traces of the cleaner and any remaining residue.

(d) Contact part of springs must meet the contact bands evenly and squarely in order to provide maximum contact. They must have sufficient pressure to provide good contact, but not enough to interfere with proper operation, especially of the quick switch. Checks must be made at least annually to insure that all springs are closed or opened at the proper point in the lever movement.

(e) On levers with 60 degree roller travel, the normal and reverse switch control bands and NX and RY bands, for the control of switch repeating relays, must be on enlarged roller sections.

415. The use of oil on latches, segments or trunnions of electric locks is prohibited.

416. Employees must not unlock switches that will in any way affect trains closely approaching or passing. Non-interlocked switches in main tracks, or leading to main tracks, when not in use, must be locked in normal position.

417. Authority must be obtained from the Division Superintendent before performing any work on a hand operated switch that will affect the signal system or the safety of train operations.

418. Air distribution system shall be so maintained that leakage in any section of the plant will not exceed one pound in one minute from normal pressure with all apparatus connected and at rest.

419. Air strainer used between air distribution system and air apparatus shall be cleaned frequently enough to avoid air pressure reduction. Chemical in air dryer shall be probed with steel bar at a frequency sufficient to prevent pellets from forming a solid mass.

420. Where circuits are not arranged as provided on Plan C. & S-862, the following action is prescribed:

At electro-pneumatic interlockings with unit compressors, where low air pressure alarms are provided, the alarm shall be set 5 pounds below the cutting-in pressure of the compressors to provide as much time as possible between the alarm and the action as herein provided.

In the event of air alarm, switches shall be placed normal or in position most likely to be needed and no further operations made until pressure is normal or Maintainer is on the ground.

At interlockings where all of the switch mechanisms are Style A-5 or A-1, equipped with friction locks, operated by cut-off type valves with restoring circuits, the operation of switch levers shall be discontinued when the air pressure is below 45 lbs., unless there is a Maintainer on duty to assist in moving the switches. At such places, when the air pressure is below 20 lbs., trains shall be stopped at home signals. Proceed signals may then be displayed. If switches are secured in accordance with Paragraph 407, proceed signals may be displayed without stopping trains.

At Interlockings where there are any No. 14 or motion plate type switch mechanisms in service, the operation of all switch levers shall be discontinued when the air pressure is below 80 lbs., unless there is a Maintainer on duty to assist in moving the switches. At such places, when the air pressure is below 35 lbs., no train movements shall be made over any of the switches until they have been secured in accordance with Paragraph 407. After switches are secured, proceed signals may be displayed without stopping trains.

421. The use of Model 9 or T20 hand-operated switch machines is restricted to cab signal territory, electrified territory and in territory where trains exceed 70 MPH. Hand-thrown switches in territory other than above shall be equipped with an approved M of W switch stand and, if required, a circuit controller.

427. Derails may be pipe-connected to main track switches. Where derails are installed and are not pipe-connected to the main track switch in automatic signal territory, the derail must be equipped with a circuit controller so connected that the signal protecting the main track switch will display its most restrictive indication when the derail is not in derailing position. Crossovers between main tracks may be protected by a center-throw lever bolt locking arrangement or equivalent electrical circuitry.

CAB SIGNAL SYSTEMS

463. Test circuit or test loop for cab signals shall be maintained in good condition and current in same properly adjusted.

464. Test loop for cab signals shall not be installed in signalled territory unless authorized by the Chief Engineer—Communications and Signals.

HIGHWAY GRADE CROSSING PROTECTION

500. During snow or sleet storms, when conditions warrant, a check must be made of all electric crossing gates, and snow or ice sufficient to interfere with proper operation of the gates must be removed.

501. (a) Gate arm torque adjustment must be checked each time that any change is made in gate arm, location of gate arm lamp, or any other alteration affecting the total weight of the assembly.

(b) Gate arm position must be properly adjusted to avoid a drooping gate arm when down and to avoid the possibility of travel beyond the desired raised position.

(c) Gate arms must be checked when in the raised position to avoid the possibility of arm fouling on wires, cable, trees, etc.

(d) Lubricants per C. & S. 40 or in accordance with manufacturer's recommendation must be used.

502. When automatic highway crossing protection fails to properly indicate approach of trains, manual crossing protection must be provided promptly and maintained until necessary repairs are made.

503. When there is an accident at a crossing protected by automatic highway crossing protection, manual protection must be provided as soon as possible. The Maintainer must make necessary observations and tests, to determine if the protection is working properly, and report conditions to the Supervisor, and be governed by his instructions. The Maintainer should, if possible, obtain the name and address of the person or persons injured, also the license number of the vehicle involved, and of as many witnesses as possible.

TRAIN INSPECTION DEVICES

525. Snow, ice or any obstruction shall be kept clear of detectors so that there will be no interference to the proper functioning of the detecting devices.

526. Self-restoring dragging equipment detectors shall be inspected monthly and after derailed equipment has passed over them to insure proper operation.

527. Self-restoring dragging equipment detectors shall be lubricated, cleaned and any loose parts made secure every three months.

528. Wheel checkers shall be inspected at least once every two weeks and on regular tour of duty following each actuation to insure proper operation. Detectors shall be gauged, loose parts made secure, and worn parts replaced at time of inspection.

529. Hot box detectors shall be maintained in correct gauge and alignment and kept free of snow, ice, and other debris which could affect their operation. Specific tests in accordance with manufacturer's instructions and/or C&S 27 to insure proper operation shall be made.

530. Hot box detector tapes shall be observed as often as practicable and scanned for any indication of a malfunction of the hot box detector or telemetry equipment.

531. High load detectors, wheel checkers shall be maintained in accordance with manufacturer's instructions.

BATTERY CAPACITY FOR SIGNAL FUNCTIONS

549. The following battery sizes will be used for the signal functions shown. Exceptions to this standard may be granted by the Chief Engineer—C&S to cover installations having unusual requirements:

(a) Switch Battery—80 AH for both H.V. and L.V. machines.

(b) Central Instrument House—Based on approach lighted signals—240 AH.

(c) Home Signal Locations and Automatic Locations—Where approach lighted 160 AH—Where constantly lighted 240 AH.

(d) Code System Battery—240 AH for both office and field location.

(e) Gates and Flashers—240 AH.

(f) Flashers Only—240 AH.

(g) Overlay Transmitter Locations—Up to 2 transmitters 80 AH—Over 2 transmitters 160 AH.

(h) Overlay Receivers—Island Circuits—For 2 receivers 80 AH—Over 2 receivers 160 AH.

(i) Overlay Receivers—Harmon Motion Detector—For 1 track 80 AH—For 2 or more tracks 160 AH.

(j) Marquardt Motion Sensor or GCP—200 AH/unit.

(k) Track Cells—Conventional DC, coded track 120 AH.

BATTERIES IN FLOATING OR TRICKLE CHARGE SERVICE

Note: Floating charge—A continuous input of current to a storage battery.

Trickle charge—A continuous input of current to a storage battery to compensate for internal losses only.

Batteries connected directly across rectifiers and load are under floating charge.

Batteries connected across rectifiers but to the load only when alternating current power supply is off are under trickle charge.

550. Jars or containers must be kept clean, level, and as dry as practicable.

551. Trays and supports must be kept clean, dry, and in such condition as to prevent surface leakage of current.

552. All connections must be kept clean and tight. Exposed brass or copper battery connections must be kept covered with a thin coating of vaseline, No-ox-id or equivalent.

553. Battery housings or compartments must be kept clean and dry and when batteries are located in a building, ventilation must be provided. Where the inside is of wood or metal, it must be painted with acid-resisting paint.

554. Ventilating filling plugs must be maintained, properly secured in each cell.

555. Hydrometers and syringes must be properly protected against breakage and against injurious effects on the apparatus from acid. Separate syringe must be used for each type of battery.

556. Distilled water, or water approved for use in batteries, must be kept in covered glass, plastic or porcelain containers, which must not be used for other purposes.

557. After tests and readings have been completed, water must be added, if necessary to maintain proper solution level. When water is added in cold weather, solution must be agitated by use of the syringes to prevent freezing.

558. Meters shall be checked for accuracy if readings are questionable.

559. An exposed flame must not be allowed near a battery, as the gases being given off may explode. Care must be exercised in the use of tools near battery terminals to prevent striking an arc. To prevent drawing an arc when connecting or disconnecting cells, the load and charging circuits must be disconnected at a point away from the battery.

Lead Acid Type Batteries

560. Careful visual inspection must be made to detect broken, cracked or buckled plates, misplaced separators, or undue accumulation of sediment and for proper height of electrolyte.

561. Each headquarters, where batteries are maintained, must be equipped with a hydrometer, a voltmeter and a thermometer with a temperature correction scale based on a normal of 77° F., designed for use with lead cells. Voltmeter must be checked frequently for calibration.

562. Hydrometers, thermometers or utensils which have been used on other than lead acid cells must not be used.

563. When battery is being charged, enough ventilation or space must be provided to avoid pocketing of the gases.

564. If electrolyte is spilled or surrounding parts are damp with acid, a solution of baking soda in the proportions of 1 lb. of soda to 1 gal. of water must be applied, after which the parts must be rinsed with water and dried. The soda solution must not be allowed to get into the cells.

565. Soda solution or ammonia should be used promptly on clothing, cement, etc. to neutralize acid. If acid comes in contact with the skin, it should be washed away promptly with plenty of water.

566. Cells must be shipped to Storehouse or Installation Point in fully charged condition.

567. Cells must be unpacked carefully, keeping them in upright position. **CELLS MUST NOT BE LIFTED BY POSTS OR COVERS.**

568. After unpacking, electrolyte in cells must be examined to determine that it is level with upper mark on jar. If electrolyte is below this point add distilled or approved water unless there is evidence of spillage, in which case add electrolyte, the specific gravity of which must be the same as that of other cells of the same shipment. If electrolyte level is lower than 1/2" below the tops of the plates, the cells may be permanently damaged. Evidence of damage will be indicated by failure of cells to respond to the treatment outlined in Instruction 578 or failure to meet requirements of test outlined in Instruction 589. If water is added during freezing weather the cells must be given a charge to mix the water with the electrolyte to prevent freezing.

569. If a shipment of cells is not to be unpacked at once, remove the lid from the packing case and check for electrolyte level and proceed as in Instruction 568.

570. Cells must not be allowed to stand idle for more than 30 days. They must be floated continuously at a rate which will maintain an approximate voltage of 2.15 or charged periodically. A freshening charge should be given just before sending cells out for installation. A freshening charge consists of a continuing charge at one half of the 8 hour discharge rate as long as the specific gravity of the lowest cell shows any increase and then for six hours after the last increase is shown. If the charge rate is much lower

than the 8 hour rate, the three hour period should be lengthened in proportion. The minimum rate for a freshening charge should be at least $\frac{1}{8}$ of the 8 hour rate.

571. Before connecting cells, all surfaces which are to be bolted together must be scraped bright and then coated with pure vaseline or terminal grease supplied by the manufacturer. Vaseline or terminal grease must also be applied to the studs of the bolt connectors. Cells must be connected with standard intercell connectors and care must be used to avoid having any strain on either connectors or terminals as a strain may eventually cause breakage. If standard intercell connectors are not available, rubber covered wire may be used. Wire larger than No. 12 A.W.G. must be stranded or flexible. To hold strands together when stranded or flexible wire is used, the eye must be soldered. After connections are made, surplus vaseline or terminal grease must be wiped off.

572. A permanent number, preferably stenciled on rack, must be assigned to each cell starting from the positive end of the battery.

573. Cells must be arranged so that the positive terminal of one cell adjoins the negative of the next. Cells must be so placed that edge of plates will be to the front.

574. Cells must be separated from each other and from contact with sides of battery shelter. Cells must be held in place to prevent movement which may cause breakage of intercell connectors or battery terminals.

575. After intercell connections are completed the voltage of each cell must be taken to determine that the positive terminal of each cell is connected to negative terminal of adjoining cell.

576. Connections must be arranged so that the positive terminal of the rectifier or charging source will connect with the positive terminal of the battery. Direct current only must be used for charging.

577. The specific gravity of the electrolyte of each cell must be tested to determine that it is within the limits of 1.190 to 1.220 at 77° F. If the specific gravity (corrected for temperature) of any cell is found to be below 1.190 at 77° F., the cell must not be placed in service until given a complete charge. Specific gravity readings are corrected for temperature by adding or subtracting points as indicated on the temperature correction scale of the thermometer or by subtracting .001 for each 3° F. below 77° F. or adding .001 for each 3° F. above 77° F. For Exide Manchex cells, a complete charge is not required until the specific gravity is below 1.175 with the solution level at the upper line. On Manchex cells, a change in electrolyte level of $\frac{1}{4}$ " will result in a $\pm .008$ gravity correction.

578. After installation, cells must be charged at the maximum rated output of the rectifier and this charging rate continued until cells are fully charged. The voltage and specific gravity (corrected for temperature) of each cell must be recorded on Battery Record Card each week during original charge. Cells are fully charged when three equal consecutive voltage readings are obtained in excess of 2.25 volts per cell together with three equal consecutive specific gravity readings of 1.210 or higher (corrected for temperature). At convenient intervals thereafter, the output of the rectifier must be reduced in small steps until the voltage directly at the cell terminals generally stays between 2.10 and 2.20 volts per cell or averages 2.15 volts. The voltage may vary above or below these limits according to traffic

conditions, power interruptions or electrolyte temperature but, should not be continually above or below these limits except in cold weather when the voltage during the continuance of low temperature may be allowed to increase to the following values:

<u>Electrolyte Temperature °F.</u>	<u>Volts per Cell</u>
60	2.19
50	2.22
40	2.26
30	2.30
20	2.33
10	2.37
0	2.4

Cell voltage readings are taken with rectifier connected and charging at the normal float rate. The specific gravity (corrected for temperature) must be maintained at 1.210 or higher.

579. After proper charging rate has been established, specific gravity and voltage readings corrected for electrolyte temperature shall be taken of each cell in the spring and fall or as required by special conditions and recorded on battery record card. The temperature of the electrolyte in a pilot cell may be considered as the temperature for all similar cells in the same housing.

TWO RATE CHARGING INSTRUCTIONS FOR LEAD ACID CELLS

At many locations, the discharge from the signal battery is irregular and varies over wide limits. An example would be a switch operating battery where the discharge varies considerably depending upon traffic and the number of times the switches are operated. Such variable loads make it difficult to adjust the charging rate to an average value that will maintain the battery in a fully charged condition and yet not overcharge it excessively.

To overcome these difficulties, a two rate charge control relay may be used to periodically initiate a high-rate charge when the relay is deenergized and to transfer to a low-rate charge when the relay picks up as the battery approaches its fully charged condition. This will insure rapid automatic replacement of discharge from the battery under varying load conditions. In addition, the pick up characteristic of the relay is compensated for temperature and is similar to the "Voltage versus temperature" characteristic of a lead battery on charge and approaching a fully charged condition. The voltage of a lead cell decreases as the cell temperature increases and the two rate charge control relay is designed with inverse temperature characteristics which decrease the overall relay resistance and thus lower the pickup voltage with a temperature increase.

The two rate relay should be selected according to the number of cells in the battery.

For proper operation, the relay should be located so that it will be subject to the same ambient temperatures as the battery. The relay is connected across the battery through a suitable means for opening the circuit when an increase in charge is called for. The rectifier used should have sufficient output capacity to supply the normal load plus a high charge rate of not less than 10% of the battery 8 hour rate.

The back contact of the relay shunts a resistor in the charging circuit, thereby establishing the high rate. The high rate will be applied until the battery becomes suffi-

ciently charged to cause the relay to pick up and remove the shunt, thereby establishing the low rate. The resistor used must be of sufficient capacity to carry the low rate charging current.

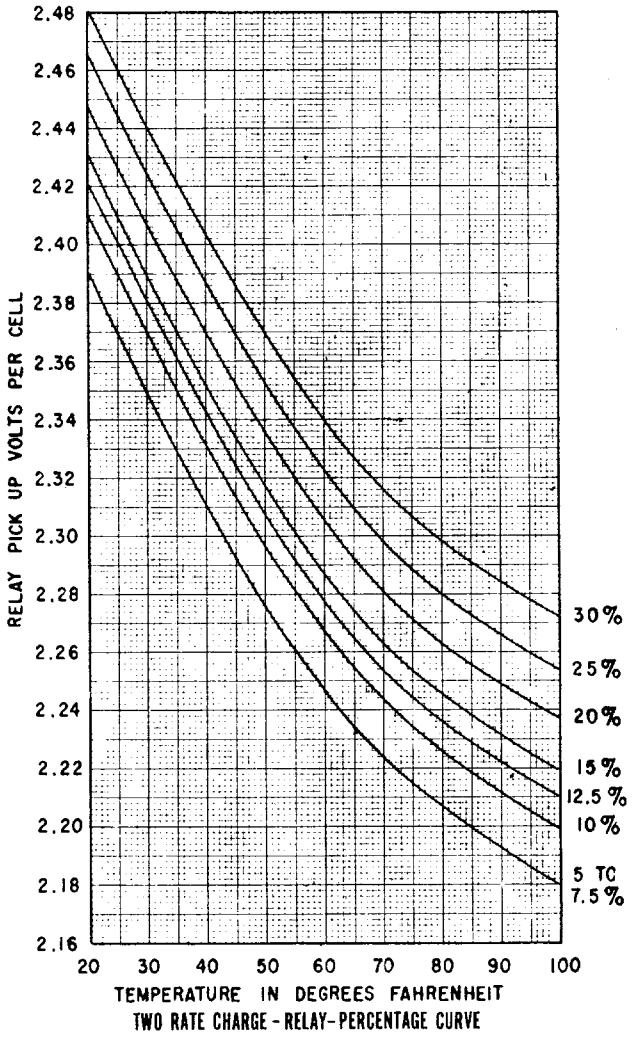
When making adjustments, the ammeter should be connected so as to read only that part of the current going into the battery and the voltmeter connected directly across the terminals of the battery. When adjusting the low rate, the voltmeter should be disconnected.

- (1) Calculate the 8 hour charge rate of the battery. (The 8 hour ampere hour capacity divided by 8.)
- (2) With the coil circuit of the two rate relay open, charge the battery at the rated output of the rectifier to a voltage of 2.15 volts per cell. Continue the charge until the cells gas freely and the specific gravity stops rising. The voltage will rise above 2.15 volts per cell and the charging current will decrease.
- (3) Adjust the final high-rate charge to approximately 10 to 30 percent of the 8 hour rate and record this final charging current for use in calculating the pick up value of the relay in (5). The higher rate is preferred for rapid recovery.
- (4) With the two rate charge relay in the energized position and with bus load at normal steady value, adjust the low rate charge by means of the adjustable resistor until a value is obtained which will supply the battery losses. (These losses may be assumed to be approximately $\frac{1}{2}$ of 1 percent of the 8 hour rate at 68°F.)
- (5) Calculate the percentage relation of the input current to the 8 hour rate.

$$\frac{\text{Battery input amperes (3)}}{\text{8 hour rate amperes (1)}} \times 100$$

- (6) Refer to the percentage curve on Page 28 nearest to but not in excess of the percentage obtained in (5) above. Knowing the electrolyte temperature, a point on the curve may be obtained at which the relay pickup voltage per cell can be established. This voltage multiplied by the number of cells will give the voltage value at which to set the pick up of the charge control relay.
- (7) Adjust the pick up of the charge control relay by turning the adjustment so as to increase the relay pick up to a value greater than the voltage present across the battery. Next turn the adjustment slowly in the opposite direction, decreasing the pick up value until the relay will just pick up at value determined from (6) above.
- (8) Connect all wires to relay and test operation by slightly discharging the battery, then tripping the two rate relay. With the high-rate charge applied, the relay should pick up as the battery voltage reaches the value determined in (6) with the current as determined in (3).
- (9) Battery should be tested for specific gravity periodically after installation to insure that it is being kept fully charged and that the relay is operating properly.
- (10) Example:

40 A.H. battery \div 8 hours = 5 amps (8 hour rate)
 Set high rate at 20% of 8 hour rate = $5 \times .2 = 1.0A$
 Set low rate at $\frac{1}{2}\%$ of 8 hour rate = $5 \times .005 = .025A$
 With electrolyte temperature of 65° F. a cell voltage of 2.29 is read from the 20% curve.
 Relay pickup = $2.29 \times 60 = 137.4$ volts.



580. If, upon regular inspection, the specific gravity reading is found to be more than 15 points below normal as indicated on the record card, (25 points for Manchex) proceed as outlined in Paragraph 578.

581. If the battery is floating at approximately the correct rate, a slow stream of gas bubbles will be noted rising from the top corners of the outside negative plates but large bubbles will not be gathering and breaking at the surface of the electrolyte. The positive plates will be dark in color. Formations of gray or white spots on the edges of the positive plates are indications that the cell may not be in good condition and requires attention.

582. Too frequent adjustments of rectifier outputs must not be made. It is unnecessary to take or record the output of the rectifier except in case of adjustment.

583. A lead plate storage battery requires a certain amount of current input to overcome loss of charge due to internal local action. This current input varies with the type and size of cell and with the temperature of the cell. As example a 120 ampere hour capacity battery (at the 8-hour rate) requires about:

.050 Amp. at 50° F.	---	.112 Amp. at 80° F.
.066 Amp. at 60° F.	---	.160 Amp. at 90° F.
.088 Amp. at 70° F.	---	.220 Amp. at 100° F.

584. The capacity of lead storage batteries decreases with decrease of temperature of cell and batteries should be protected from extreme heat or cold, as a change from 77° F. to 20° F. will decrease capacity of battery about 30%. Due to this loss of capacity more frequent inspections to determine that battery is fully charged are necessary in cold weather.

585. Separators must always be covered with electrolyte. For replacing evaporation, distilled or approved water only must be used. It should be necessary, if battery is floating properly, to add water only twice a year, preferably in the early Fall and in the Spring to avoid the danger of water freezing during cold weather. If water must be added during freezing weather a syringe must be used to stir the entire solution so as to mix the water and electrolyte. When water is added the level of the electrolyte must be brought up to the upper level line on the side of the jar. After adding water, allow 24 hours for water to mix with electrolyte before taking gravity readings.

586. Never add acid or electrolyte unless some has been spilled. When necessary to add electrolyte use one of 1.210 specific gravity.

587. Terminal nuts must be checked at intervals after installation to insure tight connections.

588. In case a battery becomes discharged to any appreciable extent, the output of the rectifier must be increased to the maximum rating and procedure as outlined in Paragraph 578 must be followed. If this condition occurs, the Supervisor must be notified since it may be advisable to replace the battery or employ rectifier of larger capacity.

589. When cells do not respond to treatment outlined in Paragraph 578 or it is suspected that cells may not be in good condition, a one minute rate test should be made using an instrument designed for making such a test. Detailed instructions for making a one minute rate test are furnished with the instrument.

590. If terminals or connectors show evidence of corrosion the corroded surface must be scraped clean and then washed with soda solution after which a thin coating of vaseline or manufacturer's terminal grease must be applied. No corrosion will occur unless electrolyte is spilled and allowed to remain.

591. If a jar is broken and the element is exposed to the air the element may be placed in a hard rubber, glass or earthenware container filled with electrolyte of any specific gravity between 1.110 and 1.210. If electrolyte is not available approved water may be used, but the element must not be stored in this manner for more than one week. If the cell is to remain out of service longer than one week and electrolyte is not available the element must be dismantled, the separators and negative groups kept in water and the positive groups thoroughly dried. For shipment the negative groups must be thoroughly dried after washing in clear water.

NICKEL-IRON ALKALINE TYPE BATTERIES

General

592. Cells must not be exposed to the gases of lead batteries or placed where they will come in contact with lead batteries or acid-soaked charging racks or trays.

593. Cells must not be placed directly on a damp floor or a damp shelf. If a dry surface is not available, they must be placed on suitable insulators to avoid grounds and possible damage to the cell containers.

594. When battery is being charged, enough ventilation or space must be provided to avoid pocketing of the gases.

595. Filler caps must be kept closed except when necessary to have them open for watering, taking temperatures, gravity, etc. Where cells are provided with screw type valve assemblies, the knurled rings must be removed when cells are placed in service. Whenever cells are to be moved, knurled rings are to be replaced.

596. If solution is accidentally spilled on the skin or clothing, it should be immediately washed away with plenty of water.

597. The elements must be covered by electrolyte at all times.

Receipt of Cells

598. After unpacking the cells, carefully remove all packing material or other foreign substance from cells and trays with particular reference to space between and underneath the cells. Cells must not be lifted by their terminals.

599. Test the height of solution in every cell to see if any has been spilled in shipment. If the solution is below the recommended level as shown in Paragraph 600 but above the plate tops, add distilled or approved water to raise level to proper height. If solution level is below plate tops, add Edison Refill Solution (1.125 specific gravity at 60° F.) undiluted, or if this is not readily available, use Edison Standard Renewal Solution (1.250 specific gravity at 60° F.) to which $\frac{1}{5}$ of distilled or approved water has been added to the total volume. Where neither Refill or Renewal Solution is available and levels are below plate tops, the battery must not be placed in service until proper solution is available.

600. The correct and minimum solution levels for cells is as follows:

	Correct Solution Height Above Plate Tops	Minimum Solution Height Above Plate Tops
"AH" (High Type Cells)	3"	1½"
"BH" (High Type Cells)	2¼"	1"
"A-B-N" (Low Type Cells)	½"	Must cover plates

601. Cells which are to be stored for an indefinite period should be trickle charged continuously at a rate equivalent to 2 mils per 8-hour ampere-hour capacity rating of cell or stored in a fully discharged condition per Paragraph 619.

Installation and Charging

Except for new cells received from manufacturer, the surface of all terminals must be cleaned with a cloth moistened with mineral solvent (Stoddard or equal) and, where necessary, polished with very fine emery or crocus cloth. Cells must be connected together with inter-cell connectors and inter-tray jumpers furnished for this purpose.

602. Cells must be permanently installed in the trays supplied and held in place to prevent movement.

603. After connecting cells in a series-connected battery, test each cell with a voltmeter to assure that the positive terminal of each cell is connected to the negative terminal of the adjoining cell.

604. Arrange connections so that positive terminal of the rectifier or charging source is connected to the positive terminal of the battery. Direct current only must be used for charging.

605. After installation, be sure all cells are fully charged before attempting to set the rectifier at the normal charging rate required at the location. If there is any doubt as to the battery being fully charged, first bring the solution to the proper level, and then set the rectifier at its maximum safe output until the cells receive a charge equal to 25% more in ampere hours than their 8 hour rating shown in Paragraph 620. During this high floating rate charge the solution must not be allowed to fall below the minimum solution level as listed in Paragraph 600.

606. After cells are fully charged, promptly reduce the high charging current to a value calculated to be slightly higher than the normal float charge rate. The charging rate should then be gradually reduced from week to week until consecutive voltage readings of individual cells at normal solution temperatures of from 60 to 70 degrees Fahrenheit consistently remain between 1.5 and 1.6 volts per cell. After establishing the proper rate in this manner, it should not be changed as voltages rise and fall due to temperature alone. The voltages shown in the following table are typical of fully charged cells when being charged at a minimum rate to offset losses of the cells. See Instruction 607.

Solution

Temp.

Degrees F. 80 70 60 50 40 30 20 10 0

Voltage

per Cell 1.48 1.50 1.52 1.55 1.58 1.60 1.61 1.62 1.63

Where the charging current is higher than the minimum rate to offset losses of the battery (Paragraph 607) the cell

voltages should remain higher than shown in the above table.

607. When making the final adjustment of the charging rate, make sure that the charging current to the battery is not less than two milliamperes for each ampere hour of rated capacity based upon the 8-hour capacity rating shown in Paragraph 620.

608. (a) If there is a noticeable reduction in cell voltage during normal operation not due to change in solution temperature, the charging current should be increased sufficiently so that consecutive voltage readings consistently remain the same in accordance with voltage information contained in Instruction 606.

(b) In the event a battery becomes discharged to any appreciable extent, increase the charging current to the maximum safe value of the rectifier after first raising the solution level of each cell to proper height, and proceed as per Paragraph 606

609. At time of installation the specific gravity reading of each cell should be recorded on Storage Battery Record Card.

Maintenance

610. Voltage readings of individual cells shall be taken in the spring and fall and should not be less than those shown in Paragraph 606 for the given electrolyte temperatures. The measured electrolyte temperature of a pilot cell may be considered as the electrolyte temperature of all similar cells in the same housing. Readings shall be recorded on battery record card.

611. A very light film of primary battery oil or Esbaline must be applied to the inner side of the valve housing and valve stem assembly to prevent creeping electrolyte and to insure proper operation of the valve. Care must be exercised to avoid spilling oil or Esbaline into the cell.

612. When terminal connections show evidence of corrosion, they must be polished with fine emery or crocus cloth.

613. Cells, other than those of monel metal which are marked MO on cell tops, must be periodically inspected to insure that cell containers are not rusting. If evidence of rust appears, containers should be repainted as per instructions in Paragraph 618.

614. Tops of cells must be kept clean and coated with a very light film of primary battery oil or Esbaline applied with a brush or cloth.

615. Electrolyte must not be added to cells except to replace loss due to spillage; then Edison REFILL electrolyte (1.215 gravity at 60° F.) should be used.

616. (a) Specific gravity readings are not taken to determine state of charge but to determine the condition of the electrolyte.

(b) Specific gravity readings of electrolyte must be taken once each year with the electrolyte level at proper height above plate tops.

(c) To obtain the proper specific gravity of electrolyte, readings should be taken only after the cells have been fully charged. In floating charge service, where cells are normally kept in a fully charged condition, the specific gravity readings should not be taken for at least 24 hours after adding water to cells.

(d) If the specific gravity is less than the value shown in the following table for the existing solution temperature, then the solution should be renewed.

Temperature of Electrolyte	Minimum Recommended Gravity
	All Type Cells
110° F.	1.147
100° F.	1.150
90° F.	1.152
80° F.	1.155
70° F.	1.157
60° F.	1.160
50° F.	1.162
40° F.	1.165
30° F.	1.167
20° F.	1.170
10° F.	1.172
0° F.	1.175

617. Solution Renewal

(a) Discharge cells to 0.5 volt per cell at normal 5-hour discharge rate.

(b) Short circuit cells for at least 2 hours in groups of not more than 5 series cells.

(c) Remove cells from trays.

(d) Pour out and discard exhausted electrolyte.

(e) The cells must then immediately be filled with Edison Standard RENEWAL Electrolyte (1.250 specific gravity at 60° F.) to the proper normal level.

(f) After electrolyte has been added, cells and trays should be painted in accordance with Paragraph 618 where necessary.

(g) To prepare cells for service, charge at the normal 5-hour discharge rate for 15 hours. (See Paragraph 620).

618. Painting

(a) Cells with monel metal containers, marked MO on cell tops, do not require painting.

(b) Remove the individual cells from the tray and apply solvent by brushing or dipping, allowing approximately one hour to soften the paint. When removing paint, particular care must be taken to prevent solvent or particles of paint from entering the cell. Naphtha is to be used as a solvent for Esbalite and Stanisol for Glyptal.

(c) Inspect the trays for defects, making repairs where necessary.

(d) When paint on the cells is sufficiently softened, remove with a stiff brush after which the surface of the container should be wiped clean with mineral solvent.

A steel brush or metal scraper must not be used to remove paint.

(e) Cells must be examined for defects. Lid group assembly should be in proper alignment so as to assure free operation of the valve. The terminal post gland caps should be screwed down tight, particularly when there is evidence of leakage around the stuffing box assembly.

(f) After inspection, the sides and bottoms of the cells should be brush-painted or dipped in Esbalite or Green Glyptal paint, taking particular care to insure that the bottoms of the cells are thoroughly coated. A thin coating of primary battery oil or Esbaline should then be applied with a brush or both to the tops of the cells.

(g) After the cells are dry, clean the poles with fine emery or crocus cloth and assemble in trays. Replace the

intercell connectors and tighten nuts securely with special wrench provided for the purpose.

619. Storage

(a) Either new or used Edison Cells may be stored for an indefinite length of time by discharging to 0.5 volt per cell at normal 5-hour discharge rate, short circuit cells for at least two hours in groups of not more than 5 series connected cells and raise solution level to proper height. Store in a cool, dry place.

(b) Cells which have been in storage may be prepared for service by cleaning cells and connectors, bringing solution level to proper height and charging for 15 hour at the 5-hour discharge rate.

620. The following table gives the ratings for the various types and sizes of Edison Storage Cells ordinarily used in signal service:

Cell Type	5 Hr. Rating		8 Hr. Rating	
	Amp. Hr. Capacity	Amp. Dis- Charge Rate	Amp. Hr. Capacity	Amp. Dis- Charge Rate
N2	11.25	2.25	12	1.50
B1, B1H	18.75	3.75	20	2.50
B2, B2H	37.50	7.50	40	5.00
B4, B4H	75.00	15.00	80	10.00
B6, B6H	112.50	22.50	120	15.00
A4, A4H	150.00	30.00	160	20.00
A5, A5H	187.50	37.50	200	25.00
A6, A6H	225.00	45.00	240	30.00
A7, A7H	262.50	52.50	280	35.00
A8, A8H	300.00	60.00	320	40.00
A10, A10H	375.00	75.00	400	50.00
A12, A12H	450.00	90.00	480	60.00
A14, A14H	525.00	105.00	560	70.00
A16, A16H	600.00	120.00	640	80.00

NICKEL CADMIUM TYPE BATTERIES

650. Upon delivery, cells should be removed from shipping containers and each cell checked to see that solution level is at the maximum mark, or top red line on side of each cell.

651. Distilled water should not be used to replace spilled electrolyte even as a temporary measure. Nickel Cadmium electrolyte of prescribed specific gravity should be used to replace spillage and for periodic electrolyte renewal.

652. Partial or complete loss of electrolyte for a limited period (up to 60 days) will not affect the performance or service life of a cell, but spillage should be replaced promptly.

653. Nickel Cadmium cells are shipped fully charged from manufacturer. However, all cells should be given a freshening charge at the 8 hour rate for a period of 11 hours or equivalent.

654. After initial charge, the charging current should be promptly reduced to approximately 5 mils/ampere hour of rated capacity at the eight hour rate. The charging rate should then be gradually reduced from week to week until voltage of individual cells remains consistently between 1.42 and 1.50 volts at normal solution temperatures of 60°-70° F. The final charging rate should never be less

than 1 mil/ampere hour (8 hour rate). After adjustment is made at normal temperature, the charging rate does not need to be adjusted as cell voltages fluctuate with the temperature of the electrolyte.

655. Cells which are being over charged will require more frequent watering to maintain solution levels.

656. Specific gravity readings have no value in determining state of charge of a cell. Gravity readings of each cell should be taken annually to determine condition of electrolyte. Gravity readings should be checked against table of maximum and minimum value for the measured temperature of the electrolyte. Cells having electrolyte of specific gravity below the minimum for that temperature should have electrolyte replaced.

Temperature of Electrolyte	Maximum Recommended Gravity (Solution at recommended level)	Minimum Recommended Gravity
110°F.	1.177	1.147
100°F.	1.180	1.150
90°F.	1.182	1.152
80°F.	1.185	1.155
70°F.	1.187	1.157
60°F.	1.190	1.160
50°F.	1.192	1.162
40°F.	1.195	1.165
30°F.	1.197	1.167
20°F.	1.200	1.170
10°F.	1.202	1.172
0°F.	1.205	1.175

657. When replacing electrolyte, cells need not be discharged, old electrolyte can be dumped and cells refilled with nickel cadmium electrolyte to the maximum solution level line of the cell. Battery oil should then be added to a depth of $\frac{1}{8}$ inch above the solution.

658. Nickel Cadmium batteries contain liquid caustic potash which is both poisonous and corrosive. It will burn or injure skin, eyes, and property. If electrolyte comes in contact with skin, flush immediately with water and apply wet compresses of household vinegar or 5% acetic acid solution. Do not apply ointment, oil or salves before treatment by a physician.

If accidental internal contact has been made, drink vinegar or lemon juice mixed with an equal amount of water and call a physician immediately.

AIR CELL PRIMARY TYPE BATTERIES

700. Air cell primary batteries are shipped dry and sealed. To place in service:

- (a) Remove filler caps and punch out filler hole seals.
- (b) Fill each filler hole with clean fresh water (± 5 pints) to bring level up to bottom of filler hole.
- (c) Allow electrolyte level to settle a minimum of 15 minutes.
- (d) Add additional water (± 1 cup) to bring level of water to bottom of filler hole opening.

701. Covering over carbon electrodes must be removed.

702. Vent holes in filler plugs must be kept open and free from salts.

703. Solution level must be maintained over top of element.

704. Air cell batteries require air to operate and ventilated battery housing must be provided with a minimum of $\frac{1}{4}$ inch diameter vent provided in such manner that rain or snow cannot enter housing.

705. Battery electrolyte contains lye (Potassium Hydroxide). Discarded batteries must be disposed of where the solution will not damage person, property, animals or pollute any stream or water supply.

TESTS

750. When making electrical tests of switch and signal circuits, the proper meters must be used, and it must be known that no unsafe conditions are set up by the application of such testing apparatus.

When using switch or signal circuits for temporary telephone, it must be known that the use of telephones will not, in any way, affect the circuits.

751. Periodical tests of signaling and interlocking devices must be made regularly. The frequency of tests specified in C. & S. 27 represents the maximum interval between tests. Local conditions may make more frequent tests advisable, in which case supplementary instructions will be issued by the Chief Engineer Communications and Signals.

752. Other tests that may be designated from time to time must be made in accordance with instructions that will be issued in connection therewith.

CAR RETARDERS

1300. When electro-pneumatic style retarders are located on adjacent tracks, the centers of which are less than 20 feet, the retarder cylinders shall be painted yellow.

NOTE: At location where retarders are not of electro-pneumatic style the man in charge shall before starting work determine if the track center distances within the work area are less than 20 feet and instruct all of his employees as to unusual situations and where to clear tracks. A Maintainer C&S or other person working alone shall measure the track center distance and clear:

(a) Outside the track, or

(b) Between the tracks where the track center distance is more than 20 feet.

1301. (a) Retarders that are out of service for maintenance shall have controls opened under the direction of the foreman, assistant foreman or other person in charge.

(b) Group and intermediate retarders that are out of service for maintenance requiring use of track shall be protected by a track switch located above the retarder secured in a position to divert cars or locomotives. Special Instructions 407, insofar as they apply, shall govern.

(c) Master retarders that are out of service for maintenance requiring the use of track shall be protected in accordance with paragraph (b) above where track switches are available. Where track switches are not available foreman, assistant foreman or other person in charge shall SECURE the hump signal controller in STOP POSITION, or open controls of hump repeater signals, and place M.P.-397, DO NOT OPERATE, warning tag on the hump signal controller.