C.E. 500(b)

NATIONAL RAILROAD PASSENGER CORPORATION (AMTRAK)
ELECTRIFIED TERRITORY
OUTLINE SPECIFICATION
FOR
ELECTRIFICATION TRANSMISSION AND DISTRIBUTION

This outline specification describes the principle features of electrification transmission and distribution system construction and shall be used as a basis for design in extensions of the present electrification.

The key design criteria are broken into two separate classifications; 1st is the Northeast Corridor and Keystone Corridor (NEC) electrified at 12 kV, 25 Hz, 2nd is the North End Electrification (NEE) electrified at 25/ 50 kV, 60 Hz autotransformer system. Items within the specification listed only for use on the NEC or NEE will be listed as such. Items that pertain to both systems will not have the separate moniker.

Standard Amtrak Specifications Listed throughout the Document:

(a) AED-2 "Catenary Structure Loading, Design Criteria and Standards for Use on the Northeast Corridor and Keystone Branch."
(b) C.E.501-(a) – "Outline Specifications for Power Supply, Substations and Control Systems"
(c) C.E.512-(a) – "Specification For Air Switches"
(d) C.E.516-(a) – "Specification for Lead Acid Type Storage Batteries"
(e) C.E.560-(b) – "Specification for Porcelain Insulators"
(f) C.E.565-(a) – "Specification for Non-Ferrous Rods, Bolts, Tubes, Bars and Forgings"
(g) Circular No. 112-C – "Specification for Electric Wire and Cable"
(h) Circular No. 112-D – "DC Switch and Control Cable"
(i) QA/P,11-A – "Specification for Silver Bearing, High Conductivity, Copper, Grooved, Contact Wire, Wound onto Reels for Electrical Purposes"

PART I – SURVEY DATA AND PRELIMINARY DESIGN

101. Survey and Data Required for Design

(a) In order to properly lay out the wire work and locate the catenary supporting structures, a right-of-way map and top-of-rail profile shall be provided. A field survey shall be made to obtain this information. The rail shall be marked with keel on 100-foot stations at the time of chaining. The right-of-way map shall show tracks to be electrified, location of signal bridges, information on future track changes, new structures, and storm water management plan. Where the new track is to be installed at yards, terminals, and interlocking plants, a 20-foot to the inch scale track plan showing all necessary track layout information shall be provided.

(b) From these plans the catenary structures shall be tentatively located and a preliminary inspection made at each location. Detail cross sections shall be made at each support point and chord surveys of curves, crossovers, and turnouts made to provide complete information for laying out the wire work. After the preliminary surveys, structures shall be designed and prints sent to the field for a final field check.

(c) Surveys shall include information on foreign-wire crossings, parallel circuits, overhead bridges, and all structures which will affect physical and electrical clearances thereby influence the design.

102. Design Considerations

(a) At all locations where direct current electric systems, or other conditions productive of electrolysis, are present, electrolysis surveys shall be made and remedial action taken as required to protect underground facilities; such as wires, cable sheaths, piping, and metallic structures, etc.

(b) In the design of transmission, distribution, signal control, and communication systems of the Railroad, provision shall be made to reduce adequately the inductive interference between such circuits and between Railroad and other electric circuits.

(c) Corona formations and radio interference shall be avoided by the use of conductors of adequate diameter, and of hardware, insulators and similar parts that are reasonably free of corona at potentials at least 25% above the normal peaks of the circuit involved.

(d) The transmission catenary structures shall be grounded to impedance bonds, non-signalled track, foundation metallic cans, neutralizing wires, ground rods, and other buried metallic structures to produce a low-resistance connection to earth. Wherever feasible the resistance of five transmission-catenary structures connected in multiple by the static wire shall not exceed 5 ohms.

(e) Structures accessible to pedestrians on platforms, protection screens, and under and over-grade bridges (having accessible metallic parts) shall be so grounded that in case of fault to

ground of the circuit supported, the accessible metallic parts will not rise to dangerous potentials between the structures and the adjacent ground.

PART II -- STEEL POLE CATENARY STRUCTURES

201. Foundations

(j) In general foundations shall be designed in accordance with Amtrak standard specification, AED-2. "Catenary Structure Loading, Design Criteria and Standards for Use on the Northeast Corridor and Keystone Branch."

(k) Foundations should be of the can type with bolted base construction as seen on drawing AET.20020.

(l) Normally the top of concrete shall be one foot below the top of rail on fill and level ground, but this may be modified to suit local ground conditions. In cuts, the top of foundation shall be approximately one foot above ground on the field side.

(m) For foundations in rock or shale, specially designed rock anchor foundations may be used in lieu of the can type foundation. Design must be based on borings performed at the specific structure locations.

(n) Under conditions of exceptionally poor soil, or where poles must be set on retaining walls, or where other special conditions exist, special foundations suited to the local conditions shall be designed. Where conditions require, poles shall be tied together by under track cross ties.

(o) Anchor bolts shall be ASTM A449, and designed to the latest edition of ACI 318 Appendix D, "Anchoring to Concrete".

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202. Guy Anchors

(a) The standard guy anchor shall be stub pole foundation types GA1-36 and GA2-36 as seen on drawing AET.20021 and AET.20022.

(b) For anchors in solid rock, an epoxy anchor system may be designed. .

(c) Guy attachment on walls shall be similar to Types TPR and TPL (ET-1605-E) and of suitable dimensions. A clevis, C-5, C-6A, C-6B (11B-100), shall be provided to receive the 1-1/2", 1-3/4", or 2" diameter guy stub.

(d) For special anchor conditions in the NEC, the following types may be used:

Type	Drawing Number	Remarks
A1	ET-1601-E	1 Rod
A2	ET-1601-E	2 Rods
B1	ET-1602-E	1 Rod
B2	ET-1602-E	2 Rods
C1	ET-1603-E	1 Rod in rock or shale
C2	ET-1603-E	2 rods in rock or shale

(e) The NEC A and C type anchors consist of guy stubs 1-1/2", 1-3/4", or 2" diameter bolted to two 8", 11.5-lb channels at the bottom, encased in concrete. The stubs are protected by 4" or 4 1/2" O.D. schedule 80, galvanized, steel pipe filled with cement grout. The type B anchor is similar except it uses two 10", 15.3-lb channels in a larger reinforced concrete block. The anchor can be cast in place or pre-cast and set in a vertically dug hole of approximately the same dimensions as the anchor.

203. Guy Assemblies

(a) Guy assemblies for the NEC shall be made up of 7/8" to 1-1/8" diameter E.H.S. galvanized steel strand with a non-adjustable u-bolt type grip Where the non-adjustable grip is used the assembly shall include a turnbuckle at the lower end.

(b) For feeder dead-ends and other light loads on the NEC, a guy assembly of 5/8" diameter E.H.S. galvanized steel may be used.

(c) Guy anchor assemblies on the NEE shall conform to drawing JVCC0103.

204. Poles

(a) In general catenary structures shall be designed in accordance with Amtrak standard specification, AED-2, "Catenary Structure Loading, Design Criteria and Standards for Use on the Northeast Corridor and Keystone Branch."

(b) Poles for the NEC shall be made from standard wide-flange sections and shall be fabricated with bolted or welded details. Sections will be used as follows:
12" WF 65 lb
14" WF 90, 109, 120, 132 lb

(c) Poles for the NEE shall be made from standard pole sections as detailed in drawings

JVCB7101 to JVCB7699. Structural Steel Tubing shall be ASTM A501 or ASTM A500, Grade B

(d) Steps made of 3/4" round bars welded between the flanges of the poles shall be supplied only at points where the use of skates is impracticable. Steps shall begin no closer than fifteen feet above grade, but normally at beam height and shall extend to top of pole unless special conditions apply.

(e) The ground wire shall be supported on the pole in accordance with Drawing ET-1190-C.

(f) Milepost and structure numbers shall be stenciled on every structure.

205. Signal Bridges

(a) Signal bridges shall consist of box-girder or truss sections with a non-skid surface provided as the top plate.

(b) Handrails, ladders, and fall protection shall be designed and provided per applicable Amtrak and safety standards and codes.

206. Catenary Beams

(a) In general, catenary beams for the NEC shall be designed as follows:

Size	Span	Pole Height
8"WF40lb	Up to 38 ft	Up to 90 ft
12" Channel 25lb 8"WF40lb	Up to 38 ft	Over 90 ft
12" Channel 25lb 8"WF40lb	39 ft to 64 ft	Up to 90 ft
15"Channel 33.9lb 10"WF49lb	39 ft to 64 ft	Over 90 ft
15" Channel 33.9 lb 10"WF49 lb	65 ft to 98 ft	Up to 90 ft
18" Channel 42.7 lb 14"WF90lb	65 ft to 98 ft	Over 90 ft
18" Channel 42.7 lb 14"WF90lb	99 ft to 114 ft	Up to 90 ft

Bolted or welded details may be used for shop fabrication.

Only copperwld

(b) Sag braces and struts shall be as shown on Drawing AET.20030.

207. Cross Catenary

(a) Cross-catenary and body spans shall be 9/16, 23/32 or 7/8 in diameter, composite copper and copper-clad steel, with compression or preform-type end fittings.

(b) Cross-catenary hanger assemblies shall be of rod and castings as shown on drawings AET-_____.

(c) Hardware shall be non-ferrous rod and bronze or ductile iron castings.

208. Brackets

(a) Catenary brackets shall consist of a double angle arm with one 1" diameter sag rod (ET-2551-D) for one track; with two 1" diameter sag rods (ET-2552-D) for two tracks, and with two 1" diameter sag rods and one 7/8" E.H.S. guy strand with socketed ends and one turnbuckle (ET-2553-D) for three tracks. All parts shall be galvanized.

209. Cross Arms

(a) The 138-kv transmission cross arms shall be single angle (ET-2201-D) for suspension, or double angle (ET-2201-D) for dead end assemblies and shall be bolted to the pole. Sag rods 7/8" in diameter shall be used with the single-angle arms.

(b) Signal transmission cross arms shall normally consist of a single angle (ET-2204-D) clamped to the pole. Sag rod or angle brace shall not be used except when indicated on drawings.

(c) Cross-track feeder cross arms shall be double arms, with struts, clamped to the pole (ET-2203-D).

(d) Longitudinal-feeder cross arms shall consist of a single angle, with sag rods, clamped to the pole (ET-2202-D).

(e) All parts shall be galvanized.

210. Miscellaneous Steel

Dead Links

(a) Ladders for plain poles shall be in accordance with the standard details (ET-2351-D).

(b) Anti-climb doors (ET-2601-D) shall consist of a steel door with a hasp that can be bolted and locked to a ladder. All parts shall be galvanized.

(c) Railings shall be in accordance with the standard details (ET-2602-CC and ET-2603-CC).

(d) Signal transformer and switch supports shall be as shown on Drawings ET-2451-D, ET-2452-D and ET-2502-D. All parts shall be galvanized.

211. Overhead Bridges

(a) Wherever possible, catenary attachments to overhead bridges should be avoided. If required, they shall consist of 4" diameter schedule 80steel pipe clamped by U-bolts to angles which are welded (46H-3002) or bolted to the overhead bridge.

(b) Protection barriers shall be provided except on railroad bridges as shown on Drawing ET-1446-D (S1&S2). All protection barriers should be a minimum of 6'-6" high with solid construction and shall be properly grounded in accordance with Drawing ET-1120-C. All parts to be hot dip galvanized after fabrication.

212. Tunnels

(a) In general, catenary attachments shall consist of ductile iron or approved equal material anchored to the roof and designated to fit the tunnel conditions.

(b) A protective coating of an approved type shall be applied to the catenary system to resist corrosive action caused by exhaust gases.

213. Stations

(a) In station areas, catenary attachments shall be limited to suspension types where ever possible, using structural steel supports designated to fit the individual station conditions.

214. Special structures

(a) In locations where unusual conditions exist, making it impracticable to follow standard procedure, special structures shall be designated to meet the individual limitations.

215. NEE Assemblies, Fittings and Hardware

(a) The work specified in this Article includes furnishing of sub-assemblies, fittings and hardware for cantilevers, registration arms, pull offs, push offs, and other components required as part of the OCS hardware, as shown on the Drawings and specified herein.

(b) Materials shall be selected for each of the required assemblies, based on the performance requirements, working loads and basic dimensions as shown on the Drawings and specified herein. Cantilever arm fittings are shown and dimensioned on the drawings. In general, cantilever arm subassemblies of components shall be furnished according to the dimensions and configurations shown.

(c) Minor variations in dimensions and configurations of components may be allowed so long as the integrity of the assembled cantilever arm is not sacrificed. Any proposed variations in cantilever components are subject to the approval of Amtrak.

(d) For standard product sub-assembly and components the drawings indicate critical and specific dimensional requirements. Manufacturing tolerances shall be based on the recognized standards in the industry. In general, tolerance for cantilever arm hardware shall be plus or minus 1/32 inch.

1. Internal parts (i.e. pins, eye fittings, etc.) shall be minus. External parts (i.e. clevis ends, hole dimensions, pipe clamps) shall be plus.

2. Manufacturing tolerances for components which are not standard products of recognized manufacturers (i.e. draft angles, etc.) are subject to review and approval prior to fabrication.

(e) All cantilever arm fittings shall be furnished by a manufacturer with a proven record of five or more years experience in the production of cantilever arm fittings.

(f) General: Material for fittings shall comply with the description in the applicable Standards referenced in these Specifications. Substitutions may be considered if all performance requirements are satisfied.

(g) Malleable Iron: Fittings or components made of malleable iron shall be Grade 32510 or

better, and shall conform to ASTM A47. All components and fittings shall be galvanized in accordance with ASTM A153.

(h) Forged Steel: Material for forged steel shall comply with AISI Types C-1035 to C-1045 SBQ and ASTM A711 or A668. All components and fittings shall be galvanized in accordance with ASTM A153.

(i) Balance Weights: Gray cast iron or ductile iron

(j) Ductile Iron: Fittings or components requiring higher yield strength shall be of ductile iron, Grade 60.40.18 or better and shall conform to ASTM. All fittings and components shall be galvanized in accordance with ASTM A153.

(k) Stainless Steel: Stainless Steel hardware shall be AISI Type 302 or 304.

(l) Non-Ferrous Metals: Grounding components shall be the Manufacturer's standard items. Copper alloys for fittings and components shall comply with ASTM 6584.

(m) Copper Alloy: All copper components shall conform to ASTM 6248 or 8249.

(n) Aluminum Bronze: All aluminum bronze castings shall conform with ASTM 6148 & 8179.

(o) Cantilever Arm Pipe: shall be per ASTM A53 type S Grade B, hot dip galvanized. For pipe sizes see JVCD0101 series drawings.

(p) Aluminum Pipe (or tube): for steady arms and other mechanical applications shall be of the dimensions and schedules shown on the drawings. Aluminum pipe shall be extruded, alloy 6061-T6 for mechanical applications, and alloy 6063-T6 for electrical purposes such as tubular bus.

(q) Manufacture and Performance:
1. The designated metals shall be produced by an approved method that will meet the requirements of the specified ASTM standards and this Specification.
2. Castings shall be of uniform quality and shall be made in such a manner that the material of the casting conforms to the chemical and mechanical properties prescribed in the applicable ASTM standards, as well as to dimensions given by shop drawings in conformance with detailed construction design drawings.

(r) Marking and Shipping:
1. The identification mark of the foundry and the pattern numbers assigned by the supplier shall be cast into all castings, of sufficient size, in such a position that they will not interfere with the further processing and serviceability of the casting. In addition any molds made for the project shall include Amtrak stock numbers.

2. Castings shall be packed in accordance with the best commercial practice, adequate to ensure acceptance and safe delivery.

216 NEE Fasteners

(a) The work specified in this Article includes furnishing various types of fasteners (bolts, nuts and washers) for general use and structural connections on the OCS, as shown on the Drawings and specified herein.

(b) Ferrous Metal Fasteners:
1. Material: The material for ferrous metal fasteners not specifically called out shall comply with the applicable portions of the referenced standards, or where not covered in referenced standards shall be commercial products of proven performance in similar service as this system.
2. Structural Joint and Fitting Connections: Ferrous fasteners used with structural connections and fittings shall comply with ASTM A325.
3. U-Bolt and Stud Connections: U-bolts and studs shall comply with ASTM A449 Washers shall comply with ASTM F436 and nuts shall comply with ASTM A563. Grade B.
4. Galvanizing: Ferrous fasteners shall be galvanized in accordance with ASTM A153, Grade C.

(c) Stainless Steel Fasteners:
1. Stainless steel bolts, studs, nuts and washers shall be used for connections between ferrous and nonferrous metals, and in other applications as shown on the Drawings.
2. Stainless steel bolts and studs shall comply with ASTM F593 Stainless steel nuts shall comply with ASTM F594.

(d) Nonferrous Metal Fasteners:
1. Nonferrous metal fasteners shall be manufactured from material conforming with the applicable portions of the referenced standards.
2. Nonferrous bolts and studs shall comply with ASTM F468 Nonferrous nuts shall comply with ASTM F467.

(e) Bolted Connections:
1. Bolted connections using standard fasteners in accordance with ASTM A307 shall conform to the applicable requirements of AISC specification for structural joints using ASTM A307 bolts.
2. Bolted connections using high tensile strength bolts in accordance with ASTM A325 shall conform to the applicable requirements of AISC specification for structural joints using ASTM

(f) Galvanizing: Bolts, nuts, washers, anchors and other items of iron or steel hardware shall be hot dipped galvanized as follows:

1. Perform galvanizing in accordance with ASTM A153, as applicable. The weight of the zinc coating shall be not less than 1.25 ounces per square foot.
2. Thread of bolts shall be standard size before galvanizing and the nuts shall be oversized to allow for galvanizing of the bolt's thread. Nuts and bolts shall conform to ASTM A325 and A563 requirements. Thread of galvanized nuts shall not be galvanized and shall be protected with suitable grease.
3. Hardware items furnished already galvanized shall be delivered with the necessary certificates of conformance with ASTM A153 and the required zinc coating specified.

PART III -- NOT USED

PART IV – TRANSMISSION AND DISTRIBUTION

401. Insulators

(a) In general, where 138 kV transmission circuits are required for the NEC, eleven Type B-1 insulators shall be used in suspension assemblies (ET-1140-C) and thirteen Type B-1 insulators used for strain assemblies (ET-1140-C).

(b) For longitudinal and cross-track NEC 12 kV feeders, Typed B-1, and A-2 insulators shall be used in accordance with Drawing ET-1105-C

(c) Unless otherwise specified, the NEE feeder support insulators shall be either ceramic, glass or composite. The insulators shall be designed for alternating currents of 27.5 kV nominal voltage phase-to ground. 60 Hz frequency.

- General Requirements: All equipment shall be designed to fulfill its required function for a working life of 50 years and to operate satisfactorily without need for attention more frequently than once every year, or as infrequently as reasonable.
- General Characteristics: Insulators shall meet the following general characteristics particular to the project.
- Climatic Conditions:
  - Ambient temperature minimum -10^0F (-23.4^0C)
  - Ambient temperature - Maximum: 100^0F ($+37.8^0$C)
  - Humidity - Relative: 67%
    -Maximum: 95% (assumed)

- Wind Speed -Maximum: 80 mph (129 km/h) no ice.
  40 mph (65 km/h) with
  0.5in (12.7 mm) radial ice

- Environment - Area 1 :Saline Atmosphere from New Haven (MP 74) to Westerly (MP 140)
  Area 2: Normal Atmosphere from MP 140 to MP 229

- Electrical Characteristics:

  - Frequency: Nominal 60 Hz

  - Maximum voltage (phase to ground): 27.5 kV

  - Minimal nominal leakage distance
    Area 2: 30 in. (762 mm)
    Area 1: 43 in. (1093 mm)

  - Impulse withstand voltage:
    (According to ANSl C29.1)
    For a minimal leakage distance of 30 in
    (See note 1): 250 kV

  - Low frequency rated 1 min. dry withstand voltage:
    For a minimal leakage distance of 30 in.
    (See note 1): 120 kV

  - Low frequency rated 10 sec, wet withstand
    For a minimal leakage distance of 30 in.
    voltage:
    (See note 1): 100 kV

Note 1: The supplier shall propose the minimum electrical values for its insulator corresponding to a 43 inch minimum leakage distance. These values for a 43 inch creepage distance insulator should be higher than the values of the proposed 30 inch creepage distance insulator.

(d) Note 2: The supplier shall list the following characteristics for both the 30 inch and 43 inch creepage distance insulators:
- Dry arcing distance (according to ANSl C29.1)
- RIV test voltage (according to ANSl C29.1)

- Maximum RIV at 1KHz (according to ANSl C29.1)
- Critical Impulse positive flashover voltage (1.2-50 ⍦s wave according to ANSl C29-1)
- Critical Impulse negative flashover voltage (1.2-50 ⍦s wave according to
- ANSl C29-1)

402. Hardware

(a) Line hardware shall be galvanized fittings in accordance with approved detailed drawings.

403. Conductors

(a) New NEC 138 kV transmission lines shall be 477 kcmil (Hawk) 26 strand Al, 7 strand steel (ACSR) conductors.

(b) ACSR transmission conductors shall be tensioned to give a 5-foot final sag in a 300-foot span at 60^0 F, (ET-1441-E). For conductors particulars see drawing AET.10100.

(c) NEC 12 kV feeder conductors shall be bare, hard-drawn copper of one of the following sizes which will satisfy the electrical requirements:

- 4/0 AWG - 7 wires
- 400,000 cir mils - 37 wires
- 750,000 cir mils - 61 wires
- 1,000,000 cir mils - 61 wires

(d) Longitudinal 12 kV NEC feeders shall be tensioned to give a 5-foot final sag in a span of 300 feet at 60^0 F (ET-1440-E). For conductor particulars see drawing AET.10103.

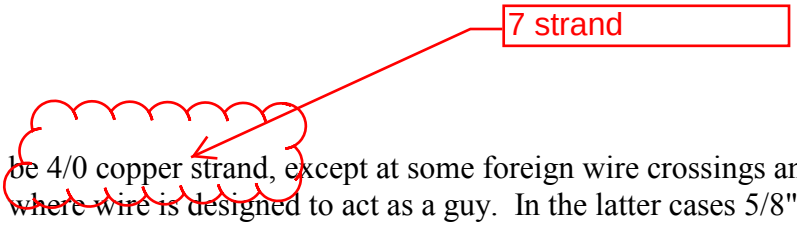
(e) NEE autotransformer feeder conductor shall be 636 kcmil ACSR, 26 strand Al, 7 strand steel (Grosebeak) with the normal tension at 59^0F of 7191 lbs. JVCA-2806_1.

(f) Since spans in cross-track feeders are relatively short, reduced tensions are used and shall be shown on the catenary wiring plans. For conductor particulars see drawing JVCA-2806_1.

404. Lightning Protection

(a) NEC grading shields with full insulation (ET-1140-C) shall be used to provide gaps in the

line each side of the substations, generally at the first or second structure and again at a structure approximately 1/2 mile from the substation.



405. Ground (Static) Wire

(a) NEC Ground wire shall be 4/0 copper strand, except at some foreign wire crossings and other special conditions where wire is designed to act as a guy. In the latter cases 5/8" diameter composite copper and copper-clad steel shall be used between head-guyed structures. Ground-wire assemblies shall be as shown on Drawings ET-1190-C

(b) The NEC ground wire shall be tensioned to give a 5-foot final sag in a span of 300 feet at 60^0F (ET-1440-E). For conductor particulars see drawing AET.10102.

(c) NEE ground wire shall be 4/0 ACSR 6 strand AL, 1 strand steel (Penguin) with a normal tension at 59^0F of 1798 lbs. For conductor particulars see drawing JVCA2806_1.

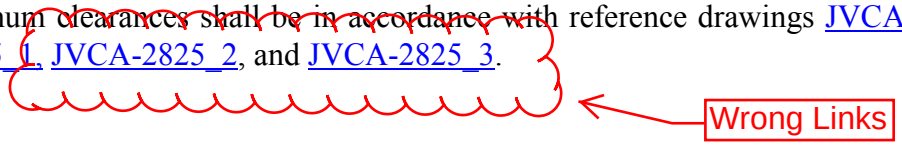
406. Transpositions

(a) In general, transpositions in the NEC transmission lines shall be located at the midpoints between substations but may vary due to local obstructions or because of electrical requirements controlling the line.

407. Clearances

(a) NEC minimum separation of wires or live parts from each other and their clearance from supporting or adjacent structures shall be in accordance with the tabulation in paragraph 408.

(b) NEE minimum clearances shall be in accordance with reference drawings JVCA-2824, JVCA-2825_1, JVCA-2825_2, and JVCA-2825_3.



408. NEC MINIMUM CLEARANCE OF WIRES OR LIVE PARTS
(IN FEET)

Clearance to	Conditions	6900-Volt Signal Transmission	12-kv Feeders and Catenary	138-kv Transmission

Pole		1.5	1.5	….
Pole or Cross Arm	Worst Temperature No Wind	….	….	4.8
	Worst Temperature and 50 mph Wind	….	….	3.0
Cross Span Wire or Steel Member		1.0	3.0*	7.0
Building Wall at Window		10	10	12
Building Wall at Eaves		15	15	15
Face of Cliff	Accessible**	25	25	30
	Inaccessible	12	12	20
Above Other Wires (For 300' span)	Same Supports	4	4	10
Above Intermediate Structure		12	15	15
Separation from Each Other (For 300' Span)	Vertically	4	4	14
Separation from Each Other	Horizontally	$4 + \frac{\text{Span} - 300}{125}$	….	$16 + \frac{\text{Span} - 300}{125}$***
* The catenary system shall have a minimum clearance of 1.5 feet				
** Class also as accessible, an overhanging cliff, i.e., one having an accessible point at a higher level than the conductors, from which a wire 20 feet in length might be thrown and thus form a contact with the conductor.				
***If strain insulators – subtract 2'-0"				

409. NEC Taps

Color

(a) Feeder taps shall be in accordance with drawing ET-1105-C with the properly sized Ampact wedge style connectors replacing the original connectors. .

(b) Taps shall be made with bare, hard-drawn, copper strand of size corresponding to feeder. Where long droppers are required, 1-1/2" O.D. hard-drawn copper tubing shall be used to supplement the strand

PART VI – NEC SIGNAL TRANSMISSION

601. Insulators

(a) Type B-1 and pin (Type S) insulators shall be used to support the signal transmission line in accordance with the following drawings:

- 11B-1254
- 11B-1255
- 11B-1258
- 11B-2952

602. Hardware

(a) The line hardware shall be galvanized fittings made in accordance with the specified detailed drawings.

603. Conductors

(a) No. 1/0 AWG, 7-wire, bare, hard drawn, copper strand shall be used. For conductor particulars see drawing AET.10100.

(b) The line shall be tensioned to give a 5-foot final sag in a span of 300 feet at 60^0 F (ET-1440-E).

604. Transpositions

(a) The location of transpositions shall be determined by electrical conditions involved in the line. In general, transpositions shall be at the end quarter points between substations.

PART VII -- CATENARY SYSTEM

701. NEC Main Track

(a) The catenary for tangent track shall be three-wire construction consisting of a 5/8" diameter composite copper and copper-clad steel, Type E messenger, a 4/0 copper, grooved auxiliary messenger and a 336,400 cir mils bronze, alloy 55, contact wire with loop-type hangers at the supports and rigid hangers in-span on 30-foot spacing as shown as Type I on Drawing ET-1100-C. The maximum span between supports shall be 225 feet. On high fill and exposed locations, special consideration shall be given to the length of span because of possible blow-off of contact wire under wind conditions.

(b) The catenary for curved track shall be the tangent-chord type. The maximum span between supports shall be 225 feet. As the lateral position of the contact wire with tangent chord will vary with the curvature and span length, the offset of the pantograph at the support and at midspan shall be shown on the erection diagrams. The maximum departure from the centerline of the pantograph shall be 9 inches at the support; at midpoint the maximum departure of the centerline shall be 6 inches at 225 foot span, and as the span shortens the departure may increase to a maximum of 12 inches.

702. NEE Main Track

(a) The catenary for tangent track shall be two-wire, auto-tension, construction consisting of a 300 kcmil, hard drawn copper messenger and a 300 kcmil, silver-copper, grooved contact wire. The maximum span between supports shall be 228 feet.

(b) The catenary for curved track shall be the tangent-chord type. The maximum departure from the centerline of the pantograph shall be 9 inches at the support; at midpoint the maximum departure of the centerline shall be 6 inches.

703. NEC Yard and Side Track

(a) Catenary shall consist of two-wire construction with a 5/8" diameter composite messenger and 4/0 bronze alloy 55, contact wire (336,400 cir mils bronze contact wire on ladder tracks) and clamped hangers, shown as Type XVI on Drawing ET-1101-C. Tangent chord construction shall be used on curved track.

704. NEE Yard and Side Track

(a) Catenary shall consist of two-wire construction consisting of a 300 kcmil, hard drawn copper messenger and a 300 kcmil, silver-copper, grooved contact wire. The maximum span between supports shall be 228 feet. Tangent chord construction shall be used on

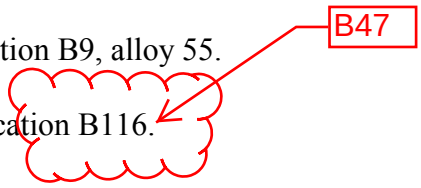
curved track. Stitched trolley wire construction may be used in yards, shops and other location where special conditions apply.

705. Material for Catenary System

(a) The 5/8" diameter composite messenger shall be bare, 19 strand concentric-lay copper and copper-clad steel composite wire conforming to ASTM Specification B229, Type 4/0 E.

(b) The NEE 300 kcmil messenger shall be bare, 37 strand concentric-lay hard drawn copper wire conforming to ASTM B8. Class B.

(c) The bronze contact wire shall conform to ASTM Specification B9, alloy 55.



(d) The copper auxiliary wire shall conform to ASTM Specification B116.

(e) The NEE silver bearing copper contact wire shall be 300 kcmil, hard drawn, solid grooved wire with a minimum breaking load of 12,800 lbs conforming to QA/P.11-A.

(f) The bronze hanger rod shall be in accordance with Class B material in accordance with P.R.R. Specification C.E. 565.

(g) The NEE bronze hanger wire shall be No. 6 AWG medium cadmium bronze alloy 80 (B105), stranded, bare, and non-destrandable, conforming to ASTM B8. Class D

(h) The NEC messenger and contact wire clips listed on Drawings ET-1100-C and ET-1101-C shall be in accordance with detailed drawings and the material shall be bronze as specified on the detail drawings.

(i) The NEE contact wire clips shall be aluminum bronze to ASTM B30 alloy 954 with silicon bronze hardware in accordance with drawing JVCC1406.

(j) Thee NEE messenger wire clips shall be ASTM B30 alloy 954 with silicon bronze hardware in accordance with drawing JVCC1407.

(k) NEC bronze or stainless steel bolts listed on Drawings ET-1100-C and ET-1101-C shall be in accordance with detail drawings referred to thereon.

706. Splices for Catenary System Wires

(a) NEC Messenger splices shall be automatic type in accordance with drawing ET-1-103-2.

(b) NEE messenger splices shall be compression type copper splices in accordance with

drawing JVCC0434.

(c) NEE contact wire splices shall be copper splices in accordance with drawing JVCC0430 and JVCC0434.

(d) The 4/0 copper auxiliary splice shall be an automatic type in accordance with drawing ET-1-103-2.

(e) The 4/0 and 336.4 kcmil bronze contact wire shall be spliced with high-speed type trolley wire splices, Ohio Brass Company Nos. 15890, 16146 or approved equal.

707. NEC Catenary Suspension Assemblies

(a) The catenary shall be supported by means of assemblies as shown on standard drawings.

(b) The standard assembly drawings list all parts required and refer to the detail drawings of these parts. The material shall be bronze, ductile iron, or steel forgings, as shown on detail drawings.

(c) Insulators shall be Type B-1 as shown on Drawing ET-1302-D.

(d) Bronze rod, where called for, shall be in accordance with Class B material, P.R.R. Specification C.E. 565, and shall be threaded in the field.

(e) Ductile iron hardware shall conform to alloy specification 65.45.12.

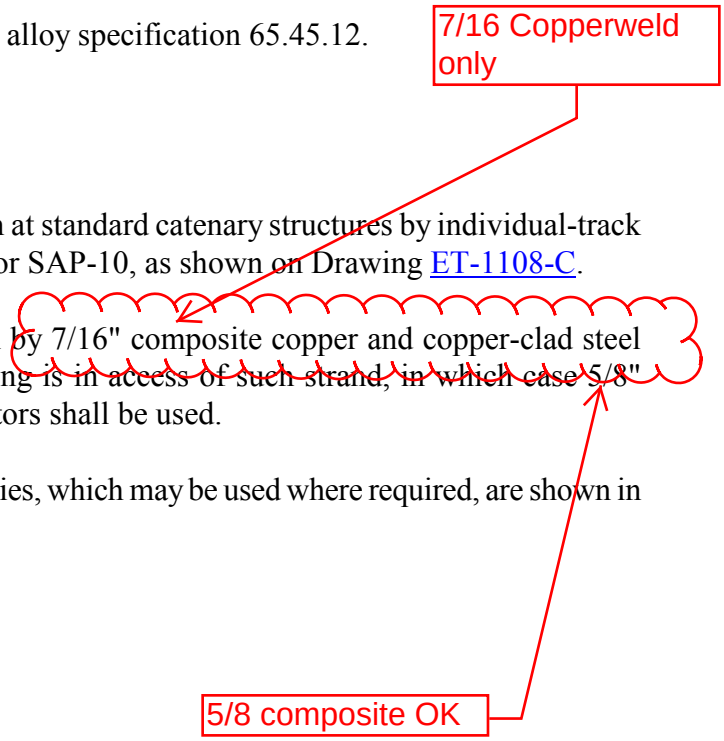
708. NEC Steadies, Pull-Offs, and Push-Offs

(a) The catenary shall be held in a position at standard catenary structures by individual-track steadies Type SAP-5, SAP-6, SAP-7, or SAP-10, as shown on Drawing ET-1108-C.

(b) The catenary shall be held in position by 7/16" composite copper and copper-clad steel strand except in locations where loading is in access of such strand, in which case 5/8" composite strand and Type A-2 insulators shall be used.

(c) Additional steady and pull-off assemblies, which may be used where required, are shown in the following drawings:

- ET-1106-C
- ET-1107-C
- ET-1108-C



(d) Hardware for above assemblies shall be made of bronze, ductile iron, or steel, as called for on individual detail drawings.

(e) Insulators shall be of suspension units Type A or B or rigid Type C as shown on Drawing ET-1302-D, and they shall be manufactured in accordance with P.R.R. Specification C.E. 560-(b).

709. NEE Catenary Assemblies

(a) The catenary shall be supported by means of cantilever arms or moveable components that allow for the along-track movement of the catenary in accordance with general arrangement drawings JVCB0101 through JVCB0355.

710. NEC Sectionalizing of Catenary System

(a) The type of air section break to be used in sectionalization of the catenary system depends on its location and type of catenary and shall be in accordance with the following tabulation:

Location	Type of Section Break	Drawing No.
Main Track- 2-Wire	Double Messenger, Full Tension	ET-1102-C
Crossover in Main Track	Double Messenger, Full Tension, or High Speed Section Insulator (HSSI)	ET-1102-C
Yards, Side Tracks and Yard Crossovers	Double Messenger, Full Tension, or High Speed Section Insulator (HSSI)	ET-1102-C
Main Track- 3-Wire	Double messenger, Full Tension	ET-1102-C

(b) Catenary dead-end and sectionalizing assemblies shall be in accordance with those on Drawing ET-1104-C. Dead-end insulators shall be put approximately 10 feet from pole except when crossing a non electrified track, in which case the insulators shall be placed between the electrified and non-electrified tracks.

(c) Deflectors for two-wire and three-wire catenary shall be in accordance with drawing ET-1109-C.

711. NEE Sectionalizing of Catenary System

(a) General arrangement of overlaps shall be in accordance with drawings JVCB0103_01 to

JVCB0105_10.

(b) Section insulators where permitted shall be installed in accordance with instructions on drawings JVCC6101 and JVCC6201.

712. Catenary at Interlockings

Catenary at interlockings shall be laid out with due consideration to the following principles:

(a) The maximum spacing between catenary structures shall be 225 feet. Close spacing shall be extended beyond each end of the interlocking to provide future extensions.

(b) A catenary structure shall not be located more than 10 feet from frog point toward the switch point.

(c) Sectionalizing insulators in the crossover catenary shall be 6 feet from the centerline of the adjacent main track. Protection of operation on the main track is more important than the length of the crossover break.

(d) In NEC high speed territory the main track contact wire at the deflector shall be placed as near as possible to one foot towards the turnout from the centerline of the pantograph on the main track.

(e) The NEC main track and the crossover messengers at the cross bucks shall be approximately the same height, and the vertical projection of the catenary shall be such as to give a 45 degree slope to the cross bucks.

713. Wire Tensions

(a) The NEC catenary wires shall be tensioned as shown on drawings AET.10000, AET.10001, AET10002 and AET.10003. The initial tension includes an allowance for inelastic stretch.

(b) NEC messenger stringing tensions shall be as shown on Drawings ET-625-E.

(c) NEE auto-tensioned system shall have a normal messenger and contact wire tension of 4400 lbs.

714. Overhead Bridges, Stations, and Tunnels

The design of catenary at these locations shall be governed by the following considerations:

(a) Where overhead bridge clearance is sufficient for the desired height of contact wire to be obtained with a clearance of 18 inches or more at 0 degrees F between messenger and nearest part of bridge structure, attachments to the bridge shall be omitted.

(b) At locations where catenary attachments are required, the type of assembly shall be selected based on the area and to suit local conditions.

(c) At locations where a review of operating conditions indicates the necessity of having the catenary offset on account of locomotive blast or heat from the oil burner stack, it shall be offset one foot from the centerline of track, providing the contact wire is less than 20 feet. At station platforms, the catenary shall be offset away from the platform.

(d) In tunnels or other points with low contact wire and where diesel locomotive traffic is heavy, all parts of the catenary system and supports shall be protected against corrosion.

(e) Minimum NEC clearances, where attached to structures, shall be 9" static and 7" passing after considering the additional allowances recommended in AREMA chapter 33, part 2, clearances.

(f) Minimum NEE clearances, where attached to structures, shall be 10" static and 8" passing after considering the additional allowances recommended in AREMA chapter 33, part 2, clearances. Applicable clearance drawings are: JVCA2830, JVCA2831, JVCA2835_01, JVCA2835_02, JVCA2835_03, and JVCA2835_04.

715. Contact Wire Height

(a) On main tracks (except as noted below) the catenary structures shall be designed for a 24'-6" normal contact-wire height, but the wire shall be installed at 22'-0" above top of rail.

(b) On mountain grades and in yards where trainmen are required to ride on top of cars in performance of their duties, structures shall be designed for 24'-6" contact wire height and the wire shall be installed at this height.

(c) In passenger car yards, structures shall be designed for and the contact wire shall be installed at 22'-0" normal height. Special sectionalizing over cars or a 24'-6" wire height shall be provided where local conditions indicate that this must be done.

(d) Minimum contact wire shall be 18'-0" except where otherwise approved.

(e) At certain locations, other than above, a contact-wire height of 24'-6" shall be provided to

permit employees to ride or work on top of cars. Such locations shall be designated as high-wire territory, and indicated by high-low wire signs.

716. Special Catenary

(a) The catenary over inspection pits shall have a double air section break at each end, and shall be energized through a manually operated switch having the blade grounded in the open position. The switch may be omitted and the section over the pit permanently grounded if required by local conditions.

(b) Where contact wire adjacent to a standpipe is 24'- 6" high, it shall have an air section break not less than 50 feet on each side of the standpipe. The type of break is shown on drawing ET-1007-C and the mechanical interlock drawings on ET-1062-C and ET-1063-C. High-low wire signs shall be installed at both ends unless in territory already designated by such signs.

Where the contact wire is less than 24' 6" high, it shall not have a double air section break not less than 50 feet on each side of the standpipe. The island section will be permanently grounded to rail return system and a sign requiring enginemen to shut off power shall be installed at both ends.

(c) The phase break shall consist of a middle section 45 feet long with an air section break at each end and equipped with phase section break signs and indicators. The middle section shall be energized through a circuit breaker. See Specification C.E. 501, Part VI, Sections 603 and 604. A typical assembly is shown on drawing 20C-3952. Control shall be so arranged that operation of any phase section break circuit breaker will light all phase section break indicators.

717. Signs

(a) Reflective high-low wire signs (Drawing ET-1480-D) shall be installed at the limits of high-wire territory.

(b) The location of a phase break shall be indicated by a sign placed on the first catenary structure in advance of the break. This sign shall have a black background with the letters "P.B" marked in white, as detailed on Drawing ET-1189-D.

(c) The end of the catenary running over any track shall be indicated by a sign with the words "A-C MOTOR STOP". The detail and mounting of the sign are shown on Drawing ET-1188-D.

(d) When a section of the catenary at a standpipe or other location is permanently grounded, it shall be indicated by a sign placed on the first catenary structure placed in advance of the dead section. This sign shall have a black background with the letters "D.S." marked in white, as detailed on drawing ET-1189-D.

(e) When a section of the catenary at the standpipe is de-energized by a switch interlocked with the standpipe mechanism, it shall be indicated by a sign placed on the first catenary structure placed in advanced of the section. This sign is made visible at night by colorless glass which outlines the words "STANDPIPE SECTION" dimensioned in accordance with Drawing ET-1098-C.

718. Clearances of Structures from Track

(a) On curved track, the side clearance shall be increased one inch per degree of curvature over that applicable for tangent track when the structure is outside the curve, and shall be increased one inch per degree of curvature (or fraction thereof) plus 3 ½ times the amount of super-elevation when the structure is inside the curve.

(b) Consideration should always be given to the probability of increased distance between track centers, and the widening of ditches.

(c) The approval of the clearance department shall be obtained for the location of any structure where minimum clearances from gage of near rail to centerline of structure cannot be obtained.

PART VIII -- TROLLEY SECTIONALIZING SWITCHES

801. Plans

(a) Trolley-sectionalizing plans shall be made from track charts and submitted to the Railroad for approval. The plans shall be developed on the basis that all main and other important tracks, such as principle ladder tracks in yards, will have motor-operated switches equipped with arcing horns; all others shall be remote manually operated without arcing horns. The operating numbers of the switches shall follow the present practice of using the track designations; as for example, number 22 for a switch in track #2 and 43 for a switch in a crossover having a normal direction of train movement from track #4 to track #3. When a feeder run is over a 1,000 feet long a manually-operated disconnect switch shall be provided at the tap. Special applications of switches at inspection pits and standpipes are covered in paragraphs (a) and (b) of Section 716.

802. Mounting

(a) The switches shall be mounted on a catenary pole as near as possible to the section break based on Drawing ET-981-C. Top of pole mounting shall be avoided if possible. An arc clearance of 10 feet shall be maintained above the switch blade and arcing horns. Where it is necessary to carry the taps from the switch to the feeders around the pole, cross arms shall be provided to obtain the minimum clearance of 3'-6" from the pole, and in no case shall the tap be carried over the pole top. To support the tap around the pole, Use rigid type insulator assembly NA-98 (ET-497-E).

(b) The catenary structure erection diagram shall show the switch mounting location, the letter that denotes the type of mounting, and the switch operating number. A tabulation drawing shall be prepared using all trolley sectionalizing switches on the job. This tabulation shall identify each switch as to location and operating number and shall contain complete information as to manufacturer, type of mechanism, and all mounting instructions that are not covered by catenary structure erection diagram. The actual location of handles, operating mechanisms, pipe guides, and pipe lengths will be determined in the field. Uniform operating assemblies of all motor or manually operated switches shall be in accordance with Specification CE 512 (a).

803. Power Supply

(a) For motor operated switches the power supply shall be 125 volts direct current fed from a nearby battery bank. All control batteries shall be in accordance with specification C.E. 516.

804. Control – General

(a) The control of these switches shall generally be connected to the power director through the SCADA system via a local RTU. This control shall consist of "close" and "open" circuits and two "indication" circuits to show switch position. D-C control shall be used.

(b) All power and control cable shall be in accordance with Specification for Wire and Cable No 112-D.

(c) A drawing shall be made for the area controlled showing a plan of the cable runs, wiring details at each junction box, and the typical wiring schemes involved. This drawing shall be similar to drawing 20D-7372 except that at the mechanism only the terminal block will be shown; a reference shall be made to the instruction book diagram giving complete internal wiring for the proper mechanism. In addition, the following notes will be standard

on these drawings:

1. All cable shall be installed at the ground at a minimum depth below top of rail at 3'-6" whether the runs are parallel to or crossing under tracks. Where cables pass under rock ballast, they shall be installed at a minimum depth at 5'-6" below top of rail. In no case shall the cables be buried less than 2'-0" below ground. All cables shall be protected with electrical warning tape a minimum of 1 foot above the cable and cables crossing the tracks shall be installed in rigid non-metallic conduit.

2. For cable connection at cabinets, junction boxes, mechanism and power supply fuse boxes, see Drawing ET-1160-C.

805. Direct-Wire Control

(a) The control switch shall be similar to Westinghouse Type "W" and the lamps showing the "indication" shall be red for closed and green for open.

(b) If the switch to be controlled is between 1,200 and 8,000 feet from the point control, the sectionalizing switch mechanism shall have an interposing relay which will limit the control current to not more than 0.15 ampere.

(c) The power leads shall be composed of #2 conductors from the source to the distribution box and from there two #4 conductors shall be used to the individual switches. The control leads shall be #10 or #14 as required. There will be four control leads for each switch. The power and control conductors shall be combined into the same cable where practicable.

806. Substation Supervisory Control

(a) Where the trolley sectionalizing switch is to be controlled by substation supervisory, the design shall be the same as Direct Control, but in addition, the necessary interposing relays will be supplied with supervisory apparatus for control and indication.

PART IX -- BONDING AND STRUCTURE GROUNDING

901. Rail Bonds

(a) Power bonding on all a-c electrified tracks shall be in accordance with current C&S department standards.

(b) Cross bonding shall be in accordance with current C&S department standards.

(c) At insulated joints where structure grounding is required in signal territory, Amtrak standard impedance bonds shall be used to provide continuous return path for traction current.

903. Ground Wire

(a) Structure shall be tied together electrically by a bare, aerial 4/0, 7-wire, hard-drawn, copper strand which, in transmission territory, shall be used as a ground wire.

904. Structure Grounding

(a) All catenary structures not connected to the ground wire shall be grounded in accordance with the details for steel structures as shown on Drawing ET-1120-C. In non-signal track circuit territory the structures may be bonded directly to the rail

(b) In general, overhead bridges, their catenary attachments and protection barriers shall be grounded to nearest grounded catenary pole in accordance with standard details (ET-1120-C)

(c) In station areas, special consideration shall be given to the method of grounding all structures.

(d) In tunnels, there shall be ground wire which may be carried on the insulator supports above the insulators and all the brackets shall be bonded to this wire. Where clearances are restricted, special consideration shall be given to location of ground wire to prevent physical injury.

(e) At oil storage tracks, special grounding connections shall be installed in accordance with current NESC standard and in general shall follow the designs shown on Drawings 45D-4002 and 47C-4002.

905. Rail-Return Wire

(a) In special cases such as where there is no transmission and the feeder is used to supplement the catenary, a rail-return wire shall be provided where necessary to improve regulation and reduce inductive interference.

(b) At each substation all electrified tracks shall be connected to the negative bus of the substation by means of rail-return conductors of such size as may be required to meet electrical conditions and applied to rail in accordance with Drawing ET-1121-C. In signal track circuit territory this connection shall be made through an impedance bond.

PART X -- POWER FOR WAYSIDE FACILITIES OTHER THAN SIGNALS

1001. Power for Sectionalizing Switches

(a) Power for track switch heaters, shall be supplied from 25-cycle catenary system or commercial services. When the supply is taken from the catenary system, the circuit shall include a step-down transformer and its protective apparatus, such as a disconnecting switch, lightning arrester, fuse and resistor in accordance with Specification C.E. 501, Part XI.

(b) Wayside facilities such as station lighting, interlocking lighting, pumps, compressors, MW tools, etc. shall come from a commercial power source exclusively,

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