NYRI
New York Regional Interconnection

NEW YORK REGIONAL INTERCONNECT INC.

NEW YORK REGIONAL INTERCONNECTION

EXHIBIT E-1

DESCRIPTION OF PROPOSED TRANSMISSION LINES AND CABLES

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EXHIBIT E-1 DESCRIPTION OF PROPOSED TRANSMISSION LINES AND CABLES

New York Regional Interconnect (NYRI) proposes to construct an approximately 190-mile, bipolar, high-voltage, direct current (HVDC) transmission line running from the Northern Converter Station near Edic Substation in the Town of Marcy in Oneida County, New York to the Southern Converter Station near the Rock Tavern Substation in the Towns of Hamptonburgh and New Windsor in Orange County, New York. The DC transmission line will be designed for and operated with a rated power flow of 1200 megawatts (MW) at a nominal voltage of ±400 kilovolts (kV) DC.

The bipolar system will be designed to operate as two independent electrical poles such that a forced outage on one electrical pole will not affect the operation of the other electrical pole. When one electrical pole is out of service, the remaining active electrical pole will operate in a monopolar configuration at 50% of the rated power flow (600 MW), with the metallic return conductor providing the return path for the DC current.

E-1.1 DC Transmission Line

E-1.1.1 DC Transmission Line Structures

The aboveground transmission lines (conductors) will be supported by either lattice towers or steel monopoles.[1] Characteristics of the two types are described in Section E-1.4. The transmission line structures proposed for the portions of the Proposed Route within railroad properties will be steel monopoles, while most of the structures proposed outside railroad properties will be lattice towers. To accommodate typical conditions found within railroad property and outside railroad property, a total of 16 representative structure types has been selected for use. Each type is summarized below; details including spatial dimensions of each are shown on the cited figures.

The design of the transmission line will be in accordance with all applicable national and state codes and regulations, and in particular the National Electrical Safety Code (NESC). The NESC specifies the minimum structural loading conditions required to determine the strength requirements for supporting structures, as well as the minimum clearances to the ground surface, adjacent transmission lines, railroads, buildings, and other facilities.

E-1.1.1.1 DC Transmission Line Structures within Railroad Properties

The DC transmission line structures within railroad properties will be constructed from tubular structural steel and will be galvanized to guard against corrosion.

In some areas, self-weathering steel may be used to reduce the visual impact of the transmission line structures against the background landscape. Self-weathering steel is a specially-formulated steel material that quickly forms a surface layer or patina to seal out the atmosphere and inhibit further corrosion. Over time the steel will naturally weather to a deep dark brown color.

[1]This information is being provided in response to the PSC interrogatory request DPS 15.3, DPS 15.4, and DPS 21.2 – See Figures.

The structure head arrangement (i.e. the geometric configuration of the conductors at the structure) has been designed to limit both the conductor surface gradient (i.e. the electric field at the surface of the conductor) and the total electric field to values that meet design criteria limits and conform to industry accepted practices. The magnetic field intensity produced by the DC line is lower than the ambient magnetic field produced by the earth. The electric and magnetic field effects are further described in Appendix G.

Several designs of transmission structures will be required for those sections of the Proposed Route within railroad properties. Details of each of these structures are shown in Figures E-1.1.1-1 through E-1.1.1-6, with short descriptions given below. The height of each structure varies with the span length used. Variations in vertical dimensions based on span length are reported in a table presented in each figure.

New York Susquehanna and Western Railroad Property

Figure E-1.1.1-1: Light Angle Suspension Structure

A single-pole suspension structure that may be placed on either side of the railway tracks, with conductor bundles suspended vertically, and designed for line angles between 0 and 4 degrees.

Figure E-1.1.1-2: Medium Angle Suspension Structure

A single-pole suspension structure that may be placed on either side of the railway tracks, with conductor bundles suspended vertically, and designed for line angles between 4 and 12 degrees.

Figure E-1.1.1-2A: Medium Angle and Dead End Structure

A single-pole, dead-end structure that may be placed on either side of the railway tracks, with conductor bundles terminated vertically on the steel pole, and designed for line angles between 12 and 45 degrees or for use as a dead-end terminal structure.

Figure E-1.1.1-3: Large Angle and Dead End Structure

A single-pole, dead-end structure that may be placed on either side of the railway tracks, with conductor bundles terminated vertically on the steel pole, and designed for line angles up to 90 degrees or for use as a dead-end terminal structure.

Norfolk Southern Railroad Property

Figure E-1.1.1-4: Light Angle Suspension Structure

A single-pole suspension structure that may be placed on either side of the railway tracks, with conductor bundles suspended vertically, and designed for line angles between 0 and 4 degrees.

Figure E-1.1.1-5: Medium Angle Suspension Structure

A single-pole suspension structure that may be placed on either side of the railway tracks, with conductor bundles suspended vertically, and designed for line angles between 4 and 12 degrees.

Figure E-1.1.1-5A: Medium Angle and Dead End Structure

A single-pole, dead-end structure that may be placed on either side of the railway tracks, with conductor bundles terminated vertically on the steel pole, and designed for line angles between 12 and 45 degrees or for use as a dead-end terminal structure.

Figure E-1.1.1-6: Large Angle and Dead End Structure

A single-pole, dead-end structure that may be placed on either side of the railway tracks, with conductor bundles terminated vertically on the steel pole and designed for line angles up to 90 degrees or for use as a dead-end terminal structure.

Transmission structure foundation requirements will vary based on the geotechnical conditions at each structure location along the Proposed Route. In soil strata, concrete caissons of varying sizes will be required, depending upon the structures they support and the load-bearing capacity of the native soils. The anticipated ranges of diameters and depths of concrete caisson foundations are presented in Figure E-1.1.1-11. In rock strata, anchor bolts will be grouted into holes drilled in solid rock. A relatively small leveling pad of concrete will be poured over and around these anchor bolts to provide a level surface for the structure base. The range of dimensions for rock anchor foundations is presented in Figure E-1.1.1-10. In wetlands and other poor soil locations, steel pile and concrete cap foundation design may be used as dictated by soil conditions. Typical pile and cap foundation outline and general dimensions are shown in Figure E-1.1.1-12. Various combinations of these types of installations may be necessary where sound rock is located several feet below grade. For augured foundations where excessive groundwater is encountered, large-diameter steel caissons will be used to keep the excavation dry while the foundation is being constructed.

E-1.1.1.2 DC Transmission Line Structures outside Railroad Properties

The vast majority of the DC transmission line structures located outside railroad properties will be lattice steel towers. Similar to the steel pole structures proposed within railroad properties, these lattice steel towers and pole structures will be galvanized to guard against corrosion.

The tower head arrangement has been designed to limit the conductor surface gradient and total electric field to values that meet design criteria limits and conform to industry-accepted practices. The magnetic field intensity produced by the DC line is lower than the ambient magnetic field produced by the earth. The electric and magnetic field effects are further described in Appendix G.

Several designs of lattice towers and steel poles will be required along the sections of the Proposed Route outside railroad properties. Details of these towers and poles are shown in Figures E-1.1.1-7 to E-1.1.1-9, with short descriptions given below. The height of each tower varies with the span length and topography. A table giving variations in vertical dimensions based on span length is given in each figure.

Figure E-1.1.1-7: Lattice Tower – Tangent and Light Angle 0º - 4º

A lattice steel suspension tower, with conductor bundles symmetrically arranged on cross-arms on each side of the tower, and designed for line angles between 0 and 4 degrees.

Figure E-1.1.1-7A: Steel Pole – Tangent Suspension Structure – Horizontal Configuration

A single pole suspension structure with conductor bundles suspended horizontally.

Figure E-1.1.1-7B: Steel Pole – Tangent Suspension Structure – Vertical Configuration

A single pole suspension structure with conductor bundles suspended vertically.

Figure E-1.1.1-7C: Lattice Tower – Double Circuit Tangent with 115 kV Line

A lattice steel suspension tower, with conductor bundles for 115 kV AC and ±400 kV DC symmetrically arranged on cross-arms on opposite sides of the tower.

Figure E-1.1.1-8: Lattice Tower - Medium Angle

A lattice steel suspension tower, with conductor bundles symmetrically arranged on cross-arms on each side of the tower, and designed for line angles between 4 and 12 degrees.

Figure E-1.1.1-8A: Steel Pole – Angle Suspension Structure

A single pole suspension structure with conductor bundles suspended horizontally.

Figure E-1.1.1-9: Lattice Tower - Large Angle

A lattice steel strain tower, with conductor bundles symmetrically arranged on cross-arms on each side of the tower, and designed for line angles between 12 and 60 degrees, or for use as a dead-end terminal tower.

Figure E-1.1.1-9A: Steel Pole Dead End Structure

A single pole dead end structure with conductor bundles suspended horizontally.

Transmission tower foundation requirements will vary based on the geotechnical conditions at each tower location along the Proposed Route. In soil strata, reinforced concrete spread footings of varying sizes will be used depending upon the tower structures they support and the load bearing capacity of the native soils. The volume of earth required to be excavated for construction of the spread footing, along with the backfill volume and column profile above ground, are presented in Figure E-1.1.1-14. In rock strata, anchor bolts will be grouted into holes drilled in solid rock. A relatively small leveling pad of concrete will be poured over and around these anchor bolts to provide a level surface for the structure base. The ranges of dimensions for rock anchor foundations are presented in Figure E-1.1.1-13. In wetlands and other poor soil locations, steel pile and concrete cap foundation design may be used. Typical pile and cap foundations and general dimensions are shown in Figure E-1.1.1-15. Various combinations of these types of installations may be necessary where sound rock is located several feet below grade.

In three areas, steel pole structures will be used in lieu of lattice towers. Steel monopole structures were selected for these areas to correspond with the use of nearby, similar, and existing monopole transmission line structures. Galvanized steel or self-weathering steel will be specified for these steel pole structures. A typical monopole structure with conductors in a horizontal configuration is shown in Figure E-1.1.1-7A. Transmission structure foundation requirements will be the same as described in Section E-1.1.1.1 for steel pole structures within railroad properties.

Steel monopole structures are designated to be used in the following areas:

1. For 4.5 miles extending from the Northern Converter Station south to the transition station (Station Number 4.5) in the Town of Whitestown;

2. For 0.7 miles extending from the transition station (Station Number 61) southeast of the City of Norwich to the top of the hill on the south side of the Johnson Creek valley (County Route 34); and

3. For 2.0 miles where the line occupies the inactive Norfolk Southern railroad property in an overhead configuration (Station Number 165.5 to Station Number 167.5).

Additionally, over approximately 0.5 mile through the D&H Canal Park (Station Number 164), there is insufficient width for the transmission line to be in a horizontal configuration. In that area, steel poles with conductors in a vertical configuration will be used. A typical monopole tangent structure proposed for use in narrow rights-of-way is shown in Figure E-1.1.1-7B. Steel pole foundation requirements within railroad properties will be the same as described in Section E-1.1.1.1

Approximately 1.9 miles of the existing Central Hudson Gas & Electric Rock Tavern – Sugarloaf 115 kV line will be rebuilt as a double circuit lattice tower. The rebuilt line will carry both the ± 400 kV DC poles on one side of the tower and the Central Hudson Gas & Electric line on the other. A typical double-circuit tangent lattice tower is shown in Figure E-1.1.1-7C. Transmission structure foundation requirements will be the same as described in this section for lattice towers.

E-1.1.2 Conductors

The conductors (overhead wires or lines) proposed for each electrical pole will consist of two 2156-thousand circular mills (kcmil) diameter aluminum conductor with steel reinforcement

(ACSR), or "Bluebird" conductors, bundled in a horizontal configuration with a conductor spacing of 18 inches. Each conductor has an overall diameter of 1.762 inches.

The metallic return conductor will consist of a single 2156-kcmil ACSR conductor with an internal core containing fiber optic light guides. These guides will provide a communication path between the two HVDC converter stations. The metallic return conductor normally carries the unbalance current (typically 1% to 2% of rated current) during bipolar operation, and the full return current during monopolar operation. The metallic return conductor will be insulated from the structure so that no return current will circulate through ground. On single-pole structures, the metallic return will also function as the shield wire for the electrical pole conductors to protect from lightning strikes. As such, it is carried in a shield wire position, with a shielding angle of approximately 15 degrees above the electrical pole conductors.

On towers and steel poles with a horizontal arrangement of the electrical pole conductors, an overhead shield wire will be required in addition to the metallic return conductor. The overhead shield wire will provide adequate lightning shielding for the electrical pole conductors. This overhead shield wire will be either galvanized steel or aluminum-clad steel, with a diameter in the range of 0.4 to 0.5 inches. The overhead shield wire will be grounded at every structure.

The conductor used for the electrical poles, the metallic return, and the shield wire will be of the non-specular (non-reflective) type to reduce the visual impact.

E-1.1.3 Insulator Assemblies

Suspension and strain insulators for the electrical pole conductors will be "DC type," manufactured from high quality porcelain, with an optimized shed profile for DC applications. Suspension insulators will be single insulator V-strings, with corona rings installed at each string's conductor end attachment point. Strain assemblies will be double-insulator strings, again with corona rings installed at the conductor end attachment point. The porcelain insulators will be gray in color. Typical details of the insulator assemblies are shown for each of the tower types in Figures E-1.1.1-1 through E-1.1.1-9A.

In areas with the potential for airborne particulate pollution from industrial or other activities, polymer insulators with silicon rubber sheds may be used, instead of the porcelain insulators, for the suspension and strain insulators. Polymer insulators with silicon rubber sheds will limit the potential for tracking and flashover due to the accumulating particulates. These silicon rubber insulators will also be gray in color.

The metallic return conductor of the DC line will be insulated along the full length of the line and will be grounded only at one of the converter stations. This design will ensure that the return current does not flow through the earth. The metallic return conductor will use the same insulator types as the electrical pole conductors, but with an insulation level approximately between 25 kV and 50 kV. As the metallic return conductor is carried in the shield wire position, it will be exposed to direct lightning strikes. The metallic return insulator assembly will require arcing horns to ensure that an arc resulting from a lightning strike will not occur directly across the insulators. This will also ensure that the arc is extinguished after the lightning has dissipated.

E-1.1.4 Overhead Line to Underground Cable Transitions

Specialized transition structures will be required where there is a transition between overhead conductors and underground cables. A plan and elevation view of the overhead to underground transition structures is given in Exhibit E-3, Figures E-3.7-1 and E-3.7-2.

E-1.1.5 Bus Spans

Specialized facilities will be required where there are proposed crossings under the existing New York Power Authority (NYPA) 345-kV double circuit AC transmission line. These facilities will avoid using structures over 200 feet tall that would be necessary to cross over the NYPA line. The proposed overhead DC line will terminate in a dead-end structure, drop down to rigid bus that will cross under the existing NYPA AC line, and rise up to a typical overhead position at a dead-end structure on the other side of the existing NYPA AC line. The bus span area will be fenced and, like in a substation, the rigid bus will be supported on insulators. Figure E-1.2.5 illustrates a plan and elevation view of a typical bus span.

E-1.2 AC Transmission Interconnections

This section describes the high-voltage AC interconnections between the converter stations and the existing 345 kV AC Edic and Rock Tavern Substations.

E-1.2.1 Edic Substation AC Interconnection

The interconnection between the 345 kV AC switchyard at the Northern HVDC Converter Station and the immediately adjacent Edic Substation will be accomplished using direct buried underground cross-linked polyethylene (XLPE) cable in conduit. The 345 kV AC interconnection will be routed to the north from the AC switchyard, and cross under the three existing NYPA 345 kV transmission lines, before heading east toward terminations, which will be located immediately outside of the expanded Edic Substation fence line. The 345kV AC interconnection will then transition from underground to an overhead strain bus and connect to an expansion bay in the Edic Substation via drop-downs from the overhead strain bus to the substation rigid bus. Reliability and protection of the interconnection will be assured by use of the redundant and highly reliable "one-and-one-half" breaker scheme in the new 345 kV AC switchyard. All clearances and spacings shall be in compliance with the requirements of the NESC and applicable standards.

E-1.2.2 Rock Tavern Substation AC Interconnection

Two interconnection lines are proposed between the 345 kV AC Switchyard at the Southern HVDC Converter Station and the immediately adjacent Rock Tavern Substation. One AC interconnection will be via a set of aluminum rigid bus, which will be similar in material and construction to the existing rigid bus at the Rock Tavern Substation. The other AC interconnection will be via a direct buried underground 345 kV XLPE cable in conduit. The rigid bus will be supported by standard steel bus structures and high-voltage insulators. To optimize the use of space, the aluminum rigid bus will overlay the underground circuit. The interconnection will take place on the eastern side of the Rock Tavern Substation where the rigid bus will connect to an expansion bay via strain bus. The underground cable will end at terminations known as potheads and connect to a different expansion bay. Reliability and protection of the interconnection will be assured by use of the redundant and highly reliable "one-and-one-half" breaker scheme in the new 345 kV AC switchyard. All clearances and spacings shall comply with the NESC and applicable standards.

E-1.2.3 Rock Tavern Substation AC Interconnection – Alternate Converter Site

An alternate converter site, approximately 1.9 miles south of the Rock Tavern Substation, has been identified for consideration. Should the alternate converter site be certified, the interconnection between the 345 kV AC switchyard at the alternate HVDC converter and the Rock Tavern Substation will be via 345 kV overhead transmission and an underground 345 kV XLPE cable. The overhead conductor will be 2156-kcmil ACSR "Bluebird" conductor, and two conductors will be used per phase. The underground installation will consist of 2,500-millimeters-squared 345 kV XLPE cable, as described in Exhibit E-3, Section 3.2.1, and shown in Figure E-3.2.1-2. Reliability and protection of the interconnections will be assured by use of the redundant and highly reliable "one-and-one-half" breaker scheme in the new 345 kV AC switchyard.

One circuit will exit the 345 kV AC switchyard at the alternate HVDC converter via underground cable. The second circuit will exit via rigid aluminum bus, to cross under the existing Con Edison Rock Tavern – Ramapo 345 kV transmission line. Once the existing Con Edison line has been crossed, the rigid aluminum bus will transition overhead and the underground cable will continue as underground installation.

The Central Hudson Gas & Electric Rock Tavern – Sugarloaf 115 kV transmission line will be rebuilt for 345 kV double circuit lattice towers, as shown in Figure E-1.3.3-1. One side of the tower will contain the Central Hudson Gas & Electric 115 kV circuit and the other side will contain the NYRI 345 kV circuit. All circuits will then travel north, paralleling the existing Con Edison 345 kV transmission line to the Rock Tavern Substation. The interconnection will take place on the eastern side of the existing Rock Tavern Substation, where the overhead line will connect to one of the expansion bays via overhead strain bus. The underground cable will terminate at potheads in a different expansion bay. All clearances and spacings shall be in compliance with the NESC and all applicable standards.

E-1.3 Transmission Line Standards

The transmission line will be designed to ensure the reliable transmission of the full output of the converter stations.[2] Since, due to the heating effect of current, the conductor temperature is normally the limiting element in a free-flowing AC transmission system, it is a common practice to

[2] This information is being provided in response to the PSC interrogatory request DPS 28, Part 4 and DPS 28, Part 5.

define the thermal transfer capacity of AC lines according to the conductor used. However, the HVDC converters define precisely the power flows; hence, the HVDC line conductor cannot experience loadings above the converter's output. Thus, at 1200 MW, the normal and emergency ratings for the DC line are the same. It should be noted that the conductor size and conductor arrangement (two-conductor bundle per pole) for the HVDC line has been selected to minimize voltage gradients and the associated corona effect, rather than for its thermal ampacity; hence, the conductor temperature at full load (1,200 MW) will be just above ambient temperature,[3] and substantially below its thermal limit. In addition to the use of bundled conductor to minimize voltage gradients and the associated corona effect,[4] corona rings will be provided, as recommended by the insulator and hardware suppliers, to limit the source of radio noise to standard values, which at time of purchase, will be validated by laboratory tests.

The design of the transmission line will be in accordance with all applicable national and state codes and regulations, and in particular the NESC. The NESC specifies the minimum structural loading conditions required to determine the structural capacity, and the minimum clearances to the ground surface, adjacent transmission lines, railroads, buildings, and other facilities. All structures will be designed to meet or exceed the requirements of the NESC.

E-1.3.1 Vertical Clearances

The following table sets forth the vertical conductor clearances for the DC transmission line over roads, railroads, agricultural lands, abandoned roads, seasonal roads, other lines (transmission, distribution, and telephone lines), etc.[5] These clearances meet or exceed the requirements of the NESC (NESC Section 23).[6]

Item	Description	NESC Minimum Clearance (feet)
1	Track rails of railroads	40.0
2	Roads, streets, and other areas subject to truck traffic	34.0
3	Driveways, parking lots, and alleys	34.0
4	Other land traversed by vehicles such as cultivated, grazing, forest, orchard, etc.	34.0
5	Spaces and ways subject to pedestrians or restricted traffic only	30.0
6	±400 kV DC Open Supply Conductors cross over 46 kV AC Open Supply Conductors and below	12.0
7	±400 kV DC Open Supply Conductors cross over 138 kV AC Open Supply Conductors	14.0

[3] This information is being provided in response to the PSC interrogatory request DPS 28, Part 5.
[4] This information is being provided in response to the PSC interrogatory request DPS 20, Part 1.
[5] This information is being provided in response to the PSC interrogatory request DPS 19, Part 1.
[6] This information is being provided in response to the PSC interrogatory request DPS 11, Part 1.

Item	Description	NESC Minimum Clearance (feet)
8	±400 kV DC Open Supply Conductors cross over 345 kV AC Open Supply Conductors	18.0
9	±400 kV DC Open Supply Conductors cross over the shield wire of HV transmission lines	12.0

Based on NESC Section 234H3, the NESC design electrical clearance between the conductor, adjacent structures, and other objects in the horizontal direction is a minimum of 14.1 feet. This electrical clearance will be maintained after displacement of the conductor due to wind conditions. As set forth in NESC Section 234A2, the conductor displacement distance varies according to span length, conductor sag, temperature, and wind conditions.

Lightning protection will be provided using the metallic return conductor and the shield wire installed above the power conductors.[7] The angle of protection will be no greater than 15 degrees and will provide a line performance of less than one outage per 100 miles per year. This is considered excellent shielding by present industry standards. Over the 190-mile length of the DC line, this equates to a probability of less than two lightning-induced outages per year for the entire line.

E-1.3.2 Loading Conditions

The temperature, ice, and wind loading conditions and overload factors, as defined by NESC, will be used in the design of structures.[8] NESC-defined loading conditions and overload factors are defined as follows.

NESC Heavy Loading District Condition

- Conductor and Shield Wire: 0° F, 4.0 psf, ½-inch radial ice, 0.3 psf constant
- Wind on Structure: 4.0 psf on round surfaces

The maximum design wind pressure acting at right angles to the line on the projected area of conductor, shield wire, and insulator strings will be 4.0 psf on round surfaces (shape factor 1.0). This is equivalent to a wind velocity of approximately 40 miles per hour at a temperature of 0° F, with ½-inch radial ice. For lattice-type tower design, quartering winds will be applied at 45-degree angle to the conductors.

Extreme Ice Loading Condition

- Conductor and Shield Wire: 0° F, no wind, 1½-inch radial ice
- Wind on Structure: no wind

[7] This information is being provided in response to the PSC interrogatory request DPS 28, Part 1.
[8] This information is being provided in response to the PSC interrogatory request DPS 28, Part 7.

High Wind Loading Condition

- Conductor and Shield Wire: 60° F, 21.0 psf wind adjusted by height, no ice
- Wind on Structure: 21.0 psf adjusted by height on round surfaces

The maximum design wind pressure acting at right angles to the line on the projected area of conductor, shield wire, and insulator strings will be 21.0 psf on round surfaces (shape factor 1.0). This is equivalent to a wind velocity of 90 miles per hour at a temperature of 60° F. Quartering winds will be applied at 45 degree angle to the conductors for lattice-type tower design.

Broken Conductor or Metallic Earth Return/Shield Wire

- Conductor and Shield Wire: 0° F, 4.0 psf wind, ½-inch radial ice, 0.3 psf constant
- Wind on Structure: 4.0 psf on round surfaces

If one conductor of one bundle, or any one metallic earth return/shield wire, were to be broken, the maximum design wind pressure acting at right angles to the line on the projected area of conductor, shield wire, and insulator strings will be 4.0 psf on round surfaces (shape factor 1.0). This is equivalent to a wind velocity of approximately 40 miles per hour at a temperature of 0° F with ½-inch radial ice.

Stringing

- Conductor and Shield Wire: 60° F, no wind or ice
- Wind on Structure: no wind

The above assumed conditions will be used to calculate anticipated loading during the stringing operation. All of the phase conductors and shield wires will be simultaneously strung and clipped in sequence. The shield wire will be the first component installed.

NESC Overload Capacity Factors

In accordance with the NESC, all structures will be designed to withstand the simultaneous vertical, transverse, and longitudinal loads, with the applied overload factors, and without failure or permanent deformation of the structure or its members.

Loading Condition	Vertical	Transverse Wind	Transverse Tension	Longitudinal
(1) NESC	1.5	2.5	1.65	1.65
(2) Extreme Ice	1.0	1.0	1.0	1.0
(3) High Wind	1.2	1.2	1.2	1.2
(4) Broken Conductor	1.5	2.5	1.65	1.65
(5) Stringing	1.5	1.5	1.5	1.5
(6a) Maintenance	2.0	1.5	1.5	1.5
(6b) Security Loads	1.2	1.2	1.2	1.2

Two basic transmission structure designs that will be used for the DC line are lattice towers and tubular steel poles. The advantages of lattice towers are that they provide a more economical line design in cross-country open areas, easier transportation of smaller lighter members in terrains of difficult access, and provide longer transmission line spans to avoid wetlands and other sensitive areas. The disadvantages are that larger foundation footprints and manual assembly of the many components are required.[9]

The advantages of tubular steel poles are that they provide a more economical design in tightly congested areas, they require a smaller foundation footprint, and they are easier and faster to assemble and erect. The disadvantages are that the large pieces constitute heavy loads and foundations require large amounts of concrete, both of which makes transportation difficult, especially across steep terrain or in areas with poor access. In addition, poles are more flexible than lattice making them less-suited for tall structures and/or long spans, and poles are more costly.

E-1.4 Cables for Underground Installation

The installation and details of the underground segments of the cable are discussed in detail in Exhibit E-3.

E-1.5 Structure Grounding

E-1.5.1 General

NESC Section 21 requires that non-current-carrying parts, such as transmission line structures, be effectively grounded.[10] Therefore, transmission line structures will be grounded to achieve a footing resistance of 30 ohms or less measured at each structure.[11] This footing resistance was selected based on known values applied to extra-high-voltage transmission lines (345 kV and above), and will be validated during the design phase by a lightning performance study.[12] The transmission line structures will be grounded using driven ground rods near the base of each structure, and the shield wire will be grounded to earth at every structure location.[13]

The grounding system will consist of a combination of ground rods, counterpoise wire, and interconnecting hardware. In general, the use of ground rods will provide satisfactory structure ground resistance. In areas having high earth resistivity, such as in sand, gravel, or rock formations, a supplementary longitudinal counterpoise wire may be needed. Counterpoise material, if required for additional grounding, will consist typically of buried copper-clad steel wire. Details of the tower grounding are shown in Figures E-1.1.4-1 and E-1.1.4-2.

The options available for grounding the structures to achieve the desired grounding resistance are:

[9] This information is being provided in response to the PSC interrogatory request DPS 28, Part 8.
[10] This information is being provided in response to the PSC interrogatory request DPS 16, Part 3.
[11] This information is being provided in response to the PSC interrogatory request DPS 16, Part 1.
[12] This information is being provided in response to the PSC interrogatory request DPS 16, Part 2.
[13] This information is being provided in response to the PSC interrogatory request DPS 16, Part 4.

- Driven copper-clad steel rods,
- Copper-clad steel counterpoise wire, and
- A mix of rods and counterpoise.

Ground resistance measurements will be made at each structure location until the specified ground resistance value is achieved.

E-1.5.2 Elements of the Grounding System

E-1.5.2.1 Ground Rods

Where soil characteristics permit, sectional grounding rods will be coupled together and driven to refusal. Ground rods will located no closer to each other than the distance equal to the depth of the installed rod. Ground rods will be made of a non-corrosive copper-clad steel material with a ¾-inch diameter and 10-foot length. The rods will be connected to the steel structures using a gauge size 4/0 bare copper wire.

Steel lattice towers will be initially grounded with two ground rods connected diagonally to opposite legs. Two additional ground rods would be connected to the other two legs of the structure to obtain the minimum-specified ground resistance if needed.

Steel poles will be initially grounded using one ground rod. Until the specified ground resistance is obtained, additional ground rods may be connected up to a maximum of four locations that are spread approximately 15 to 20 feet apart.

E-1.5.2.2 Counterpoise

Where shallow bedrock impedes driving ground rods, radial counterpoise will be installed (Figure E-1.1.4-2).[14] According to industry practices, counterpoise and grounding connections will be buried with a minimum cover of 18 inches.[15] Counterpoise wire will be made of non-corrosive, soft annealed copper-clad steel strand with 40% conductivity, and no less than a 4/0 gauge size.

Steel lattice towers will initially be grounded with 30- to 40-foot long radial counterpoise connected at each of the four legs. Steel poles will also be grounded in the same manner, by connecting four 30- to 40-foot counterpoises spread radially and connected to pole grounding plates.

When the minimum ground resistance value is not attained, additional length of counterpoise will be installed. These will be extended parallel to the line conductors on each side of the structure. In particular cases, it may be required to install continuous counterpoise spanning the full distance between structures.

[14] This information is being provided in response to the PSC interrogatory request DPS 22, Part 1.
[15] This information is being provided in response to the PSC interrogatory request DPS 17, Part 1.

Counterpoise may be used in conjunction with driven ground rods as a supplemental grounding to lower ground resistance to the specified 30 ohm value.

E-1.5.2.3 Soil Resistivity Improvement

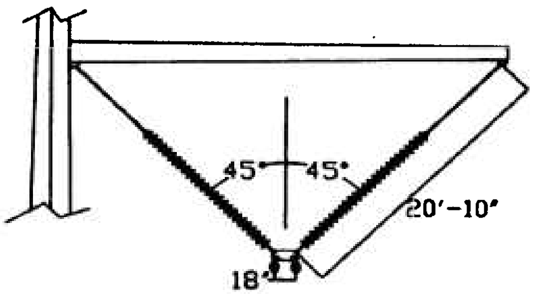
Chemically neutral high conductivity materials (such as bentonite, Sanearth, or similar) will be used, where necessary, to reduce soil resistivity around the counterpoise or ground rods.

E-1.5.2.4 Grounding Connections

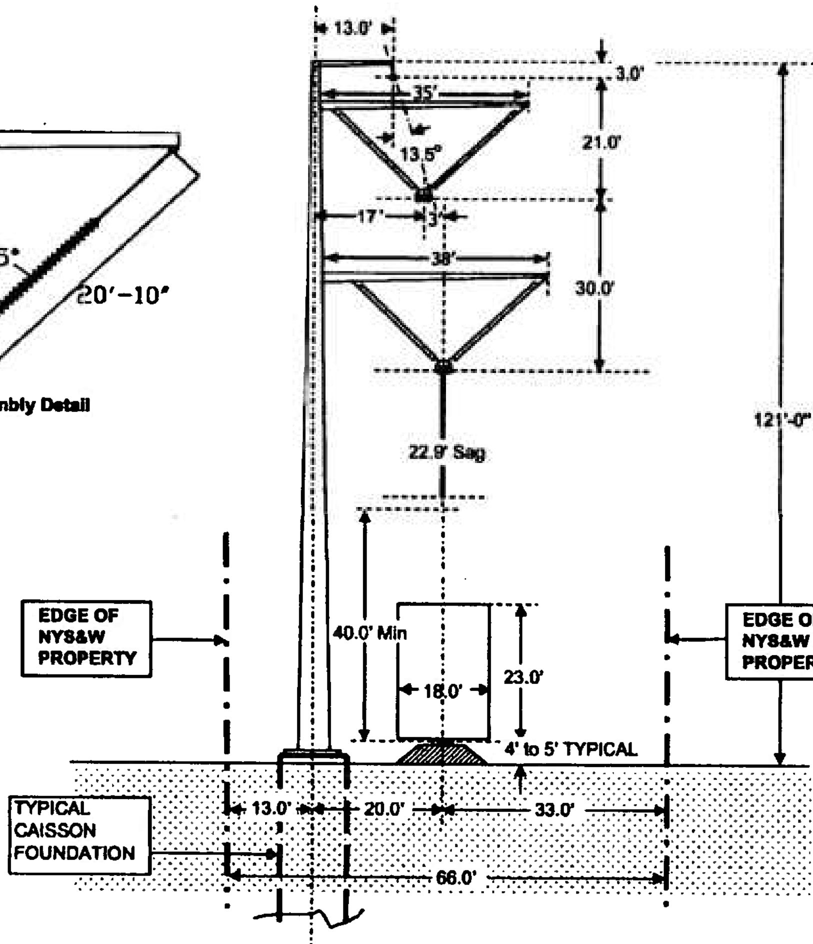
The grounds will be bolted to the steel structures' grounding plates with grounding clamps of such material and design that will prevent electrolytic corrosion between dissimilar metals.

Figures

SPAN LGTH	HOT SAG	STR HEIGHT
600'	18.1'	116'
700'	22.9'	121'
800'	28.2'	126'
900'	33.9'	132'



Suspension Assembly Detail



TYPICAL +/- 400 kV DC TANGENT STEEL POLE
(700' SPAN)

TYPICAL FOUNDATION TYPES

1. CONCRETE BLOCK & ROCK ANCHOR, FOR DETAILS SEE FIG E-1.1.1-10
2. TUBULAR CONCRETE CAISSON, FOR DETAILS SEE FIG E-1.1.1-11
3. STEEL PILE AND CONCRETE CAP, FOR DETAILS SEE FIG E-1.1.1-12

NOTE: ALL STRUCTURE DIMENSIONS MAY VARY DURING FINAL DESIGN.

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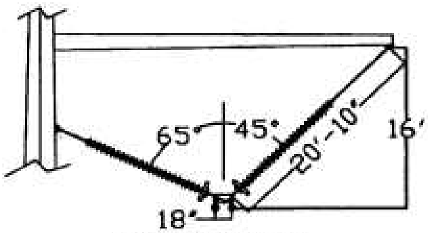
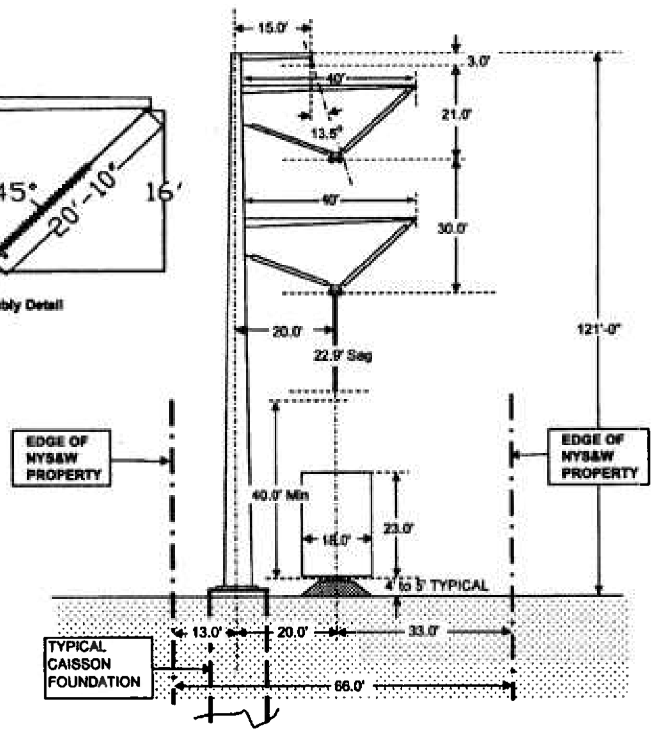
NYS&W RAILWAY SECTION LIGHT ANGLE SUSPENSION STRUCTURE
FIGURE
E-1.1.1-1

SPAN LGTH	HOT SAG	STR HEIGHT
600'	18.1'	116'
700'	22.9'	121'
800'	28.2'	126'
900'	33.9'	132'



Suspension Assembly Detail



TYPICAL +/- 400 kV DC TANGENT STEEL POLE
(700' SPAN)

TYPICAL FOUNDATION TYPES

1. CONCRETE BLOCK & ROCK ANCHOR, FOR DETAILS SEE FIG E-1.1.1-10
2. TUBULAR CONCRETE CAISSON, FOR DETAILS SEE FIG E-1.1.1-11
3. STEEL PILE AND CONCRETE CAP, FOR DETAILS SEE FIG E-1.1.1-12

NOTE: ALL STRUCTURE DIMENSIONS MAY VARY DURING FINAL DESIGN.

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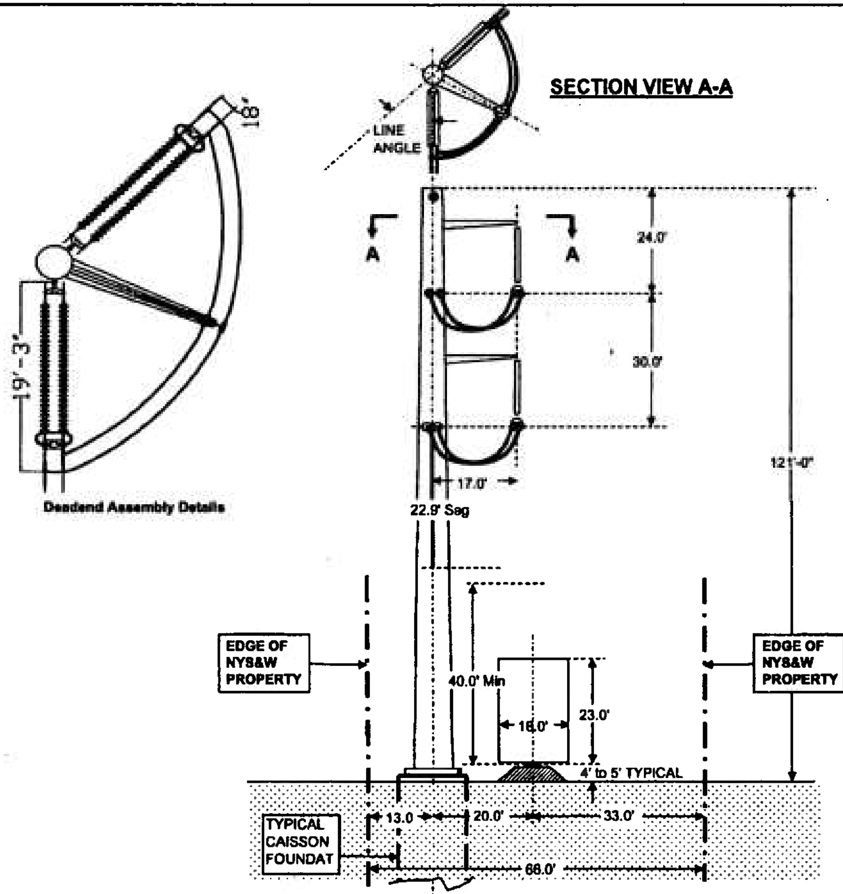
NYS&W RAILWAY SECTION MEDIUM ANGLE SUSPENSION STRUCTURE
FIGURE
E-1.1.1-2



SPAN LGTH	HOT SAG	STR HEIGHT
600'	16.1'	116'
700'	22.9'	121'
800'	28.2'	126'
900'	33.9'	132'

TYPICAL FOUNDATION TYPES

1. CONCRETE BLOCK & ROCK ANCHOR, FOR DETAILS SEE FIG E1.1.1-10
2. TUBULAR CONCRETE CAISSON, FOR DETAILS SEE FIG E1.1.1-11
3. STEEL PILE AND CONCRETE CAP, FOR DETAILS SEE FIG E1.1.1-12

TYPICAL +/- 400 kV DC MEDIUM ANGLE & DEADEND STEEL POLE
(700' SPAN)

NOTE: ALL STRUCTURE DIMENSIONS MAY VARY DURING FINAL DESIGN.

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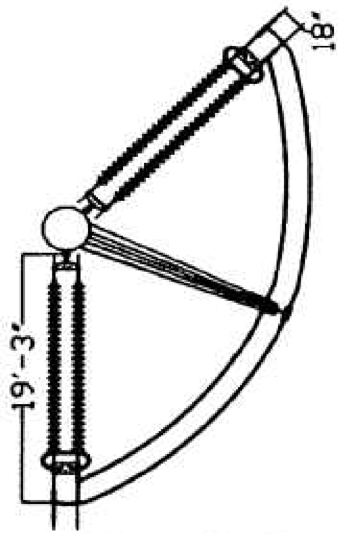
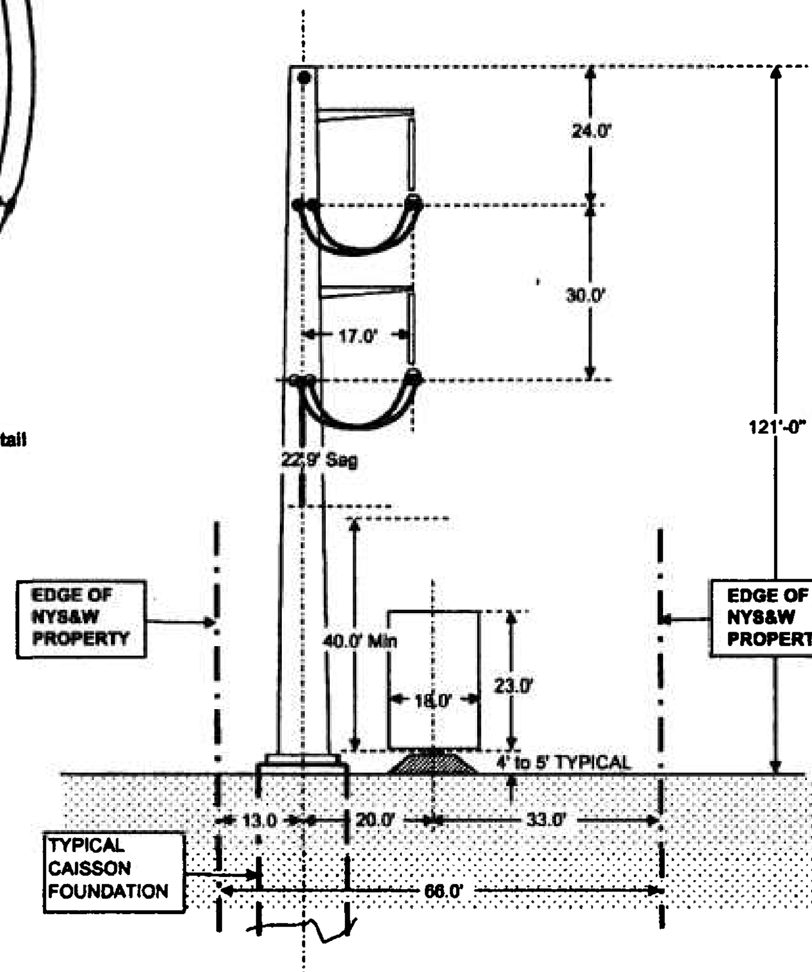
NYS&W RAILWAY SECTION MEDIUM ANGLE AND DEAD END STRUCTURE
FIGURE
E-1.1.1-2A

SPAN LGTH	HOT SAG	STR HEIGHT
600'	18.1'	116'
700'	22.9'	121'
800'	28.2'	126'
900'	33.9'	132'



Deadend Assembly Detail



TYPICAL +/- 400 kV DC DEADEND STEEL POLE
(700' SPAN)

TYPICAL FOUNDATION TYPES

1. CONCRETE BLOCK & ROCK ANCHOR. FOR DETAILS SEE FIG E-1.1.1-10
2. TUBULAR CONCRETE CAISSON. FOR DETAILS SEE FIG E-1.1.1-11
3. STEEL PILE AND CONCRETE CAP. FOR DETAILS SEE FIG E-1.1.1-12

NOTE: ALL STRUCTURE DIMENSIONS MAY VARY DURING FINAL DESIGN.

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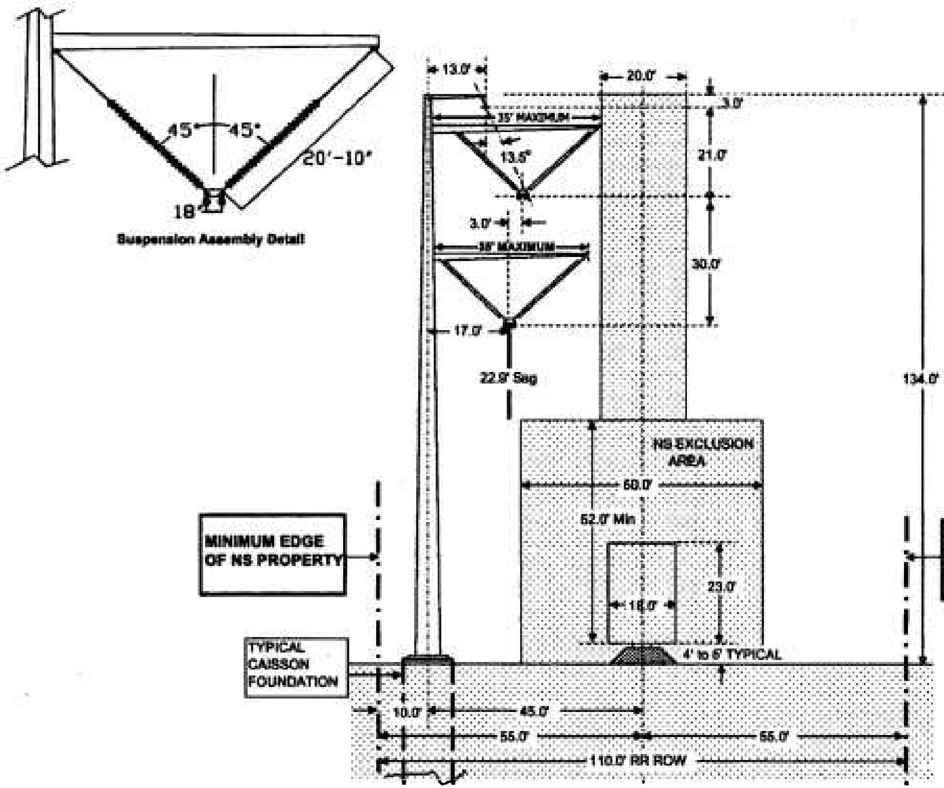
NYS&W RAILWAY SECTION LARGE ANGLE AND DEAD END STRUCTURE
FIGURE
E-1.1.1-3

SPAN LGTH	HOT SAG	STR HEIGHT
500'	13.8'	125'
600'	18.1'	129'
700'	22.9'	134'



TYPICAL FOUNDATION TYPES

1. CONCRETE BLOCK & ROCK ANCHOR, FOR DETAILS SEE FIG E1.1.1-10
2. TUBULAR CONCRETE CAISSON, FOR DETAILS SEE FIG E1.1.1-11
3. STEEL PILE AND CONCRETE CAP, FOR DETAILS SEE FIG E1.1.1-12

TYPICAL +/- 400 kV DC TANGENT STEEL POLE
(700' SPAN)

NOTE: ALL STRUCTURE DIMENSIONS MAY VARY DURING FINAL DESIGN.

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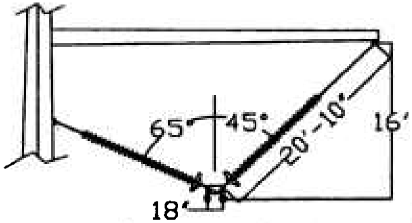
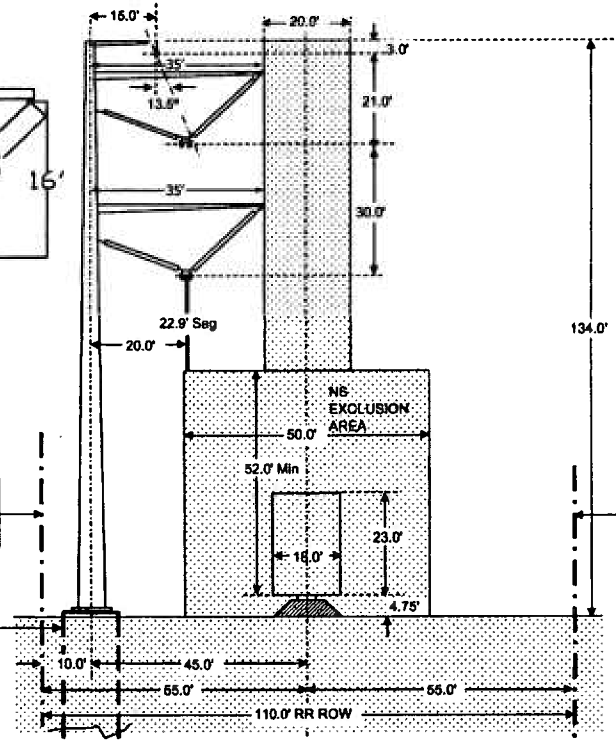
NS RAILWAY SECTION LIGHT ANGLE SUSPENSION STRUCTURE
FIGURE
E-1.1.1-4

SPAN LGTH	HOT SAG	STR HEIGHT
500'	13.8'	125'
600'	18.1'	129'
700'	22.9'	134'



Suspension Assembly Detail



TYPICAL FOUNDATION TYPES

1. CONCRETE BLOCK & ROCK ANCHOR, FOR DETAILS SEE FIG E1.1.1-10
2. TUBULAR CONCRETE CAISSON, FOR DETAILS SEE FIG E1.1.1-11
3. STEEL PILE AND CONCRETE CAP, FOR DETAILS SEE FIG E1.1.1-12

TYPICAL +/- 400 kV DC ANGLE STEEL POLE

(700' SPAN)

NOTE: ALL STRUCTURE DIMENSIONS MAY VARY DURING FINAL DESIGN.

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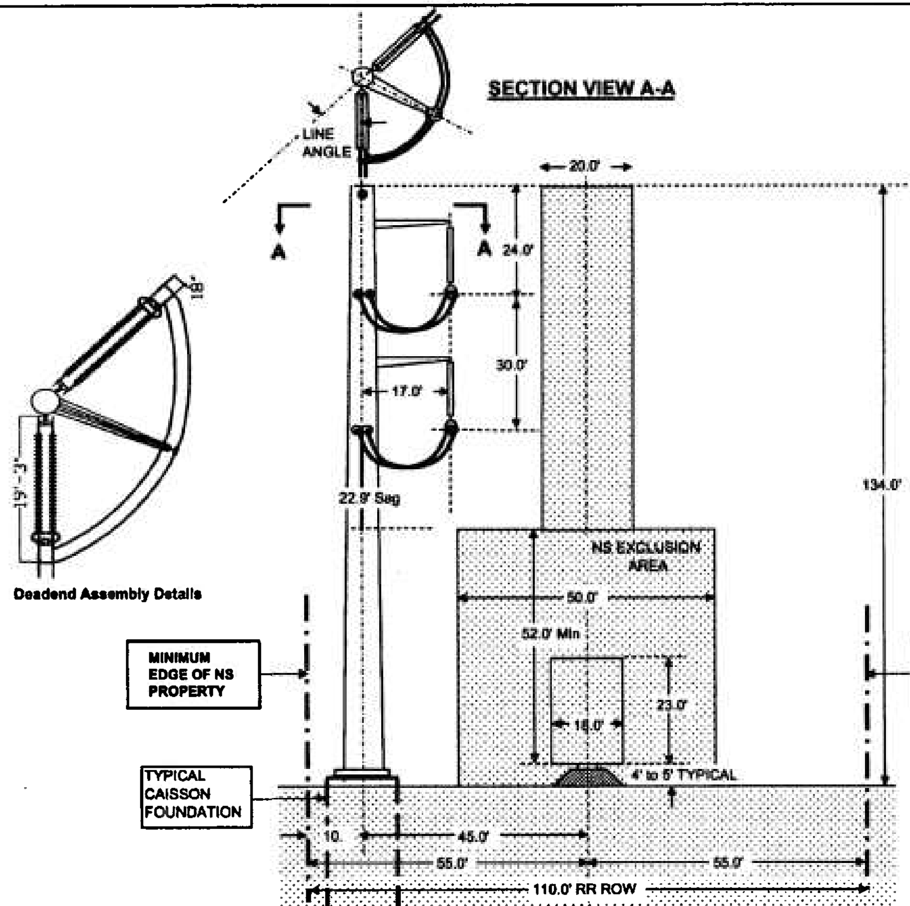
NS RAILWAY SECTION MEDIUM ANGLE SUSPENSION STRUCTURE

FIGURE E-1.1.1-5

SPAN LGTH	HOT SAG	STR HEIGHT
500'	13.8'	125'
600'	18.1'	129'
700'	22.9'	134'



TYPICAL +/- 400 kV DC MEDIUM ANGLE DEAD END STEEL POLE
(700' SPAN)

TYPICAL FOUNDATION TYPES

1. CONCRETE BLOCK & ROCK ANCHOR, FOR DETAILS SEE FIG E1.1.1-10
2. TUBULAR CONCRETE CAISSON, FOR DETAILS SEE FIG E1.1.1-11
3. STEEL PILE AND CONCRETE CAP, FOR DETAILS SEE FIG E1.1.1-12

NOTE: ALL STRUCTURE DIMENSIONS MAY VARY DURING FINAL DESIGN

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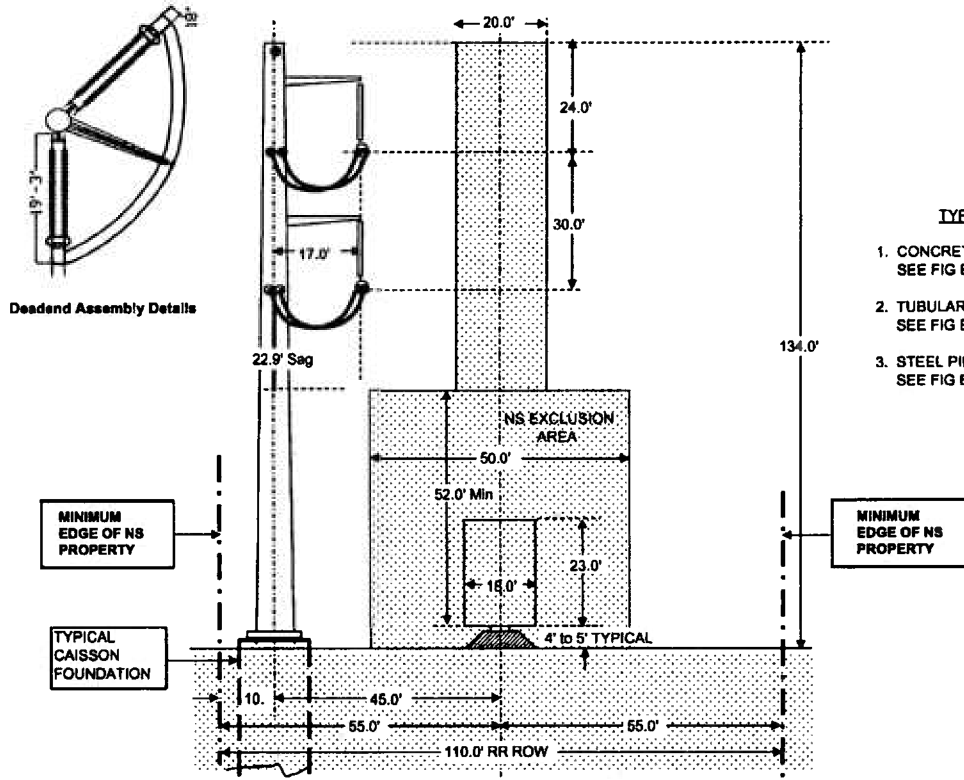
NS RAILWAY SECTION MEDIUM ANGLE DEAD END STRUCTURE
FIGURE
E-1.1.1-5A

SPAN LGTH	HOT SAG	STR HEIGHT
500'	13.8'	125'
600'	18.1'	129'
700'	22.9'	134'



TYPICAL +/- 400 kV DC DEAD END STEEL POLE
(700' SPAN)

TYPICAL FOUNDATION TYPES

1. CONCRETE BLOCK & ROCK ANCHOR, FOR DETAILS SEE FIG E1.1.1-10
2. TUBULAR CONCRETE CAISSON, FOR DETAILS SEE FIG E1.1.1-11
3. STEEL PILE AND CONCRETE CAP, FOR DETAILS SEE FIG E1.1.1-12

NOTE: ALL STRUCTURE DIMENSIONS MAY VARY DURING FINAL DESIGN.

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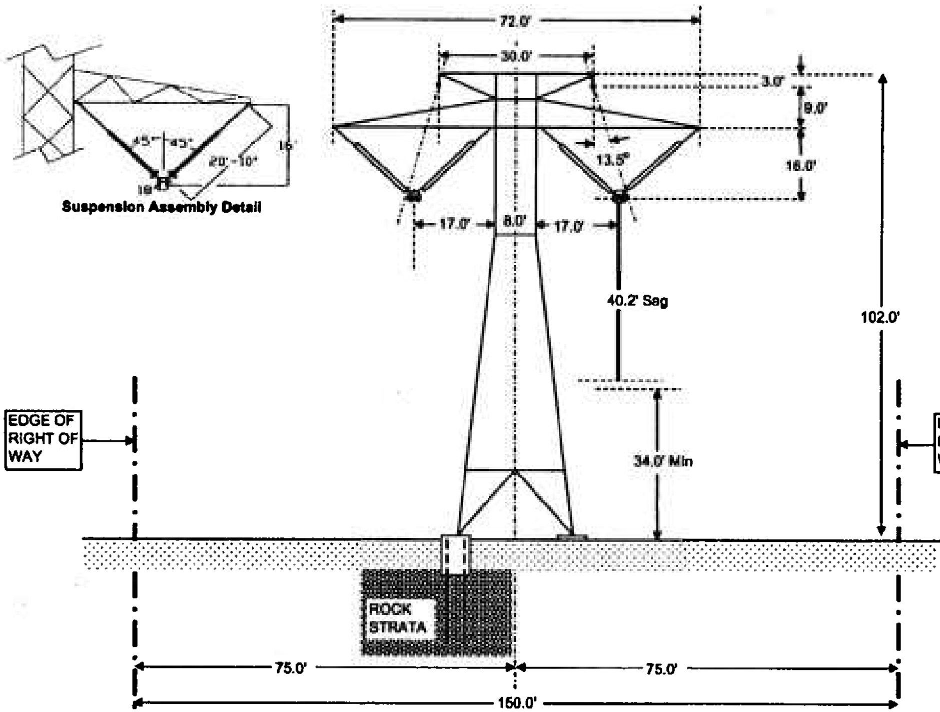
NS RAILWAY SECTION LARGE ANGLE DEAD END STRUCTURE
FIGURE E-1.1.1-6

SPAN LGTH	HOT SAG	STR HEIGHT
800'	28.2'	90'
1000'	40.2'	102'
1200'	54.0'	116'
1300'	61.6'	124'



Suspension Assembly Detail

TYPICAL +/- 400 kV DC TANGENT LATTICE TOWER
(1000' SPAN)

TYPICAL FOUNDATION TYPES

1. CONCRETE BLOCK & ROCK ANCHOR (AS SHOWN THIS DRAWING) FOR DETAILS SEE FIG E1.1.1-13
2. TUBULAR CONCRETE CAISSON, FOR DETAILS SEE FIG E1.1.1-14
3. STEEL PILE AND CONCRETE CAP, FOR DETAILS SEE FIG E1.1.1-15

NOTE: ALL STRUCTURE DIMENSIONS MAY VARY DURING FINAL DESIGN.

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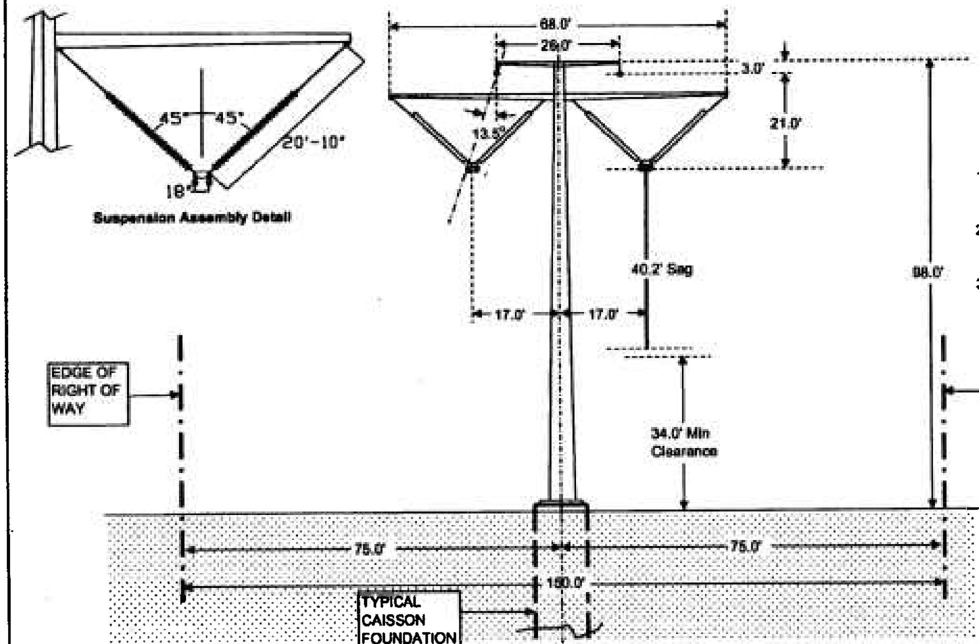
LATTICE TOWER - TANGENT AND LIGHT ANGLE 0° - 4°
FIGURE
E-1.1.1-7

SPAN LGTH	HOT SAG	STR HEIGHT
600'	18.1'	76'
700'	22.9'	81'
800'	28.2'	86'
1000'	**40.2'**	**98'**
1200'	54.0'	112'
1300'	61.6'	120'



TYPICAL +/- 400 kV DC TANGENT HORIZONTAL CONFIGURATION

(1000' SPAN)

TYPICAL FOUNDATION TYPES

1. CONCRETE BLOCK & ROCK ANCHOR, FOR DETAILS SEE FIG E1.1.1-10
2. TUBULAR CONCRETE CAISSON, FOR DETAILS SEE FIG E1.1.1-11
3. STEEL PILE AND CONCRETE CAP, FOR DETAILS SEE FIG E1.1.1-12

NOTE: ALL STRUCTURE DIMENSIONS MAY VARY DURING FINAL DESIGN.

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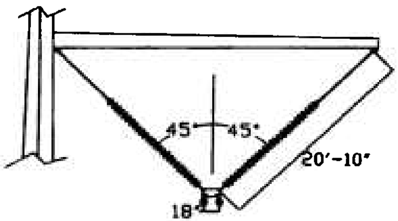
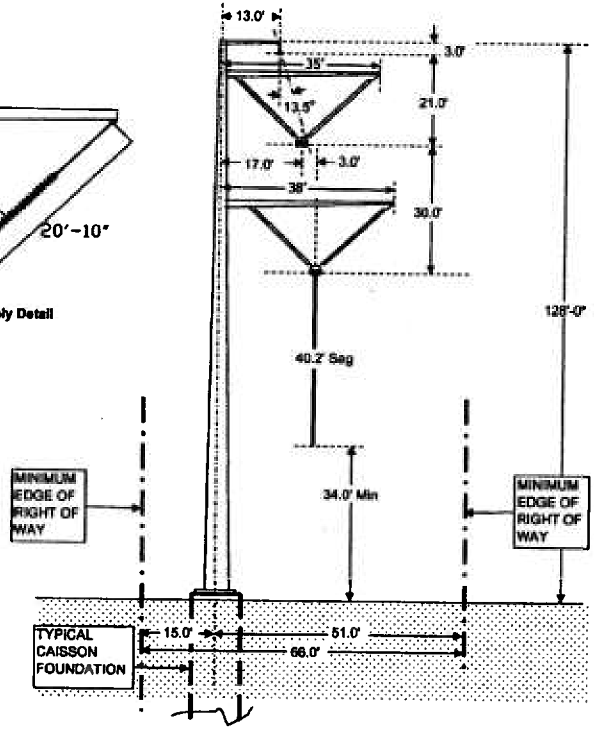
STEEL POLE TANGENT SUSPENSION STRUCTURE HORIZONTAL CONFIGURATION

FIGURE E-1.1.1-7A

SPAN LGTH	HOT SAG	STR HEIGHT
700'	22.9'	111'
800'	28.2'	116'
900'	33.9'	122'
1000'	40.2'	128'



Suspension Assembly Detail



TYPICAL +/- 400 kV DC NARROW ROW TANGENT STEEL POLE
(1000' SPAN)

TYPICAL FOUNDATION TYPES

1. CONCRETE BLOCK & ROCK ANCHOR, FOR DETAILS SEE FIG E-1.1.1-10
2. TUBULAR CONCRETE CAISSON, FOR DETAILS SEE FIG E-1.1.1-11
3. STEEL PILE AND CONCRETE CAP, FOR DETAILS SEE FIG E-1.1.1-12

NOTE: ALL STRUCTURE DIMENSIONS MAY VARY DURING FINAL DESIGN.

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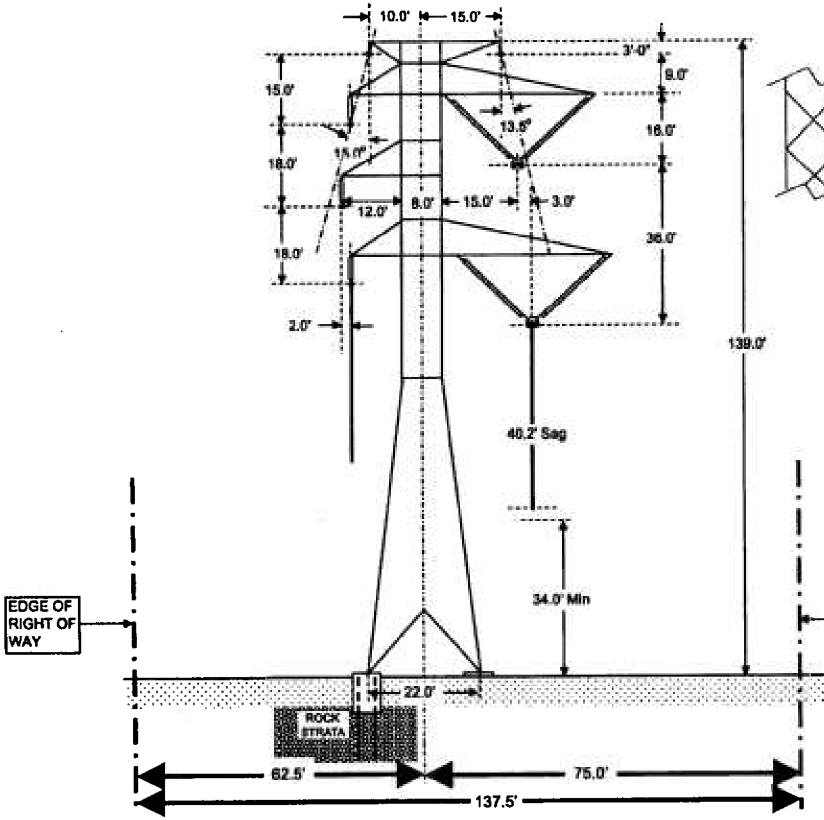
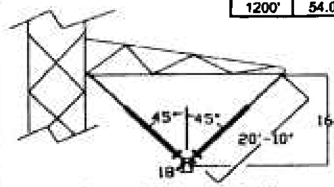
STEEL POLE TANGENT SUSPENSION STRUCTURE
VERTICAL CONFIGURATION
FIGURE
E-1.1.1-7B



SPAN LGTH	HOT SAG	STR HEIGHT
600'	18.1'	117'
800'	28.2	127'
1000'	40.2'	139'
1200'	54.0'	153'



Suspension Assembly Detail

TYPICAL FOUNDATION TYPES

1. CONCRETE BLOCK & ROCK ANCHOR (AS SHOWN THIS DRAWING) FOR DETAILS SEE FIG E-1.1.1-13
2. CONCRETE SPREAD FOOTING, FOR DETAILS SEE FIG E-1.1.1-14
3. STEEL PILE AND CONCRETE CAP, FOR DETAILS SEE FIG E-1.1.1-15

TYPICAL +/- 400 kV DC DBL CKT TANGENT LATTICE TOWER w/115 kV LINE

(1000' SPAN)

NOTE: ALL STRUCTURE DIMENSIONS MAY VARY DURING FINAL DESIGN.

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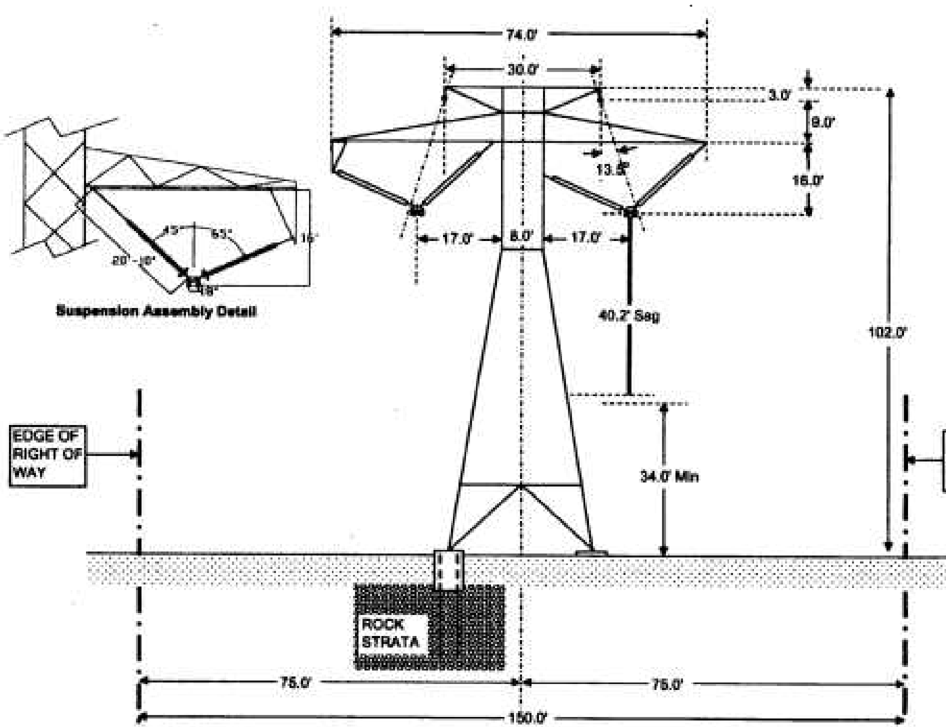
LATTICE TOWER -- DOUBLE CIRCUIT TANGENT WITH 115KV LINE
FIGURE
E-1.1.1-7C

SPAN LGTH	HOT SAG	STR HEIGHT
800'	28.2'	90'
1000'	**40.2'**	**102'**
1200'	54.0'	116'
1300'	61.6'	124'



TYPICAL +/- 400 kV DC 4-12° ANGLE LATTICE TOWER
(1000' SPAN)

TYPICAL FOUNDATION TYPES

1. CONCRETE BLOCK & ROCK ANCHOR (AS SHOWN THIS DRAWING) FOR DETAILS SEE FIG E1.1.1-13
2. TUBULAR CONCRETE CAISSON, FOR DETAILS SEE FIG E1.1.1-14
3. STEEL PILE AND CONCRETE CAP, FOR DETAILS SEE FIG E1.1.1-15

NOTE: ALL STRUCTURE DIMENSIONS MAY VARY DURING FINAL DESIGN.

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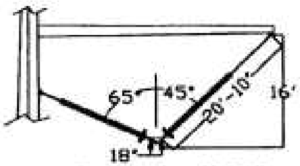
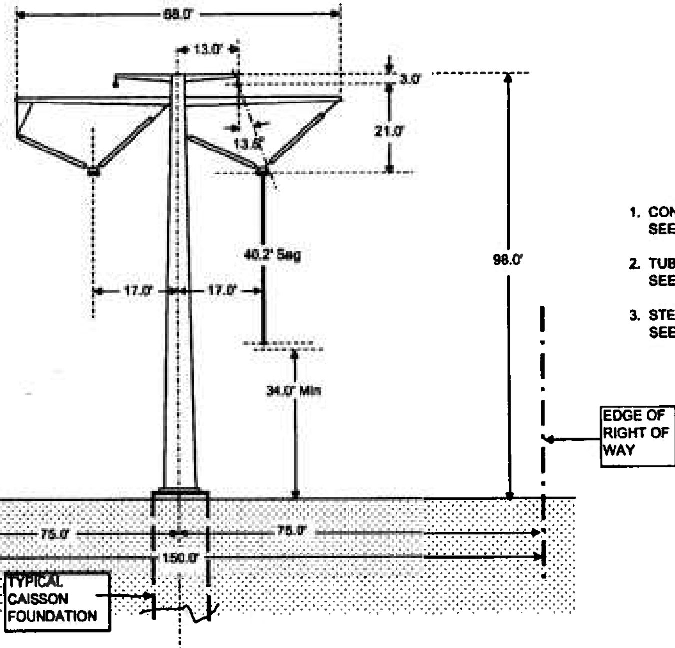
LATTICE TOWER – MEDIUM ANGLE 4° - 12° SUSPENSION STRUCTURE
FIGURE
E-1.1.1-8

SPAN LGTH	HOT SAG	STR HEIGHT
600'	18.1'	76'
700'	22.9'	81'
800'	28.2'	86'
1000'	40.2'	98'
1200'	54.0'	112'
1300'	61.6'	120'



Suspension Assembly Detail



TYPICAL +/- 400 kV DC ANGLE HORIZONTAL CONFIGURATION
(1000' SPAN)

TYPICAL FOUNDATION TYPES

1. CONCRETE BLOCK & ROCK ANCHOR, FOR DETAILS SEE FIG E1.1.1-10
2. TUBULAR CONCRETE CAISSON, FOR DETAILS SEE FIG E1.1.1-11
3. STEEL PILE AND CONCRETE CAP, FOR DETAILS SEE FIG E1.1.1-12

NOTE: ALL STRUCTURE DIMENSIONS MAY VARY DURING FINAL DESIGN.

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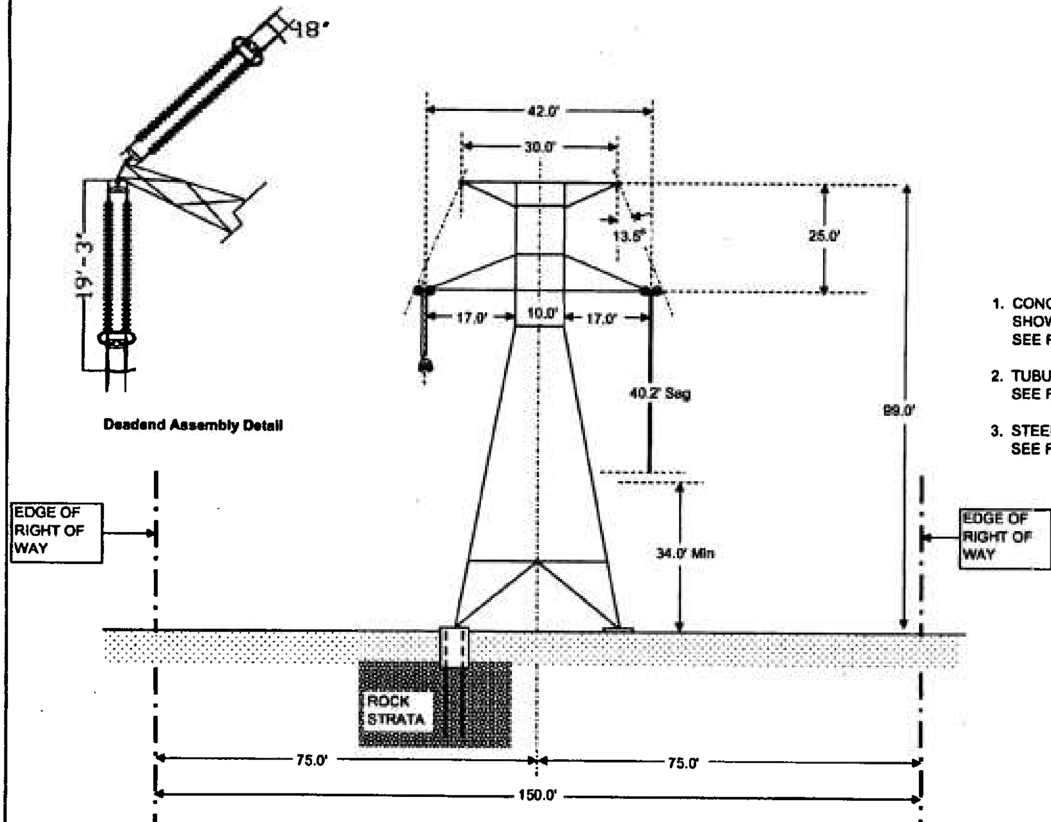
STEEL POLE - ANGLE SUSPENSION STRUCTURE
FIGURE
E-1.1.1-8A

SPAN LGTH	HOT SAG	STR HEIGHT
800'	28.2'	87'
1000'	40.2'	99'
1200'	54.0'	113'
1300'	61.6'	121'



TYPICAL FOUNDATION TYPES

1. CONCRETE BLOCK & ROCK ANCHOR (AS SHOWN THIS DRAWING) FOR DETAILS SEE FIG E1.1.1-13
2. TUBULAR CONCRETE CAISSON, FOR DETAILS SEE FIG E1.1.1-14
3. STEEL PILE AND CONCRETE CAP, FOR DETAILS SEE FIG E1.1.1-15

TYPICAL +/- 400 kV DC DEADEND LATTICE TOWER
(1000' SPAN)

NOTE: ALL STRUCTURE DIMENSIONS MAY VARY DURING FINAL DESIGN.

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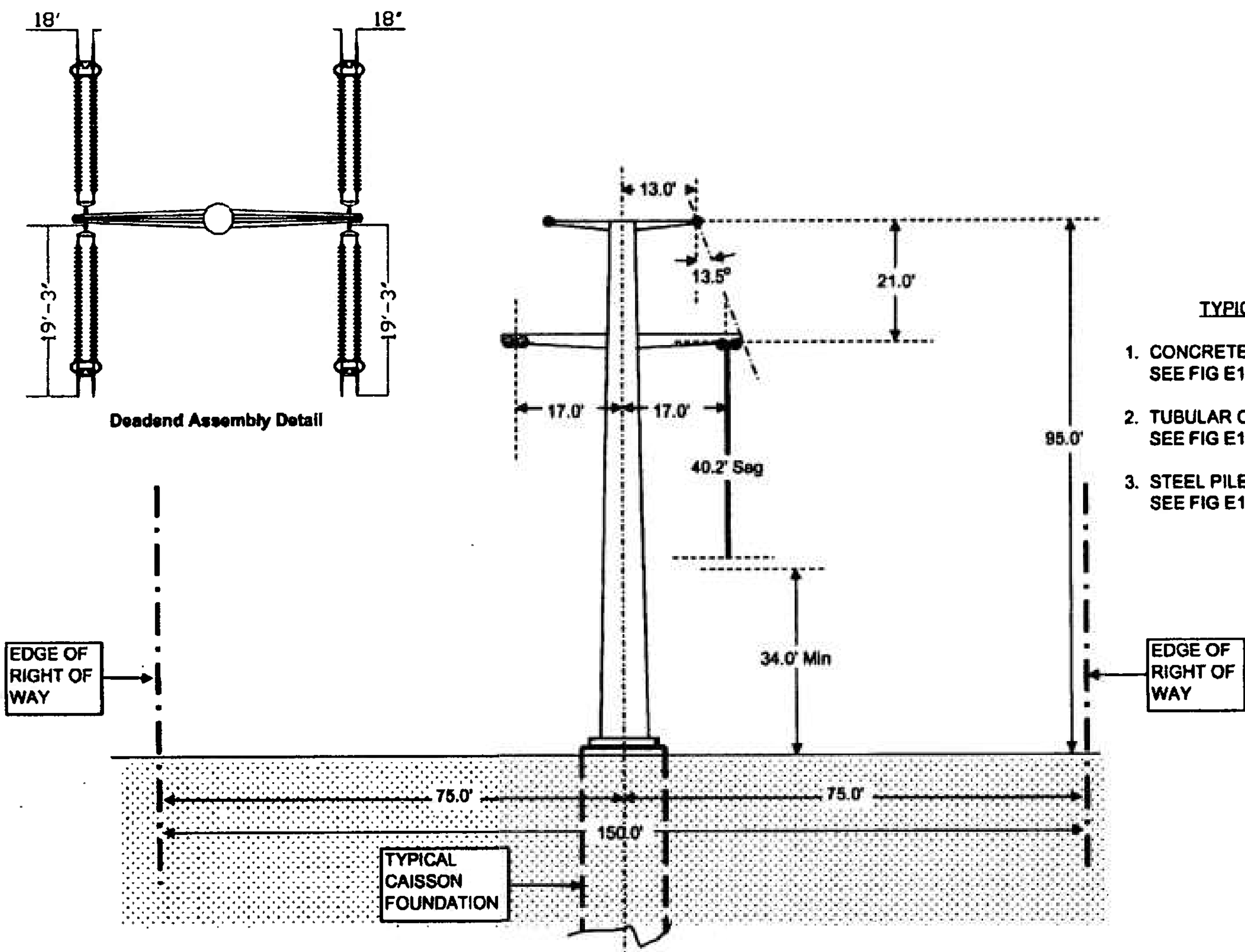
LATTICE TOWER - LARGE ANGLE
12° - 60° DEAD END & TERMINAL
FIGURE
E-1.1.1-9

SPAN LGTH	HOT SAG	STR HEIGHT
600'	18.1'	73'
700'	22.9'	78'
800'	28.2'	83'
1000'	**40.2'**	**95'**
1200'	54.0'	109'
1300'	61.6'	117'



Deadend Assembly Detail

TYPICAL FOUNDATION TYPES

1. CONCRETE BLOCK & ROCK ANCHOR, FOR DETAILS SEE FIG E1.1.1-10
2. TUBULAR CONCRETE CAISSON, FOR DETAILS SEE FIG E1.1.1-11
3. STEEL PILE AND CONCRETE CAP, FOR DETAILS SEE FIG E1.1.1-12

TYPICAL +/- 400 kV DC DEAD END HORIZONTAL CONFIGURATION

(1000' SPAN)

NOTE: ALL STRUCTURE DIMENSIONS MAY VARY DURING FINAL DESIGN.

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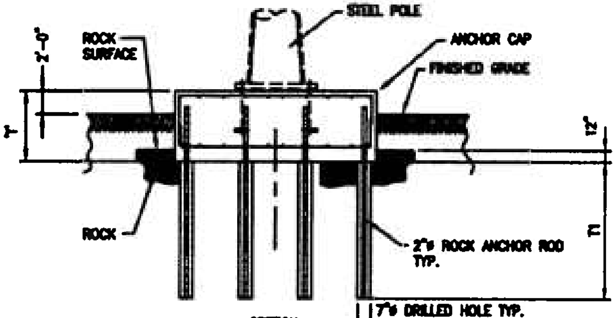
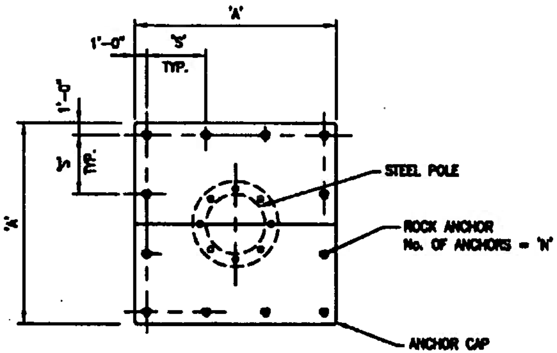
STEEL POLE DEAD END STRUCTURE
FIGURE:
E-1.1.1-9A

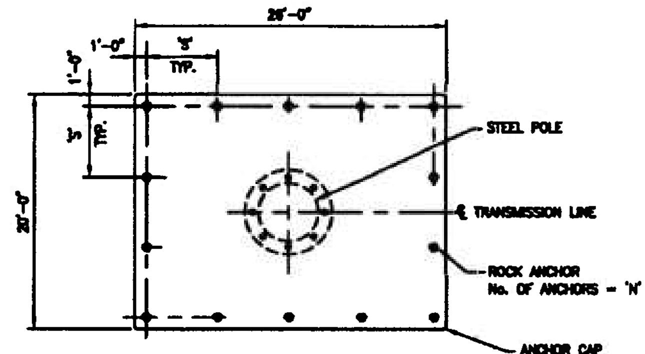


SECTION



PLAN

TANGENT AND ANGLE POLE ROCK ANCHOR FOUNDATION



PLAN

DEAD END POLE ROCK ANCHOR FOUNDATION

POLE FOUNDATION SCHEDULE

STRUCTURE TYPE	DIMENSIONS					VOLUME PER FOOTING (yd³)
	'A' (ft)	'T' (ft)	'N'	'S' (ft)	'T1' (ft)	CONCRETE
TANGENT	17	8	12	8	26	66
ANGLE	20	8	12	8	40	120
DEAD END	SEE PLAN	10	14	8	40	200

CONCRETE: CHARACTERISTIC COMPRESSIVE STRENGTH AT 28 DAYS 3000 PSI

REINFORCING BARS : HIGH STRENGTH STEEL, ASTM A615 YIELD POINT 60000 PSI

ROCK TYPE : HARD

NOTE: ALL DIMENSIONS MAY VARY DURING FINAL DESIGN

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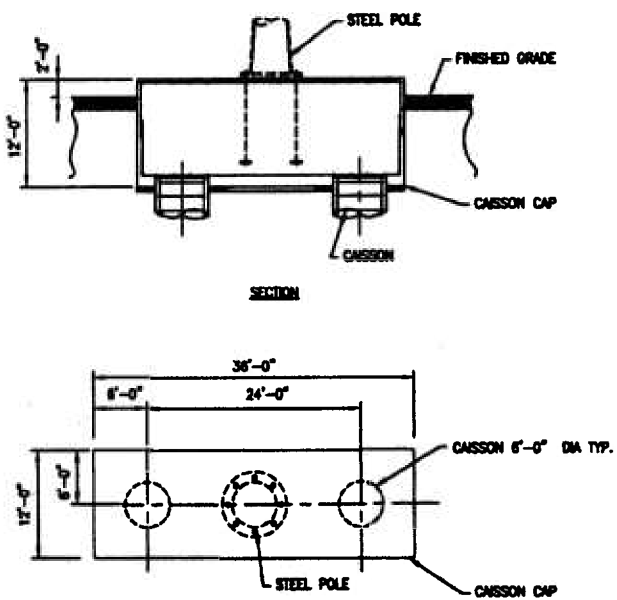
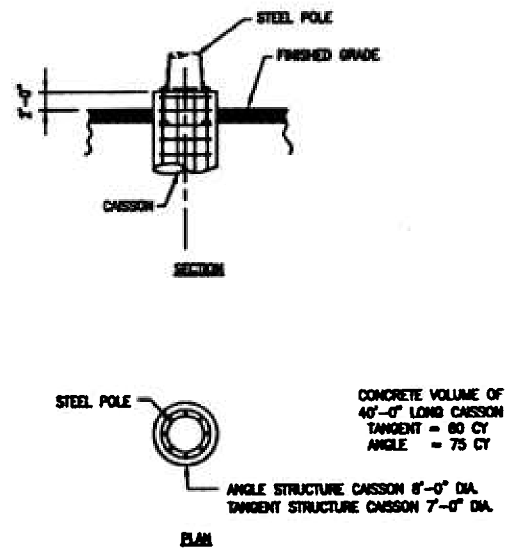
STEEL POLE ROCK ANCHOR FOUNDATION
FIGURE:
E-1.1.1-10



TYPICAL POLE CAISSON FOUNDATION

DEAD END STRUCTURE

CONCRETE VOLUME OF CAP PER FOOTING = 195 CY
CONCRETE VOLUME OF CAISSONS (2) = 85 CY
BASED ON 40'-0 LONG CAISSON



CONCRETE VOLUME OF 40'-0" LONG CAISSON
TANGENT = 60 CY
ANGLE = 75 CY

TYPICAL POLE CAISSON FOUNDATION

ANGLE STRUCTURE

TANGENT STRUCTURE

CONCRETE:	CHARACTERISTIC COMPRESSIVE STRENGTH AT 28 DAYS	3000 PSI
REINFORCING BARS :	HIGH STRENGTH STEEL, ASTM A615 YIELD POINT	60000 PSI

NOTE: ALL DIMENSIONS MAY VARY DURING FINAL DESIGN

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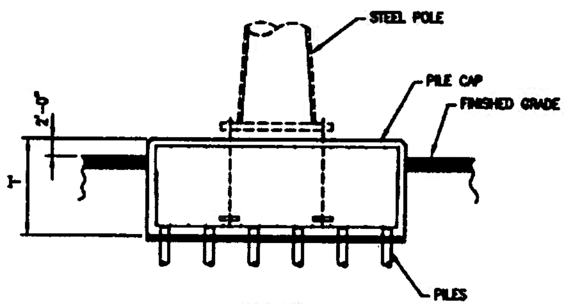
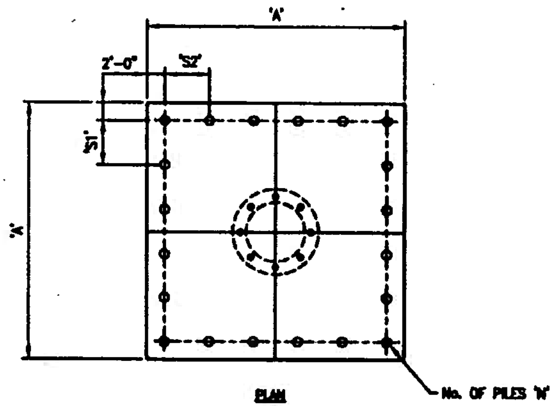
STEEL POLE CONCRETE CAISSON FOUNDATION
FIGURE:
E-1.1.1-11

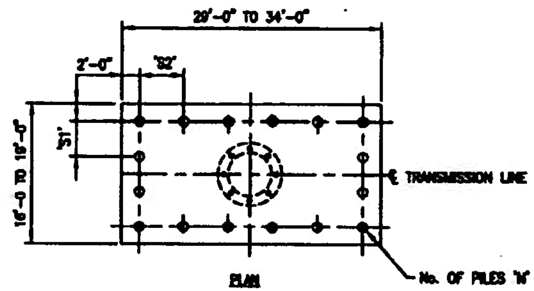


SECTION



PLAN

TANGENT AND ANGLE POLE
PILE FOUNDATION



PLAN

DEAD END POLE
PILE FOUNDATION

POLE FOUNDATION SCHEDULE

STRUCTURE TYPE	DIMENSIONS					VOLUME PER FOOTING (yd³)
	'A' (ft)	'S1'(ft)	'S2'(ft)	'N'	'T' (ft)	CONCRETE
TANGENT	14 TO 16	5 TO 6	5 TO 6	8	8	60 TO 80
ANGLE	17.5 TO 19	4.5 TO 5	4.5 TO 5	12	10	110 TO 135
DEAD END	SEE PLAN	4 TO 6	5 TO 6	18	12	210 TO 260

CONCRETE: CHARACTERISTIC COMPRESSIVE STRENGTH AT 28 DAYS 3000 PSI

REINFORCING BARS : HIGH STRENGTH STEEL, ASTM A615 YIELD POINT 60000 PSI

PILES: 12" DIA. STEEL PIPE OR 'H' PILE DRIVEN TO DEVELOP DESIGN CAPACITY OF 50 TONS COMPRESSION 40 TONS TENSION

ESTIMATED LENGTH OF EACH PILE 40 FEET

NOTE: ALL DIMENSIONS MAY VARY DURING FINAL DESIGN

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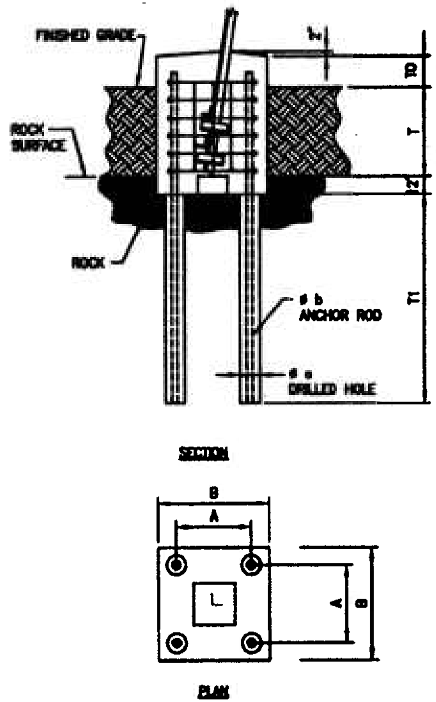
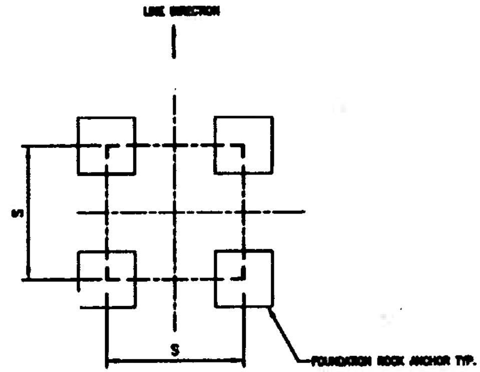
STEEL POLE PILE AND CAP FOUNDATION
FIGURE:
E-1.1.1-12



TYPICAL LATTICE TOWER ROCK ANCHOR FOUNDATION



TOWER FOUNDATION ORIENTATION

TOWER FOUNDATION SCHEDULE

STRUCTURE TYPE	DIMENSIONS								VOLUME PER FOOTING (yd³)
	A (in)	B (in)	T (in)	Td (in)	T1 (in)	ø a (in)	ø b (in)	S (ft)	CONCRETE
TANGENT	24	40	60	18	192	3.5	0.75	24	3.5
ANGLE	48	72	60	18	192	4	1	30	10.5
TERMINAL	84	108	60	18	216	4	1	40	23

CONCRETE: CHARACTERISTIC COMPRESSIVE STRENGTH AT 28 DAYS 3000 PSI
REINFORCING BARS : HIGH STRENGTH STEEL, ASTM A615 60000 PSI (YIELD POINT)
ROCK TYPE: HARD

NOTE: ALL DIMENSIONS MAY VARY DURING FINAL DESIGN

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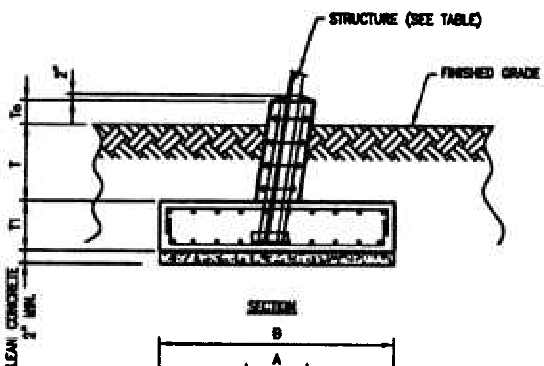
LATTICE TOWER ROCK ANCHOR FOUNDATION
FIGURE
E-1.1.1-13



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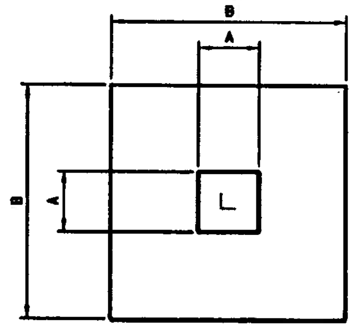
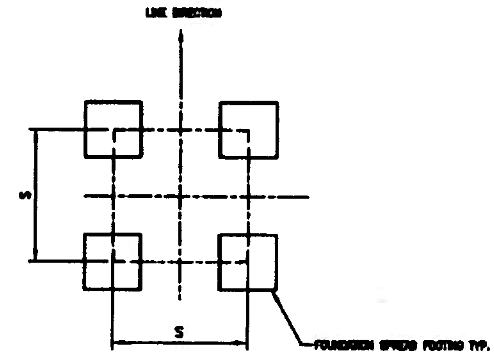


PLAN



TOWER FOUNDATION ORIENTATION

TOWER FOUNDATION SCHEDULE

STRUCTURE TYPE	DIMENSIONS						VOLUME PER FOOTING (yd³)
	S (ft)	A (in)	To (in)	T1 (in)	T (in)	B (in)	CONCRETE
TANGENT	24	24	18	24	96	144	12
ANGLE	30	24	18	30	96	216	31.5
TERMINAL	40	24	18	36	96	240	40

CONCRETE	CHARACTERISTIC COMPRESSIVE STRENGTH AT 28 DAYS	3000 PSI
REINFORCING BARS :	HIGH STRENGTH STEEL, ASTM A615	60000 PSI (YIELD POINT)
SAFE SOIL BEARING PRESSURE		1.5 T/FT²

NOTE: ALL DIMENSIONS MAY VARY DURING FINAL DESIGN

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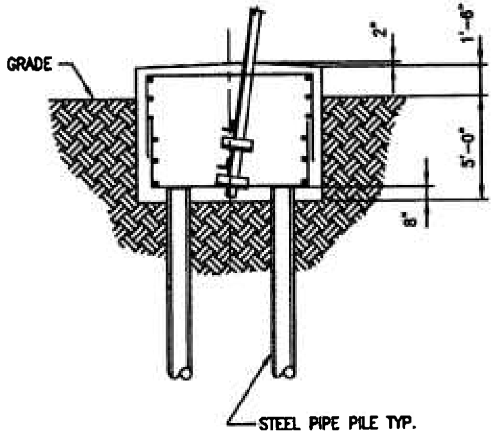
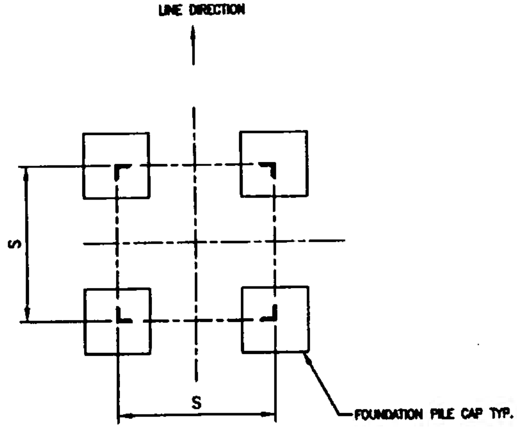
LATTICE TOWER CONCRETE SPREAD FOOTING FOUNDATION
FIGURE:
E-1.1.1-14



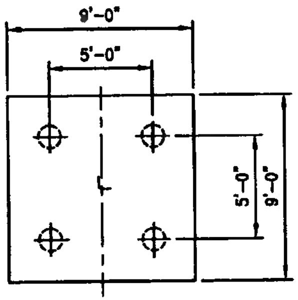
SECTION



TOWER FOUNDATION ORIENTATION

TOWER FOUNDATION SCHEDULE

TANGENT STRUCTURE: S = 24 FEET
ANGLE STRUCTURE: S = 30 FEET
TERMINAL STRUCTURE: S = 40 FEET



PLAN

CONCRETE:	CHARACTERISTIC COMPRESSIVE STRENGTH AT 28 DAYS	3000 PSI
REINFORCING BARS :	HIGH STRENGTH STEEL, ASTM A615 YIELD POINT	60000 PSI
PILES:	12" DIA. STEEL PIPE OR 'H' PILE DRIVEN TO DEVELOP DESIGN CAPACITY OF	80 TONS COMPRESSION 40 TONS TENSION
CONCRETE VOLUME PER FOOTING:		20 YDS³
ESTIMATED LENGTH OF EACH PILE:		40 FEET

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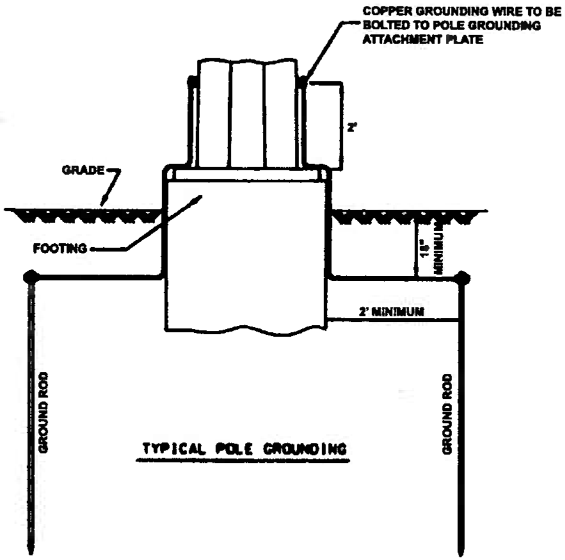
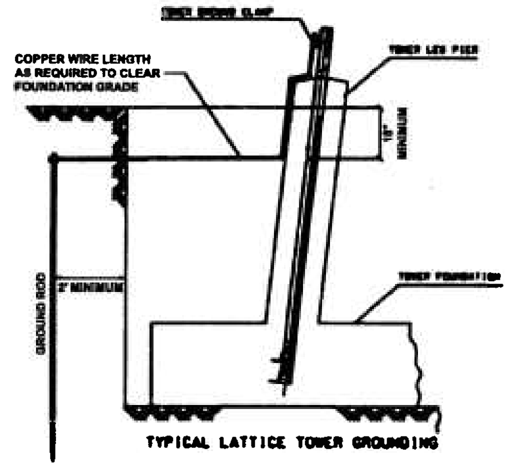
LATTICE TOWER PILE AND CAP FOUNDATION FIGURE
E-1.1.1-15



TYPICAL POLE GROUNDING



TYPICAL LATTICE TOWER GROUNDING

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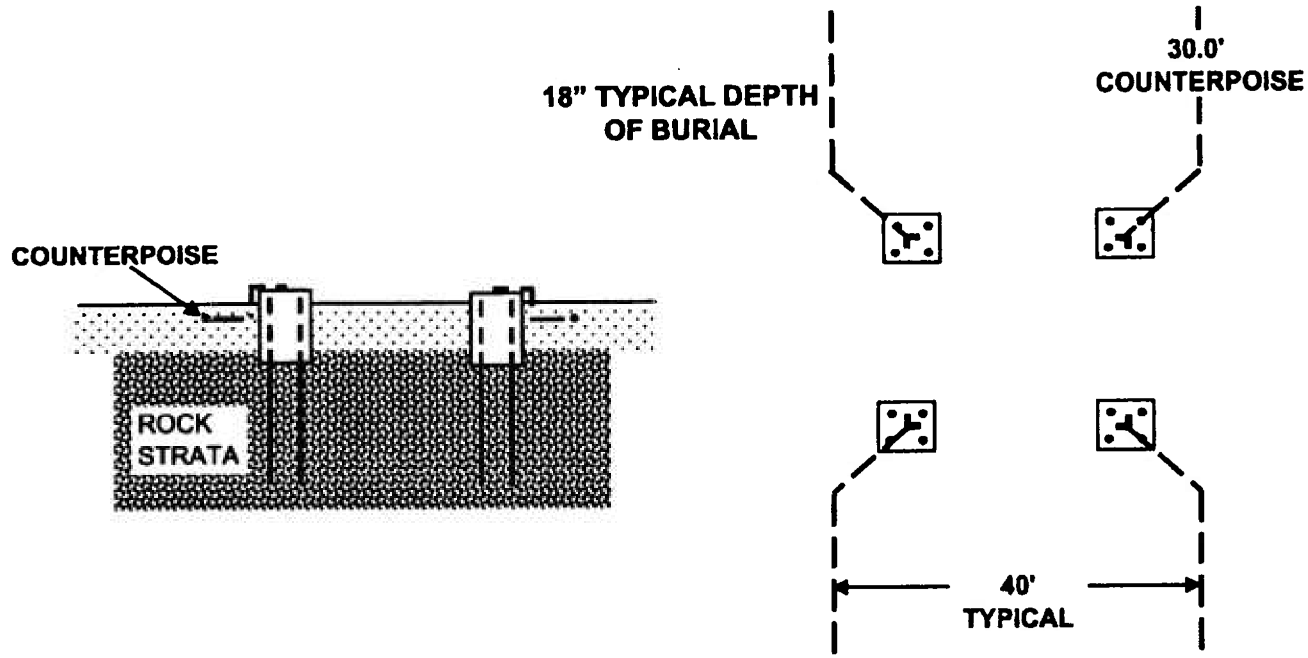
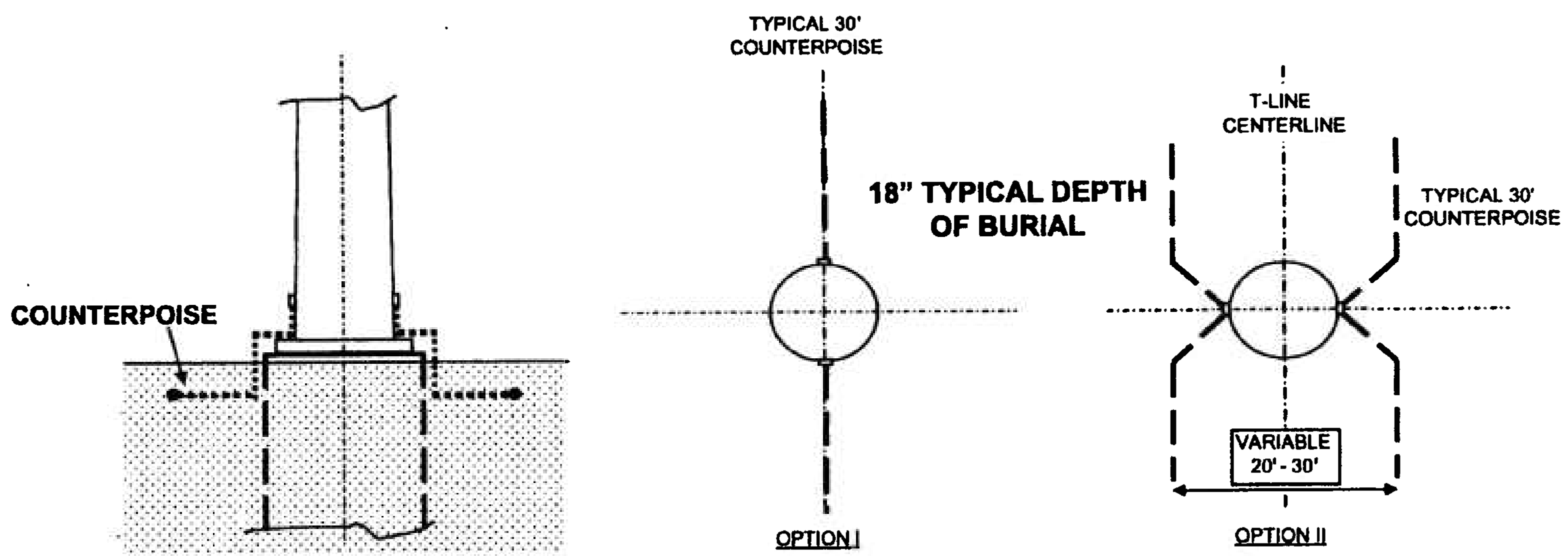
TYPICAL STRUCTURE GROUNDING DETAIL
FIGURE:
E-1.1.4-1



LATTICE STRUCTURE TYPICAL COUNTERPOISE GROUNDING



POLE STRUCTURE TYPICAL COUNTERPOISE GROUNDING

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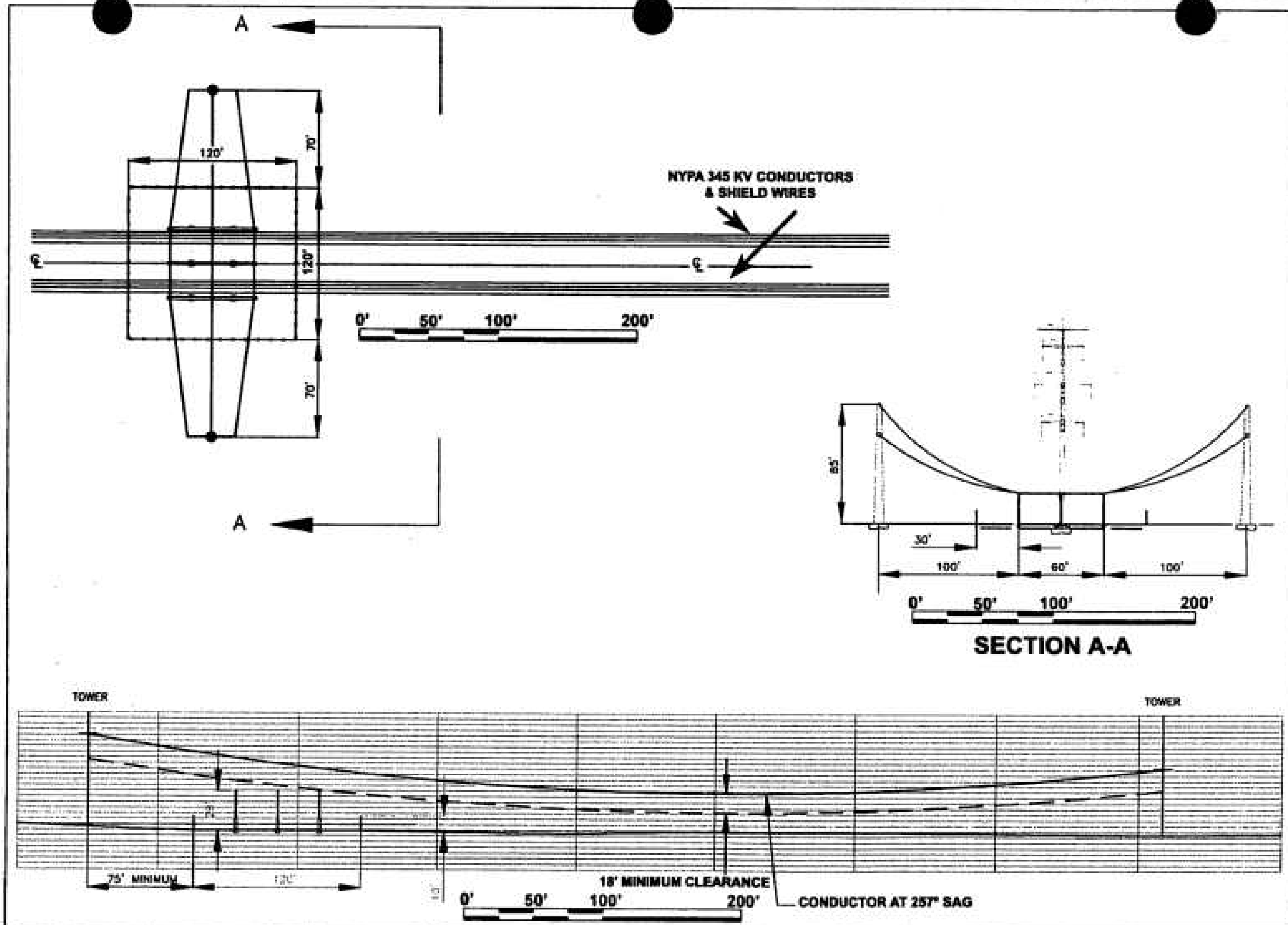
TYPICAL STRUCTURE GROUNDING DETAILS – COUNTERPOISE
FIGURE:
E-1.1.4-2



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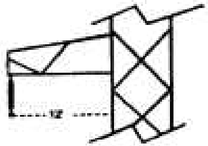
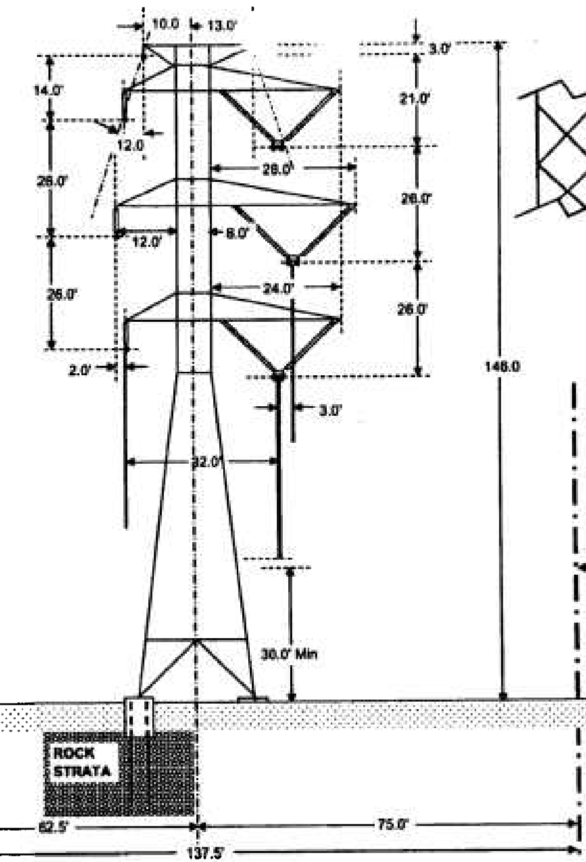
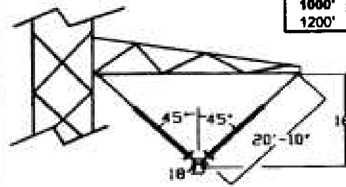
TYPICAL RIGID BUS SPAN AND
OVERHEAD LINE TRANSITION
FIGURE
E-1.2.5

SPAN LGTH	HOT SAG	STR HEIGHT
600'	18.1'	124'
800'	28.2	134'
1000'	40.2'	146'
1200'	54.0'	160'



Suspension Assembly Detail





Suspension Assembly Detail

TYPICAL FOUNDATION TYPES

1. CONCRETE BLOCK & ROCK ANCHOR (AS SHOWN THIS DRAWING) FOR DETAILS SEE FIG E1.1.1-13
2. TUBULAR CONCRETE CAISSON, FOR DETAILS SEE FIG E1.1.1-14
3. STEEL PILE AND CONCRETE CAP, FOR DETAILS SEE FIG E1.1.1-15

TYPICAL DBL CKT 345 kV/115 kV LATTICE TANGENT TOWER

(1000' SPAN)

NOTE: ALL STRUCTURE DIMENSIONS MAY VARY DURING FINAL DESIGN.

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DOUBLE CIRCUIT 345 KV - 115 KV AC SUSPENSION TOWER
FIGURE:
E-1.3.3-1

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