

EXHIBIT D – ENGINEERING DESCRIPTION

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EXHIBIT D – ENGINEERING DESCRIPTION

1.0 Proposed Line Design

PPL Electric Utilities Corporation (“PPL Electric”) proposes to construct a new 500 kV transmission line between PPL Electric’s Susquehanna 500 kV Substation and the Public Service Electric & Gas (“PSE&G”) section of the Susquehanna-Roseland 500 kV Transmission Line at the Delaware River south of Bushkill, PA in the Delaware Water Gap National Recreation Area (DEWA). The Pennsylvania portion of the new line will be approximately 101 miles long. It will be a mixture of single circuit and double circuit design. All circuits will be designed for 500kV operation, but on the double circuit portion of the line one circuit will be operated initially at 230kV. The proposed transmission line will be built in portions of the following counties:

- **Luzerne County:** Salem, Union, Hunlock, Plymouth, and Jackson Townships; Larksville Borough, Courtdale Borough, Kingston Township, West Wyoming Borough, and Exeter Township.
- **Lackawanna County:** Ransom, Newton, South Abington and Scott Townships; City of Scranton; Dickson City, Blakely, and Archbald Boroughs; and Jefferson Township.
- **Wayne County:** South Canaan, Lake, Paupack, and Palmyra Townships.
- **Pike County:** Palmyra, Blooming Grove, Greene (right-of-way), Porter, and Lehman Townships.
- **Monroe County:** Middle Smithfield Township.

The proposed project can be broken down into seven discrete segments, including two minor segments involving small line section addition and removals, and five major segments composing the bulk of the new line. The two small segments include:

- **Susquehanna 230 kV:** A 0.44-mile section of new 230 kV single circuit transmission line from PPL Electric’s **Susquehanna T10 230 kV Switchyard** to a section of existing 230 kV line that will be disconnected as a result of re-energizing at 500 kV. This line will be named **Susquehanna T10 Yard – Susquehanna 230 kV line**. In this section, line structures will be single steel poles installed on concrete foundations with phase conductors vertically configured (phase-over-phase) and one overhead ground wire at the top of the pole. There will be approximately four (4) structures in this line section with an average span length of 460 feet. Additionally, some structures may be guyed. The proposed structure types are shown in Photo D-1. All structures will be located on PPL Susquehanna SES owned property. Typical structures in this segment will range from 125 to 185 feet tall.

- **Susquehanna 500 kV:** A 0.9-mile section of new 500 kV single circuit transmission line from PPL Electric's **Susquehanna 500 kV Substation** north to a connection point with an existing line section that is currently energized at 230 kV but designed for 500 kV operation. In this section, tangent and light angle structures (angles less than 30 degrees deflection) will be 2-pole H-frame type steel pole structures installed with three horizontally configured phases and two overhead ground wires above the phase conductors. Heavy angle structures will consist of 3-pole steel structures with phases horizontally configured and two overhead ground wires above the phase conductors. One overhead ground wire will be an overhead ground wire with fiber optic cables inside ("OPGW"); the other will be a stranded steel cable overhead ground wire ("OHGW"). All structures will be installed on concrete foundations; additionally, some structures may be guyed. There will be approximately five (5) structures in this section with an average span of 715 feet. The proposed structure types are shown in Photo D-2. Typical structures in this segment will range from 150 to 195 feet tall.

A description of the five major line segments is as follows:

- **Segment 1:** An existing 29.7-mile long 500 kV single circuit line section, located between Susquehanna and a point near PPL Electric's **Stanton Substation**, located near Pittston, will utilize an existing 230 kV line that was initially designed and built in the 1970s with tubular steel H-Frame structures and designed for ultimate 500 kV operation. The line utilizes double-bundle 2493 ACAR 54/37 conductors (two per phase on 18-inch subconductor spacing) and two 19#9 Alumoweld conductors for overhead ground wires. Typically, the right-of-way is 200-foot wide. This line section will be reconnected at both ends to provide the needed 500 kV path. One of the existing overhead ground wires will be replaced with one new 36 fiber OPGW. A 450-foot section of existing 230 kV line currently connecting the 30-mile section to **Stanton Substation** will be removed. Existing structure types are shown in Photo D-2. Typical structures in this segment are approximately 120 feet tall.
- **Segment 2:** A 13.4-mile section of new 500 kV transmission line from the end of Segment 1 at the Susquehanna River northeastward to PPL Electric's proposed **Lackawanna 500 – 230 kV Substation** on a PPL Electric owned site adjacent to PPL Electric's existing **Lackawanna 230 – 69 kV Substation** in Blakely Borough, Lackawanna County. The 500 kV line will be designed as a double circuit 500 kV line with only one circuit installed initially on one side of the new structures. This line section parallels an existing 230 kV double circuit line and will share the existing 325-foot wide right-of-way. In this section, tangent structures will be either single shaft steel poles or 3-pole portal type steel poles. Light angle structures (i.e., angles less than 30 degrees deflection) will be 3-pole portal type steel pole structures. Heavy angle structures will consist of 2-pole steel structures. All structures will be installed on concrete foundations, and some structures may be guyed. There will be approximately 76 structures in this section with an average span of 930 feet. The proposed structure types are shown in Figures D-1 through D-5. Typical structures in this segment will range from 150 to 195 feet tall.
- **Segment 3:** An 8.4-mile-section of new 500 kV transmission line from the end of Segment 2 at **Lackawanna 500 – 230 kV Substation** eastward to a point where the line rejoins an

existing 230 kV line in Jefferson Township, Lackawanna County. The 500 kV Line will be designed as a double circuit 500 kV line with only one circuit installed initially on one side of the new structures. In this section, tangent structures will be either single shaft steel poles or 3-pole portal type steel poles. Light angle structures will be 3-pole portal type steel pole structures. Heavy angle structures will consist of 2-pole steel structures. All structures will be installed on concrete foundations, and some structures may be guyed. There will be approximately 40 structures in this section with an average span of 950 feet. The proposed structure types are shown in Figures D-1 through D-5. Typical structures in this segment will range from 150 to 195 feet tall.

- **Segment 4:** A 19.5-mile section of new 500 kV transmission line from the end of Segment 3 in Jefferson Township, Lackawanna County to a point near the northern tip of Lake Wallenpaupack, just east of Hawley in Pike County. In this segment, the new line will replace an existing 230 kV line. The line will be designed as a double circuit 500 kV line with one circuit energized at 230 kV and the other circuit energized at 500 kV. The new double circuit line will occupy the same centerline as the existing 230 kV line. In this section tangent structures will be either single shaft steel poles or 3-pole portal type steel poles. Light angle structures will be 3-pole portal type steel pole structures. Heavy angle structures will consist of 2-pole steel structures. All structures will be installed on concrete foundations, and some structures may be guyed. The existing 230 kV line and structures will be removed in this line section. There will be approximately 112 structures in this section with an average span of 920 feet. The proposed structure types are shown in Figures D-1 through D-5. Typical structures in this segment will range from 150 to 195 feet tall.

- **Segment 5:** A 29.2-mile section of new 500 kV transmission line from the end of Segment 4 just east of Hawley in Pike County to the Delaware River in Monroe County near Bushkill, PA. In this segment, the new line will replace an existing 230 kV line. The line will be designed as a double circuit 500 kV line with one circuit energized at 230 kV and the other circuit energized at 500 kV. The new double circuit line will occupy the same centerline as the existing 230 kV line. The 230 kV line will terminate into **Blooming Grove Substation** and **Bushkill Switchyard** on single circuit structures, while the 500 kV line bypasses to the East on single circuit structures. In this section, tangent structures will be either single shaft steel poles or 3-pole portal type steel poles. Light angle structures will be 3-pole portal type steel pole structures. Heavy angle structures will consist of 2-pole steel structures. All structures will be installed on concrete foundations and some structures may be guyed. The existing 230 kV line and structures will be removed in this line section. There will be approximately 169 structures in this section with an average span of 950 feet. The proposed structure types are shown in Figures D-1 through D-6. Typical structures in this segment will range from 150 to 195 feet tall.

The proposed new line construction described above will be designed according to, and will meet, all National Electrical Safety Code standards. Design specifications and safety rules practiced by PPL Electric are described in Appendix E-7. The 500 kV circuit will consist of nine conductors arranged in triple-bundles with 18-inch spacing in a triangular configuration. Each of three phases will be 3 – 1590 KCMIL 45/7 stranding ACSR sub-conductors. The 230 kV circuit will consist of three conductors; each of the three phases will be a single 1590 KCMIL 45/7 stranding ACSR

conductor. There will be two overhead ground wires, one will be an OPGW with 36 single mode optical fibers and the other will be 19 NO 9 Alumoweld steel OHGW or equivalent.

The designed minimum conductor clearance of the proposed 500 kV Susquehanna-Roseland line and 230 kV line at Susquehanna are shown in Tables D-1 through D-3. The conductor thermal ratings for both the proposed 500 kV and 230 kV lines are shown in Tables D-4 and D-5.

Table D-1. Designed Minimum Conductor Clearances for 1590 KCMIL 45/7 Stranding ACSR Susquehanna 500 kV Segment and Segments 2-5		
Condition	Clearance-to-Rail (feet)	Clearance-to-Ground (feet)
Normal Load average weather (16°C ambient temperature)	61	61
Predicted extreme thermal load (140°C conductor temperature)	53	53
Predicted extreme weather conditions (1½ inch ice, 0 lb wind, 18°C)	58.5	58.5

Clearances based on a maximum tension of 21,100 pounds and a ruling span of 950 feet. Conductors are bundled 3 per phase on the 500 kV energized side.

Table D-2. Designed Minimum Conductor Clearances for 2493 KCMIL 54/37 Stranding ACAR Segment 1		
Condition	Clearance-to-Rail (feet)	Clearance-to-Ground (feet)
Normal Load average weather (16°C ambient temperature)	45.1	43.1
Predicted extreme thermal load (100°C conductor temperature)	35	33
Predicted extreme weather conditions (1½ inch ice, 0 lb wind, 18°C)	39.3	37.3

Clearances based on a maximum tension of 33,366 pounds and a ruling span of 1000 feet. Conductors are bundled 2 per phase.

Table D-3. Designed Minimum Conductor Clearances for 1590 KCMIL 45/7 Stranding ACSR Susquehanna 230 kV Segment		
Condition	Clearance-to-Rail (feet)	Clearance-to-Ground (feet)
Normal Load average weather (16°C ambient temperature)	39.2	38.2
Predicted extreme thermal load (140°C conductor temperature)	33	32
Predicted extreme weather conditions (1 inch ice, 0 lb wind, 18°C)	40.3	39.3

Clearances based on a maximum tension of 16,000 pounds and a ruling span of 800 feet

Table D-4. Conductor Thermal Rating for 1590 KCMIL 45/7 Stranding ACSR 140°C Maximum Conductor Temperature Susquehanna 500 kV Segment and Segments 2-5			
Condition	Ambient Temp. (°C)	Wind Speed (Knots)	Ampacity (Amps)
Summer Normal	35	0	1795
Winter Normal	10	0	1996
Summer Emergency	35	1½	2138
Winter Emergency	10	1½	2346

Table D-5. Conductor Thermal Rating for 2493 KCMIL 54/37 Stranding ACAR 100°C Maximum Conductor Temperature Segment 1			
Condition	Ambient Temp. (°C)	Wind Speed (Knots)	Ampacity (Amps)
Summer Normal	35	0	1735
Winter Normal	10	0	1950
Summer Emergency	35	1½	2180
Winter Emergency	10	1½	2305



Photo D-1: Proposed 230 kV Structure - Susquehanna 230 kV Segment.



Photo D-2: Proposed 500 kV Structure - Susquehanna 500 kV Segment and Segment 1.

6-46-076
 SHEET 1

500KV STEEL POLE LINE CONSTRUCTION
 DOUBLE CIRCUIT - SINGLE POLE - STRAIGHT ARMS
 TANGENT AND LIGHT ANGLE 0°-1' 5DPT__H
 FOR SPANS UP TO 700 FEET

6-46-076
 SHEET 1

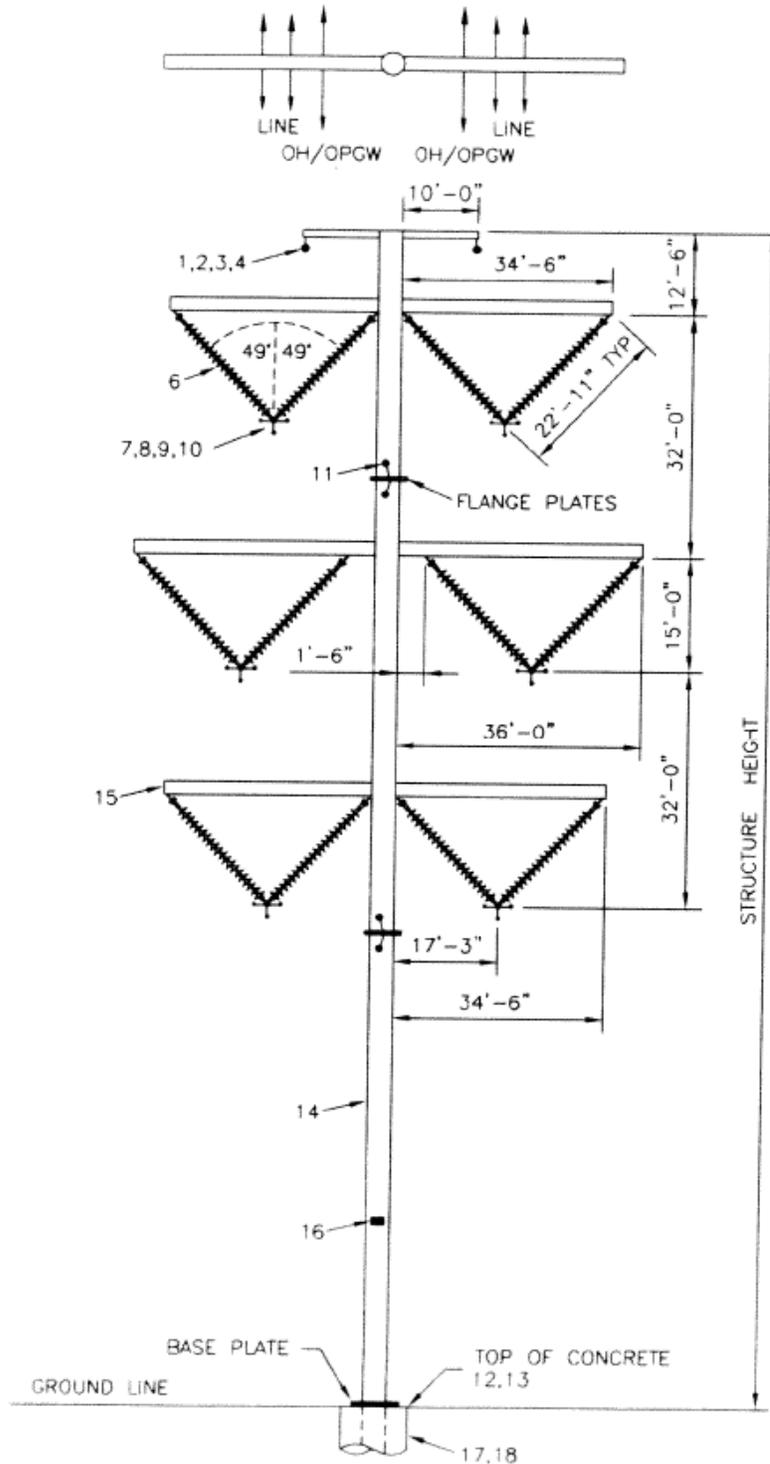


Figure D-1: Double Circuit Tangent and Light Angle Structure – Single Pole.

6-46-078	500KV STEEL POLE LINE CONSTRUCTION DOUBLE CIRCUIT- THREE POLE STRUCTURE TANGENT AND LIGHT ANGLE 0° TO 1° 5DMT__H FOR SPANS GREATER THAN 700 FEET	6-46-078
SHEET 1		SHEET 1

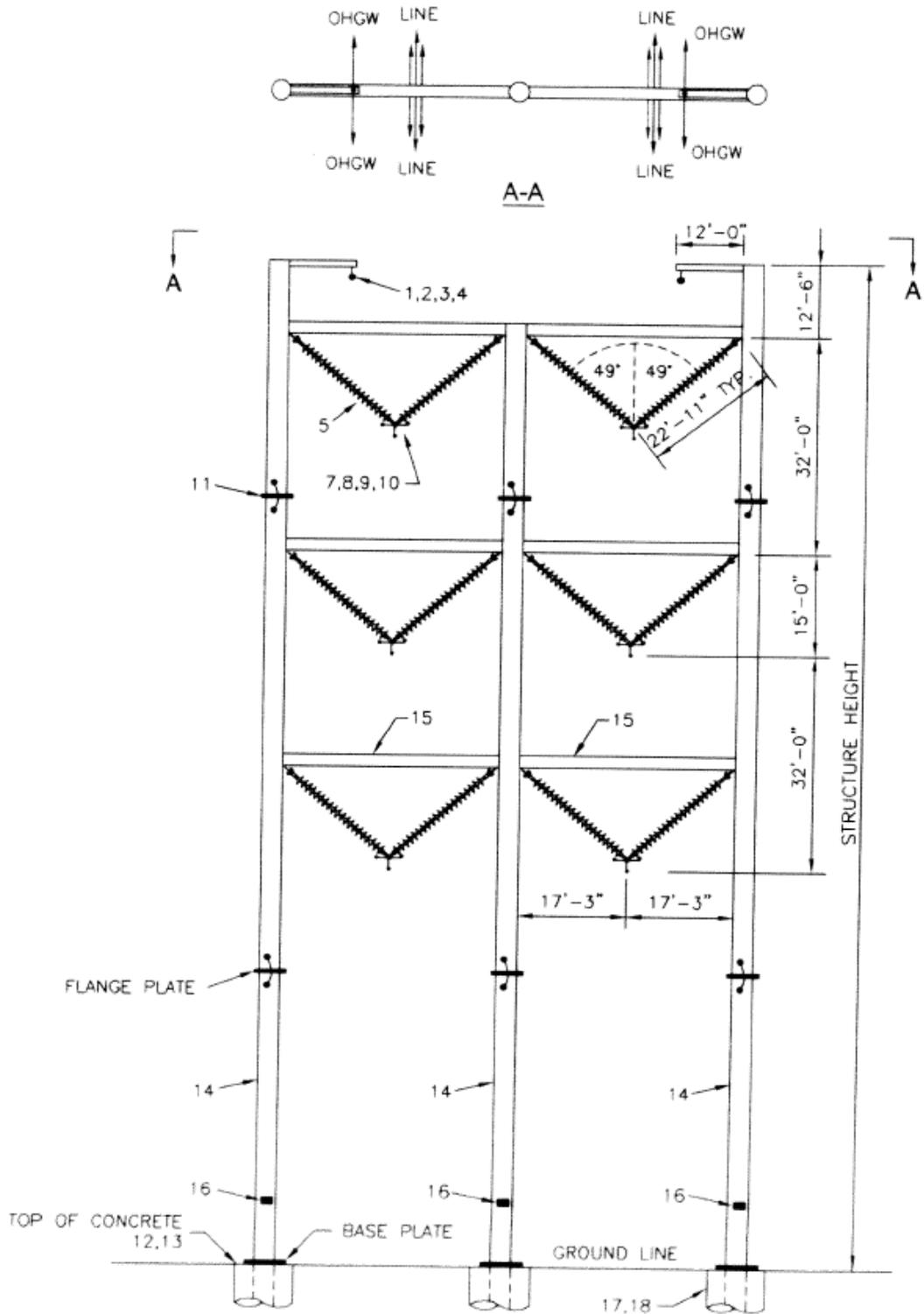


Figure D-2: Double Circuit Tangent and Light Angle Structure –Three Pole.

6-46-080
 SHEET 1

500KV STEEL POLE LINE CONSTRUCTION
 DOUBLE CIRCUIT-THREE POLE STRUCTURE
 RUNNING ANGLE STRUCTURE 2° TO 20° 5DMA__H

6-46-080
 SHEET 1

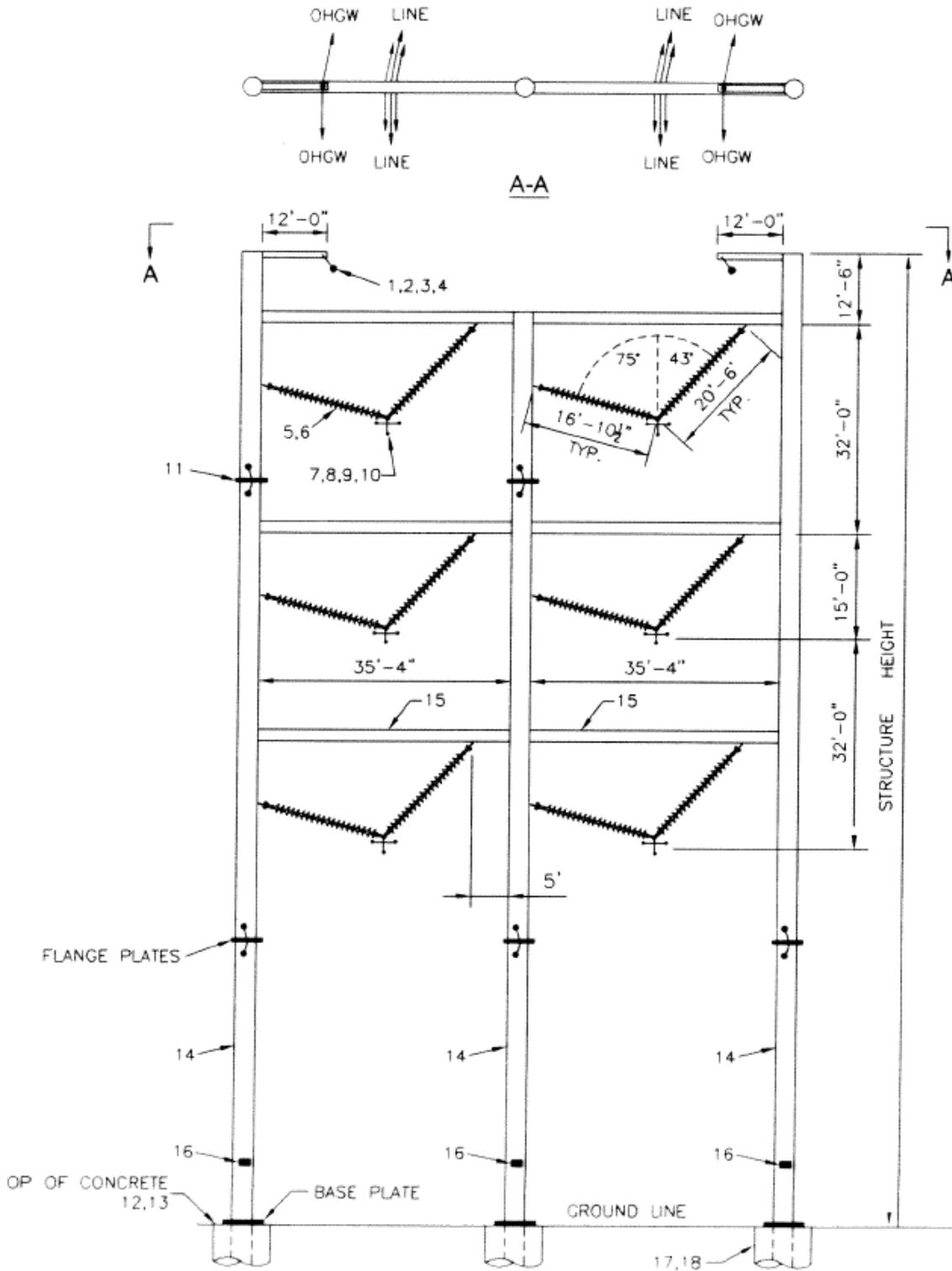


Figure D-3: Double Circuit Running Angle Structure –Three Pole.

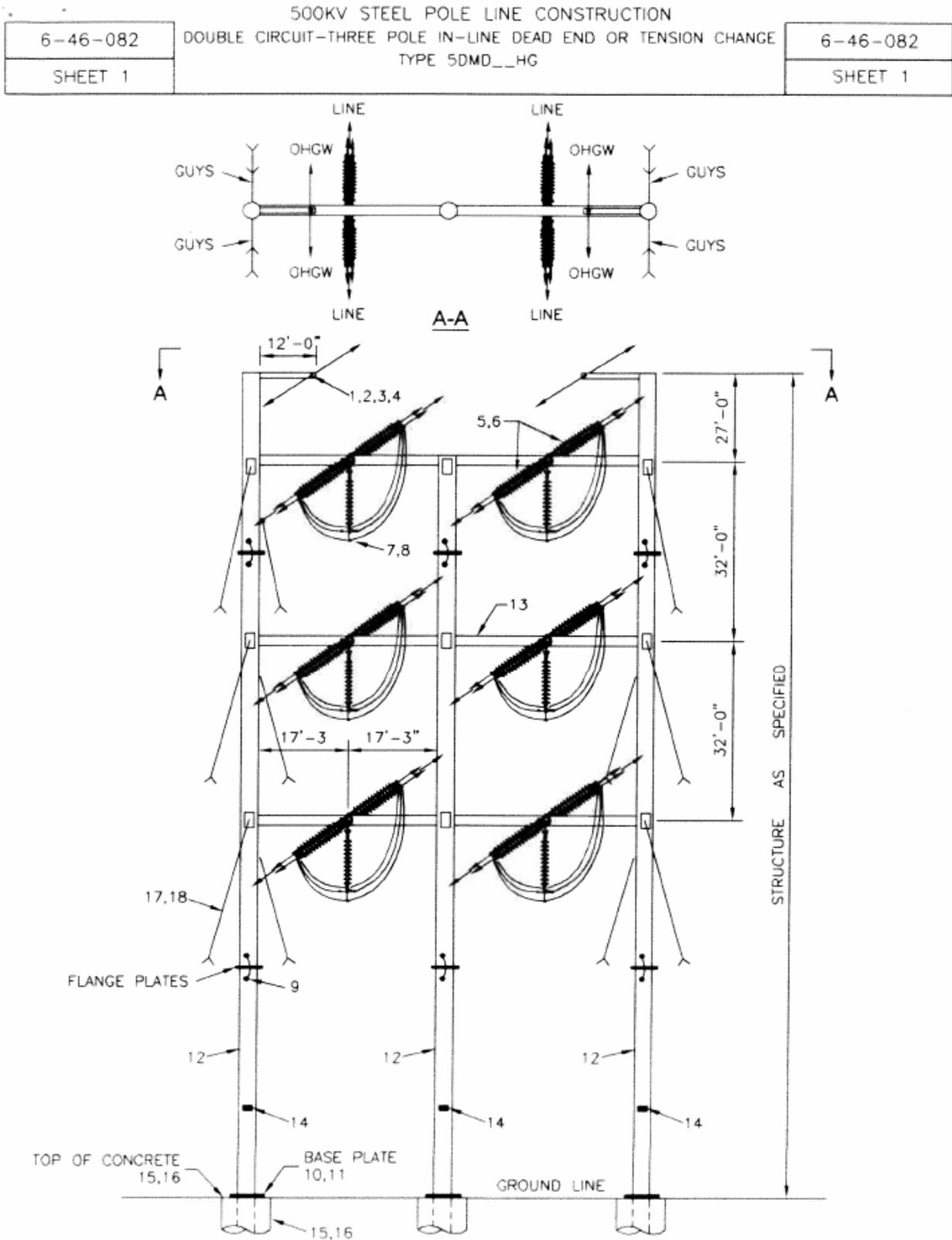


Figure D-4: Double Circuit In-Line Dead End or Tension Change Structure – Three Pole.

6-46-084	500KV STEEL POLE LINE CONSTRUCTION DOUBLE CIRCUIT - TWO POLE HEAVY ANGLE STRUCTURE ANGLES GREATER THAN 20° (AT REDUCED TENSION) TYPE 5DMD-- $\frac{L}{R}$	6-46-084
SHEET 1		SHEET 1

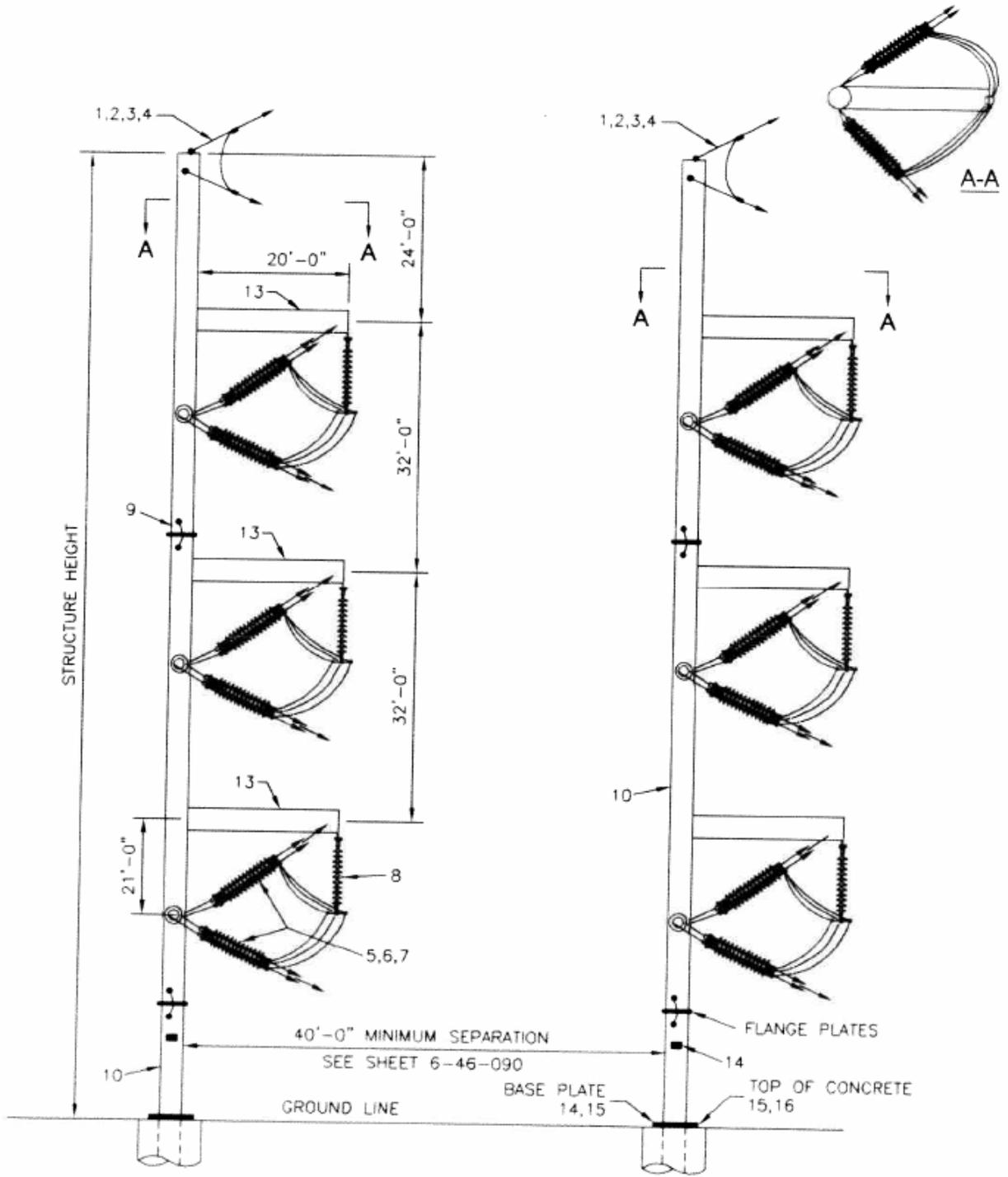


Figure D-5: Double Circuit Heavy Angle Structure – Two Pole.

6-46-085	500KV STEEL POLE LINE CONSTRUCTION SINGLE CIRCUIT – ONE POLE HEAVY ANGLE STRUCTURE ANGLES GREATER THAN 20° (AT REDUCED TENSION) TYPE 5SMD__R	6-46-085
SHEET 1		SHEET 1

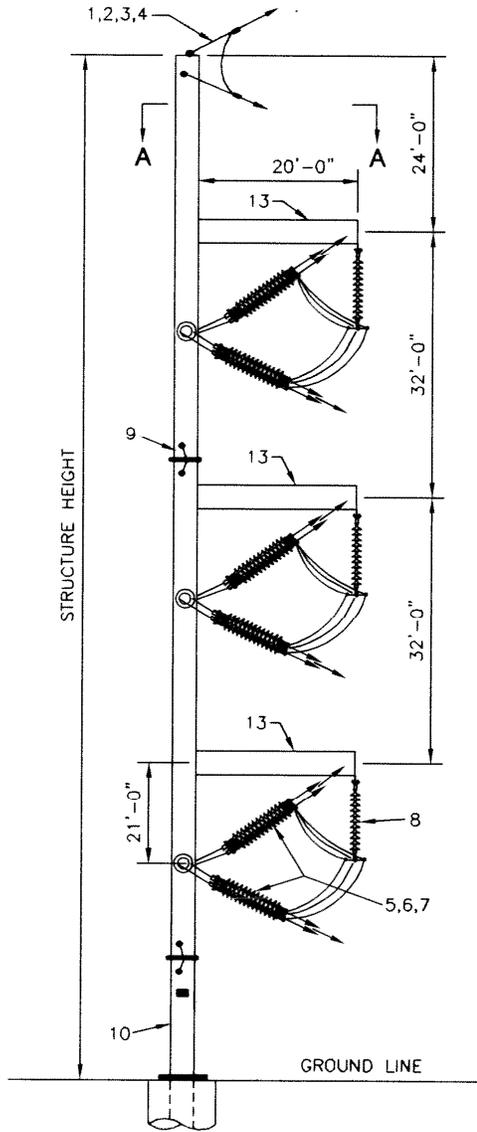


Figure D-6: Single Circuit Heavy Angle Structure – Single Pole.

2.0 Magnetic Field Management Plan

Since the 1970s, many credible scientific panels, government agencies and public health entities have reviewed the scientific research on electric and magnetic fields and none of these review groups has concluded that electric or magnetic fields (“EMF”) cause or contribute to cancer or any other disease. In 2007, the World Health Organization (“WHO”) conducted an extensive review of EMF based on its own independent review of the research. That review noted that some statistical studies provide “limited” evidence of an association between EMF and childhood leukemia, but also noted that controlled laboratory studies do not provide any support for that association and no cause-and-effect relationship has been established. WHO’s evaluation concluded that EMF have not been established as a cause of any disease or illness.

PPL Electric has determined, as matter of corporate policy, to design both its new and rebuilt transmission lines to reduce magnetic fields when that can be done at no or low additional cost and is consistent with meeting the functional requirements of the line. PPL Electric’s Magnetic Field Management Program was developed to implement that policy decision. PPL Electric and its predecessor companies have had a Magnetic Field Management Program for new and rebuilt transmission lines since the early 1990s. The Program most recently underwent minor revisions in 2004.

For each new 500 kV transmission line, PPL Electric’s Magnetic Field Management Program requires that PPL Electric conduct a study to “determine optimum structure types, ground clearances, configurations and designs to reduce field levels.” The principal factors that affect magnetic field levels are current, distance, phase arrangement, phase spacing, and current balance. Such a study can include but is not limited to analysis of reduction measures such as additional minimum ground clearances, increasing conductor tensions, using reduced-phase spacing (a “Delta” configuration on a single circuit line), installing the second circuit initially, and/or adding a second set of conductors that are reverse-phased and operated in parallel with the first set (bundled/split phased).

As a result of this work, PPL Electric has determined that, in order to reduce magnetic fields, all new structures for this line will be designed with 20 feet of additional ground clearance. This additional ground clearance has the added benefit of reducing the amount of vegetation clearing that is required in some areas. In addition, PPL Electric has determined that reverse phasing will be applied wherever this line is designed for double circuit construction, even though the one circuit will be 500 kV and the other circuit will be 230 kV. These measures will significantly reduce magnetic fields produced by the line. Overall, PPL Electric estimates that the magnetic field management measures to be implemented for this project will increase the overall project cost by about 3 to 5 percent, an amount within the low or no cost guidelines of PPL Electric’s Magnetic Field Management Program.