Relocation project calls for innovation - Zelitchenko, Abram; Kilga, Edmund E.

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Abstract

Several transmission lines had to be relocated in conjunction with the installation of a 230-kV bus-sectionalizing breaker at Bonneville Power Administration's Tacoma 500/230-kV substation.

For Tacoma City Light, the Tacoma-Cowlitz No. 2 230-kV transmission line had to be relocated from Bay No. 9 to Bay No. 3, which required construction of a new section of 230-kV line. Three potential configurations were considered for this relocation. The one chosen was found to be preferable for a number of reasons, including:

1. It eliminated crossing over the 230-kV transformer-bank feeders and existing 115-kV and 12.5-kV circuits.
2. It included a lower cost for the poles and foundation.
3. Less time would be needed for construction activities because this work could be performed by TCL crews with their equipment.

In conjunction with the installation of a 230-kV bus-sectionalizing breaker at Bonneville Power Administration's (BPA) Tacoma 500/230-kV substation, several transmission lines had to be relocated. For Tacoma City Light (TCL), the Tacoma-Cowlitz No. 2 230-kV transmission line had to be relocated from Bay No. 9 to Bay No. 3, which required construction of a new section of 230-kV line.

Three potential configurations were considered for this relocation. Two configurations (version "A" and version "B") involved construction along the common boundary between TCL's Northeast 230-kV substation and BPA's Tacoma 500/230-kV substation.

The two adjacent substations were connected by three 230-kV transformer-bank feeders. The third configuration (version "C") bypassed TCL's Northeast 230-kV substation, crossing all outgoing overhead 115-kV and 12.5-kV lines.

Version "A" routing began at an existing steel terminal pole on the Tacoma-Cowlitz No. 2 line. The line then traveled to a 90 deg wood pole and turned left to traverse the common fence between the two substations -- passing underneath three 230-kV transformer-bank feeders. Finally, it turned a 90 deg angle into Bay No. 3 to connect to the Tacoma substation 230-kV bus. The length of this route was 593 ft. This version required a compact 230-kV line design because of the limited clearance between the transformer-bank feeders and this proposed route. In addition, phase-to-ground clearances were critical.

Version "B" routing was similar to version "A" with the exception that the line passed over the three transformer-bank feeders rather than below them. This version would have required the installation of two deadend steel poles, 130 and 135 ft in height, with extra-deep foundations. One span would have crossed over two 230-kV transformer-bank feeders. The length of the route for version "B" was 590 ft.

Version "C" started at the third pole before the terminal pole passing Northeast substation on the west side and crossing over four 115-kV lines and one 12.5-kV circuit. This version would have required the installation of two deadend steel poles, 120 ft and 85 ft in height, with appropriate foundations. Length of this route was 1390 ft.

Version "A" was found to be preferable because:

* It eliminated crossing over the 230-kV transformer-bank feeders and existing I15-kV and 12.5-kV circuits.

* It included a lower cost for the poles and foundation.

* Less time would be needed for construction activities because this work could be performed by TCL crews with their equipment.

* Valuable experience was provided in specific aspects of construction for compact 230-kV transmission lines which could be used for future line construction in urban areas.

To construct the line, a strip of land 20 ft by 450 ft had to be transferred from BPA to Tacoma. Therefore, all construction activities and preliminary designs for the compact 230-kV line had to be coordinated with BPA. The design criteria for this new section of line used the same initial parameters and conditions as the original line:

* Conductor -- bundled 1272 AAC

* Ground wire -- 12.5 M (Alumoweld)

* Weather conditions -- medium by NESC-93

* Maximum wind speed -- 80 MPH

* Maximum temperature - 105deg F

* Minimum temperature -- 0deg F

* Exposure category -- "B" and "C"

* Construction grade -- "B"

* Number of thunderstorm days -- less than 10

All clearances between conductors at crossings and in spans, conductors to ground, and clearances from conductors to poles were in accordance with NESC-93 and were reviewed with BPA. In addition to reducing the phase spacing to an acceptable minimum, the triangular conductor configuration (delta) provided minimum electric and magnetic fields (EMF).

The three in-line delta poles had a minimum height that provided the necessary clearances from conductors to ground and to the overhead crossing 230-kV transformer-bank feeders (Fig. 1). (Fig. 1 omitted) The poles were cedar, 35-ft length, class 2. At each pole the ground clearance for the lower conductor was 23 ft and for the upper conductor was 32.2 ft. The spans between these poles were 70 and 75 ft (Fig. 2).(Fig. 2 omitted) The delta deadend poles on each end of the line were constructed with 13 ft, No. 9 double crossarms with braces and were backed-up with two in-line downguys. The conductor elevation on these deadend poles was the same as on the in-line poles. Each delta deadend pole was connected to a Douglas Fir, 90 deg, deadend corner pole, 75 ft and 90 ft in length with vertical phase configuration. Span lengths were 30 ft and 35 ft.

The deadend corner poles were supported by downguys attached to screw "swamp" anchors. In-line and deadend delta poles were installed in the conventional manner.

The tall deadend corner poles with downguys experienced considerable compression and stress in the soil as determined by pole buckling calculations. Special foundations were needed for these poles because of the soil capacity of 2000 PSI. One of the corner poles was 66 ft in height above grade and set in a foundation 3.5 ft in dia and 10.5 ft in depth. The other corner pole was 79 ft in height above grade and set in a foundation of 5 ft in dia and 12.5 ft in depth. These poles were set in steel-reinforced concrete culverts with the bottom end closed. The void was then filled with rocks and gravel.

This compact line used 230-kV polymer line posts and suspension insulators from Ohio Brass Co.: line post insulators -- type 0B522012-1002; vertical post insulators type 0B-522-012-1305; and suspension insulators -- type 0B-511012. All insulators were HiLite XL type from catalogs No. 102 and No. 101 with the corona rings on the conductor side. The in-line delta poles used two horizontal-line-post insulators and one vertical-post insulator.

The conductor was deadended at the pole with suspension insulator strings and yoke plates for attaching the two conductors.

Jumper conductors were trained above the deadend insulators and attached to vertical post insulators (Fig. 2). Some jumper conductors on the tall single deadend comer poles were attached to horizontal line-post insulators to provide necessary clearances between conductors and the pole (Fig. 4).(Fig. 4 omitted) The 18-inch spacers (Alcoa Catalog No. 3318) were mounted on conductors in all spans and jumpers.

Lightning protection for the new line was provided by existing overhead ground wires on each of the three 230kV transformer bank feeds and other transmission lines and by the installation of a new groundwire in the terminal span into Bay 3.

Many calculations were necessary to determine the sag and tension requirements for mounting heavy conductors (1272 AAC) in short spans with large differences in elevation. Calculation results provided minimum differences in tension at the crossarms of the delta deadend poles under low temperature and ice conditions.

Tensions were verified with a dynamometer.

Magnitudes of the electric- and magnetic-field profiles under conductors at different distances from the centerline were obtained using the Electric Power Research Institute's (EPRI) ENVIRO program (Fig. 3).(Fig. 3 omitted) Electric and magnetic field values were 4.4 kV/m and 86.7 mG, respectively, at a line current of 400 A These readings were well within acceptable limits for 230-kV substations in the area where the compact 230-kV lines were located. Actual magnetic field measurements were taken with an EMDEX II Gaussmeter after the line was energized. The magnitude of the magnetic field measured 36-46 mG, which corresponded well with predicted values (34.6 mG) for 184A line current. As expected, the magnitudes of the field increased in the vicinity of any one of the three 230-kV transformer-bank feeders.

The design and construction of this new compact 230kV line on single wood poles in a delta configuration provided valuable experience and insights regarding transmission line construction in confined areas. For future lines, it will be necessary to fabricate a new double conductor clamp assembly to attach conductors to vertical post insulators at in-line delta poles. Such an attachment is currently not available, except for jumper applications. In addition, Protecta Lite arresters were installed for lightning protection.

Based on this project's experiences, the cost of construction for a compact, delta configuration, 230-kV line with twin conductor bundles (2 by 795 AAC) on single wood poles in urban areas is estimated at approximately $160,000 - $170,000 per mile.