Ulteig

Energy, Water, and Our Built-Environment

Facility Study Report
June 3, 2013

Center to Heskett
230kV Transmission Line
Minnkota Power Cooperative
UEI Project No. 12.01375

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BACKGROUND

The Center to Heskett 230kV Transmission Line is located between Center, ND and Mandan, ND. The existing line is constructed of steel lattice tangents and wood h-frame tangents, with guyed angles and guyed deadend structures, and has 954 45/7 ACSR “Rail” conductors, and 3/8” or 7/16” EHS shieldwires installed. The line is presently 22.5 miles in length. The Heskett end of the line will be re-terminated at a new substation named Mandan in the sping 2013, reducing the line length by approximately 1 mile.

The survey data was lidar-based. KBM performed the PLS-CADD model development, initial structure placements, and wire sagging. The structures were general 230kV PLS-CADD structures, snapped to the lidar cable attachment for each structure. Tensions were based on lidar survey data.

An analysis of two different types of conductors was required to determine the most cost effective solution to provide the anticipated increase in capacity for the line. The two conductors were 954 45/7 ACSS “Rail” and 959 Type 16 ACSS/TW “Suwannee”. The target operating temperatures were initially 130°C (266°F) and 145°C (293°F) for both conductors, and then modified to include an operating temperature of 150°C (302°F) in the analysis.

ANALYSIS Requirements

The owner, Minnkota Power Cooperative (hereafter referred to as Minnkota), directed Ulteig to determine the most cost effective conductor selection for maintaining clearances for the 130°C, 145°C, and 150°c operating temperatures, while reusing the existing wood pole and lattice tower structures. Structures were to be modified to achieve adequate clearances. From each of the analyses for the conductor/temperature options, Ulteig developed a cost estimate to select the most cost effective option.

MODEL DEVELOPMENT & OTHER ASSUMPTIONS

1. Confirm Model

Ulteig restored the three different furnished PLS-CADD files from Minnkota. The first restored model was named “01_cntr_hskt” with a file date of 6/12/2008. The second restored model was named “center-heskett” with a file date of 5/20/2008. The final model was named “center-heskett-9-27-2012 (nesc 22.4 ft)” with a file date of 9/27/2012. All data from the three models were merged into a single model.

The model contained structures that had been preliminary located by KBM, and were generally placed close to the existing structure locations in order to string in the existing conductor. New PLS-Pole structure models were developed to better represent Minnkota’s actual 230kV standard structures and match the existing structures on the line. The new structures were then placed on the exact locations based on the lidar data. The structures were also height adjusted to match the existing cable attachment points accurately. Guys and anchors were also modeled to match the exact locations determined by the lidar data for angle and deadend structures.

The lattice tower portion of this line was modeled as regular wood pole structures, due to the complexity to model each lattice structure. Load calculations were performed to determine the capacity of these structures. Additional survey data was also obtained to gather the exact location of the lattice structures and all of the attachment heights of the wires on the lattice structures because the photogrammetric data did not contain this information.

2. Stringing Method used to String New Conductors.

The tensioning analysis was completed for 20% of Ultimate RBS @ -20°F, Initial. Both of the conductor options were sagged according to this criteria and clearance checks were performed for with the "Suwannee" conductor at the 130°C, 145°C, and 150°C temperatures, and the "Rail" conductor was only tested at the 150°C temperature. The comparison of these runs can be viewed in **Attachment A**. As seen in the attachment, the "Rail" conductor has considerably more clearance violations than does any of the scenario's with the "Suwannee" conductor.

3. Ground Clearance Criteria

Ground clearance after the upgrade will be a minimum of NESC+3' (25.4'). A margin is needed to account for unknown quantities such as discrepancies in the input data and future changes in ground elevation and vegetation. Additionally, this margin is needed based on a recommendation from Southwire© as a suitable allowance for the differential temperatures that can occur between the core of the conductor and the outer strands. The differential temperature becomes an issue during operation at temperatures above 100°C, and can be in the range of 10°C to 12°C.

4. Develop Construction Estimate

Based on the structure modifications that are needed to maintain the desired ground clearance, a construction estimate was assembled using pricing gathered from various suppliers and from Minnkota's previous projects. **Attachment C** shows the pricing for the various material provided by Border States© and Laminated Wood Systems©. Labor estimates were also gathered from Minnkota's previous projects along with other construction documents that Ulteig has received recently from contractors. The construction estimate and totals for the line upgrade can be found in **Attachments D and E**.

ANALYSIS OF EXISTING CONDUCTOR

The exiting “Rail” ACSR conductor was also analyzed to determine spans that did not meet current NESC clearance requirements. For this analysis, a ground clearance of NESC+6” (22.9’) was used. The additional 6” was to account for variations in lidar data and structure modeling. The conductors were previously modeled by KBM, before Ulteig had received the model, so the analysis was run using previously developed tensions. When the thermal rating report was run in PLS-Cadd, it identified 11 spans which did not meet the NESC+6” criteria. In order to fix these spans, 13 structures would have to be raised. The cost of raising these 13 structures will be covered by Minnkota Power, and excluded from the cost sharing portion of the project, between Minnkota and Minnesota Power. The cost for these raises is not reflected in this document or appendices, but can be found in separate documents.

ANALYSIS OF NEW CONDUCTORS

After the conductors were sagged-in, a Thermal Rating Report was run from PLS-CADD to determine which spans did not meet the desired temperature rating. This function in PLS-CADD analyzes each individual span to determine the maximum operating temperature of the wire while maintaining a specified ground clearance. From this report, it was determined that the “Suwannee” conductor has 63 and 72 span violations for the 130°C and 145°C, respectively. The 150°C line operating temperature had 75 span violations for the required ground clearance. When the report was created for the “Rail” ACSS conductor, there were 124 span violations for the 150°C temperature requirement. Refer to **Attachment A**.

The “Suwannee” conductor was analyzed first because of the fewer number of span violations. Before any of the structures were modified, the structure capacities were checked to determine if the existing structures would be capable of handling the new conductor loadings. The NESC Design Tensions for this conductor were comparable to the existing “Rail” ACSR conductor design tension of 10,000#. After the structure checks were completed for the existing structures, it was determined that the existing structures had the capacity to carry the new conductor. However, some insulators would need to be replaced due to inadequate strengths for the new tensions and current code strength reduction factors. The anticipated insulator replacements are included in the table in **Attachment D**.

The lattice tower section of this line was analyzed separately using calculated loads based on the new stringing tensions. These new loads were compared to existing load and design drawings that were supplied by Minnkota for these types of lattice structures. Comparing the newly calculated loads with the loads that were supplied on the load and design drawings, the existing 12 lattice structures are adequate for the new “Suwannee” conductor. See **Attachment B** for calculation comparisons.

Since the existing structures have the capacity to carry the new conductor, PhaseRaisers® where added to the wood pole structures to gain additional height where there were clearance violations. The PhaseRaiser® sizes used are 5’, 10’, and 15’. There are no locations in this design that require more than

15’ of height adjustment. There are a total of 63 structures that require adjustments for the operating temperature of 150°C. 56 of these can be raised with PhaseRaisers® or in the case of lattice structure #4, by adding 10’ to the lattice. The other 7 structures will need to be replaced because they are angle/deadend structures or are not in good enough condition for phaseraising. Also, one additional structure is required (structure #01). A complete listing of the adjustments, replacements, and new structures is shown in **Attachment D** along with estimates of associated costs.

In addition to the structure changes summarized above, the three new structures that are required for the line to be routed into the new Mandan Substation are also documented in **Attachment D**. They are structures #267, #268 and #269.

Once a span was determined to have a clearance violation based on the NESC+3’ (25.4’) criteria, the span was then adjusted to meet a final ground clearance of NESC+3’ (25.4’) with the conductor at its maximum operating temperature of 200°C (392°F).

The “Rail” ACSS conductor, although costing less, would require many more structure adjustments. To conserve time, Ulteig completed a cost comparison based on a comparison of span violations between the “Rail” and “Suwannee” conductors, assuming that the number of structure changes per span violation would be the same for either conductor. Analysis for the “Suwannee” conductor at 150°C revealed 75 span violations. For the “Rail” conductor, the analysis at 150°C revealed 124 span violations. The proportion of 1.65 (124/75) was used to estimate the cost of replacing the additional structures required to maintain ground clearance with the “Rail” conductor. The estimated structure adjustment cost for “Suwannee” at 150°C was multiplied by 1.65 to estimate the cost of structure adjustments for “Rail”. With the new conductor pricing that Minnkota received for the “Suwannee” conductor, the estimated cost for the two conductors is relatively the same. The cost comparisons can be viewed in a table in **Attachment F**. The difference between the two conductor options is about $796,031 when calculated by this method. The “Rail” option however, would most likely require additional structures to be replaced because PhaseRaisers® are no longer an option, either because of the height required or because of angle/deadend structures needing to be raised, adding to the total cost difference between the conductors.

CONCLUSION

Ulteig recommends the “Suwannee” conductor to be used for the reconductoring of this line, due to the fact that the new material pricing of the conductor is relatively the same as the “Rail” conductor and that the required modifications to the existing structures will cost less and most of the structural modifications can be done while the line is still energized.

A summary of the total estimated cost of all structure modifications can be found in **Attachment E.** The summary includes all material and labor associated with the re-conductoring for the “Suwannee” conductor.

During the construction process, some structures may be encountered that are not in good enough condition for phaseraising. Estimated cost for such structures is included in the 10% contingency allowance. Construction crews will visually inspect each of the structures to determine if they are adequate.

Attachments to this Report

Attachment	Title
A	Span Violation Comparison – Temperature Comparison
B	Lattice Tower Load Comparison
C	Estimated Pricing from Vendors
D	Construction Estimate for 150°C (302°F)
E	Summarized Construction Estimate
F	Conductor Cost Comparison

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