UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

Revisions to Reliability Standard	**)**	**Docket Nos. RM12-4-000**
For Transmission Vegetation Management	**)**	**RM12-4-001**

INFORMATIONAL FILING OF THE NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

Pursuant to Order No. 777[1] of the Federal Energy Regulatory Commission ("FERC" or the "Commission"), the North American Electric Reliability Corporation ("NERC") submits this informational filing to provide an interim status update, as required, on NERC's testing to develop empirical data regarding the flashover distances between conductors and vegetation ("Project").

I. Background

In Order No. 777, the Commission directed NERC to undertake testing to develop empirical data regarding the flashover distances between conductors and vegetation to calculate the minimum vegetation clearance distances ("MVCD"). To that end, the Commission directed NERC to submit: (1) a schedule for testing; (2) the scope of work; (3) funding solutions; and (4) a deadline for submitting a final report on the test results to the Commission along with interim reports if a multi-year study is conducted. NERC submitted a compliance filing in accordance with Order No. 777 on July 12, 2013.[2] As noted in the filing, NERC has engaged the Electric Power Research Institute ("EPRI") to complete the Project. The Commission accepted NERC's compliance filing on September 4, 2013.[3]

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[1] *Revisions to Reliability Standard for Transmission Vegetation Management*, Order No. 777, 142 FERC ¶ 61,208 (2013).

[2] Compliance Filing of NERC, Docket No. RM12-4-000 (Jul. 12, 2013).

[3] *N. Am. Elec. Reliability Corp.*, Docket No. RM12-4-001 (Sept. 4, 2013) (delegated letter order).

II. Interim Status Report

NERC has made significant progress towards completing the Project since July 2013. Key milestones achieved are discussed below.

A. Finalization of the Scope of Work

Since the July 2013 compliance filing, NERC's Reliability Assessments and Performance Analysis staff finalized the Project's scope of work with EPRI staff, members of industry, and Commission staff. The final scope of work, as described in the compliance filing, seeks to empirically validate the gap factor used for calculating the MVCD as specified in the currently enforceable version of NERC's vegetation management Reliability Standard, FAC-003-3[4], designed to avoid flashovers between conductors and vegetation. The gap factor is utilized as a multiplier within the Gallet Equation, which adjusts the MVCD required for different configurations of objects and conductors. A lower gap factor correlates with a higher MVCD. Validation of the gap factor will verify that the MVCD values in Reliability Standard FAC-003-3 will support reliable operation of the Bulk Electric System ("BES"). The scope of work has not undergone significant changes or revisions since the July 2013 compliance filing.

B. Assembly of an Advisory Team

NERC has assembled an advisory team to execute the scope of work for the Project. This team is responsible for developing the test plan (described in greater detail below), monitoring

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[4] MVCD values in the FAC-003-3 Reliability Standard are based on the Gallet Equation. The Gallet Equation is an accepted method for calculating the air gap required between a conductor and a transmission line tower (*i.e.*, the grounded object) to avoid flashover. The Gallet Equation is used to calculate the minimum air gap that could exist between a conductor and vegetation (conductor-to-vegetation gap) to avoid a flashover. This calculated minimum conductor-to-vegetation gap would then be used to set the MVCD. The Gallet Equation is particularly useful as it works for a variety of conductor-to-vegetation gap configurations. The conductor-to-vegetation gap configuration may consist of the conductor being located vertically above and horizontally to the side of the vegetation in concern, or any combination thereof. *See* NERC Reliability Standard FAC-003-3 at 29-30, *available at* http://www.nerc.com/_layouts/PrintStandard.aspx?standardnumber=FAC-003-3&title=Transmission%20Vegetation%20Management&jurisdiction=United%20States.

testing, and vetting the analysis and conclusions to be submitted in the final report filed with the Commission. The advisory team is made up of 22 individuals representing NERC staff, EPRI staff, arborists, and industry members with wide-ranging expertise in transmission engineering, insulation coordination, and vegetation management.

C. Creation of a Detailed Test Plan

The advisory team developed a detailed test plan that is serving as a guide for the Project. A summary of the test plan and a brief outline of the technical elements of the testing that has been completed and is scheduled to take place is described below.

The primary objective of this Project is to determine the appropriate gap factor for use with the Gallet Equation. NERC and EPRI have designed a scope of work and detailed test plan for the Project that recognizes the complex nature of the research given the number of variables to consider, which include, but are not limited to, vegetation type, health of the vegetation, condition of the root system and soil, moisture levels, altitude, humidity, and other atmospheric factors. Sufficient empirical data is being gathered to statistically validate the gap factor specified in Reliability Standard FAC-003-3, taking into consideration the range of variables associated with testing in an open air environment.

The testing of the conductor-to-vegetation gap configurations involves selecting representative vegetation geometries, transmission line voltages, and conductor configurations to determine the statistical probability of flashover. This portion of the testing is well underway. Vegetation species can be expected to vary both regionally and by site type. Therefore, the test has been designed to cover the range of vegetation shapes and types that could be expected in and around transmission rights-of-way for all NERC Regions. It is important to test representative vegetation shapes, as they may produce varying influences on the electric field between a transmission line conductor and vegetation. These influences may have an effect on the probability of flashover between a conductor and vegetation, and must be considered in order to conservatively determine the lowest value of gap factor for a given conductor-to-vegetation gap configuration. The different types of vegetation can be organized into three basic shapes:

- Pyramidal - Conifers (*i.e.*, spruce, fir, pine) that have a well-defined central leader.
- Columnar - Deciduous trees that may exhibit less central dominance, commonly referred to as having a random form.
- Broadly vase-shaped - Involves larger trees with crowns that have been maintained by pruning. This occurs when an organization has been unable to remove trees within the wire zone. The crown form in this case would be asymmetrical or perhaps even "flat-topped".

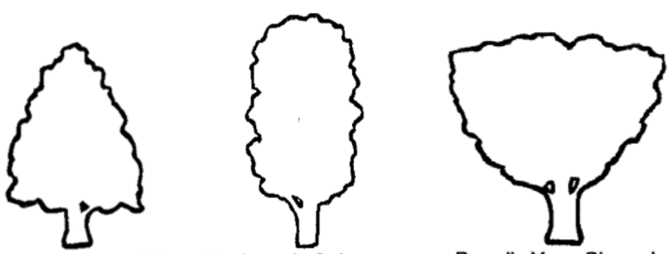

Figure 1 – Vegetation shapes to be tested - Vertical conductor-to-vegetation gap configuration

The physical arrangements of both the vegetation and transmission line conductors were also a consideration in determining the types of conductor-to-vegetation gap configurations to be tested. Encroachment between vegetation and transmission lines could occur vertically, from below, or horizontally, from the side. Therefore, both vertical and horizontal conductor-to-vegetation gap configurations were incorporated into the test plan. All three vegetation shapes are being tested in a vertical conductor-to-vegetation gap configuration, as they may produce varying electric field influences between a conductor and vegetation, as noted above.

With regard to horizontal conductor-to-vegetation gap configurations, vegetation shape varies based on maintenance practices. When viewed from the side, maintained vegetation appears planar in shape. However, vegetation that has not been maintained may have a less consistent appearance, with branches that protrude out toward a transmission line. As such, the horizontal conductor-to-vegetation gap configurations were developed to test both a columnar geometry (*i.e.*, maintained look) and a modified columnar form of vegetation that simulates a branch protruding toward a transmission line.

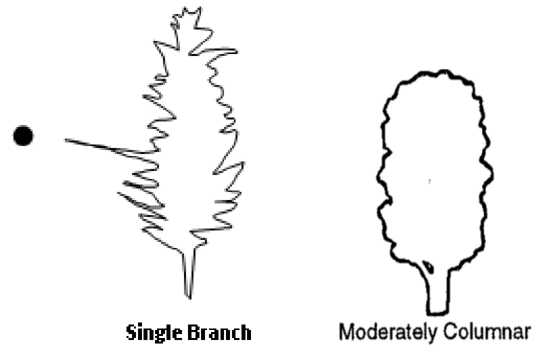

Figure 2 – Vegetation shapes to be tested - Horizontal conductor-to-vegetation gap configuration

The resulting conductor-to-vegetation gap configurations are being used to demonstrate that the gap factor determined for the artificial vegetation represents a conservative estimate of the gap factor for natural vegetation. The artificial vegetation used in the tests will replicate the full crown of a recently harvested tree (including stems, branches, twigs, and leaves) with the permittivity[5] of natural vegetation. The crown of the harvested tree will be pruned to represent the particular vegetation shapes to be tested for a given system voltage and conductor-to-vegetation gap configuration. The artificial vegetation will include a grounded metal center rod extending through to the crown. The purpose of the metal center rod is to avoid changes to the electrical characteristics of the vegetation being tested and to allow for repeatable, statistically

[5] The ability of a material to permit or maintain an electric field across its body, thereby making it susceptible to electrical breakdown.

valid switching impulse test measurements to be obtained. Artificial vegetation testing will be completed for system voltages of 230 kV, 345 kV, 500 kV, and 765 kV with a sufficient number of test impulses to produce scientifically and statistically valid conclusions about the critical flashover voltage ("CFO").

The gap factors of the representative conductor-to-vegetation gap configurations will be determined by testing for CFO, using positive polarity switching impulse waveforms,[6] as defined by the IEEE Standard for High-Voltage Testing Techniques ("IEEE Standard 4").[7] The switching impulse waveform that yields the highest probability of flashover for the range of conductor-to-vegetation gap sizes was selected for use in testing.

Positive polarity switching impulses were selected for testing, as they typically create the highest voltage stress at the conductor and yield the lowest values of CFO for an air gap similar to the conductor-to-vegetation gap configurations relevant to the Project.[8] EPRI was able to demonstrate that positive polarity switching impulses resulted in breakdown voltages that were approximately 100 kV lower than the negative polarity switching impulses applied at the test site. This determination indicated that positive polarity switching impulses would yield the most conservative values of CFO. The CFO values empirically obtained during testing will be used to calculate withstand voltages based on the statistically valid methods in IEEE Standard 4. Those withstand voltages will be used to support validation of an appropriate gap factor.

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6 As noted in the *Transmission Vegetation Management Standard FAC-003-2 Technical Reference*, MVCD is determined using the maximum expected switching surge impulse, not a lightning impulse. *See Transmission Vegetation Management Standard FAC-003-2 Technical* Reference at 7, *available at* http://www.nerc.com/pa/Stand/Project%20200707%20Transmission%20Vegetation%20Management/Transmission_Veg_Man_Standard_FAC-003-2_Technical_Ref_093011.pdf.

7 *IEEE Standard for High-Voltage Testing Techniques*, IEEE Standard 4, 2013.

8 *IEEE Guide for the Application of Insulation Coordination*, IEEE Standard 1313.2, p. 13, 1999.

The conductor-to-vegetation gap configurations and system voltage combinations that yield the lowest gap factors will be retested with a wooden electrode at least one meter in length at the end of the grounded metal center rod to simulate a tree branch within the crown. The conductor-to-vegetation gap spacing and statistical testing methods used during the metal electrode tests will be maintained for the wooden electrode tests. The intent of this test is to validate that the switching impulse strength of a gap between an energized conductor and a wooden electrode is greater than that of an identical gap between an energized conductor and a metal electrode. This configuration is expected to behave, from a flashover voltage perspective, more like that of natural vegetation.

Finally, the conductor-to-vegetation gap configurations and system voltage combinations that yield the lowest gap factors based on the aforementioned tests will be tested using natural vegetation. The voltage withstand values calculated will be used to statistically verify that the gap factor determined for the artificial vegetation represents a conservative estimate of the gap factor for the natural vegetation.

D. Testing Progress

EPRI continues to provide progress reports to NERC covering all stages of the Project, including necessary refinements of the detailed test plan as the Project progresses through the various stages. NERC has informally engaged Commission staff and invited them to view testing as each phase of the Project is being completed. NERC and EPRI have also engaged FERC staff to provide input on the test plan. A final test plan will be submitted along with the final report in this docket following completion of the Project. While the testing and data collection processes are underway, drawing meaningful conclusions will involve extensive analysis and evaluation by the advisory team of the all the accumulated data after all testing has been concluded. At this time, NERC still anticipates the final report will be filed with the Commission in June 2015.

III. Project Schedule

The Project was initiated in August 2013. The chart below outlines Project milestones based on the current status of work efforts and may be adjusted during the remainder of the Project to take to account for unforeseen circumstances. Should the project schedule change significantly, NERC will submit a second informational filing containing an updated schedule.

Project Milestones	Date
Initial Test Plan Completed	March 2014
Cataloging of Vegetation Species Completed	March 2014
Selection of Vegetation Shapes to be Tested	March 11, 2014
Test Setup Commissioned	June 19, 2014
Artificial Vegetation Testing Initiated	June 30, 2014
Natural Vegetation Testing Initiated	Early Fall 2014*
Testing Completed	November 2014*
Draft Report to Advisory Team	December 2014*
Final Report filed with the Commission	June 2015*

*****Projected at the time of filing of this informational report.

IV. Conclusion

NERC respectfully requests that the Commission accept this filing for informational purposes.

Respectfully submitted,

<u>/s/ Brady A. Walker</u>

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Dated: July 31, 2014

CERTIFICATE OF SERVICE

I hereby certify that I have served a copy of the foregoing document upon all parties listed on the official service list compiled by the Secretary in this proceeding.

Dated at Washington, D.C. this 31st day of July, 2014.

/s/ Brady A. Walker
Brady A. Walker

Counsel for North American Electric Reliability Corporation