Standard Development Timeline

This section is maintained by the drafting team during the development of the standard and will be removed when the standard becomes effective.

Development Steps Completed

1. SC approved SAR for initial posting (January 11, 2007).
2. SAR posted for comment (January 15–February 14, 2007).
3. SAR posted for comment (April 10–May 9, 2007).
4. SC authorized moving the SAR forward to standard development (June 27, 2007).
5. First draft of proposed standard posted (October 27, 2008-November 25, 2008)).
6. Second draft of revised standard posted (September 10, 20-October 24, 2009).
7. Third draft of revised standard posted (March 1, 2010-March 31, 2010).
8. Forth draft of revised standard posted (June 17, 2010-July 17, 2010).

***Note from the Project 2010-07 SDT**: The redline changes included in this document are the work of the Project 2010-07 SDT and are provided as a companion to the team's White Paper; the aim is to provide an example to convey the direction of our proposal. This is not intended to be a comprehensive rewrite of the standard. Any formal standard revision would require coordination with the work of the drafting team currently revising FAC-003-2 under Project 2007-07.*

Proposed Action Plan and Description of Current Draft

This is the third posting of the proposed revisions to the standard in accordance with Results-Based Criteria and the fifth draft overall.

Future Development Plan

Anticipated Actions	Anticipated Date
Recirculation ballot of standards.	January 2011
Receive BOT approval	February 2011

Effective Dates

First calendar day of the first calendar quarter one year after the date of the order approving the standard from applicable regulatory authorities where such explicit approval is required.

Exceptions:

A line operated below 200kV, designated by the Planning Coordinator as an element of an IROL or as a Major WECC transfer path, becomes subject to this standard 12 months after the date the Planning Coordinator or WECC initially designates the line as being subject to this standard.

An existing transmission line operated at 200kV or higher that is newly acquired by an asset owner and was not previously subject to this standard, becomes subject to this standard 12 months after the acquisition date of the line.

Version History

Version	Date	Action	Change Tracking
1	TBA	1. Added "Standard Development Roadmap." 2. Changed "60" to "Sixty" in section A, 5.2. 3. Added "Proposed Effective Date: April 7, 2006" to footer. 4. Added "Draft 3: November 17, 2005" to footer.	01/20/06
1	April 4, 2007	Regulatory Approval — Effective Date	New
2			

Definitions of Terms Used in Standard

This section includes all newly defined or revised terms used in the proposed standard. Terms already defined in the Reliability Standards Glossary of Terms are not repeated here. New or revised definitions listed below become approved when the proposed standard is approved. When the standard becomes effective, these defined terms will be removed from the individual standard and added to the Glossary. When this standard has received ballot approval, the text boxes will be moved to the Guideline and Technical Basis Section.

Right-of-Way (ROW)
The corridor of land under a transmission line(s) needed to operate the line(s). The width of the corridor is established by engineering or construction standards as documented in either construction documents, pre-2007 vegetation maintenance records, or by the blowout standard in effect when the line was built. The ROW width in no case exceeds the Transmission Owner's legal rights but may be less based on the aforementioned criteria.

The current glossary definition of this NERC term is modified to address the issues set forth in Paragraph 734 of FERC Order 693.

Vegetation Inspection
The systematic examination of vegetation conditions on a Right-of-Way and those vegetation conditions under the Transmission Owner's control that are likely to pose a hazard to the line(s) prior to the next planned maintenance or inspection. This may be combined with a general line inspection.

The current glossary definition of this NERC term is modified to allow both maintenance inspections and vegetation inspections to be performed concurrently.

Current definition of Vegetation Inspection: The systematic examination of a transmission corridor to document vegetation conditions.

Introduction

1. Title: Transmission Vegetation Management

2. Number: FAC-003-2

3. Objectives: To maintain a reliable electric transmission system by using a defense-in-depth strategy to manage vegetation located on transmission rights of way (ROW) and minimize encroachments from vegetation located adjacent to the ROW, thus preventing the risk of those vegetation-related outages that could lead to Cascading.

4. Applicability

4.1. Functional Entities:

Transmission Owners

Generator Owners

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4.2. Facilities: Defined below (referred to as "applicable lines"), including but not limited to those that cross lands owned by federal[1], state, provincial, public, private, or tribal entities:

4.2.1. Overhead transmission lines operated at 200kV or higher.

4.2.2. Overhead transmission lines operated below 200kV having been identified as included in the definition of an Interconnection Reliability Operating Limit (IROL) under NERC Standard FAC-014 by the Planning Coordinator.

4.2.3. Overhead transmission lines operated below 200 kV having been identified as included in the definition of one of the *Major WECC Transfer Paths in the Bulk Electric System*.

4.2.4. This standard applies to overhead transmission lines identified above (4.2.1 through 4.2.3) located outside the fenced area of the switchyard, station or substation and any portion of the span of the transmission line that is crossing the substation fence.

Rationale

-The areas excluded in 4.2.4 were excluded based on comments from industry for reasons summarized as follows: 1) There is a very low risk from vegetation in this area. Based on an informal survey, no TOs reported such an event. 2) Substations, switchyards, and stations have many inspection and maintenance activities that are necessary for reliability. Those existing process manage the threat. As such, the formal steps in this standard are not well suited for this environment. 3) The standard was written for Transmission Owners. Rolling the excluded areas into this standard will bring GO and DP into the standard, even though NERC has an initiative in place to address this bigger registry issue. 4) Specifically addressing the areas where the standard applies or doesn't makes the standard stronger as it relates to clarity.

[1] EPAct 2005 section 1211c: *"Access approvals by Federal agencies"*.

4.3. Enforcement: *The reliability obligations of the applicable entities and facilities are contained within the technical requirements of this standard. [Straw proposal]*

5. Background:

This NERC Vegetation Management Standard ("Standard") uses a defense-in-depth approach to improve the reliability of the electric Transmission System by preventing those vegetation related outages that could lead to Cascading. This Standard is not intended to address non-preventable outages such as those due to vegetation fall-ins or blow-ins from outside the Right-of-Way, vandalism, human activities and acts of nature. Operating experience indicates that trees that have grown out of specification have contributed to Cascading, especially under heavy electrical loading conditions.

With a defense-in-depth strategy, this Standard utilizes three types of requirements to provide layers of protection to prevent vegetation related outages that could lead to Cascading:

a) Performance-based — defines a particular reliability objective or outcome to be achieved.

b) Risk-based — preventive requirements to reduce the risks of failure to acceptable tolerance levels.

c) Competency-based — defines a minimum capability an entity needs to have to demonstrate it is able to perform its designated reliability functions.

The defense-in-depth strategy for reliability standards development recognizes that each requirement in a NERC reliability standard has a role in preventing system failures, and that these roles are complementary and reinforcing. Reliability standards should not be viewed as a body of unrelated requirements, but rather should be viewed as part of a portfolio of requirements designed to achieve an overall defense-in-depth strategy and comport with the quality objectives of a reliability standard. For this Standard, the requirements have been developed as follows:

- Performance-based: Requirements 1 and 2
- Competency-based: Requirement 3
- Risk-based: Requirements 4, 5, 6 and 7

Thus the various requirements associated with a successful vegetation program could be viewed as using R1, R2 and R3 as first levels of defense; while R4 could be a subsequent or final level of defense. R6 depending on the particular vegetation approach may be either an initial defense barrier or a final defense barrier.

Major outages and operational problems have resulted from interference between overgrown vegetation and transmission lines located on many types of lands and ownership situations. Adherence to the Standard requirements for applicable lines on any kind of land or easement,

whether they are Federal Lands, state or provincial lands, public or private lands, franchises, easements or lands owned in fee, will reduce and manage this risk. For the purpose of the Standard the term “public lands” includes municipal lands, village lands, city lands, and a host of other governmental entities.

This Standard addresses vegetation management along applicable overhead lines and does not apply to underground lines, submarine lines or to line sections inside an electric station boundary.

This Standard focuses on transmission lines to prevent those vegetation related outages that could lead to Cascading. It is not intended to prevent customer outages due to tree contact with lower voltage distribution system lines. For example, localized customer service might be disrupted if vegetation were to make contact with a 69kV transmission line supplying power to a 12kV distribution station. However, this Standard is not written to address such isolated situations which have little impact on the overall electric transmission system.

Since vegetation growth is constant and always present, unmanaged vegetation poses an increased outage risk, especially when numerous transmission lines are operating at or near their Rating. This can present a significant risk of multiple line failures and Cascading. Conversely, most other outage causes (such as trees falling into lines, lightning, animals, motor vehicles, etc.) are statistically intermittent. These events are not any more likely to occur during heavy system loads than any other time. There is no cause-effect relationship which creates the probability of simultaneous occurrence of other such events. Therefore these types of events are highly unlikely to cause large-scale grid failures. Thus, this Standard’s emphasis is on vegetation grow-ins.

Requirements and Measures

R1. Each Transmission Owner and Generator Owner shall manage vegetation to prevent encroachments of the types shown below, into the Minimum Vegetation Clearance Distance (MVCD) of any of its applicable line(s) identified as an element of an Interconnection Reliability Operating Limit (IROL) in the planning horizon by the Planning Coordinator; or Major Western Electricity Coordinating Council (WECC) transfer path(s); operating within its Rating and all Rated Electrical Operating Conditions.[2]

1. An encroachment into the MVCD as shown in FAC-003-Table 2, observed in Real-time, absent a Sustained Outage,
2. An encroachment due to a fall-in from inside the Right-of-Way (ROW) that caused a vegetation-related Sustained Outage,
3. An encroachment due to blowing together of applicable lines and vegetation located inside the ROW that caused a vegetation-related Sustained Outage,
4. An encroachment due to a grow-in that caused a vegetation-related Sustained Outage.

[VRF – High] [Time Horizon – Real-time]

Rationale
The MVCD is a calculated minimum distance stated in feet (meters) to prevent flash-over between conductors and vegetation, for various altitudes and operating voltages. The distances in Table 2 were derived using a proven transmission design method. The types of failure to manage vegetation are listed in order of increasing degrees of severity in non-compliant performance as it relates to a failure of a TO's vegetation maintenance program since the encroachments listed require different and increasing levels of skills and knowledge and thus constitute a logical progression of how well, or poorly, a TO manages vegetation relative to this Requirement.

M1. Each Transmission Owner and Generator Owner has evidence that it managed vegetation to prevent encroachment into the MVCD as described in R1. Examples of acceptable forms of evidence may include dated attestations, dated reports containing no Sustained Outages associated with encroachment types 2 through 4 above, or records confirming no Real-time observations of any MVCD encroachments.

If a later confirmation of a Fault by the Transmission Owner or Generator Owner shows that a vegetation encroachment within the MVCD has occurred from vegetation within the ROW, this shall be considered the equivalent of a Real-time observation.

[2] This requirement does not apply to circumstances that are beyond the control of a Transmission Owner or Generator Owner subject to this reliability standard, including natural disasters such as earthquakes, fires, tornados, hurricanes, landslides, wind shear, fresh gale, major storms as defined ~~either~~ by the Transmission Owner, the Generator Owner, or an applicable regulatory body, ice storms, and floods and~~;~~ human or animal activity such as logging, animal severing tree, vehicle contact with tree, arboricultural activities or horticultural or agricultural activities, or removal or digging of vegetation. Nothing in this footnote should be construed to limit the Transmission Owner's right to exercise its full legal rights on the ROW.

Multiple Sustained Outages on an individual line, if caused by the same vegetation, will be reported as one outage regardless of the actual number of outages within a 24-hour period. (R1)

R2. Each Transmission Owner and Generator Owner shall manage vegetation to prevent encroachments of the types shown below, into the MVCD of any of its applicable line(s) that is not an element of an IROL; or Major WECC transfer path; operating within its Rating and all Rated Electrical Operating Conditions.[2]

1. An encroachment into the MVCD as shown in FAC-003-Table 2, observed in Real-time, absent a Sustained Outage,
2. An encroachment due to a fall-in from inside the ROW that caused a vegetation-related Sustained Outage,
3. An encroachment due to blowing together of applicable lines and vegetation located inside the ROW that caused a vegetation-related Sustained Outage,
4. An encroachment due to a grow-in that caused a vegetation-related Sustained Outage.

[VRF – Medium] [Time Horizon – Real-time]

Rationale

The MVCD is a calculated minimum distance stated in feet (meters) to prevent flash-over between conductors and vegetation, for various altitudes and operating voltages. The distances in Table 2 were derived using a proven transmission design method. The types of failure to manage vegetation are listed in order of increasing degrees of severity in non-compliant performance as it relates to a failure of a TO's vegetation maintenance program since the encroachments listed require different and increasing levels of skills and knowledge and thus constitute a logical progression of how well, or poorly, a TO manages vegetation relative to this Requirement.

M2. Each Transmission Owner and Generator Owner has evidence that it managed vegetation to prevent encroachment into the MVCD as described in R2. Examples of acceptable forms of evidence may include dated attestations, dated reports containing no Sustained Outages associated with encroachment types 2 through 4 above, or records confirming no Real-time observations of any MVCD encroachments.

If a later confirmation of a Fault by the Transmission Owner or Generator Owner shows that a vegetation encroachment within the MVCD has occurred from vegetation within the ROW, this shall be considered the equivalent of a Real-time observation.

Multiple Sustained Outages on an individual line, if caused by the same vegetation, will be reported as one outage regardless of the actual number of outages within a 24-hour period. (R2)

R3. Each Transmission Owner and Generator Owner shall have documented maintenance strategies or procedures or processes or specifications it uses to prevent the encroachment of vegetation into the MVCD of its applicable transmission lines that include(s) the following:

3.1 Accounts for the movement of applicable transmission line conductors under their Facility Rating and all Rated Electrical Operating Conditions;

3.2 Accounts for the inter-relationships between vegetation growth rates, vegetation control methods, and inspection frequency.

Rationale
The documentation provides a basis for evaluating the competency of the Transmission Owner's vegetation program. There may be many acceptable approaches to maintain clearances. Any approach must demonstrate that the Transmission Owner avoids vegetation-to-wire conflicts under all Rated Electrical Operating Conditions. See Figure 1 for an illustration of possible conductor locations.

[VRF – Lower] [Time Horizon – Long Term Planning]

M3. The maintenance strategies or procedures or processes or specifications provided demonstrate that the Transmission Owner or Generator Owner can prevent encroachment into the MVCD considering the factors identified in the requirement. (R3)

R4. Each Transmission Owner and Generator Owner, without any intentional time delay, shall notify the control center holding switching authority for the associated applicable transmission line when the Transmission Owner or Generator Owner has confirmed the existence of a vegetation condition that is likely to cause a Fault at any moment.

Rationale
To ensure expeditious communication between the Transmission Owner and the control center when a critical situation is confirmed.

[VRF – Medium] [Time Horizon – Real-time]

M4. Each Transmission Owner and Generator Owner that has a confirmed vegetation condition likely to cause a Fault at any moment will have evidence that it notified the control center holding switching authority for the associated transmission line without any intentional time delay. Examples of evidence may include control center logs, voice recordings, switching orders, clearance orders and subsequent work orders. (R4)

R5. When a Transmission Owner or Generator Owner is constrained from performing vegetation work, and the constraint may lead to a vegetation encroachment into the MVCD of its applicable transmission lines prior to the implementation of the next annual work plan then the Transmission Owner or Generator Owner shall take corrective action to ensure continued vegetation management to prevent encroachments.

[VRF – Medium] [Time Horizon – Operations Planning]

Rationale
Legal actions and other events may occur which result in constraints that prevent the Transmission Owner from performing planned vegetation maintenance work.
In cases where the transmission line is put at potential risk due to constraints, the intent is for the Transmission Owner to put interim measures in place, rather than do nothing.
The corrective action process is intended to address situations where a planned work methodology cannot be performed but an alternate work methodology can be used.

M5. Each Transmission Owner and Generator Owner has evidence of the corrective action taken for each constraint where an applicable transmission line was put at potential risk. Examples of acceptable forms of evidence may include initially-planned work orders, documentation of constraints from landowners, court orders, inspection records of increased monitoring, documentation of the de-rating of lines, revised work orders, invoices, and evidence that a line was de-energized. (R5)

R6. Each Transmission Owner and Generator Owner shall perform a Vegetation Inspection of 100% of its applicable transmission lines (measured in units of choice - circuit, pole line, line miles or kilometers, etc.) at least once per calendar year and with no more than 18 months between inspections on the same ROW.[3]

[VRF – Medium] [Time Horizon – Operations Planning]

M6. Each Transmission Owner and Generator Owner has evidence that it conducted Vegetation Inspections of the transmission line ROW for all applicable

Rationale
Inspections are used by Transmission Owners to assess the condition of the entire ROW. The information from the assessment can be used to determine risk, determine future work and evaluate recently-completed work. This requirement sets a minimum Vegetation Inspection frequency of once per calendar year but with no more than 18 months between inspections on the same ROW. Based upon average growth rates across North America and on common utility practice, this minimum frequency is reasonable. Transmission Owners should consider local and environmental factors that could warrant more frequent inspections.

[3] When the Transmission Owner or Generator Owner is prevented from performing a Vegetation Inspection within the timeframe in R6 due to a natural disaster, the Transmission Owner or Generator Owner is granted a time extension that is equivalent to the duration of the time the Transmission Owner or Generator Owner was prevented from performing the Vegetation Inspection.

transmission lines at least once per calendar year but with no more than 18 months between inspections on the same ROW. Examples of acceptable forms of evidence may include completed and dated work orders, dated invoices, or dated inspection records. (R6)

R7. Each Transmission Owner and Generator Owner shall complete 100% of its annual vegetation work plan to ensure no vegetation encroachments occur within the MVCD. Modifications to the work plan in response to changing conditions or to findings from vegetation inspections may be made (provided they do not put the transmission system at risk of a vegetation encroachment) and must be documented. The percent completed calculation is based on the number of units actually completed divided by the number of units in the final amended plan (measured in units of choice - circuit, pole line, line miles or kilometers, etc.) Examples of reasons for modification to annual plan may include:

Rationale
This requirement sets the expectation that the work identified in the annual work plan will be completed as planned. An annual vegetation work plan allows for work to be modified for changing conditions, taking into consideration anticipated growth of vegetation and all other environmental factors, provided that the changes do not violate the encroachment within the MVCD.

- Change in expected growth rate/ environmental factors
- Circumstances that are beyond the control of a Transmission Owner or Generator Owner[4]
- Rescheduling work between growing seasons
- Crew or contractor availability/ Mutual assistance agreements
- Identified unanticipated high priority work
- Weather conditions/Accessibility
- Permitting delays
- Land ownership changes/Change in land use by the landowner
- Emerging technologies

[VRF – Medium] [Time Horizon – Operations Planning]

M7. Each Transmission Owner and Generator Owner has evidence that it completed its annual vegetation work plan. Examples of acceptable forms of evidence may include a copy of the completed annual work plan (including modifications if any), dated work orders, dated invoices, or dated inspection records. (R7)

[4] Circumstances that are beyond the control of a Transmission Owner or Generator Owner include but are not limited to natural disasters such as earthquakes, fires, tornados, hurricanes, landslides, major storms as defined either by the TO or GO or an applicable regulatory body, ice storms, and floods; arboricultural, horticultural or agricultural activities.

Compliance

Compliance Enforcement Authority

- Regional Entity

Compliance Monitoring and Enforcement Processes:

- Compliance Audits
- Self-Certifications
- Spot Checking
- Compliance Violation Investigations
- Self-Reporting
- Complaints
- Periodic Data Submittals

Evidence Retention

The Transmission Owner retains data or evidence to show compliance with Requirements R1, R2, R3, R5, R6 and R7, Measures M1, M2, M3, M5, M6 and M7 for three calendar years unless directed by its Compliance Enforcement Authority to retain specific evidence for a longer period of time as part of an investigation.

The Transmission Owner retains data or evidence to show compliance with Requirement R4, Measure M4 for most recent 12 months of operator logs or most recent 3 months of voice recordings or transcripts of voice recordings, unless directed by its Compliance Enforcement Authority to retain specific evidence for a longer period of time as part of an investigation.

If a Transmission Owner is found non-compliant, it shall keep information related to the non-compliance until found compliant or for the time period specified above, whichever is longer.

The Compliance Enforcement Authority shall keep the last audit records and all requested and submitted subsequent audit records.

Additional Compliance Information

Periodic Data Submittal: The Transmission Owner will submit a quarterly report to its Regional Entity, or the Regional Entity's designee, identifying all Sustained Outages of applicable transmission lines determined by the Transmission Owner to have been caused by vegetation, except as excluded in footnote 2, which includes as a minimum, the following:

- The name of the circuit(s), the date, time and duration of the outage; the voltage of the circuit; a description of the cause of the outage; the category associated with the Sustained Outage; other pertinent comments; and any countermeasures taken by the Transmission Owner.

A Sustained Outage is to be categorized as one of the following:

- Category 1A — Grow-ins: Sustained Outages caused by vegetation growing into applicable transmission lines, that are identified as an element of an IROL or Major WECC Transfer Path, by vegetation inside and/or outside of the ROW;

- Category 1B — Grow-ins: Sustained Outages caused by vegetation growing into applicable transmission lines, but are not identified as an element of an IROL or Major WECC Transfer Path, by vegetation inside and/or outside of the ROW;
- Category 2A — Fall-ins: Sustained Outages caused by vegetation falling into applicable transmission lines that are identified as an element of an IROL or Major WECC Transfer Path, from within the ROW;
- Category 2B — Fall-ins: Sustained Outages caused by vegetation falling into applicable transmission lines, but are not identified as an element of an IROL or Major WECC Transfer Path, from within the ROW;
- Category 3 — Fall-ins: Sustained Outages caused by vegetation falling into applicable transmission lines from outside the ROW;
- Category 4A — Blowing together: Sustained Outages caused by vegetation and applicable transmission lines that are identified as an element of an IROL or Major WECC Transfer Path, blowing together from within the ROW.
- Category 4B — Blowing together: Sustained Outages caused by vegetation and applicable transmission lines, but are not identified as an element of an IROL or Major WECC Transfer Path, blowing together from within the ROW.

The Regional Entity will report the outage information provided by Transmission Owners, as per the above, quarterly to NERC, as well as any actions taken by the Regional Entity as a result of any of the reported Sustained Outages.

Time Horizons, Violation Risk Factors, and Violation Severity Levels

Table 1						
R#	Time Horizon	VRF	Violation Severity Level			
			Lower	Moderate	High	Severe
R1	Real-time	High	The Transmission Owner had an encroachment into the MVCD observed in Real-time, absent a Sustained Outage.	The Transmission Owner had an encroachment into the MVCD due to a fall-in from inside the ROW that caused a vegetation-related Sustained Outage.	The Transmission Owner had an encroachment into the MVCD due to blowing together of applicable lines and vegetation located inside the ROW that caused a vegetation-related Sustained Outage.	The Transmission Owner had an encroachment into the MVCD due to a grow-in that caused a vegetation-related Sustained Outage.
R2	Real-time	Medium	The Transmission Owner had an encroachment into the MVCD observed in Real-time, absent a Sustained Outage.	The Transmission Owner had an encroachment into the MVCD due to a fall-in from inside the ROW that caused a vegetation-related Sustained Outage.	The Transmission Owner had an encroachment into the MVCD due to blowing together of applicable lines and vegetation located inside the ROW that caused a vegetation-related Sustained Outage.	The Transmission Owner had an encroachment into the MVCD due to a grow-in that caused a vegetation-related Sustained Outage.
R3	Long-Term Planning	Lower		The Transmission Owner has maintenance strategies or documented procedures or processes or specifications but has not accounted for the inter-relationships between	The Transmission Owner has maintenance strategies or documented procedures or processes or specifications but has not accounted for the	The Transmission Owner does not have any maintenance strategies or documented procedures or processes or specifications used to prevent the

				vegetation growth rates, vegetation control methods, and inspection frequency, for the Transmission Owner's applicable lines.	movement of transmission line conductors under their Rating and all Rated Electrical Operating Conditions, for the Transmission Owner's applicable lines.	encroachment of vegetation into the MVCD, for the Transmission Owner's applicable lines.
R4	Real-time	Medium			The Transmission Owner experienced a confirmed vegetation threat and notified the control center holding switching authority for that transmission line, but there was intentional delay in that notification.	The Transmission Owner experienced a confirmed vegetation threat and did not notify the control center holding switching authority for that transmission line.
R5	Operations Planning	Medium				The Transmission Owner did not take corrective action when it was constrained from performing planned vegetation work where a transmission line was put at potential risk.
R6	Operations Planning	Medium	The Transmission Owner failed to inspect 5% or less of its applicable transmission lines (measured in units of choice - circuit, pole line, line miles or	The Transmission Owner failed to inspect more than 5% up to and including 10% of its applicable transmission lines (measured in units of choice - circuit, pole line, line miles or kilometers, etc.).	The Transmission Owner failed to inspect more than 10% up to and including 15% of its applicable transmission lines (measured in units of choice - circuit, pole line, line miles or kilometers, etc.).	The Transmission Owner failed to inspect more than 15% of its applicable transmission lines (measured in units of choice - circuit, pole line, line miles or kilometers, etc.).

			kilometers, etc.)			
R7	Operations Planning	Medium	The Transmission Owner failed to complete up to 5% of its annual vegetation work plan (including modifications if any).	The Transmission Owner failed to complete more than 5% and up to 10% of its annual vegetation work plan (including modifications if any).	The Transmission Owner failed to complete more than 10% and up to 15% of its annual vegetation work plan (including modifications if any).	The Transmission Owner failed to complete more than 15% of its annual vegetation work plan (including modifications if any).

Variances
None.

Interpretations
None.

Guideline and Technical Basis

Requirements R1 and R2:
R1 and R2 are performance-based requirements. The reliability objective or outcome to be achieved is the prevention of vegetation encroachments within a minimum distance of transmission lines. Content-wise, R1 and R2 are the same requirements; however, they apply to different Facilities. Both R1 and R2 require each Transmission Owner to manage vegetation to prevent encroachment within the Minimum Vegetation Clearance Distance ("MVCD") of transmission lines. R1 is applicable to lines "identified as an element of an Interconnection Reliability Operating Limit (IROL) or Major Western Electricity Coordinating Council (WECC) transfer path (operating within Rating and Rated Electrical Operating Conditions) to avoid a Sustained Outage". R2 applies to all other applicable lines that are not an element of an IROL or Major WECC Transfer Path.

The separation of applicability (between R1 and R2) recognizes that an encroachment into the MVCD of an IROL or Major WECC Transfer Path transmission line is a greater risk to the electric transmission system. Applicable lines that are not an element of an IROL or Major WECC Transfer Path are required to be clear of vegetation but these lines are comparatively less operationally significant. As a reflection of this difference in risk impact, the Violation Risk Factors (VRFs) are assigned as High for R1 and Medium for R2.

These requirements (R1 and R2) state that if vegetation encroaches within the distances in Table 1 in Appendix 1 of this supplemental Transmission Vegetation Management Standard FAC-003-2 Technical Reference document, it is in violation of the standard. Table 2 tabulates the distances necessary to prevent spark-over based on the Gallet equations as described more fully in Appendix 1 below.

These requirements assume that transmission lines and their conductors are operating within their Rating. If a line conductor is intentionally or inadvertently operated beyond its Rating (potentially in violation of other standards), the occurrence of a clearance encroachment may occur. For example, emergency actions taken by a Transmission Operator or Reliability Coordinator to protect an Interconnection may cause the transmission line to sag more and come closer to vegetation, potentially causing an outage. Such vegetation-related outages are not a violation of these requirements.

Evidence of violation of Requirement R1 and R2 include real-time observation of a vegetation encroachment into the MVCD (absent a Sustained Outage), or a vegetation-related encroachment resulting in a Sustained Outage due to a fall-in from inside the ROW, or a vegetation-related encroachment resulting in a Sustained Outage due to blowing together of applicable lines and vegetation located inside the ROW, or a vegetation-related encroachment resulting in a Sustained Outage due to a grow-in. If an investigation of a Fault by a Transmission Owner confirms that a vegetation encroachment within the MVCD occurred, then it shall be considered the equivalent of a Real-time observation.

With this approach, the VSLs were defined such that they directly correlate to the severity of a failure of a Transmission Owner to manage vegetation and to the corresponding performance level of the Transmission Owner's vegetation program's ability to meet the goal of "preventing a Sustained Outage that could lead to Cascading." Thus violation severity increases with a Transmission Owner's inability to meet this goal and its potential of leading to a Cascading

event. The additional benefits of such a combination are that it simplifies the standard and clearly defines performance for compliance. A performance-based requirement of this nature will promote high quality, cost effective vegetation management programs that will deliver the overall end result of improved reliability to the system.

Multiple Sustained Outages on an individual line can be caused by the same vegetation. For example, a limb may only partially break and intermittently contact a conductor. Such events are considered to be a single vegetation-related Sustained Outage under the Standard where the Sustained Outages occur within a 24 hour period.

The MVCD is a calculated minimum distance stated in feet (or meters) to prevent spark-over, for various altitudes and operating voltages that is used in the design of Transmission Facilities. Keeping vegetation from entering this space will prevent transmission outages.

Requirement R3:
Requirement R3 is a competency based requirement concerned with the maintenance strategies, procedures, processes, or specifications, a Transmission Owner uses for vegetation management.

An adequate transmission vegetation management program formally establishes the approach the Transmission Owner uses to plan and perform vegetation work to prevent transmission Sustained Outages and minimize risk to the Transmission System. The approach provides the basis for evaluating the intent, allocation of appropriate resources and the competency of the Transmission Owner in managing vegetation. There are many acceptable approaches to manage vegetation and avoid Sustained Outages. However, the Transmission Owner must be able to state what its approach is and how it conducts work to maintain clearances.

An example of one approach commonly used by industry is ANSI Standard A300, part 7. However, regardless of the approach a utility uses to manage vegetation, any approach a Transmission Owner chooses to use will generally contain the following elements:

1. *the maintenance strategy used (such as minimum vegetation-to-conductor distance or maximum vegetation height) to ensure that MVCD clearances are never violated.*
2. *the work methods that the Transmission Owner uses to control vegetation*
3. *a stated Vegetation Inspection frequency*
4. *an annual work plan*

The conductor's position in space at any point in time is continuously changing as a reaction to a number of different loading variables. Changes in vertical and horizontal conductor positioning are the result of thermal and physical loads applied to the line. Thermal loading is a function of line current and the combination of numerous variables influencing ambient heat dissipation including wind velocity/direction, ambient air temperature and precipitation. Physical loading applied to the conductor affects sag and sway by combining physical factors such as ice and wind loading. The movement of the transmission line conductor and the MVCD is illustrated in Figure 1 below.

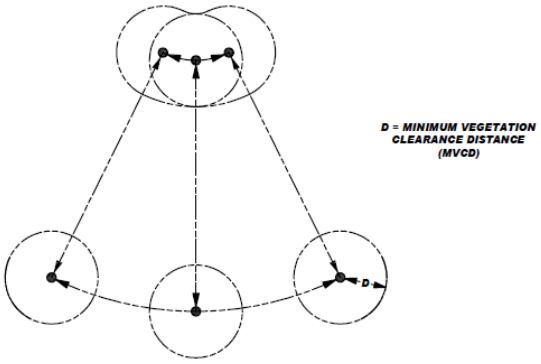

Figure 1

Cross-section view of a single conductor at a given point along the span showing six possible conductor positions due to movement resulting from thermal and mechanical loading.

Requirement R4:

R4 is a risk-based requirement. It focuses on preventative actions to be taken by the Transmission Owner for the mitigation of Fault risk when a vegetation threat is confirmed. R4 involves the notification of potentially threatening vegetation conditions, without any intentional delay, to the control center holding switching authority for that specific transmission line. Examples of acceptable unintentional delays may include communication system problems (for example, cellular service or two-way radio disabled), crews located in remote field locations with no communication access, delays due to severe weather, etc.

Confirmation is key that a threat actually exists due to vegetation. This confirmation could be in the form of a Transmission Owner's employee who personally identifies such a threat in the field. Confirmation could also be made by sending out an employee to evaluate a situation reported by a landowner.

Vegetation-related conditions that warrant a response include vegetation that is near or encroaching into the MVCD (a grow-in issue) or vegetation that could fall into the transmission conductor (a fall-in issue). A knowledgeable verification of the risk would include an assessment of the possible sag or movement of the conductor while operating between no-load conditions and its rating.

The Transmission Owner has the responsibility to ensure the proper communication between field personnel and the control center to allow the control center to take the appropriate action until the vegetation threat is relieved. Appropriate actions may include a temporary reduction in the line loading, switching the line out of service, or positioning the system in recognition of the increasing risk of outage on that circuit. The notification of the threat should be communicated in terms of minutes or hours as opposed to a longer time frame for corrective action plans (see R5).

All potential grow-in or fall-in vegetation-related conditions will not necessarily cause a Fault at any moment. For example, some Transmission Owners may have a danger tree identification program that identifies trees for removal with the potential to fall near the line. These trees would not require notification to the control center unless they pose an immediate fall-in threat.

Requirement R5:
R5 is a risk-based requirement. It focuses upon preventative actions to be taken by the Transmission Owner for the mitigation of Sustained Outage risk when temporarily constrained from performing vegetation maintenance. The intent of this requirement is to deal with situations that prevent the Transmission Owner from performing planned vegetation management work and, as a result, have the potential to put the transmission line at risk. Constraints to performing vegetation maintenance work as planned could result from legal injunctions filed by property owners, the discovery of easement stipulations which limit the Transmission Owner's rights, or other circumstances.

This requirement is not intended to address situations where the transmission line is not at potential risk and the work event can be rescheduled or re-planned using an alternate work methodology. For example, a land owner may prevent the planned use of chemicals on non-threatening, low growth vegetation but agree to the use of mechanical clearing. In this case the Transmission Owner is not under any immediate time constraint for achieving the management objective, can easily reschedule work using an alternate approach, and therefore does not need to take interim corrective action.

However, in situations where transmission line reliability is potentially at risk due to a constraint, the Transmission Owner is required to take an interim corrective action to mitigate the potential risk to the transmission line. A wide range of actions can be taken to address various situations. General considerations include:

- Identifying locations where the Transmission Owner is constrained from performing planned vegetation maintenance work which potentially leaves the transmission line at risk.
- Developing the specific action to mitigate any potential risk associated with not performing the vegetation maintenance work as planned.
- Documenting and tracking the specific action taken for each location.
- In developing the specific action to mitigate the potential risk to the transmission line the Transmission Owner could consider location specific measures such as modifying the inspection and/or maintenance intervals. Where a legal constraint would not allow any vegetation work, the interim corrective action could include limiting the loading on the transmission line.
- The Transmission Owner should document and track the specific corrective action taken at each location. This location may be indicated as one span, one tree or a combination of spans on one property where the constraint is considered to be temporary.

Requirement R6:
R6 is a risk-based requirement. This requirement sets a minimum time period for completing Vegetation Inspections that fits general industry practice. In addition, the fact that Vegetation Inspections can be performed in conjunction with general line inspections further facilitates a Transmission Owner's ability to meet this requirement. However, the Transmission Owner may determine that more frequent inspections are needed to maintain reliability levels, dependent upon such factors as anticipated growth rates of the local vegetation, length of the growing season for the geographical area, limited ROW width, and rainfall amounts. Therefore it is expected that some transmission lines may be designated with a higher frequency of inspections.

The VSL for Requirement R6 has VSL categories ranked by the percentage of the required ROW inspections completed. To calculate the percentage of inspection completion, the Transmission Owner may choose units such as: line miles or kilometers, circuit miles or kilometers, pole line miles, ROW miles, etc.

For example, when a Transmission Owner operates 2,000 miles of 230 kV transmission lines this Transmission Owner will be responsible for inspecting all 2,000 miles of 230 kV transmission lines at least once during the calendar year. If one of the included lines was 100 miles long, and if it was not inspected during the year, then the amount failed to inspect would be 100/2000 = 0.05 or 5%. The "Low VSL" for R6 would apply in this example.

Requirement R7:
R7 is a risk-based requirement. The Transmission Owner is required to implement an annual work plan for vegetation management to accomplish the purpose of this standard. Modifications to the work plan in response to changing conditions or to findings from vegetation inspections may be made and documented provided they do not put the transmission system at risk. The annual work plan requirement is not intended to necessarily require a "span-by-span", or even a "line-by-line" detailed description of all work to be performed. It is only intended to require that the Transmission Owner provide evidence of annual planning and execution of a vegetation management maintenance approach which successfully prevents encroachment of vegetation into the MVCD.

The ability to modify the work plan allows the Transmission Owner to change priorities or treatment methodologies during the year as conditions or situations dictate. For example recent line inspections may identify unanticipated high priority work, weather conditions (drought) could make herbicide application ineffective during the plan year, or a major storm could require redirecting local resources away from planned maintenance. This situation may also include complying with mutual assistance agreements by moving resources off the Transmission Owner's system to work on another system. Any of these examples could result in acceptable deferrals or additions to the annual work plan. Modifications to the annual work plan must always ensure the reliability of the electric Transmission system.

In general, the vegetation management maintenance approach should use the full extent of the Transmission Owner's easement, fee simple and other legal rights allowed. A comprehensive approach that exercises the full extent of legal rights on the ROW is superior to incremental

management in the long term because it reduces the overall potential for encroachments, and it ensures that future planned work and future planned inspection cycles are sufficient.

When developing the annual work plan the Transmission Owner should allow time for procedural requirements to obtain permits to work on federal, state, provincial, public, tribal lands. In some cases the lead time for obtaining permits may necessitate preparing work plans more than a year prior to work start dates. Transmission Owners may also need to consider those special landowner requirements as documented in easement instruments.

This requirement sets the expectation that the work identified in the annual work plan will be completed as planned. Therefore, deferrals or relevant changes to the annual plan shall be documented. Depending on the planning and documentation format used by the Transmission Owner, evidence of successful annual work plan execution could consist of signed-off work orders, signed contracts, printouts from work management systems, spreadsheets of planned versus completed work, timesheets, work inspection reports, or paid invoices. Other evidence may include photographs, and walk-through reports.

FAC-003 — TABLE 2 — Minimum Vegetation Clearance Distances (MVCD)[5]

For **Alternating Current** Voltages

(AC) Nominal System Voltage (kV)	**(AC) Maximum System Voltage (kV)**	**MVCD feet (meters) sea level**	**MVCD feet (meters) 3,000ft (914.4m)**	**MVCD feet (meters) 4,000ft (1219.2m)**	**MVCD feet (meters) 5,000ft (1524m)**	**MVCD feet (meters) 6,000ft (1828.8m)**	**MVCD feet (meters) 7,000ft (2133.6m)**	**MVCD feet (meters) 8,000ft (2438.4m)**	**MVCD feet (meters) 9,000ft (2743.2m)**	**MVCD feet (meters) 10,000ft (3048m)**	**MVCD feet (meters) 11,000ft (3352.8m)**
765	800	8.06ft (2.46m)	8.89ft (2.71m)	9.17ft (2.80m)	9.45ft (2.88m)	9.73ft (2.97m)	10.01ft (3.05m)	10.29ft (3.14m)	10.57ft (3.22m)	10.85ft (3.31m)	11.13ft (3.39m)
500	550	5.06ft (1.54m)	5.66ft (1.73m)	5.86ft (1.79m)	6.07ft (1.85m)	6.28ft (1.91m)	6.49ft (1.98m)	6.7ft (2.04m)	6.92ft (2.11m)	7.13ft (2.17m)	7.35ft (2.24m)
345	362	3.12ft (0.95m)	3.53ft (1.08m)	3.67ft (1.12m)	3.82ft (1.16m)	3.97ft (1.21m)	4.12ft (1.26m)	4.27ft (1.30m)	4.43ft (1.35m)	4.58ft (1.40m)	4.74ft (1.44m)
230	242	2.97ft (0.91m)	3.36ft (1.02m)	3.49ft (1.06m)	3.63ft (1.11m)	3.78ft (1.15m)	3.92ft (1.19m)	4.07ft (1.24m)	4.22ft (1.29m)	4.37ft (1.33m)	4.53ft (1.38m)
161*	169	2ft (0.61m)	2.28ft (0.69m)	2.38ft (0.73m)	2.48ft (0.76m)	2.58ft (0.79m)	2.69ft (0.82m)	2.8ft (0.85m)	2.91ft (0.89m)	3.03ft (0.92m)	3.14ft (0.96m)
138*	145	1.7ft (0.52m)	1.94ft (0.59m)	2.03ft (0.62m)	2.12ft (0.65m)	2.21ft (0.67m)	2.3ft (0.70m)	2.4ft (0.73m)	2.49ft (0.76m)	2.59ft (0.79m)	2.7ft (0.82m)
115*	121	1.41ft (0.43m)	1.61ft (0.49m)	1.68ft (0.51m)	1.75ft (0.53m)	1.83ft (0.56m)	1.91ft (0.58m)	1.99ft (0.61m)	2.07ft (0.63m)	2.16ft (0.66m)	2.25ft (0.69m)
88*	100	1.15ft (0.35m)	1.32ft (0.40m)	1.38ft (0.42m)	1.44ft (0.44m)	1.5ft (0.46m)	1.57ft (0.48m)	1.64ft (0.50m)	1.71ft (0.52m)	1.78ft (0.54m)	1.86ft (0.57m)
69*	72	0.82ft (0.25m)	0.94ft (0.29m)	0.99ft (0.30m)	1.03ft (0.31m)	1.08ft (0.33m)	1.13ft (0.34m)	1.18ft (0.36m)	1.23ft (0.37m)	1.28ft (0.39m)	1.34ft (0.41m)

* Such lines are applicable to this standard only if PC has determined such per FAC-014 (refer to the Applicability Section above).

[5] The distances in this Table are the minimums required to prevent Flash-over; however prudent vegetation maintenance practices dictate that substantially greater distances will be achieved at time of vegetation maintenance.

Table 2 (cont.) — Minimum Vegetation Clearance Distances (MVCD)
For **Direct Current** Voltages

(DC) Nominal Pole to Ground Voltage (kV)	**MVCD feet (meters) sea level**	**MVCD feet (meters) 3,000ft (914.4m) Alt.**	**MVCD feet (meters) 4,000ft (1219.2m) Alt.**	**MVCD feet (meters) 5,000ft (1524m) Alt.**	**MVCD feet (meters) 6,000ft (1828.8m) Alt.**	**MVCD feet (meters) 7,000ft (2133.6m) Alt.**	**MVCD feet (meters) (8,000ft (2438.4m) Alt.**	**MVCD feet (meters) 9,000ft (2743.2m) Alt.**	**MVCD feet (meters) 10,000ft (3048m) Alt.**	**MVCD feet (meters) 11,000ft (3352.8m) Alt.**
±750	13.92ft (4.24m)	15.07ft (4.59m)	15.45ft (4.71m)	15.82ft (4.82m)	16.2ft (4.94m)	16.55ft (5.04m)	16.9ft (5.15m)	17.27ft (5.26m)	17.62ft (5.37m)	17.97ft (5.48m)
±600	10.07ft (3.07m)	11.04ft (3.36m)	11.35ft (3.46m)	11.66ft (3.55m)	11.98ft (3.65m)	12.3ft (3.75m)	12.62ft (3.85m)	12.92ft (3.94m)	13.24ft (4.04m)	(13.54ft 4.13m)
±500	7.89ft (2.40m)	8.71ft (2.65m)	8.99ft (2.74m)	9.25ft (2.82m)	9.55ft (2.91m)	9.82ft (2.99m)	10.1ft (3.08m)	10.38ft (3.16m)	10.65ft (3.25m)	10.92ft (3.33m)
±400	4.78ft (1.46m)	5.35ft (1.63m)	5.55ft (1.69m)	5.75ft (1.75m)	5.95ft (1.81m)	6.15ft (1.87m)	6.36ft (1.94m)	6.57ft (2.00m)	6.77ft (2.06m)	6.98ft (2.13m)
±250	3.43ft (1.05m)	4.02ft (1.23m)	4.02ft (1.23m)	4.18ft (1.27m)	4.34ft (1.32m)	4.5ft (1.37m)	4.66ft (1.42m)	4.83ft (1.47m)	5ft (1.52m)	5.17ft (1.58m)

Notes:

The SDT determined that the use of IEEE 516-2003 in version 1 of FAC-003 was a misapplication. The SDT consulted specialists who advised that the Gallet Equation would be a technically justified method. The explanation of why the Gallet approach is more appropriate is explained in the paragraphs below.

The drafting team sought a method of establishing minimum clearance distances that uses realistic weather conditions and realistic maximum transient over-voltages factors for in-service transmission lines.

The SDT considered several factors when looking at changes to the minimum vegetation to conductor distances in FAC-003-1:

- avoid the problem associated with referring to tables in another standard (IEEE-516-2003)
- transmission lines operate in non-laboratory environments (wet conditions)
- transient over-voltage factors are lower for in-service transmission lines than for inadvertently re-energized transmission lines with trapped charges.

FAC-003-1 uses the minimum air insulation distance (MAID) without tools formula provided in IEEE 516-2003 to determine the minimum distance between a transmission line conductor and vegetation. The equations and methods provided in IEEE 516 were developed by an IEEE Task Force in 1968 from test data provided by thirteen independent laboratories. The distances provided in IEEE 516 Tables 5 and 7 are based on the withstand voltage of a dry rod-rod air gap, or in other words, dry laboratory conditions. Consequently, the validity of using these distances in an outside environment application has been questioned.

FAC-003-01 allowed Transmission Owners to use either Table 5 or Table 7 to establish the minimum clearance distances. Table 5 could be used if the Transmission Owner knew the maximum transient over-voltage factor for its system. Otherwise, Table 7 would have to be used. Table 7 represented minimum air insulation distances under the worst possible case for transient over-voltage factors. These worst case transient over-voltage factors were as follows: 3.5 for voltages up to 362 kV phase to phase; 3.0 for 500 - 550 kV phase to phase; and 2.5 for 765 to 800 kV phase to phase. These worst case over-voltage factors were also a cause for concern in this particular application of the distances.

In general, the worst case transient over-voltages occur on a transmission line that is inadvertently re-energized immediately after the line is de-energized and a trapped charge is still present. The intent of FAC-003 is to keep a transmission line that is *in service* from becoming de-energized (i.e. tripped out) due to spark-over from the line conductor to nearby vegetation. Thus, the worst case transient overvoltage assumptions are not appropriate for this application. Rather, the appropriate over voltage values are those that occur only while the line is energized.

Typical values of transient over-voltages of in-service lines, as such, are not readily available in the literature because they are negligible compared with the maximums. A conservative value for the maximum transient over-voltage that can occur anywhere along the length of an in-service ac line is approximately 2.0 per unit. This value is a conservative estimate of the transient over-voltage that is created at the point of application (e.g. a substation) by switching a capacitor bank without pre-insertion devices (e.g. closing resistors). At voltage levels where capacitor banks are not very common (e.g. 362 kV), the maximum transient over-voltage of an in-service ac line are created by fault initiation on adjacent ac lines and shunt reactor bank switching. These transient voltages are usually 1.5 per unit or less.

Even though these transient over-voltages will not be experienced at locations remote from the bus at which they are created, in order to be conservative, it is assumed that all nearby ac lines are subjected to this same level of over-voltage. Thus, a maximum transient over-voltage factor of 2.0 per unit for transmission lines operated at 242 kV and below is considered to be a realistic maximum in this application. Likewise, for ac transmission lines operated at 362 kV and above a transient over-voltage factor of 1.4 per unit is considered a realistic maximum.

The Gallet Equations are an accepted method for insulation coordination in tower design. These equations are used for computing the required strike distances for proper transmission line insulation coordination. They were developed for both wet and dry applications and can be used with any value of transient over-voltage factor. The Gallet Equation also can take into account various air gap geometries. This approach was used to design the first 500 kV and 765 kV lines in North America [1].

If one compares the MAID using the IEEE 516-2003 Table 7 (table D.5 for English values) with the critical spark-over distances computed using the Gallet wet equations, for each of the nominal voltage classes and identical transient over-voltage factors, the Gallet equations yield a more conservative (larger) minimum distance value.

Distances calculated from either the IEEE 516 (dry) formulas or the Gallet "wet" formulas are not vastly different when the same transient overvoltage factors are used; the "wet" equations will consistently produce slightly larger distances than the IEEE 516 equations when the same transient overvoltage is used. While the IEEE 516 equations were only developed for dry conditions the Gallet equations have provisions to calculate spark-over distances for both wet and dry conditions.

While EPRI is currently trying to establish empirical data for spark-over distances to live vegetation, there are no spark-over formulas currently derived expressly for vegetation to conductor minimum distances. Therefore the SDT chose a proven method that has been used in other EHV applications. The Gallet equations relevance to wet conditions and the selection of a Transient Overvoltage Factor that is consistent with the absence of trapped charges on an in-service transmission line make this methodology a better choice.

The following table is an example of the comparison of distances derived from IEEE 516 and the Gallet equations using various transient overvoltage values.

Comparison of spark-over distances computed using Gallet wet equations
vs.
IEEE 516-2003 MAID distances
using various transient over-voltage factors

(AC) Nom System Voltage (kV)	(AC) Max System Voltage (kV)	Transient Over-voltage Factor (T)	Clearance (ft.) Gallet (wet) @ Alt. 3000 feet	Table 5 IEEE 516 MAID (ft) @ Alt. 3000 feet
765	800	1.4	8.89	8.65
500	550	1.4	5.65	4.92
345	362	1.4	3.52	3.13
230	242	2.0	3.35	2.8
115	121	2.0	1.6	1.4

(AC) Nom System Voltage (kV)	(AC) Max System Voltage (kV)	Transient Over-voltage Factor (T)	Clearance (ft.) Gallet (wet) @ Alt. 3000 feet	Table 5 (historical maximums) IEEE 516 MAID (ft) @ Alt. 3000 feet
765	800	2.0	14.36	13.95
500	550	2.4	11.0	10.07
345	362	3.0	8.55	7.47
230	242	3.0	5.28	4.2
115	121	3.0	2.46	2.1

Table 7

(AC) Nom System Voltage (kV)	(AC) Max System Voltage (kV)	Transient Over-voltage Factor (T)	Clearance (ft.) Gallet (wet) @ Alt. 3000 feet	IEEE 516 MAID (ft) @ Alt. 3000 feet
765	800	2.5	20.25	20.4
500	550	3.0	15.02	14.7
345	362	3.5	10.42	9.44
230	242	3.5	6.32	5.14
115	121	3.5	2.90	2.45