Project 2013-03 (GMD Mitigation)

TPL-007-1 Common Questions and Responses

June 12, 2014

Provided below is information regarding: (i) general questions about the proposed standard and the NERC standard development process; (ii) the benchmark GMD event; (iii) the technical details of the standard requirements, including models, studies, assessments and analysis; and (iv) the applicability of the proposed standard.

This document is based on the currently posted draft of the proposed standard and is subject to change.

General

These are general questions about the standard and the NERC standard development process.

When TPL-007-1 is approved, will EOP-010-1 be retired?

No, EOP-010-1 and TPL-007-1 complement one another and together fulfill the Commission's directives in Order No. 779. EOP-010-1 – Geomagnetic Disturbance Operations provides a reliability benefit by requiring all Reliability Coordinators and applicable Transmission Operators to have Operating Plans, Processes, or Procedures to mitigate the effects of geomagnetic disturbance (GMD) events. TPL-007-1 applies to Planning Coordinators, Transmission Planners, and some transformer owners and establishes requirements for Transmission system planned performance during GMD events. If mitigation plans are required to meet performance requirements, they may include operational measures that become part of an entity's GMD Operating Plans, Processes, or Procedures.

How soon will utilities be required to implement the requirements in TPL-007-1?

The proposed implementation plan for TPL-007-1 is phased over a four-year period. In general, the following effective dates beginning the first calendar quarter after regulatory approval are proposed:

- 60 days: Planning Coordinator determines responsibilities for GMD Vulnerability Assessments in its planning area (Requirement R1)
- 14 months: Develop System models (Requirement R2)
- 18 months: Planning entities calculate geomagnetically-induced current (GIC) flows and provide to applicable Transmission Owners and Generator Owners (Requirement R5)
- 36 months: Owners complete transformer thermal impact assessments (Requirement R6)
- 48 months: GMD Vulnerability Assessments and Corrective Action Plans (Requirements R3, R4, and R7)

What periodicity is required for GMD Vulnerability Assessments? Is it related to the solar cycle?

In the proposed standard, GMD Vulnerability Assessments must be conducted once every 60 months. The periodicity is not tied to the 11-year sunspot solar cycle because the solar cycle is an indicator of the frequency of solar storms but not necessarily of their intensity.

Organization of TPL-007-1

Commenters suggested reorganizing the requirements to better reflect the order of required studies and analysis in the GMD assessment process. The SDT has made changes in the revised standard.

How has the drafting team taken into account potential costs associated with the reliability standard?

The proposed standard addresses the directives for a stage 2 GMD standard in FERC Order No. 779. In the order, FERC stated their expectation that "NERC and industry will consider the costs and benefits of particular mitigation measures as NERC develops the technically-justified Second Stage GMD Reliability Standards (P.28)"

NERC Reliability Standards are technology-neutral and focus on the reliability objectives to be accomplished rather than the specific activities to be performed. The drafting team has approached cost considerations in a manner that is consistent with other reliability standards by providing latitude to responsible entities. Like other planning standards, TPL-007-1 does not prescribe specific mitigation measures or strategies. When mitigation is necessary to meet the performance requirements specified in the standard, responsible entities can evaluate options using criteria which can include cost considerations.

Benchmark GMD Event

Questions about the benchmark, application, and models.

Previous analysis of IMAGE magnetometer data by Antti Pulkkinen and others indicated that a 1-in-100 year storm could be expected to produce geoelectric fields of 20 V/km at the reference location. What is the justification for using a peak geoelectric field value of 8 V/km for the benchmark GMD event?

The same data set used to arrive at 20 V/km was used in the analysis presented in the white paper. The difference is that instead of characterizing an event by the magnitude of the peak in any single geomagnetic observatory, this analysis examines averaged geoelectric field values which occur simultaneously over a large geographic area. In other words, the prior research examined recorded peaks which include localized intensifications which are not suitable for evaluating wide area GMD impacts that could lead to uncontrolled cascading blackouts. The 1-in-100 year storm reference peak geoelectric field was 20 V/km in the 2012 GMD Report. With spatial averaging, the same data produces a conservative 1-in-100 year peak geoelectric field of 8 V/km for the reference geomagnetic latitude and earth model. This reference geoelectric field includes engineering margin above the 5.77 V/km value that is the calculated using extreme value analysis.

Did the drafting team consider the Carrington event or the 2012 coronal mass ejection (CME) as a basis for the Benchmark GMD Event? Yes, but the drafting team did not base the benchmark GMD event on these specific events. Data is not available that would allow direct determination of the geoelectric fields experienced during the Carrington event and estimates of the storm intensity vary. Furthermore, research suggests the occurrence rate for a Carrington event to be in a wide range of 1 in 70-600 years. The SDT applied extreme value analysis to the data set of spatially averaged IMAGE magnetometer observations to determine that a peak geoelectric field of 5.8 V/km at the reference location is a conservative estimate based on the available data. A conservative margin was added to be consistent with the visual extrapolation of the statistical data to arrive at 8 V/km. This frequency of occurrence is consistent with utility practices where a design basis frequency of 1 in 50 years is common as the storm return period for determining wind and ice loading of transmission infrastructure.

A powerful but non-Earth directed CME in 2012 was measured by space-based instruments and has been suggested by some space weather researchers as a criterion for GMD analysis of the power system. However, because the event did not impact the Earth, research models had to be utilized to assess what could have happened if the event hit the Earth's space environment. Due to the complex nature of the space weather phenomena and fairly immature state of space science models, such model-based assessments contain inherent uncertainties that are not well known or understood at present time. Consequently, the drafting team did not base the benchmark GMD event on this CME event.

An earth model for southern and central Florida is not available through the U.S. Geological Survey website. What model or scaling factor for earth conductivity should be used?
TPL-007-1 and the Benchmark GMD Event Description white paper include calculated scaling factors to account for all of the earth conductivity models available on the USGS and Natural Resources Canada (NRCan) websites. These cover the majority of the North America. A planner may always use a technically-sound earth model for the planning area, even when a USGS model is available. With an earth model, the plane wave method can be used to calculate the peak geoelectric field from the reference geomagnetic time series or waveshape. This is described in the Application Guide for Computing GIC in the Bulk-Power System:
(http://www.nerc.com/comm/PC/Geomagnetic%20Disturbance%20Task%20Force%20GMDTF%202013/GIC%20Application%20Guide%202013_approved.pdf)

Additionally, Attachment 1 now states that when a ground conductivity model is not available, either from USGS or some other technically-supportable source, the planning entity should use the resistive reference ground model (Beta = 1).

Is the 10-s magnetometer data for the waveform available?
The file is posted on the GMD Task Force web page: http://www.nerc.com/comm/PC/Pages/Geomagnetic-Disturbance-Task-Force-(GMDTF)-2013.aspx

Models, Studies, Assessments, and Analysis

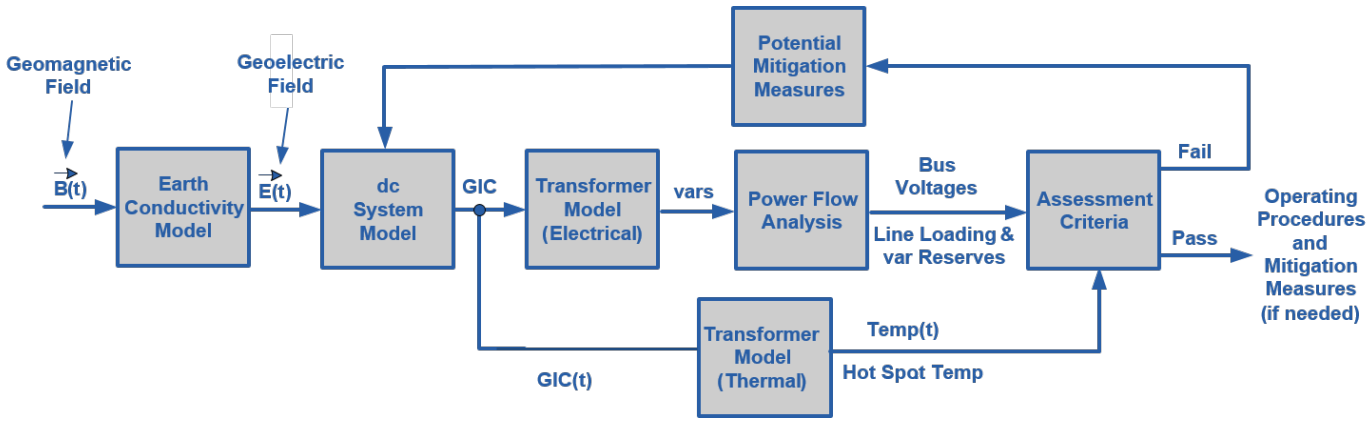
Questions about the technical details of the TPL-007-1 requirements.

What analysis is required by TPL-007-1?

In the proposed standard, planning entities must conduct power flow analysis that accounts for var absorption in power transformers as a result of GIC from the benchmark GMD event. In the System being analyzed, Reactive Power compensation devices and other Transmission Facilities should be removed if the planner determines that Protection Systems may trip the devices or Facilities due to the effects of harmonics. The planner may make this determination based on harmonics analysis or may use a screening approach that accounts for the type of the Protections System in use. The standard does not require entities to perform stability analysis.

The proposed standard also requires applicable owners to conduct a transformer thermal impact assessment. Examples of technically-justified approaches are described in the Transformer Thermal Impact Assessment white paper.

An overall diagram of the GMD Vulnerability Assessment process is provided in the diagram below:



The GMD Planning Guide developed by the NERC GMD Task Force provides technical information on GMD-specific considerations for planning studies. It is available at: http://www.nerc.com/comm/PC/Geomagnetic%20Disturbance%20Task%20Force%20GMDTF%202013/GMD%20Planning%20Guide_approved.pdf

Guidance for developing the GIC System model is provided in the NERC GMD Task Force guide: Application Guide for Computing Geomagnetically-Induced Current in the Bulk-Power System. The guide is available at:

http://www.nerc.com/comm/PC/Geomagnetic%20Disturbance%20Task%20Force%20GMDTF%202013/GIC%20Application%20Guide%202013_approved.pdf

Is N-1 contingency analysis required?
The proposed standard does not require traditional contingency analysis described in TPL-001. In performing the analysis in TPL-007 Table 1 the planner removes all equipment that is deemed to be susceptible to tripping due to harmonics. This study addresses the directives in the FERC order and examines a potential effect of severe GMD events such as the tripping of SVCs in the 1989 Hydro-Quebec event that resulted in blackout.

When considering loss of Reactive Power compensation devices and other Transmission Facilities in the steady state analysis required by Table 1, is the planner expected to consider the loss individually (one-at-a-time) or simultaneously (all-at-once)?
Facilities that may be susceptible to tripping should be removed from the System being analyzed to simulate simultaneous common-mode failure, as occurred to SVCs during the 1989 Hydro Quebec event. The planner may make this determination based on a harmonics analysis or may use a screening approach that accounts for the type of Protection System in use. Conservative engineering judgment should be applied and supported in the analysis.

Do applicable entities in lower latitudes have to do the same studies as those in higher latitudes?
Yes, TPL-007 is a continent-wide standard and requires that system studies be conducted by all applicable planning entities. However, transformer thermal impact assessment is only required when the maximum effective GIC at the power transformer is 15 Amperes per phase or greater.

Where does the geomagnetically-induced current (GIC) time-series information necessary for the Transmission Owner's thermal assessment come from?
The transformer thermal impact assessment specified in TPL-007 is based on GIC time series information for the benchmark GMD Event. This GIC information is determined by the planning entity through simulation of the GIC system model and must be provided to the owning entity responsible for conducting the thermal impact assessment.

The maximum effective GIC value (provided in R5 part 5.1) is used to screen the transformer fleet such that only those transformers that experience an effective GIC flow of 15A or greater are evaluated. The effective GIC time series, GIC(t), (provided in R5 part 5.2) is used to conduct the transformer thermal impact assessment (see white paper for details).

In addition to transformers, other elements of the Bulk-Power System may be susceptible to the effects of GIC. Does the standard address any other equipment impacts?
In the System being analyzed, Reactive Power compensation devices and other Transmission Facilities that the planner determines have Protection Systems that may trip due to the effects of harmonics should be removed. The planner may make this determination based on a harmonics analysis or may use a screening approach that accounts for the type of hardware in use by the Protection System. Guidance for making these determinations is contained in the GMD Planning Guide:
http://www.nerc.com/comm/PC/Geomagnetic%20Disturbance%20Task%20Force%20GMDTF%202013/GMD%20Planning%20Guide_approved.pdf

Why are generator impacts not specifically addressed in TPL-007? While technical literature has been written on potential generator impacts due to GIC, planning tools are not available to conduct the necessary detailed harmonic analysis. The standard reflects the currently available tools and techniques. The standard does not preclude an entity from conducting additional studies.

How should a planning entity account for adjacent systems in the GMD Vulnerability Assessment steady state analysis?
Reactive Power losses in neighboring systems will affect the analysis of the system in the planning area. An acceptable approach for considering these losses is to model two or more key buses into the neighboring network. For systems that are considerably smaller than those adjacent to them, additional buses may need to be included in the model. This is described in the GMD Planning Guide, available here: http://www.nerc.com/comm/PC/Geomagnetic%20Disturbance%20Task%20Force%20GMDTF%202013/GMD%20Planning%20Guide_approved.pdf

How does TPL-007-1 address concerns that mitigation actions in one system may adversely affect reliability in a neighboring system? The proposed standard requires planning entities to provide their Corrective Action Plans to their Reliability Coordinator, adjacent Planning Coordinators, and adjacent Transmission Planners. An entity with reliability concerns resulting from the Corrective Action Plan is expected to resolve their concerns, which could include submitting written comments to the originator of the Corrective Action Plan. TPL-007-1 requires planning entities to respond to documented comments on their Corrective Action Plan within 90 calendar days of receipt.

Where do I get transformer thermal models? Models may be available from the manufacturer or in published technical literature. The GMD Task Force is in the process of publishing conservative default models on the basis of testing and published information. Implementation plan provides time to obtain the necessary models.

Applicability

These questions concern what entities and equipment are applicable in the proposed standard.

Are any geographic areas or regions exempt from the standard?
No geographic areas or regions are exempt from the proposed standard. TPL-007-1 is a continent-wide standard to meet the FERC directives for assessments of the potential impact of a benchmark GMD event on the Bulk-Power System equipment and Bulk-Power System as a whole (P.56-62). However, the standard does not ignore the geographic variability of GMD events. The benchmark GMD event is tailored to the specific location of the system being analyzed through scaling factors that account for geomagnetic latitude and earth conductivity models.

What functional entities are applicable to the proposed standard?
The proposed standard will establish planned performance requirements during a benchmark GMD event and is applicable to Planning Coordinators, Transmission Planners, Transmission Owners, and Generation

Owners with transformers or areas with transformers that have a high-side, wye-grounded winding connected at 200 kV or higher. The drafting team used the NERC Functional Model as a guide in determining applicability. The selected entities have functions that enable them to meet the FERC directives to evaluate the effects of GICs on Bulk-Power System transformers and other equipment (P.67), consider wide-area effects and coordinate across regions (P.67), and develop plans to address potential impacts (P. 79). Justification for the 200 kV voltage threshold may be found in the whitepaper that was developed by the drafting team for the stage 1 standard, EOP-010-1 – Geomagnetic Disturbance Operations. In requirement R1, the Planning Coordinator determines the responsibilities for planning entities in the planning area. Based on this determination, subsequent requirements for maintaining models, conducting studies and assessments, and distributing information must be completed by the appropriate responsible entity.

Are instrument transformers or station services transformers considered applicable within the TPL-007-1 standard? Instrumentation transformers and station service transformers do not have significant impact on GIC flows; therefore, they are not included in the applicability for this standard. These types of transformers have much higher resistances compared to power transformers and would not result in significant effect on station GIC flows.

Is the standard limited to Bulk Electric System equipment? No; the requirements in TPL-007-1 apply to any Planning Coordinator, Transmission Planner, Generator Owner, or Transmission Owner with Facilities listed in section 4.2 of the standard. Any power transformer with high side, wye-grounded winding with terminal voltage greater than 200 kV may have potential impacts that must be included in a GMD planning study.

Can the standard provide an entity applicability / screening criteria on basis of geoelectric field? No, but the SDT has developed a technically-supported screening criteria for thermal assessment on the basis of GIC.

What is the role of the Reliability Coordinator (RC) in TPL-007-1? The RC is not an applicable entity in the planning standard, but they will receive information as a result of planning studies conducted in TPL-007 in accordance with R7.