« *Technical Rationale and Justification for Reliability Standard* » (Justification technique) (version anglaise)

NERC

NORTH AMERICAN ELECTRIC
RELIABILITY CORPORATION

Transmission System Planned Performance for Geomagnetic Disturbance Events

Technical Rationale and Justification for Reliability Standard TPL-007-4

November 2019

RELIABILITY | RESILIENCE | SECURITY




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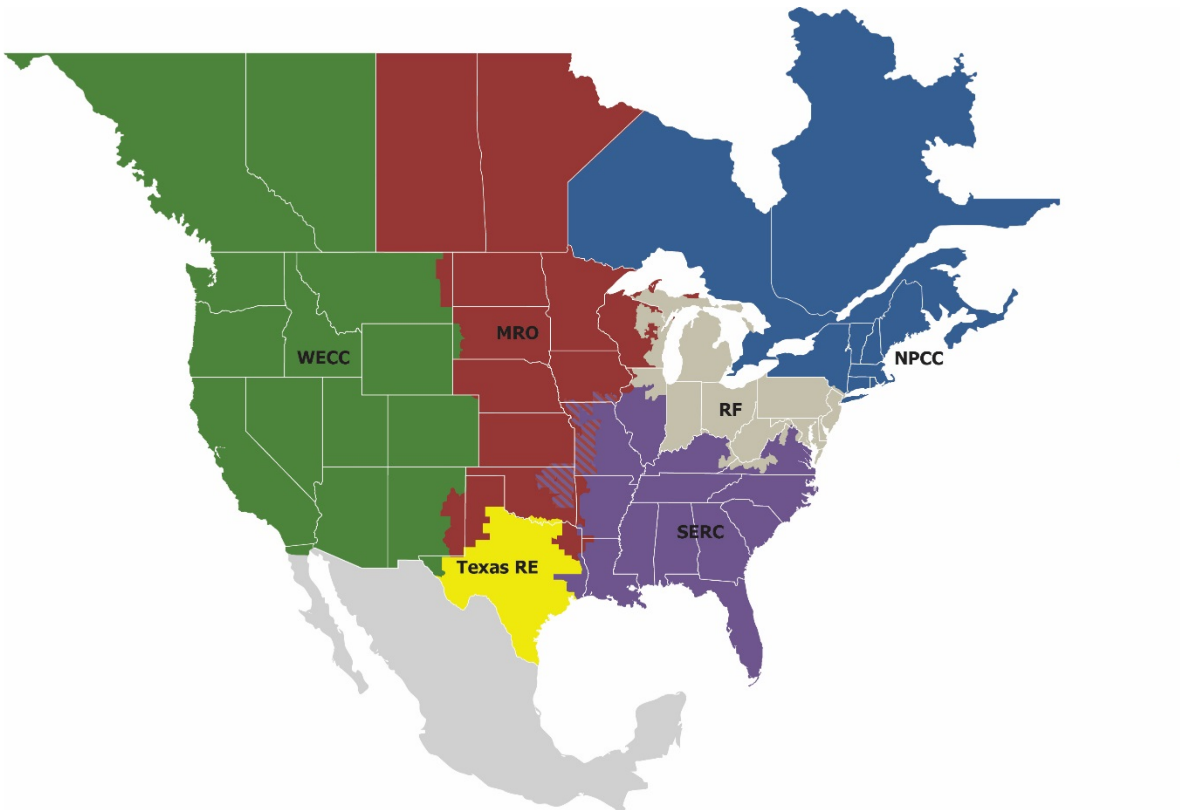
Preface

Electricity is a key component of the fabric of modern society and the Electric Reliability Organization (ERO) Enterprise serves to strengthen that fabric. The vision for the ERO Enterprise, which is comprised of the North American Electric Reliability Corporation (NERC) and the six Regional Entities (REs), is a highly reliable and secure North American bulk power system (BPS). Our mission is to assure the effective and efficient reduction of risks to the reliability and security of the grid.

Reliability | Resilience | Security

Because nearly 400 million citizens in North America are counting on us

The North American BPS is divided into six RE boundaries as shown in the map and corresponding table below. The multicolored area denotes overlap as some load-serving entities participate in one Region while associated Transmission Owners/Operators participate in another.



MRO	Midwest Reliability Organization
NPCC	Northeast Power Coordinating Council
RF	ReliabilityFirst
SERC	SERC Reliability Corporation
Texas RE	Texas Reliability Entity
WECC	Western Electricity Coordinating Council

Introduction

Background

This document explains the technical rationale and justification for the proposed Reliability Standard TPL-007-4 – Transmission System Planned Performance for Geomagnetic Disturbance Events. It provides stakeholders and the ERO Enterprise with an understanding of the technical requirements in the Reliability Standard. It also contains information on the standard drafting team's intent in drafting the requirements. This document, the Technical Rationale and Justification for TPL-007-4, is not a Reliability Standard and should not be considered mandatory and enforceable.

The first version of the standard, TPL-007-1, approved by FERC in Order No. 779 [1], requires entities to assess the impact to their systems from a defined event referred to as the "Benchmark GMD Event." The second version of the standard, TPL-007-2, adds new Requirements R8, R9, and R10 to require responsible entities to assess the potential implications of a "Supplemental GMD Event" on their equipment and systems in accordance with FERC's directives in Order No. 830 [2]. Some GMD events have shown localized enhancements of the geomagnetic field. The supplemental GMD event was developed to represent conditions associated with such localized enhancement during a severe GMD event for use in a GMD Vulnerability Assessment. The third version of the standard, TPL-007-3, adds a Canadian variance for Canadian Registered Entities to leverage operating experience, observed GMD effects, and on-going research efforts for defining alternative Benchmark GMD Events and/or Supplemental GMD Events that appropriately reflect Canadian-specific geographical and geological characteristics. No continent-wide requirements were changed between the second and the third versions of the standard. The fourth version of the standard, TPL-007-4, addresses the directives issued by FERC in Order No. 851 [3] to modify Reliability Standard TPL-007-3. FERC directed NERC to submit modifications to: (1) require the development and implementation of corrective action plans to mitigate assessed supplemental GMD event vulnerabilities (P 29); and (2) to replace the corrective action plan time-extension provision in TPL-007-3 with a process through which extensions of time are considered on a case-by-case basis (P 54).

The requirements in this standard cover various aspects of the GMD Vulnerability Assessment process. Figure 1 provides an overall view of the GMD Vulnerability Assessment process:

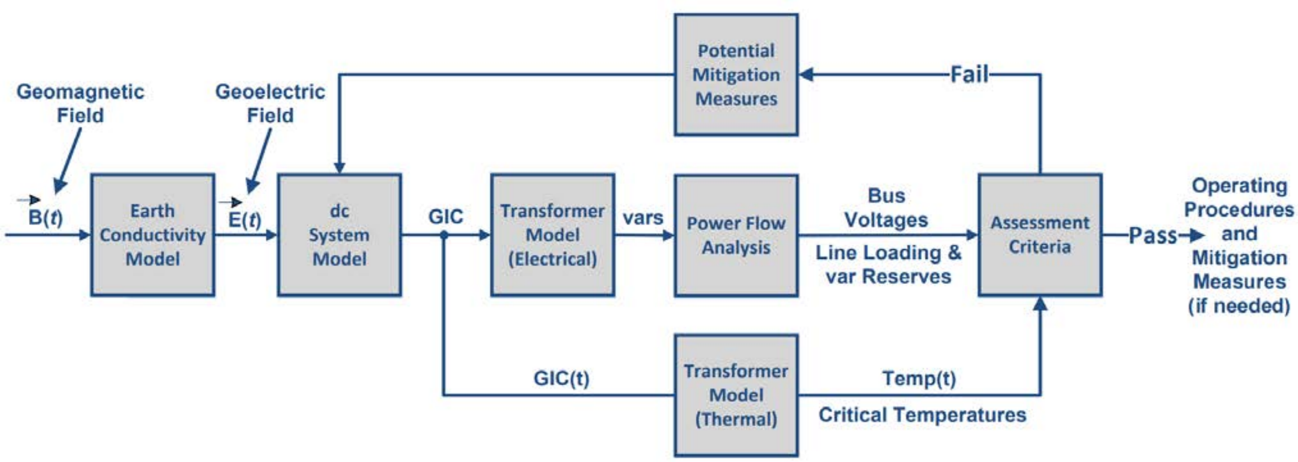


Figure 1. GMD Vulnerability Assessment Process.

General Considerations

Rationale for Applicability

Reliability Standard TPL-007-4 is applicable to Facilities that include power transformer(s) with a high side, wye-grounded winding with terminal voltage greater than 200 kV.

Instrumentation transformers and station service transformers do not have significant impact on geomagnetically-induced current (GIC) flows; therefore, these types of transformers are not included in the applicability for this standard. Terminal voltage describes line-to-line voltage.

Benchmark GMD Event (TPL-007-4 Attachment 1)

The benchmark GMD event defines the geoelectric field values used to compute GIC flows that are needed to conduct a benchmark GMD Vulnerability Assessment. The *Benchmark Geomagnetic Disturbance Event Description*, May 2016 [4], includes the event description, analysis, and example calculations.

Supplemental GMD Event (TPL-007-4 Attachment 1)

The supplemental GMD event defines the geoelectric field values used to compute GIC flows that are needed to conduct a supplemental GMD Vulnerability Assessment. The *Supplemental Geomagnetic Disturbance Event Description*, October 2017 [5], includes the event description and analysis.

Requirement R2

A GMD Vulnerability Assessment requires a GIC System model, which is a dc representation of the System, to calculate GIC flow. In a GMD Vulnerability Assessment, GIC simulations are used to determine transformer Reactive Power absorption and transformer thermal response. Guidance for developing the GIC System model are provided in the *Application Guide – Computing Geomagnetically-Induced Current in the Bulk-Power System*, December 2013 [6].

System models specified in Requirement R2 are used in conducting steady state power flow analysis, that accounts for the Reactive Power absorption of power transformer(s) due to GIC flow in the System, when performing GMD Vulnerability Assessments. Additional System modeling considerations could include facilities less than 200 kV.

The GIC System model includes all power transformer(s) with a high side, wye-grounded winding with terminal voltage greater than 200 kV. The model is used to calculate GIC flow in the network.

Requirement R4

The *Geomagnetic Disturbance Planning Guide*, December 2013 [7], provides technical information on GMD-specific considerations for planning studies.

The GMD Vulnerability Assessment includes steady state power flow analysis and the supporting study or studies using the models specified in Requirement R2 that account for the effects of GIC. Performance criteria are specified in Table 1: Steady State Planning GMD Event found in TPL-007-4. At least one System On-Peak Load and at least one System Off-Peak Load shall be included in the in the study or studies (see Requirement R4).

Requirement R5

The benchmark thermal impact assessment of transformers, specified in Requirement R6, is based on GIC information for the benchmark GMD Event. This GIC information is determined by the responsible entity through simulation of the GIC System model and shall be provided to the entity responsible for conducting the thermal impact assessment (see Requirement R5). GIC information for the benchmark thermal impact assessment should be provided in accordance with Requirement R5 each time the benchmark GMD Vulnerability Assessment is performed since, by definition, the GMD Vulnerability Assessment includes a documented evaluation of susceptibility to localized equipment damage due to GMD.

The peak GIC value of 75 A per phase, in the benchmark GMD Vulnerability Assessment, has been shown through thermal modeling to be a conservative threshold below which the risk of exceeding known temperature limits established by technical organizations is low.

This GIC information is necessary for determining the benchmark thermal impact of GIC on transformers in the planning area and shall be provided to entities responsible for performing the thermal impact assessment so that they can accurately perform the assessment (see Requirement R5). GIC information should be provided in accordance with Requirement R5 as part of the benchmark GMD Vulnerability Assessment process since, by definition, the GMD Vulnerability Assessment includes documented evaluation of susceptibility to localized equipment damage due to GMD.

GIC(t) provided in Part 5.2 can be used to convert the steady state GIC flows to time-series GIC data for the benchmark transformer thermal impact assessment. This information may be needed by one or more of the methods for performing a thermal impact assessment. Additional guidance is available in the *Transformer Thermal Impact Assessment White Paper*, October 2017 [8].

Requirement R6

The transformer thermal assessment will be repeated or reviewed using previous assessment results each time the responsible entity performs a GMD Vulnerability Assessment and provides GIC information as specified in Requirement R5.

Thermal assessments for transformers with a high side, grounded-wye winding greater than 200 kV are required because the damage of these types of transformers may have an effect on the wide-area reliability of the interconnected Transmission System.

Requirement R7

This requirement addresses directives in FERC Order No. 851 to replace the time-extension provision in Requirement R7.4 of TPL-007-2 (and TPL-007-3) with a process through which extensions of time are considered on a case-by-case basis.

Technical considerations for GMD mitigation planning, including operating and equipment strategies, are available in Chapter 5 of the *Geomagnetic Disturbance Planning Guide*, December 2013 [7]. Additional information is available in the *2012 Special Reliability Assessment Interim Report: Effects of Geomagnetic Disturbances on the Bulk Power System*, February 2012 [9].

Supplemental GMD Vulnerability Assessment

The requirements, R8-R11, address directives in FERC Order No. 830 for revising the benchmark GMD event used in GMD Vulnerability Assessments (PP 44, 47-49). The requirements add a supplemental GMD Vulnerability Assessment based on the supplemental GMD event that accounts for localized peak geoelectric fields.

Requirement R8

The *Geomagnetic Disturbance Planning Guide*, December 2013 [7], provides technical information on GMD-specific considerations for planning studies.

The GMD Vulnerability Assessment includes steady state power flow analysis and the supporting study or studies using the models specified in Requirement R2 that account for the effects of GIC. Performance criteria are specified in Table 1: Steady State Planning GMD Event found in TPL-007-4. At least one System On-Peak Load and at least one System Off-Peak Load shall be included in the study or studies (see Requirement R8).

Requirement R9

The supplemental thermal impact assessment of transformers, specified in Requirement R10, is based on GIC information for the supplemental GMD Event. This GIC information is determined by the responsible entity through simulation of the GIC System model and shall be provided to the entity responsible for conducting the thermal impact assessment (see Requirement R9). GIC information for the supplemental thermal impact assessment should be provided in accordance with Requirement R9 each time the supplemental GMD Vulnerability Assessment is performed since, by definition, the GMD Vulnerability Assessment includes a documented evaluation of susceptibility to localized equipment damage due to GMD.

The peak GIC value of 85 A per phase, in the supplemental GMD Vulnerability Assessment, has been shown through thermal modeling to be a conservative threshold below which the risk of exceeding known temperature limits established by technical organizations is low.

This GIC information is necessary for determining the supplemental thermal impact of GIC on transformers in the planning area and shall be provided to entities responsible for performing the thermal impact assessment so that they can accurately perform the assessment (see Requirement R9). GIC information should be provided in accordance with Requirement R9 as part of the supplemental GMD Vulnerability Assessment process since, by definition, the GMD Vulnerability Assessment includes documented evaluation of susceptibility to localized equipment damage due to GMD.

GIC(t) provided in Part 9.2 can be used to convert the steady state GIC flows to time-series GIC data for the supplemental transformer thermal impact assessment. This information may be needed by one or more of the methods for performing a thermal impact assessment. Additional guidance is available in the *Transformer Thermal Impact Assessment White Paper*, October 2017 [8].

Requirement R10

The supplemental thermal impact assessment of a power transformer may be based on manufacturer-provided GIC capability curves, thermal response simulation, thermal impact screening, or other technically justified means. Justification for this criterion is provided in the *Screening Criterion for Transformer Thermal Impact Assessment White Paper*, October 2017 [10].

The transformer thermal assessment will be repeated or reviewed using previous assessment results each time the responsible entity performs a GMD Vulnerability Assessment and provides GIC information as specified in Requirement R9.

Thermal assessments for transformers with a high side, grounded-wye winding greater than 200 kV are required because the damage of these types of transformers may have an effect on the wide-area reliability of the interconnected Transmission System.

Requirement R11

The requirement addresses directives in FERC Order No. 851 to develop and submit modifications to Reliability Standard TPL-007-2 (and TPL-007-3) to require corrective action plans for the assessed supplemental GMD event vulnerabilities.

Technical considerations for GMD mitigation planning, including operating and equipment strategies, are available in Chapter 5 of the Geomagnetic Disturbance Planning Guide, December 2013 [7]. Additional information is available in the *2012 Special Reliability Assessment Interim Report: Effects of Geomagnetic Disturbances on the Bulk Power System*, February 2012 [9].

Requirement R12

GMD measurement data refers to GIC monitor data and geomagnetic field data in Requirements R12 and R13, respectively. This requirement addresses directives in FERC Order No. 830 for requiring responsible entities to collect GIC monitoring data as necessary to enable model validation and situational awareness (PP 88, 90-92).

Technical considerations for GIC monitoring are contained in Chapter 9 of the *2012 Special Reliability Assessment Interim Report: Effects of Geomagnetic Disturbances on the Bulk Power System*, February 2012 [9]. GIC monitoring is generally performed by Hall effect transducers that are attached to the neutral of the wye-grounded transformer and measure dc current flowing through the neutral. Data from GIC monitors is useful for model validation and situational awareness.

The objective of Requirement R12 is for entities to obtain GIC data for the Planning Coordinator's planning area or other part of the system included in the Planning Coordinator's GIC System model to inform GMD Vulnerability Assessments. Technical considerations for GIC monitoring are contained in Chapter 9 of the *2012 Special Reliability Assessment Interim Report: Effects of Geomagnetic Disturbances on the Bulk Power System*, February 2012 [9].

Requirement R13

GMD measurement data refers to GIC monitor data and geomagnetic field data in Requirements R12 and R13, respectively. This requirement addresses directives in FERC Order No. 830 for requiring responsible entities to collect magnetometer data as necessary to enable model validation and situational awareness (PP 88, 90-92).

The objective of Requirement R13 is for entities to obtain geomagnetic field data for the Planning Coordinator's planning area to inform GMD Vulnerability Assessments.

Magnetometers provide geomagnetic field data by measuring changes in the earth's magnetic field. Sources of geomagnetic field data include:

- Observatories such as those operated by U.S. Geological Survey, Natural Resources Canada, research organizations, or university research facilities;
- Installed magnetometers; and
- Commercial or third-party sources of geomagnetic field data.

Geomagnetic field data for a Planning Coordinator's planning area is obtained from one or more of the above data sources located in the Planning Coordinator's planning area, or by obtaining a geomagnetic field data product for the Planning Coordinator's planning area from a government or research organization. The geomagnetic field data product does not need to be derived from a magnetometer or observatory within the Planning Coordinator's planning area.

References

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