NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

TPL-007-1

Project 2013-03 Geomagnetic Disturbance (GMD) Mitigation

Standard Drafting Team
Industry Webinar
November 5, 2014

RELIABILITY | ACCOUNTABILITY




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Agenda

- Project status
- Summary of revised TPL-007
- Overview of transformer thermal assessment changes
- Implementation Plan
- Other changes in third posting
- Next steps
- Question and answer

Presentation posted on the project page:
http://www.nerc.com/pa/Stand/Pages/Geomagnetic-Disturbance-Resource.aspx

GMD Standards Project Status

- TPL-007-1 is in development to address FERC directives requiring assessment of GMD impact on the Bulk-Power System
- Posted for comment and additional ballot October 28 – November 21, 2014
- Proposed standard must be filed with FERC by January 21, 2015

Comment and Ballot Periods		
Date	Quorum	Approval Vote
June 13 – July 30	82.67%	55.77%
August 27 - October 10	82.93%	57.95%

TPL-007 Summary

- Requires a Geomagnetic Disturbance (GMD) Vulnerability Assessment of the system to determine its ability to withstand a Benchmark GMD Event without causing voltage collapse
  - Assessment performed once every five years
  - Applicability: Planning Coordinators, Transmission Planners
- Requires a transformer thermal impact assessment to ensure high-side, wye grounded Bulk Electric System (BES) transformers connected at 200kV or higher will not overheat based on the benchmark event
  - Applies to transformers where effective GIC ≥ **75 A** per phase in GIC studies (not 75 A continuous)
  - Performed once every five years with GMD Vulnerability Assessment
  - Applicability: Generator Owners, Transmission Owners

Benchmark GMD Event Description

- The Benchmark GMD Event is described by:
  - Reference geoelectric field amplitude **(8V/km)**
    - 1-in-100 year amplitude determined statistically from geomagnetic field measurements for a reference earth model
    - Used for **GIC studies** and **load-flow simulations** that account for transformer Reactive Power absorption caused by half-cycle saturation
  - Reference geomagnetic field waveshape
    - March 13-14, 1989 GMD event selected from recorded GMD events
    - Used for **time-domain analysis** on equipment such as **transformer thermal impact assessment** and/or to determine local geoelectric field if alternative or multiple earth models are used in GIC studies
- Scaling factors for geomagnetic latitude and earth conductivity can be used to adjust geoelectric field amplitude

GMD Benchmark Geoelectric Field

$$E_{peak} = E_{benchmark} \times \alpha \times \beta \text{ (in V/km)}$$

where,

E_{peak} = Benchmark geoelectric field magnitude at System location

$E_{benchmark}$ = Benchmark geoelectric field magnitude at reference location (60° N geomagnetic latitude, resistive ground model)

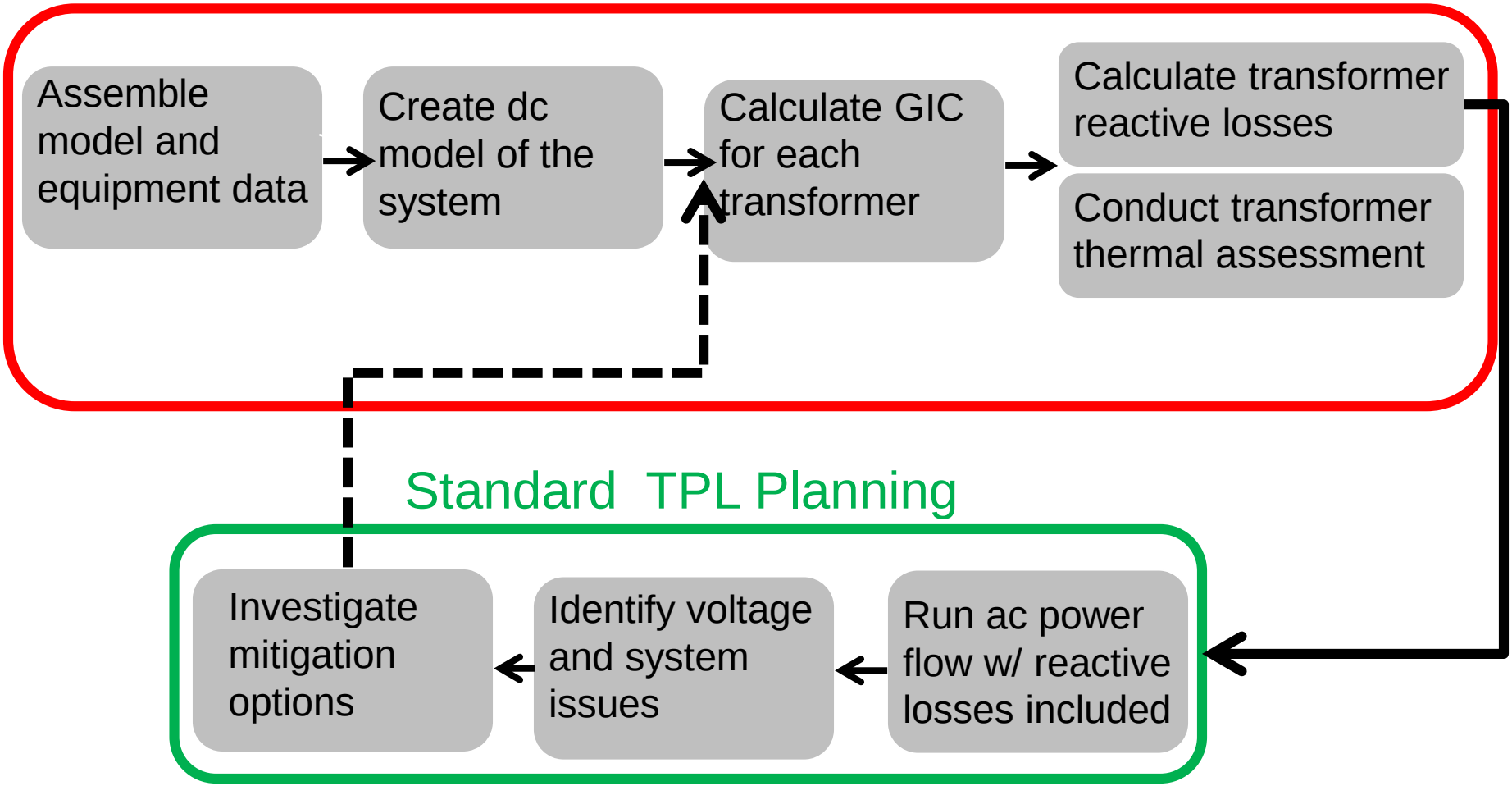
α = Factor adjustment for geomagnetic latitude

β = Factor adjustment for regional earth conductivity model

Assessment Process Overview

GMD-specific Planning Steps

GIC calculation is now available on most power system analysis software



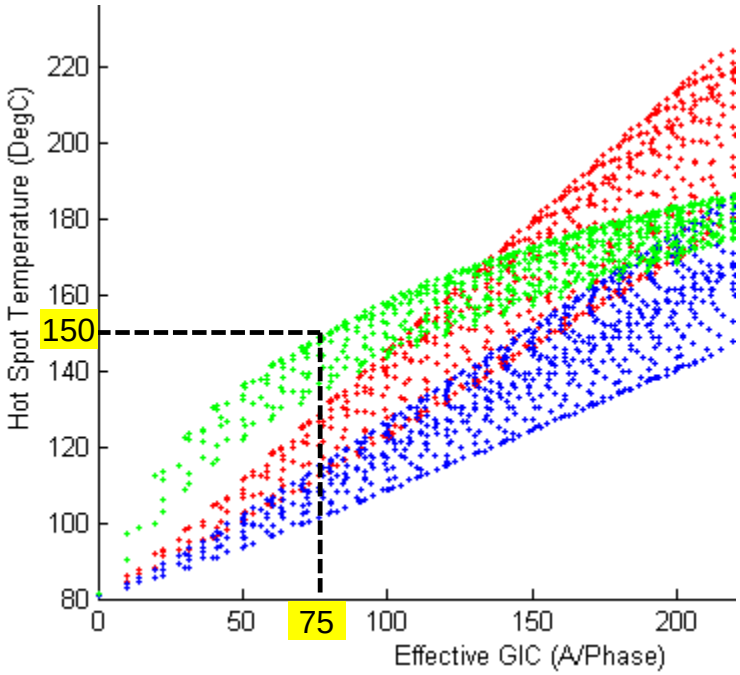
Transformer Thermal Assessment

- Transformer thermal assessments are required when GIC studies indicate effective GIC is 75 A per phase or greater
  - Increased in response to manufacturer and stakeholder input
  - Supported by analysis of benchmark event on available models
- Thermal Screening Criterion white paper:

http://www.nerc.com/pa/Stand/Project201303GeomagneticDisturbanceMitigation/GMD_Thermal_screening_Oct27_clean.pdf

Screening Criterion Selection

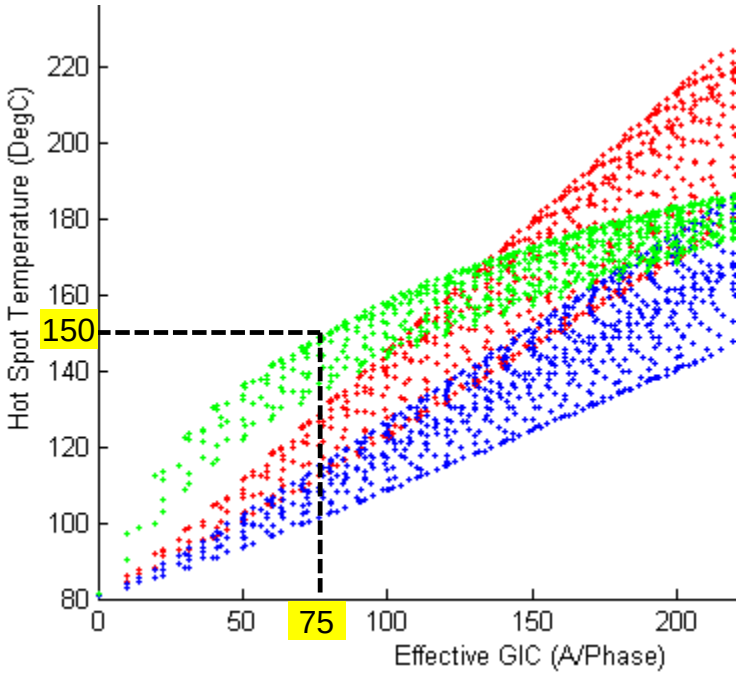
- Screening criterion in previous draft was extremely conservative
  - Based on heating effects from constant 15 A per phase effective GIC
- Revised criterion is based on effective GIC time series GIC(t)
- Effective 75 A per phase is a conservative screening criterion
  - Based on conservative thermal models
  - Peak hot spot temperature of 150° C is well below IEEE Std C57.91 recommended limits
  - Applicable to single-phase and three-limb, three-phase transformers



Metallic hot spot temperatures for the benchmark GMD event

Screening Criterion Selection (cont.)

- Each dot in this graph represents the result of a thermal analysis using GIC(t) from the benchmark event
  - For given peak effective GIC, the orientation of circuits connected to the transformer produce different heating effects
  - Effective GIC of 75 A per phase is obtained from GIC studies where the geoelectric field is rotated to find the maximum
  - Different colors represent different thermal models
  - Plot summarizes about 33,000 thermal assessments



Metallic hot spot temperatures for the benchmark GMD event

Transformer Thermal Assessment

- Revisions to the Transformer Thermal Assessment white paper address concerns with model availability
- A simplified method for thermal assessment is described
  - Table of peak hot-spot temperatures v. effective GIC was developed from simulation of the benchmark GMD event on available models
  - Transformers that do not pass assessment criteria should undergo detailed analysis (thermal simulation or manufacturer)
- Transformer Thermal Assessment white paper:

http://www.nerc.com/pa/Stand/Project201303GeomagneticDisturbanceMitigation/thermal_impact_assessment_whitepaper_Oct27_clean.pdf

Table of Peak Hot Spot Temperatures

- The table provides the highest hot spot temperatures for the benchmark GMD event

Table 1: Upper Bound of Peak Metallic Hot Spot Temperatures Calculated Using the Benchmark GMD Event			
Effective GIC (A/phase)	Metallic hot spot Temperature (°C)	Effective GIC (A/phase)	Metallic hot spot Temperature (°C)
0	80	140	172
10	106	150	180
20	116	160	187
30	125	170	194
40	132	180	200
50	138	190	208
60	143	200	214
70	147	210	221
75	150	220	224
80	152	230	228
90	156	240	233
100	159	250	239
110	163	260	245
120	165	270	251
130	168	280	257

Transformer Thermal Impact Assessment
White Paper p. 4

Example

- Thermal assessment of a transformer with effective GIC of 150 A per phase
  - Oil temperature: 80° C
- Peak temperature from Table 1 below suggested limits = Pass

Excerpt from maximum temperature limits suggested in IEEE C57-91 2011.

	Normal life expectancy loading	Planned loading beyond nameplate rating	Long-time emergency loading	Short-time emergency loading
Insulated conductor hottest-spot temperature °C	120	130	140	180
Other metallic hot-spot temperature (in contact and not in contact with insulation), °C	140	150	160	200
Top-oil temperature °C	105	110	110	110

Table 1: Peak Metallic Hot Spot Temperatures

Effective GIC (A/phase)	Metallic hot spot Temperature (°C)
140	172
150	180
160	187
170	194
180	200
190	208
200	214
210	221
220	224
230	228
240	233
250	239
260	245
270	251
280	257

Transformer Thermal Impact Assessment White Paper p. 4

Example

- Thermal assessment of a transformer with effective GIC of 210 A per phase
  - Oil temperature: 80° C
- Peak temperature from Table 1 exceeds suggested limits = perform detailed analysis

Excerpt from maximum temperature limits suggested in IEEE C57-91 2011.

	Normal life expectancy loading	Planned loading beyond nameplate rating	Long-time emergency loading	Short-time emergency loading
Insulated conductor hottest-spot temperature °C	120	130	140	180
Other metallic hot-spot temperature (in contact and not in contact with insulation), °C	140	150	160	200
Top-oil temperature °C	105	110	110	110

Table 1: Peak Metallic Hot Spot Temperatures

Effective GIC (A/phase)	Metallic hot spot Temperature (°C)
140	172
150	180
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180	200
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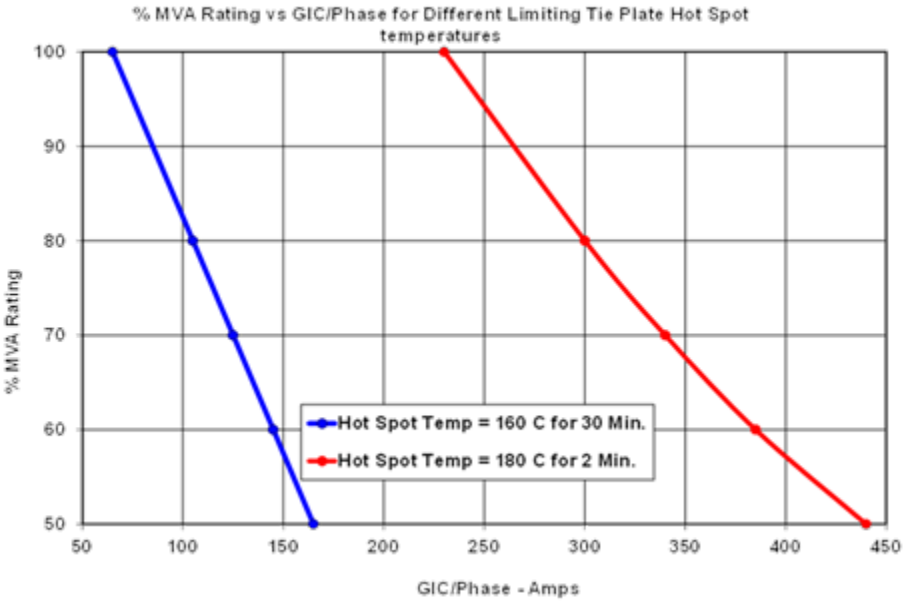
220	224
230	228
240	233
250	239
260	245
270	251
280	257

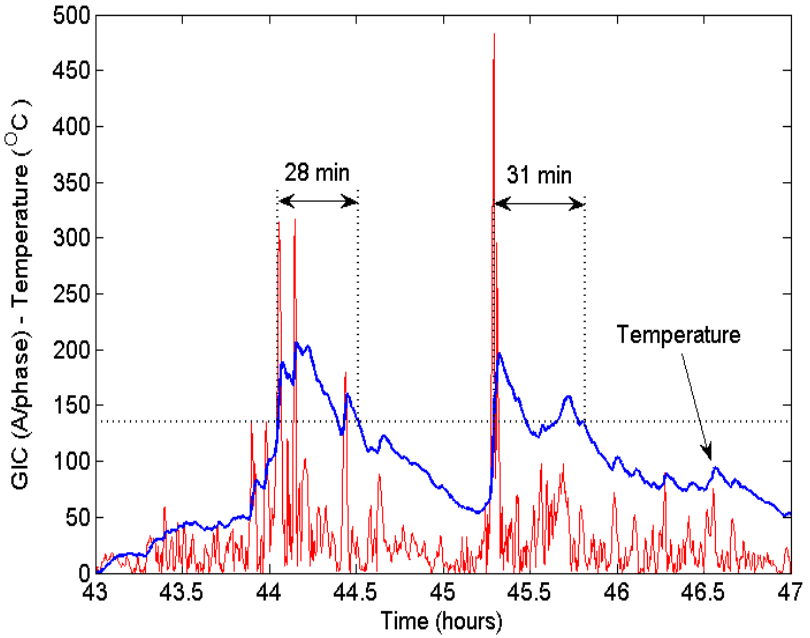
Transformer Thermal Impact Assessment White Paper p. 4

Transformer Thermal Assessment

- Consult manufacturer or IEEE Std C57.91 for temperature limits
- Some assessment approaches are described in the Transformer Thermal Assessment white paper:

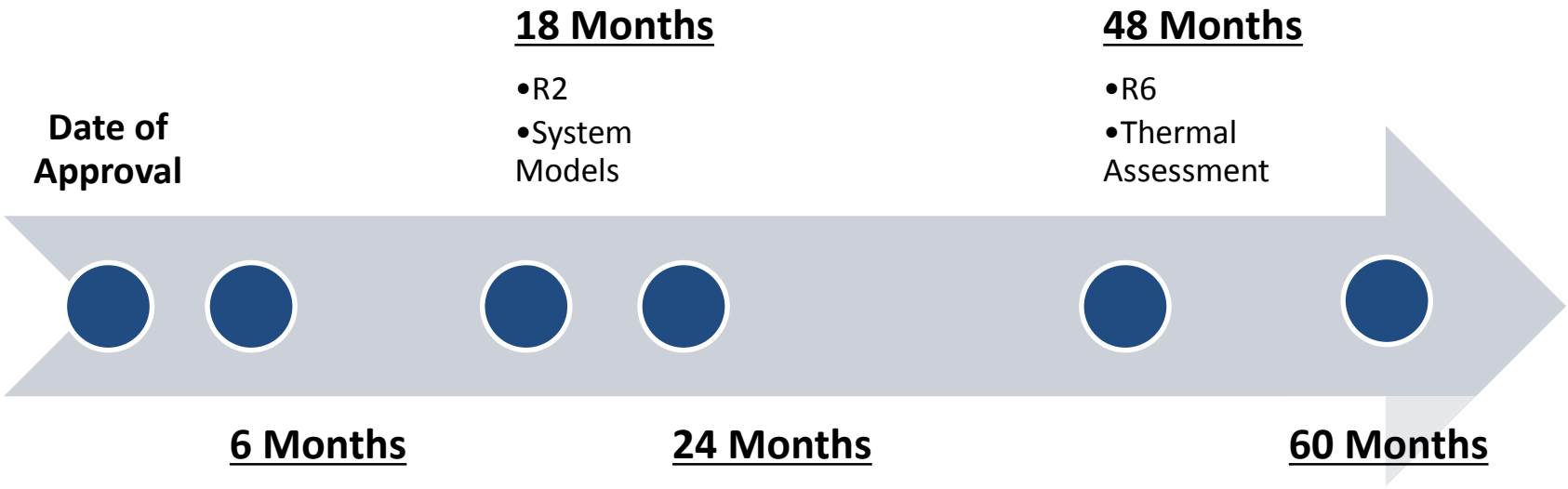


Transformer manufacturer capability curves



Thermal response simulation

Implementation Plan



Other Changes

- Table 3 Conductivity Scaling Factors updated with U.S. Geological Survey (USGS) ground model and naming convention for Florida peninsula (FL1)
- VRF for Requirement R2 changed from Medium to High
  - NERC filed revised VRF for TPL-001-4 Requirement R1 in August 2014
- Clarifications and editorial changes throughout the standard and white papers

Project Status and Schedule

- Revised standard posted for comment and additional ballot October 28 – November 21, 2014
  - Standards Committee authorized 25-day comment period
  - Additional ballot November 12 – 21, 2014
- File with FERC in January 2015
- Project page: http://www.nerc.com/pa/Stand/Pages/Project-2013-03-Geomagnetic-Disturbance-Mitigation.aspx

Questions and Answers

Send questions by chat