Procedure Background

A Geomagnetic Disturbance (GMD) is the disturbance of the Earth's magnetic field. This disturbance can come from different sources like a Solar Magnetic Disturbance (SMD) or an electromagnetic pulse. This procedure will refer to the disturbance generally as GMD.

The sun emits streams of charged protons and electrons known as solar wind. The intensity of the solar wind is determined by sunspot activities (solar flares, coronal holes and coronal mass ejections). The charged solar energetic particles that escape the sun’s halo (corona) take between 14 to 96 hours to travel to Earth. The solar wind interacts with the earth's magnetic field producing auroral currents that follow circular paths around the earth's geomagnetic poles. These non-uniform currents then cause time-varying fluctuations in the earth’s magnetic field, which in turn induce a potential difference on the surface of the earth (Earth Surface Potential) and result in Geomagnetically Induced Current (GIC). The GIC is a quasi-de current that enters and exits the power system at transformer grounds disrupting the normal operation of the power system and can, in some cases, saturate transformers causing large amounts of abnormal VAR absorption, depressing voltage and can also create harmonic currents affecting relays, erroneously tripping needed capacitors banks and SVCs. Saturated transformers may also overheat, thus shortening life cycle.

The Earth Surface Potential is measured in volts per kilometer and its magnitude and direction are functions of the change in magnetic field, Earth's resistivity, and geographic latitude. Earth surface potential increases with increasing latitudes and its gradient is highest on facilities having an east-west orientation. Earth surface potential is highest in igneous rock areas and where transmission lines terminate near water. Due to the Earth Surface Potential being greater at higher latitudes, areas with close proximity to the Earth's magnetic north pole typically experience greater effects of GMDs. However, a severe storm can affect equipment and systems even at lower latitudes.

Current is also induced on the transmission lines through voltage induction on the loop formed by the grounded transmission line and Earth. Induction can occur along a loop of transmission lines, which are connected by ground.

Geomagnetic activity is normally reported in terms of the “A” and “K” Indexes. The "A" index is a measure of the expected geomagnetic activity, based on solar observations, for Fredericksburg, Virginia. The Ap value is the averaged “A” index value for the planet. The "K" index is “a code that is related to the maximum fluctuations of horizontal components (nT) observed on a magnetometer relative to a quiet day, during a three-hour period." The Kp value is the averaged “K” index value for the planet.

Notification of geomagnetic activity may be done using the A, Ap, K or Kp index value. Attachment 1 - GMD Activity Reference Tables identifies the Solar Activity in terms of the A and K Index values and the National Oceanic and Atmospheric Administration (NOAA) Rating to the Kp Index value.

A detailed description of geomagnetic disturbances is contained in NPCC C-15.
Solar Terrestrial Dispatch (STD) Geomagnetic Storm Mitigation System (GSMS) allows for continuous updating on current GMD activity and forecast predictions on GMD activity up to three days in advance. The GSMS software provides an alert for forecasted and actual GMD events of Kp 6 or greater. In GSMS an Actual (observed) event will be shown as a thick red trace on the activity plot and identified as such in the event description. In GSMS an Alert (warning, forecasted, or predicted) event will be shown as a thick green trace on the activity plot and identified as such in the event description. GSMS is kept continuously up to date by Solar Weather Specialists located at Solar Terrestrial Dispatch (www.spacew.com/).

Monitoring is also performed by the Space Weather Prediction Center (SWPC) of the NOAA located in Boulder, Colorado and the Geological Survey of Canada, Department of Natural Resources Canada (NRCAN), located in Ottawa, Ontario, Canada. If the communication path fails for GSMS, the following notification paths will be used:
1. SWPC-Boulder notifies FRCC.
2. NRCAN-Ottawa notifies IESO and HQTE. IESO notifies NYISO. NYISO notifies ISO-NE

FRCC, by directions from NERC, is the GMD Monitor for the Eastern Interconnection. SWPC will initiate a call using the NERC Hotline and provide GMD Alerts (an actual/observed event) or Warnings (forecasted/predicted event) that meet a specific threshold. FRCC (as the GMD Monitor) will perform a roll call of the RCs expected to participate in the NERC Hotline call.

All time references in GMD, Actual and Alerts, received from SWPC (Boulder) and NRCAN (Ottawa) are in universal coordinated time (UTC). Universal coordinated time is a constant scientific time reference and NOT a time zone. Greenwich Mean Time (GMT) is the same time as universal coordinated time (UTC) and neither change for Daylight Savings Time (DST).
- Eastern Standard Time (EST) lags UTC/GMT by 5 hours.
- Eastern Daylight Time (EDT) lags UTC/GMT by 4 hours.

Common Procedure Information
A. Any ISO-NE qualified Control Room Operator has the authority to take actions required to comply with NERC Reliability Standards. A qualified ISO-NE Control Room Operator has met the following requirements:
   1. Have and maintain a NERC certification at the RC level (per R.1 of PER-003-1)
   2. Applicable Requirements of PER-005-2
   3. Approved to cover a Control Room Operator shift position by the Manager, Control Room Operations
   4. Is proficient at the current qualified level.
B. Real-Time operation is defined as the current hour and the current hour plus one.
C. Future hours are those beyond Real-Time operation.
D. All verbal communications with Local Control Centers (LCC), neighboring Reliability Coordinators/Balancing Authorities (RC/BA), Designated Entities (DE), Demand Designated Entities (DDE) and/or SCADA centers shall be made on recorded phone lines unless otherwise noted.
E. Use the Basic Protocol for All Operational Communications as defined in M/LCC 13
   1. Use 'ISO New England' or 'New England'. Refrain from using 'ISO'.
   2. Use Asset ID's when communicating with DE/DDEs.
F. Primary responsibilities are stated for each step within the procedure, but any ISO Control Room Operator qualified at that position or higher can perform the step.
G. The use of ensure within this document means that a verification has been performed and if the item is not correct, corrective actions will be performed.
Procedure

Condition(s) to perform this section:
- Notified of a GMD (Alert or Actual) of intensity 6 or greater from the GSMS software; Or
- Notified of a GMD (Alert or Actual) of intensity 6 or greater from NYISO; Or
- Notified of a GMD (Alert or Actual) from an RC/BA external to NPCC.

Section 1 Notification of a GMD Event of intensity 6 or greater

Notes
The primary source for GMD notification comes from the GSMS software.
The backup source for GMD notification when GSMS is down for ISO-NE comes from NYISO.
FRCC provides notification to the Eastern Interconnection for GMD events as well.

Step 1.1 Primary Responsibility: Senior System Operator

Condition(s) to perform this step:
- Notification originated from the GSMS software.

Click "Confirm Receipt" in GSMS.

Step 1.2 Primary Responsibility: Senior System Operator

Contact the Maine LCC Operator to determine the GIC activity at the Chester SVC site.

Notes
When provided an amp value, ensure it is a transformer neutral dc ground current value.

Step 1.3 Primary Responsibility: Senior System Operator

Contact the VELCO LCC Operator to determine if GIC activity is being observed on the available monitors.

Notes
When provided an amp value, ensure it is a transformer neutral dc ground current value.

Step 1.4 Primary Responsibility: Senior System Operator

Condition(s) to perform this step:
- Notification originated from the GSMS software.

Select the applicable "Observed GIC Strength" level and enter the "Strength and Location of Observed GICs" (specific amps and location), if applicable

Instructions
Access the "GIC Reports" tab to report GIC activity.

If the LCC Operators report no GIC activity or GIC activity less than 5 amps (neutral dc ground current), select "None".

Use the following table to associate the reported GIC activity to the selection in GSMS.

<table>
<thead>
<tr>
<th>XFMR Neutral dc ground current</th>
<th>GSMS Selection</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 - 14 Amps</td>
<td>Weak GIC activity has been observed</td>
</tr>
<tr>
<td>15 - 29 Amps</td>
<td>Moderately strong GIC activity has been observed</td>
</tr>
<tr>
<td>≥ 30 Amps</td>
<td>Strong GIC activity has been observed</td>
</tr>
</tbody>
</table>
Step 1.5  Primary Responsibility: Senior System Operator

**Condition(s) to perform this step:**
- Notified of an Actual GMD of intensity 7 or greater; Or
- Notified of a GMD Alert of intensity 7 or greater with a probability of 40% or greater.

**Inform Seabrook DE of the GMD intensity level and request the Seabrook station GIC level reading.**

**Instructions**
Seabrook station has active GIC monitoring on the GSU transformer.

**Notes**
If the neutral dc ground current reading is > 190 Amps sustained for 60 minutes or greater, Seabrook is required to initiate either a normal down power or a rapid down power.

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Step 1.6  Primary Responsibility: Senior System Operator

**Condition(s) to perform this step:**
- Notified of an Actual GMD of intensity 7 or greater; Or
- Notified of a GMD Alert of intensity 7 or greater with a probability of 40% or greater.
- Notified of a change in intensity level of 7 or greater.

**Notify each LCC of the intensity level, probability (if applicable), and duration.**

---

Step 1.7  Primary Responsibility: Senior System Operator

**Condition(s) to perform this step:**
- Notification of an Actual GMD event of intensity 7 or greater with GIC activity of 10 Amps or greater; Or
- Notified of a GMD Alert of intensity 7 or greater with a probability of 40% or greater with GIC activity of 10 Amps or greater.

**Notify each DE and DDE using ENS of the current GMD condition and request they report any unusual MVAR loading or voltage swings their unit experiences.**

---

Step 1.8  Primary Responsibility: Senior System Operator

Log the GMD Event.

**Instructions**
Use log entry: > EMERGENCY PROCEDURE EVENTS > GEOMAGNETIC DISTURBANCE > Geomagnetic Disturbance

Make a log entry by:
- Select the GMD Event type from the dropdown menu.
- Indicate who reported the GMD Event (GSMS or an RC/BA)
- If the GMD was reported by an RC/BA, specify the Site where the information originated.
- Enter in the intensity level (both Actual and Alert)
- Enter in the Probability (for an Alert)
- For an Actual GMD event with an intensity of ≥ K 7 or an Alert with intensity ≥ K 7 with probability of ≥ 40%, the notifications section is required to be filled out.

**Notes**
Log entries are made for events K 6 or greater.
Step 1.9  Primary Responsibility: Senior System Operator

Condition(s) to perform this step:
• The Preliminary or Morning Report has NOT been published for the day.

Enter GMD information on the Morning Report.

Step 1.10  Primary Responsibility: Operations Shift Supervisor

Condition(s) to perform this step:
• Notification of an Actual GMD event of intensity 7 or greater with GIC activity of 10 Amps or greater; Or
• Notified of a GMD Alert of intensity 7 or greater with a probability of 40% or greater with GIC activity of 10 Amps or greater.

Evaluate the current and forecasted operating information for possible actions that may need to be taken.

Step 1.11  Primary Responsibility: Operations Shift Supervisor

Condition(s) to perform this step:
• Notification of an Actual GMD event of intensity 7 or greater with GIC activity of 10 Amps or greater; Or
• Notified of a GMD Alert of intensity 7 or greater with a probability of 40% or greater with GIC activity of 10 Amps or greater.

Determine if any actions will be taken.

Instructions
While determining what actions to take, the Operations Shift Supervisor may consult LCCs; neighboring RC/BA; GMD monitoring sites; Manager, Control Room Operations; or the Director, Operations to help with evaluating the situation.

The following are possible actions that could be taken:
 a. Discontinue maintenance work and restore out of service high voltage transmission lines. Avoid taking long lines out of service
 b. Maintain system voltages within acceptable operating range to protect against voltage swings
 c. Review the availability of the Chester SVC and capacitor banks to respond to voltage deterioration, if necessary
 d. Reduce the loading on Inter-RCA/BAA ties, on other internal critical transmission lines, and interfaces to 90%, or less, of their security limits
 e. Do NOT lower TMSR below 50%, spinning units online will provide more reactive reserves. If geomagnetic activity is severe enough, consider increasing TMSR forcing more units with reactive reserves online.
 f. Consider posturing Generators operating at their Eco Max to provide room for reserves and reactive capacity in accordance with CROP.25001 Posturing.
 g. Dispatch generation to manage system voltage, tie line loading, and to distribute operating reserve
 h. Bring equipment capable of synchronous condenser operation on-line to provide reactive power reserve
 i. In conjunction with personnel at those locations where GMD measurements are to be taken, ensure the monitoring equipment is in service
 j. Closely monitor RTCA Voltage contingencies and consider the impact of tripping large shunt and series capacitor banks and static VAR compensators.
 k. If conditions are severe enough, consult with LCCs and consider reclosing tripped capacitor banks and SVCs ASAP that are likely tripped by erroneous relay action and NOT damage.

Step 1.11.1  Primary Responsibility: Operations Shift Supervisor

Condition(s) to perform this step:
• M/LCC 2 determined to be required.

Implement M/LCC 2 per CROP.25011 Implement Operations During Abnormal Conditions.
Step 1.11.2  Primary Responsibility: Operations Shift Supervisor

Condition(s) to perform this step:
- Actions have been taken to help mitigate the GMD effects.

Notify ISO management and staff via e-mail using the "Control Room Mgmnt" distribution list identifying the GMD information and the actions taken.

Step 1.11.3  Primary Responsibility: Senior System Operator

Condition(s) to perform this step:
- Actions have been taken to help mitigate the GMD effects.

Notify each LCC and NPCC RC/BA for the actions taken.

Instructions
Notify the following RC/BA:
- NYISO
- NB
- HQTE
- IESO

Step 1.11.4  Primary Responsibility: Operations Shift Supervisor

Condition(s) to perform this step:
- Actions have been taken to help mitigate the GMD effects.

Log the GMD information and the actions taken.

Instructions
Use log entry: > EMERGENCY PROCEDURE EVENTS > GEOMAGNETIC DISTURBANCE > Geomagnetic Disturbance
Condition(s) to perform this section:

- Notified of termination for the GMD event from all sources.

Section 2 Notification of GMD Termination

Notes

Actions in this section are only performed when all sources that provided a notification of a GMD event have provided a notification that the event has been terminated.

The intermittent nature of geomagnetic storm effects makes it difficult to tell when the storm activity is over. There may be lulls in activity followed by additional severe activity. Any actions taken to mitigate the effect will be maintained in place for a period of time, usually two to four hours, after the last observed indication of geomagnetic activity. Termination notifications should be sent at < K7.

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Step 2.1 Primary Responsibility: Senior System Operator

Condition(s) to perform this step:

- Notification originated from the GSMS software.

Click "Confirm Receipt" in GSMS.

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Step 2.2 Primary Responsibility: Senior System Operator

Condition(s) to perform this step:

- If Seabrook DE was initially notified of the K7 or greater GMD event.

Notify the Seabrook DE of the termination.

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Step 2.3 Primary Responsibility: Senior System Operator

Condition(s) to perform this step:

- If LCCs were initially notified of the K7 or greater GMD event.

Notify each LCC of the termination.

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Step 2.4 Primary Responsibility: Senior System Operator

Condition(s) to perform this step:

- If DEs/DDEs were notified of the K7 or greater GMD event.

Notify each DE and DDE of the termination using ENS.

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Step 2.5 Primary Responsibility: Senior System Operator

Log the GMD Termination.

Instructions

Use log entry: > EMERGENCY PROCEDURE EVENTS > GEOMAGNETIC DISTURBANCE > Geomagnetic Disturbance Termination
Condition(s) to perform this section:
- An LCC Operator reports a GIC alarm.

Section 3  Notified of GIC Alarm

Step 3.1  Primary Responsibility:  Senior System Operator
Access GSMS.

Step 3.2  Primary Responsibility:  Senior System Operator
Select the applicable "Observed GIC Strength" level and enter the "Strength and Location of Observed GICs" (specific amps and location), if applicable.

Instructions
Access the "GIC Reports" tab to report GIC activity.

Use the following table to associate the reported GIC activity to the selection in GSMS.

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<tr>
<td>≥ 30 Amps</td>
<td>Strong GIC activity has been observed</td>
</tr>
</tbody>
</table>

Step 3.3  Primary Responsibility:  Senior System Operator
Log the identified GIC Level.

Instructions
Use log entry: > EMERGENCY PROCEDURE EVENTS > GEOMAGNETIC DISTURBANCE > GIC Alarm

Notes
If multiple GIC alarms occur during one shift at the same GSMS Selection levels, then logging may occur only once per shift. If multiple GIC alarms occur during one shift at different GSMS Selection levels, then each variance should be done.
Condition(s) to perform this section:
• Notification received from NYISO or external RC/BA conflicts with the information in GSMS.

Section 4  **Respond to conflicting information**

**Step 4.1**  
Primary Responsibility: Senior System Operator  
Access GSMS.

**Step 4.2**  
Primary Responsibility: Senior System Operator  
Report the discrepancy and request clarification in GSMS.

**Instructions**
To report a discrepancy and request clarification perform the following:
- Click on the "Communications" tab;
- Describe the "Communicate with the Duty Forecaster" field;
- Click "Submit Communications" button to send.

Solar Terrestrial Dispatch has a forecaster on duty that will receive notification when the communication is sent.
# Revision History

<table>
<thead>
<tr>
<th>Rev. No.</th>
<th>Date (MM/DD/YY)</th>
<th>Reason</th>
<th>Contact</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>02/20/13</td>
<td>Initial revision of this Procedure</td>
<td>Steven Gould</td>
</tr>
<tr>
<td>1</td>
<td>06/19/13</td>
<td>Established a connection between this CROP and IRO-005-3.1a R3. Specified the individual sections for the conditions to enter the procedure. Rearranged steps within section one. Grammar corrections made.</td>
<td>Steven Gould</td>
</tr>
<tr>
<td>2</td>
<td>07/01/14</td>
<td>Added clarification to steps Update log entries Added Step 1.10.3</td>
<td>Steven Gould</td>
</tr>
<tr>
<td>3</td>
<td>05/20/15</td>
<td>Title changed to align with NERC Reliability Standard Procedure background; changed SMD to GMD Added clarification to condition to perform for Section 1</td>
<td>Steven Gould</td>
</tr>
<tr>
<td>4</td>
<td>07/10/15</td>
<td>Change the method of disseminating information about mitigating actions being taken by ISO-NE</td>
<td>Steven Gould</td>
</tr>
<tr>
<td>5</td>
<td>12/01/15</td>
<td>Removed minimum 40% loading on the HVdc tie lines</td>
<td>Steven Gould</td>
</tr>
<tr>
<td>6</td>
<td>12/03/15</td>
<td>Administrative update to background and Step 1.10.1</td>
<td>Steven Gould</td>
</tr>
<tr>
<td>7</td>
<td>01/27/16</td>
<td>Added a step to section 1 for contacting VELCO Modified the steps for selecting GIC level in STD GSMS software Changed MISO to PJM</td>
<td>Steven Gould</td>
</tr>
<tr>
<td>8</td>
<td>11/09/16</td>
<td>Remove harmonic current from steps</td>
<td>Steven Gould</td>
</tr>
<tr>
<td>9</td>
<td>01/25/17</td>
<td>Approved on 01/25/17 but will not be effective until 02/01/17 to coincide with assuming GMD Monitor role. Addition of language for performing the role of eastern interconnection GMD Monitor</td>
<td>Steven Gould</td>
</tr>
<tr>
<td>10</td>
<td>01/18/18</td>
<td>Rewrite based on ISO-NE no longer being the GMD Monitor. Approved on 01/18/18 but will not be effective until 02/01/18 to coincide with no longer being the GMD Monitor</td>
<td>Steven Gould</td>
</tr>
<tr>
<td>11</td>
<td>04/25/18</td>
<td>Update Step 1.5</td>
<td>Steven Gould</td>
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</tbody>
</table>
Attachment 1 - GMD Activity Reference Tables

<table>
<thead>
<tr>
<th>Solar Activity</th>
<th>A Index</th>
<th>K Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quiet</td>
<td>A &lt; 7</td>
<td>Usually no K-indices &gt; 2</td>
</tr>
<tr>
<td>Unsettled</td>
<td>7 &lt; A &lt; 15</td>
<td>Usually no K-indices &gt; 3</td>
</tr>
<tr>
<td>Active</td>
<td>15 ≤ A &lt; 30</td>
<td>A few K-indices of 4</td>
</tr>
<tr>
<td>Minor Geomagnetic Storm</td>
<td>30 ≤ A &lt; 50</td>
<td>K-indices mostly 4 and 5</td>
</tr>
<tr>
<td>Major Geomagnetic Storm</td>
<td>50 ≤ A &lt; 100</td>
<td>K-indices mostly 5 and 6</td>
</tr>
<tr>
<td>Severe Geomagnetic Storm</td>
<td>A &gt; 100</td>
<td>K-indices 7 or greater</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>NOAA Category Descriptor</th>
<th>NOAA Category Scale</th>
<th>Effect</th>
<th>Kp Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minor</td>
<td>G 1</td>
<td>Weak power grid fluctuations can occur</td>
<td>Kp-5</td>
</tr>
<tr>
<td>Moderate</td>
<td>G 2</td>
<td>High-latitude systems may experience voltage alarms; long duration storms may cause transformer damage</td>
<td>Kp-6</td>
</tr>
<tr>
<td>Strong</td>
<td>G 3</td>
<td>Voltage corrections may be required; false alarms triggered on some protection devices</td>
<td>Kp-7</td>
</tr>
<tr>
<td>Severe</td>
<td>G 4</td>
<td>Possible widespread voltage control problems and some protective systems will mistakenly trip key assets</td>
<td>Kp-8</td>
</tr>
<tr>
<td>Extreme</td>
<td>G 5</td>
<td>Widespread voltage control and protective system problems can occur; some grid systems may experience complete collapse or blackouts and some transformers may experience damage</td>
<td>Kp-9</td>
</tr>
</tbody>
</table>