

CROP.24003 Geomagnetic Disturbance		
©2024	Approved By: Director, Operations	Effective Date: 02/20/2024
Rev # 15	Procedure Owner: Manager, Control Room Operations	Valid Through: 01/23/2026

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References

1. CROP.25001 Posturing
2. CROP.25011 Implement Operations During Abnormal Conditions
3. M/LCC 2 – Abnormal Conditions Alert
4. M/LCC 19 - Geomagnetic Disturbance Operating Plan
5. NPCC Document C-15 Procedures for Geomagnetic Disturbances Which Affect Electric Power Systems
6. NERC Geomagnetic Disturbance Monitoring Reference Document

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-dc 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.

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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/).

The NPCC Reliability Coordinator (RC) Areas receive information tailored specifically for the NPCC region, on a continual twenty-four by seven basis, the status of solar activity and geomagnetic storm alerts from the Solar Terrestrial Dispatch (STD). The primary mechanism for notification to the NPCC RC Areas is the Solar Terrestrial Dispatch’s Geomagnetic Storm Mitigation System (GSMS), an active communications software package accessed by the operator. In the event that an RC Area observes GIC activity absent the notification of a geomagnetic storm alert, the operator is to use the “GIC Reports” feature of GSMS to automatically notify the other NPCC RC Areas and the Solar Terrestrial Dispatch of the strength and location of the GIC activity. The primary NPCC notification will be via the GSMS software for which the actions of this procedure will be used. The backup NPCC notification (if the GSMS software is unavailable) will be via NYISO or the designated GMD Monitor.

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. The SWPC in some cases speaks of all of these messages, including warnings, alerts and rapid alerts, as “alerts,” and thus all of the messages can carry an alert code. If the communication path fails for GSMS, the following notification paths will be used:

1. SWPC-Boulder notifies NYISO and NYISO notifies ISO-NE.
2. NRCAN-Ottawa notifies IESO. IESO notifies NYISO and HQTE. NYISO notifies ISO-NE

A Reliability Coordinator assigned by NERC on a yearly basis, 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. The Interconnection 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.

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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 PER-003
 - 2. Applicable Requirements of PER-005
 - 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 prescribed in M/LCC 13
 - 1. Use the Basic Protocol for All Operational Communications as prescribed in M/LCC 13.
 - 2. Use 'ISO New England' or 'New England'. Refrain from using 'ISO'.
 - 3. Use Asset ID's when communicating with DE/DDEs.
 - 4. Use three-part communication in all situations where its use will enhance communication.
- 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. The Primary Responsibility may be delegated to an Operator in a lower qualified position, but the responsibility for its completion remains with the identified individual.
- 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.

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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; And**
- **The GSMS software is not operational.**

Section 1 : Notification of a GMD Event or Change 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.
- The Interconnection GMD Monitor provides notification to the Eastern Interconnection for GMD events as well.
- The SWPC in some cases speaks of all of these messages, including warnings, alerts and rapid alerts, as “alerts,” and thus all of the messages can carry an alert code.

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

Evaluate the GIC activity being observed on the available monitors

Instructions

GIC readings are visible via either:

- GIC Situational Awareness display that summarizes all GIC monitoring points and displays current Amp levels for each point.
- Substation Tabular display for each station that has GIC monitoring.

Notes

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

Step 1.2.1 Primary Responsibility: Senior System Operator

Condition(s) to perform this step:

- **ICCP link is unavailable from the applicable LCC(s); Or**
- **The RTU for the applicable substation is out-of-service.**

Contact the applicable LCC(s) to determine the GIC activity being observed on the available monitors.

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Step 1.3 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.

XFMR Neutral dc ground current	GSMS Selection
5 - 14 Amps	Weak GIC activity has been observed
15 - 29 Amps	Moderately strong GIC activity has been observed
≥ 30 Amps	Strong GIC activity has been observed

Step 1.4 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 of level 7 or greater.

Inform Seabrook DE of the GMD intensity level and request the Seabrook station GIC level reading and any actions that they have taken or may be potentially taking.

Notes

- Seabrook station has active GIC monitoring on the GSU transformer.
- Seabrook has trip and power reduction actions they will take depending on the neutral DC ground current readings from SMD events.

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.
- Notified of a change in intensity level of 7 or greater.

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

Step 1.6 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 20 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 20 Amps or greater; Or
- A GIC alarm is received during an active GMD Alert or Actual GMD event of intensity 7 or greater and notifications to DEs and DDEs have not been performed yet.

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.

Notes

If an initial ENS message has already been sent, it is not necessary to make an additional ENS message as the GMD level is not specified in the message and is only a notification that there is an active GMD condition.

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Step 1.7 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 \geq K 7 or an Alert with intensity \geq K 7 with probability of \geq 40%, the notifications section is required to be filled out.

Notes

Log entries are made for events K6 or greater.

Step 1.8 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 1.19 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 20 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 20 Amps or greater; Or
- Notified of a Change in intensity level of 7 or greater.

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

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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 20 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 20 Amps or greater; Or
- Notified of a Change of intensity of level 7 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:

- Discontinue maintenance work and restore out of service high voltage transmission lines. Avoid taking long lines out of service
- Maintain system voltages within acceptable operating range to protect against voltage swings
- Review the availability of the Chester SVC and capacitor banks to respond to voltage deterioration, if necessary
- Reduce the loading on Inter-RCA/BAA ties, on other internal critical transmission lines, and interfaces to 90%, or less, of their security limits
- Consider posturing Generators operating at their Eco Max to provide room for reserves and reactive capacity in accordance with CROP.25001 Posturing.
- Dispatch generation to manage system voltage, tie line loading, and to distribute operating reserve
- Bring equipment capable of synchronous condenser operation on-line to provide reactive power reserve
- In conjunction with personnel at those locations where GMD measurements are to be taken, ensure the monitoring equipment is in service
- Closely monitor RTCA Voltage contingencies and consider the impact of tripping large shunt and series capacitor banks and static VAR compensators.
- 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 1.10.1 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 1.10.2 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 Mgmt" distribution list identifying the GMD information and the actions taken.

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Step 1.10.3 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/BAs for the actions taken.

Instructions

Notify the following RC/BAs:

- NYISO
- NBP-SO
- HQTE
- IESO

Step 1.10.4 Primary Responsibility: Operations Shift Supervisor

Condition(s) to perform this step:

- Actions have been taken to help mitigate the GMD effects.

Update the previously GMD event log entry with actions taken in the “ACTIONS TAKEN AND OTHER NOTIFICATIONS” section.

Step 1.11 Primary Responsibility: Operations Shift Supervisor

Condition(s) to perform this step:

- Notified of equipment damage that may be related to the GMD event.

Update the previously made GMD event log entry with the equipment damage in the “REPORTED EQUIPMENT DAMAGE” section.

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Condition(s) to perform this section:

- **Notified of termination for the GMD event from the GSMS software or NYISO; Or**
- **Notified of termination for the GMD event from an external RC/BA; And**
- **The GSMS software is not operational.**

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.

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.

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.

Notes

If the GMD notification is received from GSMS, Seabrook may receive additional information from SWPC that is contrary to what GSMS is providing and further clarification with the Seabrook DE may be necessary.

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.

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.

Notes

If the GMD notification is received from GSMS, DEs/DDEs that also dispatch resources outside the NPCC area may receive additional information from SWPC or other Reliability Coordinators outside the NPCC area that is contrary to what GSMS is providing and further clarification may be necessary.

Step 2.5 Primary Responsibility: Senior System Operator

Log the GMD Termination.

Instructions

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

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Condition(s) to perform this section:

- An LCC Operator reports a GIC alarm; Or
- GIC alarm is received in EMS.

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.

XFMR Neutral dc ground current	GSMS Selection
5 - 14 Amps	Weak GIC activity has been observed
15 - 29 Amps	Moderately strong GIC activity has been observed
≥ 30 Amps	Strong GIC activity has been observed

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.

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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.

Notes

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

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Revision History

Rev. No.	Date (MM/DD/YY)	Reason	Contact
--	12/01/15	For previous revision history, refer to Rev. 5 available through Ask ISO	Steven Gould
6	12/03/15	Administrative update to background and Step 1.10.1	Steven Gould
7	01/27/16	Added a step to section 1 for contacting VELCO Modified the steps for selecting GIC level in STD GSMS software Changed MISO to PJM	Steven Gould
8	11/09/16	Remove harmonic current from steps	Steven Gould
9	01/25/17	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	Steven Gould
10	01/18/18	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	Steven Gould
11	04/25/18	Update Step 1.5	Steven Gould
12	03/31/20	Biennial Review. Reformatting of bullets, note and instruction evaluation	Steven Gould
13	03/08/22	Biennial Review; Updated Common Procedure Information; Updated References; deleted FRCC and updated to the term used in NERC for Geomagnetic Disturbance Monitoring Reference Document.	Jonathan Gravelin
14	03/06/23	Updated Procedure Background, Added Condition to Enter and Note to Section 1; Added Condition to Enter in Section 2; Removed instruction from Step 1.11.	Jonathan Gravelin
15	01/23/24	Deleted Step 1.2 and Step 1.3; Added Step 1.2.1, 1.11; Updated Condition To Enter in Section 3 and Steps 1.4, 1.8, 1.10; Added Notes to Steps 1.4, 2.2 and 2.4, Modified Step 1.10.4; Updated Attachment 1.	Jonathan Gravelin

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Attachment 1 - GMD Activity Reference Tables

Solar Activity	A Index	K Index
Quiet / Unsettled	$A \leq 19$	Usually no K-indices > 3
Active	$20 < A \leq 29$	A few K-indices of 4
Minor Geomagnetic Storm	$30 < A \leq 49$	K-indices mostly 4 and 5
Major Geomagnetic Storm	$50 < A \leq 99$	K-indices mostly 5 and 6
Severe Geomagnetic Storm	$A \geq 100$	K-indices 7 or greater

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