Space Weather Workshop

April 16, 2013
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Geomagnetic Storm Levels

<table>
<thead>
<tr>
<th>Date</th>
<th>Solar Flare</th>
<th>Omni-Directional</th>
<th>Main CME</th>
<th>Magnetic Intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2 September 1859</td>
<td>Sept 1 Carrington</td>
<td></td>
<td></td>
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<tr>
<td>12 October 1859</td>
<td>White Light Flare [2]</td>
<td></td>
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<tr>
<td>4 February 1872</td>
<td></td>
<td></td>
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<tr>
<td>17-18 November 1882</td>
<td></td>
<td></td>
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<tr>
<td>18 March 1894</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>30 October 1903</td>
<td>X15</td>
<td></td>
<td>19 hours</td>
<td></td>
</tr>
<tr>
<td>29 October - 5 November 2003</td>
<td>Oct 28 X17.2</td>
<td></td>
<td>19 hours</td>
<td></td>
</tr>
</tbody>
</table>

**March 1989 Geomagnetic Storm**

**GMD Related Actions**

- NERC – GMDTF (9/10)
- NERC – Interim Report on GMD (2/12)
- FERC – Technical Conference on GMD (4/12)
- FERC – GMD NOPR (10/12)
- UK Defence Committee EMP Threats (2/12)
- EMP Commission Report (4/08)
- ORNL – Metatech Report (1/10)
- NERC/DOE – HILF REPORT (6/10)
- NAS – Severe Space Weather Workshop (3/08)
- HR 5026 (6/10)
- HR 668 (2/11)

Source: NOAA Technical Memorandum OAR SEC-08
HALLOWEEN SPACE WEATHER STORMS OF 2003
1989 North American Impacts

Salem Nuclear Plant Estimated GIC/phase - March 13-14, 1989

HQ system collapse
Geomagnetic Storm Comparison

1859 Carrington Event

May 1921 Railroad Storm

March 1989

Preliminary Results

E and H Field Simulation (1859)
Reports Relating Geomagnetic Disturbances to Electric Grid Impacts
Chronology of Major Incidents

- March 24, 1940 - widespread disturbances, equipment trips, voltage swings
- September 22, 1957 - numerous disturbances
- February 11, 1958 - Toronto blackout, numerous other disturbances
- August 4, 1972 - numerous events
- October 1980 - 500 kV line trip
- April 1981 - 500 kV line trip
- July 11, 1982 - four transformers and 15 lines tripped
- February 7-8, 1986 - numerous effects
- March 13-14, 1989 - Hydro-Quebec blackout, widespread problems, transformer damage
- September 1989 - voltage problems and relay misoperation
- October 1980 - 500 kV line trip
- March 24, 1991 - nine line trips, transformer trip, Quebec-New England line trip
- October 28, 1991 - line trip Quebec to New England
- April 3, 1994 - Transformer failures
- May 2, 1998 - widespread effects
- July 22, 1998 - effects in Northeastern U.S.
- April 6-7, 2000 - numerous problems on Hydro-Quebec and Bonneville
- November 6, 2001 - New Zealand transformer loss
- October 2003 - Malmo blackout, Transformer damage in South Africa, preventive actions taken in the U.S. appear to circumvent major problems
Space weather events more severe than we have experienced in modern times have occurred in the past and are likely to occur again.

Large power transformers are unique in their design and you cannot make blanket judgments as to whether a particular type or group of transformers will or will not be damaged.

While there is agreement that reactive power requirements will influence system stability, we do not know at exactly what level it will cause the system to collapse.

In the end, it is indeterminable if transformer damage, system collapse or both will be the most likely consequence of a GMD event; we simply lack the information to draw either conclusion.

Neither system collapse nor extensive transformer failure is an acceptable result of a GMD event when we have the capability to act to prevent it.
Notice of Proposed Rulemaking
Reliability Standards for Geomagnetic Disturbances

DEPARTMENT OF ENERGY
Federal Energy Regulatory Commission
18 CFR Part 40
[Docket No. RM12–22–000]
Reliability Standards for Geomagnetic Disturbances
AGENCY: Federal Energy Regulatory Commission, DOE.
ACTION: Notice of Proposed Rulemaking.
SUMMARY: Under section 215 of the Federal Power Act, the Federal Energy
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Federal Register/Vol. 77, No. 206
CONCLUSION

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Reliability Standards for Geomagnetic Disturbances

Federal Register / Vol. 77, No. 206/ Wednesday, October 24, 2012
Proposed Rules - pages 64935 – 64943

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