Doyle, Daniel

From: Doyle, Daniel
Sent: Wednesday, January 12, 2011 8:12 AM
To: Perkins, Leslie
Subject: FW: Salem/Hope Creek Susceptibility to Geomagnetic Storms

Categories: Salem Hope Creek

FYI, the region responded to Mr. Greenhill about his solar storm comments.

Dan Doyle

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From: Ennis, Rick
Sent: Wednesday, January 12, 2011 8:06 AM
To: Doyle, Daniel
Subject: FW: Salem/Hope Creek Susceptibility to Geomagnetic Storms

fyi

From: Cline, Leonard
Sent: Thursday, August 26, 2010 10:11 AM
To: john.greenhill@dhs.gov
Cc: Burritt, Arthur; Ennis, Rick; Welling, Blake; Schroeder, Daniel; Chernoff, Harold; Pham, Bo
Subject: Salem/Hope Creek Susceptibility to Geomagnetic Storms

Below please find the NRC's answers to seven of your questions about the impact of solar magnetic disturbances on the safe operation of nuclear power plants that you provided to us following the Salem and Hope Creek annual assessment meeting on April 6, 2010. At that time you informed us that you had also provided these questions to the NRC's Division of License Renewal via a November 21, 2009, email to the NRC, but that you had as of yet received no response. At that time we informed you that we would follow up on the status of the Division of License Renewal's response to your questions.

Sometime after our inquiry about your questions, we received a draft response to your questions that we were told would be included in the draft supplemental impact statement (SEIS) that would be published in the Federal Register for public comments on September 17, 2010. However, when we reviewed this response, we did not feel that it adequately addressed all of your questions, because some of the issues that you raised were outside the scope of license renewal. As a result, we attempted to gather the information that you requested through discussions with employees of both PSEG and the NRC.

Included below are six responses to your seven questions. There are only six responses because two of the questions that you provided, questions 5 and 6, were answered in a single response. It was our belief that the topics addressed in questions 5 and 6 were directly related.

Your November 21, 2009, email also included a question about the impact of the probability and potential consequences of solar magnetic storms on the results of the NRC's review of a plant's license renewal application. This question will be addressed by the Division of License Renewal and included in the draft SEIS that will be issued for comment in September as discussed above.

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Thank you for your interest in this area. If you have any additional questions feel free to contact us via email or telephone as listed below.

Questions:

1. Is there a publically available report that describes these incidents?

There are several sources of publically available information regarding the transformer damage that occurred at Salem Nuclear Power Station as a result of the geomagnetic disturbances that occurred on the March 13 and September 19, 1989. One such source is located at the following world wide web hyperlink: http://www.nerc.com/files/1989-Quebec-Disturbance.pdf. However, we were unable to locate any publicly available NRC or PSEG reports that describe these incidents and the damage that was caused by them.

2. What was the magnitude of the currents that caused the damage?

During the magnetic storm on March 13, 1989, according to the NERC document referenced above, the generator reactive power output (MVAR) charts for Salem 1 and Hope Creek (Salem 2 was shutdown), indicated numerous uninitiated VAR swings. The VAR swings were significant, with peaks that exceeded 200 MVAR at both sites; however, only Salem 1 experienced significant damage due to the swings.

The approximate magnitude of the induced direct current (GIC) can be calculated using an empirical equation developed in EPRI report EL-1949, "High Voltage Direct Current Converter Transformer Magnetics." Solving this equation using the actual conditions seen at Salem 1 on March 13, 1989, yields a total direct current of 224 A, or 74.7 A per phase for the transformers.

3. How long did the damaging currents persist?

There was no monitoring of the damaging currents available in March of 1989, so the duration of the damaging currents is not known. However, equipment failures and system problems, believed to be associated with the geomagnetic storm of March 13, 1989, occurred over a 24-hour period across North America. The intensity of the storm varied considerably over that 24-hour period.

4. What was the protective relay system in place at that time such as the IEEE Std C37.91-1985?

IEEE Std C37.91-1985 contains practical applications, general philosophy, and economic considerations for power transformer protection. The standard does not contain requirements for protective schemes. Therefore, a protective relay scheme cannot be said to be in accordance with, or not in accordance with, IEEE C37.91. Differential protection, over-excitation protection, and over-current protection are some of the methods used to provide protection for the types of transformers described in IEEE C37.91

The protective relay scheme for the generator step-up transformers at Salem station in 1989 consisted of differential protection and over-excitation protection. The generator step- up transformers were directly connected to the generator. Therefore, the generator protective relaying scheme provided over-current protection for the generator step up transformers.

5. Were there any modifications to the transformer protective system put into effect? How will the step-up transformers at Salem and Hope Creek sites be protected if a super geomagnetic storm (10 times the size of the 1989 storms) occurs during the 20 year extension? The next solar maximum is expected 2013-2014? (Because the topics were directly related, this question combined question 5 and 6 from your November 21, 2009 email to the NRC).

PSEG completed the following corrective actions after the 1989 geomagnetic storms to improve the reliability of potentially affected transformers at Salem and Hope Creek during future solar magnetic storms.

- All of the original West HAM model generator step-up transformers (GSUs) at Salem were replaced with models less susceptible to geo-magnetically induced currents (GIC) and the original Hope Creek Unit

GSUs were replaced with GSUs that included a design margin specifically for handling anticipated GIC levels.

- Vendor guidance for the new transformers at Salem and Hope Creek were evaluated to determine the level of GIC that could be tolerated. The vendor also specified actions that should to be taken at specific GIC levels to protect the transformers. The most significant of these actions was reducing generator output to increase the available operating margin on potentially affected transformers.
- The operating procedures at Salem and Hope Creek Stations were upgraded to specify operator actions at measured GIC levels. The actions specified were based on the results of engineering analyses conducted in this area and included reducing generator output to increase the available operating margin on potentially affected transformers.
- Continuous solar magnetic disturbance (SMD) neutral ground current monitors were installed on the Salem Unit 2 GSU transformers that are monitored in the Salem main control room, at the PSE&G Missouri Ave switching station and at the PSE&G electric system operations center (ESOC). This monitoring allows operators to take the specific action directed by the site's procedures, to protect the site's GSI susceptible transformers.
- An excess MVAR alarm is now provided in both the Salem and Hope Creek main control rooms. These alarms respond to significant MVAR swings on both the power grid and the site main generator. PJM and PSE&G ESOC now have procedural guidance to alert the Salem and Hope Creek Generating Stations when high SMD warnings/alerts are in effect.

6. Do the sites have spare step-up transformers?

Yes, each Salem unit has one, single phase, spare generator step up transformer.