July 16, 2013

MEMORANDUM TO: Roy K. Mathew, Acting Chief
Electrical Engineering Branch
Division of Engineering
Office of Nuclear Reactor Regulation

FROM: Sergiu Basturescu, Electrical Engineer ***/RA/***
Electrical Engineering Branch
Division of Engineering
Office of Nuclear Reactor Regulation

SUBJECT: SUMMARY OF PUBLIC MEETING HELD ON JUNE 27, 2013 - BULLETIN 2012-01, "DESIGN VULNERABILITY IN ELECTRIC POWER SYSTEM."

On June 27, 2013, a Category 2 public meeting was held between the U.S. Nuclear Regulatory Commission (NRC) and representatives of the Nuclear Energy Institute and nuclear power plant industry at NRC Headquarters, Two White Flint North, 11545 Rockville Pike, Rockville, Maryland. The purpose of the meeting was to discuss proposed actions to resolve the single-phase open circuit issue. The enclosure contains an overview of specific presentations and the list of meeting attendees.

The NRC staff presented the current status of licensee responses and proposed actions necessary to resolve issues identified in the Bulletin. Specifically, the staff discussed the industry responses to the Bulletin, proposed regulatory requirements, and the initiatives related to adequate monitoring and testing of offsite power systems.

The industry representatives provided the current status of new hardware installed at some operating plants, progress report on new software developed to analyze the open circuit conditions and different approaches by several licensees to identify open circuit conditions on the offsite sources. Attendees from new reactor designs provided an overview of their plant design and proposed detection schemes. The slides used during the meeting are available in the Agencywide Documents Access and Management System under Accession Number ML13196A002.

CONTACT: Sergiu Basturescu, NRR/DE/EEEB
301-415-1237

Enclosure:
1. Summary of public meeting held on June 27, 2013
2. List of Attendees

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ADAMS Accession No.: ML13196A002 ***via email**

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SUMMARY OF PUBLIC MEETING HELD ON JUNE 27, 2013

On July 27, 2012, the U.S. Nuclear Regulatory Commission (NRC) issued Bulletin (BL) 2012-01, "Design Vulnerability in Electric Power System," (Agencywide Documents Access and Management System (ADAMS) Accession No. ML12074A115). On June 27, 2013, a Category 2 public meeting was held between the NRC and representatives of the Nuclear Energy Institute (NEI) and nuclear power plant industry at NRC Headquarters, Two White Flint North, 11545 Rockville Pike, Rockville, Maryland. The purpose of the meeting was to discuss proposed actions to resolve the single-phase open circuit issue. The NRC staff provided its responses to the industry questions during the meeting. A short summary of specific presentations discussed during the meeting is provided below.

NRC Presentation

The NRC staff provided a summary of key issues related to the Bulletin, an overview of licensee responses and the ongoing efforts of industry discussions. Specifically, the staff stated that the purpose of the Bulletin was to identify a design vulnerability in offsite power system related to detection of loss of single phase (with and without high impedance ground fault) and potential degradation of the performance capabilities of onsite safety related power systems. In the responses to Bulletin questions, the licensees of the operating fleet indicated that the current design of all the plants was not capable of detecting and automatically responding to a single-phase open circuit condition or high impedance ground fault condition and that detection of a single-phase open circuit condition is beyond the approved design and licensing basis of the plant. The licensees also stated that detailed analyses were required to adequately evaluate the vulnerability of the specific designs and develop corrective actions. One plant indicated that the vulnerability may not exist due to the design of the switchyard associated with offsite power system.

The new reactors (Vogtle and Summer) currently in construction phase, have stated that:

- Current design does not include detection of loss of single phase in the offsite power source.
- In the event that offsite power was degraded, the passive design features of the plant using the onsite battery systems can be used to safely shutdown the plant.
- The loss of single phase in the offsite power system can be detected by the battery charging system.

The staff discussed industry proposals for corrective actions and indicated that a Class 1E detection/protection scheme is preferred. However, a nonsafety-related detection/protection scheme providing an equivalent function to monitor loss of single phase (with and without high impedance ground fault) on the high voltage side of a transformer connecting a GDC-17 offsite power circuits to the transmission system is acceptable with justifications for complying with NRC regulations. The staff emphasized that the detection circuit sensitivity should be evaluated for all operating electrical system configurations and loading conditions. In addition, in order to have high reliability and eliminate spurious actuations, coincidence or equivalent logic from two independent sensing circuits should be considered. Other factors such as voltage unbalance normally expected in the transmission system that may impact the sensitivity of pickup and time-setting of protection devices should be evaluated.

In view of the low probability of a loss of a single phase event, some licensees have indicated a preference for annunciating an alarm in the control room with manual actions implemented in a timely manner. The staff indicated that the consequences of such an event can result in degraded voltage conditions on the safety related busses and may not allow the onsite sources to power the safety related busses. As such, in case of an open phase condition concurrent with an accident condition, the protection scheme should transfer the ESF buses to an operable source (alternate offsite power source or emergency diesel generator). In case of an open phase condition without an accident condition, if the circuit is not isolated within a short time, plants should demonstrate that the safety-related equipment will not be adversely impacted.

For new plants with passive reactor design, the staff recommended that as a minimum, the open phase condition should be detected and alarmed in the control room. Other designs should follow the recommendations for the current operating fleet.

The staff stated that surveillance and testing of the proposed detection/protection schemes should be performed on a routine basis to demonstrate the reliability of the systems. In the event, that detailed analytical evaluations indicate that features of the existing design, such as excess margins in existing transformers, will not adversely impact the capability of plant to safely shutdown for all operating modes, the staff expects field verification of such capabilities.

From a regulatory perspective, the staff is considering all regulatory tools available to the staff to ensure that licensees, design centers, and applicants take appropriate actions to correct the design vulnerability. The staff stated that the design features implemented by licensees to demonstrate compliance with single phase open conditions should be documented in the plant safety analyses report and will be considered part of the licensing basis of the plant(s).

Industry Presentations

Nuclear Energy Institute (NEI) representative provided an overview of the industry strategy with goals and objectives that all plant designs (active and passive) demonstrate that safety functions remain available given an open phase condition. The industry is developing a guidance document outlining methods for plant operators to demonstrate capability to cope with loss of a single phase event (with or without high impedance fault conditions) and have it endorsed through the NEI Nuclear Strategic Issues Advisory Committee (NSIAC) for implementation by all licensees. For plants with active designs, modifications may be needed to detect and automatically separate the plant busses from the open phase condition in order to provide assurance that safety functions can be maintained.

The proposed schedule assumes industry acceptance of NEI initiatives by July 31, 2013 with individual licensees establishing compliance with the open phase strategy criteria through analysis or identifying appropriate actions required to demonstrate compliance by December 31, 2014. The completion dates for plant modifications is projected to be December 31, 2016 with closeout and full compliance including update of licensing basis documents by December 31, 2017.

Westinghouse AP1000

Westinghouse AP1000 proposal considers the battery charger as the interface point of safety related power system and nonsafety related AC systems used for normal operation. The passive design feature does not require AC systems for safe shutdown of the plant following an accident and hence the loss of a single phase in the offsite power system is not considered a critical concern. Westinghouse has indicated that the battery charger system is capable of detecting loss of single phase conditions and providing indication in the control room. However, the staff noted that there were no details provided in their discussion as to how the battery charger operating at the low voltage level detects loss of phase condition at the high voltage side of the offsite source transformer.

Electric Power Research Institute (EPRI)

EPRI has been involved in evaluating protecting relaying capabilities for varying configurations of offsite power system and developing transformer modeling schemes for the open phase design vulnerability. In 2012, EPRI issued two reports related to this issue," Analysis of Station Auxiliary Transformer Response to Open Phase Conditions" (EPRI 1025772) and "Development and Analysis of an Open-Phase Detection Scheme" (EPRI 1026484). In 2013, EPRI released a report for modeling transformers "Development and Analysis for Various Configurations of Auxiliary Transformers", (EPRI 3002000764).

EPRI stated that the current research efforts are concentrated on detecting open phase condition on lightly loaded transformers as this is the most prevalent condition for the standby transformers at the nuclear plants. The monitoring schemes under consideration involve signal injected via coupling capacitors to form current loops through primary of station service transformer and detecting open phase conditions by change in injected current or impedance.

ETAP Nuclear Utility Users Group (NUUG)

ETAP provides Electrical Engineering software for analyzing electrical networks. According to the users group (NUUG), majority of the licensees in US use the software for evaluating nuclear plant electrical systems. A representative from NUUG provided a progress report on the development of software for open-phase fault analysis and concluded that ETAP 12 is a validated analysis software package that is now available to allow current nuclear users to quickly move towards performing a qualitative analysis of their plant's response to an open-phase fault condition.

Exelon

Exelon is working in partnership with a commercial relay manufacturer and has developed a microprocessor based relay scheme that would detect the open phase or open phase with a ground fault condition. The protective scheme has been deployed in "alarm only" mode at seven units with balance of the fleet to be deployed throughout 2013 and early 2014. Trip functions will be enabled after a successful monitoring period. Exelon is sharing the lessons learned with the industry. Future work involves development of the algorithm for different transformer configurations used in the industry.

First Energy

First Energy is evaluating power system state estimation method to detect open phase conditions. This method involves estimating the state of the network from telemetry measurements. The process involves redundant measurements in order to filter out errors and find an optimal estimate. The measurements include current, voltage, real and reactive power flow in all the phases of the electrical systems. An open phase condition is identified when successive snapshots of the measured parameters indicate an unexpected change in a single phase. First Energy is proceeding with a feasibility study to evaluate future corrective actions related to the open phase fault conditions as identified in the NRC Bulletin.

Progress/Duke-Energy

Duke Energy is proposing to use revenue grade meters to monitor the three individual phase current magnitudes. The open phase circuit is expected to have zero current flow compared to the non-zero value in the other two circuits. Duke Energy stated that the meters are capable of monitoring down to less than the transformer excitation (no load) current and the meter contacts can be logically programmed to compare and actuate alarm or trip the circuitry when required.

This scheme appears to offer a simple design that can be easily implemented. However, further research is needed to ensure that meters can discriminate for electrical noise and are not prone to spurious actuations.

Southern Nuclear

Southern Nuclear has performed fault analyses on transformers with single and double open phase conditions under varying load conditions with high and low impedance faults. The intent is to measure parameters such as negative sequence and neutral currents coupled with voltage unbalance conditions during the postulated conditions on the high and low side of offsite power transformers. Preliminary indications are that heavy to moderately loaded transformers with an open phase can be detected and reliably protected with conventional relay schemes. However, reliable open-phase detection for very lightly loaded or unloaded transformers is challenging and requires further evaluation.

TVA

TVA provided an overview of their strategy to resolve the open phase issue. They plan to use ETAP to analyze the electrical systems at the plants, evaluate the consequences and implement corrective actions recommended by the industry.

Forsmark 3 Event.

The NRC staff briefly discussed the recent event at Forsmark 3 Nuclear Power Plant (NPP). On May 30, 2013, Forsmark 3 NPP had an event similar to the Byron station. The plant was in an outage with one incoming feeder from the 400 kV offsite power source. Human error resulted in actuating an open signal to the feeder breaker. Two poles of the three pole breaker opened leaving the third phase closed. This resulted in unbalanced voltage conditions on the plant busses. Motors with phase unbalance protection tripped automatically but some motors were

damaged. The onsite emergency diesel generators (EDGs) did not start automatically as the induced voltage on the open phases was higher than the actuating point for the undervoltage relays. Operators manually separated the safety busses and EDGs started and energized the safety busses after 14 minutes. Offsite power was restored within 40 minutes.

NRC staff indicated that US plants should be analyzed for similar open phase conditions for all modes of plant operation.

LIST OF ATTENDEES IN PERSON
JUNE 27, 2013, MEETING WITH NUCLEAR INDUSTRY, EXTERNAL STAKEHOLDERS
ON BULLETIN 2012-01, "DESIGN VULNERABILITY IN ELECTRIC POWER SYSTEM

Pat Hiland	NRC
Vijay Goel	NRC
Mike Eudy	NRC
Surinder Arora	NRC
Larry Burkhart	NRC
Manny Coman	NRC
Peter Kang	NRC
Amy Snyder	NRC
Gurcharan Matharu	NRC
Bob Fitzpatrick	NRC
Ngola Otto	NRC
Nicole Coleman	NRC
Darrell Murdock	NRC
Prem Sahay	NRC
Brian Bavol	NRC
S.K. Mitca	NRC
Christina Antonescu	NRC
Andrea Russell	NRC
Sheila Ray	NRC
Sergiu Basturescu	NRC
David Misenhimer	NRC
Tanya Mensah	NRC
Bob Daley	NRC
Robert Arrit	EPRI
Wayne Johnson	EPRI
Kati Austgen	NEI
Gordon Clefton	NEI
Scott Greenlee	EXELON
Kirk Robbins	EXELON
John Lockwood	EXELON
Mark Bowman	TVA
Tamatha Womack	TVA
Kim Yon Ho	KHNP

ENCLOSURE 2

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ON BULLETIN 2012-01, "DESIGN VULNERABILITY IN ELECTRIC POWER SYSTEM
(CONTINUED)

George Pannell	AREVA
George Kusic	FIRST ENERGY
John Flaherty	FIRST ENERGY
Mike Brandon	DTE ENERGY
Patricia Campbell	GEH
Don Durkosh	WESTINGHOUSE
Duane Brock	SOUTHERN NUCLEAR
D. Rick Grahm	SOUTHERN NUCLEAR
Charlotte Graham	SOUTHERN NUCLEAR
R. Roy Lyon	SOUTHERN NUCLEAR
Bob Kitchen	DUKE ENERGY
Paull Guill	DUKE ENERGY
Paul Gaffeney	DUKE ENERGY
Paul Colaianni	DUKE ENERGY
Sandhya Madan	MPR
Mohm Malik	MPR
Mohamed Mujtafa	ENTERGY
Mike McAnelly	ENTERGY
Brian McKercher	DOMINION
Francisco Velez	DOMINION
Jana Bergman	SCIENTECH
Roco R Sgarro	PPL
David Sullivan	UNISTAR

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JUNE 27, 2013, MEETING WITH NUCLEAR INDUSTRY, EXTERNAL STAKEHOLDERS
ON BULLETIN 2012-01, "DESIGN VULNERABILITY IN ELECTRIC POWER SYSTEM

Cody Tipton	SOUTHERN NUCLEAR
Russell W. Patterson	PATTERSON POWER ENGINEERS
Larry Parker	STARS ALLIANCE
Mitch Mathews	EXELON GENERATION
Phil Lashley	FIRST ENERGY
Stephen Copeland	LUMINANT
Dan Stiffler	WESTINHOUSE
Steve Franzone	NNP
Hideki Tanaka	MITSUBISHI NUCLEAR ENERGY SYSTEMS
Kevin Lynn	MITSUBISHI NUCLEAR ENERGY SYSTEMS
Jim Rogers	MITSUBISHI NUCLEAR ENERGY SYSTEMS
Jim Peschel	CERTEC CORPORATION
Tim Enfinger	GE HITACHI NUCLEAR ENERGY
Alex Chereskin	PPL NUCLEAR DEVELOPMENT
Tony Sleva	ALTRAN SOLUTION
Chris Georgeson	STPEGS
Charles Karlson	PALO VERDE NUCLEAR GENERATING STATION
Robert Doyle	PALO VERDE NUCLEAR GENERATING STATION
Edvin Kozo	PALO VERDE NUCLEAR GENERATING STATION
Carl Stephenson	PALO VERDE NUCLEAR GENERATING STATION
Stephen Beckman	PALO VERDE NUCLEAR GENERATING STATION
Shawn Simon	INPO
Kenneth J. Caldwell	DUKE ENERGY
Dave Waters	DUKE ENERGY
James E. Stoner	DUKE ENERGY
Gilbert Lowe	FERC
Thanh Luong	FERC
Jake Strasser	XCEL ENERGY
Nader Eldeiry	ENERCON
Steve Franzone	FP&L
Terry McCool	FP&L

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(CONTINUED)

Ray Burski	FP&L
Jack Carter	CBI
Michael Chan	DTE
Rober Kimmic	WEC
John Liu	URS
Gregg Reimers	PG&E
Richard Siekierski	BRUCE POWER
Dennis Sitkowsky	ENTERGY