



**UNITED STATES  
NUCLEAR REGULATORY COMMISSION  
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS  
WASHINGTON, DC 20555 - 0001**

December 17, 2014

Mr. Mark A. Satorius  
Executive Director for Operations  
U.S. Nuclear Regulatory Commission  
Washington, DC 20555-0001

**SUBJECT: DRAFT BRANCH TECHNICAL POSITION 8-9 ON OPEN PHASE CONDITIONS  
IN ELECTRIC POWER SYSTEMS**

Dear Mr. Satorius:

During the 620<sup>th</sup> meeting of the Advisory Committee on Reactor Safeguards, December 4-6, 2014, we reviewed Draft Branch Technical Position (BTP) 8-9, "Open Phase Conditions in Electric Power System." Our Digital Instrumentation & Control Systems Subcommittee also reviewed this matter during a meeting on November 17, 2014. During these meetings we had the benefit of discussions with representatives of the NRC staff, the Nuclear Energy Institute (NEI), and the Electric Power Research Institute (EPRI). We also had the benefit of the documents referenced.

**RECOMMENDATIONS:**

1. BTP 8-9 should be issued, after consideration of the Recommendation below.
2. The staff should require similar protection for onsite power circuits connecting to the high voltage side of a plant transformer, unless the circuit is fully contained in an isolated-phase bus.

**BACKGROUND**

An open phase condition at Byron Station in 2012 drew attention to the fact that nuclear power plants may not detect single-phase faults in the offsite AC power supplies. Such faults can create unbalances in three-phase currents, and these unbalanced currents can damage plant equipment.

Based on the Byron event, the staff issued NRC Bulletin 2012-01, "Design Vulnerability in Electric Power System," requesting licensees to provide information regarding their protection scheme to detect and automatically respond to a single-phase open circuit condition or a high impedance ground fault condition on power circuits that can supply plant safety systems.

The staff's investigation identified eleven other open phase events at operating plants over the past fourteen years. Depending on transformer wiring and loading, such conditions can be difficult to detect, because phase voltage measurements can appear to be normal. Many of the identified events went undetected for several weeks. These findings were sufficient for the staff to conclude that an open phase condition is a credible event of safety significance and must be considered in the electric power system design for nuclear power plants.

The staff now proposes to issue BTP 8-9, which will establish their position vis-à-vis open phase conditions and other faults. The purpose of the BTP is to provide guidance to the staff in reviewing various licensing actions related to electric power system design vulnerability due to open phase conditions in offsite electric power systems. In brief, the draft BTP requires both detection of single- and double-phase faults, alarms to alert the operators, and actuation circuits to separate the faulted source from the plant and to transfer safety-related loads to an alternative source. The draft BTP has been further clarified in a staff letter to NEI dated November 25, 2014.

## **DISCUSSION**

The draft BTP requirements for detection and automatic actuation are clearly defined and well supported. Automatic actuation is required only when an open phase condition signal is coincident with a plant accident signal.

In response to the original bulletin, licensees have been examining approaches to provide reliable detection. Recently, EPRI has developed an elegant and cost-effective method of detection. Analysis and testing show that the system can reliably detect a wide variety of fault conditions.

Licensees are developing procedures to assist operators in identifying and isolating faults. Combined with the effective detection systems, faults should be cleared in minutes, rather than hours, days, or weeks. NEI reported that they require actuation on the open phase signal alone, if a transformer supplies more than one safety bus.

The draft BTP does not require similar protection for onsite power supplies that feed plant transformers. The staff advised us that generator supplies are typically enclosed in grounded isolated-phase bus duct structures that ensure failed conductors will short to ground, which will actuate protective relays. The staff should require the same protection for these onsite supplies as it does for offsite supplies, unless the circuit is fully contained in an isolated-phase bus.

Sincerely,

*/RA/*

John W. Stetkar  
Chairman

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*/RA/*  
John W. Stetkar  
Chairman

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## REFERENCES

1. Branch Technical Position 8-9, "Open Phase Conditions in Electric Power System," Draft Revision 0, May 2014 (ML14057A433)
2. NRC Bulletin 2012-01, "Design Vulnerability in Electric Power System," July 27, 2012 (ML12074A115)
3. Code of Federal Regulations, Title 10, Part 50 Appendix A, "General Design Criteria for Nuclear Power Plants, General Design Criterion 17, Electric Power Systems"
4. Electric Power Research Institute Report 1025772, "Analysis of Station Auxiliary Transformer Response to Open Phase Conditions," June 2012
5. Electric Power Research Institute Report 3002004432, "Interim Report: EPRI Open Phase Detection Method," October 2014
6. Electric Power Research Institute Report 3002003256, "Development and Analysis of a Double Open – Phase Detection Scheme for Various Configurations of Auxiliary Transformers," July 2014
7. Electric Power Research Institute Report 3002000764, "Nuclear Maintenance Application Center: Development and Analysis of an Open Phase Detection Scheme for Various Configurations of Auxiliary Transformers," May 2013
8. Basler Technical Paper, "A Practical Guide for Detecting Single-Phasing on a Three-Phase Power System," October 2002
9. NRR Letter, Subject: "Review of the Regulatory Requirements for Open Phase Condition Detection and Isolation," November 25, 2014 (ML14120A203)