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Sent: Monday, April 29, 2013 11:43 AM
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Subject: APOG Presentation Slides - Electrical Bulletin 2012-01
Attachments: APOG Presentation - Loss of Phase Response (Bulletin 2012-01).pdf

Don – Attached are the slides that we plan to use for the NRC public meeting on 5/1/13 to discuss Electrical Design Bulletin 2012-01. Let me know if you have questions.

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Review of NRC Bulletin 2012-01
Design Vulnerability in Electric Power System

AP1000 Design Center

May 1, 2013

Agenda

- Meeting Objectives
- Overview of Byron Event
- Discussion of AP1000 Design
- Summary

Meeting Objectives

- Describe AP1000 response to loss of phase event
- Demonstrate that a loss of phase event does not present a safety hazard for AP1000
- Review how loss of phase event on AP1000 is:
  – Visible to the plant operator
  – Provides time to implement corrective action

Byron Event

- Unit trip due to under-voltage on 6.9kV buses
  - Caused by broken insulator on one phase of 345 kV offsite power to SAT
- SATs continued to power ESF buses
- Equipment protective devices actuated to prevent damage due to unbalanced overcurrent
- 8 minutes for operators to identify loss of phase
  - SAT feeder breakers opened
  - EDGs started and restored power to ESF buses

Byron Design Vulnerability

- Loss of power instrumentation relied on two-out-of-two logic
  - Voltage monitored on A-B and B-C phase of each ESF bus
- Phase C open circuit not sensed on A-B phase
  - Two-out-of-two logic not met
- Loss of phase events at other stations
  - Undetected since offsite power not normally aligned to plant loads
  - Surveillances did not detect

Impact of Byron Event

- Failure of protection to sense the loss of single phase resulted in:
  - Unbalanced voltage at both ESF buses
  - Trip of several safety-related components
  - Unavailability of onsite electric power system
- Neither the onsite or offsite electric power system was able to perform its intended safety function

AP1000 Design Requirements

- 10 CFR 50.55a(h)(3) and IEEE Std. 603-1991
- Protection systems must automatically initiate protective actions at preset levels
- Protective actions should be completed without manual intervention

Westinghouse AP1000® Electrical System Response to Single Phase Open Circuit Events

(NRC Bulletin 2012-01)

May 1, 2013

Presentation Outline

- Background

- **AP1000** Electrical System Overview
  - Key Differences Between **AP1000** Design and Operating Fleet
  - **AP1000** Plant response to Single Phase Open Circuit Faults

Background

- On July 27, 2012, the NRC issued NRC Bulletin 2012-01, DESIGN VULNERABILITY IN ELECTRIC POWER SYSTEM.
- The document was addressed to holders of operating licenses and combined licenses for nuclear power reactors
- The NRC's stated purpose of issuing this bulletin is to obtain information about the facilities' electric power system designs, in light of the recent operating experience that involved the loss of one of the three phases of the offsite power circuit (single-phase open circuit condition)
- Plant responses due to the NRC in late October 2012.

Background (cont'd)

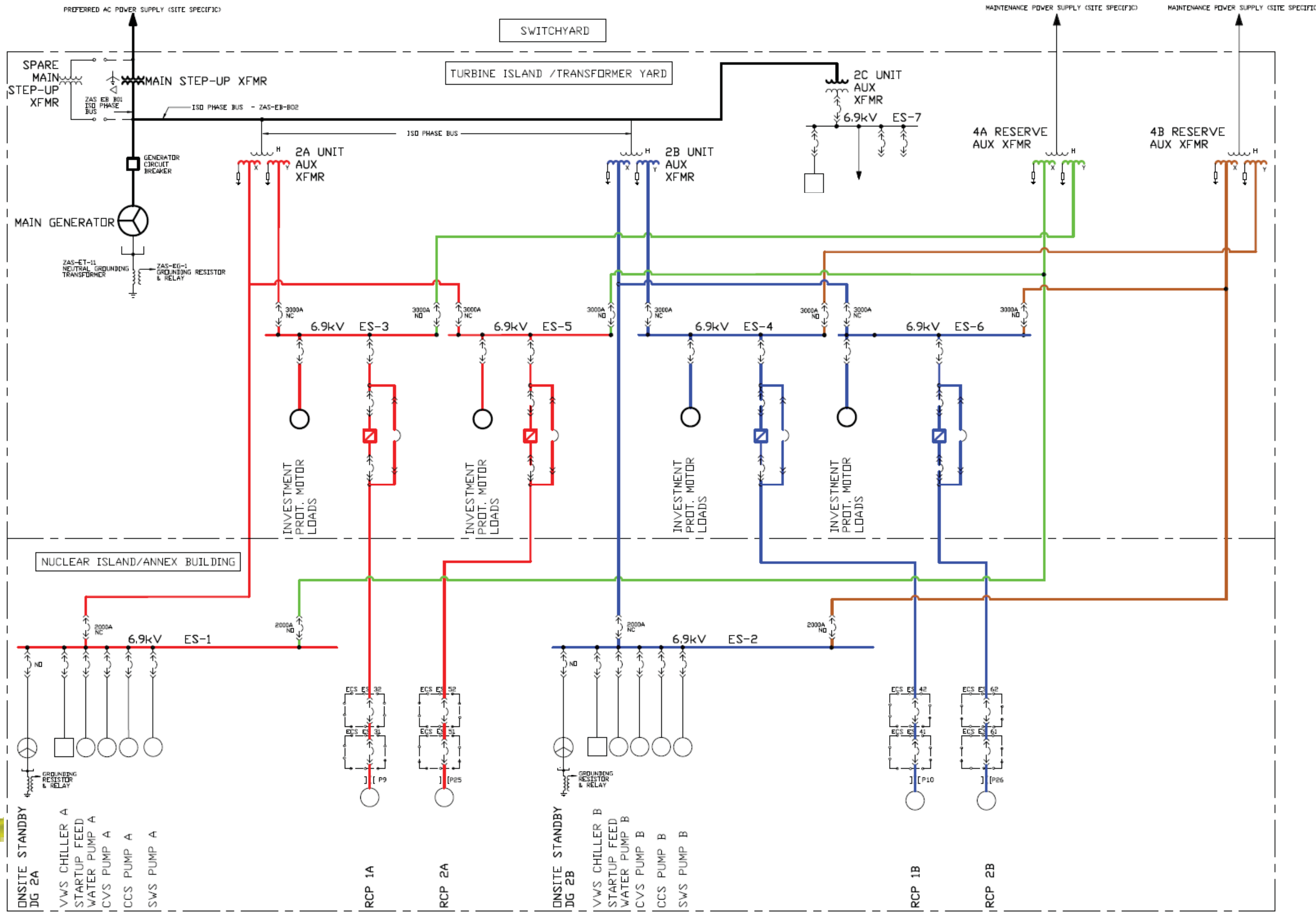
- On August 15, 2012, the NRC issued "Request for Additional Information Letter No. 109 Related to SRP Section 8.3, for the Levy County Nuclear Plant, Units 1 and 2 Combined Licenses Application
- Duke Energy's response was provided on September 14, 2012 via letter NPD-NRC-2012-032
- The information requested in this RAI appears to be closely related to the information requested by the NRC in Bulletin 2012-01
- Subsequent responses sent by Southern Company, SCE&G and FP&L

AP1000 Electrical System Overview

- The Electric Power portion of the **AP1000** standard plant design is comprised of several systems as described in Chapter 8 of the **AP1000** Design Control Document (DCD), Revision 19. These include:
  - **Class 1E and Emergency Power Systems**
    - IDS, Class 1E DC and UPS System
  - **Non-Class 1E Power Systems**
    - ECS, Main AC Power System
    - EDS, Non-Class 1E DC and UPS System
    - ZAS, Main Generation System
    - ZOS, Onsite Standby Power System

- DCD Figure 8.3.1-1 is the AC power system one line diagram showing high voltage and medium voltage interconnections and major equipment configurations.

AC POWER STATION SIMPLIFIED ONE LINE DIAGRAM



AP1000 Electrical System Overview (cont'd)

- The **AP1000** main generator is connected to the generator bus (26 kV) through a generator circuit breaker. The grid is connected to the generator bus through the three single phase main step-up transformers and the grid breaker(s).
- Three unit auxiliary transformers (UATs) are used to step down the generator bus to the seven medium voltage (6.9 kV) electrical buses (ES-1 through ES-7)
- Two reserve auxiliary transformers (RATs) provide an alternate maintenance supply from the grid to the medium voltage buses (ES-1 through ES-6)

AP1000 Electrical System Overview (cont'd)

- During normal plant operation, the main generator supplies power to the grid via the main step-up transformers and to medium voltage buses via the UATs.
- The medium voltage buses provide power to support plant auxiliary systems (including the reactor coolant pumps). This includes 6.9 kV, 480 VAC, and 120 VAC loads and the Class 1E and non-Class 1E UPS interfaces.
- The **AP1000** design enables backfeed from the grid via the main step-up transformers to the UATs with the generator breaker open.

AP1000 Electrical System Overview (cont'd)

- The **AP1000** design features enable the RAT(s) to power the medium voltage buses:
  - A fast bus transfer scheme to automatically transfer a bus from UAT supply to RAT supply on a zone fault
  - A slow bus transfer scheme to automatically transfer a bus from UAT supply to RAT supply in the event the fast bus transfer is not successful
  - UAT to RAT manual operator alignment

AP1000 Electrical System Overview (cont'd)

- The **AP1000** medium voltage buses use an open delta undervoltage sensing scheme that monitors two (2) phase-to-phase conditions to indicate an undervoltage condition.
  - Loss of any Single Phase will result in a dead-bus alarm on a 1 out of 2 monitored logic condition
  - A 2 out of 2 monitored logic condition provides a bus undervoltage alarm
  - A 2 out of 2 monitored logic condition provides bus stripping, DG start and DG output breaker closure
- ES-1 and ES-2 busses automatically realign on some single open phase conditions

Key Differences Between **AP1000** Design and Operating Fleet

- There are no ESF loads powered from the Offsite or Onsite AC power system that is fed directly from offsite AC sources.
  - Class 1E AC Power is isolated from the Offsite and Onsite AC sources by Class 1E isolation.
  - The credited onsite power system is the IDS Class 1E batteries.

- Automatic backfeed of the medium voltage buses via the main step-up transformers following opening of the generator circuit breaker (e.g., generator trip)

- On a total loss of grid (100% load rejection), turbine runback occurs *without* reactor trip and the generator continues to carry house loads

Key Differences Between **AP1000** Design and Operating Fleet (cont'd)

- Majority of the medium voltage and low voltage electrical systems, including the onsite diesel generator portion, are non-Class 1E due to the use of passive safety features.

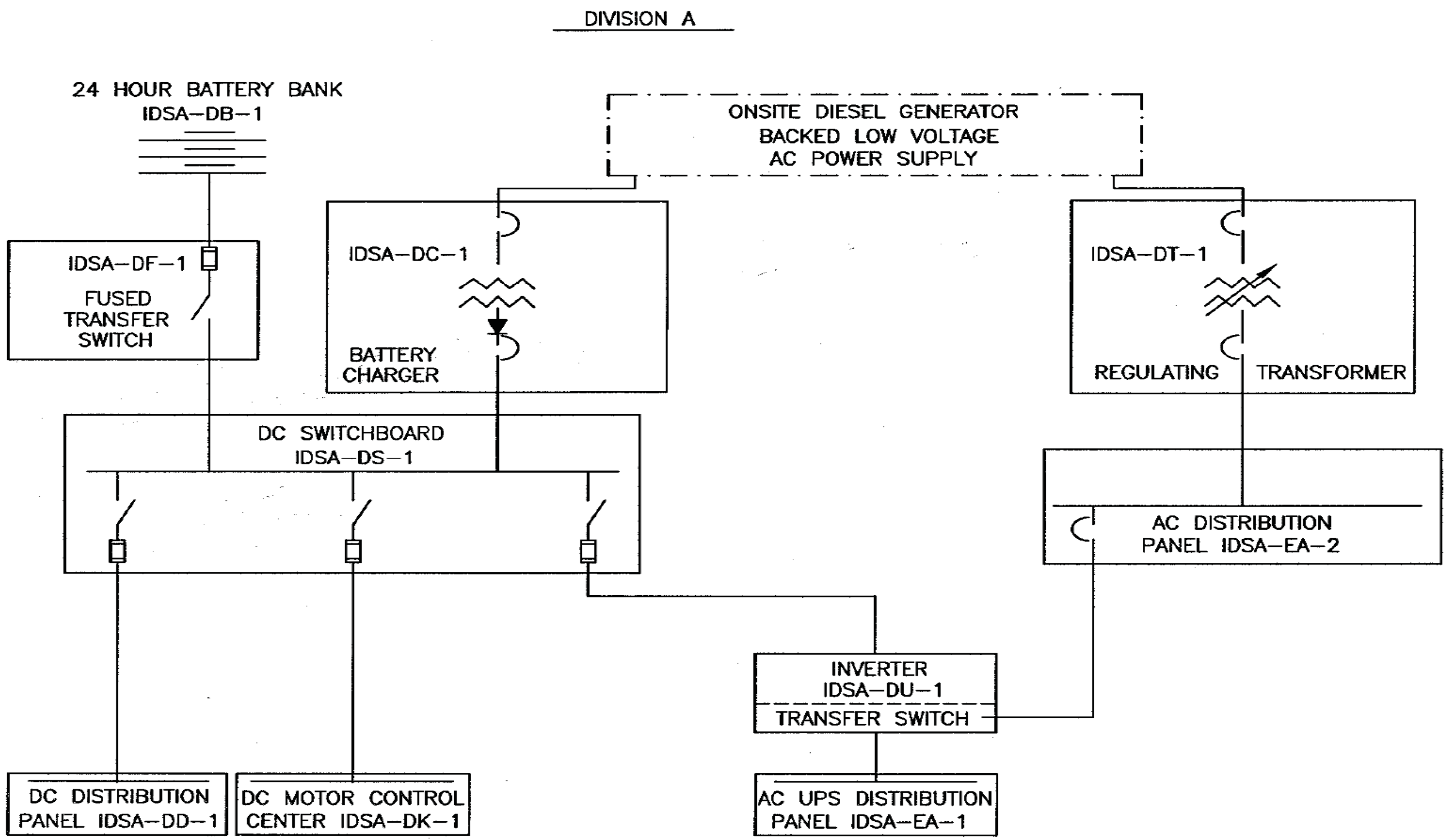
- The only class 1E function of the 6.9 kV reactor coolant pump switchgear is to ensure that these pumps are tripped, as dictated by the plant safety analysis.

  – The reactor coolant pump switchgear Class1E trip signals originate from the reactor protection and ESF system (PMS).

Key Differences Between **AP1000** Design and Operating Fleet (cont'd)

- The non-Class 1E to Class 1E electrical system interface occurs at the 480 VAC interface for IDS UPS equipment (battery charger and/or regulating transformer).
- These critical interfaces provide a Class 1E isolation function, and are not required to provide a source of power during a loss of offsite power.
  - The IDS battery charger receives non-Class 1E power for the support of loads and recharging of the plant batteries *when AC power is available.*

IDS Overview (Typical for Divisions A & D)



Key Differences Between **AP1000** Design and Operating Fleet (cont'd)

- Both the IDS battery charger and the IDS regulating transformer have monitoring features that detect the loss of input phase voltage and automatically isolate the Class 1E system from the non-Class 1E system.
  - Detection of loss of single phase is a common industrial practice at the low voltage level.
  - Operator gets alarms through PMS (e.g., Charger Input U/V, 22 hr. ADS Timer, 10 min MCR Isol Timer)
- The train related regulating transformer provides support for the Class 1E loads when the inverter on any train is unavailable (technical specification action condition – limiting condition of operation).
- The Class 1E batteries are designed for significantly longer load profiles of 24 and 72 hours.

AP1000 Plant Response to Open Phase

- At Power (assuming fault is not cleared)
  - Main Generator Trips (ES-1 & ES-2 backfed from Mains/UAT)
  - Charger Alarms through PMS (Loss of Charger input AC and Timers)
  - Reactor Trips
  - Running Motor Loads on ES-1 & ES-2 trip on individual negative sequence or overcurrent
  - PRHR Cooling is automatically initiated
  - Once loss of phase is diagnosed, ES-1 & ES-2 can be recovered & start-up FWS / RNS placed in service.

AP1000 Plant Response to Open Phase (cont'd)

- Shutdown
  - Running RNS/CCS/SWS pumps would trip on individual overcurrent or negative sequence
  - Charger Alarms through PMS (Loss of Charger input AC and Timers)
  - Operators determine if other train of RNS available.
  - If not…
    - Depending on Mode/RCS condition, place PRHR HX in service or initiate IRWST Injection/Containment Recirculation.
    - Once ES-1 & 2 restored, RNS/CCS/SWS may be placed in service

AP1000 Plant Response to Open Phase (cont'd)

- Consequence of manual transfer to undetected open phase source (e.g., Transfer of an ES bus to the RAT)
  - Running Motor Loads trip on individual negative sequence or overcurrent protection
  - Charger Alarms through PMS (Loss of Charger input AC and Timers)
  - Operators can diagnose prior to transferring other bus
  - Depending on plant mode, PXS system continuously available for core cooling until RNS/CCS/SWS available

Conclusions

- The **AP1000** plant nonsafety related AC electrical system is ***not*** specifically designed to detect and isolate all single-phase open circuit or high impedance ground fault conditions
  - In the case where a medium voltage bus detects an undervoltage condition due to an open phase or a high impedance ground fault, the affected medium voltage bus would separate from the faulted source and be repowered from either the associated RAT or the associated onsite standby diesel generator (ES-1 and ES-2 only).
  - If the fault is not detected by the medium voltage system, the **AP1000** design safety functions would continue to be supported by the passive systems and the onsite safety-related DC power system (IDS) without interruption. Operators would be alerted to the loss and have time to diagnose condition and re-power DiD loads.

Conclusions (cont'd)

- The IDS charger and the IDS regulating transformer have monitoring features that detect the loss of input phase voltage, automatically isolate the Class 1E system from the non-Class 1E system and alert the operator through PMS alarms that a loss of AC power to the Chargers has occurred.

- Some open phase or high impedance ground faults would be detected at ES-1 & 2 by the actuation logic. If not automatically isolated, the running motor loads would be protected from damage by individual negative sequence or overcurrent protection.

- The **AP1000** Electrical Power Systems provide adequate protection from single phase open circuit faults whether they are detected and automatically isolated at the medium voltage level to open the feeder breakers or not. ESF Loads and Passive systems continue to operate uninterrupted.

Conclusions
AP1000 Loss of Phase Event

- Loss of single phase on AP1000 will NOT result in:
  - Unbalanced voltage at ESF buses
  - Trip of safety-related components
  - Unavailability of onsite electric power system
  - Inability of the IDS onsite electric power system to perform its intended safety function