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United States Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555-0001

H. B. ROBINSON STEAM ELECTRIC PLANT, UNIT NO. 2
DOCKET NO. 50-261/ RENEWED LICENSE NO. DPR-23

RESPONSE TO NRC BULLETIN 2012-01: DESIGN VULNERABILITY IN ELECTRIC POWER SYSTEM

Ladies and Gentlemen:

On July 27, 2012, the Nuclear Regulatory Commission issued NRC Bulletin 2012-01: Design Vulnerability in Electric Power Systems to all power reactor licensees and holders of combined licenses for nuclear power reactors. The purpose of this bulletin is to notify Licensees of a recent operating experience concerning the loss of one of the three phases of the offsite power circuit at Byron Station, Unit 2 in order to determine if further regulatory action is warranted. NRC Bulletin 2012-01 requires that each licensee provide a response to the Requested Actions within 90 days of the date of this bulletin. Enclosure 1 provides the response to the Requested Actions.

There are no regulatory commitments contained in this letter.

Please address any comments or questions regarding this matter to W. Richard Hightower, Supervisor - Licensing/Regulatory Programs at (843) 857-1329.

I declare under penalty of perjury that the foregoing is true and correct. Executed on October 25, 2012.

Respectfully,

William R. Gideon
Site Vice President
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IE76
NRR

WRG/msc

Enclosure: Response to NRC Bulletin 2012-01

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H. B. ROBINSON STEAM ELECTRIC PLANT, UNIT NO. 2

RESPONSE – BULLETIN 2012-01

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System Description

Items 2., 1.d, 2.a, 2.c request system information and will be addressed in this section:

> ***2. Briefly describe the operating configuration of the ESF buses (Class 1E for current operating plants or non-Class 1E for passive plants) at power (normal operating condition).***

See Attachment 1, for a simplified one-line diagram.

One ESF bus (E1) receives power under normal conditions from the main generator through a unit auxiliary transformer (UAT). The other ESF bus (E2) receives power under normal conditions from the offsite 115 kV system via a start-up transformer (SUT).

> ***1.d. Describe the offsite power transformer (e.g., start-up, reserve, station auxiliary) winding and grounding configurations.***

See Attachment 2, Table 4 for offsite power transformer winding and grounding configurations.

> ***2.a. Are the ESF buses powered by offsite power sources? If so, explain what major loads are connected to the buses including their ratings.***

For at power (normal operating condition) configurations, one ESF bus (E2) is powered by offsite sources. The offsite power transformer does carry loads (safety and non-safety) during normal operations.

See Attachment 2, Tables 1 and 2 for ESF bus power sources

See Attachment 2, Table 3 for ESF bus major loads.

> ***2.c. Confirm that the operating configuration of the ESF buses is consistent with the current licensing basis. Describe any changes in offsite power source alignment to the ESF buses from the original plant licensing.***

The normal operating condition configurations to the ESF buses have changed from the original plant licensing. The ESF busses are now powered by dedicated station service transformers, rather than a shared transformer supplying an ESF bus and a Balance of Plant (BOP) bus. The upstream 4160 V power supply and the offsite alignment have not changed.

The following at power (normal operating condition) configurations have been confirmed to be consistent with the current licensing basis as described in Technical Specifications Basis for 3.8.1 (AC Sources, Operating) and UFSAR Sections 8.1 and 8.2:

1. Power to one ESF bus (E1) via main generator (UAT)
2. Power to one ESF bus (E2) via 115kV switchyard (SUT)

System Protection

Items 1., 1.a, 2.b, 2.d request information regarding electrical system protection and will be addressed in this section:

> ***1. Given the requirements above, describe how the protection scheme for [Engineered Safety Feature] ESF buses (Class 1E for current operating plants or non-Class 1E for passive plants) is designed to detect and automatically respond to a single-phase open circuit condition or high impedance ground fault condition on a credited off-site power circuit or another power sources. Also, include the following information:***

Per Updated Final Safety Analysis Report (UFSAR) Section 3.1, the General Design Criteria (GDC) in existence at the time the plant was licensed (July, 1970) for operation was contained in Proposed Appendix A to 10CFR50, General Design Criteria for Nuclear Power Plants, published in the Federal Register on July 11, 1967 (Appendix A to 10CFR50, effective in 1971 and subsequently amended, is somewhat different from the proposed 1967 criteria.). The plant was evaluated with respect to the proposed 1967 GDC and the original Final Safety Analysis Report (FSAR) contained a discussion of the criteria as well as a summary of the criteria by groups. The original FSAR did not define degraded voltage as an unbalanced system. As such, the industry failure mode effects analysis (FMEA) (implied or otherwise) did not address an open phase as design. Therefore, open phase detection was not credited in the plant's design or licensing basis.

Consistent with the current licensing basis, existing protective circuitry will separate the ESF buses from a connected failed offsite source due to a loss of voltage or a sustained, balanced degraded grid voltage concurrent with certain design basis accidents. The relay systems were not specifically designed to detect an open single phase of a three phase system.

During normal plant operation, offsite power is aligned as follows:

- Offsite power is aligned to ESF Bus E1 through the Main Transformer (MT), Unit Auxiliary Transformer (UAT), and Station Service Transformer. An open phase on the primary-side of the MT would have no direct effect on ESF bus voltage with the unit on-line since the main generator feeds three phase power to the secondary-side of the MT through the UAT and onto the ESF bus (reference Attachment 1). If the main generator trips from such a condition (possibly due to high negative sequencing currents), the ESF bus and the upstream balance of plant (BOP) buses will automatically transfer to the SUT. Therefore, an open phase on the MT high side while the plant is in normal operation is not of concern.
- Offsite power is aligned to ESF Bus E2 through the Startup Transformer (SUT) and Station Service Transformers. No analysis exists to evaluate the impact of an open phase to the SUT on the ESF bus voltage. The SUT is energized during normal and shutdown operation but is lightly loaded.

Response of the ESF buses, or the response of the main generator to such a condition, was not specifically analyzed for an open phase. As stated above, even in the presence of such a condition, if voltage at the ESF buses degrade to the point of detection by the protective relaying circuitry, the essential buses will be isolated from offsite power (reference Request 1.a, below, for further detail).

High Impedance Ground Fault Conditions

The electrical analyses for off-site circuits have been reviewed with regard to high impedance grounds. The effect of a high impedance ground has been analyzed to be as follows.

SUT (115 kV side) and MT (230 kV side):

The neutral connections of the SUT and the MT windings are solidly grounded. A ground fault between the switchyard circuit breakers and the SUT will be detected by the SUT transformer bus differential relay 87ST, whose function is to isolate the transformer by opening the switchyard Circuit breakers and all the BOP bus supply breakers from the SUT. Similarly, a ground fault between the switchyard circuit breakers and the MT will be detected by the main generator transformer differential relay 87GT, whose function is to isolate the main generator, MT and UAT by opening the switchyard circuit breakers and BOP 4.16 kV bus 1 and 4 supply breakers from the UAT. A high impedance ground fault which does not generate sufficient current to actuate the differential relays, cannot possibly result in a voltage imbalance due to this section of the system being directly connected to the 115 kV or 230 kV grid; the entire grid voltage would have to be distorted (imbalanced) as a result of the high impedance fault, which is not credible. Such a fault cannot be sustained and will rapidly propagate into a full blown ground fault, which will be cleared by the differential relays.

UAT/MT Primary and Isophase Bus (22kV):

The main generator neutral connections of the secondary windings (X and Y) are high resistance grounded via the neutral grounding transformer. With the main generator online, ground fault protection in this portion of the distribution system is provided by the main generator ground detection relay 59N, which monitors the neutral grounding transformer voltage and whose function is to isolate the transformers and lock out the main generator. In the UAT backfeed mode, with the main generator offline and the main generator disconnected, ground detection is still provided on the UAT secondary. The Isophase bus and main transformers are still protected by the 87GT differential relays. Although a ground in this portion of the distribution system while in the backfeed mode can affect line to ground voltages, transformer line to line voltages are not affected. Therefore, a ground in this section of the distribution system cannot result in imbalanced voltages on the 4.16kV buses.

UAT/SUT Secondary Side (4.16 kV):

The neutral connection of the secondary windings (X and Y) of these transformers is high resistance grounded via the neutral grounding transformers. The first ground of any impedance is limited and incapable of producing an imbalance in the transformer secondary voltage. A second ground is effectively a phase to phase short circuit. Ground detection relays (59N) monitor the neutral grounding transformer voltage and provide control room annunciation.

Based on the above, grounds of any impedance value anywhere in the distribution system, including transformer connections to the switchyard circuit breakers, will either be rapidly detected and automatically isolated by ground and/or differential protection relay circuitry or will have no adverse affect with respect to bus voltage imbalance.

1.a. The sensitivity of protective devices to detect abnormal operating conditions and the basis for the protective device setpoint(s).

Consistent with the current licensing basis, existing electrical protective devices are sufficiently sensitive to detect design basis conditions like a loss of voltage or a sustained degraded voltage, but were not specifically designed to detect a single phase open circuit condition at the switchyard. See Attachment 2, Table 5 for undervoltage protective devices and settings.

Existing electrical protective devices are also sufficiently sensitive to detect a high impedance ground fault.

2.b. If the ESF buses are not powered by offsite power sources, explain how the surveillance tests are performed to verify that a single-phase open circuit condition or high impedance ground fault condition on an off-site power circuit is detected.

One ESF bus (E2) receives power under normal conditions from the offsite 115 kV system via the start-up transformer (SUT). The other ESF bus (E1) receives power under normal conditions from the main generator through the unit auxiliary transformer (UAT).

Consistent with Technical Specification Surveillance Requirement (SR) 8.3.1.1, surveillance tests verify proper circuit breaker alignment and power availability for both ESF buses. Operations Surveillance Test OST-022, Weekly Surveillances, verifies, on a weekly basis, proper breaker alignment in the switchyard and the 4.16 kV buses supplying the ESF buses. Additionally the surveillance verifies voltage on all three phases of the 480 V ESF buses is greater than 91% of nominal voltage, as well as the availability of DC control power. The tests are not designed to verify single-phase open circuit conditions.

There are no specific surveillance tests for the detection of high impedance ground fault conditions on the offsite circuit.

2.d. Do the plant operating procedures, including off-normal operating procedures, specifically call for verification of the voltages on all three phases of the ESF buses?

Weekly surveillances, completed per OST-022, require verification of all three phase voltages on the ESF buses to be greater than 91% of nominal voltage. There are no other procedures that require verification of all three phases.

Consequences

Items 1.b, 1.c, 2.e request information regarding the consequences of an event and will be addressed in this section:

> ***1.b. The differences (if any) of the consequences of a loaded (i.e., ESF bus normally aligned to offsite power transformer) or unloaded (e.g., ESF buses normally aligned to unit auxiliary transformer) power source.***

During normal operation power is provided to ESF bus E1 via the UAT powered from the main generator, while ESF bus E2 is powered via the startup transformer. As such, the SUT and UAT are always considered "loaded" during normal operation. During shutdown conditions, both ESF buses are fed from the SUT.

Installed relays were not designed to detect single phase open circuit conditions at an offsite power source. Existing loss of voltage and degraded voltage relays may respond, depending on the location of the open circuit. No formal analysis has been performed to determine the response of the undervoltage protection circuitry to potential open circuit failures. The plant response for a loaded power source cannot be calculated without specifying the amount of loading and the specific loads involved.

> ***1.c. If the design does not detect and automatically respond to a single-phase open circuit condition or high impedance ground fault condition on a credited offsite power circuit or another power sources, describe the consequences of such an event and the plant response.***

A high impedance ground fault will have no immediate effect on plant operation. If the ground is sufficiently large to affect plant operation, protective relaying will isolate the ground automatically.

The Current Licensing Basis (CLB) of the protection scheme for the ESF buses does not address the ability to detect and automatically respond to a single-phase open circuit condition on the credited off-site power source. As such, an open phase fault was not included in the design criteria for either the loss of voltage or the degraded voltage relay scheme design criteria and no design basis calculations or design documents exist that previously considered this condition.

Without formalized engineering calculations or engineering evaluations, the electrical consequences of such an open phase event (i.e., including plant response), can only be evaluated to the extent of a generic overview. To provide more specifics, detailed plant specific models would need to be developed (e.g., transformer magnetic circuit models, electric distribution models operating with unbalanced input power, motor models; including positive, negative, and

Simplified One-Line Diagram

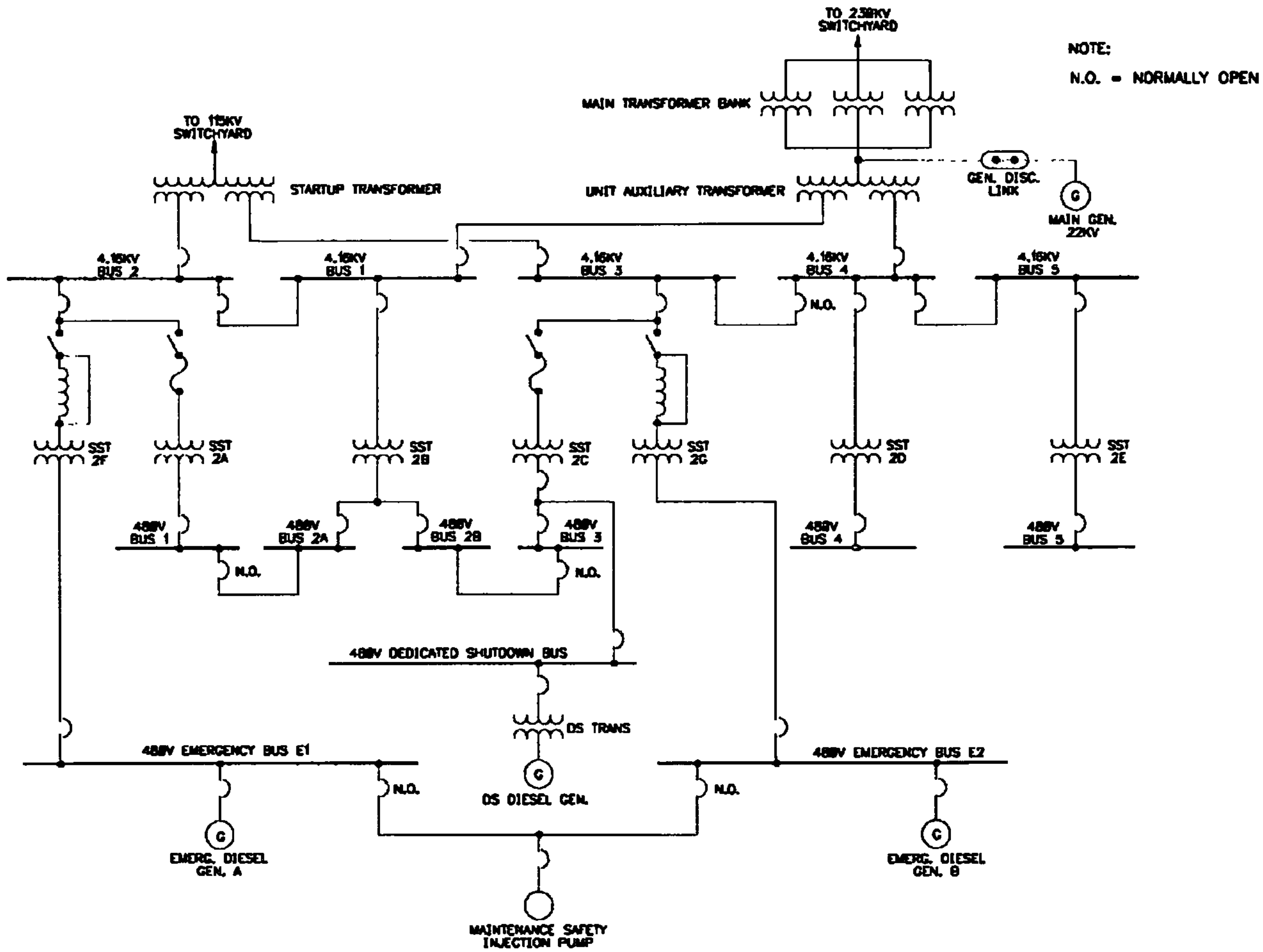

Table 1 - ESF Buses Continuously Powered From Offsite Power Source(s)

Description of ESF Bus Power Source	ESF Bus Name (normal operating condition)	Original licensing basis configuration (Y/N)
115 kV Switchyard via Start-up Transformer (SUT)	480 V Bus E2	No The normal operating condition configurations to the ESF buses have changed from the original plant licensing. The ESF busses are now powered by dedicated station service transformers, rather than a shared transformer supplying an ESF bus and a BOP bus. The upstream 4160 V power supply and the offsite alignment have not changed.

Table 2 - ESF Buses Not Continuously Powered From Offsite Power Source(s)

Description of ESF Bus Power Source	ESF Bus Name (normal operating condition)	Original licensing basis configuration (Y/N)
Main Generator via Unit Auxiliary Transformer (UAT)	480 V Bus E1	No The normal operating condition configurations to the ESF buses have changed from the original plant licensing. The ESF busses are now powered by dedicated station service transformers, rather than a shared transformer supplying an ESF bus and a BOP bus. The upstream 4160 V power supply and the offsite alignment have not changed.

zero sequence impedances (i.e., voltage and currents)) and the models would need to be compiled and analyzed for the plant specific electric distribution system.

> ***2.e. If a common or single offsite circuit is used to supply redundant ESF buses, explain why a failure, such as a single-phase open circuit or high impedance ground fault condition, would not adversely affect redundant ESF buses.***

The normal "at power" operating condition configuration does not have a single preferred offsite circuit supplying both ESF buses since power to one ESF bus (E1) is via the main generator (UAT) and power to the other ESF bus (E2) is via the 115kV switchyard (SUT).

Consistent with the CLB, protective circuitry will separate the ESF buses from a failed offsite source due to a loss of voltage or a sustained balanced degraded grid voltage concurrent with certain design basis accidents. An open phase detection was not credited in the plant design or licensing basis, no design basis calculations or design documents exist that previously considered this condition.

Without formalized engineering calculations or engineering evaluations, the electrical consequences of such an open phase event (including plant response), cannot be evaluated at this time.

Ground faults of any impedance value anywhere in the distribution system, including transformer connections to the switchyard circuit breakers, will either be rapidly detected and automatically isolated by protective relay circuitry or will have no impact on bus voltages.

Interim actions have been taken as a response to IER 2012-14 recommendations. Standing Instruction 12-015, Single Phase Electrical Failures, has been issued to raise awareness of the subject event to plant operators. Site procedure OST-022 has been revised to require weekly visual inspections of the SUT, UAT, and the MT high voltage connections and the electrical path to the associated switchyard. The visual inspections verify physical continuity of all (three) phases between the switchyard and the transformer high voltage connections. Site procedure AOP-026, Grid Instability, was revised to provide operator guidance in diagnosing and responding to open single phase conditions based on observed equipment symptoms.

Table 3 - ESF Buses Normally Energized Major Loads

ESF Bus	Load	Voltage Level	Rating (hp)
E1	Containment Vessel (CV) Recirculation Fan, HVH-1	480 V	350 hp
E1	CV Recirculation Fan, HVH-2	480 V	350 hp
E1	Service Water Pump A, SW-PMP-A	480 V	300 hp
E1	Service Water Pump B, SW-PMP-B	480 V	300 hp
E1	Component Cooling Water Pump B, CCW-PMP-B	480 V	350 hp
E1	Charging Pump B, CHG-PMP-B	480 V	150 hp
E2	CV Recirculation Fan, HVH-3	480 V	350 hp
E2	CV Recirculation Fan, HVH-4	480 V	350 hp
E2	Service Water Pump C, SW-PMP-C	480 V	300 hp
E2	Service Water Pump D, SW-PMP-D	480 V	300 hp
E2	Component Cooling Water Pump C, CCW-PMP-C	480 V	350 hp
E2	Charging Pump C, CHG-PMP-C	480 V	150 hp

Table 4 - Offsite Power Transformers

Transformer	Winding Configuration	MVA Size (AO/FA)	Voltage Rating (Primary/Secondary)	Grounding Configuration
Start-up Transformer (SUT)	Wye-Wye-Wye (3 Leg)	H: 44/49.2 X: 22/24.6 Y: 22/24.6	115/4.16/4.16 kV	H: Solidly Grounded X: High Resist Grounded Y: High Resist Grounded
Unit Auxiliary Transformer (UAT)	Delta-Wye-Wye (3 Leg)	H: 44/49.2 X: 22/24.6 Y: 22/24.6	20.9/4.16/4.16 kV	H: Ungrounded X: High Resist Grounded Y: High Resist Grounded
Main Transformer (MT)	Wye-Delta (Three single phase banks)	990 MVA (330 MVA/Bank)	230kV/21.5 kV	HV(Wye): Solidly Grounded LV (Delta): Ungrounded

Table 5 - Protective Devices

Protection Zone	Protective Device	UV Logic	Setpoint (Nominal)	Basis for Setpoint
480 V ESF Buses E1 & E2	Loss of Voltage Relay	1 of 2	328 V (68.3%) <1 second at 0 V	To actuate upon complete loss of ESF Bus voltage condition
480 V ESF Buses E1 & E2	Degraded Grid Voltage Relay	2 of 3	430 V (89.5%) 10 second time delay	To actuate upon degraded voltage condition