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U S Nuclear Regulatory Commission
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Prairie Island Nuclear Generating Plant Units 1 and 2
Dockets 50-282 and 50-306
Renewed License Nos. DPR-42 and DPR-60

Response to NRC Bulletin 2012-01 "Design Vulnerability in Electric Power System"

On July 27, 2012, the Nuclear Regulatory Commission (NRC) issued Bulletin 2012-01 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML12074A115). Bulletin 2012-01 requested each licensee to submit a written response addressing two issues related to their facility electric power system design within 90 days pursuant to the provisions of 10 CFR 50.54(f).

Northern States Power Company, a Minnesota corporation, doing business as Xcel Energy (hereafter "NSPM"), provides the requested information for the Prairie Island Nuclear Generating Plant (PINGP), Units 1 and 2, in the enclosure to this letter. NSPM submits this information in accordance with the provisions of 10 CFR 50.54(f).

If there are any questions or if additional information is needed, please contact Mr. Dale Vincent, P.E., at 651-388-1121.

Summary of Commitments

This letter contains no new commitments and no revisions to existing commitments.

I declare under penalty of perjury that the foregoing is true and correct.
Executed on OCT 18 2012

Joel P. Sorensen

Joel P. Sorensen
Acting Site Vice President, Prairie Island Nuclear Generating Plant
Northern States Power Company - Minnesota

Enclosures (1)

cc: Administrator, Region III, USNRC
Project Manager, PINGP, USNRC
Resident Inspector, PINGP, USNRC

Enclosure

Response to NRC Bulletin 2012-01, "Design Vulnerability in Electric Power System" for the Prairie Island Nuclear Generating Plant (PINGP) submitted by Northern States Power Company, a Minnesota corporation, doing business as Xcel Energy (hereafter "NSPM"), the licensee

Bulletin Response

Overview:

Attachment 1 - Bulletin Response

- System Description – Bulletin Items 2., 1.d, 2.a, 2.c
- System Protection - Bulletin Items 1., 1.a, 2.b, 2.d
- Consequences - Bulletin Items 1.b, 1.c, 2.e

Attachment 2 - Simplified One-Line Diagram

Attachment 3 - Tables

- Table 1 - Engineered Safety Features (ESF) Buses Continuously Powered From Offsite Paths
- Table 2 - ESF Buses Not Continuously Powered From Offsite Paths
- Table 3 - ESF Buses Major Loads
- Table 4 - Offsite Power Transformers
- Table 5 - Protective Devices

System Description

Bulletin Items 2., 1.d, 2.a, and 2.c request system information and are 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 2 for a simplified one-line diagram.

There are four 345 kV transmission lines that connect PINGP to the offsite transmission grid. The basic scheme used in the two bus 345 kV portion of the substation is the breaker-and-one-half system. The 161 kV portion of the substation is a single bus arrangement. The 161 kV substation is connected to 345 kV Bus 2 by 345/161/13.8 kV No. 10 Transformer. A fifth transmission line connects to the 161 kV bus. These substation features are described in more detail in PINGP Updated Safety Analysis Report (USAR) Section 8.2.1.

PINGP 4 kV ESF buses are connected to the offsite transmission grid through one of four paths as described in USAR Section 8.2.4.1 for Unit 1 and through one of four paths as described in Section 8.2.4.2 for Unit 2. PINGP ESF buses are normally powered directly from the offsite transmission grid and are not connected to the main generator during normal operation.

Two of the paths discussed in the USAR come from the opposite unit transformers through installed bus-tie breakers. The use of these paths requires operator action.

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

See Attachment 3, 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, ESF buses are powered by offsite paths, namely from the following offsite power transformers: 1R Transformer (1R/XFMR); Cooling Tower No. 1 Transformer (CT1/XFMR); Cooling Tower No. 11

Transformer (CT11/XFMR); 2RS Transformer (2RS/XFMR); 2RY Transformer (2RY/XFMR); No. 10 Transformer (10/XFMR); and Cooling Tower No. 12 Transformer (CT12/XFMR). Normally Unit 1 auxiliary non-ESF buses are supplied power by 1M Transformer (1M/XFMR) (which is powered by the Unit 1 generator (1G)). Similarly the Unit 2 auxiliary non-ESF buses are supplied power by 2M Transformer (2M/XFMR) (which is powered by the Unit 2 generator (2G)). Note that offsite power transformers may also be aligned to carry non-safety loads during normal operations (at power).

The 4 kV ESF buses carry normal loads including the Component Cooling pumps and two each 480 V switchgear ESF buses that feed all of the ESF motor control centers (MCC). See Attachment 3, Table 3 for more detail on energized loads.

See Attachment 3, Tables 1 and 2 for ESF bus power sources. See Attachment 3, Table 3 for ESF bus major loads energized during normal power operations, including their ratings.

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 current design basis for offsite paths is contained in Section 8.1 of the USAR which states:

> Each main generator feeds electrical power at 20 KV through its isolated phase bus to the associated Generator Step Up Transformer. The power requirements for station and unit auxiliaries are supplied by a Main Auxiliary Transformer connected to the isolated phase bus, following practices that have been highly satisfactory for fossil fueled and other nuclear units. Auxiliary power for startup, shutdown and normal backup is supplied from Reserve Auxiliary Transformers designated 1R and 2RS. Transformer 1R is the normal backup source for Unit 1 and is connected to the 161kV external power system. Transformer 2RS is the normal backup source for Unit 2 and is connected to the 345kV external power system. Bus ties are provided to allow cross feeding should one transformer be out of service. Redundant offsite power sources are provided of sufficient capacity to supply all critical loads for either or both units. Each ESF bus has a preferred and alternate offsite source consisting of a Reserve Auxiliary Transformer and a Cooling Tower Substation Transformer, respectively. The Cooling Tower Substation sources are not large enough to also serve as a redundant startup source. Emergency backup power, to ensure continuity of supply for critical loads, is supplied from four onsite, quick-start Emergency Diesel Generators. The function of the Auxiliary Electrical System is to provide reliable power to those auxiliaries required during any normal or emergency mode of plant operation. The design of the system is such that sufficient

independence or isolation between the various sources of electrical power is provided in order to guard against concurrent loss of all auxiliary power.

The following at power (normal operating condition) configurations have been confirmed to be consistent with the current licensing basis:

For Unit 1 normal plant operating conditions, there are four possible paths between the offsite transmission grid and the safeguard 4 kV buses which are described in USAR Section 8.2.4.1. Each path is capable of providing the required power to shut down the unit and maintaining it in a shutdown condition. These four paths are as follows:

1. The first path is fed from the 161 kV switchyard bus. This feeds the 1R transformer which in turn supplies power to ESF buses 15 and 16.

2. The second path is fed from the 345 kV switchyard bus 1. This feeds the 345/13.8 kV CT1/XFMR which is connected via an underground cable to the 13.8/4.16 kV CT11/XFMR. The secondary winding of this transformer feeds ESF buses 15 and 16 through breakers CT11-1 and CT11-6.

3. The third path is fed from the 345 kV switchyard bus to transformer 2RS, transformer 2RY, breaker 2RYBT, breaker 12RYBT, breaker 1RYBT and then to ESF buses 15 and 16.

4. The fourth path is fed from the 13.8 kV tertiary winding of the 345/161/13.8 kV 10/XFMR. This 13.8 kV feed supplies underground cable to 13.8/4.16 kV CT12/XFMR. From here is it fed through bus-tie breaker CT-BT112 to breaker CT11-6 and finally to ESF buses 15 and 16.

Likewise for Unit 2 normal plant operating conditions, there are four possible paths between the offsite transmission grid and the safeguard 4 kV buses which are described in USAR Section 8.2.4.2. Each path is capable of providing the required power to shut down the unit and maintaining it in a shutdown condition. These four paths are as follows:

1. The first path is fed from the 345 kV switchyard bus to transformer 2RS, breaker 2RSY, transformer 2RY and then to ESF buses 25 and 26.

2. The second path is fed from the 13.8 kV tertiary winding of the 345/161/13.8 kV 10/XFMR. This 13.8 kV feed supplies underground cable to 13.8/4.16 kV CT12/XFMR. From here it is fed through breaker CT12-6 to ESF buses 25 and 26.

3. The third path is fed from the 161 kV switchyard bus. This feeds the 1R transformer, breaker 1RYBT, breaker 12RYBT, breaker 2RYBT and then to ESF buses 25 and 26.

4. The fourth path is fed from the 345 kV switchyard bus 1. This feeds the 345/13.8 kV CT1/XFMR which is connected via an underground cable to the 13.8/4.16 kV CT11/XFMR. The secondary winding of this transformer feeds breaker CT-BT 112 to breaker CT12-6 and then to ESF buses 25 and 26.

The paths 3 and 4 discussed above come from the opposite unit transformers through installed bus-tie breakers. The use of these paths requires operator action.

See Attachment 3, Table 1 and 2 for changes in the offsite transmission grid path alignment to the ESF buses from the original plant licensing.

System Protection

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

> ***1. Given the requirements above, describe how the protection scheme for 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:***

Consistent with the current licensing basis and Atomic Energy Commission (AEC) General Design Criterion (GDC) 39 (Reference 1), existing protective circuitry will separate the ESF buses from a connected failed offsite path 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. Detection of a single-open phase condition is beyond the approved design and licensing basis of the plant.

The electrical analyses for offsite paths have been reviewed with regard to high impedance grounds. The effect of a high impedance ground has not been analyzed at PINGP. It is not clear what the results would be of a high impedance ground. The results would depend upon the size of the high impedance ground and its location. Regardless of the result, the opposite train of ESF power would be available to provide its safety functions.

The degraded voltage protection scheme at PINGP was not designed to detect and automatically respond to a single-phase open circuit condition on a credited offsite power circuit. However, during normal plant operation (Modes 1, 2, 3 and 4) the Unit 1 ESF buses are powered either from the reserve transformer (1R) or the cooling tower transformer (CT11 through CT1) and the Unit 2 ESF buses are powered either from the reserve transformer (2RY through 2RS) or the cooling tower transformer (CT12 through 10/XFMR tertiary winding). An open phase on the high side of any of these transformers, if not detected and automatically disconnected would only affect the associated train ESF bus power source, that is the other train of ESF power would continue to be available to fulfill required safety functions.

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 and AEC GDC 39 (Reference 1) (USAR Section 8.1), existing electrical protective devices are sufficiently sensitive to detect design basis conditions like undervoltage or degraded voltage, but were not designed to detect a single phase open circuit condition. See Attachment 3, Table 5 for undervoltage protective devices and the basis for the device setpoints. In addition PINGP has loss of voltage relays to determine that residual voltage on a dead bus has decayed to less than or equal to 25% of nominal before a new path is used to energize a dead bus.

Existing electrical protective devices are also sufficiently sensitive to detect a ground fault. Attachment 3, Table 5 lists ground protection devices on the ESF buses and the basis for the device setpoints.

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.

Bulletin Item 2.b is not applicable to PINGP since the ESF buses at PINGP are powered by offsite paths.

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?

PINGP procedures do not require verification of voltage on all three phases of the ESF buses because the plant does not have installed instrumentation to monitor all three phases of voltage. However, current plant operating procedures, including operating procedures for off-normal alignments, require a designated operator in the control room to monitor the three phases of current in both buses to watch for any current imbalance on the buses if both 4 kV ESF trains are fed from the same path (that is, Technical Specification (TS) 3.8.1, "AC Source – Operating", Condition A as required by compensatory measures during the resolution of this design vulnerability). If a current imbalance is observed, the procedures require the offsite path to be tripped so that the emergency diesel generators will automatically start and supply the ESF loads.

Consequences

Bulletin Items 1.b, 1.c, and 2.e request information regarding the electrical consequences of an event and are 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.***

PINGP ESF buses are normally energized from the offsite transmission grid path. However, the installed relays were not designed to detect single phase open circuit conditions. Existing loss of voltage and degraded voltage relays may respond depending on load and possible grounds. 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.***

1. PINGP did not credit in the current licensing basis (CLB) that the Class 1E protection scheme (for the ESF buses) was designed to detect and automatically respond to a single-phase open circuit condition on the credited offsite transmission grid path as described in the USAR and TS.

   The offsite transmission grid path at PINGP consists of two independent paths from the offsite transmission grid to the onsite 4 kV ESF distribution system as specified in TS 3.8.1. Failure of one train would not affect the ability of the other train to perform its safety functions.

2. Since PINGP did not credit the ESF bus protection scheme as being capable of detecting and automatically responding to a single phase open circuit condition, an open phase fault was not included in the design criteria for either the loss of voltage, the degraded voltage relay (DVR) scheme or secondary level undervoltage protection system (SLUPS) design criteria. Since open phase detection was not credited in the PINGP design or licensing basis, no design basis calculations or design documents exist that previously considered this condition.

3. Without formalized engineering calculations or engineering evaluations, the electrical consequences of such an open phase event (including plant response), can only be evaluated to the extent of what has already been published by the Electric Power

Research Institute (EPRI) Technical Report 1025772 (Reference 2) and Basler Electric Company (Reference 3) which is a generic overview. The difficulty in applying these documents to the PINGP specific response is that these are generic assessments and cannot be formally credited as a basis for an accurate response. The primary reason is that detailed plant specific models would need to be developed (for example, transformer magnetic circuit models, electric distribution models, motor models; including positive, negative, and zero sequence impedances (voltage and currents), and the models would need to be compiled and analyzed for the PINGP specific Class 1E electric distribution system).

Since PINGP is not designed to detect a single open phase or a high impedance ground on a single phase of 4 kV ESF power, current plant operating procedures, including operating procedures for off-normal alignments, have been revised incorporating compensating actions so that if both 4 kV ESF buses for a unit are fed from the same path (that is, TS 3.8.1 Condition A as required by compensatory measures during the resolution of this design vulnerability) then a designated operator is stationed in the control room to monitor all three phases of current on both buses to watch for bus current imbalance. If a current imbalance is observed, the path is tripped so that the emergency diesel generators will automatically start and supply the ESF loads.

This design vulnerability has been identified throughout the nuclear industry. Industry meetings have occurred to determine an industry standard and potential solutions for resolution. As of the date of this letter, determination of the best resolution has not been made.

This design vulnerability issue has been entered into the NSPM Corrective Action Program (CAP) for tracking short-term and long-term resolutions at PINGP. The procedure changes discussed above were developed as part of the short-term resolution. Long-term resolution of this design vulnerability issue may require a design modification that would require significant time and funding.

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.

Bulletin Item 2.e is not applicable since PINGP does not use a common or single offsite circuit to supply redundant ESF buses under normal conditions. If both ESF buses are fed from the same path, PINGP is operating under TS 3.8.1 Condition A as required by compensatory measures during the resolution of this design vulnerability. In this event the operating procedures have been revised to include defense in depth to verify the remaining paths are viable. In particular, a designated operator is stationed at the main control room G-Panel to monitor electrical current in each of the three phases of the ESF 4 kV buses which are fed from the offsite path and isolate the path if the currents become unbalanced.

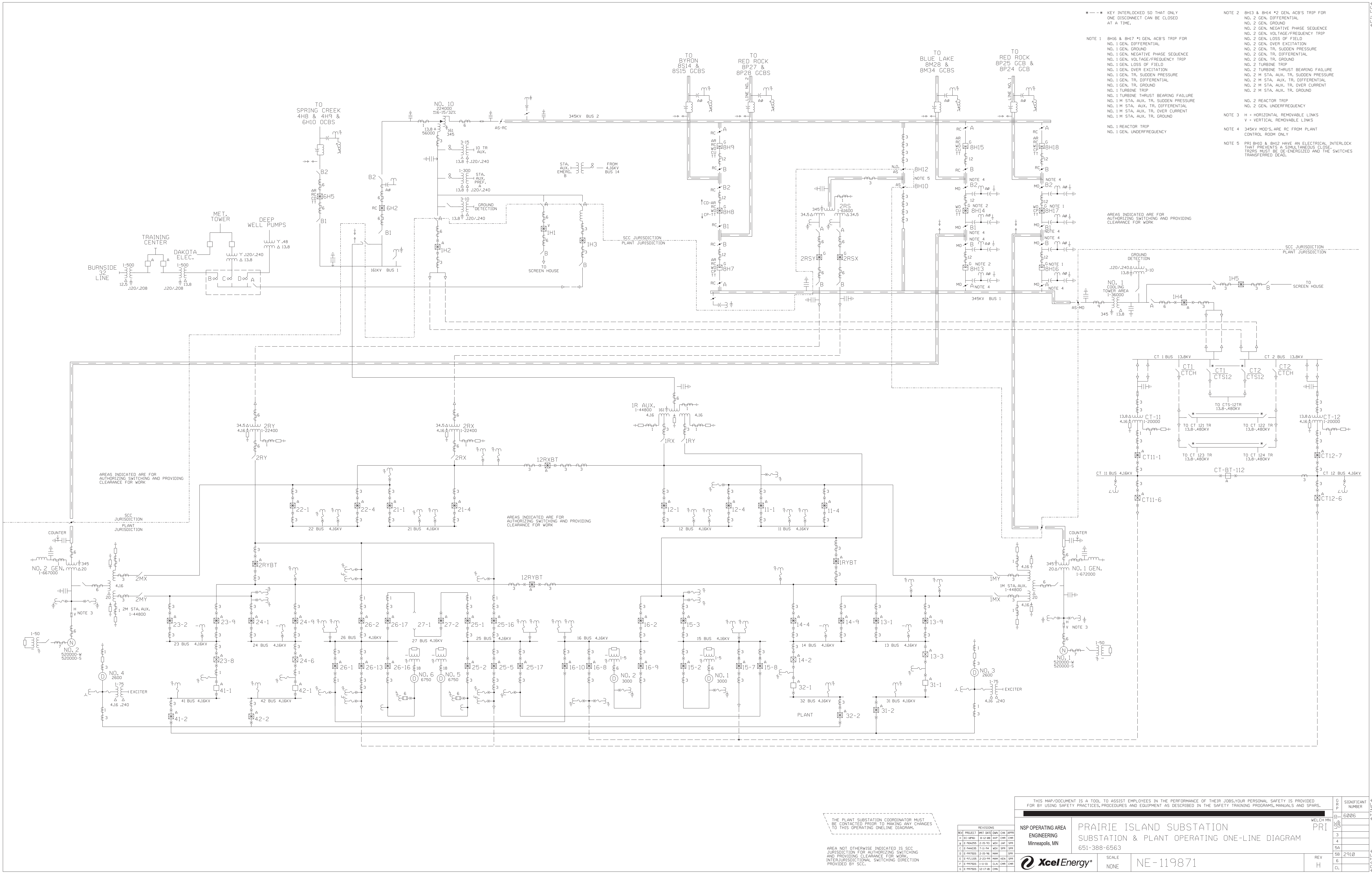
References:

1. AEC "General Design Criteria for Nuclear Power Plant Construction Permits," Criterion 39, issued for comment July 10, 1967.

2. Electric Power Research Institute Technical Report 1025772, "Analysis of Station Auxiliary Transformer Response to Open Phase Conditions", Technical Update, June 2012.

3. "A Practical Guide for Detecting Single-Phasing on a Three-Phase Power System", by John Horak and Gerald F. Johnson, Basler Electric Company, October 2002.

Attachment 2
Simplified One-Line Diagram



Attachment 3 - Tables

Table 1 - ESF Buses Continuously Powered From Offsite Paths

Description of ESF Bus Power Source	ESF Bus Name (normal operating condition)	Original licensing basis configuration (Y/N)
1R/XFMR (RY secondary winding)	Bus 15	N Note 1
CT11/XFMR	Bus 16	Y
2RY/XFMR	Bus 25	N Notes 1 and 2
CT12/XFMR	Bus 26	Y Note 2

Note 1: Modification 79YB81 added 2RS, 2RY, and 2RX transformers as well as reconfiguration of associated bus work. 1M/XFMR, 2M/XFMR, and 1R loads were also reconfigured per Modification 79YB81. Thus ESF buses were no longer fed from the auxiliary transformers.

Note 2: Modification 89Y976 relocated Bus 25 and Bus 26 to a new building. As part of this change Bus 26, which was originally identified as an A-Train ESF bus, was changed to B-Train. Bus 26 was normally fed by the offsite path from CT12/XFMR before and after implementation of modification 89Y976. Similarly, Bus 25 was changed from B-Train to A-Train. Bus 25 was normally fed from 2RY/XFMR before and after implementation of modification 89Y976.

Table 2 - ESF Buses Not Continuously Powered From Offsite Paths

Description of ESF Bus Power Source	ESF Bus Name (normal operating condition)	Original licensing basis configuration (Y/N)
N/A	N/A	N/A
N/A	N/A	N/A

Table 3 - ESF Buses Normally Energized Major Loads

ESF Bus	Load	Voltage Level	Rating (HP)
Bus 15 (A-Train 4160 V)	11 Component Cooling Pump	4160 Volt	250
Bus 15 (A-Train 4160 V)	111M XFMR (4160/480) Bus 111 (480V ESF)	4160 Volt	1000 kVA
Bus 15 (A-Train 4160 V)	112M XFMR (4160/480) Bus 112 (480V ESF)	4160 Volt	1000 kVA
Bus 16 (B-Train 4160 V)	12 Component Cooling Pump	4160 Volt	250
Bus 16 (B-Train 4160 V)	121M XFMR (4160/480) Bus 121 (480V ESF)	4160 Volt	1000 kVA
Bus 16 (B-Train 4160 V)	122M XFMR (4160/480) Bus 122 (480V ESF)	4160 Volt	1000 kVA
Bus 25 (A-Train 4160 V)	21 Component Cooling Pump	4160 Volt	250
Bus 25 (A-Train 4160 V)	211M XFMR (4160/480) Bus 211 (480V ESF)	4160 Volt	1000 kVA
Bus 25 (A-Train 4160 V)	212M XFMR (4160/480) Bus 212 (480V ESF)	4160 Volt	1000 kVA
Bus 26 (B-Train 4160 V)	22 Component Cooling Pump	4160 Volt	250
Bus 26 (B-Train 4160 V)	221M XFMR (4160/480) Bus 221 (480V ESF)	4160 Volt	1000 kVA
Bus 26 (B-Train 4160 V)	222M XFMR (4160/480) Bus 222 (480V ESF)	4160 Volt	1000 kVA

Table 4 - Offsite Power Transformers

Transformer	Winding Configuration	MVA Size (AO/FA/FA)*	Voltage Rating (Primary/Secondary)	Grounding Configuration
1R RES AUX XFMR 1R/XFMR	WYE-WYE-WYE	24/32/40 (at 55°C)	161/4.16/4.16	Solid ground/low resistance ground/ low resistance ground (1.6Ω)
No. 1 CLG TWR AREA XFMR CT1/XFMR	WYE-DELTA	36/40	345/13.8	Neutral low resistance ground
No. 11 CLG TWR AREA XFMR CT11/XFMR	DELTA-WYE	12/16/20 (at 55°C)	13.8/4.16	Neutral low resistance ground
No. 12 CLG TWR AREA XFMR CT12/XFMR	DELTA-WYE	12/16/20 (at 55°C)	13.8/4.16	Neutral low resistance ground
2RS RES AUX XFMR 2RS/XFMR	WYE-DELTA-DELTA	33/44/55 16.5/22/27.5 16.5/22/27.5	345/34.5/34.5	Neutral low resistance ground
2RY RES AUX XFMR 2RY/XFMR	DELTA-WYE	12/16/20 (at 55°C)	34.5/4.16	Neutral low resistance ground (2RY/GND RES)
2RX RES AUX XFMR 2RX/XFMR	DELTA-WYE	12/16/20 (at 55°C)	34.5/4.16	Neutral Low resistance ground (2RX/GND RES)
No. 10/XFMR 10/XFMR	WYE- WYE-DELTA (3 leg with tertiary)	120/160/200 (at 55°C)	345/161/13.8	Neutral solid ground (primary)/ no ground on tertiary or secondary WYE

* Air cooled/forced air/forced air

Table 5 - Protective Devices

Protection Zone	Protective Device	UV Logic	Setpoint (Nominal)	Basis for Setpoint
4 kV ESF Buses 15, 16, 25, and 26	Four Loss of Voltage Relays for each bus	Modified 2 of 2	1040 V (25% of 4160 V)	The loss of voltage relay setting is 25% to verify that the bus is dead and that the residual voltage from previously energized motors is decayed to a safe level before reenergizing the bus with a new source.
4 kV ESF Buses 15, 16, 25, and 26	Four Undervoltage Relays for each bus	Modified 2 of 2	3120 V (75% of 4160 V)	The undervoltage setpoint is 75 ± 2.5% with a time delay of 4 ± 1.5 seconds.
4 kV ESF Buses 15, 16, 25, and 26	Four Degraded Grid Relays for each bus	Modified 2 of 2	3973 V (95.5% of 4160 V)	The Technical Specification requires that the degraded voltage relays operate within -0.7% and +0.7% of the trip setpoint of 95.5% nominal bus voltage Degraded voltage Allowable Value > 3944 V and < 4002 V with a degraded voltage time delay of 8 ± 0.5 seconds and degraded voltage diesel generator start time delay of 7.5 to 63 seconds (Reference TS SR 3.3.4.3).
4 kV ESF Buses 15, 16, 25, and 26	Ground Protection Relay (51G-1)	NA	180 A (primary) 6 A (relay)	The ground relay current transformer encompasses all three phase conductors and detects only ground fault current. The setting should coordinate with the source relays and the transformer damage curve. The settings will be kept low so that a ground fault with high impedance will be picked up by the relay. The transformers are connected delta-wye, so the ground relay does not need to coordinate with the 480 V source breaker.