POWER AUTHORITY OF THE STATE OF NEW YORK

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May 30, 1980
IPN-80-53

Director of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Attention: Mr. Steven A. Varga, Chief
Operating Reactors Branch No. 1
Division of Operating Reactors

Subject: Indian Point 3 Nuclear Power Plant
Docket No. 50-286
Degraded Grid Voltage and Adequacy of Station Electric Distribution Systems Voltages

Dear Sir:

Pursuant to your letter dated August 8, 1979 and our letter dated February 11, 1980 (IPN-80-16), we are providing supplementary information in the attachment to this letter on the above subject for Indian Point 3.

Very truly yours,

Paul J. Early
Vice President and
Assistant Chief Engineer-Projects

cc: Mr. T. Rebelowski
Resident Inspector
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ATTACHMENT

DEGRADED GRID VOLTAGE AND ADEQUACY OF STATION
ELECTRIC DISTRIBUTION SYSTEMS VOLTAGES

POWER AUTHORITY OF THE STATE OF NEW YORK
INDIAN POINT 3 NUCLEAR POWER PLANT
DOCKET NO. 50-286
MAY 29, 1980

Question 1: "Review the electric power systems to determine analytically if, assuming all onsite sources of AC power are not available, the offsite power system and the onsite distribution system is of sufficient capacity and capability to automatically start as well as operate all required safety loads."

Response 1: In our previous response dated August 29, 1977, we demonstrated the capacity and capability of our offsite power system to auto start and operate our safety loads. Sections lb, lc & lf of that response are now modified to meet the NRC guidelines for voltage drop calculations and changes in system conditions and are included in this submittal as la, lb & lc.

Since the 13.8kV power supply is considered an alternate back-up offsite supply to 480V buses 2A, 3A, 5A & 6A, the voltage drop calculations required for the normal offsite power supply (138kV) were performed for the 13.8kV system. This case is included in la of the modified responses.

Question 1a: "The voltage used to describe the grid distribution system is usually "nominal" value. Define the normal operating range of your grid system voltage and the corresponding voltage values at the safety related buses and equipment."

Response 1a: The normal operating range of the voltages at the Buchanan Substation buses are 347 to 358kV for the 345kV system and 136 to 142kV for the 138kV system. Table 1 lists the corresponding voltages at safety buses and at the terminals of our safety loads. These results are very conservatively based on a maximum plant auxiliary load of 37MW with the unit at power and all station loads assumed to be fed from the station auxiliary transformer.

The motor voltage drops are based for running on full load current and for starting on locked rotor current as specified by the equipment manufacturer.

Selected safety related motor operated valves were chosen for this study. The following criteria was used as a basis for selection of those valves with the greatest voltage drop from the MCC to the MOV terminals:

- Valves with the largest motor sizes
- Valves with high locked rotor current
- Valves with high cable impedance.

Table 1

Full Plant Load Including All Safeguards Are Supplied from the 138kV Offsite Power Supply

138kV Bus Voltage		136kV to 141kV	
6.9kV Bus 1, 2, 3, 4, 5 & 6 Voltages		6.9kV	(Held by Automatic LTC)

Bus 2A	.944 PU	453 Volts	
	Running	Starting	Required Voltage
Component Cooling Pump 32	447	413	368*
Safety Injection Pump 32	448	424	352*
Containment Recir. Fan 32	442	384	352*
Service Water Pump 32	436	374	352*

Bus 3A	.960 PU	461 Volts	
	Running	Starting	Required Voltage
Residual Heat Removal Pump 31	457	439	368*
Containment Recirc. Fan 34	451	400	352*
Service Water Pump 35	452	408	352*
Service Water Pump 38 (Back-Up)	452	412	352*
Charging Pump 32	457	436	393**
Auxiliary Feedwater 31	456	433	352*

Bus 5A	.944 PU	453 Volts	
	Running	Starting	Required Voltage
Component Cooling Pump 31	448	420	368*
Safety Injection Pump 31	449	429	352*
Recirc. Pump 31	443	401	352*
Containment Spray Pump 31	448	422	368*
Containment Recirc. Fan 31	445	400	352*
Containment Recirc. Fan 33	445	400	352*

Table 1 (Cont'd.)

Bus 5A	.944 PU	453 Volts	
	Running	Starting	Required Voltage
Service Water Pump 31	445	407	352*
Service Water Pump 34	443	400	352*
Service Water Pump 37	444	405	352*
Charging Pump 31	449	424	393**

Bus 6A	.950 PU	456 Volts	
	Running	Starting	Required Voltage
Component Cooling Pump 33	449	403	368*
Residual Heat Removal Pump 32	451	426	368*
Safety Injection Pump 33	451	427	352*
Recirc. Pump 32	446	403	352*
Containment Spray Pump 32	450	423	368*
Containment Recirc. Fan 35	444	385	352*
Service Water Pump 33	448	410	352*
Service Water Pump 36	447	407	352*
Service Water Pump 39 (Back-Up)	447	408	352*
Charging Pump 33	451	421	393**
Auxiliary Feedwater 33	449	410	352*

MCC 36A (Fed from Bus 5A)	.930 PU	446 Volts	
	Running	Starting	Required Voltage
Motor Operated Valve 730	443	432	308
Motor Operated Valve 746	422	409	308
Motor Operated Valve 747	425	413	308
Motor Operated Valve 894A	440	419	317
Motor Operated Valve 894C	439	414	317

MCC 36B (Fed from Bus 6A)	.936 PU	449 Volts	
	Running	Starting	Required Voltage
Motor Operated Valve 894B	442	416	343
Motor Operated Valve 894D	440	410	317
Motor Operated Valve 731	446	433	308
Motor Operated Valve 899A	428	415	308
Motor Operated Valve 899B	426	413	308

MCC 36C (Fed from Bus 2A)	.920 PU	442 Volts

* Voltage values refer to .8PU of the motor voltage rating. Calculations were performed to determine starting torque at this voltage. Since the actual starting voltage is higher for the motors listed, it was not necessary to determine the absolute minimum starting voltage.

** Minimum starting voltage to develop required starting torque.

Response 1a: (Cont'd.) The 13.8kV backup preferred power supply from Buchanan can be used to supply buses 2A, 3A, 5A & 6A. The voltage at Buchanan is maintained by automatic load tap changers and ranges from 14.1kV to 13.7kV depending on load. The running and startup voltages are listed in Table 2. The calculations were made considering the lowest voltage at the Buchanan 13.8kV Substation.

Table 2

All Safeguards Are Supplied from the 13.8kV Offsite Power Supply

13.8kV Bus Voltage	.993 PU	13.7kV	
6.9kV Bus 2, 3, 5 & 6	.971 PU	6.70kV	
Bus 5A	.913 PU	438 Volts	
	Running	Start Up	Required Voltage
Component Cooling Pump 31	433	406	368*
Safety Injection Pump 31	434	415	352*
Recirc. Pump 31	428	387	352*
Containment Spray Pump 31	433	408	368*
Containment Recirc. Fan 31	430	387	352*
Containment Recirc. Fan 33	430	387	352*
Service Water Pump 31	429	394	352*
Service Water Pump 34	428	387	352*
Service Water Pump 37	429	392	352*
Charging Pump 31	434	410	393**
Bus 6A	.919 PU	441 Volts	
	Running	Start Up	Required Voltage
Component Cooling Pump 33	434	390	368*
Residual Heat Removal Pump 32	436	413	368*
Safety Injection Pump 33	436	413	352*
Recirc. Pump 32	431	390	352*
Containment Spray Pump 32	435	409	368*

Table 2 (Cont'd.)

Bus 6A	.919 PU	441 Volts	
	Running	Start Up	Required Voltage
Containment Recirc. Fan 35	429	373	352*
Service Water Pump 33	432	397	352*
Service Water Pump 36	432	394	352*
Service Water Pump 39	432	394	352*
Charging Pump 33	435	407	393**
Auxiliary Feedwater 33	433	397	352*
MCC 36A (Fed from Bus 5A)	.899 PU	432 Volts	
	Running	Start Up	Required Voltage
Motor Operated Valve 730 (MOV)	428	418	308
Motor Operated Valve 746	407	395	308
Motor Operated Valve 747	409	399	308
Motor Operated Valve 894A	426	405	317
Motor Operated Valve 894C	423	400	317
MCC 36B (Fed from Bus 6A)	.905 PU	434 Volts	
	Running	Start Up	Required Voltage
Motor Operated Valve 894B (MOV)	426	403	343
Motor Operated Valve 894D	425	396	343
Motor Operated Valve 731	431	418	308
Motor Operated Valve 899A	412	402	308
Motor Operated Valve 899B	410	399	308
MCC 36C (Fed from Bus 2A)	.909 PU	436 Volts	
Bus 2A	.913 PU	438 Volts	
	Running	Starting	Required Voltage
Component Cooling Pump 32	432	400	368*
Safety Injection Pump 32	433	410	352*
Containment Recir. Fan 32	426	371	352*
Service Water Pump 32	421	362	352*
Bus 3A	.929 PU	446 Volts	
	Running	Starting	Required Voltage
Residual Heat Removal Pump 31	442	425	368*
Containment Recirc. Fan 34	436	387	352*

Table 2 (Cont'd.)

Bus 3A	.929 PU	446 Volts	
	Running	Starting	Required Voltage
Service Water Pump 35	436	395	352*
Service Water Pump 38	437	399	352*
Charging Pump 32	442	422	393**
Auxiliary Feedwater 31	441	419	352*

* Voltage values refer to .8PU of the motor voltage rating. Calculations were performed to determine starting torque at this voltage. Since the actual starting voltage is higher for the motors listed, it was not necessary to determine the absolute minimum starting voltage.

** Minimum starting voltage to develop required starting torque.

Question 1b: "The transformers utilized in power systems for providing the required voltage at the various system distribution levels are normally provided with taps to allow voltage adjustment. Provide the results of an analysis of your design to determine if the voltage profiles at the safety related buses are satisfactory for the full load and no load conditions on the system and the range of grid voltages."

Response 1b: 138kV Offsite Power Supply - For the full load condition on the station buses and the lowest nominal 138kV grid voltage (136kV) the station auxiliary transformer with their load tap changers will maintain 1.0 per unit voltage on the 6.9kV station buses. Corresponding voltage values at the safety related buses and equipment are identified in the response to item la.

For the highest nominal grid voltage (142kV) with no load on the station buses the station auxiliary transformer with their load tap changers will maintain 1.0 per unit voltage on the 6.9kV station buses. The 480 volt switchgear and motor control center voltages will also be maintained at 480 volts (one (1) per unit). The nominal upper range for 440 volt equipment is 484 volts.

13.8kV Offsite Power Supply - The 13.8kV backup preferred power supply system maintains the voltage at Buchanan at or below 14.1kV by means of load tap changers. The analysis for all safeguards supplied from the 13.8kV source is shown in Table 2. At no load the maximum 480 volt system voltage will be 1.02 per unit or 490 volts. Prior to any loads being connected this voltage is 1.4% above the nominal upper range. However, when load is applied, the voltage will drop. The overvoltage would have negligible effect on equipment life and will not cause equipment damage.

Question 1c: "Assuming operation on offsite power and degradation of the grid system voltage, provide the voltage values at the safety related buses corresponding to the maximum value of grid voltage and to the degraded grid voltage corresponding to the undervoltage trip setpoint."

Response 1c: The load on each of the six (6) 6.9kV buses (including station service transformer feeds to 480 volt safeguard buses 2A, 3A, 5A and 6A) is tripped by a CV-7 inverse time undervoltage relay set at 81% (5580 volts); minimum trip time is 31 seconds (relay plus auxiliary timer). Theoretically, if we assume this voltage on the 6.9kV buses, the voltages on the safety related buses will be 353 volts (.735 per unit) at 480 volt switchgear 2A, 363 volts (.757 per unit) at 480 volt switchgear 3A, 353 volts (.735 per unit) at 480 volt switchgear 5A, 357 volts (.743 per unit) at 480 volt switchgear 6A, 344 volts (.717 per unit) at 480 volt motor control center 36A, 348 volts (.726 per unit) at 480 volt motor control center 36B and 350 volts (.730 per unit) at 480 volt motor control center 36C.

However, it must be recognized that this is not a credible condition and no conceivable contingency on the offsite grid system could result in sustained voltage conditions as low as these.

Degraded Grid Voltage Condition

The worst 138kV degradation would result if Buchanan 345/138kV transformer TA5 is lost coincident with loss of 138kV feeder 96952 and associated Millwood 345/138kV transformer TA1. The Buchanan North 345kV voltage would be 1.04 per unit immediately after these losses. Generator voltage regulator response would immediately restore the generator terminal voltage to normal and

Response 1c: (Cont'd.)

buses 2A and 3A will return to .944 and .960 as shown in Table 1. The Buchanan 138kV voltage will be .945 per unit. The station auxiliary transformer tap changer will adjust the voltage on buses 5 and 6 to one (1) per unit and the voltage on the 480 volt system will be the same as in Table 1.

Maximum Grid Voltage Condition

The maximum 138kV grid voltage on a contingency is 145.7kV. At no load the 6.9kV bus voltage would rise to 1.029 per unit. The resulting motor control center voltages would also rise 2.9% from nominal to 494 volts. This is 2.2% above the nominal upper range for the 440 volt equipment. It must be recognized that as load is applied the voltage will drop within the acceptable upper voltage tolerance level. The overvoltage would have a neglibible effect on equipment life and will not cause equipment damage.

Question 2: "Assuming the loss of all onsite power, demonstrate that the distribution system is designed to automatically initiate all safety loads without the need for manual shedding of any electric loads in the event of (1) an anticipated transient (such as a unit trip) or (2) an accident (such as LOCA)."

Response 2: The electric power system has adequate capacity to automatically initiate all required safety loads for a LOCA and a safe unit shutdown without the need for manual shedding of any electric loads since the transformer from the 138kV preferred power supply is rated at 20 MVA while the minimum required LOCA loads are approximately 4 MVA.

The electric power system has adequate voltage at the equipment terminals to automatically initiate all required safety loads for a LOCA and a safe unit shutdown without the need for manual shedding of any electric loads since we examined the double contingency which produces the lowest 138kV grid voltage, .945 per unit, which resulted in satisfactory voltages on the 480 volt system as shown in Response 1c. A unit trip at Indian Point No. 3 would only reduce the 138kV grid voltage to 1.018 per unit. The loads in our analysis are the worst case (LOCA) loads on the 480 volt system.

Question 3: "Protection of safety loads from undervoltage conditions must be designed to provide the required protection without causing voltages in excess of maximum voltage ratings of safety loads and without causing spurious separations of safety buses from offsite power."

Response 3: Our response to Question 1 shows the maximum and minumum voltages which will be applied to our safety equipment and demonstrate that the required protection is provided without causing voltages in excess of maximum voltage ratings of safety loads.

The following is a description of the voltage relays and the standard operations performed.

Each of the four (4) 6.9kV buses (1,2,3 & 4) normally fed from the generator output has an SV type instantaneous undervoltage relay set at 75% (5175V). Operation of any two (2) of the four (4) relays (when above 10% reactor power level) initiates a reactor scram after a 18 cycle delay. This will transfer buses 1 & 2 via bus 5 to the 138kV grid and buses 3 & 4 via bus 6 to the 138kV grid.

In addition, each of the six (6) 6.9kV buses has a CV-7 inverse-time undervoltage relay set at 81% (5580V), with a minimum trip time (voltage declines to zero) of 31 seconds.

The CV-7 relay will automatically strip all associated loads on the 6.9kV bus including the station service transformer supplying the 480V safeguard bus (failure of any one relay would affect only its associated bus).

Each of the four (4) 480V safeguard buses is equipped with CV-7 inverse-time undervoltage relays set at 46% (220V) which automatically strip their associated loads (except safeguard MCC 36A, 36B

Response 3: (Cont'd.)

and 36C) after a minimum delay of 120 cycles (voltage declines to zero). The above relays are used for starting the emergency diesel generators and sequencing required loads. Transient disturbances on the grid or the 6.9kV system (faults, etc.) which could produce 480V bus voltages approaching zero will be cleared in less than 39 cycles. For this condition the undervoltages relays on the 6.9kV buses are set at 31 seconds which is 48 times longer than the 39 cycle protection. This large margin will prevent spurious separations of safety buses from offsite power.

In addition, we will install on each of the 480V safeguard buses two (2) redundant qualified relays to trip the service transformer feeder and isolate the 480V buses under degraded voltage conditions. The proposed undervoltage protection will be Class 1E, meet IEEE 279-1971 and have coincident logic. The proposed settings is .8PU for 60 seconds. The .8PU setpoint is equivalent to a .86 setpoint on the 6.9kV bus when the 480V buses are loaded.

Industry standards and operating experience have shown this setting would protect equipment while minimizing spurious trips from transient grid disturbances and the starting of large motors on the 6.9kV buses.

In accordance with our previous conversation with the NRC staff, this combination of relays provides complete independence between the functions of isolating safeguard buses from offsite power disturbances and tripping/sequencing of all 480V safeguard loads.

Question 4: "NRC should be informed of any required sequential loading of any portion of the offsite power system or the onsite distribution system which is needed to assure that power provided to all safety loads is within required voltage limits for these safety loads."

Response 4: Our analysis shown in Tables 1 & 2 was performed assuming maximum load being applied to the offsite power system and in accordance with your guidelines for voltage drop calculations.

Question 5: "The adequacy of the onsite distribution of power from the offsite circuits shall be verified by test to assure that analysis results are valid. Please provide (1) a description of the method for performing this verification and (2) the test results."

Response 5: We shall verify the accuracy of our calculations by making voltage and current measurements at the buses and safety related MCCs while the plant is in operation. We shall then use these currents values to calculate voltages by the same technique used in our other analysis. These voltages will be compared to the actual voltage measurements at the 480 volt buses and MCC 26A & 26B. Our calculations will be considered satisfactory if the computed voltages are equal or below the measured voltage. This will verify the accuracy of our procedure and demonstrate our calculations for the other cases are correct. The test results will be forwarded upon completion.

Question 6: "Review the electric power systems to determine if there are any events or conditions which could result in the simultaneous or consequential loss of both required circuits to the offsite network to determine if any potential exists for violation of GDC-17 in this regard."

Response 6: Both offsite sources are available immediately and are independently routed. The 138kV source is an overhead line and the 13.8kV source is an underground cable. Therefore, the simultaneous loss of both required circuits to the offsite network is improbable and no potential exists for violation of GDC-17 in this regard.