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October 3, 1977

Mr. John F. Stolz, Chief
Light Water Reactors Branch No. 1
Division of Project Management
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Re: Docket No. 50-275-OL
Docket No. 50-323-OL
Diablo Canyon Units 1 & 2

Dear Mr. Stolz:

Attached are answers to the questions on the Millstone grid undervoltage condition contained in your letter of June 6, 1977.

Very truly yours,

Philip A. Crane, Jr.

Attachments
CC w/attachment: Service List

7727800 25

ANSWERS TO QUESTIONS ON MILLSTONE GRID UNDERVOLTAGE CONDITION - NRC LETTER OF JUNE 6, 1977

Question 1-a. Describe the plant conditions under which the plant auxiliary systems (safety related and non-safety related) will be supplied by offsite power. Include an estimate of the fraction of normal plant operating time in which this is the case.

Answer 1-a. Plant auxiliary systems will be supplied from offsite power during some period when the generator is separated from the system grid. The fraction of the normal operating time that the plant auxiliary systems would be supplied by offsite power would only be during start-up and shutdown sequences which is estimated at one week per year.

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

Answer 1-b. Pacific Gas and Electric (PG&E) has a transmission grid system with portions operating at several different voltages. Offsite sources of two different voltages are brought into the Diablo Canyon site. 500 kV is used for transmission of the plant's output from the site. The 500 kV system will normally operate

from 500 kV to 550 kV. A 230 kV source also is provided from another generating station (conventional) about 10 miles away for standby and start-up power, and it has a normal operating range of 225 kV to 235 kV at the Diable Canyon site. The corresponding voltage values at Engineered Safety Features (ESF) buses are given in response to Item 1-c.

Question 1-c. 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 voltage.

Answer 1-c. Transformer taps are set to provide the following voltages at the ESF buses for the maximum and minimum transmission voltages and auxiliary power loads at the station.

System Voltages-kV		Auxiliary Load	ESF Bus Voltages	
Nominal	Minimum Maximum		4160 V. System	480 V. System
230	225	min.	4160	480
		max.	3627	410
	235	min.	4345	501
		max.	3789	429
500	500	min.	3962	457
		max.	3630	411
	550	min.	4358	503
		max.	3992	452

ESF electrical loads can operate satisfactorily continuously when the voltages applied are within the limits given in ANSI Standard C84.1-1970 and NEMA Standard MG-1. Electric motors constitute the greatest part of the ESF loads and will operate continuously without harm with voltages within ± 10% of their rating. Larger electric motors are rated 4,000 volts, and will operate satisfactorily from 3,600 to 4,400 volts. Smaller motors are rated 460 volts, and have an operating range from 414 to 506 volts. The motors are also able to start and accelerate to full speed with 80% of rated voltage. This value is 3,200 volts for 4,000 volt motors, and 368 volts for 460 volt motors. Once started, the motors will operate with applied voltages as low as 70% of rated without breakdown, but the time is limited because of motor heating. A comparison of these values with those in the preceding analysis shows that the electrical ESF equipment can be operated within its capabilities for the normal range of transmission voltages with tap changes needed only on 480 volt at maximum load and minimum source voltages.

<u>Question 1-d</u>. Assuming the facility auxiliary loads are being carried by the station generator, provide the voltage profiles at the safety buses for grid voltage at the normal maximum value, the normal minimum value, and at the degraded conditions (high or low voltage, current, etc.) which would require generator trip.

Answer 1-d. The maximum and minimum voltages for the ESF Buses when served by the main generator are given below:

Normal System Conditions				
Generator Voltage-kV		Auxiliary Load	ESF Bus Voltage	
Nominal	Minimum Maximum		4160V. System	480 V. System
25	23.75	Min. Max.	3952 3616	456 409
	26.25	Min. Max.	4368 3997	504 453

Under degraded conditions when the main generator voltages have decreased to a value where generator trip occurs, the ESF Buses will have these voltages:

Degraded Conditions at Generator Undervoltage Trip			
Generator Voltage kV.	Auxiliary Load	ESF Bus Voltage	
		4160 V. System	480 V. System
19,375	Min. Max.	3255 2978	372 335

Question 1-e. Identify the sensor location and provide the trip setpoint for your facility's Loss of Offsite Power (undervoltage trip) instrumentation. Include the basis for your trip setpoint selection.

Answer 1-e. No sensor is provided specifically for an undervoltage trip on loss of offsite power. Sensors are provided on each 4160 V. ESF bus to detect low and no voltage conditions and initiate automatic transfer. At Diablo Canyon, there are 3 ESF buses and each has its own voltage sensors. These sensors are set to operate at 2,870 V. on the 4-kV system. When the undervoltage

sensors have operated for a short time on a given bus, its on-site emergency engine generators are started and the bus is stripped of its motor loads. After the generator attains 3,500 volts or more it is connected to the ESF bus. The loads are then connected sequentially. The sequence is given in Chapter 8 of the FSAR. The undervoltage setpoint and time delay were selected to allow the loads to ride through short duration voltage dips and failures without actuating a transfer or starting the load shedding sequence. Motors have an approximate breakdown torque of 200% rated at rated voltage. The torque is a function of the voltage squared, and therefore the 70% voltage provides approximately full load torque, which will allow running motors to carry full loads without breakdown.

Question 1-f. 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 the degraded grid voltage corresponding to the undervoltage trip setpoint.

Answer 1-f. The voltage values at ESF Buses when supplied by offsite power for maximum values of grid voltages are given in answer to question 1-c. The degraded offsite grid voltages corresponding to the undervoltage trip setpoint of 2870 V. on the 4160 V. ESF Bus are 156 kV for 230 kV system and 360 kV for the 500 kV system. Undervoltage is sensed only at ESF buses; therefore, the trip value is the same regardless of which offsite source is used.

Question 1-g. Utilizing the safety related bus voltage values identified in (f), evaluate the capability of all safety related loads, including related control circuitry and instrumentation, to perform their safety function. Include a definition of the voltage range over which the safety related components, and non-safety components, can operate continuously in the performance of their design function.

Answer 1-g. In general, safety related loads could operate only a short time with 2870 volts on the 4160 volt bus. Overcurrent protection would cause tripping of motor loads. Control for large (4 kV) motors would not be lost. Control for 480-volt motors would not be assured but no fuses would blow. The voltage range over which electrical components can operate continuously is given in answer to question 1-c.

Question 1-h. Describe the bus voltage monitoring and abnormal voltage alarms available in the control room.

Answer 1-h. Undervoltage relays are provided to sense low voltage conditions on each of the ESF buses with a time delay setting at 0.8 sec. Also, another undervoltage relay to monitor standby source (230 kV) voltage with a time delay setting at 1 sec. is provided. Any tripping of either of these two undervoltage relays will alarm in the control room and start corresponding engine generators. Engine start is also alarmed in the control room. To make sure load shedding can take place properly, undervoltage relays on the ESF buses sense degraded voltage conditions and trip all the motors at about 2870 volts on the 4 kV buses after 4 sec. A voltmeter and a potential indicating light are provided in the main control room to indicate voltage conditions on each ESF bus.

Question 2. The functional safety requirement of the undervoltage trip is to detect the loss of offsite (preferred) power system voltage and initiate the necessary actions required to transfer safety related buses to the onsite power system. Describe the load shedding feature of your design required prior to transferring to the onsite (diesel generator) systems and the capability of the onsite systems to perform their function if the load shedding feature is maintained after the diesel generators are connected to their respective safety buses. Describe the bases (if any) for retention or reinstatement o- the load shedding function after the diesel generators are connected to their respective buses.

Answer 2. Load shedding of electric motors takes place whenever the bus voltage is below the undervoltage setpoint or the release voltage of controllers. Other loads are not shed on low voltage. The 4000 volt motors are shed when the bus voltage goes below 2870 volts ± 5% for 4 seconds. The load shedding is maintained until this feature is reset. Reset occurs at 110% of the trip setpoint, or about 3160 volts. However the starting sequence timers do not reset until the voltage is reduced below 2100 volts on the ESF 4160 volt buses. Therefore if the voltage were maintained above 2100 volts after load shedding, the loading sequence would not repeat. But the timers are not activated until the ESF loads are separated from the offsite power source and are supplied by the engine-generators. With the settings now in use, loading of the engine-generator, operating normally, will not result in voltage drops enough to

cause load shedding to occur. The minimum voltage is about 3500 volts on loading and recovers to normal in about one second.

If the engine-generator or load shedding and sequencing were to malfunction, it is possible that ESF loads may not be started. However, the engine-generator and load shedding system is independent for each of the three ESF buses and a single failure would still leave adequate equipment to perform the safety functions. In addition, the load shedding feature on each bus requires the operation of two relays in a two out of two configuration. The failure of one undervoltage relay would not initiate load shedding.

Question 3. Define the facility operating limits (real and reactive power, voltage, frequency and other) established by the grid stability analyses cited in the FSAR. Describe the operating procedures or other provisions presently in effect for assuming that your facility is being operated within these limits.

Answer 3. I. The rated generation at rated .9 power factor for each unit are:

Unit 1:		Unit 2:	
P_{MAX} =	1170 MW	P_{MAX} =	1210 MW
$Q_{LAG\ MAX}$ =	550 MVAR	$Q_{LAG\ MAX}$ =	580 MVAR
$Q_{LEAD\ MAX}$ =	520 MVAR	$Q_{LEAD\ MAX}$ =	510 MVAR

II. Permissible voltage variation is ± 5% of the rated terminal voltage of 25 kV.

III. Upon loss of one of the two units the system frequency is reduced less .2 HZ, i.e., the frequency remains higher than 59.8 HZ.

IV. System studies indicate that the facility can be operated within these limits by use of the following elements:

1. Midway Substation

   360 MVAR of switchable 500 kV shunt reactors
   180 MVAR of switchable tertiary shunt reactors

2. Gates Substation

   100 MVAR of switchable 500 kV shunt reactors
   180 MVAR of switchable tertiary shunt reactors

3. Diablo Canyon

   High initial response exciter equipped with continuous acting automatic voltage regulator and power system stabilizer.

Question 4. Provide a description of any proposed actions or modifications to your facility based on the results of the analyses performed in response to items 1-3 above.

Answer 4. A condition exists such that if offsite power results were somehow maintained at an abnormal voltage between 2870 and 3600 volts, transfer to the engine-generator may not occur and yet motors would be operated below their minimum continuous rating. We propose to add a voltage alarm on each ESF bus to alert the operator to a low voltage condition existing for several minutes. As mentioned before in our answer to Question 1-a, operation of plant auxiliaries on the offsite system will occur only infrequently.