William J. Cahill, Jr.
Vice President

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Regulatory File Cy

August 29, 1977
Re: Indian Point Unit No. 3
Docket No. 50-286

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U.S. NUCLEAR REGULATORY COMMISSION
Mail Section

Director of Nuclear Reactor Regulation
ATTN: Mr. Robert W. Reid, Chief
Operating Reactors Branch #4
Division of Operating Reactors
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Reid:

Enclosed herewith is our complete response to your August 12, 1976 information request relating to the effects degraded grid voltage may have on plant operation. An update of the previous partial response which was submitted to you on September 24, 1976 is also included in the attachment.

Should you or your staff have any further questions regarding the information presented in the attachment, we would be pleased to discuss them with you at your convenience.

Very truly yours,

William J. Cahill, Jr.
Vice President

Attachment

Copy to: Mr. George T. Berry
General Manager and Chief Engineer
Power Authority of the State of New York
10 Columbus Circle
New York, New York 10019

1.a Question: 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?

During "on line" unit operation 6900 volt buses 1 through 4 are normally fed from the unit via the 22KV main generator isolated phase buses and the Unit Auxiliary Transformer. Bulk power from the 138KV offsite system is normally supplied to the plant via connections to 6900 volt buses 5 and 6 through the Station Auxiliary Transformer. Two 50% trains of safety related equipment are in turn powered from the offsite source (480 volt switchgear 5A and 480 volt motor control center 36A via 6900 volt bus 5 and 480 volt switchgear 6A and 480 volt MCC 36B via 6900 volt bus 6), while a third 50% train is powered from the unit (480 volt switchgears 2A, associated motor control center 36C and 480 volt switchgear 3A via 6900 volt buses 2 and 3 respectively).

It is estimated that these conditions prevail in excess of 98% of normal plant operating time. The exceptions to the above operating mode are 8 hours each month when the diesels are tied to the auxiliary buses as part of their required surveillance testing and a conservatively estimated total of 30 hours each year, during which the diesels may be automatically initiated and operated.

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?

The specified range of "Nominal" voltages at the Buchanan Substation buses are 347 to 358KV for the 345KV system and 136 to 142KV for the 138KV system. Based on calculations made for Indian Point Unit No. 2 the lowest corresponding voltages on the plant's safety related buses would be at least 459 volts (.956 per unit) at 480 volt switchgear 2A, 464 volts (.967 per unit) at 480 volt switchgear 3A, 448 volts (.934 per unit) at 480 volt switchgear 5A, 458 volts (.955 per unit) at 480 volt switchgear 6A, 441 volts (.919 per unit) at 480 volt motor control center 36A, 452 volts (.941 per unit) at 480 volt motor control center 36B and 452 volts (.941 per unit) at motor control center 36C. 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.

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.

For the full load condition on the station buses and the lowest nominal 138KV grid voltage (136KV) the station auxiliary transformers will maintain 1.0 per unit voltage on the 6.9KV station buses. Corresponding voltage values at the safety related buses will be identical with those identified in the response to item lb.

For the highest nominal grid voltage (142KV) with no load on the station buses the station auxiliary transformer 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 1.0 per unit.

1.d 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.

For the worst degradation of the unit supply, the voltage on 480 volt buses 2A and 3A will be 451 volts (.94 per unit) or higher. The worst generator terminal voltage degradation that will not cause a unit trip would result in the Buchanan 345KV bus operating at 336KV (97%). This postulated condition would be caused by low generator excitation, just outside the loss of field relay trip characteristic. Under this condition buses 2A and 3A would be at 451 volts (.94 per unit) or higher. Buses 5A and 6A will be at or above 448 volts (.934 per unit) and 458 volts (.955 per unit) respectively.

This unusually low 345KV grid voltage (97%) results from the large reactive power flow into the generator due to the abnormally low generator excitation.

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.

Sensors and trip setpoints for our facility's loss of Offsite Power instrumentation are as follows:

a) An SV instantaneous undervoltage relay is located on each of the four 6900V buses (one per bus for buses 1, 2, 3, and 4) which are normally fed from the Unit Auxiliary Transformer. The trip setpoint for each relay is 5175V, (.75 per unit). There is a timer associated with each relay which is set to time out at 18 cycles. Operation of any two of the four relays above 10% reactor power will initiate a reactor scram.

The basis for the SV trip setpoint at Indian Point No. 3 is to provide adequate reactor protection in anticipation of a primary system loss of flow while maintaining coordination with phase and ground fault protection on the 6.9KV buses in order to prevent unnecessary reactor trips.

These set points are within the limits of the I.P.3 FSAR ($\geq$ 70% normal voltage).

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.

The load (including station service transformer feeds to 480 volt safeguards buses 2A, 3A, 5A, and 6A) on each of the six 6.9KV buses 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 at least 361 volts (.752 per unit) at 480 volt switchgear 2A, 368 volts (.767 per unit) at 480 volt switchgear 3A, 347 volts (.723 per unit) at 480 volt switchgear 5A, 360 volts (.751 per unit) at 480 volts switchgear 6A, 337 volts (.703 per unit) at 480 volt motor control center 36A, and 352 volts (.733 per unit) at 480 volt motor control centers 36B and 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.

1.f (Cont'd)

The worst 138KV degradation would result if Buchanan 345/138KV transformer TA5 is lost coincident with loss of 138KV feeder 96962 and associated Millwood 345/138KV transformer TA. During this contingency the Buchanan 138KV offsite power supply bus will be supplied only from Pleasant Valley 345KV S/S (S1 transformer) and Pleasant Valley 115KV S/S (Transformers 1 & 2) through 138KV feeder 96951.

The Buchanan South 345KV voltage would be 1.02 per unit immediately after these losses. Generator voltage regulator response would immediately restore the generator terminal voltage to normal. Thus buses 2A and 3A will be normal and buses 5A and 6A will be at 433 volts (.902 per unit) and 444 volts (.924 per unit) respectively with 480 volt motor control centers 26A and 26B at 425 volts (.885 per unit) and 436 volts (.908 per unit) respectively.

The maximum 138KV grid voltage on a contingency is 145KV. At no load the 6.9KV bus voltage would rise to 1.024 per unit. The resulting motor control center voltages would also rise 2.4% from nominal.

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 functions. 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.

As stated in the response to item (f) no conceivable contingency on the offsite grid system will result in sustained voltage conditions approaching the undervoltage relay setpoints.

The following motors will start, or if running will continue to run, at .80 per unit bus voltage (384 volts):

| Application | Pump or Fan No. | Horsepower | Nameplate Voltage |
|---|---|---|---|
| Residual Heat Removal Pump | 31, 32 | 400 | 460 |
| Auxiliary Feedwater Pump | 31, 33 | 400 | 440 |
| Containment Spray Pump | 31, 32 | 400 | 460 |
| Component Cooling Pump | 31, 32, 33 | 250 | 460 |
| Safety Injection Pump | 31, 32, 33 | 400 | 440 |
| Containment Recirculation Fan | 31, 32, 33, 34,35 | 225 | 440 |
| Recirculation Pump | 31, 32 | 350 | 440 |
| Service Water Pump | 31, 32, 33,34,35 36 | 350 | 440 |

The charging pumps (non-safety) will not start at 80% bus voltage, however, if these pumps are running and the voltage drops to 80%, the pumps will continue to run. A minimum bus voltage of 81.7% (392 volts) will be required to start these pumps against design discharge pressure. These motors are 200 horsepower, 440 volts.

1.g (Cont'd)

Manufacturer's literature indicates that the 480 volt motor control center motor starters will close at 408 volts (.85 per unit) and will operate when already closed down to 288 volts (.6 per unit).

All motor operated valves are designed to operate down to 414 volts (.862 per unit).

The four 120 volt A.C. instrument buses are supplied by battery fed static inverters (Instrument Buses 31, 32 and 33) or constant voltage transformers (Instrument Bus 34). The inverters and constant voltage transformers will insulate the instrument buses from voltage disturbances on the plant distribution system.

A comparison of the voltages required for operation of safety related components with the worst case contingency voltages identified for the unit supply degradation (item d) and the 138KV degradation (item f), indicates that the safety related components can operate continously under these conditions.

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

Separate voltmeters are provided in the control room for the 6900 volt and 480 volt systems. By operating the selector switches associated with each of these voltmeters, voltage on any 480 volt or 6900 volt bus can be displayed. Voltmeters for main generator output and system (345 Kv) voltages are provided on the flight panel.

Some of the individual alarms provided in the control room which could be indicative of abnormal voltage include:

1) Panel SEF (Supervisory Annunciator)

   a. Volts/Hertz
   b. Over Excitation
   c. Exciter Trouble
   d. Gen. Voltage Regulator Trip
   e. Exciter Field Overcurrent

2) Panel SGF (Supervisory Annunciator)

   138 Kv Substation Trouble

3) Panel SHF (Supervisory Annunciator)

   a. Unit Aux Trans Tap Changer Hangup
   b. Unit Aux Trans Trouble
   c. Station Aux Trans Trouble
   d. Station Service Trans Trouble (1 for each trans)
   e. Station Aux Trans Tap Changer Hangup
   f. 6900 volt Motor Trip
   g. 480 Volt Swgr Motor Trip

4) Panel FDF (reactor trip first out annunciator)

   Undervoltage Trip

b) A CV-7 inverse time under-voltage relay is connected to the six 6900V buses (one per bus). The trip setpoint for each relay is 5580V (.81 per unit). The minimum operating time for relay plus auxiliary timer is 31 seconds. This delay is at least one order of magnitude longer than necessary to ride through transient grid disturbances. Relay operation trips all loads connected to its associated 6.9KV buses including the station service transformer feeding the 480 volt safety related switchgear. The basis for the trip set point of the CV-7 relay located on the 6.9KV buses is to provide undervoltage protection for the motors and allow starting of large motor loads from the 20MVA 13.8/6.9KV auto transfomer source.

c) On each of the 4-480V safety related buses there is a set of two CV-7 voltage relays. During on line operation buses 2A and 3A are normally fed from the Unit Auxiliary Transformer and buses 5A and 6A from the Station Auxiliary Transformer. The trip set-point is 220V (approx. 46% of 480V) and for a drop of voltage from 480V to zero each relay will operate in 120 cycles. Transient disturbances on the grid which will produce 480 volt bus voltages approaching zero will be cleared in less than 30 cycles under worst case conditions. These relays trip the breakers associated with normal bus supply, and activate diesel start, bus stripping and load sequencing operation.

c) (Cont'd)

The basis for the settings of the CV-7 relays on the 480 volt buses is to provide rapid actuation for diesel start and sequencing in the event of complete loss of power without creating a potential for spurious actuation during limited momentary voltage dips caused by motor starts, bus transfer, or transient conditions affecting the plant distribution system.

The time delay setting (120 cycles nominal, for drop to zero voltage) prevents operation for a 6.9KV fault which can be cleared without interrupting supply to any 480V buses. Any fault on the 6.9KV buses that will cause the CV-7 relays to begin dropout will be cleared in 39 cycles maximum.

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 of the load shedding function after the diesel generators are connected to their respective buses.

Independent relays with significantly different settings are used to accomplish the separate functions of isolating the safety related buses from any offsite voltage abnormalities and providing necessary support (e.g. load shedding) for diesel startup and sequencing. CV-7 relays on each of the 6900 volt buses set at 5589 volts (.81 per unit) of nominal voltage will after a time delay of approximately 31 seconds, trip the feeds to the 6900/480 volt station service transformers. Completely independent relays on the 480 volt safety related switchgear set at approximately 220 volts (.46 per unit) of nominal voltage support diesel start, bus stripping and load sequencing operations. In addition these relays also initiate isolation of the safety related buses by tripping breakers on the low side of the station service transformers.

At a relatively high voltage (81%) safety related buses will be isolated from the offsite source. Independent circuitry and relatively low "live bus" voltage

(46%) is used to support the diesel sequence. Since this relay has a nominal dropout of 46% voltage it is not affected by motor starting dips; therefore load shedding will not occur with a diesel connected to its 480V bus. This design guarantees the independence of the safety related buses from any problems effecting offsite power, assures more than adequate margins to accommodate inrush related voltage dips during the diesel loading sequence. Because of the relatively low setting of the 480 volt undervoltage relays their load shedding feature does not have to be defeated after the diesel generators are connected to the safety related buses.

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 assuring that your facility is being operated within these limits.

The operating limits for real and reactive power for Indian Point No. 3 at various hydrogen pressures and generator terminal voltages are given by the Generator Capability Curve as shown in attachment No. 1. The generator may be safely operated anywhere within the region enclosed by these curves.

The unit terminal voltage is maintained during start up at or below the limits shown in the following tabulation:

| Speed (RPM) | Max. Terminal Voltage (KV) |
|---|---|
| 1750 | 22 |
| 1800 | 22 |

During normal operating conditions, the generator terminal voltage is allowed to deviate from the nominal output voltage of 22 kV to a maximum of 23.10 kV or to a minimum of 19.80 kV.

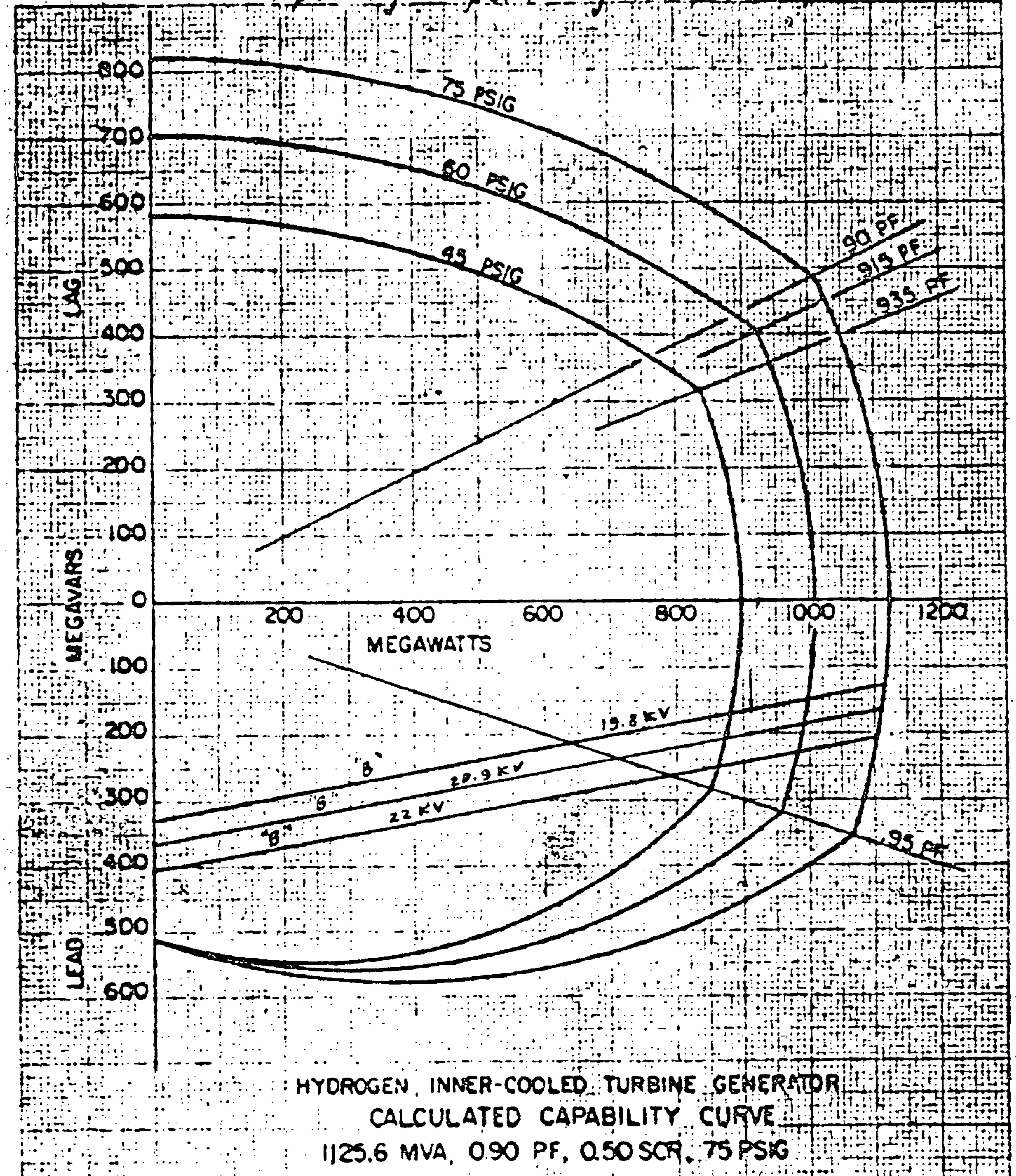
The terminal voltage is adjusted within these limits in order to maintain the 345 kV voltage on the high side of the generator main power transformer in accordance with the following schedule:

| Date | 345kV Bus Voltage |
|---|---|
| October 1 to May 31 | 350 $\pm$ 3 kV |
| June 1 to September 30 | 355 $\pm$ 3 kV |

The generator frequency while connected to the Edison System under steady state conditions is maintained at all times at nominally 60 Hz.

Unit operating procedures have been established to assure that Indian Point No. 3 is operated in adherence with the above limits for real and reactive power, voltage and frequency.

Indian Point No. 3
Temporary Operating Limit ATTACHMENT No. 1




Reviewed by [signature]

Approved by [signature]

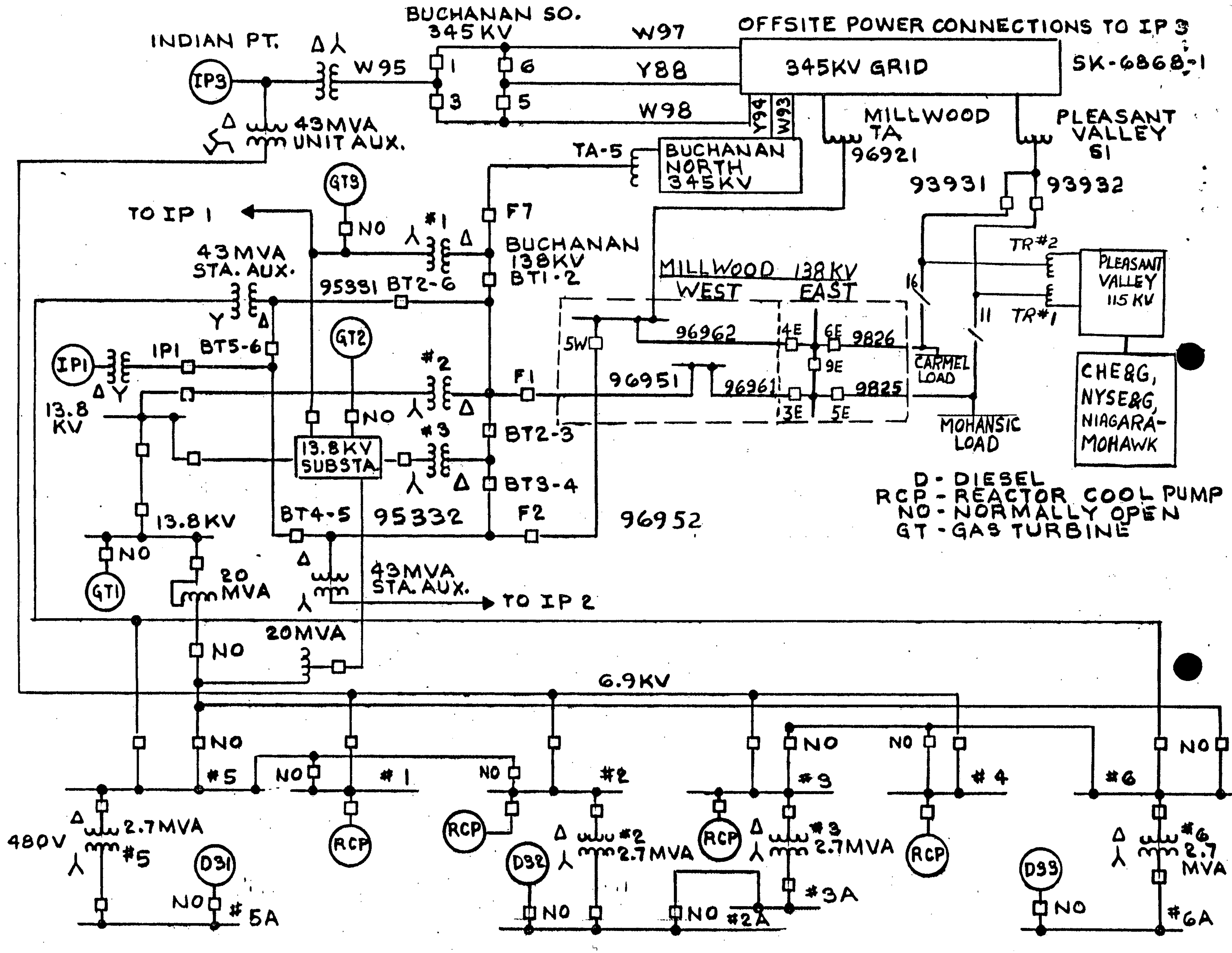
EL-1
Rev. 1

Curve 600478 Capability Curve Fig. 1

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.

Based on our analyses to further improve the reliability of grid and main generator voltage sources undervoltage alarms will be provided to alert the operator to low voltage on any 480 volt safeguard bus. Alarm settings and time delays will be coordinated with operational capability of equipment and existing undervoltage protection.

We feel that the existing normal power systems provide an adequate, diverse, and reliable supply to plant safety equipment. The above change will provide additional information to the operator.



OFFSITE POWER CONNECTIONS TO IP 3
SK-6868-1
BUCHANAN SO. 345KV
INDIAN PT.
IP3
W95
W97
Y88
W98
345KV GRID
Y94
W93
43MVA UNIT AUX.
MILLWOOD TA 96921
PLEASANT VALLEY 61
TA-5
BUCHANAN NORTH 345KV
93931
93932
GT3
NO
TO IP 1
F7
43MVA STA. AUX.
BUCHANAN 138KV BT1-2
95331
BT2-6
MILLWOOD 138KV
WEST
EAST
TR#2
TR#1
PLEASANT VALLEY 115 KV
BT5-6
GT2
IP1
5W
96962
4E
6E
9826
9E
CARMEL LOAD
13.8 KV
96951
96961
3E
5E
9825
MOHANSIC LOAD
CHE&G, NYSE&G, NIAGARA-MOHAWK
13.8KV SUBSTA.
BT2-3
BT3-4
D - DIESEL
RCP - REACTOR COOL PUMP
NO - NORMALLY OPEN
GT - GAS TURBINE
13.8KV
BT4-5
95332
F2
96952
F1
GT1
20 MVA
43MVA STA. AUX.
TO IP 2
20MVA
6.9KV
#5
#1
#2
#3
#4
#6
RCP
480V
2.7MVA
D31
D32
D33
#5A
#2A
#3A
#6A
2.7 MVA