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RECIP.NAME RECIPIENT AFFILIATION
KNIGHTON,G. Licensing Branch 3

SUBJECT: Forwards evaluation of multiple high impedance cable failures in Class 1E power distribution sys,per 841029 request.Failures cannot cause deenergization of any circuit not directly affected by exposure fire.

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# Arizona Public Service Company

Director of Nuclear Reactor Regulation
Attention: Mr. George Knighton, Chief
Licensing Branch No. 3
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

November 28, 1984
ANPP-31234 TFQ/KLM

Subject: Palo Verde Nuclear Generating Station (PVNGS)
Units 1, 2 and 3
Docket Nos. STN-50-528/529/530
10CFR50, Appendix R Associated Circuits
File: 84-056-026; G.1.01.10

Reference: Letter to G.W. Knighton, NRC, from E.E. Van Brunt, Jr., APS, dated October 5, 1984; Subject: 10CFR50, Appendix R Associated Circuits.

Dear Mr. Knighton:

As requested in a phone conversation with Nick Fioravante, of your staff, held on October 29, 1984, enclosed is the Evaluation of Multiple High Impedance Cable Failures in the PVNGS Class IE Power Distribution System.

This evaluation provides the justification to demonstrate that simultaneous multiple high impedance faults cannot cause deenergization of any circuit which was not directly affected by an exposure fire.

If you should have any questions, please contact me.

Very truly yours,

E. E. Van Brunt

E. E. Van Brunt, Jr.
APS Vice President
Nuclear Production
ANPP Project Director

EEVBJr/KLM/no
Attachment

cc: E. A. Licitra w/a
R. P. Zimmerman w/a
A. C. Gehr w/a

B002
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November 28, 1984
ANPP-31234

STATE OF ARIZONA )
) ss.
COUNTY OF MARICOPA)

I, Edwin E. Van Brunt, Jr., represent that I am Vice President, Nuclear Production of Arizona Public Service Company, that the foregoing document has been signed by me on behalf of Arizona Public Service Company with full authority to do so, that I have read such document and know its contents, and that to the best of my knowledge and belief, the statements made therein are true.

Edwin E. Van Brunt
Edwin E. Van Brunt, Jr.

Sworn to before me this 28th day of November, 1984.

Nora E. Meador
Notary Public

My Commission Expires:
My Commission Expires April 6, 1987

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# EVALUATION OF MULTIPLE HIGH IMPEDANCE CABLE FAILURES IN THE PVNGS CLASS IE POWER DISTRIBUTION SYSTEM

## I. PURPOSE

This discussion provides justification that multiple, fire-induced high impedance cable failures which result in an incoming main bus circuit breaker tripping are not credible events. The faults considered are such that the individual high impedance fault currents are below the associated distribution center feeder circuit breaker trip settings, but the combined effect of the faults is to trip the distribution center's incoming breaker. This analysis is done at the request of the Nuclear Regulatory Commission.

## II. EVALUATION BASIS

A. The minimum high impedance fault current contribution from a single circuit will be assumed to be 5% of the circuit's normal operating current, for the Class IE 4.16 kV switchgear and 480 V load centers.

Basis: 5% fault current is below both the +10% normal maximum current limit based on +5% -10% voltage regulation and below the minimum ground fault trip settings for incoming and feeder circuit breakers; therefore, incoming circuit breakers will not trip with a cumulative fault plus load current of 105%.

This fault current is considered to flow in the insulation between conductors or between conductors and ground within each cable assembly exposed to the fire.

B. Raceways contain cables of varying construction, since approximately 150 different cable types are used with differing insulation materials, jacket materials, shielding, and number of conductors. Therefore, the cables in a given raceway will not have the same combustible loading and will behave differently during an exposure fire. Additionally, discussion with Rockbestos and Okonite (cable manufacturers); indicates that, when multiple cable assemblies are exposed to a single fire, the time to cable failures occur at various times.

C. High impedance failures occur in the thermal region of the breaker coordination curves, so expected fault times and time to circuit breaker interruption are on the order of minutes.

D. For the 4.16 kV and 480 V systems, the smallest load connected to a bus is used to establish the minimum high impedance fault current. Therefore, cables for larger loads will be subject to higher fault energy levels, resulting in more extensive cable damage.

E. Sprinklers are provided in most areas of the plant. Introduction of water onto burning cables would cause rapid transition from a high impedance fault to a bolted or solid fault.

## III. DETAILED EVALUATION

### A. 4.16 kV System

The smallest load is 455 kW, resulting in 22.8 kW being dissipated at a 5% high impedance fault. 22.8 kW energy dissipation at a high impedance cable fault will cause nearly instant propagation to a bolted fault condition; therefore, the persistance of high impedance faults is not a credible event in the 4.16 kV Class IE system.

### B. 480 V Load Centers

The smallest load is 100 hp, resulting in 3.8 kW being dissipated at a 5% high impedance fault. 3.8 kW energy dissipation at a high impedance cable fault will cause nearly instant propagation to a bolted fault condition; therefore, the persistance of high impedance faults is not a credible event in 480 V load centers.

### C. 480 V Motor Control Centers (MCCs)

MCC incoming (supply) breakers will trip at a minimum current value (1000 sec or 16.7 min) of 600 amps. Per the design criteria, in order to meet ampacity and voltage drop limits, Class IE MCCs are limited to a maximum load of 369 amps. As discussed in Item III.B, 3.8 kW energy dissipation at a high impedance cable fault will cause nearly instant propagation to a bolted fault condition; therefore, persistance of a high impedance fault that dissipates this energy level is not a credible event. 3.8 kV energy dissipation corresponds to a fault current at 460 V of less than 5 amps. The maximum number of feeders on a MCC (including spares and spaces) is 35, resulting in a cumulative maximum high impedance fault current of 175 amps. The total current on a MCC under this condition would be less than 544 amps. Since this value is less than the incoming breaker trip setting of 600 amps and the 1000 sec or 16.7 min. emergency overload supply cable rating of 620 amps, multiple high impedance cable failures cannot cause an incoming circuit breaker to trip. Please note that motor-operated valves (MOVs) connected to MCCs complete their required operation and their power circuits are deenergized in less than 80 seconds (most are less than 30 seconds), so the minimum incoming breaker trip value when MOVs are considered is higher than 700 amps.

Please note that the postulated event is inconsistent with Regulatory Guide 1.63 and Regulatory Guide 1.106 for the following reasons:

1. Regulatory Guide 1.63 requires that containment penetration electrical conductors be sized on the basis that only one conductor in an assembly is faulted at a time. However, the postulated event would assume several simultaneous faults per assembly.

2. Regulatory Guide 1.106 states that thermal overloads can be bypassed for MOVs important to safety; however, high impedance faults occur in the thermal region of circuit breakers. Therefore, bypassing thermal overloads would eliminate the high impedance fault protection provided by individual MOV feeder circuit breakers.

D. 120 V MCC Panels (D31 and D32)

The panel incoming (supply) fuse will blow at a minimum current value (1000 sec or 16.7 min) of 340 amps. The total rated load is less than 208 amps (based on the 25 kVA transformer rating). Using a multiplication factor of 70% for load diversity, the load current is less than 146 amps.

Assuming 100% high impedance faults (actually low impedance faults), the total current on a panel under this condition would be less than 292 amps. Since this value is less than 340 amps, multiple high impedance cable failures cannot cause an incoming fuse to blow. Since 18 feeders on the panels are for loads in other fire zones, this would result in 973-watt energy dissipation at a high impedance cable fault, which is higher than the normal connected load, so the energy released at the fault will cause the fault level to rapidly propagate to a bolted fault condition before the incoming fuse will blow. Please note that, with the cumulative fault and load current at a value equal to the incoming fuse blow current, 1.3 kW would be dissipated at high impedance cable faults.

E. 120 V Instrument Buses (D25 and D26)

The panel incoming (supply) breaker will trip at a minimum current value (1000 sec or 16.7 min) of 290 amps. The total connected load is less than 150 amps, including a multiplication factor of 70% for load diversity. Assuming 100% high impedance faults (actually low impedance faults), the total current on a panel under this condition would be less than 300 amps. The existing interrupting device (circuit breaker and fuse) coordination for 120 V instrument buses meets the multiple high impedance fault requirements for the following reasons:

1. The panels have ten spare feeders. The resultant 1000-watt energy dissipation, without spares, or 643-watt energy dissipation, including spares, is sufficient to cause the fault level to rapidly propagate to a bolted fault condition before the incoming breaker will trip.

2. Although the total current on the panels under this condition exceeds the minimum incoming circuit breaker trip level by 10 amps, for times less than 600 sec or 10 min, the trip level is greater than the 300 amp total current value.

F. 125 V-dc Motor Control Centers (MCC)

Since the 120 V-ac inverter, the 125 V-dc distribution panel, and, for C and D channels, the MOV inverters are in the same fire zone as their associated 125 V-dc MCC, high impedance failures on the cabling between this equipment are not considered.

MCC incoming (supply) breakers will trip at a minimum current value (1000 sec or 16.7 min) of 1400 amps. Per Calculation 13-EC-PK-100, the maximum total steady-state load (battery with the highest steady-state load) is 327 amps; 400 amps will be used to account for future load growth. As discussed in Item III.B, 3.8 kW energy dissipation at a high impedance cable fault will cause nearly instant propagation to a bolted fault condition; therefore, persistance of a high impedance fault that dissipates this energy level is not a credible event. 3.8 kV energy dissipation corresponds to a fault current at 125 V-dc of less than 35 amps. The maximum number of feeders not in the same fire zone as a MCC (including spares and spaces) is 14, resulting in a cumulative maximum high impedance fault current of 490 amps. The total current on a MCC under this condition would be less than 890 amps. Since this value is less than 1400 amps, multiple high impedance cable failures cannot cause an incoming circuit breaker to trip. Please note that motor-operated valves (MOVs) connected to MCCs complete their required operation and their power circuits are deenergized in less than 80 seconds (most are less than 30 seconds), so the minimum incoming breaker trip value when MOVs are considered is higher than 2900 amps.

G. 125 V-dc Panels

Panel incoming (supply) breakers will trip at a minimum current value (1000 sec or 16.7 min) of 500 amps for A and B channels and 190 amps for C and D channels. Per Calculation 13-EC-PK-100, the maximum total steady-state load (panel with highest steady-state load), is 73 amps for A and B channels and 5.4 amps for C and D channels. To account for future load growth, 100 amps will be used for A and B channels and 40 amps will be used for C and D channels.

## A and B Channels

Assuming 100% high impedance faults (actually low impedance faults), the total current on a panel under this condition would be less than 200 amps. Since this value is less than 500 amps, multiple high impedance cable failures cannot cause an incoming circuit breaker to trip. Since 30 feeders are provided on the panels, this would result in 416-watt energy dissipation at a high impedance cable fault, which is higher than the normal connected load, so the energy released at the fault will cause the fault level to rapidly propagate to a bolted fault condition before the incoming breaker will trip. Please note that, with the cumulative fault and load current at a value equal to the incoming circuit breaker trip setting, 1.7 kW would be dissipated at high impedance cable faults.

## C and D Channels

Assuming 100% high impedance faults (actually low impedance faults), the total current on a panel under this condition would be less than 80 amps. Since this value is less than 190 amps, multiple high impedance cable failures cannot cause an incoming circuit breaker to trip. Since nine feeders on the panels are for loads in other fire zones, this would result in 556-watt energy dissipation at a high impedance cable fault, which is higher than the normal connected load, so the energy released at the fault will cause the fault level to rapidly propagate to a bolted fault condition before the incoming breaker will trip. Please note that, with the cumulative fault and load current at a value equal to the incoming circuit breaker trip setting, 2.1 kW would be dissipated at high impedance cable faults.

## IV. SUMMARY TABLE

| | Fault Energy Level Shown to be Sufficient to Cause Nearly Instant Propogation to a Solid Fault | Load Current Plus High Impedance Fault Current Less Than Minimum Incoming Breaker Trip Setting |
|---|---|---|
| 4.16 kV Switchgear | Yes | Yes |
| 480 V Load Center | Yes | Yes |
| 480 V MCC | Yes | Yes |
| 120 V-ac Panels | No | Yes |
| 120 V Instrument Buses | No | Yes |
| 125 V-dc MCC | Yes | Yes |
| 125 V-dc Panels | No | Yes |

## V. CONCLUSION

The above discussion justifies that in no case can simultaneous multiple high impedance faults cause deenergization of any circuit which has not been directly affected by an exposure fire.