BECHTEL STUDY 13-ES-600

RG 1.75 LOW ENERGY CIRCUIT ANALYSIS

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RG 1.75 Low Energy Circuit Analysis

1.0 Purpose

This study provides justification by analysis that, although some instrument circuits/cables do not meet the separation requirements of RG 1.75-1975[1, 3], the affected Class 1E circuits cannot be degraded below an acceptable level. The results of this study will only be used to justify deviations from the RG 1.75 separation requirements (i.e., due to construction configuration/interference problems) on a case by case basis. The analysis shows that conservatively established maximum fault currents in one cable assembly cannot cause degradation of another cable assembly in the vicinity.

2.0 Evaluation Basis

A. Circuit Classifications

Only instrument circuits are evaluated in this study as to be "low energy circuits." Power and control circuits are only considered from the standpoint that these low energy Class 1E or non Class 1E instrument circuits cannot degrade the Class 1E power or control circuits below an acceptable level.

B. Cable Construction

In that the cables installed at the Palo Verde Nuclear Generating Station meet the requirements of IEEE 383-1974[2], they are considered flame retardant and will self-extinguish when the flame source is removed. (With the exception of some fiber optic and coaxial cables, the cabling installed passed the flame test with a 210,000 Btu per hour source which is three times the requirement).

C. Circuit Impedance

Except where the separation problem is at a specific single point, this analysis does not determine the fault limiting characteristics of cables. Circuit impedance, if considered, would further limit fault currents due to the small wire size (i.e., yielding high resistance) of the instrument cables.

D. Power Supply Voltages

In most cases power supply performance data under faulted conditions is not available. Therefore, the output is considered to remain constant at its normal value. This basis is conservative since most power supplied to these circuits is provided by regulated power supplies (amplifiers) in which a shorted circuit will cause saturation resulting in a near zero output source voltage.

E. Interrupting Devices Actuated by Fault Current

Although usually included in the design, this analysis does not take credit for any internal circuit breakers or fuses.

3.0 Detailed Analysis

The following is a case by case analysis justifying that the identified circuits are low energy and therefore cannot cause degradation of any Class 1E cables in the vicinity.

A. Non Class 1E Fiber Optic Cables

Fiber optic cables do not carry any electrical signals. The optical signals that they carry cannot generate heat; therefore, fiber optic cables are considered low energy circuits. Failures in fiber optic cables cannot affect any other cables in the vicinity..

B. Non Class 1E Fire Detection Protectowire

Protectowire consists of two conductors individually encased in heat sensitive material. The encased conductors are twisted together to impose a spring pressure between them. When heated to the critical or operating temperature the heat sensitive material yields to the pressure on it, permitting the conductors to move into contact with each other. A supervisory current of 1.1 ma normally flows through the Protectowire.(15) During an alarm condition this current rises to 12 ma.(15) Therefore, Protectowire is considered a low energy circuit, which is designed to short during an alarm condition, and cannot affect any other cables in the vicinity.

C. Non Class 1E Fire Detector Cables Within Panels

When an ionization fire detector alarms, it closes a contact which shorts out the loop(+) and loop (-) terminals.(4) The detector circuits have a normal operating current of 300 microamps and an alarm current of 29 milliamps.(4) Fire system alarms are checked by shorting out the end of line resistors. Fire detector cabling within panels is designed to be shorted during an alarm condition, therefore, is considered a low energy circuit which cannot affect any other cables in the vicinity.

D. Non Class 1E Radiation Monitoring System Computer Signal and Information Cables

The computer power supply can provide 5 $\pm$ .05 or 12 $\pm$ .07 volts DC.(19) (Since the data for the 5 volt power supply is more conservative it is used in this analysis.) This data indicates that the 5 VDC power supply will current limit to 4.5 amps. The cable has a current rating of 16 amps.(12) Comparing the cables ampacity rating to the maximum current during a fault the Radiation Monitoring System Computer Signal and Information Cables can be considered low energy circuits which cannot affect any other cables in the vicinity.

(NOTE: Based on the fact that the power supply voltage is 5 volts, and there is inherent voltage drop within the circuit, fault current will be substantially reduced from the 4.5 amp value indicated.)

E. Class 1E Radiation Monitoring System Detector Cables

The power supply for the radiation monitoring detectors has an output of 500 to 1500 VDC.[16] The circuit resistance is at least 10 kohms due to a 10 kΩ resistor in series. Assuming that the regulating power supply is not current limiting (conservative assumption since the power supply data sheet for C-15 high voltage power supplies indicates that the rating is 1 ma), the 10 kΩ resistor will limit the fault current to 0.15a or 150 ma. Therefore, the Radiation Monitoring System Detector Cables can be considered low energy circuits which cannot affect any other cables in the vicinity.

F. Non Class 1E Plant Telephone System

Discussion with Teleflex Communications indicates that telephone ringer current is 50 ma. Discussion with Brand Rex (system cable manufacturer) indicates that the No. 19 telephone cable has an ampacity of 7 amps. Since maximum telephone current occurs during ringing, (50 ma) and the cables ampacity is 7 amps the telephone circuits can be considered low energy circuits.

G. Non Class 1E Plant Paging System

The amplifier output is 70V at an impedance of 100 Ω[5, 18]. Discussion with Brand Rex (system cable manufacturer) indicates that the No. 19 speaker cable has an ampacity of 7 amps. This cable has a resistance of 8.51 Ω/1000 ft.[17] The shortest cable to a speaker is 300 ft. which results in a cable resistance of 2.55 Ω. Since the average cable length is about 1000 ft. it is likely that some additional resistance due to cable will be present to limit fault current. However, conservatively neglecting the cable resistance and assuming the output of the amplifier remains constant during a fault, the maximum fault current is .7 amps. Comparing the cables ampacity of 7 amps with the maximum fault current of .7 amp, the plant paging circuits can be considered to be low energy circuits, which cannot damage any associated cabling given a fault condition.

H. Non Class 1E Main Steam and Feedwater Isolation System (MSFIS) Trouble Alarm Wiring

MSFIS trouble alarms employ photosensitive resistance detectors whose resistance changes from 90 ohms to one megaohm when trouble is detected in the MSFIS cabinet[11]. The alarm wiring is No. 22 AWG Tefzel insulated and is terminated on terminal blocks

within two metal boxes interconnected by a rigid metal conduit within the MSFIS cabinet.

Plant annunciator employs a 24 VDC power supply to interrogate the resistance detectors through interconnecting wiring. A signal input card in the annunciator is designed to limit the signal current to 2 milliamps when the input is shorted at the annunciator terminals.

Considering the short circuit fault across the resistance detector, the current in non 1E alarm wiring would increase to 2 milliamps, as limited by signal input card, resulting in an insignificant temperature rise in non 1E wiring and no effect on 1E wiring.

Considering a short circuit fault across the annunciator signal input card, the current in non 1E wiring will be limited by the internal resistance of the annunciator power supply, the interconnecting wiring, and the resistance detector (90 ohms minimum). Disregarding the internal resistance of the annunciator power supply and the resistance in wiring, the maximum current would be: 24 V/90 ohms = 0.266 amp. Since the wiring in the cabinet is rated at 3 amps, the temperature rise due to fault current would be negligible.

Considering the ground fault in a non 1E MSFIS cabinet wire, a negligible current would flow only in annunciator ground detector since the annunciator is otherwise ungrounded. The 1E wiring would not be affected.

Therefore, since there is no degradation of 1E circuits by any fault in non 1E circuits, these circuits can be considered low energy circuits which cannot affect any other cables in the vicinity.

I. Non Class 1E RCP Temperature Sensor Monitoring System Spec. 13-JM-111

Power is fed through a 332 ohm resistor to an operational amplifier, which in turn feeds this power to the temperature sensor.[6] The 20 VDC power supply is ungrounded.[6] This analysis does not take credit for the current limiting operational amplifier. The power supply will be considered grounded. With the above assumptions, the conservative maximum fault current at the temperature sensor will be 0.060 amp to ground. Therefore, the temperature sensors: 13-J-RCN-TE-118, -128, -138, -148, -150, -151, -156, -157, -160, -161, -166, -167, -170, -171, -176, -177, -180, -181, -186, -187, -190, -191, -192, and -193 can be considered low energy circuits which cannot affect any other cables in the vicinity.

J. Non Class 1E RCP Temperature Recording System Spec. 13-JM-304

There is a resistor of 40K ohms in series with a 21 VDC supply to the temperature sensor.[7] The maximum fault current at the

temperature sensor will be 0.001 amp to ground. Therefore the temperature sensors: 13-J-RCN-TE-152, -153, -158, -162, -163, -168, -172, -173, -178, -182, -183, and -188 can be considered low energy circuits which cannot affect any other cables in the vicinity.

K. Class 1E and Non Class 1E RCP Shaft Speed Sensing System

The maximum current for a fault at the speed sensing probe would be less than 0.030 amp.[13, 8] Therefore, these probes 13J-RCN-SE-154, -155, -164, -165, -174, -175, -184, -185, 13J-RCA-SE-113A, -123A, -133A, -143A, 13J-RCB-SE-113B, -123B, -133B, -143B, 13J-RCC-SE-113C, -123C, -133C, -143C, 13J-RCD-SE-113D, -123D, -133D, and -143D can be considered low energy circuits which cannot affect any other cables in the vicinity.

L. Non Class 1E RCP Vibration Monitoring System Spec. 13-JM-803

The maximum current for a fault at the proximity probe would be less than 0.005 amp.[14, 9] Therefore, the proximity probes 13J-SVN-YE-21, -22, -23, -24, -25, -26, -27, and -28 can be considered low energy circuits which cannot affect any other cables in the vicinity.

M. Non Class 1E Valve Vibration Monitoring System Spec. 13-JM-366

The accelerometer probes create a small electrical charge (e.g., 0-2.4 x 10^{-9} coulombs) which is amplified to 0-5 volts by a charge converter.[10] The converter sends no voltages or currents to the probes, it only measures the charges created by these probes. Since these probes 1-J-SGE-ZE-697, -699, -701, -706, -707, and -708 produce such a small charge they can be considered low energy circuits which cannot affect any other cables in the vicinity.

4.0 Conclusion

The above discussion justifies that the analized circuits do not provide sufficient energy under faulted conditions to cause degradation of other Class 1E circuits in the vicinity.

5.0 References

1. Regulatory Guide 1.75 Rev. 1 1975
2. IEEE Standard 383-1974
3. IEEE Standard 384-1974

4. Instruction Manual M651-92-2

5. Instruction Manual E048A-13-1

6. Instruction Manual J111-91-6 (Model 2A1-P2V)

7. Instruction Manual J304-8-3 (Model M11E)

8. Instruction Manual N001-6.02-171-4

9. Instruction Manual J803-23-11

10. Instruction Manual J366-431-2

11. Instruction Manual J108-229-3

12. Telephone Notes TN-3671 dated 2/24/84

13. Telephone Notes TN-E-3951 dated 11/5/84

14. Telephone Notes TN-E-3915 dated 10/19/84

15. Power Requirements of Circuits Protectowire Panels M650-722-1

16. Operation Manual N997-274-2

17. QVDR E033-11-1

18. Altec Lansing Catalog 183.2.5M Rev. 11 (1593B Amplifiers)

19. N997-561-1