ELECTRICAL DEPARTMENT	**ELECTRICAL DESIGN CRITERIA** **ELECTRICAL CIRCUIT PHYSICAL SEPARATION AND CABLE TRAY LOADING**	 Revision 2 Date 4/13/93

CRYSTAL RIVER UNIT 3

FLORIDA POWER CORPORATION

NUCLEAR SAFETY RELATED

FLORIDA POWER CORPORATION
NUCLEAR ENGINEERING DEPARTMENT
CRYSTAL RIVER - UNIT 3

REVIEWED AND ACCEPTED BY:

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Rev.	Description	Prepared By	Verifier	Approved
2	Revise criteria for internal panel wiring other than 1E to 1E and enhancement	T.D. Patel 4-13-93	R.R. Stashel 4-13-93	4/13/93
1	Added SILTEMP as a Thermal Barrier and Enhancement	T.D. Patel 6-18-92	D.A. Rhoads 6-18-92	R.P. Cronk C.G. Kramer 6-18-92
0	Combined and added new criteria for both inside and outside of rack, panel, etc.	S.M. Cisek T.D. Patel	R.B. Porter R.G. McNabe	R.P. Cronk C.G. Kramer

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ATTACHMENTS

1. Separation Criteria Exceptions
2. Separation Criteria Exceptions Evaluation Form

1. SCOPE

The purpose of this document is to establish separation criteria applicable to wiring and components located in Class 1E enclosures as well as for electric cable and raceway which are routed outside of Class 1E enclosures. It also establishes separation criteria for 1E to non-1E wiring, components and raceways. In addition, this document establishes the criteria for cable tray loading and cable application for electrical power, control, and instrumentation cable and raceways which are routed to safety-related equipment. The criteria contained herein is applicable to existing as well as new construction for Florida Power Corporation, Crystal River Unit 3.

The criteria identified in Section 4.A of this document applies to external field cabling and raceway starting at the opening where a cable or raceway enters/leaves equipment or enclosures.

The criteria identified in Section 4.B of this document applies to all internal cabling and wiring starting at the opening where a cable enters an enclosure such as control boards, equipment cabinets and relay racks. It includes, but is not limited to construction and wiring practices. The panels and relay racks which are governed by this document are the following:

1) Main Control Board in Control Room (All Sections)
2) RR1
3) RR2
4) RR3
5) RR1A/RR2A
6) RR1B/RR2B
7) RR1AB/RR2AB
8) RR3A/RR3B
9) RR4A/RR4B
10) RR5B1/RR5B2
11) RRHV
12) Transmitter Power Supply Cabinet (TPC)
13) Nuclear Sample Panel NS
14) RRPSA
15) EFIC A, B, C, & D Cabinets
16) EFIC A & B Aux. Cabinets
17) EFIC C & D Relay Boxes
18) RSP A/RSP AB/RSP B
19) RSP-RRA/RSP-RRA1
20) RSP-RRB/RSP-RRB1
21) RSP A & B Aux. Equipment Cabinets
22) RCITS A & B Cabinets

The separation criteria for Engineered Safeguard Actuation cabinets (4A, 4B, 4C, 4D, 5A, 5B, 5C & 5D) and Engineered Safeguard Channel cabinets (1, 1A, 1B, 2, 2A, 2B, 3, 3A & 3B) are considered in Appendix 3 of this design criteria.

The fire service panel is a Non-Class 1E panel and even though the power to this panel is fed from safety related buses, it has been isolated by a Class 1E isolation device in the distribution panel. Therefore, the fire service panel is not governed by this separation criteria.

The radioactive waste disposal panel is a vendor supplied Non-Class 1E panel. It is not governed by this separation criteria since separation requirements were not imposed on this panel during procurement and construction. All wires inside the radwaste panel are gray with the exception of two brown conductors connected to Non-1E relay (device VG). This circuit with brown conductors is fed from Class 1E power source, however, it has been isolated by a Class 1E fuse at the MCC. Also in the radwaste panel, wiring has been routed in the flex conduit up to device VG to maintain separation from other Non-1E circuits.

Any work performed as a maintenance activity on a circuit located inside or outside of an enclosure listed above must be performed in accordance with this criteria as applicable. Any future design activities to the above listed enclosures shall also observe these requirements unless otherwise justified by analysis as identified herein.

The requirements of the following documents for electrical circuit physical separation are incorporated in the design criteria:

- Draft 1 dated 10/20/71, Section 8.0 of the proposed Guide for the Design and Installation of Cable Systems in Power Generating Stations, (Ref. 3R)
- Criteria Relating to Electrical Circuit Physical Separation and Cable Tray Loading dated January 24, 1977 (Ref. 3C)
- FSAR Separation Criteria (Ref. 3E)
- E-91-0001, Rev. 0, Electrical Separation Criteria for Class 1E Control Boards, Equipment Cabinets and Relay Racks (Ref. 3A)
- Control Board and Relay Rack Engineered Safeguard Separation Criteria Report, Rev. 9, May 1975 (Ref. 3W)
- IEEE 279-1968, Criteria for Nuclear Power Plant Protection Systems

Guidance on the use of barriers for fire protection is provided in the Crystal River Unit 3, 10CFR50, Appendix R Fire Study. Circuits that are required for safe shutdown in the event of a fire are identified on the E-213 series of drawings and in Section 7 of the 10CFR50 Appendix R Fire Study Report.

2. DEFINITIONS

To clarify terms used within this document, the following definitions shall apply:

A. Associated Circuits - Non-Class 1E circuits that are routed with Class 1E circuits and are not separated from Class 1E circuits by acceptable separation distance, barriers or isolation devices. (NOTE: Crystal River Unit 3 does not use associated circuits as defined by IEEE 384. When used in this document, the term is to define non-class 1E circuits routed with Class 1E circuits.)

B. Barrier - A device or structure interposed between redundant Class 1E equipment or circuits, between Class 1E and Non-Class 1E equipment or circuits, or between Class 1E equipment or circuits and a potential source of damage to limit damage to Class 1E systems to an acceptable level.

C. Channel - The designation applied to a given system or set of components that enables the establishment and maintenance of physical, electrical, and functional independence from other redundant sets of components. The terms division, train, channel, separation group, and safety group are interchangeable in the context of this document.

D. Class 1E - The safety classification of the electrical equipment and systems that are essential to emergency reactor shutdown, containment isolation, reactor core cooling and containment and reactor heat removal, or are otherwise essential in preventing a significant release of radioactive material to the environment. This classification includes, but is not restricted to the reactor protection, engineered safeguards and EFIC systems.

E. Class 1E Cabinet - A rack, panel, switchboard, or similar enclosure fitted with Class 1E equipment. As used within the context of this document, the cabinet can be open (i.e., a frame structure without sides or doors) or closed (i.e., a complete enclosure).

Note:
- Even though the Main Control Board was built by assembling many individual sections (some safety and non-safety related), the Main Control Board is considered as one enclosure for the purposes of this document. Equipment racks located inside the Main Control Board are considered as separate Class 1E cabinets, and as such, each is to satisfy the requirements of this criteria document.
- MCC's, switchgear and HVAC cabinets also meet this definition, but are not governed by this separation criteria

since separation requirements were not imposed on this equipment during procurement and construction.

F. Control Circuits - Low Voltage Control Circuits utilizing relatively low-current levels or used for intermittent operation to change the operating status of a utilization device of the plant auxiliary system.

G. Design Basis Event - A postulated abnormal event used in the design to establish the acceptable performance requirements of the structures, systems, and components.

H. Engineered Safeguard System - The equipment, instrument c[illegible], power supplies, actuation logic and manual controls that compr[illegible] system which takes automatic action to prevent or mitigate the effects of a design basis accident.

I. Flame Retardant - Capable of limiting the propagation of a fire beyond the area of influence of the energy source that initiated the fire.

J. Independence - The state in which there is no mechanism by which any single design basis event can cause redundant equipment to be inoperable.

K. Instrumentation Circuit - A low energy circuit used for transmitting variable current or voltage signals (analog) or those used for transmitting coded information (digital).

L. Isolation Device - A device in a circuit which prevents malfunctions in one section of a circuit from causing unacceptable influences in other sections of the same circuit or in other circuits.

M. Limited Hazard Areas - Limited hazard areas are those plant areas other than cable spreading room and control room from which potential hazards such as missiles, exposure fires, and pipe whip are excluded.

N. Low Energy Circuit - Low energy circuits are those circuits that either are inherently limited requiring no overcurrent protection or limited by a combination of a power source and overcurrent protection (NEC Article 725-31 for Class 2 and Class 3 circuits). They are comprised of analog and digital circuits used for transmitting:

   a. Variable current or voltage signals for the control and/or instrumentation of plant equipment and systems.

   b. Coded information signals, such as those derived from the output of an analog-to digital converter or the coded output from a digital computer or other digital transmission terminals.

For CR3, low energy circuits are defined as those having the following nominal characteristics:

- 32-160 mV
- 28V DC
- 4-20 mA
- 10-50 mA
- 1-5V DC
- 0-10V DC
- 24V DC
- 24V AC
- -10 to +10V DC
- 125V DC high impedence current limited annunciator logic loops

125 VDC annunciator circuits are digital circuits which are routed in control cable tray or conduit. Since they are connected to a high impedance source (60 K), the current is limited in these circuits to qualify them as low energy circuits. The cable insulation for annunciator circuits is rated at 600 volts.

O. Low-Voltage Power Circuit - A circuit which supplies power to utilization devices of the plant auxiliary systems rated at 600V or less.

P. Medium-Voltage Power Circuit - A circuit which supplies power to utilization devices of plant auxiliary systems rated at 601 V to 15,000 V.

Q. Non-Hazard Areas - An area meeting the following requirements may be designated as a nonhazard area (cable spreading room and control room only).

(1) The area shall not contain high energy equipment such as switchgear, transformers, rotating equipment, or potential sources of missiles or pipe failure hazards, or fire hazards.

(2) Circuits in the area shall be limited to control and instrument functions and those power supply circuit cables and equipment serving the equipment located within the area.

(3) Power circuit cables in this area shall be installed in enclosed raceways.

(4) Administrative control of operations and maintenance activities shall control and limit introduction of potential hazards into the area.

R. Protection System - The protection systems, which consists of the Reactor Protection System (RPS) and the Engineered Safeguard Actuation System (ESAS), perform important control and safety functions. The protection systems extend from the sensing instruments to the final actuating devices, such as circuit breakers and pump or valve motor contactors.

S. Raceway - Enclosures such as conduit, cable tray, ducts, wireway penetrations, etc., which provide a method of routing support, and physical protection for the electrical cable system.

T. Reactor Protection System - The overall compliment of instrument channels, trip logic and wiring which make up redundant channels to form a matrix to generate a reactor trip signal.

U. Redundant Circuits, Equipment or System - Circuits, equipment or systems that duplicate the essential function of another piece of equipment or systems to the extent that either may perform the required function regardless of the state of operation or failure of the other.

V. Safety-Related (Class 1E) - The safety classification of the equipment and systems that are essential to assure the integrity of the Reactor Coolant System boundary and the capability to shutdown the reactor, to maintain it in a safe shutdown condition and to prevent or mitigate the consequences of accidents which could result in potential offsite exposures comparable to those referred to in 10CFR100.11.

W. Separation Distance - Space which has no interposing structures, equipment, or materials that could aid in the propagation of faults or that could otherwise disable safety-related systems or equipment.

X. Single Failure Criteria - The single failure criteria as defined in IEEE Standard No. 279-1971 states: "Any single failure within the protection system shall not prevent proper protective action at the system level when required." This is applied to all systems that have safety related functions.

3. REFERENCES

The design basis for internal and external separation requirements of safety related circuits stated in this document is provided in Appendix 1. The use of the references in the preparation of this document does not imply FPC commitment to the referenced document.

A. E-91-0001, Rev. 0, Electrical Separation Criteria for Class 1E Control Boards, Equipment Cabinets and Relay Racks (To be superceded by this criteria).

B. Crystal River Unit 3, 10CFR50, Appendix R Fire Study.

C. Criteria Relating to Electrical Circuit Physical Separation and Cable Tray Loading dated January 24, 1977 (To be superceded by this criteria).

D. Electrical Design Criteria - Cable Tray and Conduit Fill and Weight Limitations.

E. CR3 Final Safety Analysis Report, Chapter 7, paragraphs 7.1.1.1 to 4 and 7.1.3.15 and Chapter 8, paragraph 8.2.2.11 to 13.

F. Regulatory Guide 1.75, Rev. 2: Physical Independence of Electric Systems.

G. IEEE 384-1974, IEEE Standard Criteria for Independence of Class 1E Equipment and Circuits.

H. IEEE 420-1982, IEEE Standard for the Design and Qualification of Class 1E Control Boards, Panels, and Racks Used in Nuclear Power Generating Stations.

I. IEEE 690-1984, Cable Systems for Class 1E Circuits in Nuclear Power Generating Station.

J. RO-3065, Addendum G: Requirement outline for Engineered Safeguards Actuation Relay Cabinets.

K. RO-3138, Addendum M: Requirement Outline for Main Control Board, and Control Cubicle.

L. Drawing E-214-061, Miscellaneous Cable Tray Details.

M. Drawing S-520-001 thru 013, Standard Appendix R Fire Wrapping Details.

N. Electrical Design Criteria - 10CFR50 Appendix R Compliance Review Criteria.

O. Electrical Design Criteria - Cable Ampacity Sizing.

P. IEEE 384-1992; IEEE Standard Criteria for Independence of Class 1E Equipment and Circuits.

Q. IEEE Paper 71 TP 83-PWR; Working Group Report for Design and Installation of Wire and Cable Systems in Power Generating Stations [First draft to IEEE 422. NOTE: This document is committed in FSAR Chapter 8, Section 8.2.2.12].

R. IEEE 422; Guide for the Design and Installation of Cable Systems in Power Generating Stations.

S. IEEE Paper 90 WM 254-3 EC; Cable Separation - What Do Industry Testing Programs Show?

T. IEEE Paper CH2040-4184/0000-0108$01.00; Arcing Fault in Metallic Conduit at 120 and 240 volts.

U. Crystal River Unit 3, Fire Hazard Analysis.

V. RP-5515-096-1.00-CS, Rev. 0; Engineered Safeguards Actuation System Electrical Separation Considerations.

W. Control Board and Relay Rack Engineered Safeguard Separation Criteria Report, Rev. 9, May 1975.

X. IEEE 279-1968; Proposed IEEE Criteria for Nuclear Power Plant Protection Systems.

Y. E91-0052, Rev. 0; Evaluation of SILTEMP as a Thermal Barrier for Separation.

Z. Test Report - Design Verification for Internal Panel Control Wiring Separation Criteria by Philadelphia Electric Company, Report No. 48503 dated September 1, 1982.

AA. Test Report - Electrical Separation Verification Testing for Duquesne Light Company's Beaver Valley Power Station - Unit 2, Report No. 17666-02 dated April 19, 1985.

AB. Test Report - Electrical Separation Verification for South Texas Project Electrical Generating Station Units, Report No. 53575 dated February 12, 1987.

AC. Test Report - Electrical Separation Verification Testing for Northeast suclear Energy Company's Millstone Power Station - Unit No. 3, Report No. 47506-02 dated March 11, 1985.

AD. IPCEA Publication No. P-46-426, Power Cable Ampacities, Volume 1 - Copper Conductors (American Institute of Electrical Engineers, 1962).

AE. IEEE-383-1974; IEEE Standard for Type Test of Class 1E Electric Cables, Field Spices, and Connections for Nuclear Power Generating Stations.

4. ELECTRICAL SEPARATION

A. FOR OUTSIDE OF PANELS, CABINETS, AND RACKS

1) General Considerations

a. Routing Location

Whenever possible, raceways carrying safety-related circuits shall be routed through non-hazardous or limited hazard areas.

In non-hazard or limited hazard environment, separation distances are based on hazards being limited to fire and faults or failures internal to the cable. Internal failures are such occurrences as short circuits, open circuits, and grounds and include raceway interaction during a seismic event.

Where raceways with safety-related circuits are located in a hazard area, they shall be analyzed such that the defined hazard will not cause a common failure of both redundant safety-related systems. Therefore, the effects of external hazards such as pipe whip, jet impingement, water/chemical sprays, flooding, radiation, pressurization, elevated temperature or humidity and missiles shall be considered. However, where such a location is unavoidable, either protective shielding is provided for redundant Class 1E raceways or only one Class 1E channel raceway is allowed to occupy the area.

b. Physical Space and Functional Limitations

The preferred method for achieving independence is to physically and electrically separate redundant systems of safety-related cables and raceways from each other. Physical space and functional limitations and considerations may warrant the grouping of Safety-related and Nonsafety-related cable within the same raceway. Where this condition occurs, the specific circuit separation criteria defined in subsection 4.A.2 below shall be met.

c. Classification of Electrical Cable Trays

In the original plant design, cable trays at CR-3 were designated as safety classification A, B, AB, and X. Intersection between A and X or B and X was permitted. Cables classified as X were allowed to route in either A or B trays but not both. Separation was assured as a result of the non intersection between selected combinations of cable trays. These consisted of A and X, B and X and X alone. In 1984, the CR-3 cable routing program was updated to utilize G/C's CKS cable routing program. Due to additional restrictions placed on classification intersections (i.e. A and X were not allowed to intersect), X trays intersecting with A trays were redesignated as XA. Similarly X trays intersecting with B trays were redesignated as XB. Trays designated as X that did not intersect with any other classification of tray remained classified as X and contained only non-safety circuits. Circuit classifications were also changed to match this approach. Due to the fact that the plant was fully constructed and these changes only affected non-safety related cables and trays, the field identification (color id #'s) of the cable trays were not changed. This resulted in all X, XA and XB cable trays being identified with white numeric markers.

Note: MAR NO. 88-10-20-01 created a case that necessitated the creation of an XX classified tray that connects an XA tray and an XB tray. This MAR was prepared to install the Non-1E 250/125 VDC battery in the CR-3 Turbine Building. This MAR required an XX tray (#61) to route power cable from the Non-1E main distribution panel to the existing Non-1E subpanels. This is the only XX tray at CR-3. The cables routed within this tray are all Non-Safety related and classified as XX. The CR-3 cable routing program is restricted such that XX cables are not allowed to route in any safety related tray system. As a result, XX cable can never provide a bridge between the redundant tray systems within the plant. Therefore, the cables routed via this MAR are isolated from the class 1E system and satisfy the CR-3 separation criteria.

Based on the above the following routing combinations are permitted:

Cable Tray	Circuit Classification
A	A, XA
B	B, XB
AB	AB
XA	XA, XX
XB	XB, XX
X	X, XX
XX	XX

As a result of this reclassification effort, cable trays routing control cable within the Control Complex are A, B, AB, or XB with the exception of trays 125, 126, and 127 which contain only circuits routed to the Control Rod Drive equipment and are classified as X. Therefore any non-safety cable entering cabinets (other than the Control Rod Drive Cabinets) within the Control Complex routed via non-safety cable tray can be considered as XB and shall adhere to the separation limitations imposed on the XB cabling.

d. Exceptions

Exceptions to this criteria should be strongly discouraged. However, for those cases where the criteria are found to be physically impractical or unduly restrictive, relaxation of the requirements may be considered. The individual considering the exception to this criteria shall fill out the "Separation Criteria Exception Evaluation Form" (Attachment 2) and forward it to the NOE supervisor of Nuclear Engineering (Electrical) to maintain as part of the plant records. Any deviation or exception to these design criteria shall be justified and approved by the NOE Supervisor of Nuclear Engineering (Electrical). All exceptions shall be included in Attachment 1 of these design criteria.

2) Specific Circuit Separation Criteria

a. Safety-Related (Class 1E) Circuits

In order to assure safety function integrity, a safety-related circuit of one channel shall remain independent of any other channel. The independence can be achieved by running the circuits of one channel in raceways and penetrations that are physically separated by some distance from the raceways and penetrations used by circuits of a redundant channel. If routed in cable tray, safety-related cables are designated as either train A or train B and are only permitted to route in their respective A or B cable tray.

Where the minimum physical separation distance cannot be maintained between redundant channels and Class 1E to Non-Class 1E Raceways/Cables, a separation barrier shall be provided [Refer to Subsection 4.A.4].

i. Minimum separation distance between redundant Class 1E Raceways/Cables in the field and at the Reactor Building Penetrations shall be as defined in Table C.

Note that AB cables are to run separately from A train and from B train cables (reference Table A). For valves MUV 23 and 24, their cables are train AB but are to be run separately from the cables for valves MUV 25 and 26 which are also train AB. The reason being valves MUV 23 and 24 are redundant to valves MUV 25 and 26.

ii. Minimum separation distance between Class 1E to Non-Class 1E Raceways/Cables in the field and at the Reactor Building Penetration shall be as defined in Table E.

iii. Distances between external raceways carrying circuits of the same separation group but of different voltage level and cable type should be as defined in Table F.

The recommended separation distances given in Table F are based on industry accepted installation practices and the need to reduce noise in analog circuits run in close proximity with power circuits.

b. Associated Circuits

Associated circuits as defined in Section 2 "Definitions" refers to nonsafety-related circuits routed along with safety-related circuits. If these associated circuits are routed in cable trays, they shall be given XA or XB designation and are only permitted by computer program to route in A, XA or B, XB cable trays. These circuits do not perform a safety function and once a nonsafety-related circuit has been routed with a safety-related circuit, the nonsafety-related circuit shall be treated as the same channel as the safety-related circuit to which it has been grouped. These associated circuits shall not be routed with safety-related circuits of a redundant channel [Refer to subsection 4.A.8 for redundant cable groupings].

c. Nonsafety-Related Circuits

i. Nonsafety-related circuits shall not be routed along with safety-related circuits except when defined and installed as "associated" (Refer to subsection 4.A.2.b above).

ii. Nonsafety-related power cables from redundant safety-related equipment shall <u>not</u> be routed in a common nonsafety-related cable trays.

iii. Non-safety cables that are inputted to the cable routing computer program as 'xx' shall be run in trays XA, X, XB, XX. They shall not be run in raceways carrying safety related cables. This does not violate separation criteria as associated trays were created to allow the intersection between safety and non-safety related trays. (NOTE: CR3 is not licensed to meet the requirements of IEEE 384 regarding the separation of associated circuits).

Note: Refer to Note in Section 4.A.1).c

iv. Non-safety cables that are inputted to the computer as 'X' shall be only allowed to run in non-safety trays 'X' and 'XX'.

d. Separation by Voltage and Cable Type

Circuits shall be separated by nominal circuit voltage and cable types and routed within separate raceways as detailed in Section 5.

e. Vendor Supplied Cable

Cables classified as EK-X shall not be run in tray unless acceptable fire propagation as defined by IEEE 383 is assured when using vendor cable.

3) Safety-Related Raceway Routing in Hazardous Areas and Common Fire Areas

Missile producing or high energy line break areas and common fire areas should be avoided when locating redundant safety-related raceways whenever possible. However, where such a location is unavoidable, protective shielding or Appendix "R" fire wrapping (Reference 10CFR50 Appendix R Fire Study, Appendix R 213 Series Drawings and the Fire Hazards Analysis (FHA)), as applicable, shall be provided to assure functional capability is maintained.

Appendix R fire barriers shall be installed using the typical fire wrapping construction details shown on drawings S-520-001 through -013. To determine if a raceway requires Appendix "R" protection, refer to electrical design criteria - 10CFR50 Appendix R Compliance Review Criteria - Reference 3.N.

4) Separation Barriers

Separation barriers (non-Appendix R application) can be used as follows when the separation distances cannot be maintained:

a. Rigid, flexible metallic conduit and armored cable are considered barriers. When these are used as a barrier, the minimum separation distance shall be as defined in Tables C and E for conduit.

b. Separation barriers for cable tray shall be as shown per Drawing E-214-061 to maintain the acceptable separation distance and structural and mechanical integrity of the cable tray and supports.

The use of asbestos materials for separation barriers is not allowed. Existing installations using asbestos need not be replaced; however, new installations or individual

replacements should utilize a non-combustible asbestos free, mineral fiber material as shown on Drawing E-214-061.

c. Metal Square "D" Duct is considered a barrier. When these are used as a barrier, the minimum separation distance shall be as defined in Tables C and E for conduit.

d. The metal enclosures of the panel or cabinet. When these are used as a barrier, the minimum separation distance shall be as defined in Tables C and E for conduit.

<u>NOTE</u>: The following non-metallic barriers are only used when none of the above barriers are feasible. The use of non-metallic barriers is limited to instrumentation, control and power circuits operating at less than 600 volts.

e. SILTEMP 188 CH (100% overlap) or SILTEMP WT-65 (50% overlap) with 3M No. 69 glass tapes (50% overlap) shall be considered appropriate thermal insulation for cables with a minimum 3/8 inch separation between the wrapped and unwrapped cable. The wrap may be applied to either cable.

f. SILTEMP WT-65 (50% overlap) with 3M No. 69 glass tapes (50% overlap) form appropriate thermal barriers between conduit (flexible or rigid) and cables (power, control or instrumentation) in free air with zero inch separation when the conduit is wrapped in the SILTEMP. This requirement is limited to a conduit containing 120 VAC/125 VDC power, control and instrumentation cables only.

5) <u>Permanent Markings</u>

a. Raceways shall be identified using permanent markings. The purpose of such markings is to facilitate cable routing identification for future modifications or additions. Refer to applicable maintenance procedure for details.

b. The permanent identification of cables and conductors shall be made at the terminal points. Refer to applicable maintenance procedure for details.

c. The color coding for permanent markers for raceway and cables is shown on Table A.

6) Splices

Cable Splicing within raceway, except for specifically identified splice boxes, is not allowed.

7) Channel Separation

Refer to Table A for channels requiring separation.

8) Redundant Safety-Related Cable Groups

There is four channel separation for the reactor protection and three channel separation for the engineered safeguard circuits. This separation is maintained from the sensor through the analog racks to the logic or relay cabinets. Where wiring in two or more cables is joined for a common alarm or events recorder point, the cables concerned are not routed in more than one engineered safeguard channel tray where routing through engineered safeguard tray is used for necessity.

For a detailed breakdown of the allowable cable groups and color coding, refer to Table A. The following is a generalized description of the systems included within the redundant safety-related channels.

a. Reactor Protection System-Channel I (RPS I)
Engineered Safeguard-Channel A (ES A)
Emergency Feedwater Initiation and Control-Channel A (EFIC A)
Associated-Channel A
Vital Bus-Channel A

b. Reactor Protection System-Channel II (RPS II)
Engineered Safeguard-Channel B (ES B)
Emergency Feedwater Initiation and Control-Channel B (EFIC B)
Associated-Channel B
Vital Bus-Channel B

c. Reactor Protection System-Channel III (RPS III)
Engineered Safeguard-Channel AB (ES AB)
Emergency Feedwater Initiation and Control-Channel C (EFIC C) - Instrumentation cable only
Associated-Channel AB
Vital Bus-Channel III

d. Reactor Protection System-Channel IV (RPS IV)
Emergency Feedwater Initiation and Control-Channel D (EFIC D)
Vital Bus-Channel IV

e. Emergency Feedwater Initiation and Control-Channel C (EFIC C) - Control cable only

f. Nuclear Instrumentation & Protection (NI & P) System
Nuclear Instrumentation and Protection cables for channels 1 through 4 shall be contained in four, physically separate groups of conduit runs. Channels 12, 13, 14, 23, 24 and 34 are designated to provide interconnections between NI & P system sub-assemblies A, B, C and D. The specific cable and conduit color identification requirements are given in Table A, page 2 of 2.

g. EFIC Logic Cabinets Interconnections
The specific color identification requirements for conduits interconnecting EFIC cabinets are given in Table A, page 2 of 2.

B. <u>FOR INSIDE 1E PANELS, CABINETS AND RACKS</u>

1) <u>General Considerations</u>

a. Physical separation of redundant circuits, devices, and components is to be provided within sections of Class 1E panels, cabinets and racks listed in section 1.0 so that no single credible event as defined in the FSAR can prevent the proper functions of the safeguard or protection systems as identified in IEEE 279-71.

b. Engineered Safeguard channel circuits for safe plant shutdown are defined as those circuits which run separately to form two redundant actuation trains. "A" train which is color coded red and must be separated from the "B" train which is color coded green. Likewise, the "B" train which is green is similarly separated. The AB actuation which is yellow, is <u>not</u> a train but a combination of A and B trains, either of which causes an AB actuation. The AB actuation must be kept separate from the A & B channels and trains except at the point of origin where reasonable isolation is required.

c. Inside a Class 1E panel, cabinet, or rack separation is required between the separation groups defined in Table B.

d. Whenever a case arises in which there is a question as to whether the separation criteria has been satisfied, the case will be resolved by Nuclear Engineering via REA. Some examples would include:

   i. Any cable running between the RPS, ES, or EFIC cabinets or internal wiring for these cabinets where two different color wires terminate on the same device, with one or more of these colors indicating Class 1E wiring.

   ii. Cases when a non-Class 1E circuit is reassigned as a Class 1E circuit or vice verse.

   iii. Any unusual wiring problems such as control switches and selector switches which are in circuits operated from a power source different from the indication, or switches containing power feeds different from the indicating lights.

e. Exceptions to this criteria should be strongly discouraged. However, for those cases where the criteria are found to be physically impractical or unduly restrictive, relaxation of the requirements may be considered. The individual considering the exception to this criteria shall fill out the "Separation Criteria Exception Evaluation Form" (Attachment 2) and forward it to the NOE supervisor of Nuclear Engineering (Electrical) to maintain as part of the plant records. Any deviation or exception to these design criteria shall be justified and approved by the NOE Supervisor of Nuclear Engineering (Electrical). All exceptions shall be included in Attachment 1 of these design criteria.

2) Internal Wiring Color Code

Wiring inside Class 1E cabinets listed in section 1.0 shall be identified by use of color coding as described in Table B. Under special circumstances where the entire cabinet is of one separation group, the cabinet may be designated as that channel, and internal color codes do not need to be applied. The internal wiring drawings for Class 1E cabinets shall be marked to show wire color codes at devices or terminal boards. Gray wire will not show an identification color code.

3) Separation Distances and Barriers

Separation by distance is the preferred method to be considered for a given design as follows:

a. Components and Wiring

Class 1E redundant components and wiring should be separated to the maximum practical distance in the cabinets in which they are located. The minimum separation distance between redundant Class 1E components and wiring shall be 6 inches. The minimum separation distance for the wiring between the following combinations is 1" (Ref. Table D):

- Class 1E to Redundant Associated
- Class 1E to Non-Class 1E
- Associated to Non-Class 1E
- Associated to Associated (i.e. XA to XB)

Exceptions to the above requirements are identified in subsection 4.B.3.b below and Appendix 3.

Inside Class 1E cabinets, it is acceptable to have Non-Class 1E wiring not separated from Class 1E wiring or associated wiring by the minimum separation distance of 1 inch or by a barrier as long as Non-Class 1E wiring or cable is not routed with redundant Class 1E wiring and/or its associated circuits.

Components shall be located to maintain this minimum separation requirement. In the case where a device is in a group or surrounded by redundant wiring or devices it may not be possible to maintain this distance. <u>If the minimum air space separation distance cannot be maintained, a barrier shall be installed between the components or wiring requiring separation</u>. Barriers to use within cabinets requiring separation are:

i. Barriers between redundant components or wiring -

a. A single sheet of 16 gauge (minimum) metal separated by at least one inch air space between the nearest redundant Class 1E component or wiring. Where one inch of air space between redundant Class 1E components cannot be achieved, a fire retardant material equivalent to one inch of free air space shall be attached to the metal sheet which: (1) extends at least one inch beyond the edge of the larger device or wire bundle; or (2) where the difference in device depths is six inches or greater extends at least one inch beyond the edge of the small device (Refer to Figures 1, 2 and 3). For new construction or modifications, a barrier with fire retardant material attached is recommended. In lieu of 1" air space on both sides of the metal sheet, 1/4" Marinite on both sides is acceptable or a minimum 1/2" thick Marinite on either side of the metal sheet as shown on Figure 4B is acceptable based on analysis in Appendix 1, Section 8.0.

b. Two sheets of 16 gauge metal (minimum) separated by a minimum of one inch air space between the metal pieces which: (1) extends at least one inch beyond the edge of the larger device or (2) where the difference in device depths is six inches or greater extends at least one inch beyond the smaller device. Refer to Figures 1, 2 and 5.

ii. Barriers between 1E and Associated or 1E and Non-1E or Associated and Non-1E or Associated (XA) and Associated (XB)

A single sheet of 16 gauge (minimum) metal with a minimum 1/2" thick Marinite on either side of the metal sheet as shown on Figure 4B is acceptable based on analysis in Appendix 1, Section 8.0.

iii. Rigid or flexible metallic conduit shall be considered a barrier. When conduit is used as a barrier, the minimum separation distance between conduits shall be as defined in Table D.

iv. Crossover of redundant Class 1E circuits shall be enclosed in conduit for a length of six inches on either side of the crossover point or a barrier shall be installed. Crossover situations will be avoided wherever possible.

Note: The following non-metallic barriers are only used when none of the above barriers are feasible. The use of non-metallic barriers is limited to instrumentation, control and power circuits operating at less than 600 volts.

v. SILTEMP sleeve with 3M No. 69 glass tapes (50% overlap) shall be considered appropriate thermal barriers with zero inch clearance between two cables. For Class 1E to Class 1E cable separation, both Class 1E cables shall be covered with SILTEMP sleeves and tape. For Class 1E to Non-Class 1E or Class 1E to redundant associated cable separation, the Non-Class 1E or redundant associated cable shall be covered with the SILTEMP sleeve and tape. For associated (XA) to associated (XB) cable separation, either XA or XB cable shall be covered with the SILTEMP sleeve and tape.

vi. SILTEMP 188CH (100% overlap) or SILTEMP WT-65 (50% overlap) with 3M No. 69 glass tapes (50% overlap) shall be considered appropriate thermal barriers with zero inch clearance between wrapped cables (i.e., wrap shall be applied to both cables).

vii. SILTEMP 188CH (100% overlap) with 3M No. 69 glass tapes (50% overlap) shall be considered an appropriate thermal barrier with 1 inch clearance between two cables of different channels.

viii. SILTEMP WT-65 (50% overlap) with 3M No. 69 glass tapes (50% overlap) shall be considered an appropriate thermal barrier with 1/2" clearance between two cables of different channels.

ix. The SILTEMP WT-65 (50% overlap) with 3M No. 69 glass tapes (50% overlap) shall be considered an appropriate thermal barrier between flexible conduit and cable in free air with zero inch separation when the flexible conduit is wrapped in the SILTEMP.

Specifically designed cabinets/components with more than one redundant Class 1E channel entering shall have barriers to effectively create separate channels (e.g., reactor trip switch, RC pump power monitor).

b. Generic Deviations

i. Control Board Indicators - Devices such as electronic indicators which have a power source separation requirement different from the associated signal shall have the field cables terminated on their respective terminal boards according to the separation criteria outline herein. The power side shall be jumpered to terminals adjacent to the signal circuit terminals. The multi-conductor cable to the device shall be terminated at that point. (Reference Figure 6).

According to the design criteria 4.B.3.a, redundant Class 1E or Non-1E circuit routed with Class 1E of redundant divisions shall not be run in a common multiconductor cable. However, based on analysis performed in Appendix 1 of this document, the use of multiconductor cables with different separation groups for Bailey RY indicators is acceptable.

ii. Non-Class 1E Low Energy Circuits - Incoming field cable entering cabinets shall satisfy the criteria of Section 4.B.4. The only exceptions to these criteria which will be allowed will be annunciator/events recorder and RECALL circuits. Due to the very low energy levels in these circuits, it is not probable that faults will be transmitted back into two different trains. Consequently, the following rules shall apply exclusively to these circuits, which are all identified either by having a "K" in the third letter of the circuit number (e.g. AHK-296) or by having "EMR" as the letter prefix of the circuit number. [Refer to Appendix 2 for Circuit Number 3rd Letter Code].

- EMR and "K" circuits running in non-Class 1E trays entering safety related cabinets through non-Class 1E openings will be allowed to run internally to the cabinet with either Class 1E train A or train B wiring but not both.

- EMR and "K" circuits running in Class 1E trays entering the control board through Class 1E floor openings will be allowed to run with non-Class 1E circuits internal to the control room.

- "K" circuits below and adjacent to holes 29 through 36 and 135 for the events recorder will be allowed to run through holes 29 through 36 and 135 without requiring separation. However, separation shall be achieved as soon as possible after exiting the floor opening.

For detail analysis of EMR and K circuits refer to Appendix 1 of this document.

iii. Terminations on Devices - For circuits that require separation and which terminate on the same device, the separation of the wiring may be less than the required distance identified in Table D providing the following practices are followed:

a. On small devices such as grouped indicating lights, selector switches, dual indicators or relays, the wires to be separated should be brought to the terminals from different directions to achieve the maximum possible separation.

b. The minimum wiring separation shall not be less than the distance between the terminals.

c. Where possible an extra stage should be added to the switch or a barrier inserted between stages.

d. Thermocouple wires run directly to the device and do not terminate on intermediate terminal blocks.

e. For circuits that require separation within the Motor Operated Valve (MOV) housing, the separation may be less than the required distance as specified in 4.B.3 provided that the wires to be separated are brought into the MOV housing through separate conduits which enter from different directions to achieve the maximum possible separation.

f. Circuits of two different channels that are connected to Solenoid Operated Valve (SOV) limit switch contacts are allowed to run together from a junction box near the SOV to the limit switch contacts without requiring separation. Separation is to be maintained after the junction box.

c. Mounting on Barriers

Components and wiring shall not be physically mounted on the barriers. However, barriers can be used to support the components other than those requiring separation for which the barrier is installed as long as the structural integrity of the barrier is maintained.

Where new runs of flex are to be installed, the flex may be secured to any:

- Structural support (including raceway supports)
- Existing flex that is properly supported
- Raceways (conduit, wireway, unistrut, trough)

Flex may not be attached to any:

- Wire bundles
- Cables
- Barriers (however, flex conduit may terminate to barrier if wires enter barriered area)

d. Barrier Materials

The use of asbestos materials for installation of new separation barriers is not allowed. Existing installations need not be replaced. However, new installation or individual replacements of existing barriers must utilize a non-combustible, asbestos free, mineral fiber material. The following are considered as suitable fire retardant materials.

i. Babcock and Wilcox - M-Board

ii. Johns Manville - Marinite

iii. Other equivalent materials as specifically approved by Nuclear Engineering.

iv. Janos Industrial Corporation SILTEMP sleeve, WT-65 wrap and 188 CH or HT188 CH wrap.

To insure that a barrier design using fire retardant material will be constructable, the thickness of the material shall be considered in the design. For barrier details, see drawings E-201-182 thru -184.

Teflon sleeving is not an acceptable material for safeguard wiring separation. Circuits identified by Δ on 210-series internal wiring drawings indicates teflon sleeving installed. The cases with teflon installed prior to April 1974 were reviewed and determined to satisfy the criteria without reliance on additional qualities added by teflon sleeving. Teflon sleeving shall not be used to maintain separation if these circuits are rerouted or relocated.

4) Incoming Field Cables

a. Cable Entrance/Terminations

Separate cable entrances, wireways and terminal points shall be provided for:

- redundant Class 1E and associated circuits
- Non-Class 1E circuits.

Incoming cables from the field arrive at the Class 1E cabinets either by tray systems or in conduit. The control room on elevation 145'-0" has floor openings through which cable can enter the relay racks or Main Control Board. For floor opening assignments of incoming cables to this elevation, refer to 201-156, 201-310 and 224-103 series drawings. The EFIC and relay rooms on elevation 124'-0" also use floor openings for cable access to Class 1E cabinets. Where floor openings are used, the opening shall be considered equivalent to a conduit or channel opening.

Barriered floor openings are to be used to maintain separation through the floor into the control boards, panels or relay racks.

i. Class 1E and Associated Circuits

(1) Class 1E cables entering the control board or relay rack from a tray or through a conduit of a specific engineered safeguard train (A, B or AB) or reactor protection channel (I, II, III or IV) shall enter through an opening dedicated to that channel and maintain the same internal separation. Non-Class 1E cables run in Class 1E trays (associated circuits) shall be bundled with the Class 1E cables of that channel. The cables shall

retain their respective separation group identification at the cabinet opening and at the terminal points. Separation internal to the control board or relay rack (including the opening) shall comply with 4.B.3.

(2) Class 1E cables of a particular channel or associated circuits shall terminate only on terminal boards or components associated with that train or channel and shall be separated from the terminal boards of redundant trains/channels and Non-Class 1E channels as noted in 4.B.3.

Where this separation becomes impractical, a barrier shall be installed on the terminal board or the following distance shall be maintained:

Class 1E to Class 1E trains/channels- 6"

Class 1E/Associated to Associated/Non-Class 1E- 1"

ii. Non-Class 1E Circuits

Non-Class 1E cables shall enter Class 1E cabinets via non-Class 1E raceways physically separated from any engineered safeguard train or reactor protection channel and shall be terminated on Non-Class 1E terminal boards physically separated or barriered from terminal boards containing Class 1E circuits. Exceptions to this are the non-class 1E low energy circuits (Refer to Subsection 4.B.3.b(ii), Generic Deviation).

5) Isolation

Electrical isolation methods shall be used to maintain the independence of redundant circuits such that required safety functions can be accomplished. This electrical isolation shall be achieved through the use of Class 1E isolation devices applied to the interconnection of:

- Class 1E and Non-Class 1E
- Associated circuits and Non-Class 1E circuits, or
- Class 1E logic circuits of redundant channels. (Reference Figures 7, 8, and 9.)

Any device used for isolation shall be qualified for its intended function and shall be considered a part of the Class 1E system.

a. Devices

Isolation devices must be demonstrated by a product class test that -

- the maximum credible voltage or current transient applied to the device's Non-Class 1E side will not degrade the operation of the circuit connected to the device's Class 1E or associated side below an acceptable level, and
- shorts, grounds or open circuits occurring in the Non-Class 1E side will not degrade the circuit connected to the Class 1E or associated side below an acceptable level.

The following devices when properly applied and qualified can be used for isolation:

i. Amplifiers

ii. Control Switches

iii. Fiber Optic Couplers

iv. Photo-optical Couplers

v. Relays

vi. Transducers

vii. Power Packs

viii. Current Transformers

ix. Circuit Breakers

b. Fuses

Fuses may be used as an isolation device to isolate Class 1E circuits from Non-Class 1E circuits if the requirements in subsection 4.B.5).a and the following additional requirements are met:

i. Each fuse shall be tested (i.e. resistance measurement to verify overcurrent protection as designed).

ii. Fuses shall provide the design overcurrent protection capability for the life of the fuse.

iii. The fuse time-overcurrent trip characteristics for all current faults shall cause the fuse to open prior to the initiation of opening of any upstream interrupting device.

iv. The power sources shall be capable of supplying the necessary current under fault conditions to ensure the proper coordination without loss of function of Class 1E loads.

Note:

Fuses shall not be used to isolate redundant channels, i.e. Channel A & Channel B.

c. Terminal Wiring

The separation of the wiring at the input and output terminals of an isolation device may be less than one inch provided that it is not less than the distance between the input and output terminals.

5. CABLE TRAY LOADING

A. 6900 Volt Power Circuits Cable Tray

1) No other type of cable other than 8KV cable shall be routed in the same tray with 6900 volt power circuits cable.

2) There shall be only one layer of cable in a tray.

B. 4160 Volt Power Cable Tray

1) No other type of cable other than 5KV cable shall be routed in the same tray with 4160 volt power circuits cable.

2) There shall be only one layer of cable in a tray.

C. 480 Volt, 120 Volt AC and 250/125 Volt DC Power Circuits Cable Tray

1) No other type of cable other than 600V or 1KV cable shall be mixed in the same tray carrying 480 volt, 120 volt AC and 250/125 volt dc power circuit cables.

2) Tray loadings of 50% maximum physical fill is the design objective. However, in certain areas where physical limitations govern, the tray fill may exceed 50%. In all cases, however, thermal loading shall be considered based on the derating factors for 40°C and 50°C ambient temperatures. (Refer to "Electrical design Criteria - Cable Tray and Conduit Fill and Weight Limitations" for specific guidance - Reference 3.D and Electrical Design Criteria - Cable Ampacity Sizing - Reference 3.O).

D. 120 Volt AC and 125 Volt DC Control Cable Tray

In general, control cable tray loading of 50% maximum physical fill is the design objective. However, in certain areas where physical limitations govern, the cable fill may exceed 50%. In all cases, however, thermal loading shall be considered. (Refer to "Electrical Design Criteria - Cable Tray and Conduit Fill and Weight Limitations" for Specific Guidance - Reference 3.D.)

NOTE: 480 volt, 120 volt AC and 125 volt DC power cables sized No. 8 AWG and smaller may be placed within control cable trays.

E. Instrument Cable Tray

1) In general, instrument cable tray loading of 50% maximum physical fill is the design objective. However, in certain areas where physical limitations govern, the cable fill may exceed 50%. (Refer to "Electrical design Criteria - Cable Tray and Conduit Fill and Weight Limitations" for specific guidance - Reference 3.D.)

2) There shall not be other types of cables mixed with instrumentation cabling except alarm, telephone, low level paging circuits and low energy inputs to computer.

6. CABLE AND WIRE APPLICATIONS

A. The application and routing of power, control and instrumentation cables shall be such as to minimize their vulnerability to damage from any source. All cables shall be selected using conservative margins with respect to their current carrying capabilities, insulation properties and mechanical construction.

Cable ampacity with respect to various installation conditions such as routing and environment temperature shall be determined in accordance with the Electrical Design Criteria - Cable Ampacity Sizing (Reference 3.0).

Power cable shall be rated at 90° C with the 600V or higher insulation. The cable jacket may be made of neoprene or Hypalon. The cable may also have an overall interlocked armor for additional mechanical protection or for non-flame retarding purposes. Interlocked armor is acceptable as a barrier for separation purposes. However, interlocked armor cable shall not be used in the Reactor Building in order to minimize the quantity of zinc so as to avoid problems with chemical spray.

Instrumentation cables shall be twisted and shielded as appropriate to minimize the effects of induced voltage and magnetic interference.

B. Wire and cables that are classified as Class 1E shall be routed and installed to maintain the integrity of their redundant trains or channels in accordance with the requirements of Section 4.A and 4.B of this criteria.

Wire and cables shall be permanently marked (color coded) in accordance with Sections 4.A.5 and 4.B.2.

C. Fire barriers shall be used where cable trays and cable runs enter or leave Class 1 areas, enter or leave the control and auxiliary buildings and where vertical trays pass through floor openings. (Refer to drawing E-214-061 for details.)

D. Power and control cable trays shall be ladder type. Where there are horizontal trays passing under grating or hatches, the top tray shall have a solid cover which is spaced (if required due to heating of the cables) above the tray for ventilation. Covers shall be installed for protection where a tray has a vertical rise near a walkway or goes through a floor (Refer to E-214 series drawings).

B:\EDCREV\TABLEA.WPF

TABLE A
ALLOWABLE RACEWAY/CABLE GROUPING AND COLOR CODE

GROUP NO. (COLOR CODE - SEE NOTE 2)															
INSTRUMENTATION					CONTROL						POWER				
1 (RED)	2 (GREEN)	3 (YELLOW)	4 (BLUE)	5 (WHITE)	6 (RED)	7 (GREEN)	8 (YELLOW)	9 (BLUE)	10 (VIOLET)	11 (WHITE)	12 (RED)	13 (GREEN)	14 (YELLOW)	15 (BLUE)	16 (WHITE)
RPS I	RPS II	RPS III	RPS IV	--	--	--	--	--	--		--	--	--	--	--
ES A	ES B	ES AB	--	--	--	--	--	--	--		--	--	--	--	--
EFIC A	EFIC B	EFIC C	EFIC D	--	EFIC A	EFIC B	--	EFIC D	EFIC C		--	--	--	--	--
Assoc. Ch. A	Assoc. Ch. B	Assoc. Ch. AB	--	See Note 1	Assoc. Ch. A	Assoc. Ch. B	Assoc. Ch. AB	--	--	See Note 1	Assoc. Ch. A	Assoc. Ch. B	Assoc. Ch. AB	--	See Note 1
Other Safety Related Ch. A	Other Safety Related Ch. B	--	--	--	Other Safety Related Ch. A	Other Safety Related Ch. B	Other Safety Related Ch. AB	--	--		Other Safety Related Ch. A	Other Safety Related Ch. B	Other Safety Related Ch. AB	--	--
--	--	--	--	Non-Safety Related	--	--	--	--	--	Non-Safety Related	--	--	--	--	Non-Safety Related
--	--	--	--	--	--	--	--	--	--	--	Vital Bus Ch. A	Vital Bus Ch. B	Vital Bus Ch. III	Vital Bus Ch. IV	--
	--	--	--	--		--	--	--	--	--	NI&P	NI&P	NI&P	NI&P	--

NOTES:

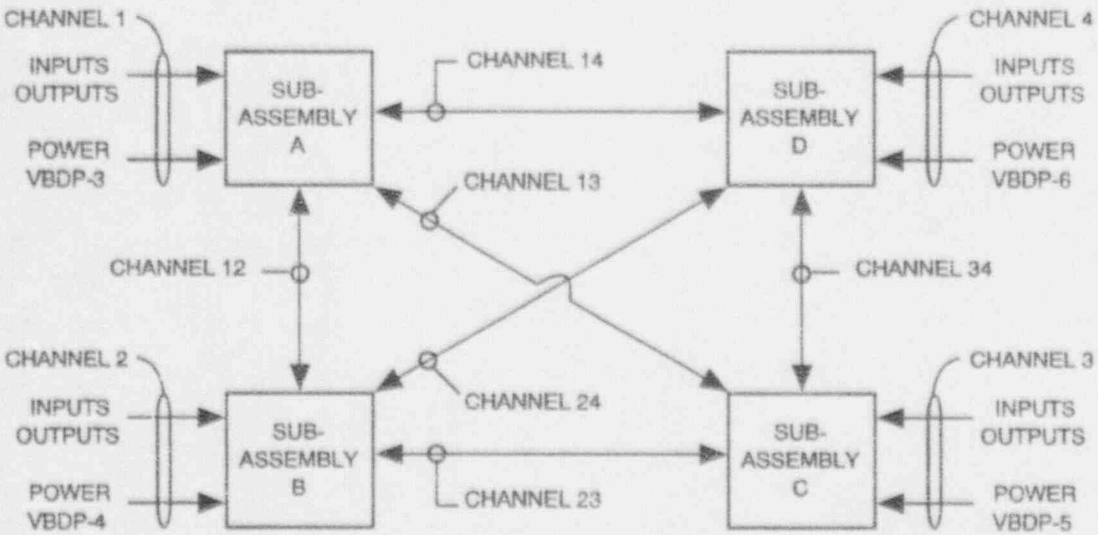
1. Associated circuits are also routed in white cable trays. For clarification, refer to Section 4.A.1).c; Classification of Electrical Cable Trays.
2. Color code given below each group number refers to the raceway color.
3. For specific raceway identification requirements, see page 2 of 2 of this Table.

(REF. SECT. 4.A.8)

TABLE A
ALLOWABLE RACEWAY/CABLE GROUPING AND COLOR CODE

SPECIFIC RACEWAY IDENTIFICATION REQUIREMENTS

1. NI & P SYSTEM



CHANNEL	CONDUIT COLOR	CABLE COLOR
1	RED	RED OR BLACK (IN CONDUIT)
2	GREEN	GREEN OR BLACK (IN CONDUIT)
3	YELLOW	YELLOW OR BLACK (IN CONDUIT)
4	BLUE	BLUE OR BLACK (IN CONDUIT)
12	RED/GREEN	BLACK
13	RED/YELLOW	BLACK
14	RED/BLUE	BLACK
23	GREEN/YELLOW	BLACK
24	GREEN/BLUE	BLACK
34	YELLOW/BLUE	BLACK

NOTE: Channels 1 through 4 are part of the reactor protection system. Channels 12, 13, 14, 23, 24 and 34 represents interconnections between: NI & P system sub-assemblies A, B, C, and D.

2. EFIC SYSTEM

Red with green stripe EFIC "A" to EFIC "B" Logic Cabinet
Red with yellow stripe EFIC "A" to EFIC "C" Logic Cabinet
Red with blue stripe EFIC "A" to EFIC "D" Logic Cabinet
Green with red stripe EFIC "B" to EFIC "A" Logic Cabinet
Green with yellow stripe EFIC "B" to EFIC "C" Logic Cabinet
Green with blue stripe EFIC "B" to EFIC "D" Logic Cabinet
Yellow with red stripe EFIC "C" to EFIC "A" Logic Cabinet
Yellow with green stripe EFIC "C" to EFIC "B" Logic Cabinet
Yellow with blue stripe EFIC "C" to EFIC "D" Logic Cabinet
Blue with red stripe EFIC "D" to EFIC "A" Logic Cabinet
Blue with green stripe EFIC "D" to EFIC "B" Logic Cabinet
Blue with yellow stripe EFIC "D" to EFIC "C" Logic Cabinet

(REF. SECT. 4.A.8)

TABLE B

COLOR CODES FOR INTERNAL CONTROL BOARD AND RELAY RACK WIRING

1. Red (R) wire for engineered safeguards train "A", reactor protection channel I, or EFIC Channel "A".

2. Green (G) wire for engineered safeguards train "B", reactor protection channel II, or EFIC Channel "B".

3. Yellow (Y) wire for engineered safeguards train "AB", reactor protection channel III or EFIC Channel "C" analog.

4. Blue (BL) wire for reactor protection channel IV, or EFIC Channel "D".

5. Brown (B) wire for non-safety related circuits running in raceway classified as "A" or "XA" and isolated from all other circuits. These circuits are considered associated XA.

6. Orange (O) wire for non-safety related circuits running in raceway classified as "B" or "XB" and separated from all other circuits. These circuits are considered associated XB.

7. Black (BK) wire for non-safety related control circuits running in raceway classified as "AB" and separated from all other circuits. These circuits are considered associated XAB.

8. Gray wire for non-safety related circuits arriving at the control board or rack in a non-safety related tray.

9. Violet (V) wire for EFIC Channel "C" control.

10. Black and white small gauge wires (#22AWG) appear on miniature devices for low voltage circuits entirely within the control board. These wires are not safeguard related; therefore, no separation is required.

11. If manufacturer's supplied multiconductor, multicolored cables are used, the color coded wire will be referred to in the manufacturer's connection drawings and the colors have no safeguard implication.

12. Bare/uninsulated wires are ground wires.

TABLE C
REDUNDANT RACEWAYS SEPARATION CRITERIA FOR 1E EXTERNAL RACEWAYS AND WIRING

	Edge to Edge Spacing[4]	Low Energy		Control		LV Power Circuits with cable size ≤ 500 MCM		LV Power Circuits with cable size > 500 MCM and All Medium Voltage Power Circuits	
		Non-Hazardous	Limited Hazard	Non-Hazardous	Limited Hazard	Non-Hazardous	Limited Hazard	Non-Hazardous	Limited Hazard
Conduit to Conduit	Horizontal Vertical	0 inches 0 inches	0 inches 0 inches	0 inches 0 inches	0 inches 0 inches	0 inches [5] 0 inches [6]	0 inches [6] 0 inches [6]	Note 1 Note 1	Note 1 Note 1
Conduit to Tray/ Cable	Horizontal Vertical	0 inches 0 inches	0 inches 0 inches	Note 2 1 inch	Note 2 1 inch	1 inch 1 inch	1 inch 1 inch	1 inch 1 inch	1 inch 1 inch
Cable to Cable/Tray	Horizontal Vertical	1 inch 3 inch	1 inch 3 inch	1 inch 3 inch	1 inch 3 inch	1 inch 3 inch	6 inch[7] 12 inch[7]	1 inch 3inch	3 feet 5 feet
Tray to Tray	Horizontal Vertical	1 foot 3 feet	3 feet Barriers	1 foot 3 feet	3 feet Barriers	1 foot 3 feet	3 feet Barriers	1 foot 3 feet	3 feet Barriers
Reactor Building Penetrations	Horizontal Vertical	N/A N/A	5 feet[3] 3 feet[3]	N/A N/A	5 feet[3] 3 feet[3]	N/A N/A	5 feet[3] 3 feet[3]	N/A N/A	5 feet[3] 3 feet[3]

NOTES:

1 An air gap (minimum 1/16") to minimize heat transfer between the conduits. Conduits may have 0 inch separation at condulet bodies only.

2 An air gap (minimum 1/16") to minimize heat transfer between the tray/cable to conduit.

3 Measured between centers.

4 All spacings shown are edge to edge of the raceway/cable and do not include attachment hardware.

5 If the two circuits are of a different voltage level, the more stringent separation criteria shall apply. Circuit spacing should also take into account installation and electrical noise concerns (Refer to Section 4.A.2.c.)

6 Conduit to conduit zero inch separation of "low voltage power circuits with cable size ≤ 500 MCM" means that it is only acceptable for conduit to touch for a minimum amount of length (<2 feet) as follows:

A. Conduits crossing each other

B. Condulet bodies touching

7 The horizontal and vertical separation distances are for non-armored cable sizes 2/0 AWG or less. If a tray contains non-armored cable sizes greater than 2/0 AWG, then the horizontal and vertical separation distances should be 3 feet and 5 feet respectively.

(REF. SECT. 4.A.2.i)

TABLE D
SEPARATION CRITERIA FOR INTERNAL 1E TO 1E AND 1E TO NON-1E PANEL COMPONENTS AND WIRING

	Edge to Edge Spacing[3]	Low Energy		Control	
		1E to 1E	1E to Associated or 1E to Non-1E or Associated to Non-1E or Associated XA to XB	1E to 1E	1E to Associated or 1E to Non-1E or Associated to Non-1E or Associated XA to XB
Component to Component or Comp. To Wire/Cable or Cable to Cable or Wire to Wire or Wire to Cable	Horizontal Vertical	6 inch 6 inch	1 inch 1 inch	6 inch 6 inch	1 inch 1 inch
Conduit to Conduit	Horizontal Vertical	0 inch 0 inch		0 inch 0 inch	
Conduit to Cable/Wireway/ Wire	Horizontal Vertical	0 inch 0 inch		Note 1, 2 1 inch, Note 2	

NOTES:

1 An air gap (minimum 1/16") or an insulating barrier to prevent thermal conductivity between the conduits.

2 If wireways are enclosed, the wireway is considered an enclosed raceway and is equivalent to a conduit (enclosed raceway).

3 All spacings shown are edge to edge of the raceway/cable and do not include attachment hardware.

(REF. SECT. 4.B.3.a)

TABLE E
RACEWAYS SEPARATION CRITERIA FOR 1E TO NON-1E EXTERNAL RACEWAYS AND WIRING

	Edge to Edge Spacing[4]	Low Energy		Control		LV Power Circuits with cable size ≤ 500 MCM		LV Power Circuits with cable size > 500 MCM and All Medium Voltage Power Circuits	
		Non-Hazardous	Limited Hazard	Non-Hazardous	Limited Hazard	Non-Hazardous	Limited Hazard	Non-Hazardous	Limited Hazard
Conduit to Conduit	Horizontal Vertical	0 inches 0 inches	0 inches 0 inches	0 inches 0 inches	0 inches 0 inches	0 inches[6] 0 inches[6]	0 inches[6] 0 inches[6]	Note 1 Note 1	Note 1 Note 1
Conduit to Tray/ Cable	Horizontal Vertical	0 inches 0 inches	0 inches 0 inches	Note 2 1 inch	Note 2 1 inch	1 inch 1 inch	1 inch 1 inch	1 inch 1 inch	1 inch 1 inch
Cable to Cable/Tray	Horizontal Vertical	1 inch 3 inch	1 inch 3 inch	1 inch 3 inch	1 inch 3 inch	1 inch 3 inch	6 inch[7] 12 inch[7]	1 inch 3inch	3 feet 5 feet
Tray to Tray	Horizontal Vertical	1 inch 3 inch	1 inch 3 inch	1 inch 3 inch	1 inch 3 inch	1 inch 3 inch	6 inch[7] 12 inch[7]	1 inch 3 inch	3 feet 5 feet
Reactor Building Penetrations	Horizontal Vertical	N/A N/A	5 feet[3] 3 feet[3]	N/A N/A	5 feet[3] 3 feet[3]	N/A N/A	5 feet[3] 3 feet[3]	N/A N/A	5 feet[3] 3 feet[3]

NOTES:

1 An air gap (minimum 1/16") to minimize heat transfer between the conduits. Conduits may have 0 inch separation at condulet bodies only.

2 An air gap (minimum 1/16") to minimize heat transfer between the tray/cable to conduit.

3 Measured between centers.

4 All spacings shown are edge to edge of the raceway/cable and do not include attachment hardware.

5 If the two circuits are of a different voltage level, the more stringent separation criteria shall apply. Circuit spacing should also take into account installation and electrical noise concerns (Refer to Section 4.A.2.c.)

6 Conduit to conduit zero inch separation of "low voltage power circuits with cable size ≤ 500 MCM" means that it is only acceptable for conduit to touch for a minimum amount of length (<2 feet) as follows:

A. Conduits crossing each other

B. Condulet bodies touching

7 The horizontal and vertical separation distances are for non-armored cable sizes 2/0 AWG or less. If a tray contains non-armored cable sizes greater than 2/0 AWG, then the horizontal and vertical separation distances should be 3 feet and 5 feet respectively.

(REF. SECT. 4.A.2.a.ii)

TABLE F
RECOMMENDED SEPARATION DISTANCES BETWEEN EXTERNAL RACEWAYS OF DIFFERENT VOLTAGE LEVEL AND CABLE TYPE

	Horizontal	Vertical
Tray to Tray	6" (Note 2)	9" (Note 1)
Tray to Conduit	1"	1"
Conduit to Conduit	1"	1"

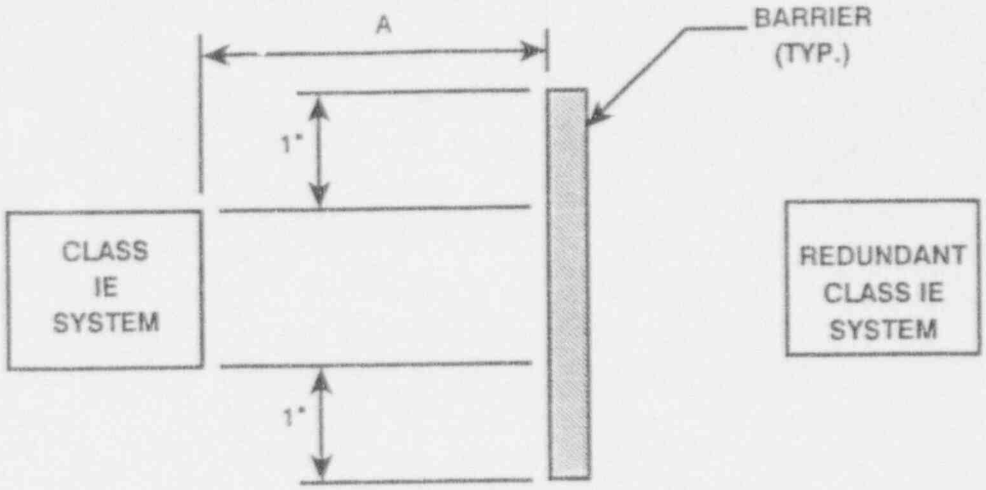
NOTES:

1 The distance between the bottom of the upper tray and top of the lower tray.

2 The distance between the adjacent sides.

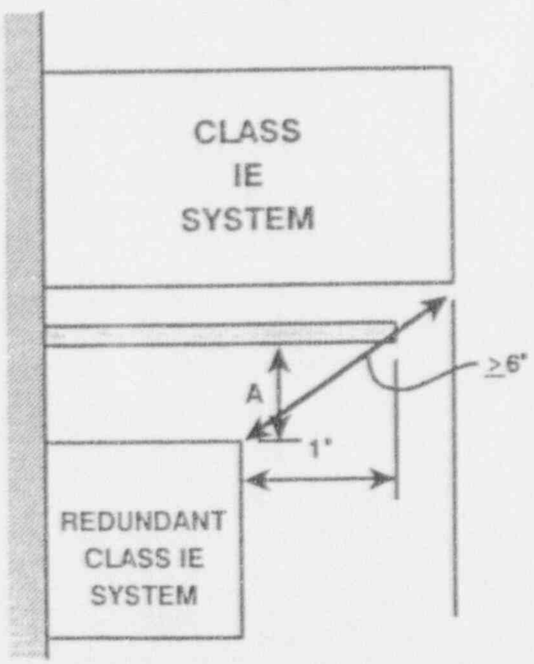
3 The recommended separation distances in above table are to minimize noise in analog circuits run in close proximity with power circuits.

(REF. SECT. 4.A.2.a.iii)



(REF. SECT. 4.B.3.a.i)

FIGURE 1



(REF. SECT. 4.B.3.a.i)

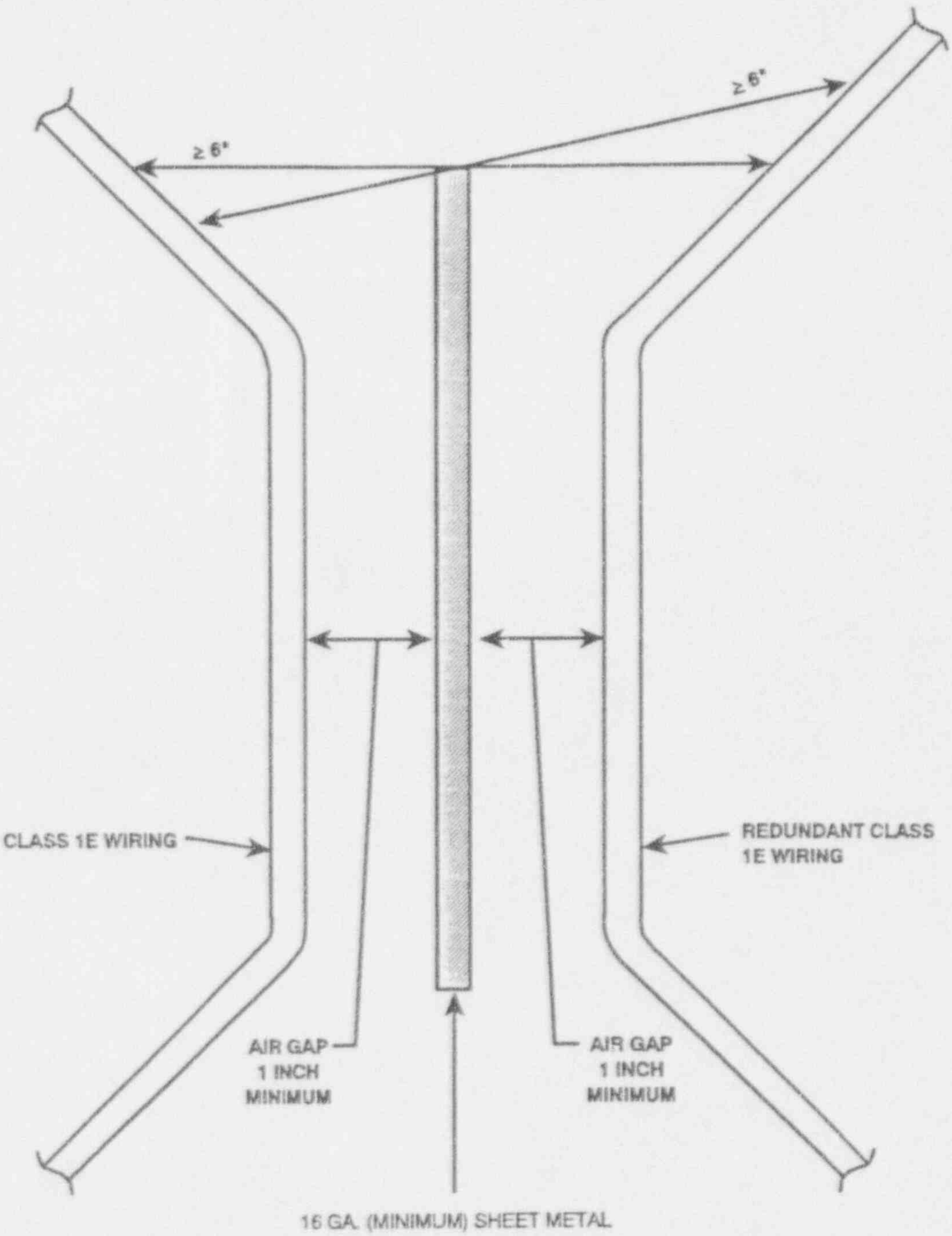
FIGURE 2

NOTE:

1. There is no minimum dimension for "A" where thermal insulation material is used in the barrier.

2. In the case where a component is in a group or surrounded by components or wire of a different separation channel, an enclosed box can be used to maintain the required separation.

When barrier is not continuous, a 6" minimum line of sight must be maintained.



(REF. SECT 4.B.3.a.i.a)

FIGURE 3

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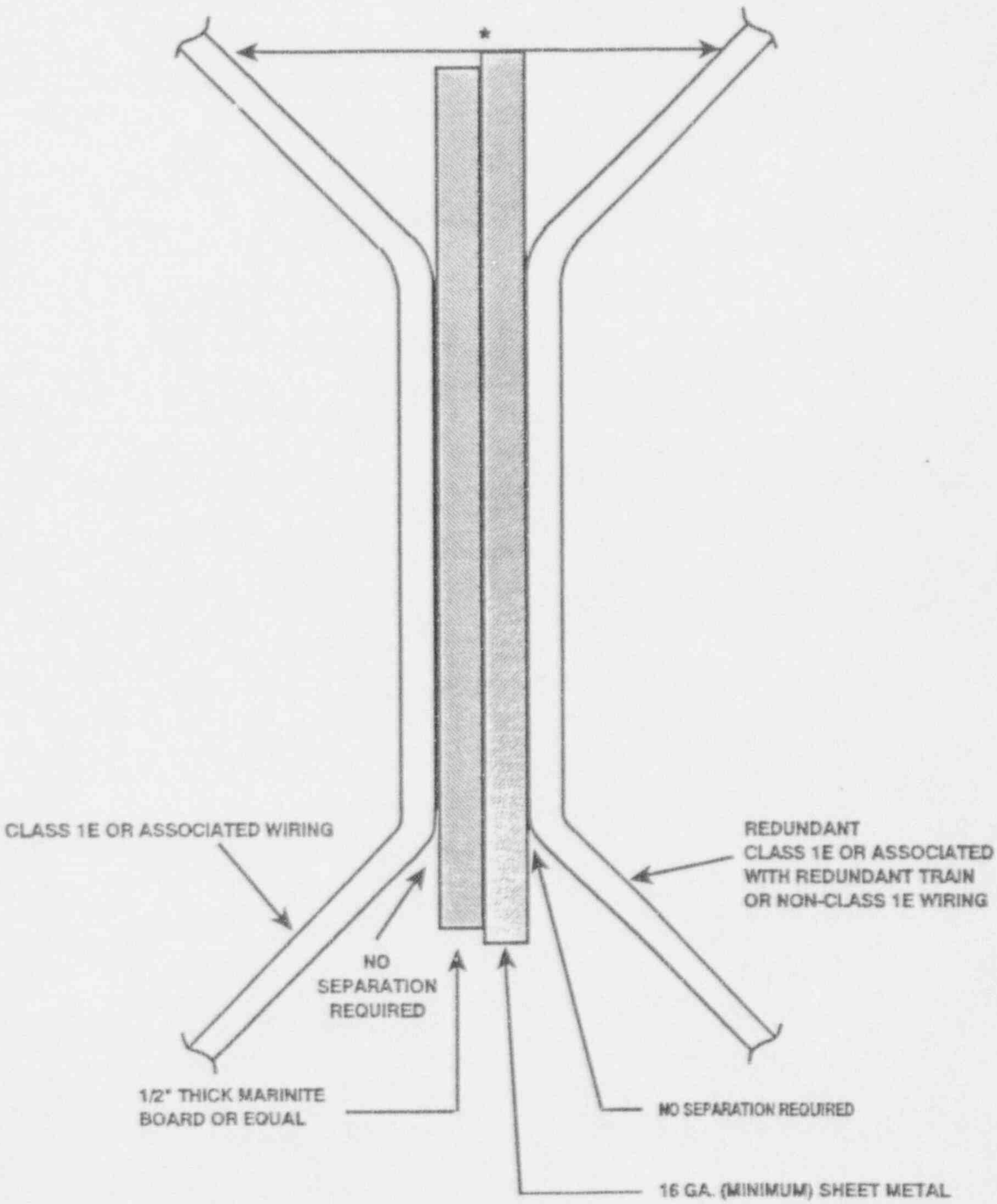
* When barrier is not continuous, a 6" minimum line of sight for Class 1E to Class 1E and a 1" minimum line of sight for Class 1E to Non-Class 1E must be maintained.



(REF. SECT. 4.B.3.a.i.a)

FIGURE 4B

CAUTION: DO NOT USE THIS CONFIGURATION FOR NEW INSTALLATIONS SINCE ASBESTOS MATERIAL IS NO LONGER ALLOWED TO BE USED.

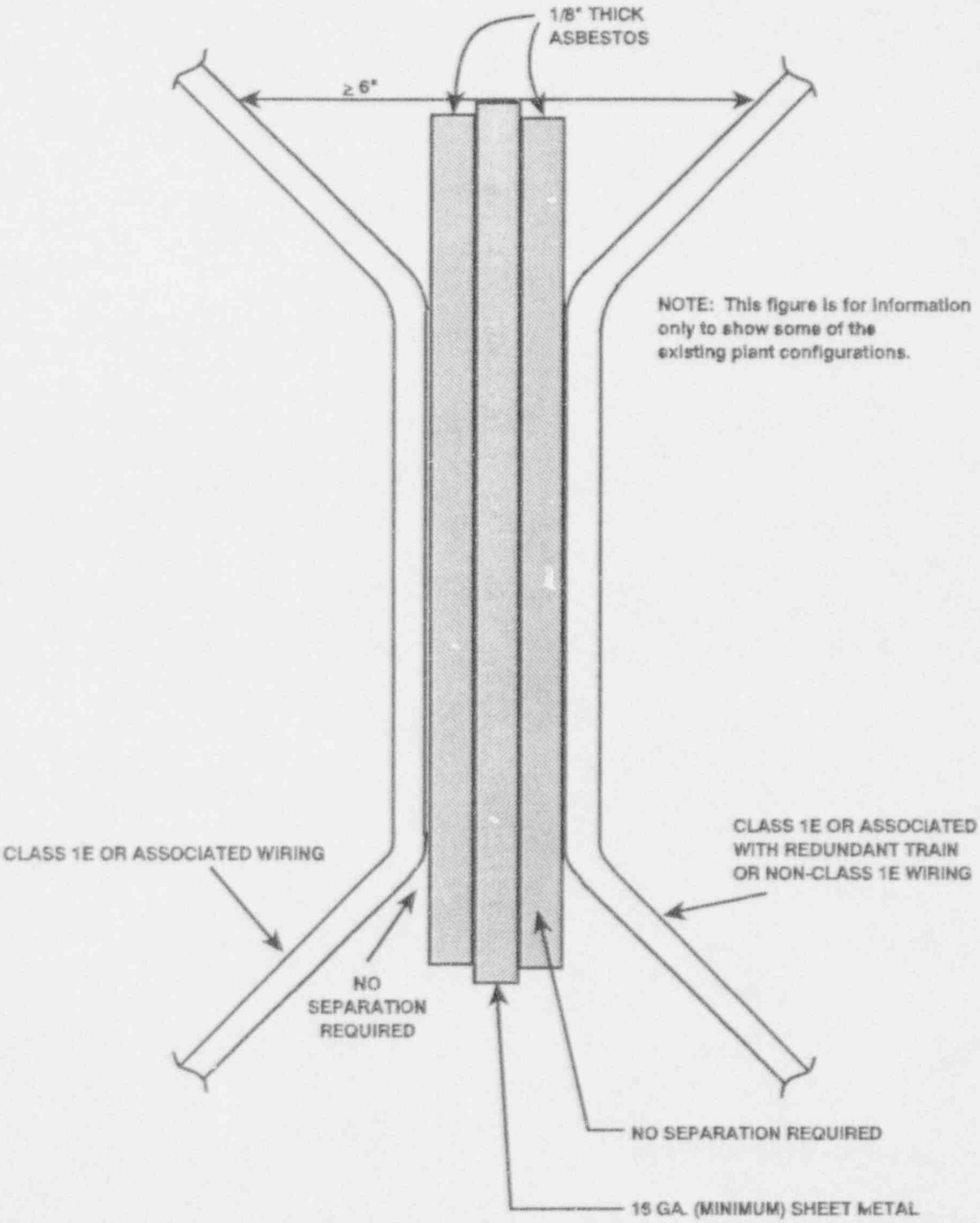
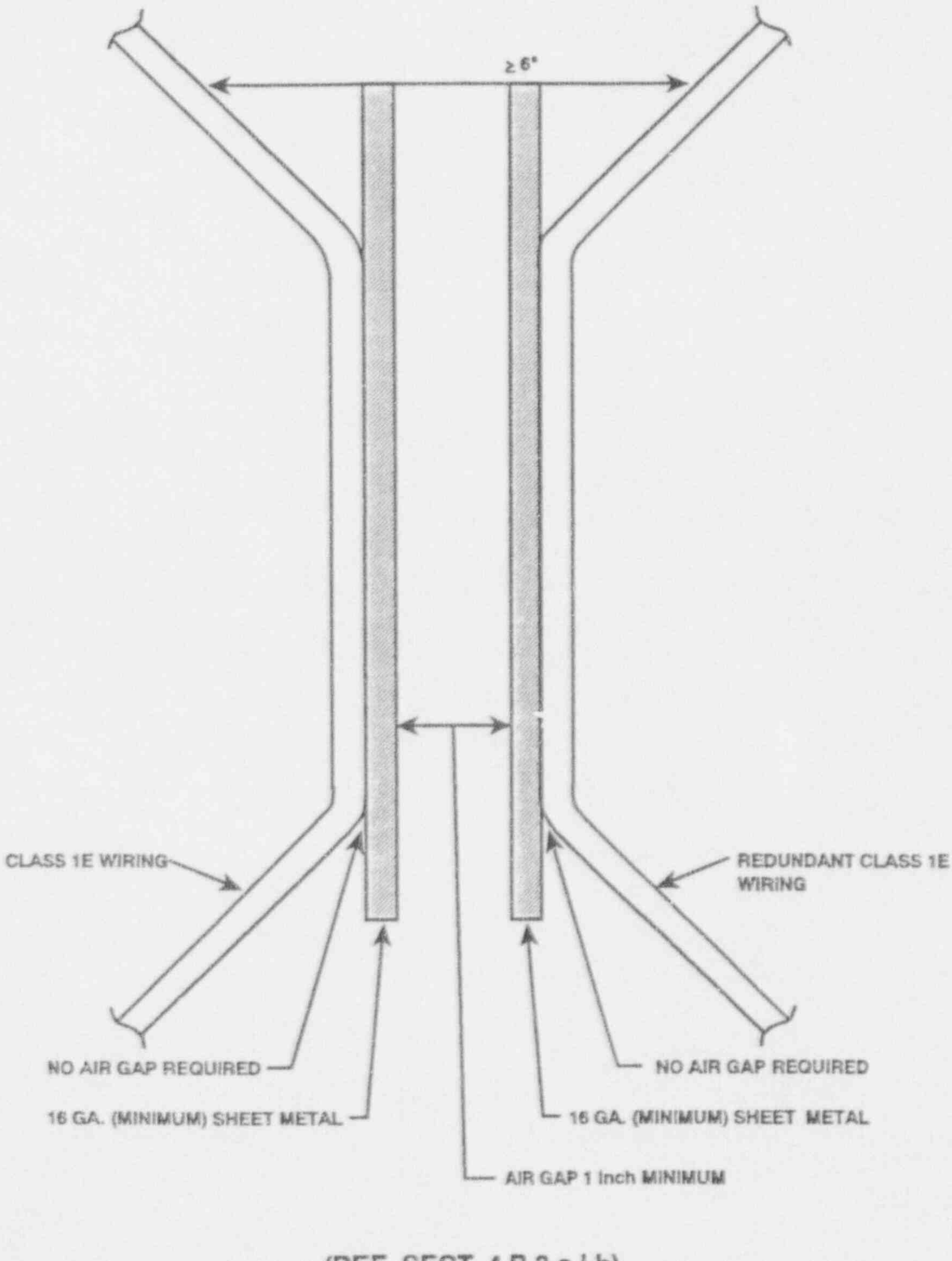


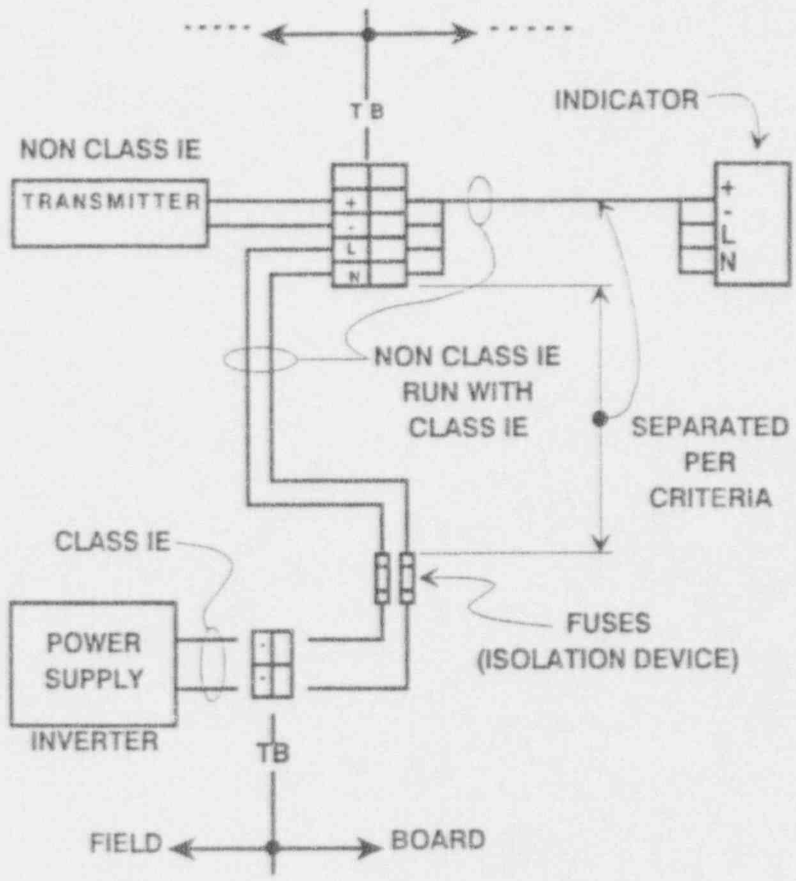
FIGURE 4C

When barrier is not continuous, a 6" minimum line of sight must be maintained.



(REF. SECT. 4.B.3.a.I.b)

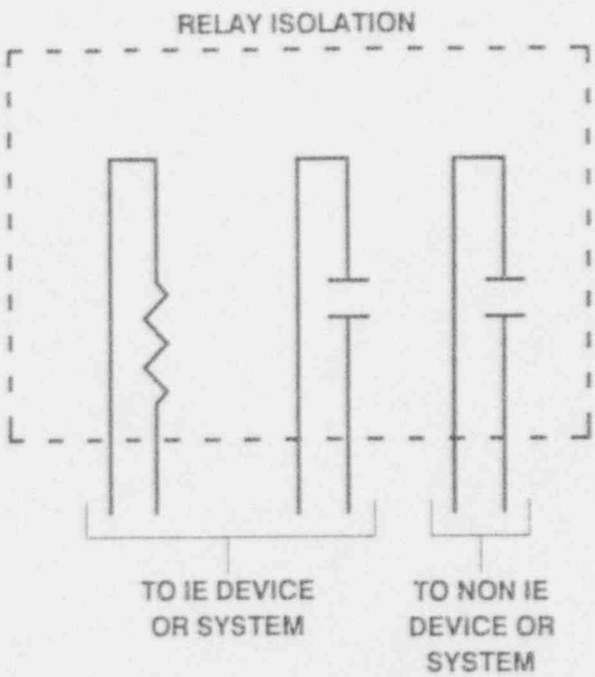
FIGURE 5



MAIN CONTROL BOARD INDICATOR WIRING

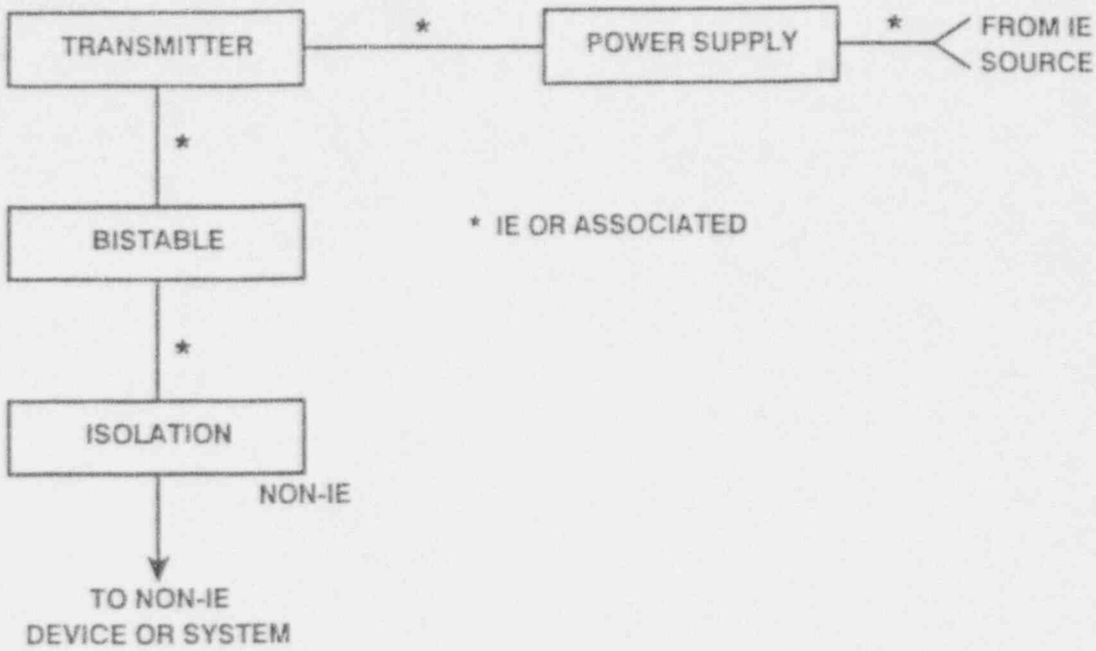
(REF. SECT. 4.B.3.b.i)

FIGURE 6



(REF. SECT. 4.B.5)

FIGURE 7



(REF. SECT. 4.B.5)

FIGURE 8

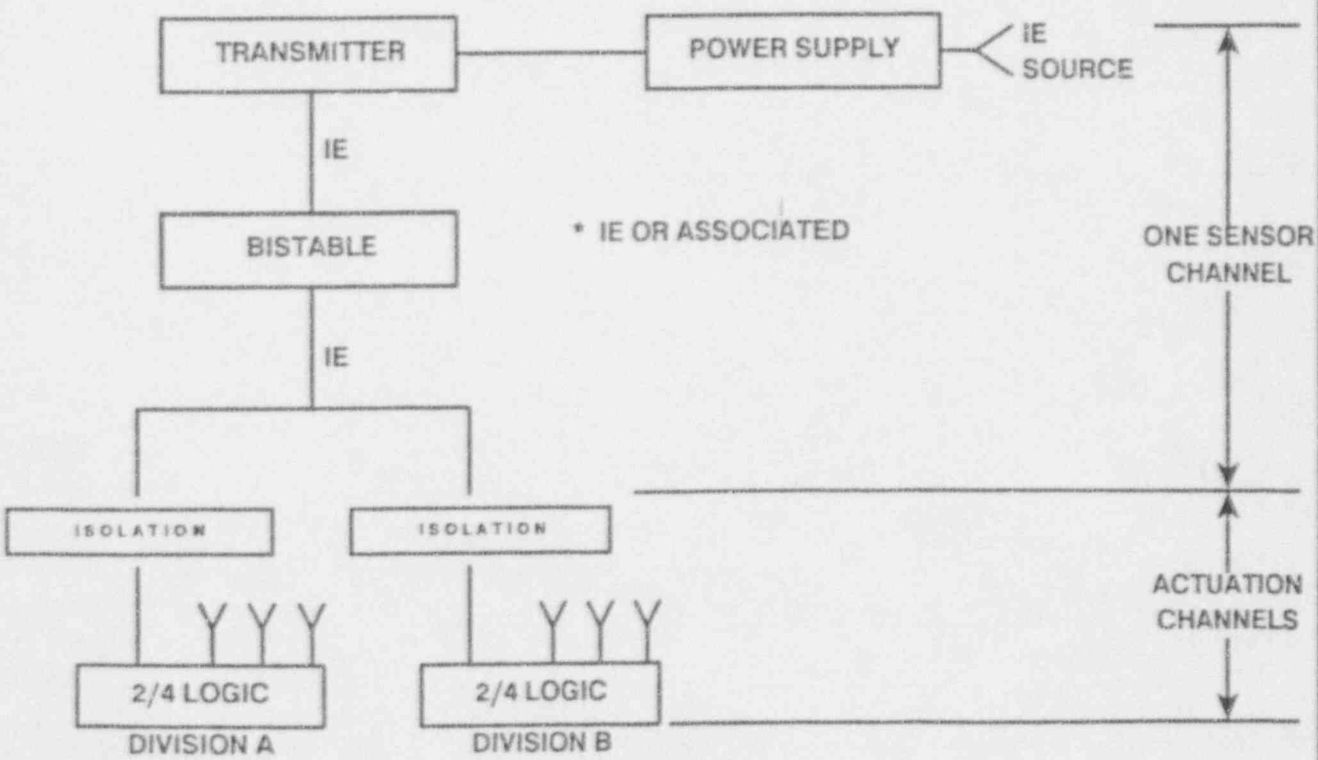


FIGURE 9 (REF. SECT. 4.B.5)

BASIS FOR REDUNDANT AND 1E TO NON-1E CIRCUIT SEPARATION CRITERIA

1.0 BACKGROUND

This appendix to the Separation Design Criteria provides the basis for separation distances found in Tables C, D and E to the Separation Design Criteria. This appendix addresses both the separation distances for 1E raceways and cable external to panels and 1E internal panel components and wiring.

For external panel raceway and cables, this justification is limited to the Non-Hazardous (cable spreading room) area and the Limited Hazard area (outside cable spreading room but not Hazardous Areas) where the only energy available to damage electrical circuits is that energy associated with failure or faults internal to electrical equipment or cables within the area. Separation for external sources of energy (e.g. exposure fires, pipe breaks, missiles, etc. in a Hazardous Area) is not included in this Appendix (Reference IEEE-384-1974).

FSAR Section 7.1.3.1.5 addresses the separation criteria internal to the control board and racks. FSAR Section 8.2.2.12 includes separation requirements for external raceways in accordance with Draft 1, dated October 20, 1971, Section 8.0 of the proposed guide for the Design and Installation of Cable Systems in Power Generating Stations. These are the commitments before CR-3 was issued an operating license. The new design criteria still meets these requirements and commitments.

The criteria given in this document, in part, are based on the IEEE paper entitled "Cable Separation - What Do Industry Testing Programs Show?" (Paper No. 90 WM 254-3 EC presented at IEEE/PES 1990 Winter Meeting). The following discussions provide basis to envelope CR-3 installation by the test results presented in the IEEE paper:

CABLE

The cables in nuclear generating stations utilize single or multiconductor construction and contain at least a conductor, insulation and a protective jacket.

The typical of power and control cable used at CR-3 was manufactured by The Kerite Company. The Kerite Power cables have standard stranded copper conductors, insulated with a minimum of 3/64" high temperature

(HT) oil base compound insulation and covered overall with a minimum of 3/64" flame-retardant (FR) jacket. The Kerite control cables have standard stranded copper conductors, insulated with a minimum of 3/64" FR insulation and covered with a minimum of 3/64" FR jacket. FR jackets were developed by the cable industry for flame resistance. The Kerite cables used at CR-3 have been qualified for use in nuclear generating stations in accordance with IEEE-383-1974. Similarly the class 1E instrumentation cable has been qualified in accordance with IEEE-383-1974. The insulation of all power, control and instrumentation cables is rated for 600 volts or higher.

All the tests presented in IEEE paper, "cable separation - what do industry testing programs show?" were conducted using cable qualified in accordance with IEEE Standard 383 with the exception of that utilized for internal panel wiring where compliance with IEEE 383 is not a requirement. Various sizes of cables were tested which envelope the size of cables at CR-3.

The wires used at CR-3 for internal panel wiring are type SIS. The wires used for control applications are rated for 600 volts. The wires used for instrumentation application are rated for either 600V or 300V.

PROTECTIVE WRAP

FPC has prepared an independent analysis (E-91-0052) to support the use of SILTEMP as a thermal barrier for CR-3. The purpose of this analysis was to demonstrate the acceptability of SILTEMP sleeve and SILTEMP wrap (188CH and WT-65) products to protect safety related cables, which do not satisfy the electrical separation criteria in free air. The conclusion of this analysis is presented in the criteria document; Section 4.A.4, for externally routed circuits and Section 4.B.3).a for internal panel wiring.

BREAKER AND FUSE CURRENT PROTECTION

Selection of the cable and current combination in the IEEE paper was based on providing a combination which produced the most severe effect on the configuration. The combination produced the worst-possible internally generated electrical fault current, and any successful test with this combination would envelope all other cable sizes and fault-current combinations.

The test current values selected in the IEEE tests are based on the following assumptions:

- A fault occurs in the electrical system which is not detected by the primary overcurrent device.
- The fault current is assumed to adjust itself to compensate for the changes in circuit impedance as the cable heated. (Note: In reality, as the conductor heats the circuit impedance increases and the current decreases).
- No additional loads are assumed to actuate which will increase the fault current level.

At CR-3, cables are protected by overcurrent protective devices such as fuses and circuit breakers. In 1992 FPC completed an AC/DC calculation review which provides plant coordination in terms of protecting individual circuits from overload conditions.

As a part of FPC's electrical system review, calculations have been performed to review cable sizing with derating based on IPCEA requirements, circuit breaker and fuse sizing to assure cable protection and coordination of protective devices for all class 1E circuits including DC and vital bus circuitry. In all cases the i^2t of the related cabling exceeds that of its primary protective device. All calculations invoked standard industry practices and identified discrepancies have been corrected. These calculations are maintained up to date through procedural requirements delineated in the Nuclear Engineering Procedures (NEP's).

The test current values utilized in the paper are presented as enveloping those of normal plant design. Since CR-3 meets or exceeds industry methodology for the selection and application of cable and protective devices, the results listed in the paper are appropriate for use in the design at CR-3 and as a basis for this criteria.

2.0 DEFINITIONS OF CABLE VOLTAGE LEVELS

2.1 LOW ENERGY CIRCUITS

Low energy circuits are those that satisfy the definitions found in Section 2.0 of the Design Criteria.

2.2 CONTROL CIRCUITS

Control circuits are those that satisfy the definitions found in Section 2.0 of the Design Criteria. For CR3, these are the 120V AC and 125V DC control circuits.

2.3 LOW VOLTAGE POWER CIRCUITS

Low voltage power circuits are those that satisfy the definitions found in Section 2.0 of the Design Criteria. For CR-3, these are the 480V AC, 250V DC, 125V DC and 120V AC power cables.

2.4 MEDIUM VOLTAGE POWER CIRCUITS

Medium voltage power circuits are those that satisfy the definitions found in Section 2.0 of the Design Criteria. For CR-3, these are the 6900 and 4160V power circuits. (The 6900V power circuits are all non-1E.)

3.0 SEPARATION DISTANCES FOR REDUNDANT 1E EXTERNAL RACEWAYS AND CABLES

This section provides the justification for the separation distances shown in Table C for redundant 1E raceways and cables external to panels.

3.1 1E CONDUIT TO CONDUIT SPACING

3.1.1 Low Energy Circuits

Should a low energy circuit fail, there will be insufficient fault current to heat the cable to a temperature which will damage or ignite the cable. Therefore cables in a redundant conduit that touch the conduit with the faulted cables will not experience degradation from heat transfer such that they will fail to perform their safety function.

A conduit to conduit spacing of 0 inches is acceptable for circuits defined as low energy based on the above justification.

3.1.2 Control Circuits and Low Voltage Power Cables Less Than or Equal to 500 MCM

The concern relative to conduit spacing is that the heat due to failure of a cable in one conduit is not transferred to cables in another conduit such that its cables are degraded to a condition that they are unable to perform their safety function.

The results of industry testing to determine distances needed to meet cable separation have been compiled in an IEEE paper entitled "Cable Separation - What Do Industry Testing Programs Show?" (Paper No. 90 WM 254-3 EC presented at the IEEE/PES 1990 Winter Meeting).

This paper was a factor used in reducing separation distance criteria as proposed for the 1991 revision of IEEE 384, Standard Criteria for Independence of Class 1E Equipment and Circuits.

The paper discusses the test methods and results of specific cable and raceway configurations, one being conduit to conduit. The test configurations used both rigid and flex conduit, aluminum sheathed cable, metal clad cable and armored cable and found no observable difference between them. Also the Fire Hazards Analysis, Section 3.3 states that interlocked armor cable is not included as a combustible since it is considered equivalent to a flex conduit. The test approach was to determine the cable type and size and current combination that produced the maximum amount of heat released to the environment as a result of fault current. This combination produced the worst-possible internally generated electrical fault, and any successful test with this combination would envelope all other sizes and fault current combinations. The tests showed no failures up to 500 MCM cable with a 0 inch separation between conduits.

A conduit spacing of 0 inches for control and low voltage power cables less than or equal to 500 MCM is acceptable based on the results of the industry testing performed to date. However, it is physically impossible for long runs of conduit to touch each other due to couplings (at most every 10 feet) and conduit clamps holding the conduit in place. For conservatism FPC has chosen to apply this justification on a limited basis. Conduit to conduit zero inch separation of "low voltage power circuits with cable size ≤ 500 MCM" means that it is only acceptable for conduit to touch for a minimum amount of length (< 2 feet) as follows:

A. Conduit crossing each other

B. Condulet bodies touching

3.1.3 Low Voltage Power Cables Greater Than 500 MCM and All Medium Voltage Cables

The concern relative to conduit spacing is that the heat due to failure of a cable in one conduit is not transferred to cables in a redundant conduit such that its cables are degraded to a condition that they are unable to perform their safety function.

The industry test results described in the paper noted previously in paragraph 3.1.2 showed that a 750 MCM low voltage cable in a conduit did cause a failure in another conduit when there was 0 inch separation. However, a second test with a 750 MCM cable with a spacing of 1 inch did not cause the cables in the other conduit to fail. Therefore, a conduit spacing somewhere between 0 inches and 1 inch will be acceptable. The results of the other cable tests noted below was used to determine what may be an acceptable distance.

The remainder of the cables in conduit in the test (from No. 12 AWG to 500 MCM) did not cause a cable failure in the other conduit when the separation was 1/4 inch or less. Therefore any air gap is acceptable separation so as to break the conductive heat transfer from the faulted cable. Based on the results of the No. 12 AWG to 500MCM cables coupled with the tests performed on 750MCM cables, an air gap to break conductive heat transfer from the faulted cable is acceptable for low voltage power cables greater than 500MCM.

No specific tests were run for medium voltage cable in conduit. For the CR3 1E electrical auxiliary distribution system, the 4160V (medium voltage) and 480V (low voltage) systems are resistance grounded. For the large majority of faults which are line to ground, the fault current will be limited to 600 amps. This is well below the current passed through the tested 750MCM cable. The 3 phase fault currents of the two systems are of a similar magnitude (30,000 amps for the 480V system and 35,000 amps for the 4160V system. In addition the proposed IEEE 384 revision, Table 1 lumps medium voltage power cables with large low voltage power cables for separation distances in a Limited Hazard Area.

Therefore as for the low voltage cables an air gap is acceptable separation for the medium voltage cables so as to break the conductive heat transfer from the faulted cable.

Condulet bodies only are allowed to have 0 inch separation given the following:

A. The conduits to which the condulets are connected will act like radiators thus cooling off the conduit and the condulet itself.

B. The condulet has a larger surface area subject to cooling and thus should be at a lower temperature than the conduits in the industry tests.

C. The possibility of the cable failing (igniting) in the condulet vs. some other point in the conduit run is remote.

Therefore, based on the preceding discussions, a visible air gap or an insulating barrier to prevent thermal conduction between the conduits for low voltage power cables greater than 500 MCM and for medium voltage power cables is acceptable based on the results of the industry testing performed to date. Conduit runs may touch only at a condulet.

3.2 1E CONDUIT TO TRAY/CABLE

3.2.1 Low Energy Circuits

A conduit to tray/cable spacing of 0 inches is acceptable for circuits defined as low energy based on the justification provided for conduit to conduit spacing for low energy circuits in Section 3.1.1.

3.2.2 Control Circuits

The test results in the IEEE paper noted in Section 3.1.2 of this Appendix are for power cables. The test results for the power cables are overly conservative for determining control circuit separation requirements. Control cables do not have the high fault energy available as do power cables since they have smaller power sources (less kVA and higher impedance), smaller conductor size (higher circuit impedance) and overcurrent protection generally limited to 15 Amp fuses or breakers.

The test results in the IEEE paper state that for the conduit to cable tray configuration, the one test performed with a 0 inch horizontal separation was successful. The test results for the conduit to cable in free air configuration showed all tests were successful for horizontal separation distances between 0 and 1 inch.

The test results in the IEEE paper noted in Section 3.1.2 of this Appendix state that for the conduit to cable tray configuration, six tests performed with a vertical separation between 0 and 1 inch were successful. The test results for the conduit to cable in free air configuration showed all tests were successful for a vertical separation distance of 0 inches.

Given the fact that control circuits have more fault current available than low energy circuits, a separation distance greater than 0 inches would be appropriate. However control circuits have less fault current available than low or medium voltage power cables and therefore a separation distance less than 1 inch would be appropriate (see the following Section 3.2.3 for low and medium voltage power cable separation distances).

To break conductive heat transfer between the faulted cable in a conduit and the tray/cable, a visible air gap or an insulating barrier to prevent the conduit having 0 inch separation with the tray/cable should be used for horizontal spacing.

To break conductive heat transfer between the faulted cable in a conduit and the tray/cable, and to minimize heat transfer to a conduit if cables are run beneath a conduit, a conservative separation distance of 1 inch should be used.

A horizontal spacing being a visible air gap or a barrier to prevent the conduit having 0 inch separation with the tray/cable and a vertical spacing of 1 inch is acceptable based on industry testing to date and the above justification.

3.2.3 Low Voltage and Medium Voltage Power Cables

As noted in the previous Section 3.2.2, the test results in the IEEE paper state that for the conduit to cable tray configuration, the one test performed with a 0 inch horizontal separation was successful. The test results for the conduit to cable in free air configuration showed all tests were successful for horizontal separation distances between 0 and 1 inch. The paper recommends a 1 inch horizontal separation for conduit to trays in a non-hazard area and 1 inch horizontal separation in all areas for conduit to cable in free air.

Also as noted in the previous section 3.2.2, the test results in the IEEE paper noted in Section 3.1.2 of this Appendix state that for the conduit to cable tray configuration, six tests performed with a vertical separation between 0 and 1 inch were successful. The test results for the conduit to cable in free air configuration showed all tests were successful for a vertical separation distance of 0 inches. However for certain test cases with 0 inch separation, the tested cable's jacket was damaged. For one test the jacket was severely damaged.

Another IEEE paper addresses tests done on faulted power cables in conduits (Reference T). The paper states that if the conduit becomes a ground return path for the fault current, the conduit may heat up to the point that a combustible material touching the conduit could ignite. Therefore a cable having 0 inch separation with a conduit that has a faulted power cable may be damaged to the point of becoming inoperable. To assure the cable remains functional, there should be separation between the cable and the conduit. No specific value was provided in this paper. It is recommended that 1 inch be used in accordance with the recommendation provided in the IEEE paper noted in Section 3.1.2 of this Appendix.

No specific tests were run for medium voltage cables. Given the high energy (fault currents) available for the tested low voltage power cables, the test results for medium voltage cables are expected to be similar to those for the low voltage power cables. This is based on the test method used to determine the worst case cable/current combination as previously defined in 3.1.2 of this Appendix.

A conduit spacing of 1 inch in both the horizontal and vertical directions between a conduit and a tray/cable is acceptable for low voltage and medium voltage power cables based on the results of the industry testing performed to date.

3.3 CABLE TO CABLE/TRAY

3.3.1 All Voltage Level Circuits

The separation requirements for cable to cable/tray spacing as shown in Table C are taken from the proposed 1991 revision to IEEE 384-1981. This revision is partially based on the IEEE paper noted previously in Section 3.1.2 of this Appendix.

The values are conservative relative to the test data in the referenced paper but are adopted in full.

3.3.2 Non-Class 1E Low Energy Circuits Analysis

Deviation from the physical separation or electrical isolation requirements is permitted for the "EMR" and "K" Non-Class 1E low level instrumentation signals provided that (a) the Non-Class 1E circuits are not routed with associated circuits of a redundant division, except through floor openings 29 through 36 and 135, and (b) the Class 1E circuits are analyzed to demonstrate that they are not degraded below an acceptable level as described below:

1. Annunciator and instrumentation circuits are low energy circuits. The annunciator circuits operate from a 125V dc high impedance (approximately 60 Kohm) source. The instrumentation systems operate on 1-5V dc or ±1-10V dc signals in high impedance circuits or 4-20 ma signals in low impedance circuits.

   All low voltage power and control cables have fire retardant insulation rated at 600V. Instrumentation cables have either 600V or 300V insulation and have grounded shields. Raceways are of fire retardant material. Instrument trays contain only instrumentation cables or telephone and low level paging circuits. Only voltages of these levels are present in control boards and relay racks.

Since only low energy can be derived from instrumentation circuits, it is not probable that these Non-Class 1E circuits will provide a mechanism for failure of redundant Class 1E circuits inside Class 1E devices or enclosures. These Non-Class 1E circuits can be exempted from separation requirements only within the same channel/division with which the circuits are connected for their inputs.

2. Low energy Non-Class 1E circuits which are not separated from Class 1E circuits at the input device can be shown not to provide a credible mechanism of failure of the Class 1E system. The general approach is to demonstrate the low probability of occurrence of a failure mechanism. To summarize this failure mode the following conditions must occur at the same time.

   a. The low energy Non-Class 1E circuit is shorted to the highest voltage circuit conductors (125V dc/120V ac).

   b. The highest voltage circuit conductors are not short circuited or grounded.

   c. The highest voltage circuit protective device (breaker or fuse) fails to perform its intended function.

   d. The low energy Non-Class 1E cable is also shorted to the redundant Class 1E circuit.

   e. The fault current is greater than the rating of the cable insulation.

   In order for the redundant Class 1E protection system to fail several independent low probability events must happen simultaneously which is considered extremely unlikely.

3. Low energy Non-Class 1E "K" circuits are allowed to run through holes 29 through 36 and 135 and in the immediate vicinity below without requiring separation. All circuits below and in the immediate vicinity of holes 29 through 36 and 135 are Non-Class 1E circuits consisting of low energy 125V DC high impedence events recorder circuits and 120V AC power circuits. 120V AC power circuits, ERF-2 and ERF-6, are routed through hole 29. Low energy events recorder circuits are routed in either A, XA, B, or XB control trays and holes 29 through 36 and 135. It is not probable that Non-Class 1E or associated low energy circuits will provide a mechanism for failure of redundant Class 1E circuits in the Class 1E control trays as described in paragraph 1 and 2 above. Due to the inherent low energy

capabilities of 120V AC power circuits and the normal overcurrent protection provided for these 120V AC circuits, a cable to cable failure in this area is not considered credible.

3.4 TRAY TO TRAY

3.4.1 The separation requirements for tray to tray as shown in Table C are based on those presently shown in the FSAR Chapter 8. These in turn were based on an interpretation of the first draft to the proposed IEEE standard for the design and installation of wire and cable systems in power generating stations (now IEEE 422).

3.5 REACTOR BUILDING PENETRATIONS

3.5.1 The physical separation of the penetration cartridges within the particular area is determined by the reactor building tendon spacing. The 12 inch diameter penetration sleeves are on a minimum vertical spacing between centers of 3'-0". Minimum horizontal spacing of redundant safeguards penetrations is 5'-0" outside containment.

4.0 SEPARATION REQUIREMENTS FOR COMPONENTS AND WIRING INTERNAL TO PANELS

This section provides the justification for the separation distances shown in Table D for components and wiring internal to panels listed in Section 1, Scope of Criteria document.

4.1 INTERNAL PANEL 1E CONDUIT TO CONDUIT SPACING

4.1.1 Low Energy and Control Circuits

A conduit to conduit spacing of 0 inches is acceptable for circuits defined as low energy and control. This is based on the justification previously provided in Section 3.1.1 and 3.1.2 for conduit to conduit spacing of 1E redundant circuits external to panels.

4.2 INTERNAL PANEL 1E CONDUIT TO CABLE/WIREWAY/WIRE

4.2.1 Low Energy Circuits

A conduit to cable/wireway/wire spacing of 0 inches is acceptable for circuits defined as low energy. This is based on the justification previously provided in Section 3.2.1 for conduit to cable/wireway/wire spacing of 1E redundant circuits external to panels.

4.2.2 Control Circuits

A conduit to cable/wireway/wire vertical spacing of 1 inch and a horizontal spacing which is a visible air gap or an insulating barrier to prevent thermal conduction between the conduit and the cable/wireway/wire are acceptable for control circuits. This is based on the justification previously provided in Section 3.2.2 for conduit to cable/wireway/wire spacing for 1E redundant circuits external to panels.

If the wireway is enclosed, it is considered an enclosed raceway and is equivalent to a conduit. Therefore the conduit to conduit spacing criteria can be used. This is based on the definition of enclosed raceways as provided in the 1991 proposed revision to IEEE 384-1981.

4.3 INTERNAL PANEL CABLE TO CABLE, WIRE TO WIRE OR WIRE TO CABLE

4.3.1 1E to 1E Low Energy or Control Circuits

The separation requirements of 6 inches in all directions are those presently shown in the FSAR Chapter 7. These were based on industry practice and IEEE Draft Standards at the time of plant design.

4.3.2 1E to Associated, or 1E to Non-1E, or Associated to Non-1E, or Associated XA to Associated XB Low Energy or Control Circuits

The separation distance of 1" as shown in Table D is based on results of testing completed by members of the nuclear industry for internally generated electrical faults. The results of industry testing have been compiled in an IEEE paper entitled "Cable Separation - What Do Industry Testing Programs Show?" (Paper No. 90WM 254-3 EC presented at the IEEE/PES 1990 Winter Meeting). In this paper there are six test results presented (Table 7 of IEEE paper) for internal panel wiring which were conducted in free air with 1" horizontal and vertical distance separation. All six tests used electrical continuity as a pass/fail criteria. In all six tests, the target cable passed the continuity test.

At CR-3, the power inside the panel comes from three primary sources which have been evaluated under calculation E-91-0052 for worst possible fault current that could be experienced by internal panel wiring. These primary sources are briefly described below:

- **120 VAC Distribution Panel:** For conservatism the breakers within the distribution panels are treated as primary protective devices even though some circuits have overcurrent protection within their panel. The secondary protective device is a upstream breaker or fuse feeding the distribution panel. The worst case sustained current available from 120 VAC distribution panels is 300 amperes based on the assumption that the primary protective device in the distribution panel fails to operate under fault condition.

- **125 VDC Distribution Panel:** For conservatism the fuses within the distribution panels are treated as primary protective devices even though some circuits have overcurrent protection within their panel. The secondary protective device is an upstream fuse feeding the distribution panel. The worst case sustained current available from 125 VDC distribution panels is 300 amperes based on the assumption that the primary protective device in the distribution panel fails to operate under fault condition..

- **120 VAC from Control Power Transformer (CPT) in MCC's:** Fault current available from these types of circuits is limited by the CPT internal impedance. The worst case at CR-3 is the 750 VA CPT which can produce a maximum current of approximately 250 amperes.

Based on the above sources, the highest magnitude of sustained fault current that can be experienced by conductor inside the panel at CR-3 is 300 amperes.

The worst case failure of internal panel wiring is a sustained overcurrent condition where the magnitude of the fault current is just below that which will cause the wire to fuse open. Three tests were performed by Philadelphia Electric Company (PECO), Report No. 48503 dated September 1 1982, to determine the maximum current which various size conductors could carry continuously, thereby maximizing the heat generated by i^2R effects which could damage adjacent wires. These tests were performed using General Electric Vulkene SIS wire sizes No. 6, No. 10, and No. 14AWG. The following is a summary of tests results:

CONDUCTOR SIZE	TEST CURRENT USED AMPERES	MAX. CONTINUOUS CURRENT TO PRODUCE PEAK TEMP.AMPERES
NO. 6 AWG	150, 200 & 360	360
NO. 10 AWG	100, 150, 175 & 200	175 *
NO. 14 AWG	50, 75, 90, & 100	90 *

* Test current greater than those determined to produce the peak temperature resulted in fusing of the wire prior to reaching the peak

temperature therefore were not considered worst case, i.e. 200 and 100 amperes.

Test results by PECO concluded that the heat generated by a sustained overcurrent condition for wire sizes (#6 AWG and smaller) used in internal panel wiring is not sufficient to damage the adjacent conductor as long as any size air gap exists between the two conductors. This conclusion was supported by several tests which were performed to determine the spatial separation that would be required to prevent propagation of failure to an adjacent conductor. The only concern noted in PECO testing resulted from sagging of the faulted wire due to conductor heating. This sagging was experienced during the testing on a six foot free standing horizontal conductor which is not representative of CR-3's control panel wiring configurations. CR-3 utilizes frequent support points (6-12"). In most cases wires are bundled, which per PECO test conclusions, provides additional support to the faulted conductor. Therefore wire sagging is not a concern for CR-3 internal wiring.

As additional support for the above basis a Duquesne Light Company (DLP) test report provides the results of their testing on SIS wire. A test was performed with a 1/C No. 12AWG SIS faulted cable unwrapped and in contact with a No. 12AWG SIS target cable wrapped with SILTEMP 188CH. A second unwrapped 1/C No. 12AWG SIS cable was mounted one inch away from the faulted cable. This tested configuration provides results of 1" separation between a faulted cable and a target cable. A fault current of 150 amperes was used. The results of this test are summarized below:

Fault Current	Test Duration
150 AMPS	26.9 MIN

The target cables successfully completed the Post-Overcurrent Test Functional Test.

In the test reports by PECO and DLP, no credit is being taken for protective devices to operate and clear the fault condition. Therefore, time-current characteristics of the breaker or fuse have no implication on this analysis.

The results of these tests indicate that the maximum continuous current to produced peak temperatures are within the maximum current available at CR-3. Therefore the results obtained from the testing are applicable for CR-3.

Control wiring inside panels at CR-3 consist of #14 and #12 AWG SIS wires rated at 90°C which is consistent with industry practice and similar to that used in the reference testing. Off gassing and subsequent ignition is not a consideration for wiring within CR-3 panels since these small conductors cannot sustain elevated temperature long enough to allow sufficient concentrations of gas to accumulate and cause ignition.

In addition, PECO test report concluded that with no separation between two conductors, damage to an adjacent conductor occurs only when unusually high current levels are maintained in a failed cable for a prolonged period of time, usually between five and twenty minutes. For this to occur, the primary overcurrent protective device, i.e. the internal panel fuse or circuit breaker in the distribution panel, must fail to clear a high impedance fault.

If the primary protective device fails to operate and a very high current such as 300 amperes is experienced, the wire will be fused open and the temperature of conductor adjacent to the faulted wire does not have time to increase significantly.

Therefore, a separation distance equal to or greater than 1" between Class 1E wiring and Associated wiring, between Class 1E and Non-Class wiring, or between Associated and Non-Class wiring is sufficient to provide adequate independence of Class 1E circuits.

5.0 <u>SEPARATION DISTANCES FOR 1E (INCLUDING NON-1E CIRCUITS THAT ARE ROUTED WITH CLASS 1E CIRCUITS) TO NON-1E EXTERNAL RACEWAYS AND CABLES</u>

This section provides the justification for the separation distances shown in Table E for 1E to non-1E raceways and cables external to panels.

5.1 CONDUIT TO CONDUIT

5.1.1 The separation requirements are the same as for the redundant 1E conduit to conduit circuits. The justification is therefore the same as previously provided in Section 3.1 of this Appendix.

5.2 CONDUIT TO TRAY/CABLE

5.2.1 The separation requirements are the same as for the redundant 1E conduit to tray/cable circuits. The justification is therefore the same as previously provided in Section 3.2 of this Appendix.

5.3 CABLE TO CABLE/TRAY

5.3.1 The separation requirements are the same as for the redundant 1E cable to cable/tray configuration. The justification is therefore the same as previously provided in Section 3.3 of this Appendix.

5.4 TRAY TO TRAY

5.4.1 The separation requirements for tray to tray are taken from the proposed 1991 revision to IEEE 384-1981. This revision is partially based on the IEEE paper noted previously in Section 3.1.2 of this Appendix.

5.5 REACTOR BUILDING PENETRATIONS

5.5.1 The separation requirements are the same as for the redundant 1E reactor building penetrations. The justification is therefore the same as previously provided in Section 3.5 of this Appendix.

6.0 SEPARATION DISTANCES FOR 1E (INCLUDING NON-1E CIRCUITS THAT ARE ROUTED WITH CLASS 1E CIRCUITS) TO NON-1E COMPONENTS AND WIRING INTERNAL TO PANELS

This section provides the justification for the separation distances shown in Table D for 1E to non-1E components and wiring internal to panels.

6.1 CONDUIT TO CONDUIT

6.1.1 The separation requirements are the same as for the redundant 1E conduit to conduit configuration. The justification is therefore the same as previously provided in Section 4.1 of this Appendix.

6.2 CONDUIT TO CABLE/WIREWAY/WIRE

6.2.1 The separation requirements are the same as for the redundant 1E conduit to cable/wireway/wire configuration. The justification is therefore the same as previously provided in Section 4.2 of this Appendix.

6.3 CABLE TO CABLE, WIRE TO WIRE, WIRE TO CABLE, COMPONENT TO COMPONENT OR COMPONENT TO WIRE/CABLE

6.3.1 The separation requirements are the same as for the redundant 1E cable to cable, wire to wire or wire to cable configuration. The justification is therefore the same as previously provided in Section 4.3 of this Appendix.

7.0 CONTROL BOARD INDICATORS - MULTICONDUCTOR CABLES CONTAINING MORE THAN ONE REQUIRED SEPARATION CIRCUIT

7.1 CIRCUIT ANALYSIS

The power sources to the Bailey RY meters on the Main Control Board are supplied from the Class 1E inverters. The Bailey indicators require both an input signal (-10 to +10 V) and a 120 VAC power source.

Each indicator has an internal transformer which reduces the input voltage to the working level required by the indicator.

The only credible fault that can be postulated is 480V to the input side of the inverters. For this fault the inverter transformer output will saturate and limit the voltage to the indicator to 120 VAC. The routing for this circuit is through seismic tray from seismic racks; hence no other fault can be imposed between the inverters and the control board.

The input signals are routed in instrument tray or conduit that contain only low level circuits (Section 3.3.2 of this Appendix) and use 600 V insulation. This insulation level would prevent the maximum voltage which can be postulated from generating any "flash-over" from one cable to an adjacent cable.

Additionally, the power supply wires are fused. Therefore, any potential fault within the indicator or input signal is isolated from the 1E inverter source. Since there are no credible events that can impose excessive voltage or current levels on the analog or power supply cable and the cable insulation is adequate to prevent "flash-over", the use of multiconductor cables with different separation groups for Bailey RY indicators is acceptable.

8.0 BARRIERS

Marinite Barriers

On April 20, 1972 in a meeting between GAI and FPC, it was established that a suitable separation barrier would be 16 gauge metal wrapped on both sides with 1/8 inch asbestos tape constituting 1/4" thickness as a thermal barrier (Reference Figure 4C). This was incorporated into the Engineered Safeguards Criteria (ESC) which was issued on May 18, 1972.

In Feb. 1974, Mr. Bower, inspector for the Atomic Energy Commission (AEC), inspected the control boards and specified changes to the ESC to satisfy his inspection (ref. Mar. 7, 1974 letter FPC to GAI). Pending those revisions, the control boards and report were to be accepted via a return visit by Mr. Bower.

Figures 3, 4A, 4C and 5 reflect the as-built conditions as specified by the ESC issued May 18, 1972.

Due to concern associated with asbestos, the use of asbestos as a fire retardant material was discontinued. A suitable barrier was defined as 16 gauge metal with the asbestos replaced with 1/4 inch thick marinite on either side of the sheet metal.

Marinite-ML structural insulation is a non-asbestos non-combustible material which provides structural strength and high thermal insulating values. Because of its machinability, it can be readily fabricated into various sizes and shapes. It is designed to be used in fire prevention applications such as fire stops, fire walls, cable trays, etc. and provides an ideal, non-combustible base for melamine veneers. Marinite being self supporting eliminates the need for through metal supports, thus reducing heat transfer through barriers from the metal supports and prevents localized "hot spots". Because Marinite is self-supporting, it requires a minimum number of bolts to hold it to the barrier (minimum of No. 16 gauge sheet metal for CR-3 application).

Marinite is a commercially available product in minimum thickness of 1/2". Therefore, based on the above discussions and engineering judgement, 1/2" thick Marinite has been chosen as a substitute for 1/8" asbestos (Reference Figure 4B).

<u>SILTEMP Barriers</u>

An analysis of different thermal materials was performed for Crystal River Unit 3. Based on this analysis presented in E-91-0052 (Reference Y), SILTEMP sleeve and wrap (188CH and WT-65) are considered as acceptable thermal barriers for redundant wiring. The installation guidelines for SILTEMP are addressed in Maintenance Procedure MP-405A.

JUSTIFICATION TO USE SILTEMP ON RIGID CONDUITS CONTAINING 120 VAC/125 VDC POWER, CONTROL OR INSTRUMENTATION CABLES

The use of SILTEMP wrap as a barrier between a rigid conduit containing 120 VAC/125 VDC power, control or instrumentation cables and external low voltage power or control cable with the SILTEMP applied to the rigid conduit with 0" spacing is considered acceptable based on the following analysis:

Test report No. 47506-02 dated March 11, 1985 for Northeast utilities describes tests that were performed using SILTEMP as a barrier between two cables. The tests were performed using a No. 8 AWG triplex cable form the Kerite Company as the faulted cable. This was considered to be the worst case cable for generating the maximum heat. There were two tests performed using SILTEMP 188CH as the thermal barrier between the cables. A test current of 1200 amperes was selected based on the worst fault current that No. 8 AWG cable could experience in the plant. In the first test the faulted cable was wrapped while in the second test the target cables were wrapped. The results of these test demonstrate that a faulted cable inside or outside of SILTEMP 188CH blanket does not affect adjacent cables with zero-inch separation.

A test performed for Duquesne Light Company (Report No. 17666-02 dated April 19, 1985) supports the use of SILTEMP WT-65 as an acceptable thermal barrier between two cables in free air with zero inch separation. Half of the faulted cable was wrapped in SILTEMP WT-65 and half in SILTEMP 188CH. The target cables were in contact with the outside of the wraps. For this configuration a fault current of 316 amperes was applied for 8.4 minutes and 600 amperes was applied for 4 seconds. The maximum temperature on the target cable adjacent to the SILTEMP WT-65 was 291.5°F, while the maximum temperature on the target cable adjacent to the SILTEMP 188CH was 887.1°F. The test results indicate the target cables met the acceptance criteria.

HL&P tested flex conduit wrapped with SILTEMP WT-65 (Test Report No. 53575 dated February 12, 1987). The fault cable was inside the flex conduit and the target cables were in contact with wrapped conduit. A test current of 600 amperes was applied to a 3/C No. 4 AWG cable inside the flex conduit. The maximum temperature recorded on the target cables which were in free air was 138°F.

The majority of the low voltage power and control cable at CR-3 are manufactured by The Kerite Company. Cables at CR-3 have flame retardant insulation jacket and are qualified to meet the requirements of IEEE-383. The control trays at CR-3 contain 120 VAC and 125 VDC control cables. The most common control wire size utilized at CR-3 is #14 AWG insulated to a minimum of 600 volts. However, to facilitate installation, 480 volt, 120 volt AC and 125 volt DC power cables size no. 8 AWG and smaller are allowed to route in the control cable trays. Based on FPC calculation E-91-0052, the No. 8 AWG power cable was selected as a worst power cable for CR-3 since it can produce the highest cable surface temperature. Calculation E-91-0052 has also established 1200 amperes as the maximum current that a No. 8 AWG cable could experience at CR-3. Therefore, conditions at CR-3 are similar to those tested for Northeast Utilities.

Based on the results of Duquesne Light Company as mentioned above the SILTEMP WT-65 is a better thermal barrier over SILTEMP 188CH due to the high temperatures observed on target cables which were in contact with SILTEMP 188CH.

Based on the above it is evident that SILTEMP WT-65 wrapped conduit is an acceptable separation barrier between a rigid conduit containing 120 VAC/125 VDC power, control or instrumentation cables and an external low voltage power or control cables.

CIRCUIT NUMBER 3RD LETTER CODE

A Computer

B Video

C Motor Control Centers (Pwr & Cont)

E D.C. Circuits

F A.C. Circuits (A.C. Dist. Pnls)

G Turbine-Generator-Exciter

H Reactor Protection (Circuits which trip the Reactor; low level Circuits which initiate safeguards logic)

K Events Recording

L 480 V Switchgear

M 6900 V & 4160 V Switchgear

P Communications

R Reactor Plant

S Secondary Plant

T Transformers

U 230 KV

V 500 KV

W Fiber Optics

ENGINEERED SAFEGUARDS ACTUATION SYSTEM (ESAS)
ELECTRICAL SEPARATION CONSIDERATIONS

SEE ATTACHED ANALYSIS

POWER AND INDUSTRIAL SYSTEMS DIVISION – READING

REVIEW AND APPROVAL RECORD

1. PROJECT	CRYSTAL RIVER UNIT 3
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W.O.	04-5515-096
CLASSIFICATION	☐ SAFETY-RELATED ☒ NON-SAFETY RELATED

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Gilbert/Commonwealth

GAI-20

ENGINEERED SAFEGUARDS ACTUATION SYSTEM

ELECTRICAL SEPARATION CONSIDERATIONS

Engineered Safeguards Actuation System

Electrical Separation Considerations

1.0 INTRODUCTION

The Engineered Safeguard Actuation System (ESAS) provides the signals required to actuate two redundant trains of safety related plant auxiliaries. The ESAS monitors both reactor coolant pressure and reactor building pressure to provide actuation should a preset value be reached.

Reactor coolant pressure is monitored by pressure transmitters which provide analog signals auctionered by bistables to provide a digital signal when a preset level is reached. Reactor building pressure is monitored by pressure switches which provides digital signals when the pressure exceeds preset values.

For redundancy, reliability and testability, each of the plant parameters monitored for ESAS actuation use multiple instrumentation channels arranged in a logic based on an enhanced two-out-of-three voting redundancy. The enhanced portion of the two-out-of-three logic is applicable only to the digital portion of the ESAS. It provides the features of a two-out-of-three-taken-twice logic. An actuation matrix made of two-out-of-three logic is provided for each actuated component. This approach, while providing significant margin against the consequences of postulated single failure, increases the complexity of the application of separation criteria.

The reactor coolant pressure is monitored by three transmitters and the reactor building pressure is monitored by six pressure switches. The integration of three reactor coolant analog instrument channels into two ESAS actuation trains (each composed of a two out of three logic) creates separation and channel identification difficulties. The source of these difficulties can often be traced to situations where redundant channels are combined for logic purposes. This situation is recognized in IEEE 279 "Criteria for Nuclear Power Plant Protection Systems" which states that "A channel loses its identity where single action signals are combined.".

The purpose of this document is to identify the features included in the design of ESAS needed to assure that the separation requirements are met. This document also includes considerations relativ: to power supply requirements and impact of the single failure requirement.

The considerations provided in this document are applicable only to the internal and intercabinet wiring of the ESAS cabinets.

The ESAS separation and isolation features also provide significant excess margins toward meeting the consequences of postulated single failures. These margins are not totally taken credit for in the Plant Technical Specifications and could be used to justify potential LCO.

2.0 ESAS ACTUATION CHANNELIZATION REQUIREMENTS

The channelization requirements of the ESAS are defined in part by the number of channels required to meet the single failure criteria and by the way these channels are interfaced to generate the output signals required to actuate both train of equipment.

A. Number of channels

The ESAS monitors both reactor coolant pressure and reactor building pressure to provide actuation of redundant safety related plant auxiliaries at a preset value.

The actuation logic selected is based on a two-out-of-three logic to provide reliability, testability and capability to meet the single failure criteria in accordance with the design requirements of IEEE 279.

A two-out-of-three logic scheme requires that the selected parameters be monitored by a minimum of three sensors. When only three sensors are used (as for the reactor coolant pressure), the scheme does not have any excess margin toward meeting the single failure criteria. This is because if one sensor fails in an unsafe mode, the remaining sensors must actuate properly to provide a two-out-of-three output. Therefore each of the input signal to a two out of three logic must be kept independent.

IEEE 279 requires that sensors be testable during normal plant operation. Testing can be performed by either perturbing the monitored process parameter or by comparing the output of redundant sensors against each other.

Since any sensor monitoring the reactor coolant pressure must be located inside the reactor building and is not readily accessible for testing during normal plant operation, pressure transmitters are used. The transmitters provide the capability for cross checking the pressure readings from the control room and thus provide on line testing capabilities.

Because the amount of hardware required for a transmitter loop is significantly greater than for a measurement utilizing a pressure switch, only three transmitters are used to produce the two redundant two out of three logic.

Reactor building pressure can be monitored by sensors located outside the reactor building. The sensors selected are pressure switches with sensing lines which penetrate the reactor building wall.

Since accessibility to the pressure switches is possible during normal plant operation, testing can be done by perturbing the process variable. Also, because the amount of hardware needed to implement a measurement using pressure switches is limited, reliability can be increased by providing three sensors, in a two out of three configuration, for each of the two trains of actuation.

B. Channel to Actuation Interface

The on-line testing requirements of IEEE 279 states in part that "Capability shall be provided for testing and calibrating channels and the devices used to derive the final system output signal....". This requirement is further clarified to indicate that capability should be provided for testing during power operation. This last requirement brings the concern that testing could cause an inappropriate actuation of the final actuated device with potential negative impact on plant operation.

This concern is the major design consideration which decided the basic feature of the ESAS actuation scheme whereby the two out of three logic is performed as the last logic element prior to actuation of the final devices. This preserves the testing capability afforded by the two out of three voting redundancy. Figure 1 shows a simplified scheme of one channel of RC pressure and one channel of RB pressure for both A and B actuation.

Referring to figure 1, the reactor coolant pressure is measured by a pressure transmitter located in the reactor building. The pressure signal is monitored for HPI actuation by a bistable (test and buffer modules omitted for simplicity), the output of which is equipped with two relays wired in parallel. One relay is assigned to Train A actuation and the other is assigned to train B actuation. The bistable is located in channel test cabinet 1 and feeds train A and B digital signals to auxiliary relays located in channel cabinets 1A and 1B.

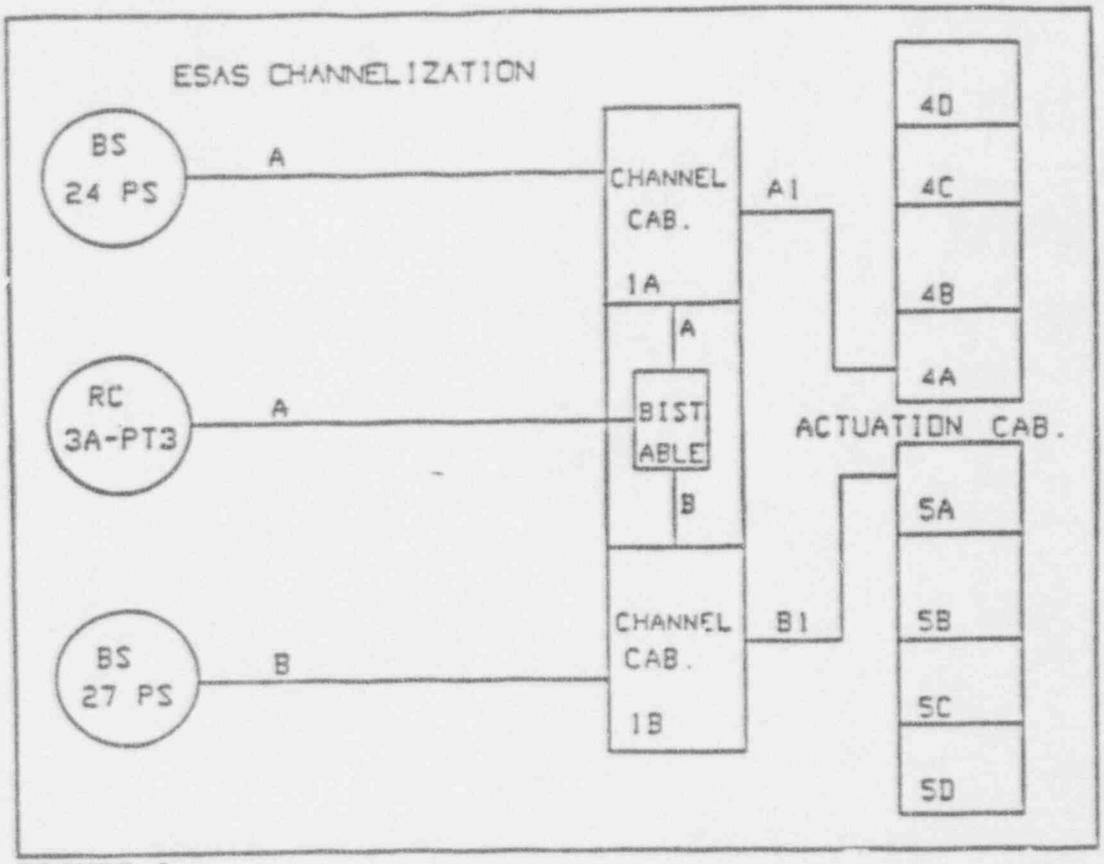


FIGURE 1

The reactor building pressure is monitored by pressure switches. One pressure switch is assigned to Train A, providing a signal to channel cabinet 1A and another is assigned to train B, providing a signal to channel cabinet 1B.

The digital signals from the pressure switches are functionally equivalent to the digital signals from the bistables. It is important to note that the analog signal from the transmitter to the bistable must be kept separated from the bistable's digital signals and the signals from the pressure switches. This is because the analog signal is actually an A or B signal as far as actuation is concerned.

The output of the channel cabinets 1A and 1B are directed to the redundant actuation cabinets 4 and 5. Each of the actuation cabinets is segregated into four compartments identified as A,B,C,D. Two out of three logic matrices, one for each plant auxiliary to be actuated, are made from relay contacts located in the A,B,C compartments of each actuation cabinet.

As represented in fig. 1, one reactor coolant pressure measurement and a set of two redundant pressure switches constitute, via the channel cabinets, one input to both the A and B actuation cabinet.

Since three separated inputs are required to form a two out of three matrix, a total of three reactor coolant pressure and three sets of two redundant reactor building pressure measurement is required to complete the actuation system.

3.0 SEPARATION CRITERIA

Electrical separation or isolation are design features which assure that 1E equipment performing redundant functions are kept independent. Independence of redundant equipment is required to meet the single failure criteria.

Electrical separation can be provided by physical distance of circuits or when it cannot be provided by electrical isolation. The level of electrical isolation required is determined by the maximum credible fault which can be postulated. Since power plant wiring is segregated by voltage levels (eg, 480 volts and 4160 volts), the highest fault voltage level credible for control circuits is 480 volts. This correspond to the since the level of voltage which exists in motor control centers and that could be imposed onto the 120 volt control wiring in that MCC.

To assure adequate electrical separation, the assigned separation grouping must be identifiable. Color coding is used for that purpose.

Assigning color coding to define separation groups for actuation systems like the ESAS is a compromise between the need to accurately identify the separation grouping of the different electrical components performing redundant functions and the practical aspect associated with implementing a color coding which truly represent the complexity of the two-out-of-three-taken-twice logic. A color code truly adapted to the channelization of the ESAS would require three colors for the analog input signals plus six colors for the pressure switches signals and two additional colors for the actuation signals for a total of 11 colors. Such color code could not be practically implemented.

As a result, only three basic colors have been used for the ESAS. These colors are red, green and yellow. This selection is consistent with separation requirements on the following basis:

A. Input signals

The input signals (analog) from the reactor coolant pressure transmitters to the ESAS must be kept separated from the digital signals of the reactor building pressure switches since each analog signal actually generates a channel A and channel B digital output.

Separation of analog transmitter signals and pressure switch digital signals is accomplish by running the analog signals in separated instrument trays or conduit. Channel A and B are run in instrument tray while channel C is run in conduit. The input signal from the reactor building pressure switches are run in individual conduits. The signals from the pressure switches are considered to be control voltage.

Therefore, the analog input signals (transmitters) are kept separate from the digital input signals (pressure switches) because of the voltage level associated with these circuits. This allows to use the same color coding and channel assignation for the analog signals (ie A,B,C) and for the digital signals (ie,A,B,C) when in fact these are kept separate by their routing.

B. Signals from the bistables to the channel cabinets

The digital signals from the bistables to the channel cabinets consist of two signals, one assigned to train A and the other to Train B actuation. However, the three digital signals (one per bistable) assigned to the Train A actuation must be kept separate from each other since the two-out-of-three voting is performed in the actuation cabinet. The same reasoning requires that the signals assigned to Train B actuation be kept separate from each other. This requirement would imply the need for six different channels. This was implemented running the signals from the bistables to the channel cabinets internally within the test cabinets or in individual conduits. Therefore, they are kept separate from the redundant channels.

C. Signals from the pressure switches to the relay cabinets

Similar to the digital signals from the bistables, the signals from the pressure switches must be kept separate from each other. This requirements require in effect 6 channels and has been implemented by routing the wiring for each pressure switches wiring in individual conduits. Three of the conduits are labelled A and the other three conduit labelled B.

D. Signals from the channel cabinets to the actuation cabinets

The signals from the channel cabinets to the actuation cabinets are an extension of the input signals and must be kept separate from each other.

The signals from the separate relay cabinets are run in conduit directly to the corresponding compartments of the actuation cabinets and; therefore are kept separate from each other.

D. Wiring associated with the two out of three matrices

The two-out-of-three matrices are formed in a separate compartment at the back of the actuation cabinets. Wiring from the output relays located in the separate compartments located in the front of the actuation cabinets is routed through openings located at the bottom of the compartments. This wiring is terminated on terminals located in the back compartment where field wiring also terminates.

This arrangement maintains the separation of the three channels while combining them to form a two-out-of-three logic.

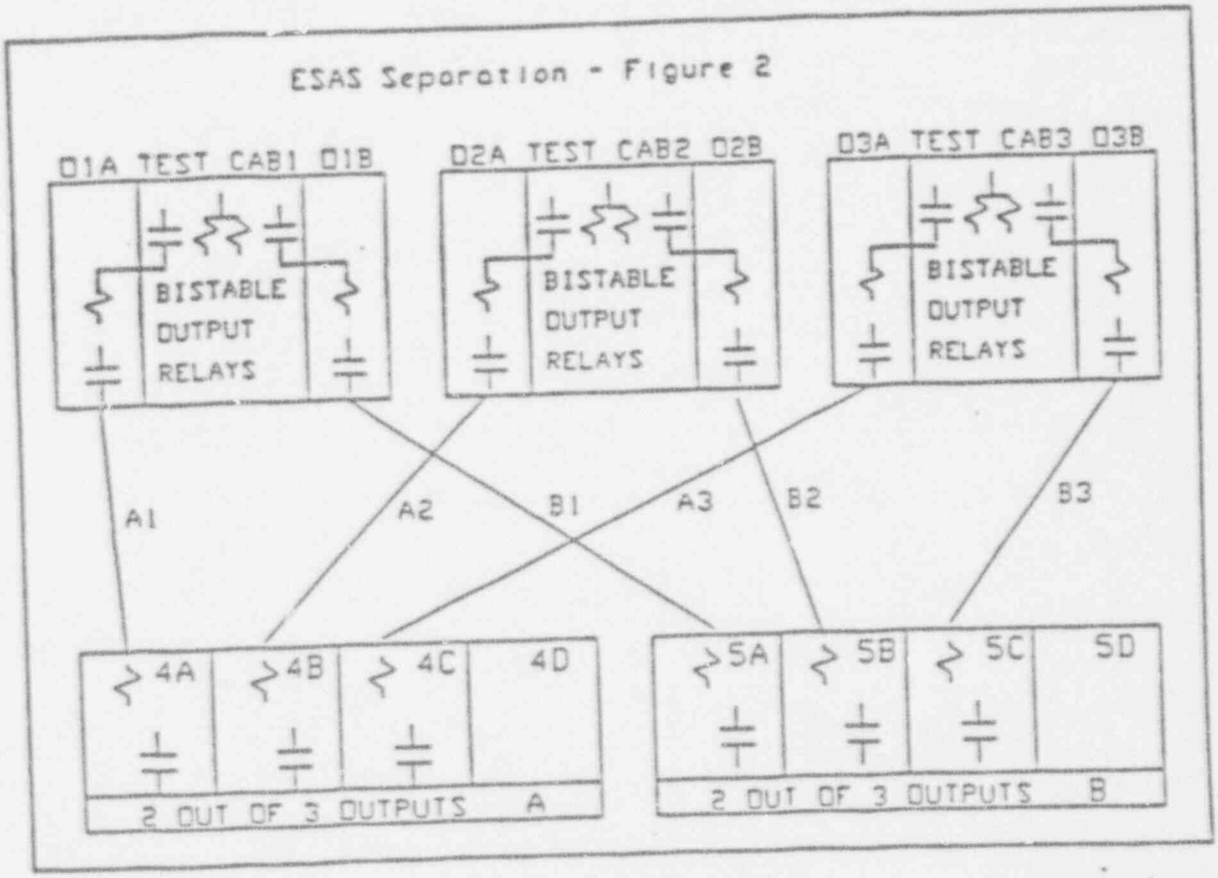
4.0 ESAS POWER SUPPLY REQUIREMENTS

The ESAS system is a basic two-out-of-three de-energize to actuate system. The power to the system is derived from the inverters which are backed-up by redundant 250 Volt batteries. A single failure of a 250 volt battery will result in the loss of the two associated inserters. This results in the potential for a simultaneous two-out-of-three actuation of both train of the ESAS.

A major requirement of the ESAS is to provide a timely loading of the eme[illegible]ency diesel generators during a loss of off-site power. In the event of postulate[illegible]tery failure in one train coincident with a loss of off-site power, a timely loa[illegible] of the diesel generator associated with the redundant train must be provided. To perform this requirement, the power supply to the ESAS timers is distributed over the 4 inserters. This assures that power is available to reset the timers associated with the redundant diesel generator and provide timely loading. Distributing the timers among the 4 inserters creates an appearance of inadequate separation but is acceptable when postulated single failures are analyzed.

5.0 DISCUSSION OF SELECTED SEPARATION FEATURES AND DESIGN IMPLEMENTATION

The ESAS is configured in such a manner that significant separation features exist, they are portrayed on figure 2.



The following provides an overview of some of the major features which assures that the ESAS complies with the single failure criteria:

A. Separation between actuation trains

Train A and Train B outputs from the ESAS are formed separately in actuation cabinets 4 and 5, respectively. A significant amount of separation exists between the actuation trains since the actuation cabinets are physically separated enclosures.

B. Separation within the actuation cabinets

Actuation cabinets 4 and 5 are designed to provide separate enclosures for each of the three channels required to form the two-out-of-three matrices. The general color coding used for the wiring inside cabinet 4 is red and green in cabinet 5. Some of the matrices are used to actuate "A/B" components (i.e., such as the third Reactor Building Cooling Unit). The color coding for these components is yellow. It was perceived at the original design stage that changing wire color from yellow to red or green across terminal blocks would create potential confusions therefore some of the contacts of output relays were wired with yellow wiring to assure a color match between the field wiring landing at the back of the actuation cabinets and the matrices wiring.

Following the TMI-2 accident, major wiring modifications were required inside the actuation cabinets to implement required changes associated with diverse Reactor Building Isolation. As a result and for practicality, the separation between red colored wiring in cabinet 4 (green in cabinet 5) and yellow wiring could not be maintained. It is important to note that the segregation of yellow and red wiring inside actuation cabinet 4 and yellow and green inside actuation cabinet 5 was not required to meet a separation requirements but to assure that a match in color coding would exist between cabinet wiring and field wiring.

The yellow field wiring can actually loop from one actuation cabinet to the other. This is acceptable since the maximum fault voltage is within the rating of the insulation of the components selected and the theory of the "hot wire" is not applicable when only safety related wiring is under consideration. The actuation cabinets are designed such that a localized fire will not propagate from one compartment to another.

The color of wires inside the different compartments of an actuation cabinet is kept as either red or green for practicality. Non-safety wires used for indicating lights and alarms are run with the safety related wires and color coded brown (A) or orange (B) to identify their channel associations.

Since the maximum voltage inside the compartment is only 480 volts (see section B), separation between wiring associated with the coil and the contacts of the relays located in the actuation cabinets is not required.

C. Separation between actuation cabinets and channel cabinets

The channel cabinets act as buffer between the bistable output relays and the actuation cabinets. The channel cabinets are designated as 1A, 2A and 3A for A train and 1B, 2B and 3B for B train. The field wiring between the compartments of the actuation cabinets and the channels cabinets is kept separate from each other even that they are color coded red or green. The separation is assured by independent conduits shown on figure 2 as A1,A2,A3 and B1, B2,B3.

This separation and isolation capabilities of the channel cabinets is required because a fault voltage of 480 volts cannot be accommodated by the bistable output relays. Without this isolation, a 480 volt fault originating in a compartment of cabinet 4 (e.g., 4A) could be transmitted to a compartment of cabinet 5 (e.g.,5A) and would not be in accordance with the design requirement for the ESAS that a fault in one train may not reduce the reliability of the B train.

D. Separation of the channel cabinets

The channel cabinets are separate compartments of an enclosure which also contain the test cabinets. Each channel cabinet is physically and electrically separated from its counterpart (i.e., 1A from 1B) and from channel cabinets associated with the other redundant channels (i.e., 2A & 2B, 3A & 3B).

E. Isolation between the channel cabinet and the bistables.

As indicated, the channel cabinets act as buffers between the bistables and the actuation cabinets by providing coil to contact isolation with an isolation capability of 600 volts (e.g., insulation rating of the wires). They also assure that a fault voltage no greater than 120 volts A.C. can be imposed on the bistable output contact and its wiring. 120 volts A.C. voltage is within the rating of the bistable contacts and associated wiring. This [illegible] because the bistable is the common link between Train A and T[illegible] [illegible]tuation.

D. Signal segregation at the bistable level.

At the bistable level, the output relays are assigned to Train A actuation and Train B actuation. No separation between Train A and Train B can be provided inside the test cabinet.

6.0 EXCESS MARGINS IN MEETING THE SINGLE FAILURE REQUIREMENT

The ESAS has separation and isolation features which provide significant excess margin in meeting the single failure criteria. The excess margin exist mostly because the system logic is essentially a two-out-of-three taken twice.

The following is a discussion of some of these features:

A. Outputs of the ES

Except for low energy applications such as alarm and indicating lights, matrices are not used in non safety applications. Therefore, for a fault voltage in excess of the normal 120 volt control voltage to be seen at the ESAS actuation cabinets, a single failure of 1E component must be postulated outside the ESAS cabinets. An example of such a failure could be the failure of a control transformer in a Motor Control Center. Since these circuits are fused below the rating of the wire used, no "hot wire" can be postulated. On this basis, no further failure needs to be postulated in the ESAS cabinets. Thus assuring the availability of the other outputs on the same train as the fault and the complete other redundant train is assured.

B. Actuation cabinets

Should a localized fire be postulated in a compartment of an actuation cabinet as an extreme interpretation of the single failure criteria, all equipment and wiring located in the affected compartment can be postulated to fail. This includes the postulation of short circuits which impose the highest voltage available in the compartment on all wires connected within the compartment.

Should a localized fire occur in the back of an actuation cabinet, the loss of a complete train of actuation may be postulated since this is where the output connections are located. This failure would not impact the redundant train because of the physical separation of the redundant cabinet.

A localized fire in any other compartment (i.e., the front compartments) will result in the loss of the equipment in that compartment only. This does not preclude the system to still be capable to meet the single failure. This excess margin is significant and is not reflected in the technical specification.

C. Channel cabinets

A localized fire in a channel cabinet does not prevent the ESAS from meeting the single failure criteria. Only the reliability of the affected train is reduced to a one-out-of-two or two-out-of-two logic. Note: Reduction to one-out-of-two or two-out-of-two is dependent on the failure mode postulated (open circuit versus short circuit).
This excess margin is not reflected in the technical specifications. However, it can be used to justify potential LCO.

D. Test cabinets.

A localized fire in a test cabinet will prevent the system to meet the single failure criteria for actuation on low Reactor Pressure. Actuation on High Reactor Building Pressure is not affected. This excess margin is not reflected in the technical specification.

7.0 REFERENCES

IEEE 279 Proposed Standard dated August 30. 1968 "Proposed IEEE Criteria for Nuclear Power Plant Protection Systems".

8.0 DEFINITIONS

Channel: An arrangement of components and modules as required to generate a single protective action signal when required by a plant condition- (IEEE 279).

Train: A train is one of the redundant set of "actuated equipment"

Actuated Equipment: The assembly of prime movers and driven equipment used to accomplish a protective action (IEEE603).

Attachment 1
Separation Criteria Exceptions

No.	Case or Exception	Equipment I.D.	Dwg. Nos.	Analysis No.
1	1. RCM81 IS AN ASSOCIATED (BROWN) CABLE TERMINATING ON TB4-7. ECN-3421 TERMINATED A GRAY WIRE ON TB4-7 WHICH IS INTERNALLY JUMPERED TO A NON-1E TERMINAL BLOCK. ADJACENT TERMINATIONS TO TB4-7 ARE ALSO BROWN. 2. RCM19 IS AN ASSOCIATED (ORANGE) CABLE TERMINATING ON TB16-25. ECN-3421 TERMINATED A GRAY WIRE ON TB16-25 WHICH IS INTERNALLY JUMPERED TO A NON-1E TERMINAL BLOCK. ADJACENT TERMINATIONS TO TB16-25 ARE ALSO ORANGE (REFERENCE CASE 39, ESSE-CB & RR).	MCB ICSAR	210-383 210-384	Ref. G/C Inc. Memorandum J.B. Haneiko/R.E. Miller Dated August 18, 1976.
2	ACF62 IS AN ASSOCIATED (BROWN) CABLE TERMINATING ON A NON-1E TERMINAL BLOCK AT TB8-29 AND TB8-30. ALL INTERNAL WIRING FOR THESE POINTS IS NON-1E (REFERENCE CASE 38, ESSE-CB & RR).	RR3	210-601 210-600	Ref. G/C Inc. Memorandum J.B. Haneiko/R.E. Miller Dated March 1, 1976.
3	CONTROL SWITCHES (DEVICES AB3 AND AC3 ON EC-210-501) HAVE ASSOCIATED WIRING OF REDUNDANT CHANNELS (ORANGE AND BROWN) TERMINATED LESS THAN 6" APART. THE EXTERNAL WIRING FOR THE SWITCHES IS PART OF ALARM CIRCUITS CIK21, CIK22, CIK23, AND CIK24. THESE EXTERNAL CIRCUITS ARE ASSOCIATED WITH SAFEGUARD CHANNEL "A" ONLY (REFERENCE CASE 37, ESSE-CB & RR).	MCB HV SECTION	210-501	Ref. G/C Inc. Memorandum J.B. Haneiko/R.E. Miller Dated February 5, 1976.

Attachment 1
Separation Criteria Exceptions

No.	Case or Exception	Equipment I.D.	Dwg. Nos.	Analysis No.
4	ORANGE AND GRAY WIRES ARE TERMINATED ON TB46-23. THE GRAY WIRE IS INTERNALLY JUMPERED TO TB45-3. A YELLOW WIRE IS ALSO TERMINATED AT TB45-3. THE EXTERNAL SIDE OF TB45-3 IS PART OF 28V INDICATING LIGHT CIRCUIT MUF253 (REFERENCE CASE 36, ESSE-CB & RR).	MCB ESB	210-144	Ref. G/C Inc. Memorandum J.B. Haneiko/R.E. Miller Dated February 5, 1976.
5	AK, AM, AP, AND AR ARE SPARE RELAYS IN RR3. SINGLE GRAY WIRES TERMINATED ON THE RELAYS ARE INTERNALLY JUMPERED TO A NON-1E TERMINAL BLOCK AT POINTS TB16-21, 24, 27, AND 30. ALL OTHER RELAY TERMINATIONS HAVE ORANGE WIRES (REFERENCE CASE 35, ESSE-CB & RR).	RR3	EC-210-597 EC-210-600	Ref. G/C Inc. Memorandum J.B. Haneiko/R.E. Miller Dated February 2, 1976.
6	ITEM CZ ON EC-210-157 CONTAINS A FUSE WHICH HAS ORANGE AND BROWN WIRES TERMINATED AT THE SAME POINT (REFERENCE CASE 34, ESSE-CB & RR).	MCB ES SECTION AB	210-157	Ref. G/C Inc. Memorandum J.B. Haneiko/R.E. Miller Dated September 24
7	JC11 IS AN INDICATING LIGHT WITH ORANGE WIRE TERMINATIONS. THE ORANGE WIRES ARE LESS THAN 6" APART FROM GRAY WIRES ON OTHER INDICATING LIGHTS (REFERENCE CASE 33, ESSE-CB & RR).	MCB ICS	210-089	Ref. G/C Inc. Memorandum J.B. Haneiko/R.E. Miller Dated September 10, 1975.
8	ED3 IS AN INDICATING LIGHT WITH ORANGE WIRE TERMINATIONS. THE ORANGE WIRES ARE LESS THAN 6" APART FROM BROWN AND GRAY WIRES ON OTHER INDICATING LIGHTS (REFERENCE CASE 32, ESSE-CB & RR).	MCB ICS	210-081	Ref. G/C Inc. Memorandum J.B. Haneiko/R.E. Miller Dated September 10, 1975.

Attachment 1
Separation Criteria Exceptions

No.	Case or Exception	Equipment I.D.	Dwg. Nos.	Analysis No.
9	GRAY WIRING IS TERMINATED WITH ASSOCIATED WIRING (ORANGE) ON TB23-43 AND TB23-44. IN ADDITION, THE PHYSICAL SEPARATION BETWEEN THE ORANGE AND GRAY WIRES IS LESS THAN 6" (REFERENCE CASE 28, ESSE-CB & RR).	MCB ICS	210-094	Ref. G/C Inc. Memorandum J.B. Haneiko/R.E. Miller Dated July 11, 1975.
10	Teflon sleeving installed on MCB wiring to provide safeguard wiring separation. (Reference Case 4, Calc E91-001, Table C and Teflon Sleeving Inspection Report dated April-May 1990)	MCB	210-007, -021, -046, -050, -111, -300, -341, -370, -379, - ALL 210-SERIES DWGS COVERED BY NOTES ON DWGS.	Teflon Sleeving Inspection Report For April-May 1990.
11	Device AL is a lockout relay with green and gray wires terminated less than 6 inches apart. (Reference Case 3, Calc E91-001, Table C)	SSTR	EC-210-328	Ref. G/C Inc. Memorandum J.B. Haneiko/R.E. Miller Dated April 15, 1975 Analyzing Similar Existing Exception.
12	Wire color changes from safeguards "A" to "B" across a fuse in Engineered Safeguard Channel Cabinet 3A. (Reference Case 1, Calc E91-001, Table C)	ES CAB A	EC-210-473 EC-210-478	I-89-0047
13	Orange and gray wires are terminated less than 6 inches apart on TB10. (Reference Case 1, ESSE-CB & RR)	RR2	EC-210-401	Ref. G/C Inc. Memorandum J.B. Haneiko/R.E. Miller Dated February 19, 1975.

Attachment 1
Separation Criteria Exceptions

No.	Case or Exception	Equipment I.D.	Dwg. Nos.	Analysis No.
14	Devices AL and EL contain terminal blocks which have orange and gray wires terminated on adjacent points. (Reference Case 2, ESSE-CB & RR)	MCB HVC SECTION	EC-210-492	Ref. G/C Inc. Memorandum J.B. Haneiko/R.E. Miller Dated February 19, 1975.
15	Device BN6 is a control switch with orange and gray wires terminated across the same contact. (Reference Case 3, ESSE-CB & RR)	MCB HVC SECTION	EC-210-495	Ref. G/C Inc. Memorandum J.B. Haneiko/R.E. Miller Dated February 19, 1975.
16	1. Device AQ is an auxiliary relay with orange and gray wires terminated less than 6 inches apart. 2. Device BG is an auxiliary relay with orange and gray wires terminated less than 6 inches apart. In addition, the orange and gray wires are terminated across the same contact. (Reference Case 6, ESSE-CB & RR)	RRHV	EC-210-520	Ref. G/C Inc. Memorandum J.B. Haneiko/R.E. Miller Dated February 19, 1975.
17	1. AHF748 AND AHF751 ARE ASSOCIATED CIRCUITS OF REDUNDANT CHANNELS. THESE CIRCUITS TERMINATE ON TB3-1, -2, -26 THRU 30. NO BARRIER EXISTS BETWEEN THE BROWN AND ORANGE TERMINATIONS. 2. ITEM CU IS A DUAL PANEL METER WITH INPUTS SUPPLIED BY CIRCUITS AHF748 AND AHF751, RESPECTIVELY. THE CONDUCTORS OF BOTH CIRCUITS ARE ROUTED IN ONE VENDOR CABLE TO THE PANEL METER. PHYSICAL SPACING IS LESS THAN 6" AND THE CONDUCTORS ARE NOT ELECTRICALLY ISOLATED. (REF. CASE 5A, ESSE-CB & RR)	MCB HV SECTION	EC-210-514 EC-210-515	Ref. G/C Inc. Memorandum J.B. Haneiko/R.E. Miller Dated June 11, 1975.

Attachment 1
Separation Criteria Exceptions

No.	Case or Exception	Equipment I.D.	Dwg. Nos.	Analysis No.
18*	ITEM R ON THE SUBSTATION MISCELLANEOUS WIRING BOARD IS A LOCKOUT RELAY WITH RED, GREEN AND GRAY WIRE TERMINATIONS LESS THAN 6" APART. (REFERENCE CASE 11, ESSE-CB & RR)	MCB MISC/SSTR	EC-210-332	Ref. G/C Inc. Memorandum J.B. Haneiko/R.E. Miller Dated April 15, 1975.
19	1. VBF27 IS A NON-1E CIRCUIT TERMINATING ON TBA1-1, 2, 3, 4 ADJACENT TERMINATIONS AT TBA1-5, 6 ARE FOR SAFEGUARD CIRCUIT VBF30 (RPS CHANNEL III). 2. VBF28 IS A NON-1E CIRCUIT TERMINATING ON TBB1-1, 2, 3, 4 ADJACENT TERMINATIONS AT TBB1-5, 6 ARE FOR SAFEGUARD CIRCUIT VBF29 (RPS CHANNEL IV). (REFERENCE CASE 10, ESSE-CB & RR)	MCB TPC CAB. A & B	EC-210-576 EC-210-580	Ref. G/C Inc. Memorandum J.B. Haneiko/R.E. Miller Dated April 4, 1975.
20	Device AP1 is a control switch with brown and yellow wires terminated less than 6 inches apart (Reference Case 4, ESSE-CB and RR).	MCB HV SECTION	EC-210-502	Ref. G/C Inc. Memorandum J.B. Haneiko/R.E. Miller Dated February 19, 1975.
21	Circuit AHC-951 is a Channel "B" safeguard power feed. This cable supplies 480V power to Emergency Diesel Generator Room Air Handling Fan Motor AHF-22C. AHC-951 is a #4AWG cable routed in the control tray system (Reference FCN 3 to MAR-89-10-07-01).		209-005 AH-030	Refer to MAR 89-10-07-01, FCN 3.

* Installation of MAR 91-03-23-01, BEST TRANSFORMER, will remove this exception.

No.	Case or Exception	Equipment I.D.	Dwg. Nos.	Analysis No.
22	Devices L, M and N are isolation relays in Remote Shutdown Relay Cabinet A. Redundant devices L, M, and N are in the Remote Shutdown Relay Cabinet B. The Cabinet A relays are Channel "A" (red) powered and the Cabinet "B" relays are Channel "B" (green) powered. Violet wires terminated on the "A" relays are less than 6" apart from red wires. Blue wires terminated on the "B" relays are less than 6" apart from green wires. (Reference Wiring Analysis ND89-1, Item 2). Also relays P & Q in Relay Cabinet	RS RELAY CAB. A & B	EC-210-726 EC-210-736	Wiring Analysis ND89-1.
23	The Remote Shutdown Auxiliary Cabinets contain Class 1E and non-1E circuits routed in the same wire burdle. The non-1E circuits terminate on non-1E terminal block TB3. (Reference Wiring Analysis ND89-1, Item 1)	RS AUX. CAB. A & B	EC-210-747, -750, -746, -749	Wiring Analysis ND89-1.
24	Device D contains two terminal blocks. Yellow and gray wires are terminated on adjacent points. (Reference Case 4, ESSE-CB & RR)	MCB HV SECTION	EC-210-502	Ref. G/C Inc. Memorandum J.B. Haneiko/R.E. Miller Dated February 19, 1975

Attachment 1
Separation Criteria Exceptions

No.	Case or Exception	Equipment I.D.	Dwg. Nos.	Analysis No.
25	1. Fuses DL1, DL2, DL3, DL4, DL5, DL6, DL7 and DL8 have brown and orange, and gray and orange wires terminated less than 6" apart. In some cases, these wires are jumpered on the same terminal point. (Reference GAI Memorandum from V. H. Willems dated March 20, 1973). 2. Fuses DM1, DM2, DM3, DM4, DM5 and DM6 have brown and gray wires terminated less than 6" apart. In some cases, these wires are jumpered on the same terminal point. (Ref. GAI Memo from V. H. Willems dated March 20, 1973). Similar to this exception is shown on various drawings.	RR1	EC-210-388 EC-210-392 Similar exceptions on Dwg. EC-210-411, 421, 422, 441, 446, 457, 462	Ref. G/C Inc. Memorandum by V.H. Willems Dated March 20, 1973.
26	Various separation violations exist between associated wiring and non-1E wiring (Reference GAI Memorandum from V. H. Willems dated March 20, 1973).	VARIOUS	VARIOUS	Ref. G/C Inc. Memorandum by V.H. Willems Dated March 20, 1973.
27	DEVICES JY AND JZ ARE CONTROL SWITCHES IN THE PRIMARY AND SECONDARY AUXILIARY SECTION OF THE MCB. THE ORANGE, BROWN, AND GRAY WIRES TERMINATED ON THE SWITCHES ARE LESS THAN 6" APART (REFERENCE CASES 29 & 30, ESSE-CB & RR).	MCB PSA	210-104	Ref. G/C Inc. Memorandum J.B. Haneiko/R.E. Miller Dated July 11, 1975.
28	Device AG is a lockout relay with red and gray wires terminated less than 6 inches apart. (Reference Case 2, Calc E91-001, Table C)	SSTR	EC-210-328	Ref. G/C Inc. Memorandum J.B. Haneiko/R.E. Miller Dated April 15, 1975 Analyzing Similar Existing Exception.

ATTACHMENT 2

ELECTRICAL DESIGN CRITERIA, ELECTRICAL CIRCUIT PHYSICAL
SEPARATION AND CABLE TRAY LOADING

SEPARATION CRITERIA EXCEPTIONS EVALUATION FORM

MAR No. ______________ Other initiating document ____________________

The following guidance criteria is to be used when evaluating potential deviations or exceptions to this document. This attachment should only be used when all possible methods of complying with the criteria have been exhausted. The first 3 questions are asked to insure that an alternative has not been missed.

- Is the proposed exception due to a situation where ALARA, industrial safety or other reason makes the exception the best choice? Describe all that apply below.

  ____
  ____
  ____

  Have all the different alternatives provided in the criteria been explored? Consider the use of Siltemp and other barriers available, and generic exceptions such as low energy circuits (annunciator, etc.).

  ☐ Yes ☐ No

- Based on the above questions, is the exception due to a situation where it is physically impossible to install in accordance to this criteria?

  ☐ Yes ☐ No

- Document the location of the proposed exception.

  Building/Elevation/Room ____________________
  Panel # ____________________
  Relay Rack # ____________________
  Tray(s) # ____________________

- Description of the exception, include physical arrangement;

  ____
  ____

- The exception occurs between which safety channel:
  Identify the first "GROUP" of Conductor(s), Cable(s) Device(s) in the exception. ______________________________
  ____
  ____
  ____

  ________ Safety channel (A, B, AB) or
  ________ associated (XA, XB, XAB) or
  ________ non 1E (XX)
  ________ Nominal circuit voltage
  ________ Energy level, (Power (P), Control (C), or Instrumentation (I).
  ________ Other Describe

  The above is an exception with:

  Conductor(s), Cable(s) Device(s) in violation. ______________________________
  ____
  ____
  ____

  ________ Safety channel (A, B, AB) or
  ________ associated (XA, XB, XAB) or
  ________ non 1E (XX)
  ________ Nominal circuit voltage
  ________ Energy level, (Power (P), Control (C), or Instrumentation (I).
  ________ Other Describe

- Provide the maximum credible voltage or current transient;

  ________ Volts or ________ Amps

  Note: The maximum credible voltage is the highest circuit voltage available among the cables involved in the request for exception. The current transient is the highest normal current interruption setting of the secondary protective devices for the cables involved in the request for exception.

- Flame retardant characteristics of the installation, including insulation and jacket material;

	Cable Group 1	Cable Group 2
Type of cable insulation:	________	________
	________	________
	________	________
	________	________
Type of jacket insulation:	________	________
	________	________
	________	________
	________	________

- Applicable drawing(s) for this exception (Layout (201), connection (210), elementary (209), etc.) ______________________________
____
____

- Type of protection in the circuit;

  ☐ Fuses protection ☐ Breaker protection
  ☐ Isolators ☐ Other Describe ______________

- Are the circuits involved mutually redundant?

  Mutual equipment or systems counterparts (i.e., HPI pump A motor and HPI pump B motor and motor controls.) must maintain separation per criteria. Non-redundant equipment may be analyzed as long as a fault in one train cannot disable the same equipment/system in another train. Document the drawing and or method used to verify the system functions are not mutually redundant. ______________________________
  ____
  ____
  ____

- Circuit power supplies (source of energy) must be analyzed such that redundant equipment is not disabled. Document the drawing and or method used to verify the source(s) are not mutually redundant. ______________
  ____
  ____
  ____
  ____

  Are the circuits redundant based on question ____ and ____ above?

  ☐ Yes ☐ No (answer must be NO for a valid exception)

- Summary Analysis of why this exception is acceptable (attach separate sheet if required.

  ____
  ____
  ____
  ____
  ____
  ____

- Document the method used to incorporate this exception into the FPC documentation system. The documentation must cover the revision of connection drawings to identify the exception and the engineering document(s) that justify this exception.

  Drawing revised via MAR, FCN or DCN, identify document type and number: ______________________________ .

  Engineering justification documented via MAR(SE & DIR), or other engineering document, identify document type and number: ______________________________
  ______________________________ .

Originator: ______________________________ / __________
Name / Date

Approved: ______________________________ / __________
Supervisor of Nuclear Engr. (Electrical) / Date

Supporting Documents for Attachment 1

memorandum Gilbert/Commonwealth

August 18, 1976

to: R. E. Miller - GIII 3NW

from: J. B. Haneiko

subject: Engineered Safeguard Separation Exception
Control Boards & Relay Racks - Case 39
ECN 3421
Crystal River Unit No. 3

The condition described in your memo of August 16, 1976, has been reviewed and found acceptable as shown. No single failure will prevent the operation of redundant E.S. equipment or negate the operation of more than one E.S. power supply.

John B. Haneiko
John B. Haneiko
Project Instrument Engineer

JBH:drc
cc: E. R. Hottenstein (2)
R. P. Cronk

memorandum Gilbert/Commonwealth

to: R. E. MILLER - 3E

March 1, 1976

from: J. B. Haneiko

subject: ENGINEERED SAFEGUARD SEPARATIONS EXCEPTIONS
CONTROL BOARDS & RELAY RACKS - CASE 38
ECN 2924A
CRYSTAL RIVER UNIT NO. 3

In response to your memo of February 26, 1976, the following exception to the E. S. separation criteria has been reviewed.

CASE 38: EC-210-601, TB8-29-30

DESCRIPTION: Non E. S. circuit routed in red tray terminates on non E. S. terminal board (gray). Although there is no color violation within the control board, this is essentially the same case as a brown and gray wire not having the required 6" separation.

CONCLUSION: The case as you describe it is acceptable by definition, since it is not a violation of the E. S. control board criteria. Nowhere in the criteria does it state that gray cannot mix with brown or orange. Furthermore, you have stated that this gray wire does not mix with orange or green anywhere in RR3. Therefore, no possible violation exists.

Please note that the 38 cases reviewed to date do not all constitute violations. Several, such as cases 37 and 38, do not violate the basic criteria but were written up since possible confusion could otherwise result. The "ESX" notation should still be put on the drawing at the appropriate place. The "ESX" on drawings indicates (a) there is no violation although it may appear to be one, or (b) there is a violation and it has been reviewed and found to be acceptable.

John B. Haneiko

John B. Haneiko

JBH:ems
xc: E. R. Hottenstein (2)
J. B. Haneiko (2)

memorandum Gilbert Associates, Inc.

Gilbert Commonwealth Companies

to: R. E. Miller

from: J. B. Haneiko

subject: Engineered Safeguard Separation Exceptions
Control Boards and Relay Racks - Case 37
GAI Field Change 76-668
Crystal River Unit No. 3

February 5, 1976

The following apparent exception to the standard CR3 separation procedure was reviewed.

Case 37: EC-210-501, devices AB3 and AC3

Description: Orange and brown wires exist on the same control switch on the HV section of the main control board. This does not show up as a violation on the appropriate elementaries (B-208-077, sheets CI-18 and CI-19) since they are part of two alarm circuits.

Conclusion: There is no E.S. violation of any sort in this case. The power source involved is the events recorder source. The circuits involved, CIK-21, 22, 23 and 24, are all alarm circuits and therefore are not even covered by the separation criteria. However, this memo is presented as justification for the apparent violation on HV section of the control board, since the wires are not identified there as being part of an alarm circuit.

John B. Haneiko

John B. Haneiko

JBH:vjk

xc: E. R. Hottenstein (2)
J. B. Haneiko (2)

memorandum Gilbert/Commonwealth

to: R. E. MILLER - 3E

February 5, 1976

from: J. B. Haneiko

subject: ENGINEERED SAFEGUARD SEPARATION EXCEPTIONS
CONTROL BOARDS AND RELAY RACKS - CASE 36
GAI FIELD CHANGE 75-662
CRYSTAL RIVER UNIT NO. 3

An exception to the standard CR3 separation procedure was reviewed in relation to the field change on MUV-64.

CASE 36: B-208-028, sheet ES-AB07
B-208-041, sheet MU-55
EC-210-144, TB 46-23

DESCRIPTION: Orange and gray wire exist on the same terminal because they must be tied together. The normal power feed is from VBDP-3, BKR. #7 (120 VAC) through a transformer to 28 volts. However, it may also be fed from VBDP-4, BKR. #7, since this is an AB bus.

CONCLUSION: These are 28 volt indicating light circuits, and do not affect any safety related equipment. Identical exceptions were previously reviewed in case 34 and case 4. See memo for case 4 dated February 19, 1975 for further discussion.

Please note that fuse "BZ" also added on this field change on drawing EC-210-157 does not require an "ESX" notation on the drawing although the wire color changes from orange to gray through the fuse. This case is not an exception to the standard separation criteria report since an even more stringent case is covered on page 1 of the report under section 3A: "The AB actuation must be kept separate from the A & B channels and trains except at the point of origin where reasonable isolation is required." Drawing ES-AB07 is a point of origin where the A and B power sources may both be used, and consequently apparent violations will appear on this drawing by definition. No further reviews of apparent exceptions to the separation criteria will be required on drawing B-208-028, sheet ES-AB07.

John B. Haneiko
JOHN B. HANEIKO

JBH:ems
xc: E. R. Hottenstein (2)
J. B. Haneiko

memorandum Gilbert/Commonwealth

February 2, 1976

to: R. E. MILLER - 3E

from: J. B. Haneiko

subject: ENGINEERED SAFEGUARD SEPARATION EXCEPTIONS
CONTROL BOARDS AND RELAY RACKS - CASE 35
GAI FIELD CHANGE 76-667
CRYSTAL RIVER UNIT NO. 3

An exception to the standard CR3 separation procedure was discussed with T. V. Garbini today relating to GAI FCN 76-667. The items affected are as follows:

CASE 35: B-208-039, sheets MS-18 and MS-19
EC-210-597, items AK, AM, AP, AR
EC-210-600, TB16-19 through TB 16-30

DESCRIPTION:

Orange and gray wire exist on the same relay and opposite each other on the same terminal board. The power feed is 125VDC from DPDP-8B, an engineered safeguards power source.

CONCLUSION:

These exceptions to the CR3 separation criteria are acceptable since no single failure, such as a random ground, open circuit or short circuit, will negate the operation of more than one E. S. power supply. In fact, no single electrical failure will negate the proper operation of the main steam isolation valves, which are the pieces of equipment directly relating to these exceptions.

John B. Haneiko
JOHN B. HANEIKO

JBH:ems
xc: E. R. Hottenstein (2)
J. B. Haneiko (2)

GAI 35 12/1

1

IMAGE EVALUATION TEST TARGET (MT-3)

150mm

6"

1

IMAGE EVALUATION TEST TARGET (MT-3)

150mm

6"

1

IMAGE EVALUATION TEST TARGET (MT-3)

150mm

6″

1

IMAGE EVALUATION TEST TARGET (MT-3)

150mm

6"

memorandum | Gilbert Associates, Inc.

Gilbert Commonwealth Companies

September 24, 1975

to: R. E. MILLER - 3E

from: J. B. Haneiko

subject: ENGINEERED SAFEGUARD SEPARATION EXCEPTIONS
CONTROL BOARDS AND RELAY RACKS - CASE 34
CRYSTAL RIVER UNIT NO. 3

Another exception to the standard CR3 separation procedures was discussed with T. V. Garbini today relating to ECN 2428 and its "A" revision. The items affected are as follows:

CASE 34: B-208-028, sheet ES-AB07 (Item CZ)
EC-210-157

This exception has been reviewed and it does not compromise the safe functioning of any safety-related equipment. The same explanation given for E. S. exception case 4(reference 2/19/75 memo to you) applies here also. In addition, low voltage signal levels(28 volts) are involved. ECN 2428 will therefore be approved as it is.

John B. Haneiko
JOHN B. HANEIKO

JBH:ems
cc: E. R. Hottenstein (2)
J. B. Haneiko (2)

memorandum Gilbert Associates, Inc.

Gilbert Commonwealth Companies

September 10, 1975

to: R. E. MILLER - 3E

from: J. B. Haneiko

subject: ENGINEERED SAFEGUARD SEPARATION EXCEPTIONS
CONTROL BOARDS AND RELAY RACKS - CASE 32
GAI FIELD CHANGE 75-642
CRYSTAL RIVER UNIT NO. 3

Two exceptions to the standard CR3 separation procedure were discussed with T. V. Garbini today relating to the following drawings:

CASE 32: EC-210-081, item ED3 (ICS)
B-208-047, sheet RC-05

CASE 33: EC-210-089, item JC11 (ICS)
B-208-032, sheet FW-38

Both cases involve an orange wire less than the required physical distance from brown and gray wires. Both of these cases have been reviewed and are acceptable from a separation standpoint. These are low voltage circuits (24 volts) fed from a non-safety related power source (ACDP-51, breaker 25). No system fault in these indicating lights would violate the integrity of any E. S. power source.

John B. Haneiko
JOHN B. HANEIKO

JBH:ems
cc: E. R. Hottenstein (2)

GAI-35-1274

M E M O R A N D U M

GILBERT ASSOCIATES, INC.

TO: R. E. Miller

FROM: J. B. Haneiko

July 11, 1975

SUBJECT: Engineered Safeguard Separation Exceptions
Control Boards and Relay Racks - Cases 12 Through 30
GAI Field Change 74-550 (Feedwater Backfit)
Crystal River Unit No. 3

The following E.S. exceptions resulted from preparation of GAI field change 74-550, and results of the review together with all affected drawings are listed below. H. M. Snyder reviewed the exceptions with me on July 9 and 10.

	Elementary	Circuit No.	
Case 12	FW-11	FWC151	EC-210-620, 623, 625 Relay Rack items AA, Z, L, M
Case 13	FW-12	FWC153	EC-210-622, 627, 629 Relay Rack items N, AB, AC, P
Case 14	FW-13	FWC155	EC-210-620, 623, 625 RR items AA, M, Z, L
Case 15	FW-14	FWC157	EC-210-622, 627, 629 RR items AB, AC, P, N
Case 16	FW-19	FWC159	EC-210-620, 622, 625, 627, 629 RR items AA, AB, M, N, Z, L, AC, P
Case 17	FW-22	FWC161	EC-210-620, 625, 629 RR items AA, M, Z, L
Case 18	FW-23	FWC163	EC-210-622, 625, 627 RR items AB, AC, N, P
Case 19	FW-28	FWE141	EC-210-620, 623, 625 RR items AA, M, Z, L
Case 20	FW-29	FWE143	EC-210-622, 627, 629 RR items AB, AC, N, P
Case 21	FW-30	FWE145	EC-210-620, 623, 625 RR items AA, M, Z, L
Case 22	FW-31	FWE147	EC-210-622, 627, 629 RR items P, N, AC, AB
Case 23	FW-49	FWE149	EC-210-620, 625, 629 RR items AA, M, Z, L
Case 24	FW-50	FWE151	EC-210-622, 623, 625 RR items AB, N, AC, P

July 11, 1975

R. E. Miller

	Elementary	Circuit No.	
Case 25	FW-19	-	EC-210-589 RR item AS
Case 26	FW-22	-	EC-210-397 RR items AJ, AK
Case 27	FW-23	-	EC-210-397 RR items AJ, AK
Case 28	-	-	EC-210-094 (Terminal block jumpers)
Case 29	FW-47	-	EC-210-106 RR items JY, JZ
Case 30	FW-48	-	EC-210-106 RR items JY, JZ

Cases 25, 29, and 30 involve separation violations between separate relay contacts whose wiring originates in an ES "A" cable tray versus wiring from an ES "B" tray. There is electrical separation (isolation) between the orange and brown wires, but not 6" physical separation. This has been reviewed and is acceptable. All other cases (12-24 and 26-28) are wiring violations between nonsafeguard wires in non E.S. tray and nonsafeguard wires in E.S. tray (one channel only). Each of these has also been reviewed on a case by case basis, utilizing all affected drawings which are listed above. No violations of E.S. system integrity exist, utilizing review methods discussed in previous E.S. exception memorandums.

John B. Haneiko

JBH:in

cc: E. R. Hottenstein (2)
R. P. Cronk
J. B. Haneiko (2)

MEMORANDUM

GILBERT ASSOCIATES, INC.
April 15, 1975

TO: R. E. MILLER - 3-E

FROM: J. B. Haneiko

SUBJECT: ENGINEERED SAFEGUARD SEPARATION EXCEPTIONS CONTROL BOARDS & RELAY RACKS - CASE 11
CRYSTAL RIVER UNIT NO. 3

In response to your memo of April 15, 1975 regarding another exception to the E. S. separation criteria, the following justification is offered:

Case 11: Reference GAI Dwgs. EC-210-332, EC-229-107, and B-208-040, sheets MT-09 and MT-10. Lockout relay 86BU/PL4(item R on MISC/SSTR board) is the item in question, and the question resulted because of GAI field change 75-555. The conclusion of my review is that the condition described(red and green wires on relay item "R") is acceptable, because it reflects the design intent and does not impair safety.

This relay must interlock into both the 4160 volt E. S. "A" bus and the 4160 volt E. S. "B" bus, because both busses are fed from the 230 kv substation and both must be tripped if a fault occurs at the substation. This is a similar situation to that existing for the CR3 startup transformer. Such a trip does not negate operation of E. S. equipment because of the backup provided by the diesel generators.

A short circuit on relay 86BU/PL4 could cause a false trip of the 4160V E. S. busses. An open circuit could prevent a trip, but then there is still backup relay protection to initiate it. A spurious ground anywhere in this circuitry would be protected by the overcurrent relays. All of these conditions are acceptable from a safety standpoint, and so the E. S. exception described is acceptable as it is.

John B. Haneiko
JOHN B. HANEIKO

JBH:ems
cc: E. R. Hottenstein (2)
R. P. Cronk
M. A. Gerhard
M. E. Ober
J. B. Haneiko (2)

MEMORANDUM

GILBERT ASSOCIATES, INC.

February 19, 1975

TO: R. E. MILLER - 3-E

FROM: J. B. Haneiko

SUBJECT: ENGINEERED SAFEGUARD SEPARATION EXCEPTIONS
GAI FIELD CHANGE 74-513
CRYSTAL RIVER UNIT NO. 3

Exceptions to standard CR3 separation procedures were discussed with T. Garbini on February 18 relating to the following elementary and wiring drawings:

	Elementary	Wiring Drawing
Case 1	AH-131	EC-210-401
Case 2	AH-20	EC-210-492
Case 3	AH-48	EC-210-495
Case 4	AH-90	EC-210-502
Case 5	AH-131	EC-210-514
Case 6	AH-15	EC-210-520

All six (6) exceptions to normal separation criteria are acceptable as they are without barriers, since they do not compromise the safe functioning of any safety related equipment or power sources. Case 4 is unique in that it is a non-safeguard device receiving power from an ES(AB) power source, but this is not a concern because of the manual transfer feature of this bus. A fault which occurs when the manual transfer switch is fed from the "A" bus will not be transferred to the "B" bus. It was verified with the electrical engineering department that the formerly named AEC had accepted the scheme of non-safety devices powered from this safety grade bus without circuit isolation at this low voltage level.

John B. Haneiko
JOHN B. HANEIKO

JBH:ems
cc: E. R. Hottenstein (2)
R. P. Cronk
J. B. Haneiko (2)

MEMORANDUM

GILBERT ASSOCIATES, INC.

TO: Mr. R. E. Miller - LA-3W

FROM: J. B. Haneiko

SUBJECT: Engineered Safeguard Separation Exceptions
Control Boards & Relay Racks - Case 5A
Crystal River Unit No. 3

June 11, 1975

In response to your memorandum of May 28, 1975, regarding the change to previously reviewed exception #5, this revised exception will be designated as case 5A. Conclusions are as follows:

Case 5A: The drawings affected are the same as those discussed for case 5 (See February 19, 1975 memo). The exception for case 5A is not significantly different from case 5 and is therefore also acceptable from a safety standpoint.

John B. Haneiko
John B. Haneiko

JBH:pam

cc: E. R. Hottenstein (2)

memorandum Gilbert Associates, Inc.

April 4, 1975

to: R. E. MILLER - 3E

from: J. B. Haneiko

subject: ENGINEERED SAFEGUARD SEPARATION EXCEPTIONS
CONTROL BOARDS & RELAY RACKS - CASE 10
CRYSTAL RIVER UNIT NO. 3

In response to your memo of March 31, 1975 regarding another exception to the E. S. separation criteria, the following justification is offered:

Case 10: Reference GAI Dwgs. EC-210-586 and EC-210-587. The circuit numbers involved with this separation exception are VBF27, VBF28, VBF29, and VBF30. The conclusion of my review is that the condition described in your memo is acceptable.

A single failure analysis was performed to see if any of the following conditions would endanger two (2) E. S. power sources simultaneously:

1) random short circuit
2) random open circuit
3) random system ground

It was determined that none of the system faults investigated would violate the integrity of more than one E. S. power source. The existing situation is therefore acceptable from a safety standpoint.

John B. Haneiko

John B. Haneiko

JBH:ems
cc: E. R. Hottenstein (2)
R. P. Cronk
J. B. Haneiko (2)

GAI-35-127

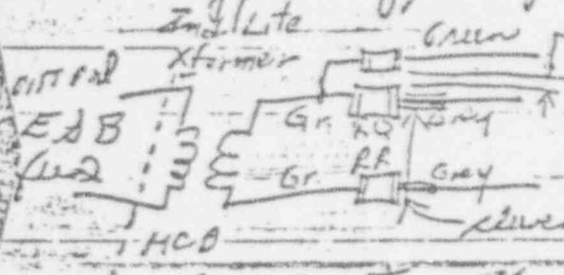
TO: J B Hrenko

FROM: R E Miller

DATE: 3/3/1975

SUBJECT: E S Sep problem 75-564, CASE #7

this is typical of past procedure used by us:



We normally would have a feed to lights and sleeve the grey wires.

sleeves (will not be installed)

Per past practice (we've added RQ, RF cabinets by us nothing) we will not sleeve as we have in past. OK or not OK

SIGNED: REM DEPT.

DATE: MARCH 3 1975 — P.S. — We're going to review today or tomorrow 3/3 3/4

This apparent violation is acceptable because the gray wires referenced are in fact green-associated wires & we have proved (per TJH) that there is no connection between these & some red-associated wires also run in non-E.S. [illegible] for the same function. Identification of cable channels by color was not [illegible] [illegible] SIGNED 79-1718 John Hrenko - 0423

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ATTACHMENT

M E M O R A N D U M

GILBERT ASSOCIATES, INC.

March 20, 1973

TO: MR. T. C. REITZ

FROM: V. H. Willems

SUBJECT: FLORIDA POWER CORPORATION
Crystal River 3
Exceptions to the Control Boards Separation Criteria

The exceptions to the separation criteria, as marked up on the attached elementaries, were reviewed for their acceptability.

A portion of the circuits indicated as possible exceptions have been identified as NON-ES circuits where parts of the circuits were run in E. S. trays and the balance in NON-ES trays. The NON-ES cables run in ES trays are color coded, brown, orange or black, in accordance with the separation criteria report, while the cable run in NON-ES trays are gray color resulting, at the terminals where they meet, in exception to the criteria.

The balance of the circuits indicated as exceptions are power feed to E. S. actuation relays cabinets and therefore E. S. circuits. Power to the E. S. cabinets is obtained from the 4 inverters. The cables associated with the inverters are color coded red, green, yellow and blue. While the wiring in the actuation cabinets is either red(A train) or green (B train).

The wiring associated with each inverter is kept separated from each other within each of the E. S. actuation cabinet therefore separation between redundant function is preserved.

The results of the review indicates that no failure of the circuits referenced above negates the separation of E. S. circuitry and are acceptable as they are.

V. Willems

V. H. WILLEMS

Attachment
VHW:cms
cc: W. J. Kerchner(w/o enc)
G. K. Henry (w/o enc)
R. E. Miller (w/o enc)

GAI-35 1

LIST OF ELEMENTARIES REVIEWED

ELEMENTARY	REVISION	ELEMENTARY	REVISION
FW-33	0	CF-09	3
MU-34	2	CD-02	6
MU-35	2	TB-21	1
MU-47	2	RC-25	1
MU-52	1	ES-A63	0
SW-07	0	ES-B22 *	0
SW-28	0	ES-B21 *	0
TD-01	3	ES-B37 *	0
DH-24	3	ES-B36 *	0
SW-08	0	ES-B46 *	0
MS-12	1	ES-B45 *	0
MU-44	2	ES-B63	0
MU-43	2	ES-A22 *	0
MD-01	3	ES-A21 *	0
SC-07	2	ES-A37 *	0
MU-33	2	ES-A46 *	0
CA-20	6	ES-A45 *	0
CF-07	2	ES-AB05	0
CI-23	1	ES-AB07	0
CD-07	6		
SW-06	0		

Elementaries with an asterisk (*) have E.S. circuits

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SUBJECT: Forwards Rev 2 to "Electrical Design Criteria Electrical Circuit Physical Separation & Cable Tray Loading," per 921117 meeting w/NRC,util design control program & util commitment to ANSI N.45.2.11.

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