DESIGN ANALYSIS
M-20594 Rev. 12/83
DOCTYPE 152
ERDP Exhibit 3.4 - IV

ATTACHMENT 3

ENGINEERING AND RESEARCH DEPARTMENT

MOD #: N/A

MOD DESCRIPTION: RACEWAY SEPARATION CRITERIA

STATION: LIMERICK

PURPOSE OF ANALYSIS:

DOCUMENT RATIONALE FOR RACEWAY SEPARATION CRITERIA CONTAINED IN SECTION 2.0 OF DRAWING #31-E-1406. THESE CRITERIA WERE GENERATED BY PEC FROM THE RESULTS OF A TEST PROGRAM.

ORGANIZATION	RESPONSIBLE ENGINEER	DATE	INDEPENDENT REVIEWER	DATE	DEPTH OF REVIEW	
					EXHIBIT 3.4 - II	SEE DOCUMENTATION
ORIGINATING ORGANIZATION	[signature]	8/13/84	[signature]	8/9/84		Referenced In Analysis
INTERFACING GROUP						
INTERFACING GROUP						

COPY TO: DAC (NG-8)

FILE: RES 17 (SEPARATION CRITERIA)

REV. NO. 0

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0. PURPOSE

The purpose of this analysis is to document the rationale used in the selection of the raceway separation criteria which were generated by PECo as the result of the raceway separation test program. This design analysis will serve to tie together the issued criteria in Drawing 8031-E-1406 and the test results obtained.

0 REFERENCES

2.1 Wyle Laboratories Test Report # 46960-3, Electrical Raceway Separation Verification Testing for the Philadelphia Electric Company Limerick Generating Station Units 1 and 2

2.2 Philadelphia Electric Co, Test Report # 48503, Design Verification Test Report, Internal Panel Control Wiring Separation Criteria

2.3 IEEE Standard 384-1981, Standard Criteria for Independence of Class 1E Equipment and Circuits

2.4 Drawing Change Notice # 205, Drwg. 8031-E-1406, Rev. 44

2.5 Field Drawing Change Notice # 851, Drwg 8031-E-1406, Rev. 44

0 METHOD

The methodology of this design analysis will be as follows: Each criterion of the above references 2.4 and 2.5 will be referenced back to specific test results. In those cases where the test results do not specifically support the issued criteria, the additional analyses required will be documented herein.

0 DESIGN INPUTS

The basic function of the raceway separation criteria is to assure that a single event will not cause the simultaneous failure of redundant safety circuits. The hazards generated by any single event have been evaluated and several different types of separation criteria have been generated. Section 5.1 of reference 2.1 discusses these hazards and how they have been addressed at Limerick. The hazard which is to be addressed by the separation criteria of this analysis is damage due to electrical failures in the raceway system.

Limerick has committed to meet the requirements of Regulatory Guide 1.75 as stated in Section 8.1.6.1.14 of the LGS FSAR. The Reg. Guide endorses reference 2.3 which in turn allows the use of testing and analysis to justify separation distances less than the standard distances given in reference 2.3. The test program documented in references 2.1 and 2.2, and the analyses contained herein, are the basis for the raceway separation distances contained in references 2.4 and 2.5.

The failure modes which were assumed in the test program and their relation to the installed raceway and cable systems at Limerick are documented in Sections 5.1 and 5.2 of reference 2.1 and Sections 2.1 and 2.2 of reference 2.2.

0. DESIGN ANALYSIS

All criteria numbers are referenced to the paragraph numbers contained in References 2.4 & 2.5

E-1406 CRITERIA	BASIS
.1 Section 2.1.1	• General Information. All criteria and separation distances are in accordance with reference 2.3.

	E-1406 CRITERIA	BASIS
2	Section 2.1.2.1 a)	• Cable tray separation of 1 ft + 3 ft is based on reference 2.3, Section 6.1.3.3 (1) • Enclosed raceway separation of 1" is based on reference 2.3, Section 6.1.3.3 (2) • Separation between totally enclosed raceway and cable tray is the same as that required between trays when the tray is considered the source of the hazard. Only 1" is required between an open 1E tray and a non-1E enclosed raceway because the source of the hazard is within the enclosed raceway which will contain the effects of the failure. Reference 2.3 implicitly allows only 1" separation when the source of the hazard is within an enclosed raceway. This is supported by reference 2.1, Section III, para. 3.4.
3	Section 2.1.2.1 b)	• Cable tray separation of 3' and 5' is per reference 2.3, Section 6.1.4
4	Section 2.1.2.2 a)	• No separation is required between enclosed raceways of different channels when both are ≤ #4/0 is based on ref. 2.1, Section III, para. 3.2 and 3.3 • 1" separation when either raceway contains > #4/0 is based on ref 2.3 Section 6.1.3.3 (1) and ref. 2.1, Section III, para 3.2
5	Section 2.1.2.2 b)	• No separation required between 1E enclosed raceway (any type cable) and non-1E enclosed raceway with ≤ #4/0 is based on ref. 2.1 Section III, para. 3.2 and 3.3 • 1" separation between 1E enclosed raceway (any type cable) and non 1E enclosed raceway with > #4/0 is based on ref 2.1, Section III, para. 3.2

6 Section 2.1.2.3 a)

- No separation between enclosed 1E raceway and 1E tray when both contain cables ≤ #4/0 is based on ref. 2.1, Section III, para. 3.2 and 3.3 and 3.6
- 1" separation between enclosed 1E raceway with > #4/0 and a 1E tray with ≤ #4/0 is based on ref. 2.1, Section III, para. 3.6 which shows that tray with cable ≤ #4/0 does not present a hazard to enclosed raceway. Also, ref 2.1, Section III, para 3.9 and Section III, para. 3.4 show that 1" separation is adequate for protection of an exposed cable from the hazards of a fault within an enclosed raceway.
- 3ft + 5ft separation if cable in tray is > #4/0 is based on ref. 2.3, Section 6.1.4

7 Section 2.1.2.3 b)

- 0 separation required between 1E enclosed raceway and non-1E tray with ≤ #4/0 is based on ref. 2.1, Section III, para. 3.6 which shows that tray with cable ≤ #4/0 does not present a hazard to enclosed raceway.
- 3' + 5' separation if cable in tray is > #4/0 is based on ref 2.3, Sect. 6.1.4

8 Section 2.1.2.3 c)

- No separation required between non-1E enclosed raceway with cable ≤ #4/0 and 1E cable tray is based on reference 2.1 Section III, para. 3.2 and 3.3 which shows that enclosed raceway will contain the effects of a fault from affecting an adjacent tray.
- 1" separation between non-1E enclosed raceway with cables > #4/0 and 1E cable tray is based on ref. 2.1 Section III, para 3.9 and Sect. III, para 3.4 which show that 1" separation is adequate to protect an exposed cable from the hazards of a fault within an enclosed raceway.

9 Section 2.1.2.3 d)

- Minimum distances must be maintained between a Class 1E cable tray and the open end of a conduit which contains a power cable. Tests 2 and 2A in Section IV of reference 2.1 indicated that power cables in conduit when exposed to prolonged overcurrents would ignite. Flames were observed spilling the ends of the conduits. This phenomenon was observed for cables as small as #6 in other tests. The flame is caused by ignition of the gases being given off from the cable jacket. Flames ranged in size of a few inches in Tests 2 and 2A in Section III of reference 2.1 to several feet for the 750 MCM cable tested in reference 2.1 Section IV. Sealing of the end of the conduit prevents the hot gases from escaping, thereby preventing flame damage to adjacent raceways. If the conduit is not sealed, the 3' and 5' separation criteria of reference 2.3 are applied. This is adequate to prevent flame impingement on open trays. Section 3.1 of Section III of reference 2.1 indicates that cables ≤ #4/0 will not ignite in gutter, therefore there is no need to seal gutter ends. Cable > #4/0 is not run in gutter at Limerick. The sealing to be done on the conduit need only be gas tight and not a rated fire barrier.

10 Section 2.1.2.4 a)

- 3" vertical and no horizontal separation between 1E trays with ≤ #4/0 is based on ref 2.1, Section II

test configurations that showed that these distances are adequate

- If either tray has a cable in it larger than #4/0, the separation of 3' + 5' is provided per reference 2.3, Section 6.1.4

11 Section 2.1.2.4 b)

- 3" vertical and 0" horizontal separation between a Class 1E tray and a non 1E tray with ≤ #4/0 is based on reference 2.1 Section III. Test configurations that show that these distances are adequate when cable in tray ≤ #4/0
- If the non 1E tray contains > #4/0, the 3' + 5' separation is provided per reference 2.3, Section 6.1.4.

12. Section 2.2

- Reference 2.1 tests in Sections II and III showed that supported cables ≤ #4/0 in open air would not ignite. Test 5A in Section I showed that a power cable could ignite. This ignition occured at the point where the cable exited the tray. The bend at this point exceeded the minimum bending radius of the cable and the weight of the entire 5' length of unsupported cable rested at the exit point on the tray side rail. Subsequent tests in Section III, tests 3 and 3A showed that properly supported cables installed within their minimum bending radius would not ignite. For this reason, the cleanout cable criteria are based on supporting the cable every 36" and installing it within its bending radius limitations. These measures will prevent excessive stress on the cable at the point of cable exit from the raceway & thereby prevent ignition.

13 Section 2.2.1 a)

- 6" separation between two dropout cables of different divisions is required if both are ≤ #4/0. This distance is based on the findings that properly installed cables as defined in 5.12. will not ignite and as such, tests in Section III of reference 2.1 showed that 6" of separation is adequate.
- If either of the dropout cables is > #4/0, then the 3'+5' separation distances of reference 2.3 section 6.1.4 apply. The only exception to this is that 6" separation is required if the 1E cable > #4/0 and the non 1E cable ≤ #4/0. This separation is adequate to protect the 1E cable from the failure of the non-1E cable. Lesser separation was shown to be adequate in Section III of reference 2.1, but additional separation is provided to account for possible movement due to conductor expansion of the non-1E cables.

14 Section 2.2.1 b)

- Instrumentation and control cables which exit from conduits are subject to the same criteria as analyzed in 5.13 because they do not originate from a power source which could cause them to ignite in the conduit.
- For power cables which dropout from conduits, it is assumed that ignition can occur within the conduit and burn down the dropout cable. This is discussed in 5.9. For these cables, if the conduit is sealed, ignition is precluded and 6" separation is adequate as addressed in 5.12. If the the conduit is not sealed, then 3'+5'

separation is provided per ref. 2.3, sect, 6.1.4

15 Section 2.2.2, a)

- 0 separation is required between a dropout cable and a cable tray side rail if all cables are ≤ #4/0, Ref. 2.1, para. 6.1.3 in the Conclusions section.
- 6" separation is required between a dropout cable and cable in an open tray if all cables are ≤ #4/0. This is based on the same criteria used in 5.1.3
- If the dropout cable is > #4/0 or if any cable in the tray is > #4/0, then the 3'+5' separation is required per ref. 2.3, section 6.1.4

EXCEPTIONS: 1) If the cable > #4/0 is in 1E tray and dropout cable is non-1E and ≤ #4/0, then 6" is required between cables (0" between cable and side rail). Per ref 2.1, Section II states, this is adequate to protect the cables in the 1E tray. 2) If the cable > #4/0 is a Class 1E dropout cable and the non-1E tray has cables ≤ #4/0, then 6" is required between cables (0" between tray side rail + cable). Per ref 2.1, para 6.1.3 in the Conclusion Section, the tray side rail will become the barrier for the 1E cable.

16 Section 2.2.2 b)

- Instrumentation and control cables which eject from conduits are subject to the same criteria as analyzed in 5.1.5 because they do not originate from a power source which could cause them to ignite in a conduit.
- For power cables which dropout of conduits, ignition is assumed to occur

if the conduit is not sealed. The rationale for the separation needed is the same as that given for Section 2.2.1.b). See item 5.15 for dropout cables > #4/0.

17 Section 2.2.3 a)

- 0 separation is required between dropout cables from tray or gutter and totally enclosed raceways when all cables are ≤ #4/0. This is supported by the results in Section III. and IV. of reference 2.1. Enclosed raceways are adequate heat sinks to contain the effects of cable failure for cables ≤ #4/0. See conclusion section of reference 2.1, Section 6.3.2.
- If the dropout cable is > #4/0, then the 3'x5' separation criteria of reference 2.3, Section 6.1.4 must be maintained. The only exception to this is that 0 separation is required if the enclosed raceway is non-1E and has all cables ≤ #4/0. This is based on the rationale presented above per reference 2.1, Section 6.3.2 of the Conclusions
- If the cable in the enclosed raceway is ≥ #4/0 then 1" is required from Class 1E dropout cables. This is per reference 2.1, Section ~~IV~~, para. 3.4
- 0 separation is required between an enclosed Class 1E raceway with cable > #4/0 and a non-1E dropout cable ≤ #4/0 As per reference 2.1, Conclusions para. 6.3.2, enclosed raceways are adequate to contain the effects of cable failure for a cable ≤ #4/0 and to act as a heat sink

to prevent cable damage.

18 Section 2.2.3 b)

- Instrument and control cables which exit from conduit are subject to the same criteria as analyzed in 5.1.1 because they do not originate from a power source which could cause them to ignite in a conduit.
- For power cables which drop out of conduit, ignition is assumed to occur if the conduit is not sealed. The separation that is needed in this case and the rationale for it is the same as that given for Item 5.1.7 for dropout cables > #4/0

9 Section 2.2.4

- Where the separation requirements of the above criteria for dropout cables cannot be met, reference 2.1 tests showed that wrapping cables with fiberglass sleeving and tape provided an adequate barrier to prevent cable damage. Reference 2.2 also performed tests which verified the adequacy of fiberglass material for small wire applications.
- When the two conflicting cables are both ≤ #10 AWG, either cable can be wrapped and 0 separation is required. This is based on Reference 2.2, Section II, Part B. The same criterion also applies if one of the cables is non-1E and is ≤ #10, and the conflicting cable is class 1E of any size. Failure of a wire ≤ #10 will be contained by sleeving with no separation required.

- For two Class 1E cables in conflict where one is greater than #10, wrap the large cable and provide 1" of separation. This was shown to be adequate in Reference 2.1, Configuration II, Test 5B. The wrap was shown to contain the effects of the failure and to prevent ignition of the large power cable. The one inch air gap is adequate to dissipate the heat generated by the fault cable.
- For a non-Class 1E cable ≥ #10 in conflict with a 1E cable of any size, the same criteria apply. The non-1E cable is wrapped and 1" separation is provided. The rationale for this criterion is the same as provided above.
- If both cables are Class 1E and both are ≥ #10, then both cables must be wrapped to prevent ignition and 1 inch separation is provided to allow heat to dissipate between the cables.
- These above criteria are also used to achieve separation between support cables and raceways. The size of cables in the raceway is considered meeting these criteria.

Raceway Separation Test Program - Discussion of Assumed Failure Modes, Procedure, and Test Results

I. Reason For Test Program

Limerick has committed to meet the requirements of Regulatory Guide 1.75 as stated in Section 8.1.6.1.14 of the Limerick FSAR. The Regulatory Guide endorses IEEE Standard 384-1974 which allows the use of testing and analysis to justify separation distances less than the standard distances given in the IEEE standard.

The Limerick raceway design, which was completed in 1974, was based on the standard separation distances contained in IEEE 384-74. Where lesser separation was required due to physical constraints, tray covers were to be installed.

Subsequent additions to the initial raceway design were required to support plant enhancements and Regulatory requirements. Due to physical constraints, some of these additions resulted in lesser separation distances than the standard separation distances contained in IEEE 384-1974.

The majority of the cases where the standard raceway separation distances could not be maintained involved separation between enclosed raceway (conduit or gutter) and cable tray. In cases where the standard separation distances between cable trays could not be maintained, the majority of these involved separation between Class 1E cable tray and non-Class 1E cable tray.

In order to provide justification for these lesser separation distances, Philadelphia Electric Co., in accordance with Section 5.1.1.2 of IEEE 384-1974, completed a raceway separation test program. The test program methodology and results are documented in Wyle Test Report No. 46960-3.

II. Description of the Limerick Raceway System

The Limerick raceway system design has the following salient features:

1. The raceway system consists of:

   a) cable tray - open ladder design
   b) enclosed raceway - conduit and gutter

2. Redundant Class 1E cables are routed in redundant Class 1E raceway. Non-Class 1E cables are routed in Non-Class 1E raceway. Non-Class 1E cables are not routed within Class 1E raceway. Limerick does not have associated circuits either by electrical connection or by proximity.

3. The power sources for cables routed in cable trays or gutters are as follows;

   a) 480 Vac from load centers to motor control centers
   b) 480 Vac from motor control centers to 480 Vac loads
   c) 125/250 Vdc from distribution busses to loads
   d) Control and instrumentation (120 Vac and lower)

4. The power sources for cables routed in Conduit are as follows;

   a) 13kV power
   b) 4.16kV power
   c) 2.3kV power
   d) All power sources shown for cable trays and gutter

5. There are very few cases where cables larger than #4/0 AWG are routed in cable tray. The power sources for cables larger than #4/0 AWG routed in cable tray fall into categories 3a and 3c above. Because cables larger than #4/0 AWG can be subjected to up to 3500A based upon the failure mode assumptions, their failure is expected to have much more severe consequences than the failure of the vast majority of cables which are #4/0 AWG or smaller and which have power sources in categories 3b and 3d. For this reason, the Limerick raceway separation test program did not test cables larger than #4/0 AWG in cable trays. For those cases in the plant where cables larger than #4/0 AWG are routed in cable tray, the standard separation distances given in IEEE Standard 384-1981 are met or cable tray covers are installed.

III. Identification of Failure Modes

In order to perform a test program to verify the adequacy of the raceway separation criteria, it was necessary to define the worst case electrical failure that could be postulated to occur internal to a raceway. Previous testing conducted by Philadelphia Electric Company for internal panel control wiring separation (Report No. 48503) showed that the heating effects of sustained overcurrent on a wire had the greatest impact on adjacent wires. A review of the raceway separation test programs conducted by the industry which postulated high magnitude, short time duration fault currents showed that this type of failure mode had little effect on adjacent cables. The short time duration of this type of failure caused little, or no heating effects on adjacent cables. We have concluded that the sustained overcurrent condition on a cable has much more impact on cables in adjacent raceway, and a much higher probability of initiating a raceway fire than the high magnitude, short time duration current condition.

To verify that a cable fault within a tray does not present as limiting a case as the sustained overcurrent failure, we also reviewed our experience with communicating cable faults; that is, the effects of a fault on those cables which are in proximity to the cable failure. Our experience which includes an industry survey shows that for voltages of 13kV and below, cable failures in manholes which cause a failure of adjacent cables are rare. Much of our experience is with distribution voltages of 4kV and 13kV. These voltage levels and their associated high fault currents have a much higher energy capacity to damage adjacent cables than the 480 volt cables contained in the Limerick cable tray system. There have also been several instances at Limerick in which 480V faults have occurred within Motor Control Center Compartments. In all cases, the adjacent control wiring, which was within 9" inches of the fault, was discolored but remained functional.

Based on the above experience, we have concluded that cable failures within a cable tray will have less impact on cables in adjacent cable trays than the sustained overcurrent condition which is the basis for our test program.

IV. Test Program Assumptions

The Limerick raceway separation test program was based on the following failure mode assumptions;

1. The cable or equipment in the circuit develops a fault that is not cleared due to the postulated failure of the primary overcurrent protective device.

2. The fault current level is just below the long-term trip setpoint of the next higher level overcurrent device so that the fault is not cleared.

3. The impedance of the fault adjusts itself automatically to maintain the fault current magnitude at a constant level as the resistance of the wire increases due to heating, thereby maximizing heat output from the fault cable.

4. There are no other loads on the same circuit which would cause the next higher level overcurrent device to trip.

V. Selection of Test Current Level and Cable Size

The fault current magnitude of 660A used in the test program was based on the failure mode assumptions discussed above. This assumes that an overcurrent condition occurs on a cable between a 480Vac motor control center and a 480Vac load. The primary overcurrent protective device which is the molded case breaker at the motor control center is assumed to fail to trip.

The next higher level overcurrent device is the load center breaker. The fault current is assumed to be just below the long-term trip setpoint of the load center breaker which is 600A. Since the load center breakers have solid state overcurrent trip devices which have a tolerance of ±10%, the 660A fault current value was selected. This current value was used for all tests involving cables in cable tray or gutter and was also used for tests involving cables of size #4/0 AWG or smaller in conduit.

In order to select the size cable to be used for tests involving cables routed in tray or gutter, tests were performed to determine which size cable when energized with 660A would deliver the most intense temperature rise for the longest duration to adjacent cables. The Configuration #1 tests of the Test Program showed that the 3/c #2/0 AWG cable was the worst case cable.

The Limerick Motor Control Centers contain Westinghouse molded case breakers which provide both overload and short circuit protection.

The Limerick Load Centers contain I-T-E K600S breakers with solid state trip devices. The solid state trip devices provide increased accuracy and repeatability over conventional trip devices. The load center breakers provide both long and short time overcurrent and instantences short circuit protection. All Load Center and Class 1E Motor Control Center breakers are tested on a periodic basis. These breakers are tested and maintained at least once every 60 months, thereby assuring that the probability of two overcurrent devices in series failing coincidently is extremely small.

For cables larger than #4/0 AWG in conduit, the fault current magnitude was selected as 3500A. This fault current magnitude is based on an overcurrent condition occurring on a 480 volt feed from a load center to a motor control center given the failure of the load center breaker to operate. Three 1/C 750 Kcmil cables were chosen as the fault cables for those tests involving cables routed within conduit and energized with 3500A. This is the largest size cable used inside areas of the plant containing equipment important to safety and based on the magnitude of the fault current applied, will generate the most heat.

The failure conditions which resulted from the cable sizes and fault currents selected above encompass the conditions which can result from failures in categories 4a, b, and c because of the high speed relaying on these systems and the high fault current availability. These features will cause either backup relaying operation or rapid cable failure, thereby preventing long term heat generation.

VI. Description of Test Procedure

The raceway separation test program included testing of the following raceway configurations:

1) Horizontal cable tray to horizontal cable tray (vertically stacked)

2) Horizontal cable tray to vertical cable tray (riser)

3) Cable tray to gutter

4) Cable tray to conduit

5) Gutter to conduit

6) Conduit to conduit

7) Dropout cable (cable routed in free air) to cable tray

8) Dropout cable to gutter

9) Dropout cable to conduit

The procedure used in conducting the tests was as follows;

1) The fault cable was installed in the raceway in the location that would transfer the most heat to an adjacent raceway.

2) The target cables were installed in the adjacent raceway in the worst case position with respect to the fault cable.

3) Pre-test Insulation Resistance and High Potential Tests were performed on the target cables.

4) Target cables were energized with 100 % rated current at 480Vac for the duration of the test.

5) The fault cable was energized with the pre-determined fault current of 660A or 3500A, depending on test configuration.

6) The fault cable remained energized with fault current until either the fault cable open-circuited or until the temperature on the adjacent target cables stabilized or decreased.

7) Post-Test Insulation Resistance tests with an acceptance criteria of $1.6 \times 10^{6}\ \Omega$ at 500Vdc and 2200Vac High Potential Tests, each conducted for one minute, were performed to determine the functionality of the target cables.

8) During the tests, selected temperature readings were recorded on the target cables, fault cable, and raceway.

9) The target cable voltages and currents and the fault cable current were monitored continuously during the test.

VII. Test Results

The salient test results with regard to establishing the Limerick raceway separation criteria are as follows:

1) Cables size #4/0 AWG and smaller when energized with 660A and routed in open cable tray did not ignite. Cables were tested in both horizontal and vertical tray configurations and did not ignite in any case. Because the faulted cables did not ignite, configurations with 1" vertical separation between cable trays and zero separation between cable tray and enclosed raceway were tested successfully. These test results provided the bases for the cable tray separation criteria contained in Section 2.0 of Drawing 8031-E-1406. (Attachment 2).

2) The test results showed that no separation was required between an enclosed raceway and another enclosed raceway or cable tray when the enclosed raceway contains cables which are #4/0 or smaller.

3) The test results showed that 1" separation between an enclosed raceway and another enclosed raceway or cable tray is required when the enclosed raceway contains cables larger than #4/0 AWG.

   The results discussed in 2. and 3. provide the bases for the enclosed raceway separation criteria contained in Section 2.0 of Drawing 8031-E-1406. (Attachment 2).

4) The test results showed that faulted cables routed within conduit will ignite. This result is the basis for the requirement in Section 2.0 of Drawing 8031-E-1406 for sealing conduits which contain power cables.

Wyle Test Report #46960-3 completely describes the Raceway Separation Test Program and the results. The Design Analysis transmitted as Attachment 3 provides the analysis and justification for the raceway separation criteria contained in Section 2.0 of 8031-E-1406.

ATTACHMENT (5)

NO CHANGE.
INFO ONLY.

e. Type Tests

LGS penetration assembly prototype tests conform to IEEE 317-1972. IEEE 317-1976 as amended by the Guide contains the following requirements, which were not considered for LGS penetration assembly prototype tests:

1. Specified sequence of required tests

2. Impulse withstand test on medium-voltage power conductors

3. Partial-discharge (corona) test

4. Cycling and aging test as related to shipping, storage, welding, and thermal cycling

5. Seismic tests in accordance with IEEE 344-1975

8.1.6.1.13 Regulatory Guide 1.73, "Qualification Tests of Electric Valve Operators Installed Inside the Containment of Nuclear Power Plants" (1/74)

Selection of electric valve operators for use inside the containment is in compliance with Regulatory Guide 1.73.

The electric valve operators for service inside the containment are tested in accordance with IEEE 382-1972, as modified by Regulatory Guide 1.73. The tests consist of aging, seismic, and accident or other special environmental requirements. Test parameters are discussed in Section 3.11.2.

8.1.6.1.14 Regulatory Guide 1.75, "Physical Independence of Electric System" (9/78)

The requirements of Regulatory Guide 1.75 are met, except as discussed and clarified below. The Regulatory Guide endorses the IEEE 384-1974, "IEEE Trial-Use Standard Criteria for Separation of Class 1E Equipment and Circuits," subject to the additions and clarifications delineated in Section C of the guide.

a. General Separation Criteria

1. Required Separation

Electrical equipment and wiring for the engineered safeguard system and the reactor protection system (RPS) are segregated into separated channels/divisions as shown in Tables 7.1-4, 7.1-5, 7.1-6 and 8.1-1, so that no single credible event

NO CHANGE.
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is capable of disabling sufficient equipment to prevent reactor shutdown, removal of decay heat from the core, or isolation of the primary containment if there is an accident. The engineered safeguard system and RPS are separated from each other, and each is further separated into four channels/divisions. Separation requirements apply to control and instrument power and motive power for all systems concerned. The degree of separation required varies with the potential hazards in a particular area.

Arrangement and/or protective barriers ensure that no locally generated force or missile can destroy redundant portions of the engineered safeguard system and/or RPS.

The arrangement of wiring is designed to eliminate, insofar as is practicable, all potential for fire damage to cables and to separate the engineered safeguard or RPS channels/divisions so that fire in one division does not propagate to another division.

Equipment and circuits requiring separation are identified on documents and drawings in a distinctive manner.

2. Methods of Separation

The separation of circuits and equipment is achieved by separate safety class structures, distance, or barriers, or combination thereof.

3. Compatibility with Mechanical Systems

The separation of Class 1E circuits and equipment ensures that the required independence is not compromised by the failure of mechanical systems served by the Class 1E systems. For example, Class 1E circuits are routed and/or protected so that the failure of related mechanical equipment of one redundant system cannot disable Class 1E circuits or equipment essential to the operation of the other redundant system(s).

4. Associated Circuits

Associated circuits are not uniquely identified as such. These circuits, with the exception of item (c) below, are treated and identified as Class 1E up to an isolation device and are isolated on a

NO CHANGE.
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LOCA signal, with the following clarifications and exceptions:

(a) When relays and other devices are used as isolation devices between Class 1E and non-Class 1E circuits, the 6-inch separation requirement at the device terminals is not maintained in accordance with IEEE 384-1974 Section 4.6.1.

(b) All non-Class 1E 4 kV motor loads that are fed from Class 1E buses are treated and identified as Class 1E even beyond the isolation device. However, these loads are tripped in the event of a LOCA and are routed in dedicated Class 1E raceway. They do not become associated with any other Class 1E division.

(c) The public address and fire alarm panel that feeds non-Class 1E loads is fed from a Class 1E bus. This panel is not tripped on LOCA, because intentional disconnection of the fire alarm system is a violation of the National Fire Code and is considered unacceptable for plant safety. The distribution transformer and panel are qualified and seismically supported to Class 1E criteria. All circuits originating from this panel are run in conduits that contain only PA and fire alarm system wiring. All circuits originating from this panel are protected by thermal magnetic circuit breakers in the panel. In addition, the 440V feed to the transformer is protected by a molded case circuit breaker in the motor control center. Each of these circuit breakers is qualified and purchased as Class 1E; therefore, two Class 1E isolation devices exist between the non-Class 1E public address and fire alarm circuits and the Class 1E 440V bus.

(d) Several non-Class 1E drywell cooler fan motors located inside the drywell are fed from a Class 1E bus, and the cabling is routed as Class 1E. The non-Class 1E RPS/UPS inverters are fed from a Class 1E dc bus, and the cabling is routed non-Class 1E. Two Class 1E circuit breakers are provided for redundant overcurrent protection on each of these circuits. These breakers provide isolation between the non-Class 1E load and the Class 1E bus and will be periodically tested in

accordance with Technical Specification requirements. These loads are not automatically isolated on a LOCA signal.

5. Non-Class 1E Circuits

Non-Class 1E circuits are separated from Class 1E circuits by the separation requirements specified in Section 8.1.6.1.14.b. Non-Class 1E 440 volt loads that are fed from Class 1E motor control centers use a shunt trip device on the motor control center breaker to isolate the circuit on a LOCA signal. These circuits are treated as non-Class 1E from the motor control center to the load and control devices or they are routed as Class 1E only in the division with which they are associated.

b. Specific Separation Criteria

1. Cables and Raceways

The minimum separation distances for raceways are given in paragraphs 4 and 5 below. The following general criteria apply to all cable installations:

IN SEVERAL CASES, REDUNDANT CLASS 1E OVERCURRENT DEVICES ARE PROVIDED IN SERIES FOR ISOLATION BETWEEN CLASS 1E POWER SOURCES AND NON-CLASS 1E INSTRUMENTATION.

NO CHANGE. INFO ONLY.

(a) Cable splices in raceways are prohibited. Cable splices are only made in manholes, boxes or suitable fittings. Splices in cables passing through the containment penetration assemblies are made in terminal boxes located next to the assemblies.

(b) Cables and raceways are flame retardant.

(c) The design basis is that the cable trays are not filled above the side rails. Tray fill for control cable trays and instrumentation cable trays is 50 percent maximum, i.e., the cross sectional area of the cable in the tray will not exceed 50 percent of the available cross sectional area of the tray, and 40 percent maximum for cable trays containing power cables. If tray fill exceeds the above-stated maximum fill, tray fill is justified and documented.

2. Identification of Non-PGCC Cables and Raceways

Exposed Class 1E raceways are identified in a distinct and permanent manner at intervals not to exceed 15 feet. In addition, these raceways are also identified where they pass through walls and/or floors. Class 1E raceways are identified before the installation of their cables.

Cables installed in cable trays are identified at intervals not exceeding 5 feet, to facilitate initial verification that the installation conforms to the separation criteria. These cable identifications are applied before or during their installation.

Class 1E cables are identified by a permanent marker at each end in accordance with the design drawings or cable schedule.

Color coding is used to meet the above requirements and to distinguish between Class 1E systems and between Class 1E and non-Class 1E systems. The coding precludes the need to consult any reference material to distinguish between redundant Class 1E and between Class 1E and non-Class 1E systems.

Panel internal wiring is marked with its connection diagram identity at each point of termination.

3. Identification of PGCC Cables and Raceways

Refer to Item 6 below.

4. Cable Spreading Room/Control Complex

The control complex consists of control room, cable spreading room, and auxiliary equipment room. The auxiliary equipment room mainly consists of relay panels and terminal cabinets integrated with module-type floor sections, with lateral and longitudinal ducts that are used as raceways and barriers. This module-type assembly, which is the PGCC, is covered separately in paragraph 6.

The control complex does not contain high-energy equipment (such as switchgear and transformers) or potential sources of missiles or pipe whip and is not used for storing flammable materials.

Circuits in the cable spreading room and control room are limited to control functions, instrument functions, and those power supply circuits and facilities serving the control room. Power supply feeders to distribution panels are installed in enclosed raceways that qualify as barriers. The circuits passing through the cable spreading room are limited to 120/208 V ac and 250 V dc, except for lighting feeder circuits in the cable spreading area. The lighting feeder circuits are 277 V ac, but are routed in conduits used explicitly for lighting.

MINIMUM HORIZONTAL SEPARATION JUSTIFIED BY TEST AND ANALYSIS IS NLI.

The minimum separation distance between the redundant Class 1E cable trays is 1 foot horizontally and 3 feet vertically. Where a 1-foot horizontal separation is not possible, lesser separation is justified by test and analysis or one of the following barrier arrangements is used: a flame retardant barrier is placed between the redundant cable trays and extends 1 foot above the trays or to the ceiling; or cables ~~of each channel/division~~ are installed in totally enclosed raceways up to a point where the ~~1 foot spacing requirement is met~~. Where cable trays of redundant channel/divisions must be stacked one above the other with less than 3 feet vertical spacing, lesser separation is justified by test and analysis or one of the following barrier arrangements is used: a flame retardant barrier is placed between the trays and extended to 6 inches beyond each side of the tray system or to the wall; or the cables ~~of~~

(AS DETERMINED BY TEST AND ANALYSIS)

MINIMUM VERTICAL SEPARATION JUSTIFIED BY TEST AND ANALYSIS IS MET.

~~each redundant channel/division~~ are installed in totally enclosed raceways to a point where the ~~3 foot vertical separation exists.~~ Where a crossover of one tray over another carrying a redundant channel/division is made, and minimum vertical separation distance cannot be maintained, fire barriers are installed between the trays extending a minimum of 1 foot beyond the crossing tray. Separation requirements between Class 1E and non-Class 1E circuits are the same as for separation of redundant channel/divisions, EXCEPT WHERE JUSTIFIED BY TEST AND ANALYSIS.

EITHER

OR CABLES ARE INSTALLED IN ENCLOSED RACEWAY EXTENDING A MINIMUM OF 1 FOOT BEYOND THE INTERSECTION.

In general, a minimum separation of 1 inch is maintained between redundant enclosed raceways and between Class 1E and non-Class 1E enclosed raceways, ~~less than 1 inch separation is permitted in those cases where testing has shown that no separation is required.~~ EXCEPT IN THOSE CASES WHERE LESSER SEPARATION IS JUSTIFIED BY TEST AND ANALYSIS. The separation provided between a totally enclosed raceway and a cable tray is the same as that provided between redundant cable trays except ~~that when the totally enclosed raceway contains non-Class 1E cables, only 1 inch separation is required from the Class 1E tray.~~ WHERE LESSER SEPARATION IS JUSTIFIED BY TEST AND ANALYSIS.

INSERT (A)

5. General Plant Areas

In plant areas where potential hazards such as missiles and pipe whip are excluded, the separation distance between redundant Class 1E cable trays is 3 feet between trays separated horizontally, if no physical barrier exists between trays. If a horizontal separation of less than 3 feet exists, alternate methods as stated in paragraph 4 above are required. Vertical stacking of trays is avoided wherever possible; however, where cable trays of redundant channel/divisions are stacked, a vertical separation distance of 5 feet is required, or alternate methods as stated in paragraph 4 above are required. Where a crossover of one tray over another carrying a redundant channel/division is made, and the minimum vertical separation distance as determined by test and analysis cannot be maintained, fire barriers are installed between the trays extending a minimum of 3 feet beyond the crossing tray, OR CABLES ARE INSTALLED IN ENCLOSED RACEWAY EXTENDING A MINIMUM OF 3 FEET BEYOND THE INTERSECTION. Separation requirements between Class 1E and non-Class 1E circuits are the same as for separation of redundant channel/divisions, EXCEPT WHERE JUSTIFIED BY TEST AND ANALYSIS.

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INSERT (A), pg 8.1-19

A THE MINIMUM SEPARATION REQUIRED BETWEEN REDUNDANT CLASS 1E DROPOUT CABLES OR BETWEEN CLASS 1E AND NON-CLASS 1E DROPOUT CABLES IS 1 FOOT HORIZONTAL AND 3 FOOT VERTICAL EXCEPT IN THOSE CASES WHERE LESSER SEPARATION HAS BEEN JUSTIFIED BY TEST AND ANALYSIS. DROPOUT CABLES ARE DEFINED AS ANY CABLE LENGTH NOT ROUTED WITHIN A RACEWAY. IN CASES WHERE THE MINIMUM SEPARATION CRITERIA JUSTIFIED BY TEST AND ANALYSIS CANNOT BE MET, DROPOUT CABLES ARE WRAPPED WITH A FIBERGLASS SLEEVING TO THE POINT WHERE THE MINIMUM SEPARATION CRITERIA IS ACHIEVED.

THE TEST RESULTS AND ANALYSIS CONTAINED IN WYLE LABORATORIES TEST REPORT NO. 46960-3 ARE THE BASIS FOR THE LESSER RACEWAY AND DROPOUT CABLE SEPARATION REFERENCED IN PARAGRAPHS 4 AND 5. THE SEPARATION CRITERIA DERIVED FROM THIS ANALYSIS ARE CONTAINED IN LIMERICK DRAWING 8031-E-1406, SECTION 2.0.

DRAFT

The separation requirements between totally enclosed raceways and between a totally enclosed raceway and a cable tray are the same as stated in paragraph 4 above.

INSERT (B)

Neutron monitoring system cables located in the sub pile room under the RPV are exceptions to these separation criteria. These cables are separated and routed in flexible conduit in this room wherever possible, but they may touch wherever necessary due to spatial limitation. Cables of different NMS divisions in this room are not bundled together where they are not in flexible conduit.

6. Power Generation Control Complex (PGCC)

Detailed design basis, description, and safety evaluation aspects for the PGCC system are documented and presented in GE Topical Report, "Power Generation Control Complex" NEDO-10466 and its amendments. The separation criteria used for the internal panel wiring of the PGCC are given in Section 8.1.6:1.14.b.9.

7. Power Supply

(a) Standby Diesel-Generators

Standby diesel-generators are housed in separate compartments within a seismic Category I structure. The auxiliaries and local controls of each unit are housed in the same compartment as the unit they serve.

(b) DC System

Redundant Class 1E batteries and their associated chargers are located in separate compartments within a seismic Category I structure. Each battery room is exhausted by an individual ventilation duct to a common exhaust plenum. Two redundant Class 1E axial flow exhaust fans service the common exhaust ductwork.

Also, the battery chargers of redundant load groups are physically separated in accordance with the requirements of Regulatory Guide 1.75.

DRAFT

INSERT (B), pg. 8.1-20

THE MINIMUM SEPARATION REQUIRED BETWEEN REDUNDANT CLASS 1E DROPOUT CABLES OR BETWEEN CLASS 1E AND NON-CLASS 1E DROPOUT CABLES IS 3 FEET HORIZONTAL AND 5 FEET VERTICAL EXCEPT IN THOSE CASES WHERE LESSER SEPARATION HAS BEEN JUSTIFIED BY TEST AND ANALYSIS. IN CASES WHERE THE MINIMUM SEPARATION CRITERIA JUSTIFIED BY TEST AND ANALYSIS CANNOT BE MET, DROPOUT CABLES ARE WRAPPED WITH A FIBERGLASS SLEEVING TO THE POINT WHERE THE MINIMUM SEPARATION CRITERIA IS ACHIEVED.

(c) AC Distribution System

All redundant Class 1E switchgear, motor control centers, and distribution panels are physically separated in accordance with Regulatory Guide 1.75.

8. Penetrations

Redundant Class 1E containment electrical penetrations are dispersed around the circumference of the containment and are physically separated in accordance with the requirements of Section 5.5 of IEEE 384-1974. In general, non-Class 1E circuits are not routed in penetrations containing Class 1E circuits. Where Class 1E and non-Class 1E circuits are routed in the same penetration, separation is maintained by routing the cables in flex conduit or FIBERGLASS ~~fireproof~~ sleeving up to the penetration feedthrough. Class 1E and non-Class 1E wiring is not routed through common feedthroughs. The feedthrough ~~of~~ steel casing forms the separation barrier between Class 1E and non-Class 1E feedthroughs. Two divisions of Class 1E thermocouple wiring are also routed through the suppression pool penetration in this manner to maintain separation.

9. Control Room and Auxiliary Equipment Room Panels

The main control panels are located in a control room within a seismic Category I structure. The control room is protected from, and does not contain, high-energy equipment such as switchgear, transformers, rotating equipment, or potential sources of missiles or pipe whip.

No single control panel includes wiring essential to the protective function of two systems that are redundant to each other, except as allowed by the following:

(a) Floor-to-panel fireproof barriers are provided between adjacent panels of different channels/divisions.

(b) Penetration of separation barriers within a subdivided panel is permitted, provided that such penetrations are sealed or otherwise treated so that an electrical fire could not reasonably be expected to propagate from one

NO CHANGE.
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section to the other and destroy the protective function.

(c) When locating manual control switches of redundant divisions on separate panels is considered prohibitively (or unduly) restrictive to manual operation of equipment, the switches are located on the same panel, provided that no credible single event in the panel can disable both sets of redundant manual or automatic controls.

Wherever wiring of two divisions exists in a single panel section, separation is maintained as follows:

(1) A minimum of 6 inches spatial separation is maintained between Class 1E wiring of different divisions.

(2) A minimum of 6 inches spatial separation is maintained between Class 1E and non-Class 1E wiring.

(3) Where the above spatial separation cannot be maintained, one or a combination of the following shall be provided:

- One of the divisions of wiring is enclosed in flexible steel conduit to the point where the above separation is achieved.
- Hygrade Thermoflex 1200 fiberglass sleeving is installed on control and instrumentation wiring to the point where the above separation is achieved.
- One-inch spatial separation is maintained between Class 1E and non-Class 1E wiring where the non-Class 1E wiring is secured with stainless steel cable ties, and between redundant Class 1E wiring where both the divisions of wiring are secured with stainless steel cable ties.

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INFO ONLY.

(4) The following exceptions to the above separation criteria are allowed:

- Relays Used as Isolation Devices: Non-Class 1E wires terminating on contacts of isolation relays are not separated from other wires in the same panel, regardless of safety status or division. They are not bundled with Class 1E wires.

  Redundant Class 1E wires terminating on a common isolation relay are not separated from each other at the relay terminals. They are routed away from the relay to achieve the required separation within a minimum distance.

- Where Class 1E wiring is located above #10 AWG or smaller non-Class 1E wiring, one-inch separation will be provided.

- In the main steam isolation valve and turbine stop valve terminal boxes, separation is not maintained within these boxes as any postulated failure in the box will not prevent the reactor protection system from performing its intended safety function.

- Other exceptions to the above criteria may be allowed. These exceptions will be analyzed to consider the magnitude and duration of a credible high impedance faulted condition and will be documented.

(5) Class 1E components of different divisions, but which are not redundant, installed on a common panel are separated by one inch or a flame retardant barrier. Non-Class 1E components are separated by one inch or a flame retardant barrier from Class 1E components. Class 1E components that serve redundant systems are separated by 6 inches or a flame retardant barrier, e.g., core spray A from core spray B. Suitable flame retardant barriers include panel steel,

Hygrade Thermoflex 1200 fiberglass and/or the device metal casing. Exceptions to these component separation criteria are allowed in cases where it has been shown that a sustained overcurrent through the device will not cause the ignition of that device. Indicating lamps, ~~and~~ isolation relays, are specific examples of this exception. PANEL METERS, AND TERMINAL BLOCKS

(d) Redundant Class 1E cables entering the control panel enclosure meet the requirements described in item (c) above.

(e) Panel internal Class 1E wiring is not color coded. Wires are marked with their respective connection diagram identity at each point of termination. The connection diagram denotes the separation division for each cable. Cables run in the floor sections are color banded every ten feet.

10. Instrument Racks and Panels:

Redundant Class 1E instruments and instrument racks are separated so that any design basis event will not cause the failure of more than one division of instrumentation needed to mitigate the effects of that event.

Physical separation of redundant circuits and devices is provided within each instrument panel as discussed in paragraph 9 above.

11. Sensors and Sensor-to-Process Connections

Redundant Class 1E sensors and their connections to the process system have been sufficiently separated so that the functional capability of the protection system is maintained despite any single design basis event or result therefrom, including the secondary effects of design basis events, such as pipe whip, steam release, radiation, missiles, or flooding.

Where practicable, redundant Class 1E sensors and process connecting lines are brought out at widely divergent points, using large components, such as pressure vessels or pipes, as protective barriers. Where necessary, additional barriers are provided to protect against damage from a credible common cause.

ATTACHMENT (2)

2.0 Raceway and Dropout Cable Separation

2.1 Raceway Separation

2.1.1 General Criteria

a. This section defines raceway separation criteria for [redacted] Safeguard System (ESS), Reactor Protection System [redacted] non-ESS raceways. A raceway is defined as conduit, [redacted] or cable tray. These separation criteria apply only [redacted] failures within the raceways. For mechanical hazards, the criteria of the separation review program apply (Spec. 8031-G-23). For fire hazards, the results of the safe shutdown analysis in the FPER apply. Bus ducts shall be considered as non-ESS raceways, and as such, the same separation criteria shall apply. The separation criteria for junction boxes shall be the same as applicable to the associated conduits for ESS, RPS, or non-Class 1E. For purposes of this section, Class 1E raceway is defined as ESS & RPS raceways. Non-Class 1E raceway is defined as non-ESS and non-RPS raceways. Enclosed raceways are conduits, gutters, junction boxes and cable trays with top and bottom covers.

b. The raceways have been designed to meet the separation requirements for Class 1E raceways. All exposed Class 1E raceways shall be installed as shown on the drawings except as allowed by Specification 8031-G-17, General Project Requirements for Field Change Notices, and Paragraph 1.1e of this document.

c. Separate raceways are provided for the Class 1E cables by channels.

d. Class 1E raceways shall be run in Class I seismic structures except when impractical.

e. The criteria in paragraph 2.1 and 2.2 also apply between Unit 1 & 2 raceways. However, if the Unit 1 & 2 raceways are of the same channel (e.g. 1A, 2A, 1B & 2B, 1C & 2C, 1D & 2D, 1W & 2W, 1X & 2X, 1Y & 2Y, 1Z & 2Z) and the raceway terminates at a common device or equipment, separation between Unit 1 & 2 raceways may not be required. Any such cases shall be submitted to Project Engineering for review and approval via FCR.

f. For ease of cable installation in the cable spreading room, control room & auxiliary equipment room, it is desirable to maintain a minimum vertical separation of 1'-3" between bottom of top tray and top of lower tray for non-ESS trays or ESS trays of the same channel when more than one level of tray is required.

4	4/14/04	INCORP. DCN 205 & (RETYPED)	GK	RC	[redacted]	[redacted]		
3	TURN 4	SEE RECORD PRINTS FOR PREVIOUS REV. (4B)						
No.	DATE	[redacted]	BY	CHK'D	[redacted]	DWG'D	PROJ. ENGR	APPD

[redacted]	[redacted]	[redacted]	ADD No. 8031
POWER DIV.	PHILADELPHIA ELECTRIC COMPANY LIMERICK GENERATING STATION UNITS 1 & 2 CONDUIT & CABLE TRAY NOTES, SYMBOLS & DETAILS	E-1406 Sheet 2.1	22

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g. For ease of cable installation in the general plant area, it is desirable to maintain a minimum vertical separation of 2'-6" between bottom of top tray and top of lower tray for non-ESS trays or ESS trays of the same channel when more than one level of tray is required.

h. Cable tray vertical separation is measured from the bottom of the top tray to the top of the siderail of the bottom tray. For horizontal separation of cable trays, see sheets 2.2.8 & 2.2.9.

i. Separation shall be maintained between vendor raceways and between vendor and Bechtel raceways. Separation between channelized raceways shall be per E-1406, paragraph 2.3.C.1 to 2.3.C.5. Vendor documents shall be reviewed to determine separation between raceways.

j. If separation of raceways described in Sections 2.1.2.3 and 2.1.2.4 cannot be met, solid aluminum covers shall be installed at top and bottom of the trays. Where minimum separation cannot be met, covers shall extend a minimum of 1 ft. beyond on both sides of an intersection in the cable spreading room and the auxiliary equipment room and 3 ft. in the general plant area. The installation of the covers on each tray shall be documented via FCR for incorporation onto the layout drawings. Cable trays which are fire-proofed with Thermo-Lag per E-1406, paragraph 8, do not require covers or any separation. Details of tray cover installation are shown on sheets 2.2.8 & 2.2.9.

k. For definition of power cables see E-1412 par. 1.22.

2.1.2 Raceway Separation Distances

2.1.2.1 Raceway Separation Criteria:

The design basis or criteria for the preparation of electrical layout drawings and installation of Class 1E raceways are as follows:

a) In the cable spreading room, control room, and auxiliary equipment room, the minimum separation requirements between Class 1E cable trays of different channels or between Class 1E and non-Class 1E cable trays shall be one foot horizontally and three feet vertically. A minimum separation of 1 inch shall be maintained between Class 1E enclosed raceways of different channels and between Class 1E and non-Class 1E enclosed raceways. The separation criteria between totally enclosed raceway and cable tray is the same as the separation criteria between cable trays, except the separation criteria between non-Class 1E enclosed raceway and Class 1E cable tray is 1 inch.

	6/14/84	INCORP. DCN#205,210 & RETYPED	GK	RC				
	TMW 6/1	SEE RECORD PRINTS FOR PREVIOUS REVISIONS						

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b) In the general plant area, the minimum separation requirements between Class 1E cable tray of different channels or between Class 1E and non-Class 1E cable trays shall be 3 feet horizontally and 5 feet vertically. The separation requirements between enclosed raceways and between enclosed raceway and cable tray are the same as stated in paragraph 2.1.2.1a.

c) If the separation criteria stated in Sections 2.1.2.1a and 2.1.2.1b cannot be met, the separation criteria stated in sections 2.1.2.2, 2.1.2.3 and 2.1.2.4 have been justified by test and shall be applied.

2.1.2.2 Enclosed Raceways:

Enclosed raceways shall be installed in accordance with the following separation requirements:

a. Between Class 1E Raceways of Different Channels:

Raceway Configuration	Cable Size	Minimum Separation Between Raceways
*1) Class 1E Raceways of Different Channels	≤ #4/0 in both	None Required
2) Class 1E Raceways of Different Channels	> #4/0 in either	1 in.

* Exception: GE-furnished RPS SITS cables, which are enclosed in flexible metallic conduit, are routed in ESS raceways. This is allowed because.

a) RPS SITS cables are in enclosed raceways.

b) It has been determined that none of the RPS SITS cables is redundant to any of the ESS cables located in the same raceway.

b. Between Class 1E and Non-Class 1E Raceways:

Raceway Configuration	Cable Size	Minimum Separation Between Raceways
1) Class 1E & non-Class 1E Raceways	Class 1E (any size) Non-Class 1E (≤#4/0)	None Required
2) Class 1E & non-Class 1E Raceways	Class 1E (any size) Non-Class 1E (> #4/0)	1 in.

4	5/14/84	INCORP. DCN 205 & RETYPED	GK	RC				
3	7/20/83	SEE RECORD PRINTS FOR PREVIOUS REVISION						
No.	Date	Description	By	Chk'd	Eng Supv	Proj Engr	Proj Mgr	Appd

Scale: | Designed: | Drawn: | Eng Supv:

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AE&C No. 8001

Drawing No. E-1406 Sheet 2.2.1

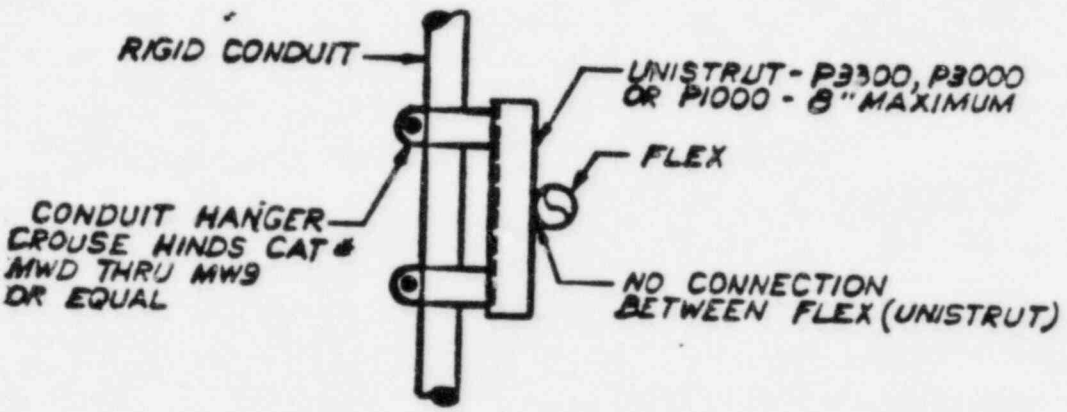
Rev. 6

If 1 inch Separation Criteria cannot be maintained between flexible conduits, or between flexible conduits and rigid steel or EMT, as required, one of the following alternates shall be used at the engineer's discretion:

1. Conduit Hangers, Crouse Hinds Cat. # MWD through MW9, or equal; bolted together with nuts, bolts and washers to achieve separation.

2. Pipe clamps, Unistrut Cat #P1112 through P1124, or equal; or conduit hangers, Crouse Hinds Cat. #MWD thru MW9 or equal, attached to either side or both sides of back-to-back unistrut P3301, length as required for largest conduit.

3.



PLAN OR ELEVATION (ALTERNATE 3)

4. Unistrut P3301, length as required, attached to cable tray siderail. Flex conduit may run in either direction. Flex conduit not to be attached to P3301.

2.1.2.3 Enclosed Raceways and Cable Trays:

The separation criteria between enclosed raceways and cable trays shall be as follows:

a. Between Class 1E Enclosed Raceway and Class 1E Cable Tray of Different Channel:

2	2/14/84	INCORP. DCN 205 & RETYPED	GK	RC	PB	RA/WR		
0 THRU 1		SEE RECORD PRINTS FOR PREVIOUS REV.						

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3

Raceway Configuration	Cable Size	Minimum Separation Between Raceways
1) Class 1E Enclosed Raceway & Tray of Different Channel	Raceway (≤ #4/0) Tray (≤ #4/0)	None required; however provide 1 in. min. air gap between the enclosed raceway and any cable in the tray.

Raceway Configuration	Cable Size	Minimum Separation Between Raceways
2) Class 1E Enclosed Raceway & Tray of Different Channel	Raceway (> #4/0) Tray (≤ #4/0)	1 in.; provide 1 in. min. air gap between the enclosed raceway and any cable in the tray.
3) Class 1E Enclosed Raceway & Tray of Different Channel	Raceway (any size) Tray (> #4/0)	5 ft. vertical and 3 ft. horizontal

b. Between Class 1E Enclosed Raceway and Non-Class 1E Cable Tray:

Raceway Configuration	Cable Size	Minimum Separation Between Raceways
1) Class 1E Enclosed Raceway & non-Class 1E Cable Tray	Raceway (any size) Tray (≤ #4/0)	None Required; however provide 1 in. min. air gap between the enclosed raceway and any cable in the tray
2) Class 1E Enclosed Raceway & non-Class 1E Cable Tray	Raceway (any size) Tray (> #4/0)	5 ft. vertical and 3 ft. horizontal

c) Between Non-Class 1E Enclosed Raceway and Class 1E Cable Tray:

6	6/14/84	ISSUED FOR CONSTR. (INCORP DCN 245)	GK	RC		LM/UL		

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Raceway Configuration	Cable Size	Minimum Separation Between Raceway
1) Non-Class 1E Enclosed Raceway and Class 1E Cable Tray	Raceway (≤ #4/0) Tray (any size)	[illegible]; however provide 1 in. min. air gap between the enclosed raceway and any cable in the tray.
2) Non-Class 1E Enclosed Raceway and Class 1E Cable Tray	Raceway (> #4/0) Tray (any size)	1 in.; provide 1 in. min. air gap between the enclosed raceway and any cable in the tray.

d. Between the Open Ends of Conduits & Cable Tray

The minimum Separation between the open end of a conduit which contains cable that originate from the power bus of switchgear, load centers, motor control centers, AC and DC Distribution Panels, and a Class 1E Cable Tray shall be as follows:

The open end of the conduit shall be separated from the Class 1E tray (or redundant Class 1E tray in the case of a Class 1E conduit) be at least 5 ft. vertically & 3 ft. horizontally when the open end of the conduit is beneath the tray. If the open end of the conduit is above the tray, 5' ft. vertical and 1 ft. horizontal separation is required. If this separation cannot be met, the end of the conduit must be sealed with a minimum of 1 inch of Kaowool and 1" of PR615 coated with a flame-retardant mastic coating (VIMISCO or QUELPYRE) or 2 inches of silicone foam.

No.	DATE	REVISIONS	BY	CH'K	DESIGN SUPV	ENG'R	PROJ ENG'R	APP'D
2	7/27/84	INCORP. FCR. E10005	GK	HW	PP	MW		
1	6/14/84	ISSUED FOR CONSTRUCTION - RETYPED						

SCALE | DESIGNED | DRAWN | CHK'D / ENG'R

DESIGN: POWER DIV.

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JOB No. 8031
DRAWING No. E-1406 SHEET 2.2.4

2.1.2.4 Cable Trays:

The following separation criteria between cable trays shall apply:

a. Between Class 1E Cable Trays of Different Channels:

Cable Size	Minimum Separation Between Raceways
1) ≤ #4/0 (in both)	3 in. vertical and none horizontal (See detail below for parallel trays)
2) > #4/0 (in either or both)	5 ft. vertical and 3 ft. horizontal

b. Between Class 1E and Non-Class 1E Cable Trays:

Cable Size	Minimum Separation Between Raceways
1) Any size (Class 1E) ≤ #4/0 (non-Class 1E)	3 in. vertical and none horizontal (See detail below for parallel trays)
2) Any size (Class 1E) > #4/0 (non-Class 1E)	5 ft. vertical and 3 ft. horizontal

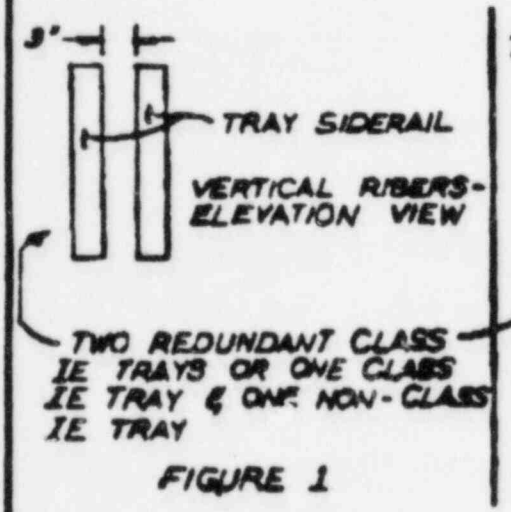

FIGURE 1

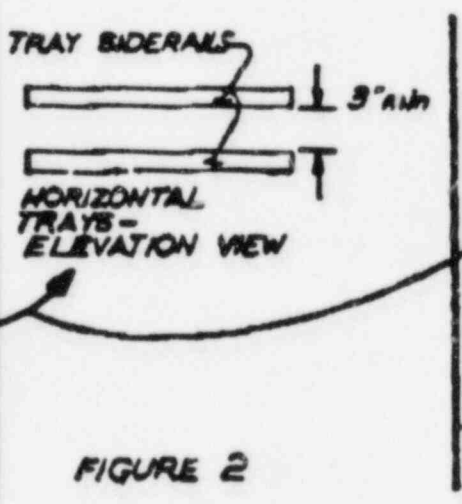

FIGURE 2

FIGURE 3

PARALLEL TRAYS DETAIL

No.	Date	Description						
2	6/14/84	ISSUED FOR CONSTR. (INCORP. DCN 205	GK	RC	SB	10/01		
1								

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2.2 Dropout Cable Separation:

A dropout cable as defined herein is any cable length not in a raceway. The maximum allowable unsupported length of any dropout cable is 36 inches nominal. The maximum allowable bend is equal to the minimum bending radius of the cable. Any dropout cable which does not meet the above criteria must be reworked prior to applying the following separation criteria. To meet the separation distances shown, the field must take into account maximum cable movements.

2.2.1 Separation Between Dropout Cables

a. For dropout cables from tray and/or gutter, if all cables involved are sizes $\leq$ # 4/0 AWG, provide 6 inches separation between Class 1E cables of different divisions or between Class 1E and non-Class 1E cables.

If any of the dropout cables is > #4/0 AWG, then the following criteria apply:

Dropout Cable > #4/0	Separation Required
Class 1E	5 ft. vertical } from redundant 3 ft. horizontal } Class 1E cable
Class 1E	5 ft. vertical } From Non-Class 3 ft. horizontal } 1E Cable >#4/0
Class 1E	6 inches - from Non-Class 1E Cable $\leq$ # 4/0
Non-Class 1E	5 ft. vertical } from all class 3 ft. horizontal } 1E cables

b. For dropout cables from conduits the following criteria apply:

1) For those dropout cables, from conduits, which do not originate at the power buses of switchgear, load centers, MCC's, AC and DC Distribution Panels, the same criteria as stated in 2.2.1.a apply.

2) For those dropout cables, from conduits, which do originate at the power buses of swgr, load centers, MCC's, AC and DC Distribution panels, do either of the following:

No.	DATE	REVISIONS	BY	CH'K	DESIGN SUPV	ENG'R	PROJ ENG'R	APP'R
3	7/27/84	INCORP FCR E10.005	GK	HW				
2	6/19/84	ISSUED FOR CONSTR. - RETYPED						

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a) Seal the end of the conduit with a minimum of 1 inch of Kaowool and 1" of PR615 coat with a flame-retardant mastic coating (VIMISCO or QUELPYRE) or 2" of Silicone foam. The criteria of [redacted] shall then be applied.

or

b) Treat the conduit dropout cable as if it were > # 4/0 and provide separation as per the criteria of 2.2.1.a.

2.2.2 Separation between Dropout Cables & Open Cable Tray

The following Separation Criteria apply between dropout cables and open cable trays:

a. For dropout cables from another tray and/or gutter, if the dropout cables & the cables in the tray are all ≤ #4/0; no separation is required from the dropout to the tray side rails, but provide (6) six inches of Separation between Class 1E cables of different divisions or between Class 1E and non-Class 1E cables. If the dropout cable is > #4/0 AWG or if the cable tray contains a cable > #4/0, then the following criteria apply:

Dropout Cables > #4/0	Separation Required
Class 1E	5 ft. vertical) from redundant 3 ft. horizontal) Class 1E Tray
Class 1E	6 inches (0" siderail distance from non-1E cable tray)
Non-Class 1E	5 ft. vertical) from class 3 ft. horizontal) 1E tray
Cable Tray Cable > #4/0	Separation Required
Class 1E Tray	5 ft. vertical) from redundant 3 ft. horizontal) channel dropout

(cont'd)

No.	DATE	REVISIONS	BY	CK'D	DESIGN SUPV	ENG'R	PROJ ENG'R	APPR
2		ISSUED FOR CONSTR. - RETYPED	GK					
1	7/27/84	INCORP. FCR E10.005						

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(Cont'd)

Cable Tray: Cable > #4/0	Separation Required
Class 1E Tray	6 inches (0" siderail distance from non-1E cable ≤ #4/0
Non-Class 1E Tray	5 ft. vertical } from Class 1E 3 ft. horizontal } Dropout

b. For Dropout Cables from Conduits the following criteria apply:

1) For those dropout Cables, from conduits, which do not originate at the power buses of swgr, load centers, MCC's, AC & DC distribution panels, the same criteria as stated in 2.2.2.a apply.

2) For those dropout cables, from conduits, which do originate at the power buses of Swgr, load centers, MCC's, AC and DC Distribution Panels, do either of the following:

a) Seal the end of the conduit with a minimum of 1" of Kaowool & 1" PR615 coat with a flame-retardant Mastic (VIMISCO or QUELPYRE) or 2" silicone foam. The criteria of 2.2.2.a shall be applied.

or

b) Treat the conduit dropout cable as if it were > #4/0 and provide separation as per the criteria of 2.2.2.a.

2.2.3 Separation Between Dropout Cables and Enclosed Raceway:

The following separation criteria apply between dropout cables and enclosed raceway:

a. For Dropout cables from tray &/or gutter, if all cables involved are ≤ #4/0, no separation is required between the dropout cable and the enclosed raceway. If the dropout cable is > #4/0 or if the enclosed raceway contains a cable > #4/0, then the following criteria shall apply:

No.	DATE	REVISIONS	BY	CH'K	DESIGN SUPV	ENG'R	PROJ ENG'R	APPD
2	7/27/84	ISSUED FOR CONSTR. INCORP. FCR E10.005	G.K.	HW	EJF	HWL		
1								

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Dropout Cable > #4/0	Separation Required
Class 1E	5 ft. vertical, 3 ft. horizontal } from redundant Class 1E enclosed raceway
Class 1E	No Separation from Non-Class 1E enclosed raceway
Non-Class 1E	5 ft. vertical, 3 ft. horizontal } from Class 1E enclosed raceway

Enclosed Raceway Cable > #4/0	Separation required
Class 1E Enclosed Raceway	1 inch } from redundant Class 1E dropout cable
Class 1E Enclosed Raceway	No Separation from Non-Class 1E Dropout Cable
Non-Class 1E Enclosed Raceway	1 inch } from Class 1E dropout cable

b. For dropout cables from conduits the following criteria apply:

1) For dropout cables, from conduits, which do not originate at power buses of swgr, load centers, MCC's, AC & DC distribution panels, the same criteria as stated in 2.2.3.a apply.

2) For dropout cables, from conduits, which do originate at the power buses of swgr, load centers, MCC's, AC & DC distribution panels, do either of the following:

a. Seal the end of the conduit with a minimum of 1" Kaowool & 1" of PR615 coat with a flame-retardant mastic coating (VIMISCO or QUELPYRE) or 2" of silicone foam. The criteria of 2.2.3.a shall then be applied.

or

b. Treat the conduit dropout cable as if it were > #4/0 and provide separation as per the criteria of Section 2.2.3.a.

No.	DATE	REVISIONS	BY	CHK'D	DESIGN SUPV	ENG'R	PROJ. ENG'R	APP'D
1	7/27/84	ISSUED FOR CONSTR. INCORP. FCR E 10.005	GK	HW				

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2.2.4 In instances where the minimum separation above cannot be achieved, wrap the dropout cables per the following:

Dropout Configuration	Cable to be Wrapped	Separation Required After Wrap
A. 1E cable ≤ #10 to 1E cable ≤ #10	either cable	[illegible]
B. 1E cable > #10 to 1E cable ≤ #10	1E cable > #10	1"
C. 1E cable > #10 to 1E cable > #10	both cables	1"
D. Non-1E cable ≤ #10 to 1E cable (any size)	either cable	0"
E. Non-1E cable > #10 to 1E cable (any size)	Non-1E cable	1"

These wrapping criteria also apply when achieving the required separation between dropout cables and raceways.

2.2.5 Wrapping Instructions

a. Wrap the dropout cables from the point where they begin to bend prior to existing the raceway to the point where the minimum separation criteria can be achieved. Apply Thermo-flex 1200 fiberglass tape in a single layer of a 50% overlap. Cover the fiberglass tape with a single layer of 3M No. 69 glass tape with a 50% overlap. Apply a stainless steel tyrap over each end of the glass tape to secure tape to cable.

No.	DATE	REVISIONS	BY	CH'K	DESIGN SUPV	ENG'R	PROJ ENGR	APPR
2	7/27/84	ISSUED FOR CONSTR. INCORP. FCR E10.005	GK	HW	EA	HJ		

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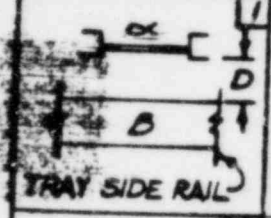
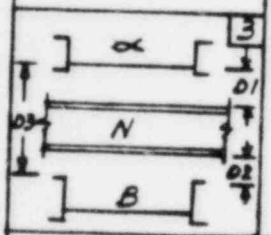
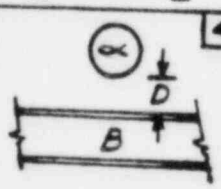
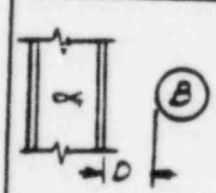
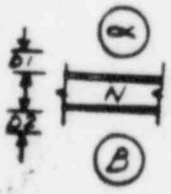
DRAWING No. E-1406 SHEET 2.2.7.3

REV. 0

TRAY COVER INSTALLATION CRITERIA

RACEWAY CONFIGURATION	RACEWAY DESIGNATION	EXTEND COVERS	NOTES
	α & B are redundant channels or either α or B is non-Class 1E (N).	1 FT. (3 FT. IN THE GENERAL PLANT) BEYOND THE EDGE OF TRAY ON BOTH SIDES OF THE TRAYS INTERSECTION	1. IF IT IS DETERMINED AFTER REVIEWING PARAGRAPHS 2.1.2.3 AND 2.1.2.4 THAT TRAY COVERS ARE REQUIRED, ONLY THE TRAY (OR TRAYS) WHICH CONTAIN > #4/0 CABLE SHALL BE COVERED. WHEN THESE TRAYS ARE COVERED THEY SHALL COMPLY WITH THE SEPARATION CRITERIA FOR ENCLOSED RACEWAYS AS STATED IN PARAGRAPHS 2.1.2.2 AND 2.1.2.3. EXCEPTION: IF BOTH CLASS 1E AND NON-CLASS 1E (N) TRAYS HAVE CABLES > #4/0, INSTALL TOP AND BOTTOM TRAY COVERS ON THE NON-CLASS 1E TRAY ONLY. THIS EXCEPTION DOES NOT APPLY TO CONFIG. 4, 5 & 6
	α & B are redundant channels; N is non-class 1E.	1 FT. (3 FT. IN THE GENERAL PLANT) BEYOND THE EDGE OF TRAY ON BOTH SIDES OF THE TRAYS INTERSECTION.	
		SAME AS 2	
	α & B ARE REDUNDANT CHANNELS, OR EITHER α OR B IS NON-CLASS 1E (N).	1 FT. (3 FT. IN THE GENERAL PLANT) BEYOND THE EDGES OF CONDUIT ON BOTH SIDES OF THE CONDUIT & TRAY INTERSECTION.	SEE NOTE 1
		SAME AS 4	SEE NOTE 1
	α & B ARE REDUNDANT CHANNELS, N IS NON-CLASS 1E.	1 FT. (3 FT. IN THE GENERAL PLANT) BEYOND THE EDGES OF THE CONDUITS ON BOTH SIDES OF THE TRAY & CONDUITS INTERSECTION.	SEE NOTE 1

NO.	DATE	REVISIONS	BY	DATE	APPD	ENG'G	PROJ. ENG'R	APPD
0	6/14/84	ISSUED FOR CONSTR. INCORP. DCN 208	GK	RC	CA	LN/WR		

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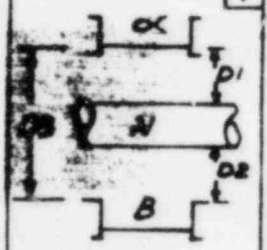
DRAWING NO. E-1406 SHEET 2.2.8

REV. 0

TRAY COVER INSTALLATION CRITERIA

RACEWAY CONFIGURATION	RACEWAY DESIGNATION	EXTEND COVERS	NOTES
7 	α & B ARE REDUNDANT CHANNELS, N IS NON-CLASS 1E	SAME AS 4	[redacted] SEE NOTE 1

1	6/14/84	ISSUED FOR CONSTR. (INCORP. DCN 205	GK	RC	[redacted]	RA/UR		
No.	DATE	REVISIONS	BY	CHK'D	[redacted]	CHK'D	PROJ. ENGR.	APPD

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