Client: Commonwealth Edison Company	Prepared by	[signature]	Date 7-31-85
Project: Byron/Braidwood	Reviewed by	[signature]	Date 8-1-85
Proj.No. 4391/2 & 4683/4	Approved by	[signature]	Date 8-1-85

Purpose:

The purpose of this calculation is to justify the separation distances of one foot (12") vertical and three inches (3") horizontal between safety-related and non-safety-related raceways. The calculation will establish that safety-related circuits will not be degraded below an acceptable level by the presence of the non-safety-related raceway.

Reference

Ref. #

1. Wyle Laboratories Test Report No. 46511-3, "Test Report on Verification Testing Between Class 1E and Non-Class 1E Power Cables in Raceways" dated March 28, 1983

2. Sargent & Lundy Standard - ESA-104a, "Electrical Engineering Reference for Current Carrying Capacities of Copper Cables"

Sargent & Lundy Specifications

3. - F/L-2823, 600V Power and Control Cable

4. - F/L-2851, 5kV and 8kV Power Cable

5. - F/L-2852, Instrumentation Cable

Sargent & Lundy Component Qualification Division (CQD) Binders

6. - CQD Binder EQ-BB031, Okonite 600V Power and Control Cable

7. - CQD Binder EQ-BB033, Samual Moore Intrumentation Cable

8. - CQD Binder EQ-BB03007, Okonite 5 & 8kV Power Cable

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Methodology

This calculation will demonstrate that fire or failure resulting from electrical faults induced in non-safety-related cables in a raceway will not cause electrical failure of safety-related cables in a raceway located 12" directly above or below 3" or horizontally away from the non-safety-related raceway. The calculation will be based on actual results of a test performed to establish electrical separation distances.

The cable failures which will be addressed in the establishment of separation distances in this calculation are those which will be induced by an electrical fault within the non-safety-related cable only. Cable failures which may result from design basis events external to the cable, such as those resulting from externally generated fires, high energy line break, moderate energy line break, flooding, etc., are addressed in separate analyses. The presence of the non-safety-related raceway does not increase the vulnerability of the safety-related raceway during any hazardous event external to the non-safety-related raceway because if the event would affect the safety-related raceway it would affect it to the same degree if the non-safety-related raceway were not nearby.

Voltage Transients:

All instrumentation cable furnished under the instrumentation cable specification for use in both safety-related and non-safety-related applications is rated for 600 volts with insulation tested to a minimum of 1500 volts with a tough overall protective jacket (Ref. 5 and 7). Instrumentation cable furnished under other specifications must be manufactured in accordance with Commonwealth Edison (CECo) Standard EM-2912D which requires that the insulation shall be rated at 600V. Instrumentation cables are applied in circuits with a system voltage of less than 30 volts. Therefore, there is a conservative design margin to assure adequate isolation from voltage transients in the non-safety-related circuit from adversely affecting a safety-related circuit.

All power and control cable used in both safety-related and non-safety-related circuits has been furnished under S&L specifications and must be manufactured in accordance with Commonwealth Edison Standards EM29105, EM29115, EM29116 or EM29150 for 600V power, 600V control, 5kV power, and 8kV control respectively. Control cables are applied in circuits with a system voltage of either 120Vac or 125Vdc. Low voltage power cables are applied in circuits with a system voltage of 480Vac. Control and low voltage power cables are required by S&L Specification F/L-2823 and CECo standards to have insulation rated at 600V. The cable is also tested to show that it can withstand voltage transients up to 1500V (Ref. 6 & 7). Medium voltage power cables are applied in circuits with system voltages of 4160V or 6900V. These are required by S&L specification F/L-2851 and CECo standards to have insulation rated at 5kV cables and 8kV respectively (Ref. 8). The cable is also tested to show that it can withstand voltage transients of up to 16kV and 22kV respectively. Therefore there is a conservative design margin in the cable to assure adequate isolation from voltage transients in the non-safety-related circuit from adversely affecting a safety-related circuit.

Current Transients:

An actual cable raceway separation verification test, Wyle Laboratories Test Report No. 46511-3, will be used to justify that a horizontal separation of 12" and a vertical separation of 3" is acceptable to prevent a fault induced by a current transient in a non-safety-related cable from degrading a safety-related cable below an acceptable level.

The electrical separation verification test was originally performed for Commonwealth Edison's LaSalle County Station. The cable which was used in the test, EPR insulation/hypolon jacket manufactured by Okonite Co., is of the same configuration and from the same manufacturer as that which was supplied to and installed at Byron and Braidwood Stations. The cable tray which was used in the test was of the solid bottom type. This is the same type of tray which is installed at Byron and Braidwood stations.

The raceway configuration which was chosen for the test is one in which an open top cable tray containing non-safety-related power cables is located 12" below a cable tray containing safety-related cables. The configuration included a 2" flexible steel conduit containing safety-related cables running vertical to and separated by 2" horizontally from the non-safety-related cable tray. Cable trays were selected for the verification of vertical separation since IEEE 384 actually allows for lessor separation between cables which are run in solidly enclosed raceways such as conduit. The non-safety-related cable located below the safety-related cable tray was selected due to the fact that heat generated as a result of a fault in the non-safety-related tray would more severely impact the safety-related tray if it is located above. Power cables were chosen for the faulted cables since they have a higher potential energy to induce damage in the safety-related raceway than instrumentation or control cables. Different sizes of power cables were faulted during the test in order to demonstrate the separation is acceptable for different sizes of cable and magnitudes of fault current. The location of the faulted cable in the lower cable tray was varied in order to assess the results at different locations.

The worst case failure of a cable for which the electrical separation criteria must protect cables in an adjacent raceway is a sustained overload condition where the magnitude of the current is such that the cable would be able to sustain the overload for a significant length of time (in comparison to the interrupting times of the protective devices, i.e., circuit breakers). This condition would allow the cable to generate the greatest amount of heat over a period of time and therefore has the greatest potential for causing damage to nearby circuits. If the cables were exposed to the maximum short circuit current which was available at the bus, the higher fault current would lead to faster open circuiting causing less energy to be deposited to the ambient and hence result in less temperature rise in the adjacent raceway.

For the purpose of the test, the cables were subjected to the overload currents for the length of time it took to open circuit the cable. This is considered to be a conservative test since no credit was taken for any current interrupting devices operating in the circuit.

The value of overload current which was selected for the test was approximately six and one half times the rated current overload value for the given cable size as specified by S&L Std. ESA-104a. This value is based on the fact that a stalled motor would draw about six and one half times rated current. The current of a stalled motor was selected because it was considered a credible overload current which may occur during normal operating conditions. The actual value of overload current which the faulted cables were exposed to during the test are:

Cable Size	Fault Current
3/C #2 AWG	462A
3/C 1/0 AWG	737A
3/C 350 MCM	2070A

The target cables in the upper cable tray and vertical flex conduit were continually energized during the test with their rated current. This current was monitored throughout the test. Functional tests, insulation resistance and high potential withstand were performed on the target cables before and after the test.

Analysis of Test Results:

The results of Wyle Laboratories Test Report No. 46511-3 indicate that all of the specimens in the upper cable tray (located 12" above the cable tray containing the faulted cable) and in the vertical conduit (located 2" horizontally away from the cable tray containing the faulted cable) maintained integrity to conduct specified current and voltage before, during, and after the fault specimens were subjected to the overload currents. The target cables passed the post-functional insulation resistance tests at 500Vdc and high potential withstand at 2200Vac. The temperatures which were measured on the cables in the upper cable tray and in the flex conduit running vertically past the cable tray containing the faulted cables were much less than the temperatures for which the cables are continuously rated (i.e., 90°C) and significantly less than the emergency temperature rating of 130°C of the power, control, and instrument cables installed at Byron and Braidwood Stations. Therefore the heat generated by a fault within a cable tray which is 12" vertically or 2" horizontally separated from a cable raceway is not sufficient to raise the temperature of the cables within the raceways to a magnitude which would degrade the ability of the cable to perform its function.

The currents which were chosen as the overload values were conservative because the actual current which a cable is designed for will always be less than the maximum rating specified in ESA-104a. This will result in a lessor overload current and as a result less heat generated by a faulted cable.

The length of time for which each of the faulted cables were energized with the overload current is also very conservative. As stated previously, the overload current value was selected because it was representative of the current which a stalled motor may draw. This was considered the most credible cause of a sustained overload current. However, the windings on the motor would eventually short together and result in a full short circuit which would be of a high enough magnitude to trip upstream circuit breakers even if one assumes the primary breaker fails. The test also indicated that the faulted cable would generate large amounts of smoke when it is subjected to an overload current. This smoke would be sensed by the ionization smoke detectors which are mounted in each of the areas of the plant which contain safety-related equipment or cables. A fire/smoke alarm would result in station personnel being dispatched to the area and actions taken to interrupt the faulted condition. Therefore, it is very unlikely that a cable would be subjected to an overload for any sustained length of time.

Therefore, the separation distances of 12" vertical and 3" horizontal between safety-related and non-safety related raceways is adequate to prevent a fault due to a current transient in non-safety related cable from degrading a safety-related cable below an acceptable level.

Environmental Qualification and Fire Retardant Characteristics

Power, control and instrumentation cable used in both safety related and non-safety related circuits, has been environmently qualified to the requirements of IEEE 383-1974, including tests to assure that it is fire retardant and will not propogate a fire. (Ref. 6, 7, and 8).

Conclusion

Based on the above calculation/analysis, it can be seen that it is acceptable for non-safety-related cable raceway to be separated by twelve inches (12") vertically and three inches (3") horizontally from a raceway containing safety-related cables. This analysis has demonstrated that the 12" vertical and 3" horizontal separation is adequate to prevent an electrically induced fault in the non-safety-related raceway from preventing safety-related circuits from performing their designed function.