ENCLOSURE

BYRON/BRAIDWOOD, UNITS 1 AND 2
SUPPLEMENT TO SAFETY EVALUATION

8.4.4 Physical Identification and Independence of Redundant Safety-Related Electrical Systems

A site visit was conducted on May 21-23, 1985 at Braidwood Station, Units 1 and 2 in order to view the installation and arrangement of electrical equipment and cables. During this visit specific issues identified during the Braidwood Station Construction Appraisal Team (CAT) inspection were discussed. The CAT inspection revealed several items regarding physical separation, particularly between Class 1E and non-Class 1E cables. Commonwealth Edison Company has established the separation criteria between redundant Class 1E raceways in accordance with R.G. 1.75 for Byron and Braidwood Stations.

However, the applicant has established separation criteria of non-Class 1E from Class 1E raceways which deviates from the specific separation distances detailed in R.G. 1.75. Acceptability of the applicant's lesser separation distance with its bases and justification were not specifically addressed in the Byron/Braidwood Safety Evaluation Report (SER).

Therefore, the staff has performed the following evaluation of the applicant's separation criteria of Class 1E cables from non-Class 1E cables to eliminate any further differences in interpretation of separation requirements in this area.

The applicant instituted a test program conducted by Wyle Laboratories and performed calculations and analysis to justify lesser separation distances. By letter dated August 6, 1985, the applicant submitted the test results, with its associated information, and the analysis on the separation criteria.

The purpose of these tests was to establish a basis of analysis which could be applied in justifying a lesser physical separation distance. Any lesser separation distance than the separation criteria specified in RG 1.75 must be established by the test results.

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 in a raceway. The Byron/Braidwood raceway separation test program was based on the following failure assumptions:

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

(2) The fault current used was the RMS value which produces the maximum possible credible heating effect without tripping the breaker by magnetic force.

(3) Load current effects from other loads on the same circuit was not considered to cause the next higher level overcurrent device to trip.

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. 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. On the other hand, if the cables were exposed to the maximum short circuit current available at the bus, the higher fault current would lead to rapid clearing of the fault by a breaker. This condition causes less energy to be generated to the ambient and hence results 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 the circuit through failure of the cable conductors. This is considered to be a very conservative test since no credit was taken for any current interrupting devices operating in the circuit.

The purpose of these tests was to establish an analytical basis for demonstrating the minimum acceptable separation distance. Any separation distance less than the separation criterion specified in RG 1.75 shall also be established by the test program.

In selection of the test configuration, the primary concern was to ensure that the quantity and types of raceway and cable arrangements tested would satisfactorily represent actual plant configurations and provide a basis for applying the results of the testing to similar configurations which were not tested. Using this criterion, the following representative configurations were selected for our evaluation:

a. Separation distances of one foot (12") vertical and three inches (3") horizontal between safety-related and nonsafety-related raceways.

   Our analysis concludes that fire or failure resulting from electrical faults induced in nonsafety-related cables in a raceway would not cause electrical failure of safety-related cables in a raceway located 12" directly above or below or 3" horizontally away from the nonsafety-related raceway. The analysis was based on actual results of tests performed to establish electrical separation distance. The cable failures addressed in the establishment of separation distance in this analysis are those which are induced by an electrical fault within the nonsafety-related cable only.

The raceway configuration chosen for the test is one in which an open top cable tray containing nonsafety-related power cables is located (2") below a cable tray containing safety-related cables. The configuration also included a 2" flexible steel conduit, containing safety-related cables running vertically, separated by 2" horizontally from the nonsafety-related cable tray.

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. 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 target cables in the upper cable tray and vertical flex conduit were continually energized during the test with their rated current. The actual value of overload current which the faulted cables were exposed to during the test are 462A for 3/C #2AWG, 737A for 3/C 1/0, and 2070A for 3/C 350 MCM. These values are based on 6.5 times rated current over-current test. The length of time for which each of the faulted cables were energized with the overload is very conservative. As stated previously, the overload current value was selected because it was representative of the test current which a stalled motor may draw. This was evaluated as the most credible cause of a sustained overload current. In reality, the motor windings 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 a feeder breaker fails. Calculated fault currents are 4600 amperes for the size 2 AWG cable, 5400 amperes for the size 1/0 AWG cables, and 6700 amperes for the size 350 MCM cables short circuit test. The test results demonstrated that these fault current values caused relatively minor damage to the fault cable insulation, particularly when compared to the extreme degradation incurred with the lower (6.5 times rated current) overcurrent tests. The major reason for the decreased insulation system damage is the fact that the conductor circuits open much faster at higher current values.

The acceptance criteria were specified by a review of applicable IEEE Standard, Underwriter Laboratories and American National Standard testing requirements in 600 Vac circuitry. At the completion of each cable test, functional tests for the target cables which consisted of the Insulation Resistance Test, High Potential Test, Overcurrent Test and Post-Test Functional Test were performed. The target cables passed the above tests in accordance with the acceptance criteria and cable manufacturer's specification.

The results of Wyle Laboratories Test Report demonstrate that all of the target cables in upper cable tray (located 12" above the cable tray containing the faulted cable) and in the vertical conduit (located 2" horizontally away from faulted cable tray) maintained their 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 500 Vdc and high potential withstand at 2200 Vac. The temperature which was measured on the target cables in the upper cable tray and in the flex conduit was much less than the temperature for which the cables are continuously rated and significantly less than the emergency temperature rating of 130°C of the power, control, and instrument cables.

The staff has reviewed the result of Test Report No. 46511-3 conducted by Wyle Laboratories and the applicant analysis. Based on the staff's review, the staff concludes that the separation distance of 12" vertical and 3" horizontal between safety-related and nonsafety-related raceway is adequate to prevent a fault in nonsafety-related cable causing failure of safety related cables and is, therefore, acceptable.

b. Separation of a safety-related cable in free-air in contact with a raceway containing a nonsafety-related cable and of a nonsafety-related cable in free-air in contact with a raceway containing a safety-related cable.

The purpose of this analysis and test is to demonstrate that fire or failure resulting from electrical faults induced in nonsafety-related cables in free-air or in raceway will not cause electrical functional failure of safety-related cables in raceway or in free-air respectively.

This configuration consists of a test between two horizontal, rigid steel conduits and various free-air instrumentation cables. The faulted cable is a 3/C 500 MCM routed in a rigid steel conduit. Three target cables located in a 1" rigid steel conduit in contact with the conduit containing the faulted cable. Three other target cables, respectively, are mounted in free air in contact with the conduit of the faulted cable. This configuration test demonstrates the adequacy of separation design that: (1) two horizontal, rigid conduits are physically separated by zero inches vertically when a worst-case electrical fault occurs in the lower conduit, or (2) free air cables are physically separated from a horizontal rigid steel conduit by zero inches horizontally when a worst-case electrical fault occurs in the conduit. All instrumentation cables for use in both safety-related and nonsafety-related applications are rated for 600 volts with insulation tested to a minimum of 1500 volts with a overall jacket and are applied in circuits with a system voltage less than 30 volts. Control cables are applied in circuits with a system voltage of either 120 Vac or 125 Vdc. Low voltage power cables are applied in circuits with a system voltage of 480 Vac. Control and low power cables have insulation rated at 600 volts. The cable is alsc tested to show that it can withstand voltage transients up to 1500 volts. Medium voltage power cables are applied in circuits with system voltages of 4160 V or 6900 V. These are required to have insulation rated at 5 kV and 8 kV respectively. The cable is also tested to show that it can withstand voltage transients of up to 16 kV and 22 kV respectively. Therefore, there is a conservative design margin in the cable to assure adequate isolation from voltage transients in the nonsafety-related circuit from adversely affecting a safety-related circuit.

For the purpose of the verification test, it was assumed that the circuit breaker feeding the overloaded cable fails to trip and the overcurrent will persist in the cable. The fault current which was considered the most credible severe overload condition which the cable may see during plant operation is that resulting from a motor failing to start but continuing to draw locked rotor current as described above. The actual test current values were selected from the largest motor which is fed with a 500 MCM 600 V cable at Byron or Braidwood. This motor is a 250 HP motor which has a locked rotor current of approximately 1700A. If the voltage drop is taken into consideration, the actual current which would be seen by the cable is approximately 1300A. The overcurrent test, therefore, consisted of energizing the 500 MCM size to 1300A for one hour and 1700A until the cable open circuited. The two step overcurrent test was selected in order to simulate a worst case condition by energizing the cables with a fault current which cause the cable to generate considerable heat but would not cause an open circuit, and then jump the fault current to a value which would eventually open circuit the cable. The one hour time limit on the 1300A portion of the test was considered conservative since a stalled motor would be alarmed and deenergized long before one hour. Alternatively, the motor winding would short together and result in a full short circuit which would be interrupted by the upstream breakers.

The target cables were energized continually during the test. The target cables passed pre and post functional tests which consisted of both insulation resistance and high potential withstand tests.

As previously stated, the primary objective in the selection of the test configuration was to ensure that the quantity of raceway and cable arrangements tested would satisfactorily represent actual plant configurations and provide a basis for applying the results of the testing to similar configurations which were not tested.

The results of these tests performed, Test Report No. 17769-1, by Wyle Laboratories indicate that all of the target cables maintained integrity to conduit specified current and voltage before, during and after the fault specimen was subjected to the overload current. At the completion of each cable test, the functional tests were performed for the target cables. The target cables passed the above tests in accordance with the acceptance criteria and cable manufacturer's specification.

The staff has reviewed the results of the Test Report No. 17769-1 conducted by Wyle Laboratories and the applicant's analysis of these configuration tests. Based on staff's review, the staff concludes that it is acceptable for (a) safety-related cables in free-air to come in contact with a raceway containing nonsafety-related cables and (b) nonsafety-related cable in free-air to come in contact with a raceway containing safety-related cables. This analysis has demonstrated that safety-related cable will not be degraded below an acceptable level due to the reduced separation as specified in the FSAR.