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8.7 WIRE, CABLE AND RACEWAY FACILITIES

8.7.1 Design Bases

8.7.1.1 Functional Requirements

In addition to transmitting electric power from the proper source to the designed load device, these facilities must be of a type and be properly installed and segregated to function during all postulated accident conditions.

8.7.1.2 Design Criteria

The electrical loading of conductors does not exceed, and is generally less than, the ampacities recommended by American Institute of Electrical Engineers - Insulated Power Cable Engineers Association (AIEE-IPCEA) "Power Cable Ampacities," (joint publications S-135-2 and P-46-426, 1962), and in open-top cable trays without maintained spacing in between cables the ampacities recommended by IPCEA-Institute of Electrical and Electronics Engineers (IEEE), joint publication, IPCEA Pub. No. P-54-440, and National Electrical Manufacturers Association (NEMA) Pub. No. WC 51-1972.

The percent cross-section fill of wireways is governed by the allowable cable ampacities.

The physical support of wireways meet the recommendations of Chapters 2 and 3 of the National Electrical Code, 1971.

Separation of conductors and of their wireways meets the requirements of Section 4 of IEEE 279, 1971, Sections 4 and 5 of IEEE Standard 308, 1971, Criteria 1, 2, 3, 4, 17 and 18 of Appendix A of 10 CFR Part 50. Electrical penetration assemblies conform to IEEE 317, 1971.

8.7.2 System Description

8.7.2.1 System

Cable types required to operate inside the containment after an accident are tested in an environment more severe than that expected in service. All cables have a sufficient degree of flame resistance to obviate the need for flame retardant coating or special fire extinguishing systems.

Fire detection is provided by a system of fire and smoke detector heads in the areas listed below. The power supply for this detector system comes from a 125-volt DC panelboard, as described in Subsection 8.6.2.1. In the event of smoke or flame in these areas, an annunciator in the control room displays the alarm. Additional fire protection is provided as described in Subsection 9.10. The areas covered by ionization type detector heads are as follows:

Computer room
Control room ventilating ducts
Main exhaust equipment room

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Fuel handling area
Auxiliary building and radwaste ventilating room
Cable spreading room
Electrical penetration rooms
Cable vault
Medium voltage switchgear rooms
Low-voltage switchgear rooms
Cable chases

8.7.2.2 Components

The raceway system is made up of cable trays, conduits and underground ducts, with the electrical cables contained therein.

Cable trays are of galvanized steel, ladder type or solid bottom, with solid covers where required. Hangers for trays carrying vital circuits are designed to withstand seismic disturbances as described in Subsections 5.8.1 and 5.8.1.1.

Conduits are galvanized rigid steel where embedded in reinforced concrete in building slabs. The duct banks going to the intake structure are heavily reinforced and will withstand a seismic disturbance, as noted in Subsection 5.8.2.3.

All in-line splices of conductors are made only in metal enclosures such as terminal boxes and junction boxes or in designated splicing areas of the cable raceways.

Table 8.7-1 lists the physical and electrical characteristics of the cables that are used, and indicates the qualification tests. The certified results of such tests are available for inspection.

The electrical penetration assemblies through the wall of the containment structure form part of the containment pressure boundary, as described in Subsection 5.2.7.1.1. The low-voltage power and control modules are mounted in a stainless steel header plate and are designed to meet or exceed all requirements of IEEE Standard 317, 1976. The medium-voltage power penetrations are designed to meet or exceed all requirements of IEEE Standard 317, 1971. A complete prototype and production test program demonstrated the suitability of the assemblies for operation under the prescribed service conditions. These tests include leak integrity, current carrying capacity (continuous, short-time overload, and fault current) dielectric strength, insulation resistance, and resistance to seismic and thermal transients. The conductors contained therein meet all criteria applying to each class of service. The high-voltage conductors terminate in a stress cone and lug. Low-voltage power cables larger than 4/0 AWG terminate in lugs rigidly fixed in a terminal box at each end of the penetration assembly. All other power, control, and instrumentation cables except for Class 1E instrumentation circuits are terminated on terminal blocks enclosed in a terminal box at each end of the penetration assembly. The Class 1E instrumentation circuit terminations inside containment are made with qualified in-line splices. Coaxial cables terminate in connectors mounted in terminal boxes at each end of the penetration assembly. All terminal boxes are designed for NEMA IV service.

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A leak rate test is performed on each penetration assembly following its installation. This test is capable of detecting a leak rate of 1×10^{-2} cc/sec of dry nitrogen at ambient temperature when maximum design pressure is applied across the penetration assembly barrier. To effect this test, each assembly is fitted with a gage to monitor the pressure, and is then charged with 30 psig of nitrogen. The assembly is so designed that all seals, including conductor seals, are monitored by the gage.

8.7.2.3 Cable Ampacities

Maximum ampacities for various installation conditions are given in Tables 8.7-2 and 8.7-3, the actual loading being always below these limits. In all cases, 90 C insulation and 50 C ambient air values are used. All ratings are based on those given in AIEE-IPCEA "Power Cable Ampacities," joint publication S-135-2 and P-46-426, 1962, and for open-top cable trays without maintained spacing in between cables in IPCEA-IEEE, joint publication, IPCEA Pub. No. P-54-440 and NEMA Pub. No. WC 51-1972.

8.7.3 Availability and Reliability

8.7.3.1 Separation

The raceway systems are so designed that any one raceway channel may be physically sacrificed under accident conditions. The layout drawings in Figure 8.7-1 show typical examples of the separation of raceways serving different channels.

The separation of redundant cables is accomplished by spatial separation of their cable trays. This spatial separation is normally not less than four feet vertically and 18 inches horizontally to guard against damage from external fire, missile, or other accidents.

Where these spacings between trays of redundant systems cannot be maintained (physical obstructions, points of necessary convergence, crossovers, etc.), barriers are provided to preserve the physical and electrical integrity of the cables.

Vertical stacking of separate redundant trays is avoided where possible.

Where separate redundant trays must be stacked with less than four-foot vertical separation, their horizontal separation is less than 18 inches, or they crossover with less than six inches clear space vertical separation, rated fire barriers or a combination of rated fire barrier/suppression system must be used.

Typically, rated fire barrier material employed to enhance raceway separation is one-half inch Marinite 36, or equivalent. Installation will be as follows: 90-9 (6/90)

a. Horizontal Separation. A vertical barrier, one foot above and one foot below the trays, or to the ceiling or floor.

b. Vertical Separation. A horizontal barrier between trays extending one foot each side of the tray system.

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c. Cross-overs. A horizontal barrier extending out one foot from each side of each tray, and five feet along each tray from the crossover. 90-5 (6/90)

In lieu of the above, conduit or a totally enclosed tray may be used and the two channels do not touch each other.

Generally, no more than one channel of separate redundant systems is run through a compartment containing machines with flywheels. Where this cannot be avoided, each case is evaluated for additional protection. Similarly, no more than one channel is generally routed through an area containing high pressure (275 psi and over) piping. Where necessary, the redundant raceway will be run at least ten feet from such piping. Where this spacing cannot be achieved, pipe restraints are provided and each case is evaluated for additional protection.

Where routing is unavoidable through an area subject to a possible open accumulation of quantities (gallons) of oil or other combustible liquids as a result of rupture or leakage of a fluid system, a single separation channel only is routed through this area. Furthermore, the cables are protected from dripping liquids by conduit or covered tray.

Raceways (exposed conduits, trays, penetrations, etc.) are generally stacked vertically in the following relative order:

a. 6900-volt power
b. 4160-volt power
c. 480-volt load center subfeeders
d. *480-volt power and general control
e. *Shielded control and instrumentation

(*Shielded control and instrumentation cables may be run with unshielded control and instrumentation for short distances such as risers into equipment).

Within each of these classifications, nonvital cable may be run with vital cables. However, a nonvital cable is never routed in raceways of more than one separation channel.

Vital circuits, components, and equipment are those that are safety related. That is, the safe operation and shutdown of the nuclear system is dependent on them. Vital systems meet the single failure criterion and therefore are redundant and separate.

Where indicators and other devices are not essential for the safe functioning of a vital system, current and potential transformer secondaries or other low energy circuits feeding such devices are considered nonvital circuits.

Equipment, devices, cables and raceways have an assigned number that indicates if they are in vital service or not, and also indicates the channel. These designations are shown on one-line and three-line diagrams, schematics, circuit and raceway schedules, and the instrument index.

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A "Z" prefix on a cable, conduit or tray number indicates a vital system. The absence of the Z prefix indicates nonvital service. The first figure of a cable, conduit or tray number designates the channel. Such an alpha-numeric prefix is called the Facility Code, and its use is further explained in Table 8.7-4.

Vital power and control cables fall mainly into two redundancy classifications; Channel Z1 and Channel Z2. In a few cases there is also a Channel Z5, which is a system that can be transferred from one source to another, and is run as described below. Cables such as those in reactor protection service are assigned to Channels Z1, Z2, Z3 and Z4. As shown in Table 8.7-4, nonvital Channel 1 may be routed with vital Channel Z1, and Channel 2 with Channel Z2. Low level buffered signal outputs from Z3 and Z4 channels of a four-channel instrument system may be run with nonvital channels 1 and 2 respectively. Where the system lacks a current limiting feature, Z3 and Z4 are run separately.

Channel Z5 is associated with the spare units fed from 4160-volt emergency bus A5; namely, service water pump P5B, Reactor Building Closed Cooling Water (RBCCW) pump P11B, and High Pressure Safety Injection (HPSI) pump P41B. The power circuits and the control circuits for this equipment are all transferred simultaneously to Channel Z1 or Z2 sources. Thus, their circuits are routed together as Channel Z5. The Z5 control circuit and power circuit for the spare 480-volt charging pump P18B, are transferred to Z1 or Z2 sources independent of the above circuits. Hence, the Z5 charging pump circuits are routed separately from those associated with bus A-5. Nonvital Channel 5 circuits are those associated with instrument loops or metering circuits. Channels 5 and Z5 circuits are routed together only where it can be demonstrated that their transfer to Channel 1 (Z1) or 2 (Z2) sources does not impair the separation of redundant safety related circuits.

Computer and annunciator circuits are considered nonvital. Their inputs are from nonvital Channels 1 and 2 that may be routed with vital circuits as shown in Table 8.7-4. The Channel 1 and 2 segregation for the nonvital circuits is lost when they enter the final raceways at the computer or the annunciator terminal cabinets. The 480-volt power supply to the computer is reduced to 120-volts by an uninterruptible power supply (preferred) or a regulating transformer (alternate). The internal power supply provides 36 volts (fused one-half amp) to the digital inputs, and the analog inputs are 10-50 mA. The power supply to the annunciator is from two separate redundant AC to DC power supply systems which isolate the annunciator DC voltage from the AC power sources and isolate the two AC power sources from each other.

The control element drive system (CEDS), including the CEDS logic cabinets, are also considered nonvital. Two separate feeders, one from each of the two nonvital 120 vac instrument buses, supply control power to the logic cabinets. The feeder cables are routed in separate raceway from the distribution panels to the cabinets, but are ultimately bundled together within a common logic cabinet. Separation of the nonvital 120 vac instrument buses is maintained, however, because separate double pole circuit breakers installed in each of the nonvital distribution panels provide isolation between the two buses. No redundancy is intended, or required, for the CEDS logic cabinet power supplies. 95-11 9/95

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All power supply equipment is identified with respect to its source. Odd first digits are assigned to Channel 1; i.e., B1, B1̲2, etc. Even first digits are assigned to Channel 2; i.e., B2, B2̲1, etc.

To assist in verifying proper separation, the jackets of all cables are color coded. Table 8.7-4 indicates the physical separation applied to cables and raceways, and the cable jacket color for each case.

Apertures for entrance of redundant vital cables into control boards, panels and relay racks are separated by at least twelve inches of air space. Where this cannot be accomplished, the entrance is made with conduit or enclosed tray.

Redundant vital cables terminate on terminal blocks at least six inches apart. Internal wiring of redundant vital circuits, and any associated devices, is separated by a minimum of six inches. Where the minimum spatial separation of six inches is not feasible, noncombustible barriers or conduit are used to provide separation. Nonvital channels may be wired to the same device, but their conductors are bundled separately. 97-18 9/97

Previously implemented 10 CFR 50.59 changes

Whenever practicable, shipping splits and structural stiffeners are utilized as natural barriers. The barriers are comprised of two sheets of steel plates with a minimum of one inch air space or insulating fire-resistant material in between, if devices and/or wiring are mounted on both faces of the barrier. If devices and/or wiring are mounted on the barrier on only one face, a single sheet of steel plate for isolation is satisfactory provided devices and/or wiring on the other side are installed at least one inch away from the barrier. The barriers are properly supported for structural strength, and extend from top to bottom and front to back to a depth which provides a minimum of six inches separation between channels. 97-18

Typical layouts illustrating the separation of redundant wireways are shown in Figure 8.7-1.

8.7.3.2 Tests and Inspections

The various documents indicating the separate routing of redundant cables are carefully cross-checked during the design of the system. The color coded jackets of the cables permit a visual inspection to verify that the separation criteria are observed.

Insulation resistance of all power cables is measured initially and spot checks are made at refueling periods. Such tests indicate significant trends in the unlikely event there has been deterioration of the insulation.

The pressure gages on the electrical penetration assemblies are located in the auxiliary building penetration rooms and are readily accessible. These assemblies remain charged with nitrogen throughout their life, and a pressure reading will be taken and recorded periodically.