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August 31, 1984

DOCKETED
USNRC

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

'84 SEP -4 A11:15

Before the Atomic Safety and Licensing Board

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| In the Matter of | ) | |
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| CAROLINA POWER & LIGHT COMPANY and NORTH CAROLINA EASTERN MUNICIPAL POWER AGENCY | ) | Docket No. 50-400 OL |
| | ) | |
| (Shearon Harris Nuclear Power Plant) | ) | |

APPLICANTS' TESTIMONY OF RICHARD M. BUCCI
AND EDWIN J. PAGAN IN RESPONSE TO
EDDLEMAN CONTENTION 9D (INSTRUMENT CABLES)

Q.1 Please state your names.

A.1 Richard M. Bucci and Edwin J. Pagan.

Q.2 Mr. Bucci, please state your address, present occupation and employer.

A.2 (RMB) I am employed as an Associate Consulting Engineer in the Corporate and Consulting Engineering Department of Ebasco Services Incorporated, 2 World Trade Center, New York, New York 10048.

Q.3 State your educational background and professional work experience.

A.3 (RMB) I was graduated from Pratt Institute in 1972 with a Bachelor of Engineering (Electrical) degree, and as a member of the Tau Beta Pi and Eta Kappa Nu Engineering Honor Societies. I attended the University of Illinois Graduate School of Electrical Engineering in Urbana-Champaign as a Research Assistant from 1972 through 1973, and joined Ebasco Services Incorporated in early 1974. My initial responsibilities at Ebasco included assignments as an electrical engineer on several Ebasco projects. These assignments included system and physical design, preparation of equipment specifications, electrical one-line diagrams, equipment economic and technical evaluations and review of nuclear equipment qualification programs.

In 1976 I was assigned to the Shearon Harris Project for which my responsibilities included the above functions, as well as preparation of electrical sections of the FSAR, monitoring of vendor supplied information, and engineering support of construction activities. I was Ebasco's Lead Electrical Engineer for the Shearon Harris Project from 1979 to 1983, and was responsible for all electrical engineering and design activities performed by Ebasco on this project. One of these activities was the implementation of the environmental qualification program for all electrical equipment.

In 1983 I became the Section Leader for nuclear services in the Corporate and Consulting Electrical Engineering Department at Ebasco. My responsibilities include managing nuclear consulting services for electrical systems and equipment, and development of corporate programs, guidance and positions on nuclear plant electrical systems. I am also Ebasco's Corporate Equipment Qualification (EQ) Program Manager, responsible for development and implementation of Ebasco's EQ Program. I head a multi-disciplined EQ Program Committee which oversees and develops guidance for EQ efforts on all Ebasco nuclear projects.

I am a registered Professional Engineer in the state of New York and a member of IEEE (Power Engineering Society) and the American Nuclear Society (ANS). I have authored a paper entitled "Developing and Maintaining Equipment Qualification Programs: A Computer-Aided Approach," which I presented at the 1983 ANS Winter Meeting.

Q.4 Mr. Pagan, please state your address, present occupation and employer.

A.4 (EJP) I am employed by Ebasco Services Incorporated as a Senior Electrical Engineer. My business address is 2 World Trade Center, New York, New York 10048.

Q.5 State your educational background and professional work experience.

A.5 (EJP) I received a Bachelor of Engineering (Electrical) degree from the City University of New York in 1978. I joined Ebasco in March 1981 as an Electrical Engineer on the Shearon Harris Nuclear Project. I am currently the Equipment Qualification Task Leader for SHNPP. My responsibilities include developing and implementing the EQ program and supervising the work of the EQ group, which consists of nine multi-disciplined engineers for non-NSSS equipment. I have reviewed and checked various EQ test reports and performed executive reviews (final checks) of most documentation packages. I have also trained engineers to review test reports, written FSAR qualification sections, provided responses to NRC EQ questions and interfaced with CP&L on all EQ related matters. In 1983 I spent four and one-half months at the SHNPP site to assist in evaluating the qualification of the NSSS vendor supplied Class 1E equipment. At Ebasco I have also had overall engineering resposibility for all plant cables, electrical containment penetrations, DC systems, and uninterruptible power supplies. Responsibilities included specifying, purchasing, performing calculations, reviewing plant layout and vendor drawings, and resolving field problems.

Prior to March 1981, I was employed by the Consolidated Edison Company of New York ("Con Ed"). Two years were spent in Quality Assurance ("QA") performing audits, surveys and inspections of Class 1E equipment manufacturers' QA programs to determine compliance with 10 C.F.R. 50 Appendix B. In addition, I witnessed testing and manufacturing of Class 1E equipment. Other QA responsibilities included field verification of equipment and pipe walkdowns at Indian Point Unit 2. At Con Ed I also spent seven years in the Electrical Engineering Group. Four of those years required performing engineering tasks associated with Indian Point Units 2 and 3. The remaining three years required performing engineering tasks associated with high voltage substations. My engineering responsibilities at Con Ed were similar to those at Ebasco, with the addition of writing construction specifications, power plant instruction manuals and lighting standards. I also spent two years in Con Ed's Estimating Group, where I estimated the costs (labor and material) of various projects.

Q.6 What is the purpose of this testimony?

A.6 (RMB, EJP) The purpose of this testimony is to respond to Eddleman Contention 9D, which states:

> The qualification of instrument cables did not include adequate consideration and analysis of leakage currents resulting from the radiation environment. These leakage currents could cause degradation of signal quality and/or spurious signals in Harris instrument cables.

Q.7 How is your testimony organized?

A.7 (RMB, EJP) First, we describe instrument cables and their safety functions. Second, we describe how instrument cables are environmentally qualified for use at SHNPP. Finally, we explain how qualification of the cables assures that leakage currents due to radiation will not cause degradation of signal quality or spurious signals in a way which would impair the safety functions of the cables.

Q.8 What is an instrument cable?

A.8 (RMB, EJP) An instrument cable, in its simplest form, is an electrical cable constructed of a conductor, insulation, shield, drain wire, and overall jacket. More complex constructions include various multiples of these basic components. Instrument cables are designed to conduct low power electrical signals.

Q.9 What safety functions are performed by instrument cables in a nuclear power plant?

A.9 (RMB, EJP) During normal operation, instrument cables are used to conduct electrical signals containing information about plant operating conditions, such as reactor coolant system pressure, reactor coolant system temperature, and containment radiation levels. These signals are transmitted from measuring instruments throughout the plant to indicating and control devices in the control room and other locations. In the event of an accident, instrument cables transmit the protective action signals required to achieve safe plant shutdown, to mitigate the consequences of the accident, and to monitor plant conditions during and after the accident.

Q.10 What kinds of instrument cables are used at SHNPP?

A.10 (RMB, EJP) There are several thousand circuits utilizing instrument cables in the SHNPP design. The instrument cables used are of various types, and have been purchased from several different vendors. The types of instrument cable used at SHNPP are included on the list of electrical equipment in FSAR Table 3.11.0-2 (Applicants' Exhibit __).

Q.11 Where are these cables located in the plant, and to what environmental conditions will they be exposed?

A.11 (RMB, EJP) Instrument cables are located throughout the plant. Because most instrument cables are routed through more than one plant area, these cables will be exposed to a variety of environmental conditions. For example, many cables are routed from instruments inside the containment to indicators in the control room.

Q.12 Please describe how instrument cables at SHNPP were qualified for the environmental conditions to which they could be subjected.

A.12 (RMB, EJP) Instrument cables at SHNPP required to be environmentally qualified by 10 C.F.R. § 50.49 were qualified by test. The test methodology employed is the one set forth in IEEE 383-1974, "IEEE Standard for Type Tests of Class 1E Electric Cables, Field Splices, and Connections for Nuclear Power Generating Stations" (1974). IEEE 383-1974 is endorsed by NRC Regulatory Guide 1.131, "Qualification Tests of Electric Cables, Field Splices, and Connections for Light-Water-Cooled Nuclear Power Plants" (August 1977).

In the tests, instrument cables were subjected to thermal aging, radiation, and other design basis accident conditions (as applicable). Each type of instrument cable used at SHNPP was qualified for its worst case location, i.e., for the most severe environmental conditions that any part of a cable of that type could experience.

In addition, during testing the SHNPP instrument cables were exposed to substantially higher radiation doses than the most severe doses to which they actually could be exposed under normal and accident conditions. For example, a sample of Samual Moore thermocouple wire, which is used in the SHNPP containment, was irradiated during testing with a total dose of $2 \times 10^8$ rads. According to conservative radiation calculations, the maximum normal plus accident dose which this instrument cable could receive at SHNPP is $5 \times 10^7$ rads, one fourth of the dose which the cable sample received during testing.

Following the tests described above, the instrument cables were required to pass a voltage withstand test, which subjected the cables to additional electrical and mechanical stresses beyond those they will experience in service. The voltage withstand test indicated that margin still existed in the integrity of the insulation after qualification testing.

Q.13 What are leakage currents?

A.13 (RMB, EJP) Leakage current is that portion of an electrical signal carried by a cable which is conducted through the insulation to ground.

Q.14 What is insulation resistance?

A.14 (RMB, EJP) Insulation resistance is the resistance of the cable insulation to the flow of leakage current.

Q.15 What is the relationship between leakage current and insulation resistance?

A.15 (RMB, EJP) Leakage current and insulation resistance are inversely proportional. That is, as insulation resistance decreases, leakage current increases (provided voltage remains constant). This relationship is described by Ohm's Law, which is a fundamental concept in electrical engineering.

Q.16 What causes leakage currents in instrument cables?

A.16 (RMB, EJP) Leakage currents occur when insulation resistance is too low, for example, when organic cable insulation has degraded as a result of environmental stresses.

Q.17 What are the safety implications of leakage currents in instrument cables for nuclear power plants?

A.17 (RMB, EJP) Depending on the sensitivity of the particular instrument to which the cable is connected, a leakage current could affect the accuracy of transmitted information. If the instrument is safety-related, plant safety could be impaired.

Q.18 Was leakage current or insulation resistance measured during qualification testing of instrument cables used at SHNPP?

A.18 (RMB, EJP) Yes. Leakage current is sensed by a measurement device and converted by the device to an insulation resistance value, which is recorded. Leakage current values are not recorded because such values, to be meaningful, depend on circuit parameters such as cable length, operating voltage, instrument accuracies and resistances, and other resistive sources (e.g., connectors), which vary from circuit to circuit. Since insulation resistance is an inherent property of the insulation material, it can be expressed as a constant value (in per unit length). These insulation resistance values can then be used to analyze the possible effects of leakage currents on instrument circuit accuracy.

Q.19 How frequently was insulation resistance measured during the qualification testing of SHNPP instrument cables?

A.19 (RBM, EJP) At a minimum, insulation resistance was measured prior to testing, after irradiation, and at frequent intervals during the remainder of the design basis accident testing (e.g., pressure, temperature, humidity, chemical spray).

Q.20 (RBM, EJP) Why was insulation resistance not measured during radiation testing?

A.20 (RBM, EJP) Changes in such conditions as pressure, temperature and humidity can affect insulation material in a way which causes fluctuations in insulation resistance during testing. Radiation, however, causes cumulative change in organic cable insulation material. This cumulative change does not result in fluctuations in insulation resistance during testing. Therefore, there is no reason to measure insulation resistance during radiation testing. Insulation resistance measurements made before testing and after irradiation adequately account for any changes in insulation resistance which could affect the accuracy of electrical signals.

Q.21 Does irradiation of instrument cable during qualification testing result in significant decrease in insulation resistance?

A.21 (RMB, EJP) No. For example, in one Samuel Moore thermocouple wire test sample, the insulation resistance before irradiation was $8.75 \times 10^{10}$ ohms per 1000 ft. The insulation resistance after irradiation was $1.75 \times 10^{10}$ ohms per 1000 ft. This value was almost an order of magnitude higher than the minimum allowable insulation resistance for new cable of this type ($3.4 \times 10^{9}$ ohms per 1000 ft ) according to Insulated Cable Engineers Association Standard S-68-516, "Ethylene Propylene Rubber Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy" (1976). Insulation resistance values of these magnitudes indicate negligible leakage currents in the circuit.

Q.22 Have the possible effects of leakage currents on instument circuit accuracy been analyzed for SHNPP instrument cables?

A.22 (RMB, EJP) Ebasco has reviewed insulation resistance values following irradiation for each type of instrument cable used at SHNPP. As discussed above, the potential effects of irradiation on insulation resistance (and therefore leakage currents) are negligible for the SHNPP instrument cables.

In addition, Ebasco currently is performing insulation resistance calculations which will consider, along with the appropriate circuit parameters, the insulation resistance measurements taken during the entire qualification test sequence. The results of the calculations must show that the quality of the instrument signals will not degrade to a point where the instrument may not be capable of performing its safety function. These results will be documented in the individual instrument cable qualification packages.

Q.23 Mr. Bucci and Mr. Pagan, in your opinions, does the environmental qualification of instrument cables at SHNPP "include adequate consideration and analysis of leakage currents resulting from the radiation environment"?

A.23 (RMB, EJP) Yes. Environmental qualification testing was conducted according to the applicable standards. Insulation resistance measurements were taken on aged and irradiated test samples. These insulation resistance values have been reviewed to ensure there will be no adverse effect on the safety functions performed by SHNPP instrument cables as a result of leakage currents caused by radiation.