August 9, 1984

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

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

APPLICANTS' TESTIMONY OF MARGARETA A. SERBANESCU
IN RESPONSE TO EDDLEMAN CONTENTION 116
(FIRE PROTECTION)

Q.1 Please state your name, address, present occupation and employer.

A.1 My name is Margareta A. Serbanescu. My business address is Ebasco Services Incorporated, Two World Trade Center, New York, NY 10048. I am employed by Ebasco Services Incorporated as a Principal Mechanical Engineer responsible for the supervision of the Ebasco Fire Protection Engineering Group. My responsibilities include development of the fire protection program for the Shearon Harris Nuclear Power Plant (SHNPP) project. A copy of my professional experience and qualifications is affixed hereto as Attachment A.

Q.2 State your educational background and professional work experience.

A.2 I am a Principal Engineer with 18 years of mechanical engineering experience, including 11 years of fire protection engineering for both nuclear and fossil power generating stations. My work experience includes engineering and design of various fire protection systems, using diversified suppression agents such as water, carbon dioxide, halon, dry chemical, and foam. My responsibilities have included conceptual design; preparation of system design criteria, flow diagrams, procurement specifications, bid evaluation, and purchase recommendations; vendor and Ebasco-generated drawing input, review and drawing approval; supervision of installation; field verification and support; and turnover of the systems to clients. I have also been involved in negotiations with authorities having jurisdiction over fire protection, such as governmental authorities, local authorities, insurance underwriters and owners. Some of my responsibilities have included preparation of Safety Analysis Reports, Fire Hazards Analyses, and Safe Shutdown Analyses in Case of Fire -- all performed in accordance with various criteria issued by the Nuclear Regulatory Commission (NRC), industry standards, National Fire Protection Association (NFPA) standards and recommended practices. I have provided technical assistance to a client during an NRC "walkdown" of a nuclear power plant's fire protection systems.

Q.3 Describe the professional services that you have provided to Applicants for the operating license for the SHNPP and the degree of involvement that you and your associates at Ebasco have had in the development of the Harris fire protection program.

A.3 Ebasco was retained by Applicants, in conjunction with providing architect-engineering services, to develop the fire protection program for the SHNPP in accordance with NRC regulatory requirements, insurance carrier's guidelines, industry standards and local authorities' requirements. I was assigned as the Fire Protection Engineer for the SHNPP in September 1978. I was involved in the preparation of the Plant Final Safety Analysis Report (FSAR) which included a detailed Fire Hazards Analysis developed from the Preliminary Safety Analysis Report. One year later I was assigned to be Fire Protection Lead Engineer for the SHNPP and was placed in charge of the Plant fire protection program within Ebasco's scope of work. In January 1981 I was promoted to Supervisor of the Ebasco Fire Protection Engineering Group, retaining responsibility for the SHNPP fire protection activities. In this capacity I was involved in the supervision of the fire protection effort within Ebasco's designated scope of work, which included preparation of the Safe Shutdown Analysis in Case of Fire for the SHNPP (SSA), coordination of the interdisciplinary reviews and comment resolution (including Applicants' comments), provision of fire protection features or justifications of deviations from separation criteria prescribed by the NRC, and the complete final report preparation. FSAR Section 9.5.1 and Appendix 9.5A, which describe the SHNPP fire protection program, are Applicants' Exhibit ___; a summary of the SSA is Applicants' Exhibit ___.

Q.4 What is the purpose of your testimony?

A.4 The purpose of my testimony is to address the first five allegations of Eddleman Contention 116, which can be stated as follows:

> (1) "The fire hazard analysis of section 9.5A (Appendix) in the FSAR does not address the availability of control and power to the safety equipment."
>
> (2) "In establishing fire resistance ratings of fire barriers with respect to fires in cable trays, Applicants have not established that qualification tests represent actual plant conditions or comparable conditions."

(3) "Another vague statement is that barriers are used 'where practical' without defining practical or stating the criteria to decide where a fire barrier is or is not practical (and what type of fire barrier is or is not practical). 9.5.1.1.1."

(4) "The 'analysis' of Appendix 9.5A does not demonstrate, as 9.5.1.1.1 claims it will, the adequacy of other fire protection measures in all cases. Rather, it estimates the BTU of combustible material, smoke generation and removal rate from the area, gives usually a qualitative description of some measures to mitigate or reduce fire effects, and assumes that the fire will be promptly detected (usually, no analysis of location of detection instruments, etc.) and the fire brigade will respond rapidly and put out the fire, or the automatic equipment will work. These assertions are made despite the time it takes to get people into the containment and to the fire (not well analyzed). Further, the 'analysis;' of what happens if the fire spreads is generally a rationalization that it can't spread much, not an analysis. See, e.g. 'Analysis of Effects of postulated fires'."

(5) "The effect of a fire in a Fire Area or Fire Zone with a combustible loading greater than 240,000 BTU/sq. ft. doesn't get dealt with in realistic terms."

My testimony demonstrates that these five aspects of the fire protection program for the SHNPP, which have been questioned by Eddleman Contention 116, meet NRC regulations and are consistent with NRC regulatory guidance and NFPA and industry standards, and, therefore, that there is no merit to any of these allegations.

Q.5 What NRC regulations and regulatory guidance are applicable to the fire protection program at the SNHPP?

A.5 The applicable NRC regulations and regulatory guidance for the SHNPP fire protection program are: 10 C.F.R. Part 50 Appendix A, General Design Criteria 3 "Fire Protection"; 10 C.F.R. § 50.48 "Fire Protection"; 10 C.F.R. Part 50 Appendix R, "Fire Protection Program For Nuclear Power Facilities Operating Prior to January 1, 1979"; Regulatory Guide 1.70, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants," Revision 3; NUREG-0800 "Standard Review Plan," Section 9.5-1 - Fire Protection; and Branch Technical Position (BTP) - Chemical Engineering Branch (CMEB) 9.5-1, "Guidelines for Fire Protection for Nuclear Power Plants," dated July 1981.

Q.6 Were all of these regulations and guidance in effect at the time the Harris FSAR was filed with the NRC Staff?

A.6 No. On June 26, 1980 Applicants filed the SHNPP FSAR with the NRC. 10 C.F.R. § 50.48 and Appendix R to Part 50 became effective in February 1981 and NUREG-0800, which included BTP CMEB 9.5-1, was issued in July 1981.

Q.7 What major changes have been made to the SHNPP fire protection program since the FSAR was first drafted?

A.7 Applicants performed an SSA which was submitted to the NRC on July 22, 1983 and was subsequently revised October 11, 1983, February 24, 1984, and June 12, 1984. Applicants have reviewed the SHNPP fire protection program against the requirements of Appendix R to 10 C.F.R. Part 50. As a result of the SSA and Applicants' review of their program against

Appendix R, additional changes were made to the SHNPP design, including the addition of suppression systems, fire barrier wrap of cable tray and conduit and cable rerouting.

Q.8 Eddleman Contention 116 first alleges that the Fire Hazard Analysis in FSAR Appendix 9.5A "does not address availability of control and power to safety equipment." How do you respond to that allegation?

A.8 The Fire Hazards Analysis in FSAR Appendix 9.5A does not directly address availability of control and power cables to safety related equipment. This is done in FSAR Subsection 9.5.1.2.2, "Fire Protection of Cables and Circuitry," FSAR Section 8.3, "Onsite Power Systems" and in Applicants' SSA.

Q.9 How do the above-referenced sections of the FSAR and the SSA demonstrate the availability of control and power to safety equipment necessary to shutdown the reactor in the event of a fire?

A.9 As stated in FSAR Subsection 9.5.1.2.2, safety related cable trays and circuits are isolated or protected from the effects of fire through the use of physical isolation, spatial separation, non-combustible covering, fire prevention through provision of automatic sprinkler systems, or any combination of these methods to ensure the integrity of essential electric circuitry needed during the fire for safe shutdown of the plant and for fire control. In this regard Applicants are complying with the guidelines found in Appendix A to BTP APCSB 9.5-1 and

10 C.F.R. Part 50, Appendix R (unless the NRC permits a deviation from the requirements of Appendix R for a particular situation). Also, as discussed in FSAR Section 8.3, Regulatory Guide 1.75, "Physical Independence of Electrical Systems," was used in the plant design. This regulatory guide addresses methods acceptable to the NRC to ensure physical independence of circuits and electrical equipment which comprise or are associated with certain safety related power and protection systems.

Furthermore, in accordance with Section C.5.6 of BTP CMEB 9.5-1, Applicants performed an SSA, which verifies that fire protection features for structures, systems and components important to safe shutdown, including control and power cables, are protected so that one train of systems necessary to achieve and maintain hot standby conditions from either the Control Room or Emergency Control Station(s) is free of fire damage, and that one train of systems necessary to achieve and maintain cold shutdown within 72 hours from either the Control Room or Emergency Control Station(s) is free of fire damage or can be repaired.

Thus the information that Mr. Eddleman could not find in FSAR Appendix 9.5A is described in other sections of the FSAR and the SSA. It is my understanding that Mr. Eddleman has not to this date identified any specific deficiency in the FSAR and SSA analysis regarding the availability of control and power to safety equipment.

Q.10 The second issue raised by Eddleman Contention 116 is an allegation that "in establishing fire resistance ratings of fire barriers with respect to fires in cable trays, Applicants have not established that qualification tests represent actual plant conditions or comparable conditions." What fire barriers are associated with a fire in a cable tray?

A.10 A fire barrier is a component of construction rated by testing laboratories in hours of resistance to fire which is used to prevent the spread of fire. Each Fire Area in the SHNPP is enclosed with three-hour fire resistance rated barriers. In addition, certain cable trays within a Fire Area are protected by three-hour or one-hour fire resistance rated enclosures (envelopes), as identified in the SSA at Table 9.5B-3. Where a cable tray penetrates a fire barrier, penetration fire seals, having a minimum fire resistance rating at least equivalent to the rating of the fire barrier, are installed as described in FSAR Subsection 9.5.1.2.2.

Q.11 What are the industry standards established for determining the fire resistance rating of a fire barrier?

A.11 The test methods established for determining the fire resistance rating of fire barriers are based on standard fire tests performed in accordance with ASTM E-119, "Standard Test Method for Fire Test of Building Construction and Materials"; NFPA-251, "Standard Methods of Fire Tests of Building Construction and Materials"; Nuclear Mutual Limited (NML), "Property Loss Prevention Standards for Nuclear Generating Stations," Appendix A-14; Underwriters Laboratories (UL) 263 "Fire Tests of Building Construction and Materials"; and American Nuclear Insurers Bulletin No. 5 "Standard Fire Endurance Test Method to Qualify a Protective Envelope for Class IE Electrical Circuits." ASTM E-119 describes methods of measuring and specifying fire resistive properties of materials and assemblies with the exception of ceiling construction and protective combustible framing. Both NFPA-251 and UL 263 are similar to ASTM E-119, but include testing and acceptance criteria for ceiling construction and protective combustible framing. NML Appendix A-14 is a modified IEEE-634 "Standard Cable Penetration Fire Stop Qualification Test." This standard covers tests of penetration fire seals when mounted in rated fire barriers. ANI Bulletin No. 5 describes methods of measuring and specifying fire resistive properties of materials and assemblies used to establish a protective envelope for safety circuits, including redundant safety circuits in the same Fire Area exposed to a fire originating either outside of the cable system or inside the protective envelope and subjected to mechanical impact damage (such as a fire hose stream).

Q.12 Describe the qualification tests associated with the fire barriers with respect to fires in cable trays.

A.12 Tests for cable tray enclosures are described in ANI Bulletin No. 5, excerpts of which are attached to this testimony as Attachment B. Penetration fire seals are tested against the detailed testing requirements and acceptance criteria set forth in NFPA-251, UL 263 and ASTM E-119, described above.

Q.13 How has it been established that the test methods for determining the fire resistance rating represent actual conditions likely to be encountered in the maximum credible fire in any given Fire Area or Fire Zone?

A.13 Test methods for determining the fire resistance rating of a fire barrier are based on an exposure fire represented by the "standard time-temperature curve." The points on the curve that determine its character are:

1000°F (538°C) at 5 min.
1300°F (704°C) at 10 min.
1550°F (843°C) at 30 min.
1700°F (927°C) at 1 hour
1850°F (1010°C) at 2 hours
1925°F (1053°C) at 3 hours
2000°F (1093°C) at 4 hours
2300°F (1260°C) at 8 hours or over

It is not the intent of the tests to simulate actual plant conditions likely to be encountered in the maximum credible fire in any given Fire Area or Fire Zone, but rather, by the use of the standard time-temperature curve, to exceed actual plant conditions by use of the standard common "worst case" exposure fire.

The standard time-temperature curve has been determined empirically to represent a common "worst case" exposure fire. Actual fire tests, conducted by the National Bureau of Standards by burning to destruction a five-story and a two-story brick, wood-joisted building loaded with waste lumber, produced overall results in approximation to the standard time-temperature curve. Additional data were obtained by burning various amounts of materials in two fire resistive buildings. By analysis of the data, a relationship of fuel loading that will produce an exposure equivalent to the standard time-temperature curve for a specific duration has been approximated and reported in Table 6-8A of the National Fire Protection Association's Fire Protection Handbook (14th Edition-1976). For a three-hour period, a combustible load of 240,000 BTU/sq. ft. yields a fire severity approximately equal to that indicative of the standard time-temperature curve over a corresponding period.

The Fire Hazards Analysis presents the combustible load for each plant Fire Area. The combustible loading in all Fire Areas in the SHNPP power block is less than 240,000 BTU/sq. ft. Thus, a fire barrier tested to withstand a fire based on the standard time-temperature curve will resist a fire from the maximum calculated combustible loading in any Fire Area in the SHNPP power block.

Q.14 What independent tests are conducted to ensure that the fire resistance rating of fire barriers for cable trays for the SHNPP meets the established standards?

A.14 Test methods and acceptance criteria are standardized and are detailed in documents such as ASTM E-119, NFPA-251, UL 263, NML Appendix A-14, and ANI Bulletin No. 5 (all mentioned earlier). For each fire barrier for cable trays that will be used in the SHNPP, a qualification test -- in accordance with the test methods and acceptance criteria referenced above -- will be performed on a "generic assembly" of that fire barrier by an independent laboratory. Tests are conducted by independent laboratories such as Underwriters Laboratories, Industrial Testing Laboratories, Southwest Research Institute, and Portland Cement Association on various generic assemblies in accordance with the applicable standards to establish fire ratings. Installation of fire barriers at SHNPP will be in accordance with the testing laboratory recommendations to ensure that the actual installed fire barrier conforms to the configuration of the tested assembly.

Q.15 The third issue raised by Eddleman Contention 116 is that FSAR Section 9.5.1.1.1 contains the "vague statement" that "[fire] barriers are used 'where practical' without defining 'practical' or stating the criteria to decide where a fire barrier is or is not practical (and what type of fire barrier should be used)." How are fire barriers used in the Harris fire protection program?

A.15 Fire barriers are used to separate Fire Areas to reduce the possibility of fire-related damage to redundant safety-related trains of equipment and to isolate safety-related systems from hazards in nonsafety-related areas.

Q.16 How is the determination made as to what the fire resistance rating of each fire barrier should be?

A.16 Fire Areas are bounded by barriers with construction that provide a minimum three-hour fire rating or equivalent, regardless of the combustible loading. In 95% of the Plant Fire Areas, the combustible loading is less than 240,000 BTU/sq. ft. Fire Zones within Fire Areas may be bounded entirely or partially with barriers having a three-hour fire rating or less. As a generally accepted fire protection practice, each combustible fire loading increment of 80,000 BTU's/sq.ft. indicates the need for an additional one hour of fire rating for the barrier. The use of fire barriers in the SHNPP is described in detail in FSAR Section 9.5.1.2.2 and Appendix 9.5A.

Q.17 Are there any circumstances where it has been determined that defined Fire Areas could not "practically" be separated by properly rated fire barriers at SHNPP?

A.17 In one instance a Fire Area is not bounded by a fire barrier on all sides -- the emergency diesel generator rooms have large intake openings required for diesel operation. With that one exception all defined Fire Areas are separated by a properly rated fire barrier.

Q.18 The fourth issue raised by Eddleman Contention 116 is a generalized criticism of Appendix 9.5A of the FSAR, claiming that Applicants have not demonstrated "the adequacy of fire protection measures in all cases." Contention 116 finds fault with the "estimates" of the BTU content of combustible material, smoke generation and removal rates, measures to reduce or mitigate fire effects, detection capability and fire brigade response and effectiveness. In this regard, please describe in general the Fire Hazards Analysis.

A.18 The SHNPP fire protection program has been designed to allow the plant equipment to maintain the ability to perform safe shutdown functions and to minimize radioactive releases to the environment in the event of a fire. The effectiveness of the fire protection program is verified through the Fire Hazards Analysis by evaluation of fire hazards, postulation of realistic potential fires, and assessment of effects of these fires in Fire Areas throughout the plant. The Fire Hazards Analysis is found at FSAR Appendix 9.5A.

The purpose of the Fire Hazards Analysis is to demonstrate that fire protection measures, suitable for control of the area hazards, have been provided. In performing the analysis, the following considerations were addressed: spread of fire; potential extent of damage to essential equipment, loss of safety function, and/or radiological release to the environment; containment of the fire and its consequences within the considered Fire Area, and/or effect on other Fire Areas; provision of detectors to sense area fire or smoke conditions for prompt fire control response; effective use of manual fire control equipment and backup systems; smoke removal to permit personnel to enter the Fire Area, assess the fire condition, and use manual equipment; effects of smoke and heat damage from the postulated fire on required operation of essential equipment in the area; protection of redundant systems, equipment or trains, if located in the same Fire Area, to maintain operability; and separation or isolation of redundant equipment.

The Fire Hazards Analysis for the SHNPP demonstrates that adequate fire protection measures are available in each Fire Area or Fire Zone analyzed. I disagree with the fourth issue raised by Eddleman Contention 116 because the combustible loading for each Fire Area is estimated conservatively; the smoke removal rates are based on NRC recommendations; the measures to reduce or mitigate fire effects are described in considerable detail and are of demonstrated effectiveness; and fire detectors to be utilized are proven designs. As discussed in Applicants' Testimony of David B. Waters, the fire brigade will be well-trained, adequate in numbers and well-equipped to fight fires.

Q.19 You have referred to Fire Areas a number of times in your testimony. How are Fire Areas defined?

A.19 The Fire Areas were established based on the nature of occupancy of the plant space, the amount and distribution of combustible materials within the area, and the location of safety-related systems and equipment. Areas important to the Plant's capability for safe shutdown, such as electrical penetration areas, cable spreading rooms, diesel generator areas, switchgear and battery rooms, were designated as Fire Areas. Other Plant areas were designated as Fire Zones within the Fire Areas to facilitate the Fire Hazards Analysis and to ensure adequate fire protection features are distributed within a Fire Area as required by potential hazards present in each Fire Zone.

Each Fire Area is bounded by barriers with construction that provide a minimum three-hour fire rating (with the one exception of the emergency diesel generator rooms, described previously).

For each designated Fire Area, the Fire Hazards Analysis evaluates separately the occupancy, boundaries, combustible loading, control of hazards, fire detection, access and initial response, fire suppression systems, Fire Area fire fighting equipment, and the effects of postulated fires.

Q.20 How is the combustible loading of a Fire Area determined?

A.20 The severity of fire that may develop and the damage that may result in the most extreme case in a Fire Area is a function of the amount of combustibles present and the total heat of combustion generated. As combustibles in an area are not point-source concentrated, a more realistic measure of the relative fire hazard or exposure to fire damage of an area is determined by spreading this combustible loading over the floor area of the space or, in the case of a localized concentration of combustibles, over the floor area within the sphere of influence of the postulated fire.

The configuration of fire loading varies from area to area. Some areas are devoid, or essentially so, of combustible materials; other areas contain one or more localized fuel concentrations, spatially separated from each other. A localized concentration of combustible material is delineated by finite parameters beyond which the fire loading is sharply reduced. Examples of local fuel concentrations considered include cable insulation in Motor Control Center units or electrical cabinets, charcoal beds in filter housings, oil in equipment reservoirs, waste materials in containers or on skids, and similar items. Linear concentrations of combustibles are usually associated with cable trays either solely within the Fire Area or extending through several Fire Areas by penetration of intervening fire barrier walls.

To simplify the calculation of area combustible loadings, conservative calorific values, based on the <u>Fire Protection Handbook</u>, were adopted for classes of combustible materials which were representative of heat values of specific materials grouped within the class. These include:

Ordinary Combustibles	8,000 BTU/lb.
Combustible or Flammable Liquids	20,000 BTU/lb. (108,000 BTU/gal.)
Charcoal	10,000 BTU/lb.

(Combustible loading for minor amounts of grease, integral with equipment, not exceeding one pound each, was not inventoried since it does not create a significant fire hazard.) Using manufacturer's data on cable construction of typical cables used in SHNPP and the BTU content of the insulation materials, BTU values were derived for each running foot (RF) of 24 in. wide cable trays, as follows:

Power	180,000 BTU/RF
Control	157,000 BTU/RF
Instrumentation	95,000 BTU/RF

These values were adjusted proportionally for trays of different widths. All cable trays were considered to be 40% loaded, the maximum design loading of a cable tray.

The combustible loading for all cables routed in conduit, cast concrete trenches, or contained within metallic cabinets or consoles was not inventoried since they do not create a fire hazard, as recognized by good fire protection engineering practice.

In addition to the combustibles normally present in an area, an inventory of "transient" combustibles which might realistically be introduced into areas as a part of planned operation was incorporated in the Fire Hazards Analysis for each Fire Area and Fire Zone. In most cases, the introduction of transient combustible materials into areas where such material may expose safety-related equipment will coincide with scheduled station maintenance. Combustible materials that may be introduced in quantities sufficient to require special attention include: construction materials, such as scaffolding, shoring, forms, etc (although in the power block such materials will be limited to fire retardant wood); resins in bulk quantities and associated packaging materials; charcoal; combustible liquids, such as lubricating oils and paints; grease (oil in solid state); plastic bags and protective sheeting; packaging materials and containers, such as plastics, wood, paper, etc; flammable liquids and gases, such as solvents and volatile fuels; rags; and anti-contamination clothing.

The quantity, movement, use and handling of all such materials as well as the provision of supplemental fire protection measures are administratively controlled in the plant through written procedures. For this reason, the fire loss exposure resulting from the addition of transient combustibles in an area during these periods of increased plant surveillance, strict procedural control and augmented area manning has been considered as being no greater than that from the inventories of nontransient combustibles normally present in each area, except for the periods of major plant outages.

After the conservative inventory of all combustible materials in a Fire Area, total BTU and BTU per sq. ft. values were calculated and then summed to indicate the total combustible fire loading for the Fire Area. The calculated combustible fire loading of a Fire Area was then used to compare the area fire hazard relative to those of other Fire Areas, to judge the adequacy of the area boundary fire barriers, and to verify the proper selection of adequate fire control and suppression systems and equipment.

Q.21 What conservatisms are built into this analytical process?

A.21 In determining the hourly rating of fire barriers in the SHNPP power block, complete combustion of all combustibles is assumed and no credit is taken for the lack of continuity of combustibles. Nor is it assumed that automatic or manual fire suppression systems will limit the extent of a fire. A fire barrier hourly rating is selected for a combustible loading in excess of that determined in the conservative calculation.

Q.22 Are smoke generation and removal rates "estimated" in the Fire Hazards Analysis as alledged in Contention 116?

A.22 No. Smoke generation rate is not estimated; there are too many variables to determine what an average or even worse case smoke generation rate should be. Nor is smoke removal rate "estimated." It is assumed to be 1.5 cfm/sq.ft. of floor area for the most severe combustible loaded area in the power block (cable spreading area) based on the capability of the HVAC system. This is consistent with BTP APCSB 9.5-1, Appendix A. Where less than the most severe combustible loading is present, a minimum assumed smoke removal rate is obtained by dividing the combustible load of the analyzed Fire Area by that maximum loading and multiplying by 1.5 cfm/sq.ft. to obtain the proportional cfm/sq.ft. required. This may be considerably less than the actual capability of the HVAC system.

Q.23 What measures are incorporated into the fire protection program "to reduce or mitigate fire effects?"

A.23 A number of defense-in-depth passive and active fire protection features/measures have been provided to reduce the fire effects on the Plant safe shutdown in case of fire and fire damage to all Plant areas. These measures include limitation of the amount of transient combustible materials, utilization of fire-resistive construction, provision of firebreaks and fire penetration seals in cable trays, utilization of IEEE 383 cable (which has a low fire propogation rate), and installation of fire detection systems and automatic fire extinguishing systems. These measures follow the fire protection guidelines issued by NRC and are described in the Fire Hazards Analysis and in the SSA in detail -- not just in a "qualitative" manner as alleged in Contention 116. The Fire Hazard Analysis constitutes a realistic and thorough assessment of the nature of fires, the effects of fires and the ability to control fire in the various Fire Areas of the SHNPP.

Q.24 What fire detection systems are provided for each Fire Area?

A.24 Three different types of fire detectors will be used in the SHNPP: ionization detectors, thermal detectors and ultraviolet flame detectors.

Ionization detectors utilize a small amount of radioactive material which ionizes the air in a sensing chamber, thus rendering it conductive and permitting a current flow through the air between two charged electrodes. This gives the sensing chamber an effective electrical conductance. When smoke particles enter the ionization area, the conductance of the air is decreased because the smoke particles attach themselves to ions causing a reduction in mobility. When the conductance is less than a predetermined level, the detector responds.

Thermal detectors operate on the rate of rise/fixed temperature principle. Thermal detectors respond when the temperature rises at a rate exceeding a predetermined amount or reaches a temperature set-point. Thermal detectors are an integral part of the fire suppression system and actuate sprinkler systems when a fire is detected.

Ultraviolet flame detectors use a Geiger-Mueller gas type cathode tube designed to detect flame radiated rays at the extreme low end of the radiation spectrum.

The Fire Hazards Analysis of each Fire Area discusses the types of fire detectors in each area.

Q.25 How were these detection systems selected?

A.25 The SHNPP detection systems were selected to optimize early warning of a fire condition in its incipient stage and thus to ensure timely fire brigade response. For this reason ionization type smoke detectors were selected as the principal detection system. These detectors respond to the first traces of fire in the form of visible smoke or invisible products of combustion. Heat or flame is not required to activate the detector.

In locations additionally protected with automatic water-type suppression systems utilizing temperature actuated fusible link sprinklers and dry piping (preaction and multi-cycle) sprinkler systems, thermal detectors are used to initiate actuation of the suppression system. These detectors have a temperature set-point approximately 30°F above environmental conditions to preclude inadvertent operation, but below the temperature required to open the fusible link sprinklers. Thus, the detectors will alarm and initiate suppression system actuation, allowing water into the system piping before any sprinklers open to discharge water on the fire.

For several specific applications such as the diesel generator building and the fuel oil pump area, ultraviolet flame detectors are utilized. These detectors are used primarily where anticipated fires will develop quickly with little or no incipient or smoldering stage and where ignition is almost instantaneous.

Q.26 What provisions are made for the SHNPP response to a fire?

A.26 A trained fire brigade will be available on each shift to respond to any fire event. A fire brigade response time of approximately 5-15 minutes is expected for most fire events within the power block. The SHNPP fire brigade, its capabilities and its training are described in Applicants' Testimony of David B. Waters.

Q.27 What automatic fire suppression systems have been provided in SHNPP?

A.27 Wet pipe sprinkler systems are the basic industrial automatic water suppression systems. This type of system utilizes water-filled piping with closed sprinkler nozzles which open one at a time when subjected to a predetermined temperature through the use of fusible links. Where the area protected by an automatic suppression system contains equipment that could be damaged by inadvertent activation of sprinklers, variations in the wet pipe sprinkler system have been developed with applications in nuclear plants. The automatic suppression systems that will be installed in the SHNPP include the following:

1. <u>Pre-Action Sprinkler Systems</u>

The pre-action sprinkler system consists of the same pipe and sprinkler arrangement as the wet pipe system, except that normally the sprinkler pipes contain no water and an electro-mechanical valve is inserted in the water supply pipe to the system. A two-step release mechanism is employed to preclude inadvertent operation or water discharge due to mechanical damage to the piping system. Thus, under non-fire conditions, mechanical damage to the piping system would not result in water discharge since the electro-mechanical valve would not have opened. Under fire conditions, thermal fire detectors sense the condition and electrically signal the electro-mechanical valve to open. This permits water to pass into the sprinkler piping before a temperature sufficient to open the fusible link sprinklers is reached. The system, in this mode, is now the basic wet pipe sprinkler system awaiting a temperature increase from the developing fire to initiate sprinkler water discharge.

This system will be installed in the areas shown in FSAR Table 9.5.1-3, which are primarily cable loaded areas and ordinary combustible loaded areas where general sprinkler coverage on an area-wide basis is provided.

2. <u>Multi-cycle Sprinkler Systems</u>

The multi-cycle sprinkler system acts in the same fashion as the pre-action system up to the point water is discharged from sprinklers. After activation, when the thermal fire detector senses a sufficient reduction in ambient temperature indicating that the fire has been suppressed, a signal is transmitted to shut the electro-mechanical valve and stop the flow of water. The system continues to function in an on/off cyclical mode as dictated by high or reduced temperature sensed by the detectors. This added feature results in a much reduced overall discharge in volume of water as compared to the wet or pre-action systems and is used primarily in areas where considerations other than fire protection indicate an advantage to reducing the overall quantity of water which must be disposed of after fire suppression has occurred. Multi-cycle sprinkler systems are installed in the areas shown in FSAR Table 9.5.1-4, including containment, diesel generator day tank enclosures and diesel oil pump rooms.

3. Water Spray Systems

The water spray system is designed and acts in a fashion similar to the pre-action system, except that open spray nozzles or sprinklers are utilized in lieu of closed, fusible link activated sprinklers. This provides for immediate water discharge on the entire protected area when the system is activated by thermal detectors. This immediate deluge is advantageous in quickly suppressing fires with a potential for rapid spread or rapid development of high heat release. Water spray systems are used to protect areas in the vicinity of certain equipment and transformers as detailed in FSAR Table 9.5.1-5.

Q.28 What design considerations went into the establishment of the fire suppression systems?

A.28 The type, coverage, actuation and supervision of fire suppression systems provided in each Fire Are . is described in the Fire Hazards Analysis. The role of automatic suppression is to ensure suppression and to extinguish a fire condition, regardless of the fire brigade response, where considerable combustible loading is present. The selection of the particular fire suppression system, mode of operation and performance criteria is based on the fire hazards found in the area, the realistic fire expected and the overall fire control approach utilized for containment of the fire.

Q.29 What additional fire fighting capability has been provided for use by the fire brigade?

A.29 Each area of the SHNPP can be reached by at least two fire hose streams. In addition, there will be a fire engine on site ready to respond immediately to a fire event. The capability of the fire brigade is discussed in more detail in Applicants' Testimony of David B. Waters.

Q.30 In summary what does the Fire Hazards Analysis demonstrate regarding the potential effects of a fire at the SHNPP?

A.30 The Fire Hazards Analysis verifies the effectiveness of the fire protection program by evaluation of fire hazards, postulation of realistic potential fires, assessment of Plant response to a fire and the effects of fires in Fire Areas throughout the Plant. The Fire Hazards Analysis provides assurance that fire protection facilities, suitable for control of the area hazards, have been provided. In summary, the Fire Hazards Analysis demonstrates that the SHNPP can safely shutdown the reactor, maintain it in a safe shutdown mode and minimize radioactive releases to the environment even in the event of a fire.

Q.31 The fifth issue raised by Eddleman Contention 116 is an allegation that "the effect of a fire in a Fire Area or Fire Zone with a combustible loading greater than 240,000 BTU/sq. ft. doesn't get dealt with in realistic terms." Is there any Fire Area or Fire Zone in the Harris Plant with a combustible loading greater than 240,000 BTU/sq. ft?

A.31 Yes. Two Diesel Generator Fuel Oil Day Tank Enclosures (Fire Areas 1-D-DTA and 1-D-DTB), each have a combustible loading of 2,920,000 BTU/sq. ft. (assuming total combustion of 3,000 gallons of diesel oil); Diesel Fuel Oil Storage Tanks A and B (Fire Areas 12-D-TA and 12-D-TB) each have a combustible loading of 17,500,000 BTU/sq. ft. (assuming total combustion of 175,000 gallons of diesel oil). For this calculation No. 2 diesel fuel oil with a BTU/gal. value of 140,000 is assumed.

Q.32 What provisions are made to deal with a postulated fire in the diesel fuel oil day tank enclosures?

A.32 The diesel fuel oil day tank enclosures are each isolated from other Fire Areas by three hour rated concrete fire walls. Although the calculated combustible loading of the enclosures are greater than 240,000 BTU/sq. ft., this calculated loading is extremely conservative since it is based on the total volume of oil in the enclosure. The only realistic way to postulate combustion of the volume of oil in the fuel oil day tank is attendant to a rupture of the tank. The diesel fuel oil day tank is a safety class 3, Seismic Category I component which is designed to remain functional after a Safe Shutdown Earthquake. NRC regulatory guidance in the Standard Review Plan (NUREG-0800, Section 9.5.1 BTP CMEB 9.5-1 ¶ C.1.b) provides that "worst case" fires need not be postulated to be simultaneous with nonfire-related failures in safety systems, plant accidents, or the most severe natural phenomena. Even in the highly unlikely event of a rupture of the diesel fuel oil day tank followed by combustion, only a thin layer of oil would actually be ignited in a fire. Furthermore in the event of fire, an automatic multi-cycle sprinkler system would be actuated by thermal detectors to cool the oil below the ignition point. If the thermal detectors or the valve automatic release failed to operate, the sprinkler system could be actuated manually. Finally, automatic fusible link fire dampers are provided to the diesel fuel oil day tank enclosures to limit the amount of air available to support continued combustion. All of these design features in combination provide assurance that in the highly unlikely event of a postulated fire in the diesel fuel oil day tank enclosures, the fire will be quickly contained.

Q.33 What provisions are made to deal with a postulated fire in the diesel fuel oil storage tanks?

A.33 Diesel fuel oil storage tanks A and B are installed underground in the yard area of the SHNPP, over 175 feet from principal plant structures. The tanks are constructed of reinforced concrete designed to Seismic Category I requirements and are lined with steel. The only access to the tanks is by a reinforced concrete hatch. Each tank vent is supplied with a flame arrestor to prevent flash-back of a flame into the tank. Yard hydrants are located adjacent to the area to fight a fire. For the reasons discussed above with respect to the diesel fuel oil day tanks, a fire in the diesel fuel oil storage tanks is extremely remote. However, in the unlikely event of a fire, the physical location of the tanks away from plant structures preclude any potential impact to safety related systems. The emergency diesel operation would not be impacted by a fire in the diesel fuel oil storage tanks since the day tanks contain enough diesel oil to operate the emergency diesels.

Q.34 In your professional opinion are these measures adequate to protect the SHNPP in the event of a fire in the diesel fuel oil day tank enclosure or diesel fuel oil storage tanks?

A.34 Yes.

Q.35 In conclusion, is the SHNPP fire protection program adequate to protect the public health and safety?

A.35 Yes.

Q.36 Please summarize the principal reasons for your confidence in the efficacy of the Harris fire protection program.

A.36 I have confidence in the efficacy of the SHNPP fire protection program because of the "defense in depth" concept that has been used in the development of the program to ensure:

a) prevention of fire initiation through the control, separation and guarding of sources of ignition;

b) prompt detection of fires or incipient fire conditions in areas containing safety related equipment or in areas of high combustible loading which may expose safety related equipment;

c) effective suppression of fires to limit consequent damage and to reduce exposure to safety related equipment;

d) confinement of fires to their areas of initiation by provision of fire barriers, spatial separation and segregation of combustibles; and

e) separation of redundant safety related equipment to maintain operational capability under postulated fire conditions.

A rigorous Fire Hazards Analysis was conducted to verify the efficacy of the fire protection program. A SSA was subsequently performed using even more stringent criteria than the Fire Hazards Analysis. The results of the Fire Hazards Analysis and the SSA demonstrate that safe shutdown of the Plant is assured even in the event of a fire. Applicants have adopted administrative controls, fire fighting procedures, fire brigade training and measures for fire protection that supplement the fire protection design features and provide added confidence in the SHNPP fire protection program.

MARGARETA A. SERBANESCU

Principal Engineer

EXPERIENCE SUMMARY

Principal Mechanical Engineer with 19 years diversified experience in engineering and design of fire protection, plumbing, HVAC and waste treatment/water pollution control systems of fossil and nuclear fueled electric generating stations and industrial projects including administrative and/or technical supervision of fire protection engineers, mechanical and/or buildings engineering designers. Responsibilities included developing fire protection, plumbing and other mechanical water system designs and basic design criteria. Prepared system flow diagrams, calculations, input criteria for physical design drawings, economic analysis of equipment options, procurement specifications, purchase requisitions, bid evaluations, equipment selection studies and purchase recommendations. Supervised equipment installation, engineering coordination with other engineering disciplines, clients and authorities having jurisdiction. As senior engineer, was assigned as Lead Fire Protection Engineer and was responsible for the design of an entire nuclear power plant fire protection system/program including licensing support, manpower planning and coordination with other project areas. Prepared preliminary, final and special safety analysis reports for nuclear fueled electric generation stations.

As Principal Engineer continued as Lead Fire Protection Engineer responsible for nuclear plant fire protection systems and programs, and prepared company fire protection standards. In January of 1981 was assigned to supervise the Fire Protection Engineering group and was responsible for technical and administrative fire protection engineering operations. Supervised engineering, design and other activities on fire protection systems for all nuclear and fossil projects in Ebasco's corporate offices, responsible for the development of company fire protection technical standards and standard specifications. Ensured these activities were performed in an efficient and timely manner, in accordance with company procedures/guides to provide a high quality product.

REPRESENTATIVE EXPERIENCE

Client	Project	Size	Fuel
Carolina Power & Light Company	Shearon Harris Nuclear Power Plant Westinghouse Pressurized Water Reactor Unit	900 MW	Nuclear
Louisiana Power & Light Company	Waterford SES Unit No. 3 Combustion Engineering Pressurized Water Reactor Unit	1165 MW	Nuclear

MARGARETA A. SERBANESCU

REPRESENTATIVE EXPERIENCE (Cont'd)

Client	Project	Size	Fuel
Washington Public Power Supply System	WPPSS Unit No. 3 Combustion Engineering Pressurized Water Reactor	1300 MW	Nuclear
Taiwan Power Company	Chin-Shan Unit Nos. 1 & 2 GE Boiling Water Reactor Units	600 MW ea	Nuclear
Carolina Power & Light Company	Shearon Harris Nuclear Power Plant Units 1 & 2 Westinghouse Pressurized Water Reactor Units	900 MW ea	Nuclear
Iowa Public Service Company	G Neal Unit No. 4	576 MW	Coal
Houston Lighting & Power Company	Allens Creek Nuclear Generating No. 1 General Electric Boiling Water Re-actor Unit	1200 MW	Nuclear
	Limestone Electric Generating Station Unit Nos. 1 & 2	750 MW ea	Lignite
Orange and Rockland Utilities Inc.	Lovett Station Coal Conversion Unit Nos. 4 & 5	200 MW ea	Coal
Florida Power & & Light Co.	St Lucie Power Plant Unit No. 1 and	890 MW	Nuclear
	St Lucie Power Plant Unit No. 2 Combustion Engi-neering Pressurized Water Reactors	690 MW	Nuclear

MARGARETA A SERBANESCU

REPRESENTATIVE EXPERIENCE (Cont'd)

Client	Project	Size	Fuel
Comision Federal de Electricidad de Mexico	Laguna Verde Power Plant Unit Nos. 1 & 2 General Electric Boiling Water Reactor Reactor	675 MW ea	Nuclear
Consolidated Edison Company of New York	Arthur Kill Unit Nos. 2 & 3	200 MW/ 300 MW Respectively	Oil to Coal Re-conversion
Knolls Atomic Power Laboratory	Knolls Facilities Modification Program	-	Nuclear
Clark Oil and Refining Corp.	Feasibility Study of Producing Gasoline from Coal	-	Synthetic
Arkansas Power & Light Co.	Coal to Medium Btu Gas	-	Synthetic
HNG Synfuels Company, Texas Inc.	The River Plant Coal to Methanol	-	Synthetic
Virginia Electric and Power Co.	Surry Unit Nos. 3 & 4 Babcock & Wilcox Pressurized Water Reactor Units	950 MW ea	Nuclear
Power Authority of the State of New York	Astoria Unit No. 6	830 MW	Oil
	Greene County Nuclear Power Plant Babcock & Wilcox Pressurized Water Reactor Unit	1300 MW	Nuclear
Electra de Viesgo, SA Spain	Santillan Nuclear Power Plant	1100 MW	Nuclear

MARGARETA A. SERBANESCU

REPRESENTATIVE EXPERIENCE (Cont'd)

Client	Project	Size	Fuel
People's Republic of China	Shiheng Power Plant	300 MW	Coal
	Huai-Nan Power Plant	600 MW	Coal
Ebasco	Nuclear Standardization Programs GE Boiling Water Reactor Unit, Combustion Engineering Pressurized Water Reactor Unit, Westinghouse Pressurized Water Reactor Unit	1200 MW	Nuclear
Ebasco	Coal-Fired Reference Plants	400 MW 600 MW 800 MW	Coal Coal Coal

EMPLOYMENT HISTORY

Ebasco Services Incorporated, New York, NY; 1978-Present

o	Principal Engineer	- Supervisory Function,	1/81-Present
		- Lead Engineer	7/80-1/81
o	Senior Engineer	- Lead Engineer	1/79-7/80
		- Support Engineer	7/78-12/78

Stone and Webster Engineering Corporation, New York, NY; 1973-1978

- o Engineer in Power

Hydrotechnic Corporation, New York, NY; 1969-1973

- o Mechanical Design Engineer

Spotnails, Incorporated, New York, NY; 1966-1969

- o Mechanical Draftsman - Designer

Interzoo, Caserta, Italy; 1965-1966

MARGARETA A. SERBANESCU

EDUCATION

Polytechnic Institute of Bucharest, Master of Mechanical Engineering - 1965

Trane Educational Division, Trane Air Conditioning Clinic - Completed Course

PROFESSIONAL AFFILIATIONS

National Fire Protection Association - Member

(Excerpts from ANI Bulletin No. 5)

2.1 SCOPE & PURPOSE

2.1 The purpose of this test is to qualify for insurance purposes a Protective Envelope for Redundant Class 1E Cables in Nuclear Power Plants when located in the same fire area. (A fire area is defined as that portion of a building that is encompassed by rated fire walls, ceilings and floors.) The maintenance of circuit integrity in these Class 1E safety circuits during a postulated fire is of prime importance.

2.2 The intent of this Test Method is to establish a protective envelope that maintains circuit integrity for safety circuits when:

---Redundant safety circuits, located in the same fire area, are exposed to a fire outside of the cable system, or

---Redundant safety circuits, located in the same fire area, are exposed by a fire originating in an adjacent "protected-in-place" cable system, or

---Redundant safety circuits, located in the same fire area, are subjected to mechanical impact damage as simulated by a hose stream, or other impact test.

3.0 ACCEPTANCE CRITERIA

ANI/MAERP Acceptance will be based on the completion and review of all of the following:

3.1 Successful passage of fire tests, as outlined in Section 3.4 of this test method, and submittal of necessary test documentation as prepared by a recognized testing laboratory or consultant.

3.2 A Quality Control/Quality Assurance Program for the system/design should be submitted for review. Complete details covering installation procedures, physical characteristics, identification methods, sample forms for third party sign-off, etc. should be included.

The QC/QA Program is considered an integral part of the acceptance process and variations between the QC/QA Program for the test and the program developed for the actual installation will not be acceptable.

3.3 All materials and components in the completed system, with the exception of the cable, shall be rated as non-combustible i.e., Flame Spread, Fuel Contributed, and Smoke Developed ratings of 25 or less.

Materials or components that are combustible or hazardous during the installation phase, should have a material hazard analysis performed with procedures developed for quantities on hand, storage practices, and precautions to be taken during installation.

3.4 The Cable Protective Envelope shall be exposed to the following fire endurance and hose stream tests. Test configuration and details should be submitted for review and comment prior to test.

3.4.1 Test I - Exposure Fire - The Protective Envelope shall be exposed to the standard temperature-time curve found in ASTM E-119-76 (ANSI A2.1) for a minimum of one hour. Sketch # 1 outlines a suggested test configuration.

3.4.2 Hose Stream Test - Immediately following Test I, accessible surfaces of the Protective Envelope shall be subjected to one of the following hose stream tests. The hose stream shall be applied for a minimum of 2 1/2 minutes, without de-energizing the circuits. PROPER SAFETY PRECAUTIONS SHALL BE EXERCISED. One of the following tests shall be used:

1. The stream shall be delivered through a 2 1/2 inch national standard playpipe equipped with 1 1/8 inch tip, nozzle pressure of 30 psi, located 20 feet from the system.

or

2. The stream shall be delivered through a 1 1/2 inch nozzle set at a discharge angle of 30° with a nozzle pressure of 75 psi and a minimum discharge of 75 gpm with the tip of the nozzle a maximum of 5 ft. from the system.

or

3. The stream shall be delivered through a 1 1/2 inch nozzle set at a discharge angle of 15° with a nozzle pressure of 75 psi and a minimum discharge of 75 gpm with the tip of the nozzle a maximum of 10 ft. from the system.

NOTE: #1 is the preferred test.

3.4.3 Test II - Internal Fire - For systems/designs that require heat to activate the Protective Envelope, the system shall also be subjected to Test II - Internal Fire. Sketch #2 outlines a suggested test configuration.

3.4.4 Cable Construction & Test Details

3.4.4.1 Cables shall be energized for circuit monitoring during Test Method I. For the purpose of this test method, "energized" means sufficient current to monitor failure.

3.4.4.2 Cable constructions shall be representative of cable used at the site. Cable tray loadings shall be in accordance with suggested test layouts.

3.4.4.3 In both test methods, cable tray construction shall be representative of actual site conditions, where applicable.

3.4.4.4 Cable system supports shall be those currently found in nuclear power plants and follow accepted installation procedures. Care should be exercised in using only supports that are necessary for the test. Supports that are used for the Protective Envelope shall be part of the final installed design.

3.4.4.5 Thermocouples shall be located strategically on the surface and at one foot intervals in the cable system and temperatures recorded throughout the test.

3.4.4.6 Fire stops or breaks, if used, shall be acceptable to American Nuclear Insurers. Failure of the fire stop or break shall not necessarily constitute a failure of the the Protective Envelope.

3.5 The tests shall be constituted a failure if any of the following occur:

1. Circuits fail or fault during the fire test as required in Test I or fail during the hose stream test.

2. Cotton waste in Test II ignites during the test period.

3.6 The minimum fire endurance rating acceptable for Test I shall be one hour. If longer ratings are desired, they shall be in one hour increments, such as 2 hr. and 3 hr. ratings.

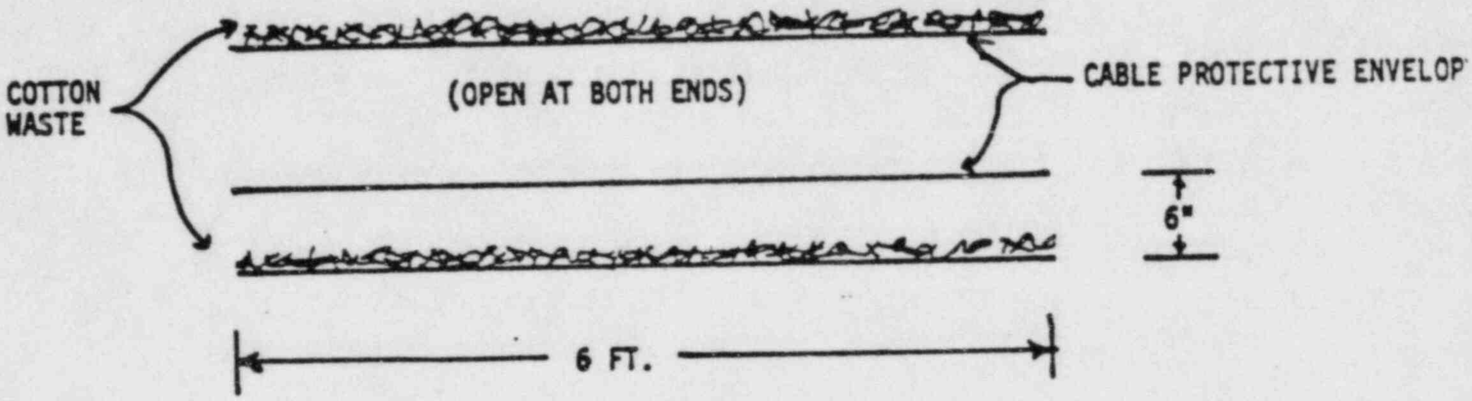
4.0 FINAL ACCEPTANCE

Prior to any installation at plants insured by American Nuclear Insurers, or Mutual Atomic Energy Reinsurance Pool, complete plans outlining system to be installed, location, etc. shall be submitted for review and acceptance.

JULY, 1979

SUGGESTED TEST LAYOUT - TEST METHOD 2

INTERNAL FIRE TEST



NOTE 1: COTTON WASTE SHALL BE PLACED OVER THE ENTIRE TOP SURFACE OF THE TEST SYSTEM AND A SAMPLE SYSTEM 6 INCHES BELOW THE TEST SYSTEM.

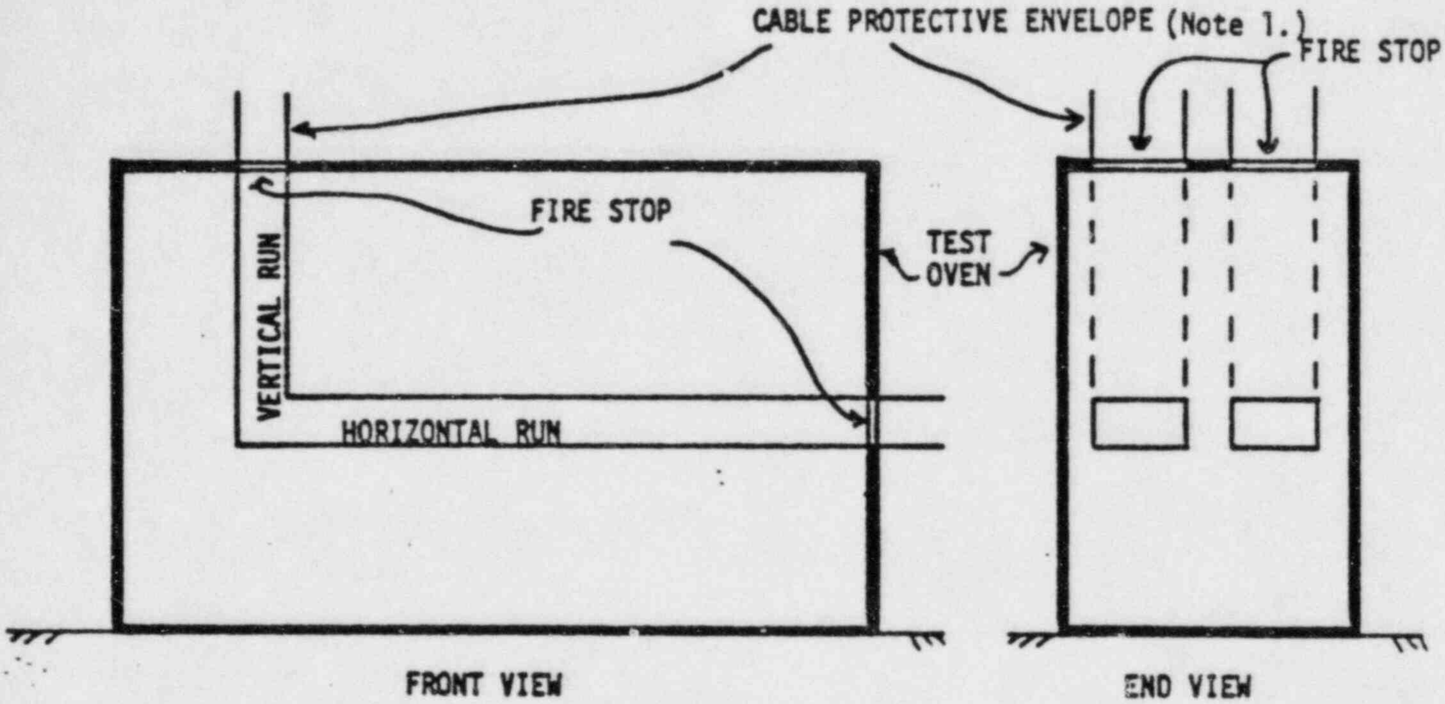
NOTE 2: THE CABLES USED IN THE TEST SHALL BE REPRESENTATIVE OF THE CABLE USED AT THE SITE. LOADINGS SHOULD BE 20% FILL WITH RANDOM LAY.

THE CABLES IN THE TRAY SHALL BE IGNITED USING THE "OIL SOAKED BURLAP" METHOD AS OUTLINED IN IEEE/ICC/WG 12-32, DATED 6/27/73, OR OTHER ACCEPTABLE "FLAME SOURCE", DEPENDING ON DESIGN AND OPERATING CONDITIONS OF THE COATING. THE FLAME SOURCE SHALL BE LOCATED AT THE MID-POINT OF THE CABLE SYSTEM. THE INTENT BEING TO PROVIDE AN IGNITION/FLAME SOURCE THAT IS DESIGNED TO LAST APPROXIMATELY 20 MINUTES AND ACTIVATE THE PROTECTIVE ENVELOPE.

OBSERVATIONS AND THERMOCOUPLE READINGS SHALL BE MAINTAINED FOR ONE HOUR FROM THE POINT OF IGNITION OF THE "FLAME SOURCE".

SUGGESTED TEST LAYOUT - TEST METHOD 1

EXPOSURE FIRE TEST



(NO SCALE)

NOTE 1: TWO PROTECTIVE ENVELOPES TO BE TESTED. ONE LOADED TO MAXIMUM (40%) DESIGN AND ONE LIGHTLY LOADED.(ONE LAYER).

SUFFICIENT CIRCUITS TO BE MONITORED TO DETECT FAILURE; CIRCUIT TO CIRCUIT, CIRCUIT TO SYSTEM, OR CIRCUIT TO GROUND.

VARIOUS TYPES OF CABLE; SUCH AS POWER, CONTROL AND INSTRUMENTATION.

CABLE SHOULD NOT EXTEND MORE THAN THREE FEET OUTSIDE THE TEST OVEN.

NOTE 2: DUE TO FURNACE DESIGN, IT MAY BE NECESSARY TO ENTER AND EXIT THE FURNACE ON THE TOP OR THE SIDE.