UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
CAROLINA POWER & LIGHT COMPANY AND NORTH CAROLINA EASTERN MUNICIPAL POWER AGENCY	)	Docket Nos. 50-400 OL 50-401 OL
	)	
(Shearon Harris Nuclear Power Plant, Units 1 and 2)	)	

AFFIDAVIT OF STEPHEN A. BROWNE

County of Wake	)	
	)	SS:
State of North Carolina	)	

Stephen A. Browne, being duly sworn according to law, deposes and says as follows:

1. I am employed by Carolina Power & Light Company ("CP&L") as a Project Specialist - Health Physics. In this position I am responsible for the technical direction of the personnel dosimetry program for all CP&L nuclear plants. My business address is: Shearon Harris Energy & Environmental Center, Route 1, Box 327, New Hill, North Carolina 27562. A summary of my professional experience and qualifications is contained in Attachment A to this affidavit. For the last eight years I have been directly involved with the supervision and direction of dosimetry programs using thermoluminescent

dosimeter (TLD) systems manufactured by Harshaw, Teledyne and Panasonic, which are the major manufacturers of TLD systems used in the United States today. Recently I have been asked by the National Bureau of Standards (NBS) to consult as a technical expert in assessing and evaluating personnel radiation dosimetry processors under the National Voluntary Laboratory Accreditation Program. I have personal knowledge of the matters stated herein and I make this affidavit in support of Applicants' Motion for Summary Disposition of Joint Intervenors' Contention IV.

2. In this affidavit I will discuss the issues of TLD accuracy and real-time monitoring capability. I will describe the major elements of Applicants' exposure control and personnel dosimetry systems and show how together they provide accurate and timely information to assure worker safety and health. I will discuss certain fundamental dosimetry principles and concepts and point out how they relate to the Joint Intervenors' contention and responses to interrogatories. I will relate Applicants' proposed programs to applicable regulatory requirements, standards, the state-of-the-art, and accepted practice in the nuclear power industry. Finally, I will show why the Joint Intervenors' recommendation to use portable pressurized ionization monitors to corroborate TLD readings is not practical.

3. When a worker is exposed to a radiation field there is a complex relationship between the source of radiation and

the dose received by the individual at a specific point in the body. Some of the factors involved include the type and energy of the radiation, variation of the dose rate in the work area with location and time, and the orientation, movement, and time spent by the individual in the work area. Since it is not possible directly to measure absorbed dose in tissue, dosimeters are placed on the surface of the body to estimate the dose received. Many different types of dosimeters are available for individual monitoring, including film, TLDs, and Self-Reading Pocket Dosimeters (SRPDs). Many factors must be weighed in selecting the type of dosimeter for a particular application. Each type has certain advantages and is suitable for certain types of monitoring.

4. At CP&L's nuclear plants, routine monitoring is performed using TLDs. The objective of routine monitoring is to assess the cumulative dose to individuals for official exposure recordkeeping purposes. TLDs are nearly ideal for routine monitoring because they are rugged, reliable, accurate, and sensitive. TLDs are capable of measuring the dose from the types and energies of radiation which represent significant external exposure hazards in nuclear power plants. For beta radiation, the TLDs proposed for SHNPP are capable of measuring dose over the energy range from about 0.1 to 2.3 MeV. Betas below 0.1 MeV are too weak to be a significant external hazard, while betas above 2.3 MeV are very rare. For gamma radiation, the TLDs have a usable energy range from about 40 keV to 7 Mev.

Gammas above this range are rare and gammas below this range contribute relatively little to the total dose. The TLD also can be used for neutron monitoring with appropriate calibration. Other types of dosimeters have disadvantages which make them less well suited for routine monitoring. Film is more susceptible to temperature and humidity extremes which are prevalent conditions in nuclear power plants, thus increasing the risk of invalid results. Film is also very energy dependent in its response to radiation. SRPDs are knocked off-scale very easily by dropping or bumping them and are insensitive to beta radiation. Pressurized ionization chambers, suggested by the Joint Intervenors as an appropriate monitoring device, cannot be used for individual monitoring, since it is impractical for them to be worn or carried by individuals. Overall, TLDs are clearly superior and were therefore chosen for use as the dosimeters of record for the Shearon Harris Nuclear Power Plant (SHNPP).

5. TLDs are worn continuously by individuals while working in the radiologically controlled areas of nuclear power plants and are processed to obtain official dose readings at regular intervals, normally monthly. More frequent processing is possible and sometimes performed under special circumstances, such as when an SRPD is lost or goes off-scale. Extensive quality control measures are applied to the processing of TLDs and recording of individual dose to ensure accuracy. Some of the major controls are: (1) semi-annual

calibration of TLDs and associated processing equipment to standards traceable to NBS; (2) daily calibration checks to assure constancy in the operation of equipment; (3) formal training and qualification of operating personnel; (4) formal review of all records and data; and (5) participation in periodic personnel dosimetry intercomparison studies. As part of the overall quality control effort, CP&L has applied for accreditation of its dosimetry laboratory under the recently announced Dosimetry Processor Laboratory Accreditation Program administered by the NBS.

6. At CP&L's nuclear plants, operational monitoring is performed using SRPDs. The objective of operational monitoring is to provide the basis for immediate actions and decisions by the worker in order to control and minimize personal exposure. The SRPD is well-suited to this purpose because it is small, rugged, and easily read. The TLD is actually more accurate and reliable than the SRPD, but it cannot be read by the worker. For operational monitoring, frequent reading of the dosimeter is necessary, therefore ease of reading by the worker himself is more important than the accuracy of the dose measurement. Because of their physical construction and principles of operation, SRPDs inherently tend to respond higher than the actual dose in normal use. This provides a built-in conservatism which is beneficial from an exposure control standpoint.

7. SRPDs are worn by individuals while performing certain tasks or while working in certain areas where

significant radiation exposure is possible and are read at varying intervals by the worker. As discussed in Applicants' FSAR at 12.5.3.6.1.1, SRPDs will be used at SHNPP for specific job exposure evaluation and to indicate current individual exposure status. Although SRPDs are only useful for gamma radiation, they will provide workers with adequate real-time monitoring, since the majority of individual dose comes from gamma exposure. In cases where significant beta exposure is possible, beta-sensitive survey instruments are used to establish beta dose rates for exposure control purposes and TLDs are used to determine the dose of record. The quality control for SRPDs includes semi-annual calibration to ensure exposure response, charging operation, and charge leakage are within established specifications. The use of SRPDs assures that workers will have adequate real-time monitoring capability which will allow prompt decisions and actions to avoid unnecessary exposure.

8. Although TLDs and SRPDs are used primarily in separate and distinct roles for dose assessment and exposure control respectively, they are also used in auxiliary roles as backup for one another. For example, if a worker loses his TLD, his SRPD can be used to estimate his dose during the period for official record purposes with only slightly less accuracy. Or, if a worker's SRPD goes off-scale as a result of being dropped, the TLD can be processed immediately instead of at the end of the month, and used to update the individual's exposure control records. Also, the results of both SRPD and

TLD readings for individuals who receive significant dose are compared and differences above designated control levels are investigated. This check serves to detect gross problems with the monitoring devices, the methods of use, or the records of dose.

9. CP&L maintains a computer-based dosimetry record keeping system in which complete dose history data is maintained for every individual who is monitored. When a TLD is first issued to an individual a record is created on the computer. Initially, the individual's prior dose history is obtained from previous employers and is entered into the computer record. Based on the applicable administrative limits and prior dose history, the computer automatically calculates the dose, known as available dose, which the individual may receive without exceeding the limits. Each time the individual's SRPD is read, the dose is entered into the computer system and a new available dose is calculated. At this point, the dose total is unofficial because it is based on SRPD readings. Normally, an individual's SRPD will be read several times and the computer record updated accordingly before the individual's TLD is read. The SRPD readings provide the interim dose status between TLD readings. When the TLD is read, which is at least monthly, the dose is entered into the computer record replacing the SRPD readings for the exposure period and the new, official dose total is calculated. Because the computer system allows on-line, real-time updating of

records, the individual's current dose status is always immediately available. The net effect is that the readings from the TLDs and the SRPDs are maintained in the record-keeping system both as separate readings and in combination such that at any point in time the total accumulated dose for an individual is known based on the latest TLD reading, plus any SRPD readings which have been made since the TLD was last read. Through this record-keeping system the needs for accurate official dose totals and up-to-date exposure control status for each individual can be satisfied effectively.

10. The use of TLDs for personnel monitoring is generally accepted as the state-of-the-art technique. Over the past few years the use of TLD badges has steadily increased, while the use of film badges has decreased. CP&L has used TLDs successfully for eight years to monitor personnel at its operating nuclear plants. During this time the NRC has always accepted the results of TLD badges as complying with the occupational exposure monitoring requirements of 10 C.F.R. Part 20. Many nuclear power plants and other organizations use TLDs for personnel monitoring. During a two year study conducted by the University of Michigan for the NRC, approximately two-thirds of the dosimeters submitted for testing by fifty-nine processing organizations of all types were TLD badges. Performance Testing of Personnel Dosimetry Services - Procedures Manual, NUREG/CR-1063 (January 1980); Performance Testing of Personnel Dosimetry Services - Final Report of Two Year Pilot Study October 1977 -

September 1979, NUREG/CR-1064 (January 1980); Performance Testing of Personnel Dosimetry Services - Supplementary Report of Two Year Pilot Study October 1977 - December 1979, NUREG/CR-1304 (January 1980); Performance Testing of Personnel Dosimetry Study - Alternative and Recommendation for Personnel Dosimetry Testing Program, NUREG/CR-1593 (August 1980); Performance Testing of Personnel Dosimetry Study - Final Report Test 3, NUREG/CR-2891 (February 1983); Performance Testing of Personnel Dosimetry Services - Revised Procedures Manual, NUREG/CR-2892 (February 1983).

11. At the present time Applicants intend to use TLDs manufactured by Panasonic Company at SHNPP as the official dosimeter of record. These TLDs have been tested and found to meet the performance specifications of ANSI N13.11-1983 for photons and betas. The testing was conducted at the University of Michigan by Dr. Phil Plato as part of a study sponsored by the NRC. During the study the dosimeters were irradiated to a variety of radiation sources whose calibrations were verified by NBS. The methods used during this study are documented by Performance Testing of Personnel Dosimetry Services - Revised Procedures Manual, NUREG/CR-2892 (February 1983) and the results of testing are documented in Performance Testing of Personnel Dosimetry Study - Final Report Test 3, NUREG/CR-2891 (February 1983). In these reports CP&L is listed as processor number 187. This study demonstrates that the TLDs proposed for SHNPP meet the accuracy requirements which have been endorsed

by the national consensus standard of ANSI and recommended by the international community of radiation protection and measurement authorities as appropriate to ensure the safety and health of workers.

12. In making their allegation that TLDs are too inaccurate to assure worker safety and health, the Joint Intervenors have been very vague, in light of the complexities in measuring radiation dose described above, about either the nature or magnitude of the inaccuracies about which they are concerned. In response to various interrogatories, the Joint Intervenors have cited inaccuracies for TLDs of 20, 30, and 50 percent without supplying specific technical references or specifying the conditions of exposure, such as radiation type, energy, dosimeter design, and irradiation geometry. Because of the lack of any detailed information, it is difficult to understand or address the Joint Intervenors' concerns.

13. The International Commission on Radiation Units and Measurements (ICRU), the International Commission on Radiological Protection (ICRP), and the Nat onal Council for Radiation Protection and Measurements (NCRP) have addressed the issue of accuracy for individual monitoring and published recommendations in ICRU Report 20, ICRP Report 12 and NCRP Report 57. These organizations are considered to be authorities in the field of radiation protection and measurements and their recommendations are the basis for radiation protection practice and regulations in countries throughout the world. In general,

they recommend greater accuracy at high (accident) dose levels than at levels below the maximum permissible levels. Disregarding dose level, their recommendations for accuracy range from within 20 to within 90 percent. Because of the low risk at low dose levels these authorities recommend that individual monitoring is not needed at doses less than 25 to 30 percent of the maximum permissible dose level. NRC regulations follow these recommendations and 10 C.F.R. § 20.202 states that personnel monitoring is not required for doses less than 25 percent of the quarterly dose limit. According to ICRU Report 20, the maximum permissible dose levels have been set so conservatively that great accuracy in dose measurement is not considered necessary.

14. The current standard for testing the performance of dosimetry processes, ANSI N13.11-1983, specifies tolerance levels which are a compromise between the various recommendations previously mentioned and the limitations of available measurement techniques determined through the series of tests conducted at the University of Michigan involving many dosimetry processors. In this standard, ANSI set the tolerance level at 50 percent for doses from 0.03 to 10 rem and at 30 percent for doses from 10 to 500 rem. It should be noted that the ANSI performance criteria specify that for a series of dosimeter measurements the sum of the average absolute bias (accuracy) plus the standard deviation must be less than the specified tolerance level. The average absolute bias is a

measure of the deviation of the average measured dose from the true dose, while the standard deviation is a measure of the variation or spread of the individual dosimeter measurements about the average measured dose. Since a series of dosimeter measurements normally contains a certain amount of statistically random variability about the average value, the bias actually must be better than 50 percent in the normal (non-accident) dose range to meet the standard. To illustrate, if the percent standard deviation for a series of measurements is 10 percent, then the bias or accuracy must be better than 40 percent to pass the combined criteria of 50 percent. Since all of the values for the accuracy of TLDs mentioned by the Joint Intervenors fall within the tolerance levels established by ANSI N13.11-1983, it is not clear on what basis the Joint Intervenors claim that TLDs are not accurate enough. The ANSI standard will be used as the basis for testing dosimetry processors under the recently announced dosimetry processor accreditation program which will be administered by the NBS and as such it appears to be the best available standard for comparison.

15. The Joint Intervenors also contend that TLDs lack real-time monitoring capability. The pertinence of real-time monitoring capability for the dosimeter of record is not clear. It appears that the Joint Intervenors do not understand the relationship between the different types of monitoring performed, routine and operational, and the types of dosimeters used, TLDs

and SRPDs. As discussed above, the purpose of routine monitoring is the assessment of individual dose for official exposure records, while the purpose of operational monitoring is the control of exposure to the individual. The two functions are closely related, yet distinct. Separate dosimeters are normally used for each purpose. The TLD is used for routine monitoring and the SRPD is used for operational monitoring. For exposure control purposes, real-time monitoring capability is important because it provides the basis for immediate decisions and actions to minimize individual exposure. For official record purposes, accuracy and reliability are more important than timeliness. This is manifest in the fact that TLDs are normally only read monthly. Real-time monitoring capability is not needed in TLDs, but SRPDs do provide this capability more than adequately to ensure the safety and health of the workers.

16. Finally, the Joint Intervenors recommend that portable pressurized ionization monitors be used to corroborate TLD readings. In response to interrogatories served by Applicants and the Staff, the Joint Intervenors amplified upon this recommendation to include real-time recording equipment as part of the proposed monitoring equipment configuration. "Joint Intervenors' Response to Applicants' Interrogatories and Request for Production of Documents to Joint Intervenors (First Set)," dated March 29, 1983, at 6; "Joint Intervenors' Response to Staff Interrogatories," dated August 31, 1983, at 5-6. The

Joint Intervenors stated that such equipment should be located near work stations and that accumulated dose could be obtained through computation from the output of the real-time recording equipment with greater accuracy than TLDs worn on the body by workers. Id. at 5-6.

17. What the Joint Intervenors actually have proposed is a work area monitoring system, rather than a personnel monitoring system. The equipment proposed by the Joint Intervenors, although technically portable, is designed to be used in a stationary position. The equipment cannot be carried or worn by the worker and the results it provides will not represent or correspond to the dose of any individual. The results from any off-the-body instrument, regardless of its inherent accuracy, are subject to many variables and inaccuracies which can only be reasonably accounted for by an on-the-body device. These variables are discussed below:

A. Spatial variations in the exposure rate within the work area: Order of magnitude variations are common between various points in a single work area at a nuclear plant. In fact the radiation fields are often so non-uniform that the dose to one part of the individual's body may differ significantly from the dose to another part (e.g. head compared to chest). Such differences are often unpredictable and necessitate the wearing of multiple dosimeters on various parts of the body. The highest dosimeter reading is selected as the dose of record. An off-the-body monitoring device would not be able to assess the dose to different parts of the body simultaneously, nor would a stationary monitor be able to assess the dose rate at multiple locations within the work area where different individuals might be working simultaneously.

B. <u>The movement of the worker within the work area</u>: Such movement will cause the worker to be exposed to varying dose rates during the time he is working in an area because of the non-uniformity of radiation fields. Even the difference between standing or kneeling may be significant to the dose received by the individual. A stationary, off-the-body monitoring device cannot account for the movement or position of the individual.

C. <u>The variation of the radiation field as a function of time</u>: In a nuclear plant the radiation fields are constantly changing and fluctuating as a function of the operating conditions. Often the work being performed affects the radiation field as shielding is installed or removed and as contaminated equipment, parts, or waste are moved about. Even the most accurate surveys of an area with portable monitoring equipment are of only transitory value because of changing radiation fields. A stationary monitor with a real-time recorder would only monitor the changes at one point in an area.

D. <u>The variable time spent by workers in radiation fields</u>: A worker spends a certain amount of time in one work area and then proceeds to other areas. The amount of dose received is a function of the exposure time in each area. Different workers will spend different amounts of time in the same or different areas. With a stationary monitoring system a worker's exposure would be extremely difficult to assess since it would require a precise knowledge of each area entered and the time spent in each area and a complex series of computations for the dose received in each area. Such an approach would still fall far short of individual monitoring by TLDs in terms of overall accuracy.

18. As a result of these variables the dose to a worker will be a complex function of his position, orientation, movement, and time in the radiation field, as well as a function of

any changes in the field itself during the period of exposure to the worker. Each individual worker will be subject to a unique combination of these variables, so that the final doses received under apparently similar conditions may be significantly different. It would be impossible for the system proposed by the Joint Intervenors to account for these variables and corroborate the accuracy of the dose measured by TLDs worn by the worker.

19. In addition, the "real-time" monitoring aspect of the Joint Intervenors' proposed system for corroborating TLD measurement is unrealistic. Since the output of the pressurized ionization monitors will be a dose rate, computations will be required to assess individual integrated doses. The time period for integration will be different for each individual who enters a given area and will require separate computation. Likewise, the dose rate in each area which an individual may enter will be different and will require separate computation. To calculate the total dose for an individual will require an exact knowledge of each area entered, the time of entry, the time of exit and the integrated dose in each area over the specific time intervals spent in each area. In fact, the computations required would be so complex and time-consuming that they could not be accomplished by any feasible means on a "real-time" basis.

20. Although pressurized ionization monitors are not suitable for the use proposed by the Joint Intervenors, CP&L

does use such equipment for other more appropriate purposes. For example, in environmental monitoring the pressurized ionization monitors are used effectively because of their accuracy and sensitivity at very low dose levels. In addition, the dose rates in the environment are relatively uniform and constant compared to the dose rates in work areas; therefore, a stationary monitor is acceptable.

21. In summary, with respect to accuracy, the TLDs proposed by Applicants for use at SHNPP are adequate and meet applicable standards. The standards themselves are reasonable, considering the state of current measurement technology and the conservatism of radiation dose limits. With respect to real-time monitoring capability, SRPD's which can be read by the individual will be used for this purpose. The primary purpose of TLDs is to assess the cumulative dose of individuals for official records, not for real-time monitoring. Finally, with respect to the Joint Intervenors' proposal for corroborating TLD measurements, the use

of portable pressurized ionization monitors with real-time recording equipment is completely impractical.

Stephen A Browne
Stephen A. Browne

Subscribed and sworn to before me

this 4th day of January 1984.

Betty J. Hicks
Notary Public

My Commission Expires 9/28/85.

ATTACHMENT A

Stephen A. Browne
Harris Energy & Environmental Center
Carolina Power & Light Company
New Hill, North Carolina 27562

Education and Training

B.S. degree in Physics, Union College (1971)

M.S. degree in Environmental Health Engineering, Northwestern University (1974)

Professional Societies

Health Physics Society

Experience

A. 1972 to 1974 - Radiation Safety Officer, Packard Instrument Company, Downers Grove, Ill.

B. 1974 to September 1978 - Health Physicist, General Electric Company, Knolls Atomic Power Laboratory, Windsor, Conn.

September 1978 to April 1979 - Lead Engineer, General Electric Company, Knolls Atomic Power Laboratory, Windsor, Conn.

C. April 1979 to October 1981 - Senior Specialist - Dosimetry, Carolina Power & Light Company, New Hill, N.C.

October 1981 to present - Project Specialist - Health Physics, Carolina Power & Light Company, New Hill, N.C.