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Date: August 13, 1984

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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
COMMONWEALTH EDISON COMPANY	)	Docket Nos. 50-454-OL
	)	50-455-OL
(Byron Nuclear Power Station, Units 1 & 2)	)	
	)	

SUMMARY OF THE TESTIMONY OF DR. EUGENE P. ERICKSEN ON CONTENTION 1 (REINSPECTION PROGRAM - INSPECTOR QUALIFICATION AND WORK QUALITY)

I. Dr. Eugene P. Ericksen is a senior sampling statistician at Mathematica Policy Research, Inc. and a professor at Temple University.

II. Dr. Ericksen has reviewed the Byron Reinspection Report, the testimony of Anand K. Singh, and portions of the testimony of Louis O. Del George, Robert V. Laney, and John Hansel. Dr. Ericksen has analyzed the ways in which Edison used statistics and probability theory to support its conclusions concerning inspector qualifications and work quality.

III. Dr. Ericksen concludes that Edison's sampling design and statistical analysis suffer from four major flaws:

A. Edison failed to distinguish elements based on their safety significance when establishing its statistical criteria. The company did not properly select confidence levels and acceptable reliabilities and failed to properly stratify its samples.

B. Edison over-generalized, offering conclusions about inspectors and elements that had no chance of being included in the reinspected sample.

C. Edison used an inappropriate formula in calculating reliabilities. Two assumptions of the formula were violated: inspections were not randomly selected and inspectors were not homogeneous.

D. Edison did not account for the added uncertainty created by clustering of inspections by inspectors.

For these reasons, Dr. Ericksen concludes that the sampling design of the Reinspection Program and the statistical analysis of the Reinspection Report are inadequate to support Edison's general conclusions about work quality and inspector qualifications.

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TESTIMONY OF DR. EUGENE P. ERICKSEN

Q1: Please state your full name for the record.

A1: Eugene P. Ericksen.

Q2: Please provide your job titles and business addresses.

A2: I am a Senior Sampling Statistician for Mathematica Policy Research, Incorporated, Box 2393, Princeton, New Jersey 08540. I am also an Associate Professor at Temple University, Philadephia, Pennsylvania 19122.

Q3: Please describe your job responsibilities at Mathematica Policy Research, Incorporated and list some of your clients.

A3: I am responsible for sample design of surveys and statistical evaluation projects. My work includes construction and evaluation of samples, including the computation of sampling errors.

I have done work for many federal agencies including the Bureau of the Census, the Department of Labor, the Department of Justice, the Social Security Administration and the Department of Health and Human Services.

I have also worked for various corporate clients such as AT&T, GTE, Metromobile, Inc., Blue Cross of Maine, Blue Cross of Massachusetts, and IMS America, and for private organizations such as the American Medical Association.

In addition, I have done work for New York City and for agencies of the States of New York, Pennsylvania and New Jersey.

Q4: Please describe your educational background and work experience.

A4: I hold a Ph.D. in Sociology and an M.A. in Mathematical Statistics from the University of Michigan and a B.S. in Mathematics from the University of Chicago. These degrees were awarded in 1971, 1965 and 1963 respectively.

In 1970, I joined the Institute for Survey Research and worked as a sampling statistician. From 1974 through 1981, I also worked as a Study Director at the Institute. I left the Institute in 1981 to became a Senior Sampling Statistician for Mathematica Policy Research, Inc. I have also taught courses in general statistics, survey sampling, and research methodology while working at Temple University as an Assistant Professor of Sociology from 1974 to 1978, and as an Associate Professor from 1978 through the present.

I have been an active member in many professional organizations for a number of years. Since 1975, I have served as a Proposal Evaluator for the National Science Foundation (NSF). I have consulted with the Center for Measurement

Methods and Data Resources of NSF on the development of standard procedures to evaluate surveys. I have served as the Chair of the Subcommittee to Review Proposed Internal Surveys of the American Statistical Association (ASA) since 1978, and was a member of the ASA Executive Committee Subsection on Survey Research Methods from 1975 through 1977. In 1978, I was appointed by the National Academy of Sciences to a committee evaluating the Census Bureau's method of estimating post-censal population size and per capita income of local areas.

I have published numerous technical papers relating to application of statistics and sampling methodology. A selected list of these publications is included in my resume, Ericksen Attachment A.

Q5: Are you familiar with the Byron Reinspection Program?

A5: Yes. I have reviewed the Report on the Byron QC Inspector Reinspection Program (Reinspection Report), the Report Supplement, all testimony of Mr. Singh, and portions of the testimony of Messrs. Tuetken, Del George, Hansel and Laney.

Q6: What is the purpose of your testimony?

A6: The purpose of my testimony is to evaluate Edison's use of statistics and probability theory in reaching conclusions concerning inspector qualifications and work quality. I also identify the limits on conclusions which can be reached because not all work elements, work attributes and inspectors had a chance of being selected for reinspection.

Q7: Is it useful to apply statistics in this context?

A7: Yes. Where a 100 percent reinspection is not possible or practical but we wish to make a judgment about inspector qualifications and plant work quality, we can use statistics to draw inferences concerning many plant items and inspectors from inspections of selected items and inspectors. We must be very careful, however, to properly choose the sample and properly determine the population about which inferences can be drawn.

Q8: Have you formed an opinion on the adequacy of the samples chosen in the reinspection program and the statistical bases of Edison's determinations of inspector qualifications and work quality?

A8: Yes. The Reinspection Program's sampling design and statistical analysis is sufficiently flawed that it does not provide adequate support for Edison's general conclusions and inferences about work quality and inspector qualifications.

Q9: What are the major problems with the sampling design and statistical analysis?

A9: First, in structuring the Reinspection Program and Report, Edison failed to distinguish elements which are most important to safety from elements which are less important, or to distinguish elements which are easy to inspect from elements which are difficult to inspect. By lumping these elements together and failing to apply different criteria depending on the safety importance of the elements, Edison has not provided adequate assurance of work quality.

Second, in stating conclusions concerning all inspections at Byron, Edison has seriously over-generalized, making inferences to inspections, work attributes and work elements that had no chance of being selected for reinspection. Edison lacks sufficient statistical basis for making such inferences.

Third, Edison's statistical methodology was faulty. The Company used an inappropriate formula in reaching its statistical judgments.

Q10: Why should Edison have distinguished elements based on their safety significance?

A10: In order to assure that a plant can be operated safely, we are primarily concerned that proper inspections are made of those inspection elements which pose serious risks if not properly inspected, especially those which are hard to inspect. To give a simple analogy, it does us little good to know that 99.5 percent of the parts of an automobile were properly inspected if the 0.5 percent that were missed are the brakes and the steering.

To provide assurance that each type of element is properly inspected, Edison should have designed a stratified sample of elements. The strata would be groups of elements categorized by attribute, type of task, difficulty of inspection, and safety significance. In each stratum, we would want to be assured that sample sizes were sufficiently large to be confident of the results. This would have enabled the Reinspection Program to establish acceptable confidence levels and reliabilities based on the importance of the element. Confidence levels indicate how certain a statistician is that his or her results are correct. Reliabilities reflect the percentage of inspection which are correct. For inspection elements where the risks caused by a poor quality are great, we might want to be certain that all were correct and, therefore, reinspect all elements. For inspection elements where the risks are not as great, but still substantial, we might want to be quite sure that 99.9 percent were correct. For other inspection elements which are less safety significant, we might be satisfied if we were reasonably certain that 99 percent were correct. In order to determine the amount of certainty and perfection required for each element, choices should have been made using engineering judgments. These judgments, along with their rationales, should have been determined when establishing the program and clearly stated in the reinspection report. A reasonable reinspection program might have required the following reliabilities and confidence levels for the following types of elements.

Type of Element	Reliability	Confidence Level
Critical to safety	100%	100%
Very important to safety	99.9%	99%
Somewhat important to safety	99%	95%
Least important to safety	90%	95%

By aggregating data, i.e., lumping elements together, Edison failed to provide adequate assurance of safety. Even if we are 95 percent certain that 99 percent of all inspections that had a chance of being included in our sample met design requirements, this does not allow us to state that we are 95 percent certain that 99 percent of the more safety significant elements met design requirements. We, of course, want to be more than 95 percent certain that more than 99 percent of very important safety elements met design requirements. In order to make such a statement, the sampling plan should have incorporated special procedures for the more safety significant elements and should have disaggregated data, breaking it down by attributes and elements.

Q11: Can you give us an example of a situation where a reliability was inflated because of aggregation?

A11: Yes. In the Reinspection Program, Table VII E-3, Edison lumped all Hunter "hardware" elements together and reported their reliability to be greater than 99.9% at a 95% confidence level. However, the sample size for the "component inspections for piping and whip restraints", which Mr. Tuetken classified in his second most important safety category (Bleuel Attachment B) is too small to provide any meaningful basis for reporting a reliability. Out of 4,321 original inspections of piping and whip restraints, only 4 reinspections were done. (Ericksen Attachment B.) This is far below the 200 minimum number of inspections required by Military Standard 105D, the standard which Mr. Singh applied in assessing the adequacy of sample size. (See tr. 9079.)

It is not possible to give an example for Hatfield because Edison did not disaggregate Hatfield data by inspection element.

Q12: In what way has Edison "over-generalized" in drawing conclusions about work quality and inspector qualifications?

A12: Statisticians are able to make generalizations to all population elements having a known, nonzero chance of being selected into the sample, and generalizations must be limited to this population. In the Byron reinspection program, numerous work elements and attributes had no chance of being included in the sample reinspected. Table 1, attached to my testimony, lists these items. In addition, in general, only inspections performed in the first three months of an inspector's employment were eligible for sample selection, and the sample provides an inadequate basis for statements concerning inspections in the second three-month period or later. Edison has not provided a statistical basis from which to draw inferences about the quality of work excluded from the sample.

Certain inspectors also had no chance of being included in the sample. Edison has not provided an adequate statistical basis from which to draw inferences about these inspectors.

Q13: Is it possible to use inspectors' performance in reinspecting those elements and attributes which had a chance of being in the sample as a basis for generalizing to elements and attributes that had no chance of being in the sample?

A13: Mr. Singh seemed to indicate during cross-examination (tr. at 9105-9106) that such inferences could be drawn because inspectors were homogeneous. However, actual data from the reinspection program show that inspectors were not homogeneous.

Q14: Why did you conclude that the Company's statistical methodology was faulty?

A14: Much of the important work in generating a statistical estimate should be done in advance. Decisions must be made concerning the reliability sought, the confidence with which the reliability must be demonstrated, and the populations and subpopulations for which generalizations are needed. Once these decisions have been made, the sample can be planned and selected. The statistical planner should determine how large the sample must be to provide the desired confidence intervals, and whether or not the sample should be stratified to provide estimates for important subgroups. Contrary to the Company's assertions, Edison failed to take large enough samples to even assure 99% reliability at a 95% confidence level.

Q15: What was the major problem with the Company's application of statistics in estimating reliabilities for work quality?

A15: Edison, in its analysis, applied a statistical methodology that assumes selection of a simple random sample of inspections (Reinspection Report, page VII-9), but the Reinspection Program did not take such a sample. Edison may have made this error because the Company designed its program to test initial qualifications of inspectors rather than quality of work.

In calculating reliabilities, Edison used the formula

$$R = 1 - \frac{2.9955}{n}$$

where R = reliability at 95% confidence level

n = number of inspections in the randomsample.

This formula was derived from page 246 of Probability and Statistics for Engineers by I. Miller and J.E. Freund (Prentice Hall, 1977).

According to Miller and Freund, the formula is an approximation that can be used, when no discrepancies are found, if the following assumptions are met:

"1. There are only two possible outcomes for each trial ....
2. The probability of a success is the same for each trial.
3. There are n trials, where n is a constant.
4. The n trials are independent."

Id. at 54-55.

It was inappropriate for Edison to use this formula in calculating reliabilities in the Reinspection Report because assumptions (2) and (4) were violated.

Assumption (2) was violated because inspectors were not homogeneous; different inspectors had different probabilities of success. Assumption (4) was violated because inspectors were not randomly chosen; the selection of inspectors were not independent from each other.

Q16: What is the basis for your conclusion that inspectors were not homogeneous?

A16: Where inspectors are not homogeneous there will be similarities between inspections made by the same inspector. This creates a commonality within the cluster which can be measured by the "intraclass correlation." The intraclass correlation can range from a value slightly less than zero to +1.0. If the intraclass correlation is equal to zero, it means that inspectors are homogeneous and there is no increase in variance associated with cluster sampling. If the interclass correlation is greater than zero, then inspectors are not homogeneous.

We can use data from Appendix B of the Reinspection Report to compute intraclass correlations. The computations show that for Hatfield, Hunter and Pittsburgh Testing Laboratory, each contractor's overall intraclass correlation was greater than zero. These positive intraclass correlations indicate that inspectors were not homogeneous.

Another indication of the lack of homogeneity among inspectors is seen from the results of "F tests." The F test is a common statistical tool that can be used to determine whether observed variation in reliability among inspectors for a given attribute is greater than one expects by chance alone. For a sufficiently high F, we can conclude that inspectors are not homogeneous, at a particular level of significance.

Applying the F test to the data from Appendix B from the Reinspection Report, we reach the following conclusion: For Hatfield, Hunter and Pittsburgh Testing Laboratory, the F results for each contactor is sufficiently high to warrant rejection of the homogeneity hypothesis. In fact, the F results are so high that we are not only justified in rejecting the homogeneity hypothesis of the 10% level of significance and the commonly used 5% level of significance, but also at the particularly stringent 1% level of significance.

Q17: What is the basis for your conclusion that the Program did not select a simple random sample of inspections?

A17: When a simple random sample is taken, the selection of each item is independent. The inclusion of any one item in the sample should not affect the likelihood that any other item will be included. In the Reinspection Program, the selections of inspections were not independent.

A simple example will make this clear. Assume Inspector A makes inspections numbered 1, 2, 3, 4 and 5 during his first three months of work. Assume that Inspectors B, C, D and E make inspections numbered 6 through 25 during their first three months of work. If a simple random sample of inspections is taken, the fact that inspection 1 is included in the sample will not affect the likelihood that inspection 2 will be included. In the Reinspection Program, however, if inspection 1 was chosen to be included in the sample, there would be a 100 percent chance that inspections 2, 3, 4 and 4 would be included in the sample. Statisticians call this "clustering." In the example, inspections are clustered by inspector.

Q18: What is the effect of clustering?

A18: Clustering almost always increases the uncertainty with which statistical estimates can be evaluated.

Let me illustrate with a simple example. Let us assume that we have a population of four inspections with two inspectors, Mr. Short and Mr. Long, each making two inspections of a pipe that is three inches long. Inspector Short's measurements are both 2 inches, while Inspector Long's measurements are both 4 inches. The average of all inspections is $1/4(2 + 2 + 4 + 4) = 3$ inches. Now let us consider all possible samples of size 2 (i.e., that include two different inspections), where no one inspection can be chosen more than once. For clarity, we will call Short's first measurement 2_A and his second measurement 2_B ; likewise we will call Long's first measurement 4_A and his second measurement 4_B . There are six possible ways in which the inspections can be selected, disregarding the order in which selections are made:

Sample	Sample Mean
2_A, 2_B	2.0
2_A, 4_A	3.0
2_A, 4_B	3.0
2_B, 4_A	3.0
2_B, 4_B	3.0
4_A, 4_B	4.0

In four out of six cases one would expect to pick a sample that yields the average inspection for the entire population. */

Now let us consider a second type of sample, a clustered sample where the inspector is the unit of selection. In other words, we take our sample of size 2 either by selecting Inspector Short's work or Inspector Long's work. Now there are two possible samples, namely:

Sample	Sample Mean
Short: 2_A, 2_B	2.0
Long: 4_A, 4_B	4.0

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*/ In statistical terms, the sample mean is exactly equal to the population mean in four of the six samples, but differs by one inch in two of the six samples. Statisticians measure these discrepancies by a concept known as the standard error, which is the square root of the average of squared deviations of sample means from the population mean. It is approximately:

Standard error $(\bar{x}) = \sqrt{\Sigma(\bar{x}_i - \mu_x)^2/n}$, where
μ_x = population mean
$\bar{x}_i$ = mean of sample i
n = number of samples.

For the example just described, the standard error is:

$$\sqrt{(1 + 0 + 0 + 0 + 0 + 1)/6} = 0.57735.$$

We have only two possible samples, and they happen to be the two whose values for the sample mean are farthest from the population mean. In no cases could we pick a sample that yields the average inspection for the entire population. The sample average would either be one inch too short or one inch too long. */

Hence, the uncertainty associated with the sample estimates generated from a clustered sample is greater than the uncertainty associated with the sample estimates generated from a simple random sample, in which all selections are independent from all other selections. Edison should not have used a formula that assumes simple random sampling in determining the reliabilities of samples that were clustered by inspector.

Q19: Can you give us an example from the Reinspection Program of a situation where a reliability was overstated because of the effect of clustering?

A19: Yes. A good example can be derived from data on the Hunter inspection element "Documentation on component inspections for piping and whip restraints." There were 37,230 original inspections of this element and 1,476 reinspections. (Ericksen Attachment B.) The 1,476 reinspections, however, are clustered.

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*/ The standard error is larger, namely:

$$\sqrt{(1 + 1)/2} = 1.0.$$

To determine inspection reliability for a clustered sample, the statistician must first calculate the "design effect," the quantitative measure of the extent to which a reliability estimate is reduced by the effect of clustering. When the actual sample size is divided by the design effect, we obtain the effective sample size, which should be used in computing reliability.

In the case of "documentation on component inspections for piping and whip restraints," the design effect is 5.2257. This yields an effective sample size of 282 reinspections. Correcting for the effect of clustering, the effective sample size of this inspection element falls from 1,476 to 282. (See Appendix 1.) 282 reinspections out of 37,230 original inspections is far below the sample size of 500 reinspections required by Military Standard 105D. Edison, therefore, cannot assert a meaningful reliability for this element.

Q20: Can you summarize the major problems, with the Reinspection Program?

A20: Yes. First, Edison did not establish adequate criteria for its statistical analysis. The Company did not properly select confidence levels and acceptable reliabilities, and failed to stratify the sample taking account of safety significance.

Second, Edison over-generalized, offering conclusions about inspectors and elements that had no chance of being included in the reinspected sample.

Third, Edison used an inappropriate formula in calculating reliabilities. Two assumptions of the formula were violated: inspectons were not randomly selected and inspectors were not homogeneous.

Fourth, Edison did not account for the added uncertainty created by clustering of inspections by inspector.

For these reasons, the sampling design of the Reinspection Program and the statistical analysis of the Reinspection Report are inadequate to support Edison's general conclusions about work quality and inspector qualifications.

TABLE 1*

ATTRIBUTES AND ELEMENTS THAT HAD NO CHANCE OF BEING SELECTED FOR REINSPECTION

HATFIELD

Embedded conduit
Underground duct runs
Material and equipment receiving
Cable installation
Non-seg bus duct
Material handling
Stud welding
Limit switch gasket replacement
Removal of heat shrink tubing on conax penetrations
Housekeeping
All welds for which the original inspector could not be identified **

HUNTER

Visual inspection of valves
Ferrite inspection
Piping hydrostatic test
Piping weld interpass temperature inspection
Joules test inspection
Code name plate change
Inspection of weld defect removal cavity
Whip restraint - fitup and tack weld
Buried pipe covering inspection
Piping - pre-heat inspection
Whip restraint - pre-heat inspection
Pipe weld - Shield gas verification
Component support - snubber stroking
Bolting - turn-of-nut

* Source: Written testimony of Richard B. Tuetken, Attachment B, tr. at 8408.

** Source: Report on the Byron QC Inspector Reinspection Program, at IV-5, discussing Hatfield second audit.

TABLE 1 (cont'd)

Documentation

Ferrite inspection
Joules test
Code name plate change
Weld defect removal cavity
Component support - snubber stroking
Bolting - turn-of-nut

PITTSBURGH TESTING LABORATORY

Rebar detection
Bolting - turn-of-nut (connections)
Calibrations (torque wrenches, thermometers, feeler gauges, scales, gauges)
Cadwelds (rebar coupling)
Soils (back fill)
Concrete field (placement)
Concrete lab (aggregate)

ATTRIBUTES AND ELEMENTS WHICH WERE REINSPECTABLE BUT WERE NOT REINSPECTED

HATFIELD

Cable pan covers
Cable pan identification

HUNTER

Component support final inspection (type 3)
Component support final inspection (type 4)
Equipment installation

Documentation

Component support - final inspection (type 3)
Component support - final inspection (type 4)

APPENDIX 1

Calculation of Design Effect and Effective Sample Size

The design effect associated with a clustered sample can be calculated by using the following formula:

$$\text{deff} = 1 + \text{roh}\ (B-1)$$

where

deff = design effect
roh = the intraclass correlation
B = the average cluster size

Below, this Formula is applied to the Hunter inspection element "Documentation on component inspections for piping and whip restraints."

Roh is the estimated intraclass correlation for Hunter inspectors and is equal to 0.0172477.

B equals the total number of reinspections divided by the total number of clusters (i.e., reinspectors). In this case, B equals 1,476 divided by 6, which is 246.

Therefore, deff = 1 + 0.0172477 (246-1)

= 5.2257

To calculate the effective sample size, and thereby adjust the actual sample size to reflect the effect of clustering, we use the following formula:

$$\text{effective sample size} = \frac{\text{actual sample size}}{\text{deff}}$$

In this case, the effective sample size is:

$$1{,}476/5.2257 = 282.45$$

or approximately 282 reinspections.

ERICKSEN ATTACHMENT A

EUGENE PENNELL ERICKSEN

EDUCATION:

1971	Ph.D., Sociology, University of Michigan
1965	M.A., Mathematical Statistics, University of Michigan
1963	B.S., Mathematics, University of Chicago

POSITIONS:

1981 -	Senior Sampling Statistician, Mathematica Policy Research, Inc.
1970 - 1981	Institute for Survey Research
1974 - 1981	Study Director
1970 - 1981	Sampling Statistician
1978 -	Department of Sociology, Temple University
1978 - 1981	Associate Professor
1974 - 1978	Assistant Professor
1969 - 1970	Student Fellow, University of Michigan
1967 - 1968, 1964 - 1966	Student Associate, Institute for Social Research, University of Michigan
1966 - 1967	Lecturer, Balham and Tooting College of Commerce, London

EXPERIENCE:

At Mathematica Policy Research, Dr. Ericksen has had responsibility for the sample design of surveys on diverse populations including households in the United States, industries using data communications equipment, physicians, social security recipients, and emergency rooms in hospitals. He has also conducted statistical evaluation projects including several which were the basis for expert testimony in courtroom litigation. He is currently the chief technical advisor for plaintiffs in several suits concerning the adjustment of the 1980 Census.

At the Institute for Survey Research, Dr. Ericksen worked on virtually every major project as Sampling Statistician. His duties included designing and constructing a national sample of households, adapting this sample to the sampling from lists, constructing national samples, and evaluating the samples with respect to computing sampling errors. He also designed, constructed, and evaluated subnational surveys for particular states and local areas. As Study Director, Dr. Ericksen conducted studies under three joint contracts with the Bureau of the Census. The objective of these studies was to develop a methodology for using regression analysis with sample data to compute postcensal estimates for local populations, and they were conducted from 1972 through 1974. He was also co-principal investigator on the studies "Ethnicity and Community in a Metropolis," supported by the National Institute of Mental Health, Center for Metropolitan Studies, 1975 through 1979, and "Fertility of an American Isolate Subculture (The Old Order Amish)," supported by the National Institutes of Health, 1976 through 1978.

At Temple University, Dr. Ericksen has taught courses in general statistics, survey sampling, research methodology, family sociology, ethnic groups, population, and human ecology. In the spring of 1980, as part of the Experimental Student Intern Program of the Bureau of the Census, he taught a special course whereby undergraduate students were trained to become enumerators in the 1980 Census.

At the Population Studies Center, University of Michigan, Dr. Ericksen, under a joint contract with the Bureau of the Census, wrote a Ph.D. dissertation to develop the methodology for using regression analysis and sample data to compute postcensal population estimates for local areas.

Dr. Ericksen is also a research associate for the Center for Philadelphia Studies, University of Pennsylvania. He is also a member of the American Statistical Association, the Population Association of America, and the American Sociological Association.

PROFESSIONAL ACTIVITIES AND OFFICES:

Member, Executive Committee, Subsection on Survey Research Methods, American Statistical Association, 1975-1977.

Member, Board of Review, American Statistical Association Project on the Assessment of Survey Research Practices, 1976 and 1977. The Committee evaluated the following report: "Developing of Survey Methods to Assess Survey Practices," by Barbara A. Bailar and C. Michael Lanphier, and published by the American Statistical Association, 1978.

Publications Liaison, Section on Survey Research Methods, American Statistical Association, 1978.

Proposal Evaluator, National Science Foundation, 1975 to present. He has also consulted on the development of standard procedures to evaluate surveys with the Center for Measurement Methods and Data Resources of the NSF.

Chair, Subcommittee to Review Proposed Internal Surveys of the ASA (American Statistical Association), 1978 to present.

Member, committee appointed by National Academy of Sciences to evaluate Census Bureau method of estimating postcensal population size and per capita income of local areas.

SELECTED PAPERS AND PUBLICATIONS:

"Voting Patterns in Pennsylvania Judicial Primaries: 1983" report to Judiciary Committee of the Pennsylvania State Senate. Presented November 30, 1983 (with Christena E. Nippert).

"Using Administrative Lists to Estimate Census Omissions: An Example," (with Joseph B. Kadane) 1983, presented at Meetings of American Statistical Association.

"Using the 1980 Census as a Populülation Standard," (with Joseph B. Kadane) 1983, presented at Meetings of American Statistical Association.

"Estimating the Population in a Census Year," presented to the Federal Court of the Southern District of New York, 1982, and to conference on "Data Needs for America in Transition," sponsored by the Congressional Research Service, Library of Congress, 1983 (with Joseph B. Kadane).

"Can Regression Be Used to Estimate Local Undercount Adjustments?" Proceedings of the 1980 Conference on Census Undercount, July 1980, pp. 55-61.

"The Cultivation of the Soil as a Moral Directive: Population Growth, Family Ties, and the Maintenance of Community Among the Old Order Amish." Rural Sociology, vol. 45, Spring 1980, pp. 49-68 (with Julia A. Ericksen and John Hostetler).

"Fertility Patterns and Trends Among the Old Order Amish." Population Studies, vol. 33, July 1979, pp. 255-276 (with others).

"The Division of Family Roles." Journal of Marriage and the Family, vol. 41, May 1979, pp. 301-313 (with Julia A. Ericksen and William Yancey).

"Antecedents of Community: Economic and Institutional Structure of Urban Neighborhoods." American Sociological Review, vol. 44, April 1979, pp. 253-262 (with William L. Yancey).

"Work and Residence in Industrial Philadelphia." Journal of Urban History, vol. 5, March 1979, pp. 147-182 (with William L. Yancey).

"Defining Criteria for Evaluating Local Estimates: Discussion of Papers by Gonzalez and Fay." In Synthetic Estimates for Small Areas: Statistical Workshop Papers and Discussion, National Institute on Drug Abuse Research Monograph No. 24, February 1979, pp. 185-191.

"A Tale of Three Cities: Blacks and Immigrants in Philadelphia, 1850-1880, 1930, and 1970. "The Annals, vol. 441, January 1979, pp. 55-81 (with others).

SELECTED PAPERS AND PUBLICATIONS: (continued)

"Immigrants and their Opportunities: Philadelphia, 1850-1936." Presented at a symposium on Immigration held at the meetings of the American Association for the Advancement of Science, Houston, Texas, January 1979 (with William L. Yancey).

"Report of the Conference on Economic and Demographic Methods for Projecting Population: Summary and Recommendations." The American Statistical Association, April 1978 (with Richard Engels).

"Reply to Levine and Bergesen." American Sociological Review, vol. 42, October 1977, pp. 825-827 (with William L. Yancey and Richard N. Juliani).

"Some Lessons Learned from Conducting Federally Sponsored Surveys." Proceedings of the Social Statistics Section, American Statistical Association, August 1977, pp. 183-185.

"Sampling a Rare Population: A Case Study." Journal of the American Statistical Association, vol. 71, December 1976, pp. 816-822.

"Emergent Ethnicity: A Review and Reformulation." American Sociological Review, vol. 41, June 1976, pp. 391-403 (with William L. Yancey and Richard Juliani).

"Outliers in Regression Analysis when Measurement Error is Large." Proceedings of the Social Statistics Section, American Statistical Association, August 1975, pp. 412-417.

"Population Estimation in the 1970s: The Stakes are Higher." Report to Bureau of the Census, May 1975.

"A Regression Method for Estimating Population Changes of Local Areas." Journal of the American Statistical Association, vol. 69, December 1974, pp. 867-875.

"Recent Developments in Estimation for Local Areas." Proceedings of the Social Statistics Section, American Statistical Association, December 1973, pp. 37-41.

"A Method for Combining Sample Survey Data and Symptomatic Indicators to Obtain Population Estimates for Local Areas." Demography, vol. 10, May 1973, pp. 137-160.

"Test of a Statistical Procedure for Computing Estimates for Local Areas." Report to Bureau of the Census, January 15, 1973.

11c.

Edison's Amended Response to Interrogatories 11(c) and 12(c) of Intervenors' First Set of Interrogatories

I.	II.	III.	IV.	V.
Inspection (by attribute)	Total Inspections Performed through 8/31/82	Total Reinspections Performed	Number of Inspectors Inspecting Attribute	Inspectors Reinspected
class I cable pan hangers	26,230	4,776	9	2
class I cable pans	1,643	80	10	1
cable terminations	78,548	7,784	16	5
equipment modifications	628	27	4	3
class I exposed conduit	30,210	2,793	15	6
A-325 bolt installation	14	8	3	1
conduit "as-built" program	180,000	44,777	28	8
visual weld inspection	312,000	27,844	17	8

Notes: The numbers in Column II are estimated and exclude inspections performed after September 1, 1982. The number of total inspections and total reinspections shown for attributes 4 and 6 refer to the number of items on an individual inspection report and inspection reports respectively. All other numbers in columns II and III refer to individual inspections of various components. The numbers in Column IV are the number of inspectors who, on their first date of certification, were certified in the inspection attribute and actually performed inspections of that attribute between the date of first certification and September 1, 1982. The total number of Hatfield inspectors employed between 1976 and September 1, 1982 is 86. Many inspectors are certified in more than one inspection procedure. For the objective inspections, inspection attributes 1, 2, 5 and 7 require similar inspection skills as do inspection attributes 3 and 4.

12c.

	Inspection (by inspection element)	Total Inspections Performed	Total Reinspections Performed	Number of Inspectors Inspecting Inspection Element	Inspectors Reinspected
1.	Documentation for piping mechanical joint witness of torque-initial, intermediate and final	9,745	247	12	1
2.	Documentation of piping hydrostatic test	430	120	3	1
3.	Documentation on piping inter pass inspection	5,896	321	13	4
4.	Documentation on name plate inspection	25	5	2	1
5.	Documentation on finished weld inspection of piping and whip restraints	187,129	14,584	16	11
	Documentation on finished weld inspection for component supports	29,272	963	10	6
7.	Documentation on component inspections for piping and whip restraints	37,230	1,476	16	6
8.	Documentation on fit up and tack welds for piping and whip restraints	98,861	3,609	16	9
9.	Documentation on piping field bonds-final visual, ovality and radius	2,434	41	10	1

Inspection (by inspection element)	Total Inspections Performed	Total Reinspections Performed	Number of Inspectors Inspecting Inspection Element	Inspectors Reinspected
0. Documentation on review of type a inspection for type 3 inspection final reivew	168,815	21,161	6	6
1. Documentation on mechanical joint inspection for piping preassembly inspection (component)	5,929	82	11	1
2. Documentation on piping mechanical joint inspections line up inspections (fit up)	4,355	29	8	1
3. Documentation on location acceptance between component support and item being supported	3,219	86	5	2
4. Documentation on component support inspection checklist	9,230	158	4	1
5. Documentation on location of field welds for piping inspections	5,707	353	8	4
6. Documentation on piping holiday jeep test	60	10	2	1
7. Documentation on component supports concrete expansion anchors	2,589	782	5	4

Inspection (by inspection element)	Total Inspections Performed	Total Reinspections Performed	Number of Inspectors Inspecting Inspection Element	Inspectors Reinspected
8. Documentation on piping and whip restraints pre-heat inspection	2,483	231	6	2
9. Documentation on piping verification of shield gas	685	10	4	1
0. Documentation on piping and component supports temporary attachments inspection	401	122	4	2
1. Small bore type 3 final hardware inspection reports	3,503	3,014	5	5
2. Small bore type 4 final documentation inspection reports	47	35	2	2
Whip restraints type 3 final documentation inspection reports	185	176	1	1
4. Whip restraints type 4 final documentation inspection report	12	6	1	1
5. Equipment type 3 final documentation inspection report	13	7	1	1
6. Documentation on large bore piping types final inspection	401	395	2	2

	Inspection (by inspection element)	Total Inspections Performed	Total Reinspections Performed	Number of Inspectors Inspecting Inspection Element	Inspectors Reinspected
[illegible]	Piping mechanical joints witness of torque initial, intermediate, and final	2,714	606	12	10
[illegible]	Component supports torques	405	150	5	2
[illegible]	Finished weld inspection for piping and whip restraints	4,395	2,291	17	17
[illegible]	Finished weld inspection for component supports	3,282	1,437	11	9
[illegible]	Piping and component supports temporary attachments inspection	27	13	4	2
2	Component inspections for piping and whip restraints	4,321	4	16	1
3.	Fit up and tack weld for piping and whip restraints	9,395	5	16	2
4.	Piping field bends inspection final, visual ovality and radius	729	417	10	9
5.	Verified location acceptable between component support and item being supported	472	254	5	4
[illegible]	Component support inspection checklist	18,378	13,932	4	4

	Inspection (by inspection element)	Total Inspections Performed	Total Reinspections Performed	Number of Inspectors Inspecting Inspection Element	Inspectors Reinspected
7.	Dimensional on location of field welds for piping inspections	976	567	8	8
.	Component support concrete expansion anchors inspection	1,154	772	5	4
[illegible].	Small bore type 3 final hardware inspection reports	22,762	10,515	5	5
	Small bore type 4 final hardware inspection reports	155	75	2	1
[illegible].	Large bore type 3 final inspection report	1,535	195	2	1
2.	Whip restraints type 3 final hardware inspection report	4,684	876	1	1
3.	Whip restraints type 4 final hardware inspection reports	134	22	1	1

NOTES: The Total Inspections Performed are those performed by the inspectors whose work was reinspected in the reinspection program. The total number of inspections is unknown. Inspections conducted after August 31, 1982, are excluded. The Number of Inspectors Inspecting Inspection Element is the number of inspectors who, were certified to perform inspections for the inspection element and whose inspections were reinspected. Information on the total number of inspectors inspecting each inspection element is not available. The total number of Hunter inspectors employed at Byron between 1976 and September 1, 1982 is 84. The certifications of these inspectors permit them to conduct inspections of more than one inspection element. Inspection attributes 1-26, 27-28, 29-31, 32-38, 39-41 and 42-43 require similar inspection skills.

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of:	)	
	)	Docket No. 50-454 OL
COMMONWEALTH EDISON COMPANY	)	50-455 OL
	)	
(Byron Nuclear Power Station,	)	
Units 1 and 2)	)	

CERTIFICATE OF SERVICE

I hereby certify I served copies of Intervenors' Motion for Leave to File Testimony of Dr. William H. Bleuel; Direct Testimony of Dr. William H. Bleuel on Contention 1 (The Reinspection Program); and Testimony of Dr. Eugene P. Ericksen on the following persons by having said copies placed in envelopes, properly addressed and postaged (first class) and having them deposited in the U.S. mail at 109 North Dearborn (or, as indicated by an asterisk, sent by Purolator Courier or Federal Express), except that Mr. Miller's copy was hand-delivered.

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