UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION IV
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1/4/79
Hendrie to
Luce

September 25, 1977

MEMORANDUM FOR: Ernst Volgenau, Director
Office of Inspection and Enforcement, HQ

FROM: E. Morris Howard, Director, Region IV
Office of Inspection and Enforcement

SUBJECT: DRAFT REPORT - LICENSEE INSPECTION AND ENFORCEMENT INDICATORS

The final Draft Report of Licensee Inspection and Enforcement Indicators which is intended to fulfill the assignment to establish and validate techniques for Licensee Inspection and Enforcement Indicators is submitted for your consideration. The Draft Report is a detailed statistical analysis which has been examined by an independent contractor (ORNL) and found to be mathematically and statistically valid. Suggestions made by ORNL are encompassed in the revision of this detailed statistical analysis.

I consider the detailed statistical as both desirable and necessary supportive information to any analysis of performance indicators; however, it is felt that a simplified technique, using the identical data base, but requiring considerably less analysis was in order. In the development of the simplified technique, items of noncompliance were assigned a value, summed, and the Z score calculated. Figure No. 1 is the flow diagram for these calculations. The Z scores, which are the number of standard deviations that an observation differs from the mean of its group, are shown on Figures No. 2 and No. 3. The comparisons between the simplified and detailed analysis are shown on Tables No. 1 and No. 2.

An attempt was made to separate functional areas in the Draft Report with what I consider less than roaring success due to the lack of data. It appears that a clearer relationship between total noncompliance and the functional areas is more clearly discernable by recalculating a new total Z score after subtracting the contribution of a given functional area, and then comparing the two total Z scores. Figure 4 shows the contribution of Safeguards to the total score of the several pressurized water reactor sites.

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This simplified concept uses the same basic techniques described in the Draft Report except for pre-weighting and it would be redundant to redescribe them here.

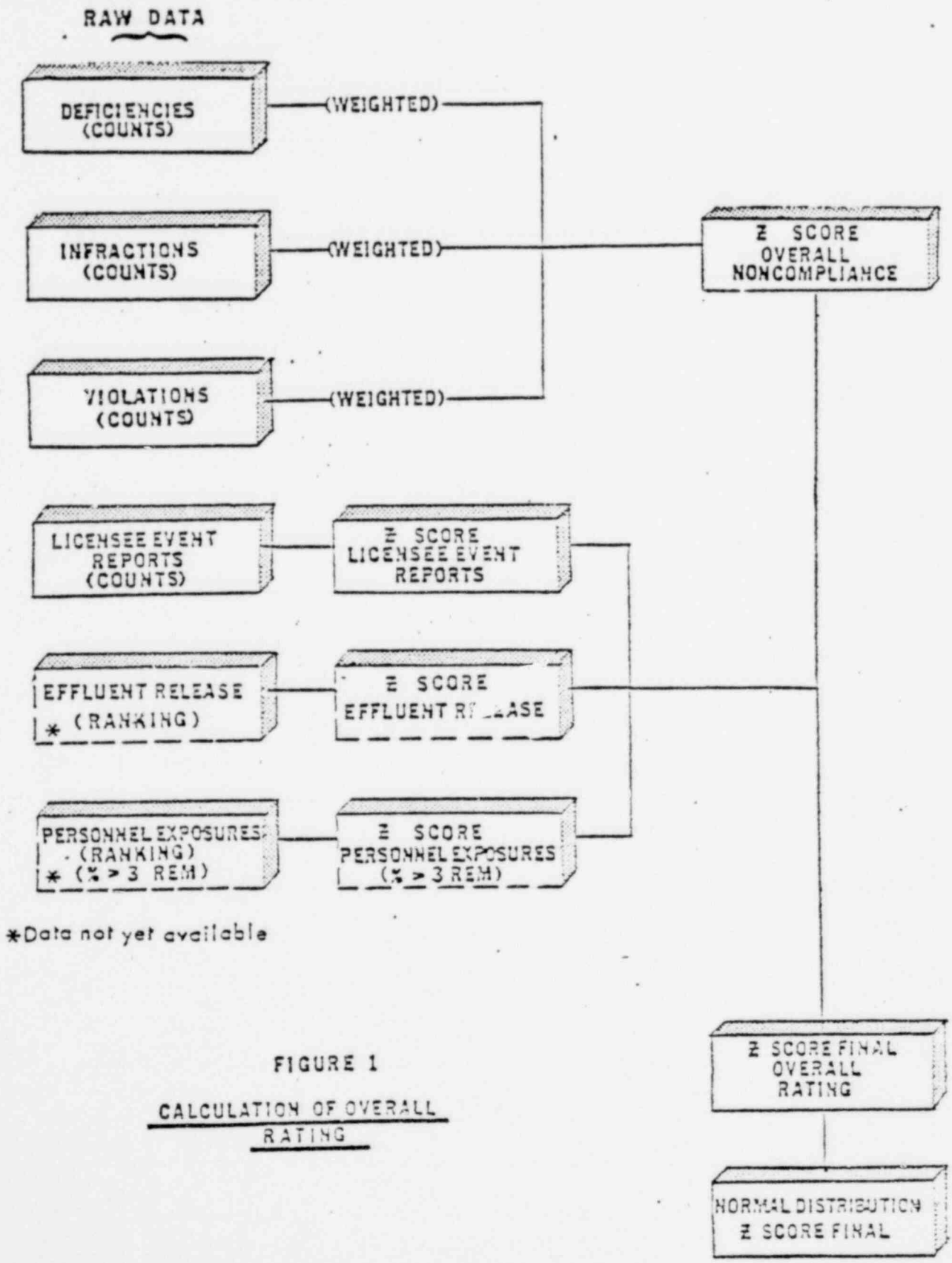
It is recommended that this simplified technique be used and that an annual detailed statistical analysis be performed to evaluate possible emerging and presently elusive relationships.

E. Morris Howard

E. Morris Howard
Director

Enclosures:
As stated

cc: J. G. Davis
H. D. Thornburg

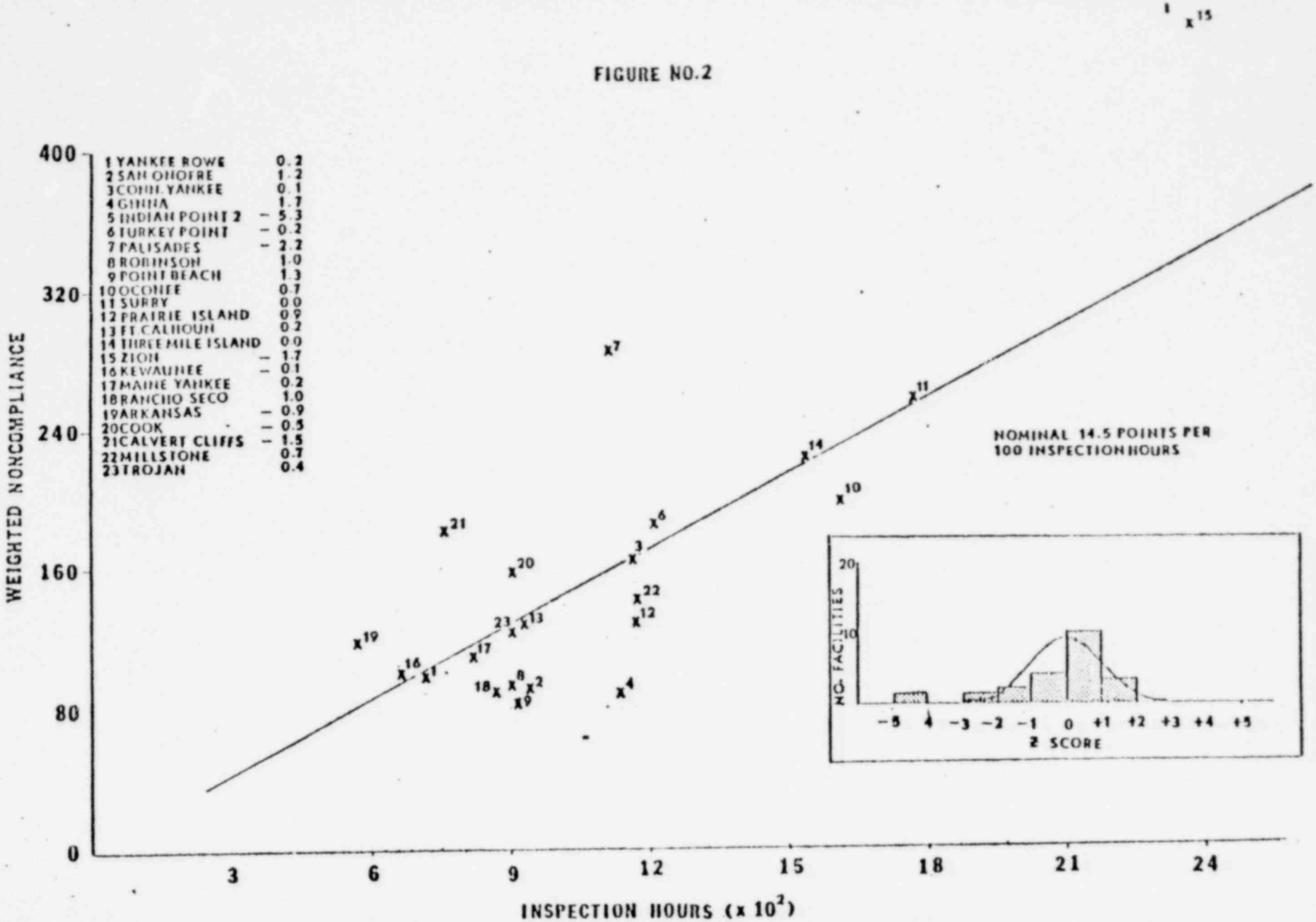


*Data not yet available

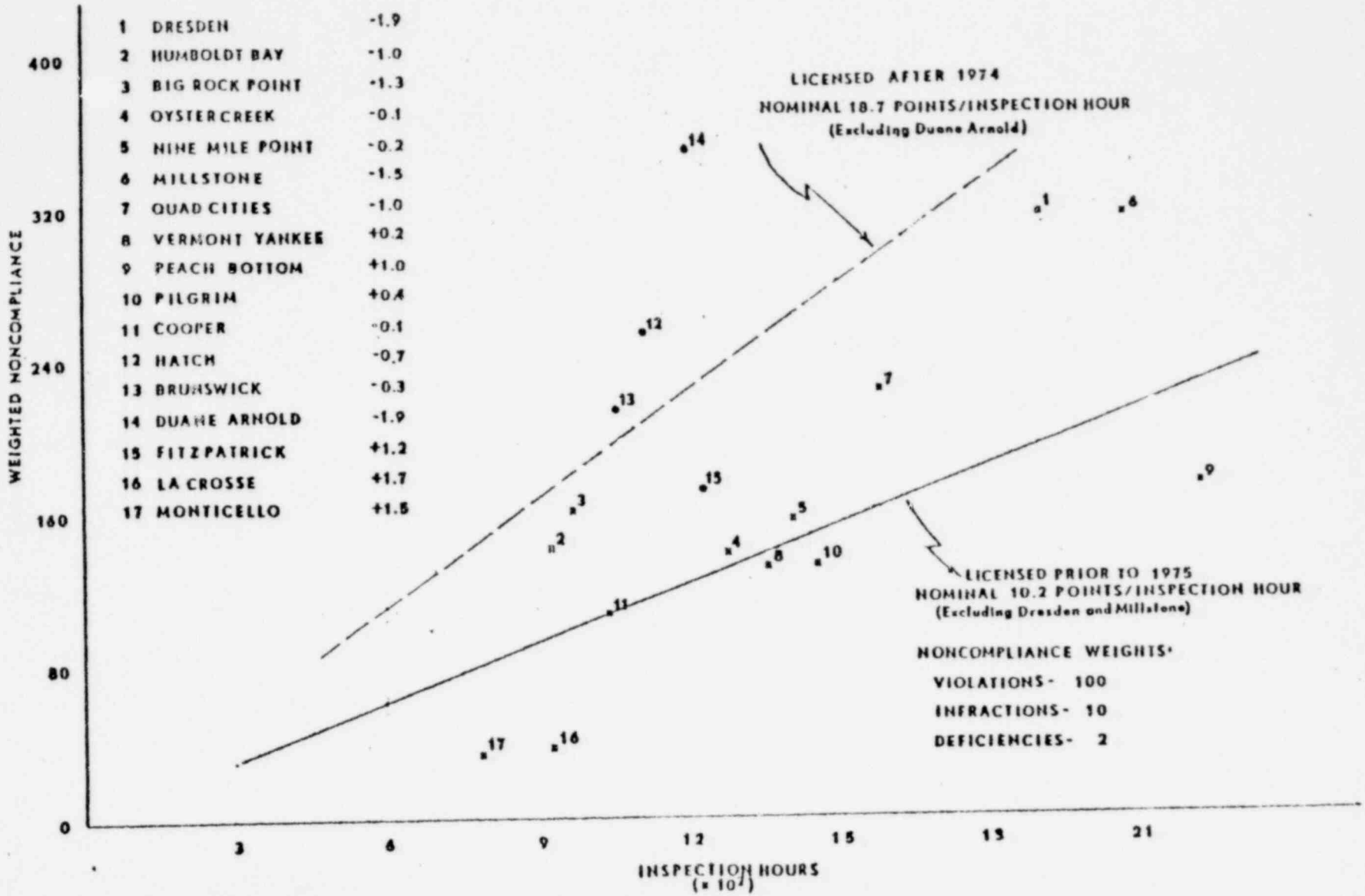
FIGURE 1

CALCULATION OF OVERALL RATING

FIGURE NO.2



PRESSURIZED WATER REACTOR-CALENDER YEAR-1976

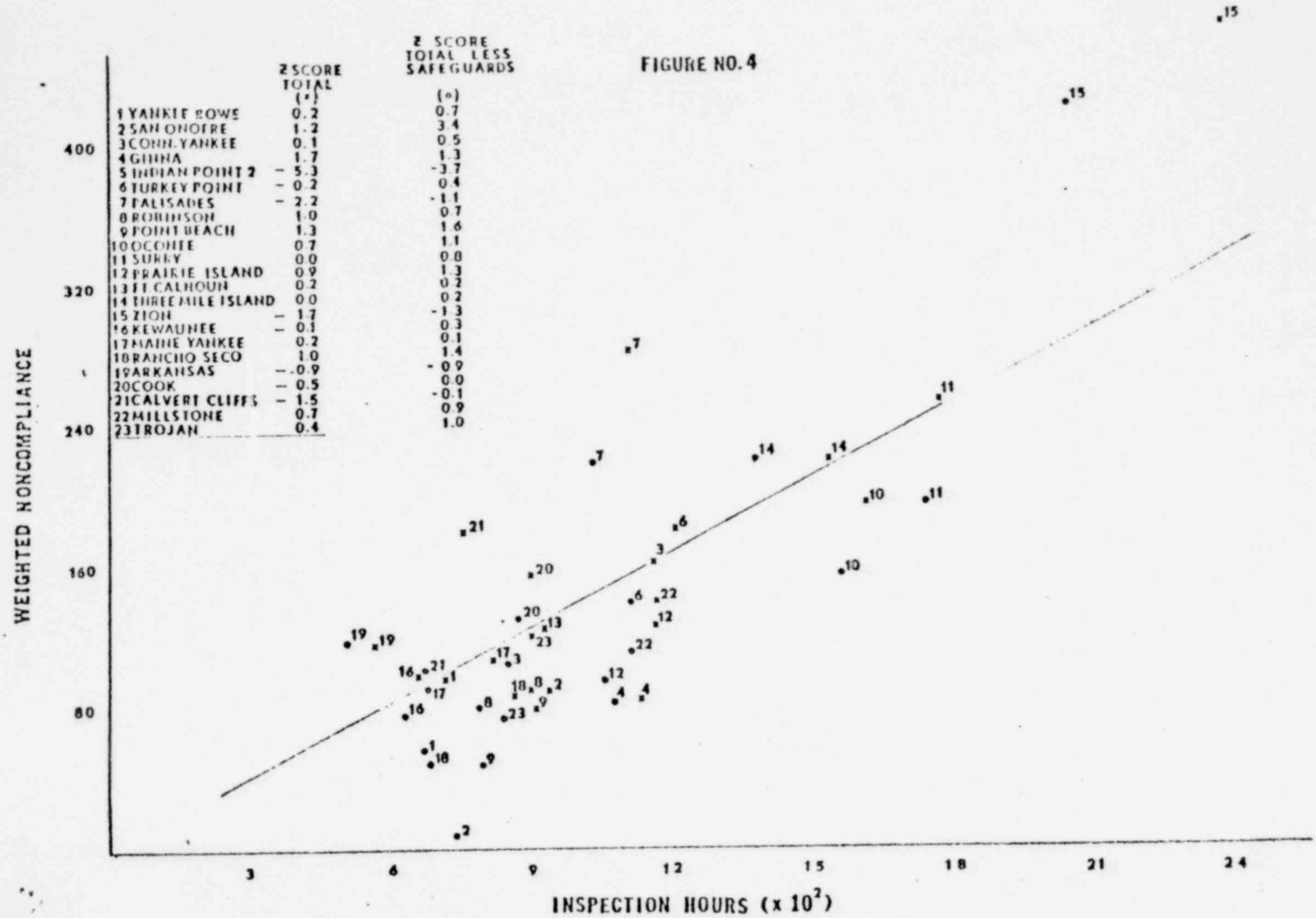


BOILING WATER REACTORS CALENDER YEAR 1976

FIGURE NO.3

FIGURE NO. 4

	Z SCORE TOTAL (*)	Z SCORE TOTAL LESS SAFEGUARDS (o)
1 YANKEE ROWE	0.2	0.7
2 SAN ONOFRE	1.2	3.4
3 CONN. YANKEE	0.1	0.5
4 GINNA	1.7	1.3
5 INDIAN POINT 2	- 5.3	-3.7
6 TURKEY POINT	- 0.2	0.4
7 PALISADES	- 2.2	-1.1
8 ROBINSON	1.0	0.7
9 POINT BEACH	1.3	1.6
10 OCONEE	0.7	1.1
11 SURRY	0.0	0.8
12 PRAIRIE ISLAND	0.9	1.3
13 FT CALHOUN	0.2	0.2
14 THREE MILE ISLAND	0.0	0.2
15 ZION	- 1.7	-1.3
16 KEWAUNEE	- 0.1	0.3
17 MAINE YANKEE	0.2	0.1
18 RANCHO SECO	1.0	1.4
19 ARKANSAS	- 0.9	- 0.9
20 COOK	- 0.5	0.0
21 CALVERT CLIFFS	- 1.5	-0.1
22 MILLSTONE	0.7	0.9
23 TROJAN	0.4	1.0



PRESSURIZED WATER REACTOR-CALENDER YEAR-1976

Table 1

COMPARATIVE

Z SCORES

PRESSURIZED WATER REACTORS

CALENDAR YEAR - 1976

FACILITY	Z SCORE NONCOMPLIANCE SIMPLIFIED	Z SCORE NONCOMPLIANCE DETAILED	Z SCORE TOTAL SIMPLIFIED	Z SCORE TOTAL DETAILED	CATEGORY SIMPLIFIED	CATEGORY DETAILED
Yankee Rowe	0.2	0.3	0.5	0.6	B	B
San Onofre	1.2	1.3	2.4	2.4	A	A
Conn. Yankee	0.1	0.1	0.2	0.2	B	B
Ginna	1.7	2.1	1.8	2.1	A	A
Indian Point #2	-5.3	-7.4	-5.0	-6.9	C	C
Turkey Point	-0.2	-0.5	0.3	0.1	B	B
Palisades	-2.2	-2.7	-2.4	-2.8	C	C
H. B. Robinson	1.0	1.0	0.6	0.6	B	B
Point Beach	1.3	1.4	1.4	1.4	A	A
Oconee	0.7	0.5	-0.1	-0.3	B	B
Surry	0.0	-0.5	-0.6	-1.1	B	C
Prairie Island	0.9	0.9	0.3	0.3	B	B
Ft. Calhoun	0.2	0.0	0.3	0.1	B	B
Three Mile Island	0.0	-0.2	-0.2	-0.4	B	B
Zion	-1.7	-3.3	-1.8	-3.4	C	C
Kewaunee	-0.1	-0.2	-0.4	-0.5	B	B
Maine Yankee	0.2	0.5	0.5	0.8	B	B

Table 1 (cont'd)

COMPARATIVE

Z SCORES

PRESSURIZED WATER REACTORS

CALENDAR YEAR - 1976

FACILITY	Z SCORE NONCOMPLIANCE SIMPLIFIED	Z SCORE NONCOMPLIANCE DETAILED	Z SCORE TOTAL SIMPLIFIED	Z SCORE TOTAL DETAILED	CATEGORY SIMPLIFIED	CATEGORY DETAILED
Rancho Seco	1.0	1.1	1.6	1.7	A	A
Arkansas	-0.9	-1.1	-0.7	-0.8	B	B
Cook	-0.5	-0.9	-0.9	-1.2	B	C
Calvert Cliffs	-1.5	-1.6	-0.8	-0.8	B	B
Millstone 2	0.7	0.8	1.0	1.1	B	A
Trojan	0.4					

Table 2

COMPARATIVE

Z SCORES

BOILING WATER REACTORS

CALENDAR YEAR - 1976

FACILITY	Z SCORE NONCOMPLIANCE SIMPLIFIED	Z SCORE NONCOMPLIANCE DETAILED	Z SCORE TOTAL SIMPLIFIED	Z SCORE TOTAL DETAILED	CATEGORY SIMPLIFIED	CATEGORY DETAILED
Dresden	-1.9	-2.6	-3.0	-3.6	C	C
Humboldt Bay	-1.0	-1.4	-0.7	-1.1	B	C
Big Rock Point	-1.3	-1.7	-1.6	-2.0	C	C
Oyster Creek	-0.1	-0.5	0.2	0.8	B	B
Nine Mile Point	-0.2	0.0	-0.2	0.0	B	B
Millstone	-1.5	-2.1	-1.6	-2.2	C	C
Quad Cities	-1.0	-1.2	-1.2	-1.4	C	C
Monticello	1.5	2.3	1.9	2.6	A	A
Vermont Yankee	0.2	0.6	0.2	0.6	B	B
Peach Bottom	1.0	1.4	1.1	1.5	A	A
Pilgrim	0.4	1.2	0.5	1.3	B	A
Cooper	-0.1	-0.4	1.1	0.8	A	B
Hatch	-0.7	-1.1	-1.1	-1.5	C	C
Brunswick	-0.3	0.6	-0.6	-0.9	B	B
Duane Arnold	-1.9	-2.8	-1.8	-2.6	C	C
Fitzpatrick	1.2	1.0	1.7	1.5	A	A
La Crosse	1.7	2.4	2.0	2.7	A	A

Draft Report

A STATISTICAL EVALUATION OF THE NUCLEAR SAFETY-RELATED PERFORMANCE OF NRC OPERATING REACTOR LICENSEES DURING 1976

(Licensee Inspection and Enforcement Indicators)

August 1977

E. Morris Howard, Project Director
Stephen K. Conver
Robert G. Easterling
Walter S. Schwink

Chapter I

INTRODUCTION

A. Background

"Licensee Inspection and Enforcement Indicators" is the term used to describe the efforts of the NRC Office of Inspection and Enforcement to evaluate the nuclear safety-related management performance of its licensees. This draft report addresses the management performance of NRC's operating reactor licensees during the calendar year 1976. This report is the culmination of an effort initiated in April 1976 to develop and test a methodology for evaluating licensee management performance, as a technique for improving manpower utilization in the Office of Inspection and Enforcement, and establishing thresholds for initiation of corrective enforcement action.

This evaluation is made on the basis of two factors that are considered to reflect the degree of success licensee management has achieved in carrying out its responsibilities for safe operation and protection of the public. These factors indicate each licensee's compliance with NRC rules and the numbers of occurrences at a licensee's facility with potential safety implications. These factors are analyzed using standard statistical techniques that permit comparisons of licensee performance both in specific areas and from an overall perspective.

There are two additional factors which are considered to be pertinent to the overall licensee management performance which were not considered in this evaluation. While pertinent when considered solely on their own merit and exclusive of their contribution to noncompliance and LER's, these two factors, radiation exposures at the licensee's facility and the extent to which the licensee limits effluents, are not an integral part of this evaluation and in no way affect the results. As these data become available they will be analyzed and incorporated in the overall evaluation, adding an additional increment of knowledge of the licensee's management performance.

The choice of measures of licensee management performance reflects the concerns that licensees be measured objectively, using measurable and collectable statistics that apply uniformly to all operating reactor licensees. It is also important that the measures of performance include only items that are controllable by the licensee.

The use of statistical analysis to develop performance measures or indices has many precedents. Economic indicators, such as the Dow Jones averages, are commonly used to give the public an appreciation of the overall state of the economy. The "Quality of Life" index published by the Midwest Research Institute is a similar effort that ranks American cities on the basis of weighted sums of a number of indicators. Overall product rankings of Consumer's Reports and NFL quarterback rankings are other examples of the process of ranking individuals, groups, or objects according to some function of selected attributes or statistics.

In all these cases, there is some "latent variable" that is of interest, but which cannot be measured directly - economic health, quality of life, product quality, or athletic ability. By carefully choosing and analyzing data, one hopes to develop useful indicators of the latent variables. The various indicators are not equivalent to the latent variables; however, as the measured indicators are improved (numbers of libraries, interceptions, etc.), often the latent variables (quality of life, athletic performance, etc.) are also improved.

This effort to determine NRC licensee inspection and enforcement indicators has similar objectives. While we recognize that "safety" cannot be measured directly, we hope to improve it by evaluating the success of licensee management in controlling safety-related indicators of performance.

B. NRC and Licensee Responsibilities

Direct responsibility for conducting nuclear operations in a manner that protects public health and safety lies with the licensee. One of the ways that the licensee satisfies this obligation is by complying with NRC rules and regulations.

NRC shares this responsibility for protecting the public with the licensees. NRC responsibilities, as described in law, are to generate rules to insure safe operations and to verify that those rules are being followed. The NRC Office of Inspection and Enforcement (IE) is the arm of NRC charged with conducting this verification. IE uses its inspection force to insure compliance with the rules. Another important function of IE is to identify existing rules that need improvement or new rules that are needed.

Compliance with NRC rules is a function of licensee management. In general, a low level of noncompliance indicates that licensee management is doing a good job of carrying out its responsibilities to NRC and to the public. On the other hand, a high level of noncompliance may indicate a low level of management interest or participation in this regard. The performance of licensee management is similarly evident in trends for LERs. The present effort proposes a method to evaluate licensee management performance on a systematic and objective basis so that negative trends can quickly be identified and so that "management breakdown" can be prevented.

C. Why Licensee Inspection and Enforcement Indicators?

The NRC practice of focusing inspection attention on "poor performers" is well established and generally accepted. This evaluation of licensee management performance is designed to permit this allocation of IE

inspection resources to be conducted more systematically than in the past. This effort should also allow a more objective allocation, because all licensees will be measured against a single set of performance standards. And because each licensee will be compared against the total population of similar facilities, the identification of poor performers and subsequent allocation of IE resources to these facilities (and to specific areas at a given facility) should be more uniform across the NRC Regional Offices.

The methodology, which is discussed in a subsequent section, must necessarily result in a ranking of licensee management performance. A numerical ranking, however, is not the intent of this study nor is there any particular merit in the exact numerical rating of a licensee. Historical data, while lacking the precision to establish an exact numerical difference between facilities, can adequately portray those facilities and areas of concern within a facility which require additional Inspection and Enforcement attention.

The primary concern of the NRC is the health and safety of the public with each undertaking oriented toward this concern. Within this context, this evaluation can be related to safety of reactor facilities. The relationship to safety, however, is clearly one of improving the efficiency of IE manpower resource allocation to effect improvement in licensee's performance where weaknesses are detectable.

D. Structure of the Report

The main body of this report is presented at a level of detail appropriate for IE and NRC management. Brief chapters summarize the methodology (Chapter II) and results (Chapter III).

Additional technical detail is provided in two appendices to the report. These consist of results (Appendix A), as well as the documentation of an analysis of the sensitivity of overall rating results to the choice of weighting factors (Appendix B).

Chapter II

METHODOLOGY

A. Introduction

This chapter describes the data elements that are considered in the evaluation, the analysis tools that are used, and the specific approach taken to analyze each distinct type of data. A detailed description of the methodology is provided in Appendix A.

B. Data Elements

This analysis is based upon two measures of performance - noncompliance history of licensees and selected Licensee Event Reports (LERs). Two other measures - effluent releases and personnel exposures, which were mentioned briefly in the introduction, will be included in future evaluations as data become available. Each of these four measures are discussed below.

Noncompliance items result from NRC regulation and inspection of licensee facilities. Noncompliance data consist of "counts" of NRC findings in a given time period. These noncompliance items are classified into three categories: in decreasing order of severity, these are violations, infractions, and deficiencies. The noncompliance data thus consist of number of violations, infractions, and deficiencies for each licensee considered. The data are further broken down to describe the licensee function or operation that is the source of each noncompliance. Six areas are used: (1) Administrative Control, (2) Operations, (3) Emergency Planning, (4) Radiological Protection and Control, (5) Safeguards, and (6) Quality Assurance. Individual counts of noncompliance data are presented for each of the three severity levels. Also, an overall measure on noncompliance is developed for each licensee that is a weighted sum of the numbers of infractions and deficiencies.

Licensee Event Report data are also stated in terms of "counts" for each licensee. LERs are reports submitted by reactor licensees when certain safety-related events occur at a facility. It is not appropriate to measure licensees by a count of all LERs submitted, because not all reportable events are controllable by the licensee, applicable to the total population of reactor licensees, or serious enough to warrant NRC enforcement action if not reported by the licensee. For this reason, only those LERs characterized as "personnel errors" and "procedural errors" are considered.

Effluent Release data will be expressed in terms of licensee rankings. This is done because the actual effluent measurements may vary over several orders of magnitude for selected licensees. Effluent data are also categorized into five types: (1) noble gases, (2) halogens and particulates, (3) tritium, (4) mixed fission and activation products, and (5) solid waste. Overall rankings for effluent release are obtained by summing the licensee rankings in each of the five categories.

Personnel exposure data for each operating reactor are reported annually in the form of a table listing the numbers of persons exposed in various ranges of exposure (in rems). This evaluation of licensee management's success in limiting exposures is measured in terms of the percent of all people receiving measurable doses of radiation that received three rems or more in one year (rather than on a "ranking" or "counting" basis).

C. Analysis Tools

Three types of statistical techniques are used in this analysis - adjustment, normalization, and weighting procedures.

Adjustment of data is necessary because direct comparisions of licensee management performance are not always meaningful. For example, if one plant has twice as much inspection effort as another, a direct comparison of the noncompliance findings resulting from those inspections may not be meaningful, and it is necessary to make appropriate adjustments. The purpose of adjustment is to compensate for those measurement factors that are not under the licensee's control. This technique is used sparingly in the analysis to preclude elimination of actual licensee differences.

The specific techniques used to make these adjustments include linear regression, goodness of fit tests, and graphical techniques. These methods are used to identify and compensate for factors beyond the control of the licensees that can account for differences in their performance. For example, using the earlier example, Figure 1 depicts the number of infractions for each operating PWR reactor as a function of the hours of inspection devoted to each during 1976. This chart shows that infractions increase as inspection effort increases. Since this relationship also has an intuitive explanation (the more you look, the more you find), an appropriate adjustment is made.

The diagonal straight line that bisects the data in Figure 1 accounts for a significant portion of the differences in the "performance" of the various licensees. It shows that every 100 hours of inspection, on the average result in about 1.27 infractions. Thus, those licensees below the line are considered in this analysis to have better performance than those above the line, and for this measure, performance is essentially measured on a "rate" basis (infractions per hour of inspection).

The line representing the average rate of infractions can be obtained by one of several analytical methods - linear regression or graphical techniques. Goodness of fit tests can be used to assess whether the residual variations in licensee performance (the deviations of the individual points from the diagonal line in Figure 1) are random (what could be expected by chance). If these tests, such as the "chi square test," show that the

residual variation (after adjustment) is random, this means that licensees are "homogeneous" with respect to the variable being measured (infractions) and that there is no need to look for further adjustments. A lack of randomness indicates either actual differences between licensees or the need to look for further adjustments. The approach in this analysis has been to make adjustments only when there is a logical cause and effect explanation for the relationships identified.

The purpose and effect of adjustment can be seen by comparing Figures 2 and 3. Figure 2 is a histogram of the PWR infractions plotted in Figure 1. If infraction frequencies were homogeneous, that is, if the expected number of infractions were the same for all facilities and only "chance" variations affected the infraction frequencies actually observed, then the histogram should agree reasonably well with the Poisson distribution, which is also shown in Figure 1. (Note that the Poisson distribution is only defined for integer numbers of infractions. The distribution is shown as a continuous curve only for visual purposes.) The lack of agreement between the observed histogram and the expected Poisson distribution is apparent even without performing a statistical goodness of fit test. A major source of the discrepancy is inspection hours, because after the infraction frequencies are adjusted for inspection hours, then normalized (as described below), the histogram of Figure 3 results. If after adjustment and normalization, the infraction frequencies are homogeneous, then their histogram would be expected to agree with the standard normal distribution and Figure 3 shows that agreement is much closer than before (Figure 2).

As discussed, it is the aim of the analysis to reduce the residual variation in a performance measure, after adjustment, to the sort of variation one would expect by chance alone. This means that for that measure, apparent differences cannot be hailed as statistically significant, although these differences can still guide IE activities. The feature of the licensee performance evaluation which will permit differences to be identified statistically is replication. If some licensees score consistently high over several performance measures and others consistently low, then this is evidence of true differences among licensees. In order to examine this possibility, the data were analyzed for the first and second halves of 1976 separately. Comparing and combining performance measures for these two periods is then done as an aid to identifying licensee differences. It should be noted that a lack of statistical significance of licensee differences does not mean no differences exist, only that they are too small to be detected by available data.

The techniques for adjustment of data explained in the preceding paragraphs enable comparisons of licensee performance for single measures of that performance. Another objective of this analysis is to combine the various performance measures so that an overall measure of performance in terms of inspection of licensee activities can be obtained.

Normalization is an analytical technique that makes these overall comparisons possible. Its purpose is to transform each performance measure into a dimensionless quantity so that a sum of difference measure is possible. The transformation used is a "Z-score," which can be regarded as the number of standard deviations that an observation differs from the mean of its group. The particular Z-score used, in the case of noncompliances and LERs, however, is not mathematically defined in terms of standard deviations. This is because the model used for such counting data is the Poisson distribution which is not symmetric about its nominal, or expected, value. In order to reduce the asymmetry, Z-scores will be calculated by

$$Z = 2(\sqrt{NCM} - \sqrt{X}),$$

where NCM is the estimated expected number of counts and X is the observed count. The factor of 2 is so that the variance of Z will be approximately that of the standard normal distribution. Note also the Z is defined so that positive scores indicate better performance, and vice-versa.

The appropriate frame of reference for Z-scores is the standard normal distribution shown in Figure 3. This distribution has a mean of zero and standard deviation of one. When converted to Z-scores, licensee performance measures can be compared to this distribution. Under the standard normal distribution about two-thirds of the Z-scores would be expected to fall between plus and minus one, with one-sixth on either side of this interval. While these fractions are rarely achieved exactly, the Z-scores are still comparable. And, because they are dimensionless and comparable, Z-scores can be summed for various performance measures.

Weighting is the process by which Z-scores for various performance measures are summed in a manner that reflects the relative importance (weight) associated with each of the factors contributing to the overall score. The process of transforming raw data for noncompliances, LERs, effluents, and exposures to overall licensee management ratings is depicted in Figure 4. While the overall rating is of interest, the raw data and all intermediate results leading to that overall rating are significant results in their own right.

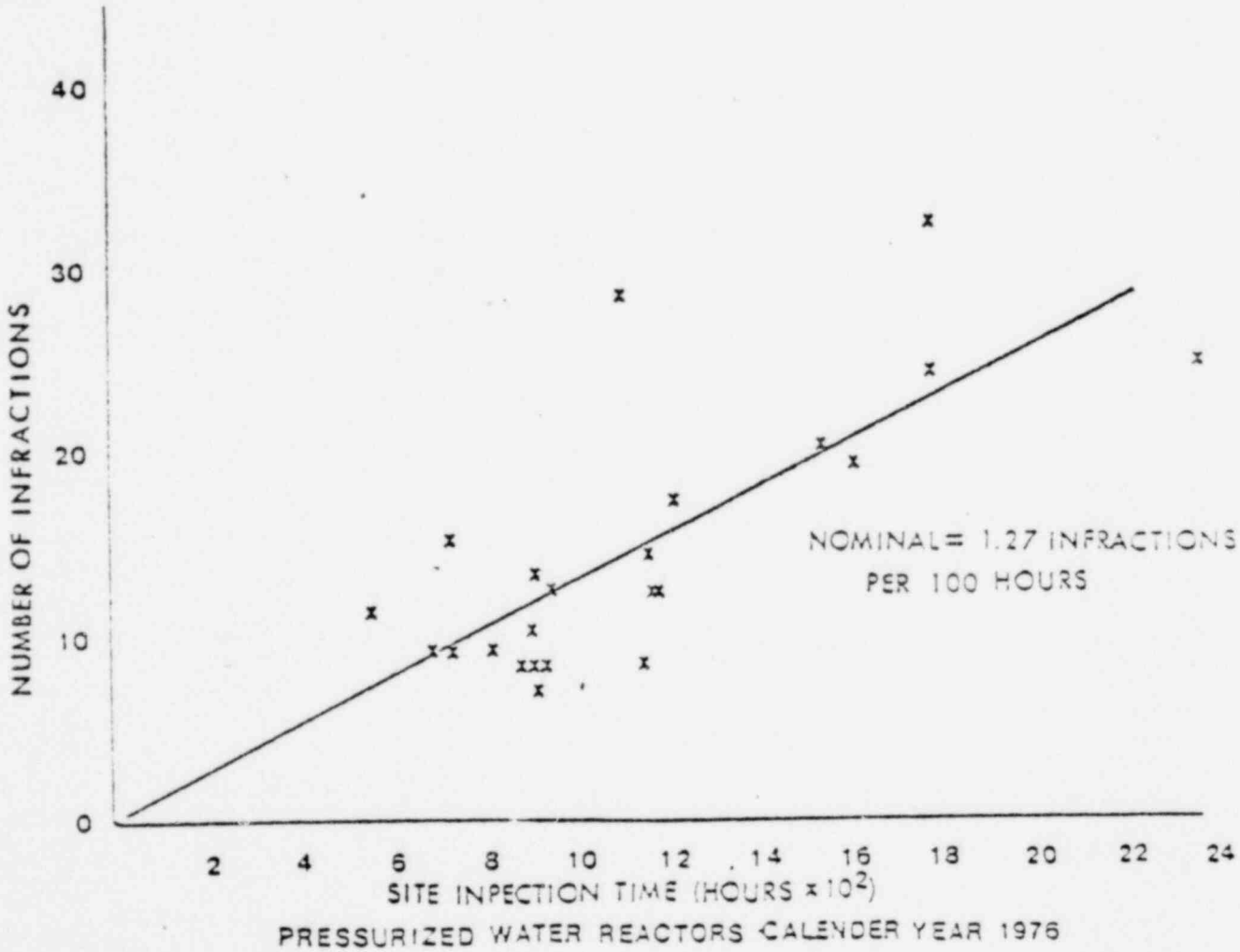
Because the process of weighting is inherently judgmental, a "sensitivity analysis" was conducted to assess the influence of a variety of alternative weightings on the overall ratings. The results of this analysis are presented in Appendix B.

In summary, the analysis process leading to overall evaluations of the performance of licensee management involves the following steps:

- Adjust data to remove factors beyond the control of licensee management.
- Normalize licensee performance in each measure to a dimensionless Z-score.
- Obtain overall ratings using weighted sums of the Z-scores.

FIGURE NO. 1

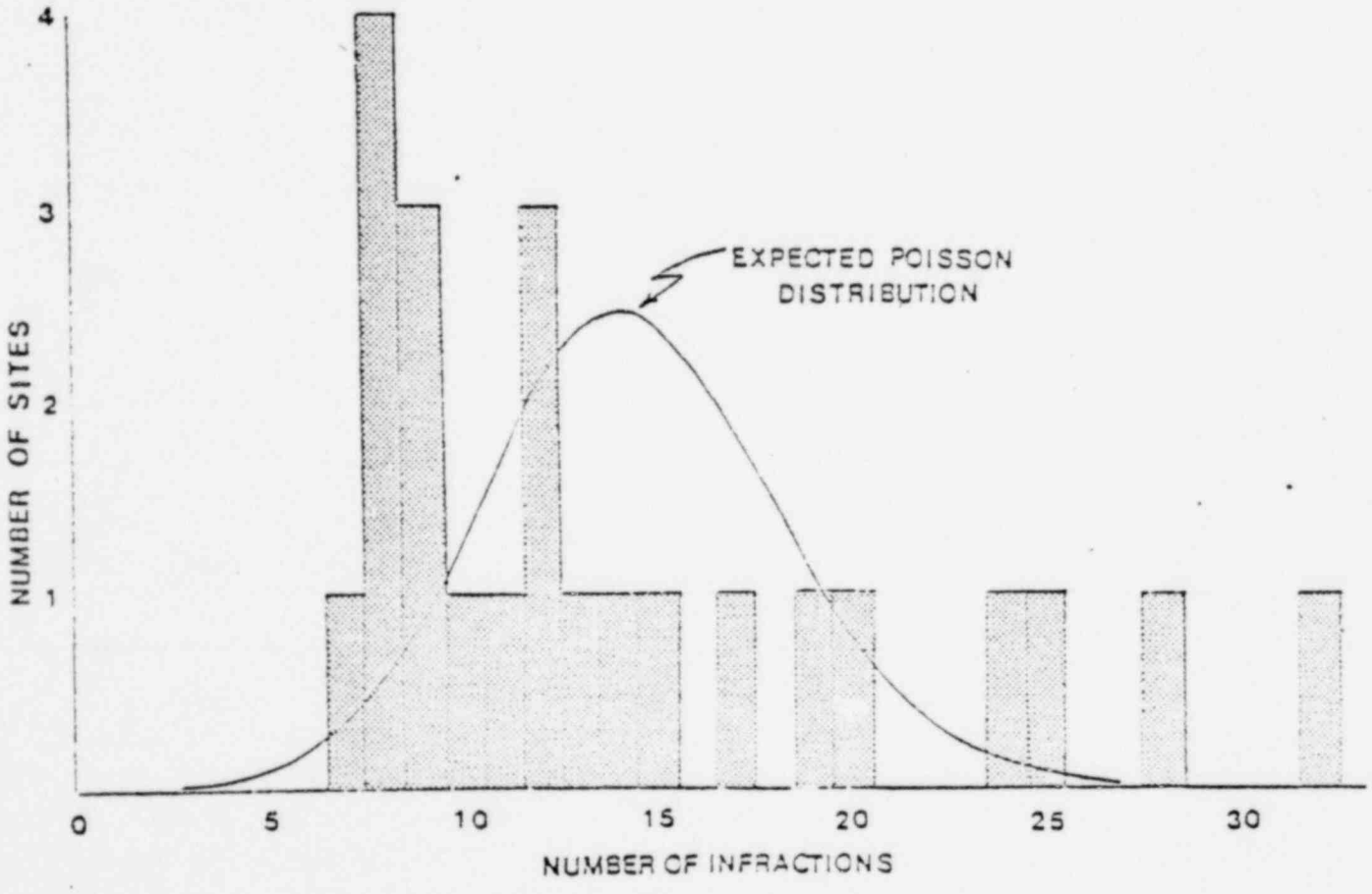
ADJUSTMENT OF PWR INFRACTION DATA FOR INSPECTION TIME



PRESSURIZED WATER REACTORS CALENDER YEAR 1976

FIGURE NO. 2

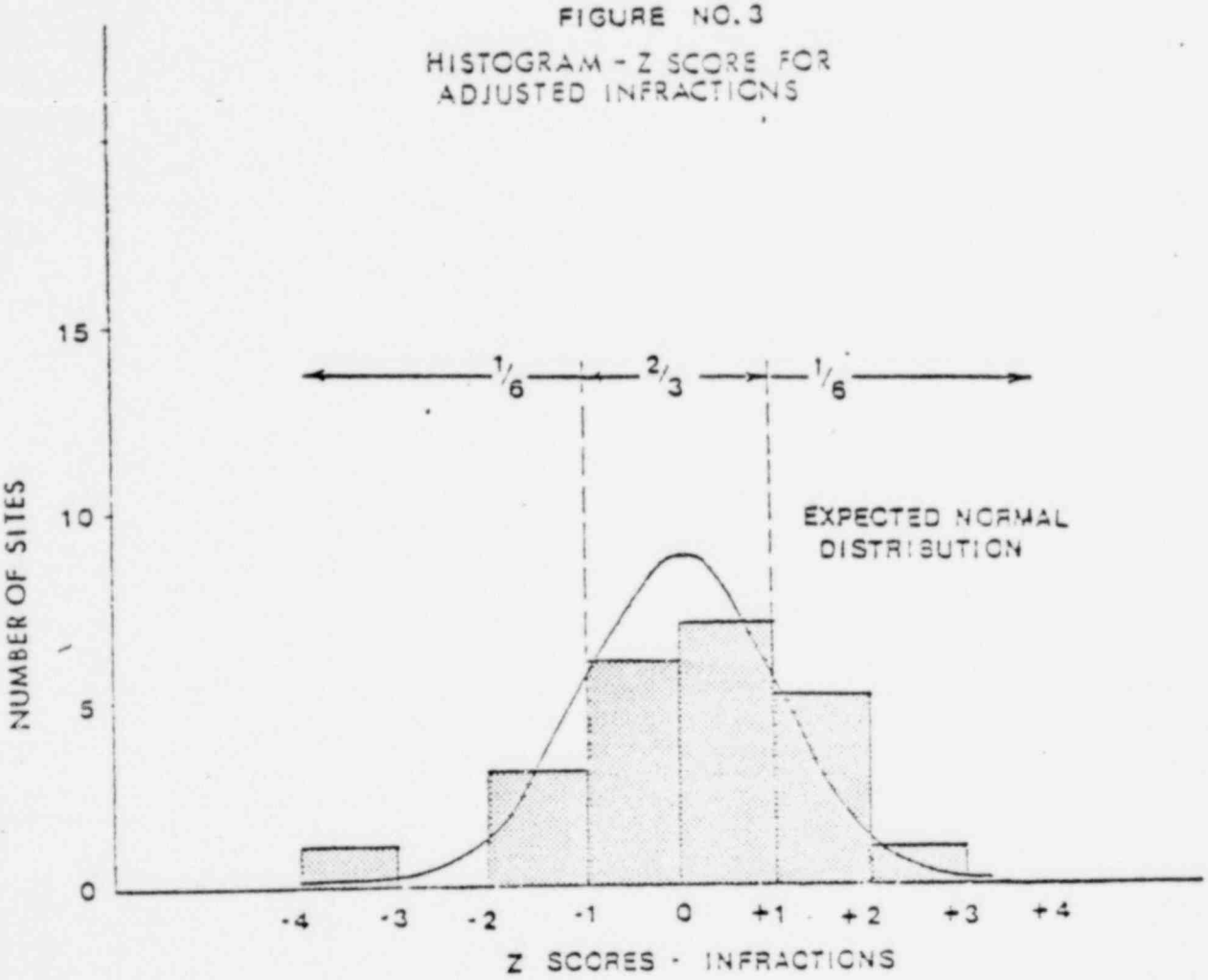
HISTOGRAM - UNADJUSTED FREQUENCY
OF INFRACTION OCCURRENCE



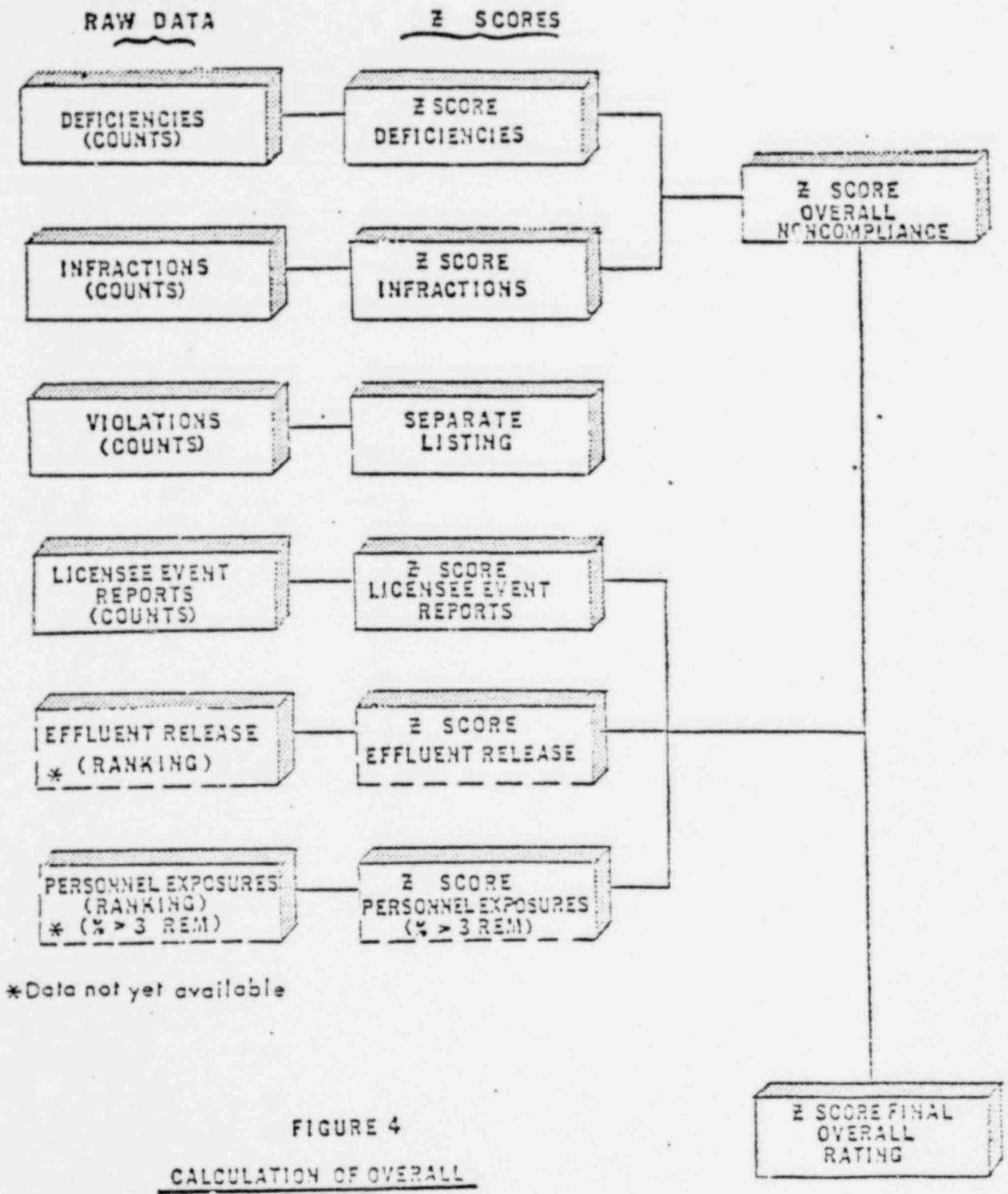
PRESSURIZED WATER REACTORS CALENDER YEAR 1976

FIGURE NO. 3

HISTOGRAM - Z SCORE FOR
ADJUSTED INFRACTIONS



PRESSURIZED WATER REACTORS CALENDER YEAR 1976



*Data not yet available

FIGURE 4

CALCULATION OF OVERALL RATING

Chapter III

ANALYSIS RESULTS

A. Introduction

The methodology described in the previous chapter has been developed through analyses of 1974 and 1975 data. This chapter summarizes the results of applying these analysis methods to data obtained in 1976. Details of the analysis are given in Appendix A.

The data analyzed are from reactors which went into commercial operation prior to 1 January 1976, with the exceptions of Indian Point 1 and Browns Ferry 1 and 2, which were shut down all or most of FH76. This leaves thirty PWRs and twenty one BWRs to be considered. At this writing, only data on noncompliances and LERs are available for FH76. Effluent release and personnel exposure data will be included in a final report on 1976 licensee performance.

The preceding chapter describes how the raw data are first to be adjusted for the effect of any identifiable variable not under management control, and then normalized. Table 1 summarizes the adjustments made for the 1976 data. Selection of the independent variables shown in Table 1 was based on patterns observed in the current and previous data and on the grounds that they were sensible. For example, one might expect that the more a reactor is inspected, the more noncompliances will be found, and the data support this hypothesis. The observed variation of performance with a variable such as date of commercial operation could reflect an aging effect or a systematic difference among reactor vintages (including license differences). In either case, it is considered appropriate to adjust the raw performance measures for this effect. There are many other candidate variables for use in adjusting performance measures. Although not all have been considered in the analysis of these 1976 data, several adjustments were included in this and previous years' analyses. The adjustments shown in Table 1 are considered meaningful, and as shown in detail in Appendix A, they do effect a considerable reduction in the variation among licensees.

Table 1

Summary of Adjustments in Analysis of 1976 Data
(Adjustments are denoted by X)

Reactor Type	Performance Measure	Independent Variable: Inspection HRS.	Age/Vintage	Reg. Office
PWR	Infractions	X		
	Deficiencies			X
	LERs		X	
BWR	Infractions	X	X	
	Deficiencies			X
	LERs		X	

As described in the preceding chapter, the analysis of licensee performance data leads to the calculation of Z-scores by which licensees can be compared. It is recognized, through, that with limited data, inexact adjustments, and basically homogeneous licensees, numerical Z-scores may convey an unwarranted sense of precision. Thus, for presentation of the results, the following categorization will be used.

Z-Score	Category	Designation
Greater than 1.0	"Above Average"	A
Between -1.0 and 1.0	"Average"	B
Less than -1.0	"Below Average"	C

If licensee performance is essentially homogeneous, after adjustment for factors not under licensee control, then about two-thirds of the licensees should fall in Category B, and one-sixth in each of the other two. Note that by the method of analysis, licensees are being compared against each other, rather than to some absolute norms, so this practically assures a mixture of A's, B's, and C's.

Licensee performance results for 1976 are summarized in Tables 2 and 3. Given there are the results for infractions and deficiencies, but excluding violations, then a combined noncompliance score obtained by weighting the scores for infractions and deficiencies in a 5:1 ratio. Also given is the score for LERs and an overall score obtained by weighting the scores for noncompliances and LERs in a 3:1 ratio. Appendix A gives the methods by which the scores were developed along with further results. These include results for the first and second halves of 1976 separately as well as for various subcategories of noncompliances and LERs. Appendix B describes a sensitivity study pertaining to the choice of weighting factors. Violations, while not discussed in Appendix B, result in a decrease of the Z-score by 1.86 for each violation, which would change the rating of Zion and Millstone #1 to C and while not changing Indian Point #2 which is already in the C category, would significantly reinforce the C categorization.

Table 2

Summary of Licensee Performance Analysis: PWRs

Station	Infractions	Deficiencies	Noncompliance	LERs	Overall
Yankee Rowe	B	A	B	B	B
San Onofre	A	B	A	A	A
Conn. Yankee	B	B	B	B	B
Ginna	A	B	A	B	A
Ind. Pt. 2	C	B	C	B	C
Turkey Pt. 3, 4	B	B	B	A	B
Palisades	C	A	C	B	C
Robinson	A	B	B	C	B
Point Beach 1, 2	A	B	A	B	A
Oconee 1, 2, 3	B	B	B	C	B
Surry 1, 2	B	B	B	C	B
Prairie Is. 1, 2	B	B	B	B	B
Ft. Calhoun	B	B	B	B	B
Three Mile Is.	B	B	B	B	B
Zion 1, 2	B	C	B	B	B
Kewaunee	B	B	B	A	B
Main Yankee	A	B	A	B	A
Rancho Seco	C	B	C	B	C
Arkansas 1	B	C	B	C	B
Cook	C	B	C	B	A
Calvert Cliffs	B	B	B	A	B
Millstone 2	B	C	B	C	B
Trojan	B	C	B	C	B

Table 3

Summary of Licensee Performance Analysis: BWRs

Station	Infractions	Deficiencies	Noncompliance	LERs	Overall
Dresden 1, 2, 3	C	B	C	C	C
Humboldt Bay	C	C	C	B	C
Big Rock Pt.	C	B	C	C	C
Oyster Creek	B	C	B	B	B
Nine Mile Pt.	B	B	B	B	B
Millstone 1	B	B	B	B	B
Quad Cities 1, 2	C	B	C	A	C
Monticello	A	A	A	B	A
Vt. Yankee	B	A	B	B	B
Peach Bottom 2, 3	A	B	A	B	A
Pilgrim	A	B	A	B	A
Cooper	B	B	B	C	B
Hatch	C	B	C	B	C
Brunswick	B	C	B	C	B
Duane Arnold	C	B	C	B	C
Fitzpatrick	A	B	B	A	A
Lacrosse	A	B	A	B	A

Appendix A

Results of Analysis of 1976 Data

A. Introduction

This appendix presents details and results of the analysis of licensee performance data for calendar year 1976 (CY76). Results are given first for noncompliances, then LERs, then for overall performance. Within each performance category the results for PWR's are given first, the results for BWR's second. The data are analyzed by six month periods, first half and second half (FH76 and SH76) in order to look for patterns in the data.

The reactors included in the analysis are those which went into commercial operation prior to 1 January 1976 and which were not shut down nearly all of 1976. This latter condition means Indian Point 1 and Browns Ferry 1 and 2 are excluded. The data from the 51 reactors thus considered are tabulated in the sections which pertain to their analysis.

B. Analysis of Noncompliances

Previous licensee performance evaluations, based on the 1974 and 1975 data, considered only the total noncompliances in each of the three severity categories - violations, infractions, and deficiencies. Much more detailed information is available, though, and it was decided to use some of it in the analysis of 1976 data. In particular, the three-letter "TAC" codes by which each item of noncompliance is labeled were used to establish 10 types of noncompliance. These types are shown in Table 1.

Table 1

Type of Noncompliance	Notation
1. Administrative Control	(1)
2. Admin. Control/Operations	(1, 2)
3. Admin. Control/Emergency Planning	(1, 3)
4. Admin. Control/Radiological Protection	(1, 4)
5. Admin. Control/Safeguards	(1, 5)
6. Operations	(2)
7. Emergency Planning	(3)
8. Radiological Protection	(4)
9. Safeguards	(5)
10. Quality Assurance	(6)

1. PWR's

Table 2 lists the noncompliance frequencies of the 30 PWR's being considered by type, severity catagories, and by time period. (The reactors are listed in docket number order.) Also listed is the total inspection time in and out of office. This latter is the independent, or explanatory, variable for which adjustment is meaningful and which has been indicated by previous analyses.

Because multiple reactors, or units, at one generating station have the same management and because noncompliance findings among multiple units show a high degree of association (in many instances one occurrence at a station results in all units at that site being assessed a noncompliance), noncompliances are analyzed on a station basis, rather than a reactor basis. Station noncompliances were obtained by tabulating noncompliance frequencies by unit and by category and type of noncompliance and then obtaining the maximum number of noncompliances of each type. For example, for the first six months of 1976 (FH76), the Turkey Point infractions were as follows:

Type of Infractions

	(1)	(1,2)	(1,3)	(1,4)	(1,5)	(2)	(3)	(4)	(5)	(6)
Turkey Pt. 3	0	2	0	2	0	2	0	0	3	0
Turkey Pt. 4	0	2	0	3	0	2	0	0	3	0
Maximum	0	2	0	3	0	2	0	0	3	0

The maximum number of infractions in each infraction type is used as an estimate of the number of distinct infractions of that type at the station. This estimate tends to underestimate the actual number of distinct infractions, but not seriously, because examination of the infraction records at multi-unit stations showed that 80-90% of the citations are multiple citations. The only instance in which station maxima were not used is for Millstone where one unit is a PWR, the other a BWR.

a. Infractions

a.1. FH76

1. Total Infractions

Previous analyses have suggested a relationship between

PRESSURIZED WATER REACTORS

TABLE NO. 2

	ADMINISTRATIVE CONTROLS TOTAL			OPERATIONS ADMINISTRATIVE CONTROLS			EMERGENCY PLANNING ADMINISTRATIVE CONTROLS			RADIOLOGICAL PROTECTION ADMINISTRATIVE CONTROLS			SAFEGUARDS ADMINISTRATIVE CONTROLS			OPERATIONS TOTAL			EMERGENCY PLANNING TOTAL			RADIOLOGICAL PROTECTION TOTAL			SAFEGUARDS TOTAL			QUALITY ASSURANCE TOTAL			TOTAL INSPECTION TIME IN & OUT OF OFFICE
	CATEGORY			CATEGORY			CATEGORY			CATEGORY			CATEGORY			CATEGORY			CATEGORY			CATEGORY			CATEGORY			CATEGORY			
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	
YANKEE ROWE																																
F.H.-76		2	1		1	1					1						4	1					1			2					3	434.5
S.H.-76																				1						1						279.0
C.Y.-76		2	1		1	1					1						4	1		1			1			3					3	713.5
SAN ONOFRE																																
F.H.-76		2												2												8	3				1	286.5
S.H.-76																															1	655.0
C.Y.-76		2												2												8	3				2	941.5
CONNECTICUT YANKEE																																
F.H.-76		5	3		2	2			1		1			1			2	4		1	4		1			5						519.0
S.H.-76			1			1											1	3								1			2		1	645.0
C.Y.-76		5	4		2	3			1		1			1			3	7		1	4		1			6			2		1	1164.0
GINNA																																
F.H.-76		2	2								1	2					2				1		2	2							1	619.9
S.H.-76		1	2			2					1						1	2			1		1			1	1				1	526.0
C.Y.-76		3	4			2					2	2					3	2			1		3	2		1	1				2	1145.9
INDIAN POINT #2																																
F.H.-76	1	8	5		1	3				1	7	1					1	5	4			3	7	1		4			5	1		874.0
S.H.-76		5	1		2	1					3						6	2	1	1			4						5	1		904.5
C.Y.-76	1	13	6		3	4				1	10	1					7	7	5	1		3	11	1		4			5	1		1778.5
TURKEY POINT #3																																
F.H.-76		4	3		2	2					2	1					4	2					2	1		3	2					284.1
S.H.-76																	2									1	1		4			364.8
C.Y.-76		4	3		2	2					2	1					6	2					2	1		4	3		4			648.9
TURKEY POINT #4																																
F.H.-76		5	3		2	2					3	1					4	2					3	1		3	2					298.0
S.H.-76																	2									1	1		2		1	286.8
C.Y.-76		5	3		2	2					3	1					6	2					3	1		4	3		2		1	564.8

PRESSURIZED WATER REACTORS

	ADMINISTRATIVE CONTROLS TOTAL	OPERATIONS ADMINISTRATIVE CONTROLS	EMERGENCY PLANNING ADMINISTRATIVE CONTROLS	RADIOLOGICAL PROTECTION ADMINISTRATIVE CONTROLS	SAFEGUARDS ADMINISTRATIVE CONTROLS	OPERATIONS TOTAL	EMERGENCY PLANNING TOTAL	RADIOLOGICAL PROTECTION TOTAL	SAFEGUARDS TOTAL	QUALITY ASSURANCE TOTAL	TOTAL INSPECTION TIME IN & OUT OF OFFICE
	CATEGORY 1 2 3	CATEGORY 1 2 3	CATEGORY 1 2 3	CATEGORY 1 2 3	CATEGORY 1 2 3	CATEGORY 1 2 3	CATEGORY 1 2 3	CATEGORY 1 2 3	CATEGORY 1 2 3	CATEGORY 1 2 3	
PRAIRIE ISLAND #1											
F.H.-76	1	3		1		1 3		2	3		336.0
S.H.-76	1	1				3 1			1		237.5
C.Y.-76	2	1		1		4 4		2	4		573.5
FORT CALHOUN											
F.H.-76	2 1	2 1				2 1			1		349.0
S.H.-76	4	1		3		3		3		3 3	579.5
C.Y.-76	6 1	3 1		3		5 1		3	1	3 3	928.5
OCONEE #3											
F.H.-76	3	3				6		2	3 1	1	297.5
S.H.-76	2			2		2		3	1	1 1	281.0
C.Y.-76	5	3		2		8		5	4 1	2 1	578.5
THREE MILE ISLAND #1											
F.H.-76	2 1	1		1	1	3 1		1	5 2	1	859.0
S.H.-76	6 3	2 2		3		4 3	1	3 1	2	1 1	632.0
C.Y.-76	8 4	2 3		4	1	7 4		4 1	5 4	2 2	1540.0
ZION #1											
F.H.-76	3 2	1 2		2		10 8		2 3		1	827.5
S.H.-76	1 6	1 6				5 6		1	4		533.2
C.Y.-76	4 8	2 8		2		15 14		2 4	4	1	1360.7
POINT BEACH #2											
F.H.-76	1	1				1 3			2		306.4
S.H.-76	1	1				1			1 2		110.5
C.Y.-75	2	2				1 4			3 2		416.9
ZION #2											
F.H.-75	2 2	2		2		6 5				1	550.5
S.H.-76	6	6				4 6		1	5		460.7
C.Y.-75	2 8	8		2		10 11		1	5	1	1010.2

PRESSURIZED WATER REACTORS

	ADMINISTRATIVE CONTROLS TOTAL			OPERATIONS ADMINISTRATIVE CONTROLS			EMERGENCY PLANNING ADMINISTRATIVE CONTROLS			RADIOLOGICAL PROTECTION ADMINISTRATIVE CONTROLS			SAFEGUARDS ADMINISTRATIVE CONTROLS			OPERATIONS TOTAL			EMERGENCY PLANNING TOTAL			RADIOLOGICAL PROTECTION TOTAL			SAFEGUARDS TOTAL			QUALITY ASSURANCE TOTAL			TOTAL INSPECTION TIME IN & OUT OF OFFICE
	CATEGORY			CATEGORY			CATEGORY			CATEGORY			CATEGORY			CATEGORY			CATEGORY			CATEGORY			CATEGORY			CATEGORY			
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	
PALISADES																															
F.H.-76		4	1		2						2	1				4							2	1		6	1		1		690.5
S.H.-75		6			6											15															421.0
C.Y.-76		10	1		8						2	1				19							2	1		6	1		1		1111.5
H. B. ROBINSON #2																															
F.H.-76		2			2											4										1					395.0
S.H.-75			3			1					2					1	2									1			2	1	510.2
C.Y.-76		2	3		2	1					2					5	2									1	1		1	1	905.2
POINT BEACH #1																															
F.H.-75																	2						.1			2					280.1
S.H.-75		2	1		2	1										2										1	2				216.5
C.Y.-75		2	1		2	1										2	2						1			3	2				496.6
OCONEE #1																															
F.H.-76		3	1		3	1										6	1						2			3	1		1		376.9
S.H.-76		2									2					1							3			1				1	251.3
C.Y.-75		5	1		3	1					2					7	1						5			4	1		1	1	628.2
OCONEE #2																															
F.H.-76		3	1		3	1										6	2						2			3	1		1		218.8
S.H.-76		2									2					1							1			1				1	186.0
C.Y.-75		5	1		3	1					2					7	2						3			4	1		1	1	404.8
SURRY #1																															
F.H.-76		4	5		1	4					2	1				4	4						3	1		4			1	1	440.5
S.H.-75		2	1			1					1					2	2						2			2					512.2
C.Y.-75		6	6		1	5					3	1				6	6						5	1		6			1	1	952.7
SURRY #2																															
F.H.-75		3	5			4					2	1				2	4						4	1		4			2		472.1
S.H.-75		2	1			1					1					4	2						2			2					346.4
C.Y.-76		3	6			5					3	1				6	6						6	1		6			2		818.5

PRESSURIZED WATER REACTORS

	ADMINISTRATIVE CONTROLS TOTAL			OPERATIONS ADMINISTRATIVE CONTROLS			EMERGENCY PLANNING ADMINISTRATIVE CONTROLS			RADIOLOGICAL PROTECTION ADMINISTRATIVE CONTROLS			SAFEGUARDS ADMINISTRATIVE CONTROLS			OPERATIONS TOTAL			EMERGENCY PLANNING TOTAL			RADIOLOGICAL PROTECTION TOTAL			SAFEGUARDS TOTAL			QUALITY ASSURANCE TOTAL			TOTAL INSPECTION TIME IN & OUT OF OFFICE
	CATEGORY			CATEGORY			CATEGORY			CATEGORY			CATEGORY			CATEGORY			CATEGORY			CATEGORY			CATEGORY			CATEGORY			
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	
KEWAUNEE																																
F.H.-76			1			1												4									2			1		470.5
S.H.-76											1																1					199.0
C.Y.-76	2			1												3											1			1		669.5
	2		1	1		1					1					3		4									3			1		
PRAIRIE ISLAND #2																																
F.H.-76		2			2												2					1			3						320.5
S.H.-76																																274.0
C.Y.-76	3			3												5	1								1							594.5
	3	2		3	2											5	3					1			4						
MAINE YANKEE																																
F.H.-76											2	2										2	2			1	2					389.5
S.H.-76	2	2									3					1						3				1			1	1		434.0
C.Y.-76	4	4		1	4						5	2										5	2		1	3			1	1		823.5
	6	6		1	4											1															
RANCHO SECO #1																																
F.H.-76																1	2															261.0
S.H.-76																3									4	2						612.2
C.Y.-76	2			2												4	2								4	2						873.2
	2			2																										1		244.0
ARKANSAS #1																																
F.H.-76																5	2															323.0
S.H.-76	3	2		3	2						2					1	1					2								3		567.0
C.Y.-76	3			1																										3	1	
	6	2		4	2						2					6	3					2										
COOK #1																																
F.H.-76																7	5		1	1		1	1		2							515.7
S.H.-76	4	5		2	4		1			1	1					1	5								1							337.0
C.Y.-76		2			2																											902.7
	4	7		2	6		1			1	1					8	10		1	1		1	1		3							
CALVERT CLIFFS #1																																
F.H.-76															1																	360.5
S.H.-76																									5							373.5
C.Y.-76	2	4		2	3										1	5	7								2	1				3	4	760.0
	2	4		2	3										1	5	7								7	1				3	4	

PRESSURIZED WATER REACTORS

	ADMINISTRATIVE CONTROLS TOTAL			OPERATIONS ADMINISTRATIVE CONTROLS			EMERGENCY PLANNING ADMINISTRATIVE CONTROLS			RADIOLOGICAL PROTECTION ADMINISTRATIVE CONTROLS			SAFEGUARDS ADMINISTRATIVE CONTROLS			OPERATIONS TOTAL			EMERGENCY PLANNING TOTAL			RADIOLOGICAL PROTECTION TOTAL			SAFEGUARDS TOTAL			QUALITY ASSURANCE TOTAL			TOTAL INSPECTION TIME IN & OUT OF OFFICE
	CATEGORY			CATEGORY			CATEGORY			CATEGORY			CATEGORY			CATEGORY			CATEGORY			CATEGORY			CATEGORY			CATEGORY			CATEGORY		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	
MILLSTONE #2															1	3		3	2								4			4		1	672.5
F.H.-76			3			2												2				1				2							503.0
S.H.-76	1		1			1					1											1				2	4		4		1	1175.5
C.Y.-76	1		4			3					1					3		5			2											
																																2		311.5
TROJAN												1				1		2				1		1									593.9
F.H.-76			2			1						2				2		5						2			5			1			905.4
S.H.-76			3			1						2				3		7				1		3			5			1		2	
C.Y.-76			5			2						3																					

infraction frequency and inspection effort and further support for such a relationship is found in the present data. The estimated relationship is

$$\widehat{INF} = 1.3 \text{ (Inspection Hrs./100)},$$

where Inspection Hours are the total in and out of office inspection hours at a station for the first six months of 1976. A chi-square goodness of fit statistic for this relationship shows a quite adequate fit ($\chi^2 = 25.0$ on 22 df) so no further adjustment seems necessary. Thus, Z-scores will be calculated by

$$ZINF = 2\sqrt{NCM} - \sqrt{INF}$$

where NCM = 1.3 (Insp. Hrs./100)

ii. Administrative Control Infractions

Total administrative control (AC) infractions are obtained by adding the infraction frequencies of (1,2), (1,3), (1,4), and (1,5) type infractions. Fitting AC infractions as a function of inspection hours yields

$$\widehat{INF}_{AC} = 0.4 \text{ (Insp. Hrs./100)}$$

and provides a fit which is not particularly good (the χ^2 value of 34.6 on 22 df falls just above the 5% significance level) but not bad enough to warrant further fitting. Thus, Z-scores will be calculated, as above, using this expression for the nominal number of AC infractions.

iii. Operations

Total operations (OP) infractions are obtained by adding types (2) and (1,2). Note that this sum overlaps that of AC infractions. Fitting OP infraction frequency versus inspection hours yields

$$\widehat{INF}_{OP} = 0.5 \text{ (Insp. Hrs./100)}$$

and a goodness of fit chi-square value, after omitting Arkansas 1, of $\chi^2 = 28.1$ of 21 df. Z-scores will be based on this fitted relationship.

iv. Emergency Planning

Too few emergency planning infractions have occurred to warrant analysis.

v. Radiological Protection and Control

Too few radiological protection and control infractions have occurred to warrant analysis.

vi. Safeguards

Total safeguards (SG) infractions are obtained by adding (1,5) and (5). The special nature of safeguards and safeguards inspection suggest that it would be inappropriate to adjust SG information frequencies for total inspection time. Examining the data indicates that the variation of SG infractions among stations is large compared to the sort of variation one would expect by chance alone ($\chi^2 = 47.5$ on 22 df). Further consideration of safeguards inspection hours, which ranged from 12 to 115 for the 23 PWRs in this period, does not reduce this variation. Because of this heterogeneity, Z-scores for SG infractions will not be calculated for first-half of 1976. This, however, does not suggest that future data cannot be used in the manner described above to obtain meaningful results. FH 76 was a period of changing emphasis in the area of safeguards, causing extreme variations in frequency and duration of inspections.

vii. Quality Assurance

Too few QA infractions occurred to warrant analysis.

a.2. SH76

i. Total Infractions

Infractions were incurred in SH76 at about the same rate as in FH76. The fitted relationship between infraction frequency and inspection hours turns out to be

$$\widehat{INF} = 1.2 \text{ (Insp. Hrs./100)}.$$

The chi-square goodness of fit statistic shows that with the exception of two stations, an adequate fit is obtained, but not as good a fit as in FH76 (χ^2 = 23.0 on 20 df, after omitting Palisades and San Onofre). Thus, Z-scores will be calculated based on the above relationship.

ii. Administrative Control

AC infractions in SH76 were less frequent and more heterogeneous than in FH76 and so were not converted to Z-scores.

iii. Operations

After omitting the data from Palisades and San Onofre, the fitted model is:

$$\hat{INF}_{OP} = 0.5 \text{ (Insp. Hrs/100)}$$

and the chi-square value obtained is 22.1 on 20 df.

iv-vii. Too few infractions of these types were incurred to warrant analysis.

a.3. CY76

i. Total Infractions

The total number of infractions for the 23 PWR stations considered in CY76 was 330 and total inspection time, in hundreds of hours, was 259.6. Thus, the average number of infractions per hundred inspection hrs. was 1.27, which is the basis of the line plotted in Figure 1, Chapter II. Thus, Z-scores for FY76 will be based on the relationship

$$\hat{INF} = 1.3 \text{ (Insp. Hrs./100).}$$

The chi-square goodness of fit statistic indicates that, with the exception of Palisades, an adequate fit is provided by this relationship (χ^2 = 21.1 on 21 df). Given the consistency shown between FH and SH76 results, this is not unexpected.

ii. Administrative Control

Results for AC infractions were not consistent for the two six-month periods, but broadening the time span to the full year provides more stability. In particular, AC infractions do not appear related to inspection time but are essentially homogeneous (after omitting Indian Pt. 2 and Palisades, $\chi^2 = 22.2$ on 20 df). The average number of AC infractions is about 4.0 so this value will be used as the nominal value in obtaining Z-scores.

iii. Operations

The adjustment of OP infractions for both FH and SH 76 data was based on the relationship,

$$\hat{INF}_{OP} = 0.5 \text{ (Insp. Hrs./100)}$$

For the full year this relationship also provides an adequate fit (excluding Palisades, $\chi^2 = 20.7$ on 21 df) and Z-scores will be based on it.

iv.,v. Emergency Planning and Radiological Protection

There were too few infractions of these two types in CY76 to warrant analysis.

vi. Safeguards

Over the full year, SG infractions were reasonably homogeneous, averaging about 4 infractions per station (and yielding a χ^2 value of 25.8 on 22 df) so Z-scores will be based on a nominal value of 4 SG infractions.

vii. Quality Assurance

There were too few QA infractions to warrant analysis.

b. Deficiencies

b.1. FH76

i. Total Deficiencies

Deficiency frequencies, in contrast to infractions, do not appear to be associated with inspection hours. A chi-square test for homogeneity shows that the variatior

among deficiency frequencies is not larger than what would be expected by chance alone ($\chi^2 = 27.6$ on 22 df). The average number of deficiencies per station is about 4.0 so this will be used as the nominal frequency in calculating Z-scores.

ii.-vii. Deficiency frequencies, by type, are too small to warrant analysis.

b.2. SH76

i. Total Deficiencies

As with FH76, total deficiencies in SH76 are fairly homogeneous, so no adjustment is made. ($\chi^2 = 32.5$ on 21 df after omitting Calvert Cliffs.) The average number of deficiencies, per station is about 3.0 for SH76 so Z-scores will be based on this nominal value.

ii.-vii. Deficiency frequencies by type are too small for further analysis.

b.3. CY76

i. Total Deficiencies

In both FH and SH76, PWR deficiencies were independent of inspection hours, but when the CY 76 totals are considered there is more evidence of heterogeneity than over the half year periods. Analysis of previous years data showed a possible association of deficiency frequency with the IE Regional Office, so this possibility was considered for the CY76 data. Comparison of deficiency frequency by regions showed that licensees in Region I incurred about twice as many deficiencies, on the average, than those in the other Regions. The nominal values on which Z-scores will be based are:

$$\hat{DEF} = 10.0, \text{ for Region I}$$
$$= 5.5, \text{ for the other Regions.}$$

The goodness of fit chi-square for this relationship, omitting Cook and Zion, is 16.8 on 19 df.

ii. Administrative Control

AC deficiencies are fairly homogeneous and do not show an association with Regional Office. The average frequency, per station, is about 3 AC deficiencies and a chi-square test based on this nominal value yields $\chi^2 = 23.7$ on 20 df, after excluding two stations, Cook and Zion. Z-scores will be based on a nominal value of 3.0.

iii. Operations

Two stations - Cook and Zion again (recall the overlap between AC and OP total frequencies) - have outlying OP frequencies, but the remaining are fairly homogeneous ($\chi^2 = 30.4$ on 20 df) about an average of 3.5 deficiencies. Z-scores will be based on a nominal of 4 OP deficiencies.

iv.-vii. Deficiency frequencies by the remaining types were too small to warrant analysis.

c. Summary of Results

Table 3 provides a summary of the results from the preceding analysis of noncompliances. Recall that a Z-score greater than 1.0 is indicated by an A, between -1.0 and 1.0 by B, and below -1.0 by C. Generally, but not always, the total Z-score is an "average" of the Z-scores by types. Exceptions can occur due to unusually large or small frequencies among the type of noncompliance for which separate Z-scores were not obtained or because several scores near a borderline can lead to a total score across the borderline.

Table 3

Summary of Licensee Performance Analysis: PWR Noncompliance

		TYPE OF NONCOMPLIANCE							
		Admin. Control		Oper-ations		Safe-guards		TOTAL	
Station	Period	INF	DEF	INF	DEF	INF	DEF	INF	DEF
Yankee Rowe	FH76	B		C		B		B	B
	SH76	-		A		-		B	A
	CY76	A	A	B	A	B		B	A
San Onofre	FH76	B		A		C		C	B
	SH76	-		A		-		A	A
	CY76	A	A	A	A	C		A	B
Conn. Yankee	FH76	C		B		B		B	C
	SH76	-		A		-		A	B
	CY76	B	B	A	C	B		B	B
Ginna	FH76	B		B		B		A	B
	SH76	-		A		-		A	C
	CY76	B	B	A	B	A		A	B
Indian Pt. 2	FH76	C		A		A		C	B
	SH76	-		B		-		C	B
	CY76	C	C	B	C	B		C	B
Turkey Pt. 3, 4	FH76	C		B		B		B	B
	SH76	-		B		-		B	B
	CY76	B	B	B	B	B		B	B
Palisades	FH76	B		B		B		C	A
	SH76	-		C		-		C	A
	CY76	C	A	C	A	B		C	A
Robinson	FH76	B		C		B		B	A
	SH76	-		A		-		B	C
	CY76	A	A	B	B	A		A	B
Point Beach 1, 2	FH76	A		A		A		A	B
	SH76	-		B		-		B	B
	CY76	A	B	B	B	B		A	B
Oconee 1, 2, 3	FH76	B		B		C		B	B
	SH76	-		B		-		B	B
	CY76	B	A	B	B	B		B	B
Surry 1, 2	FH76	B		B		B		B	B
	SH76	-		B		-		B	B
	CY76	B	C	B	C	B		B	B

Table 3 (cont'd)

Summary of Licensee Performance Analysis: PWR Noncompliance

Station	Period	TYPE OF NONCOMPLIANCE: Admin. Control INF	Admin. Control DEF	Oper-ations INF	Oper-ations DEF	Safe-guards INF	Safe-guards DEF	TOTAL INF	TOTAL DEF
Prairie Is. 1, 2	FH76	A		A		A		A	B
	SH76	-		C		-		B	A
	CY76	B	B	B	B	B		B	B
Fort Calhoun	FY76	B		B		B		B	A
	SH76	-		B		-		B	B
	CY76	B	A	B	A	A		B	B
Three M. Is.	FY76	B		B		B		B	B
	SH76	-		B		-		B	C
	CY76	C	C	B	B	B		B	B
Zion 1, 2	FH76	A		C		C		B	C
	SH76	-		B		-		B	C
	CY76	B	C	B	C	B		B	C
Kewaunee	FH76	A		A		A		B	B
	SH76	-		C		-		C	A
	CY76	A	A	B	B	A		B	B
Main Yankee	FH76	B		B		A		B	B
	SH76	-		B		-		B	C
	CY76	B	A	A	B	A		B	B
Rancho Seco	FH76	A		B		A		A	A
	SH76	-		B		-		B	B
	CY76	A	A	B	B	B		A	B
Arkansas	FH76	C		C		B		B	B
	SH76	-		B		-		C	A
	CY76	B	B	C	B	A		C	B
Cook	FH76	C		C		C		C	C
	SH76	-		B		-		A	C
	CY76	B	C	C	C	B		B	B
Calvert Cliffs	FH76	A		A		A		B	A
	SH76	-		C		-		C	C
	CY76	A	B	B	C	C		C	B
Millstone 2	FH76	A		B		B		B	C
	SH76	-		A		-		A	B
	CY76	A	B	A	B	A		B	B
Trojan	FH76	A		B		A		A	B
	SH76	-		B		-		B	C
	CY76	A	C	B	C	B		B	C

2. BWR's

Table 4 lists the noncompliance data and inspection hours for the 21 BWR's considered. As with PWR's, the data for multi-unit stations will be converted to frequencies pertaining to the station.

a. Infractions

a.1. FH76

i. Total Infractions

BWR infraction frequencies, by stations, again show evidence of an association with inspection hours, but the pattern is not consistent across stations as it was among PWRs. In particular, the four BWRs which began commercial operation (CO) in 1975 show about twice as many infractions per hour of inspection as do the remainder. The relationship fitted is

$$\widehat{INF} = 1.0 \text{ (Insp. Hrs./100, if CO prior to 1975}$$
$$= 2.0 \text{ (Insp. Hrs./100), if CO in 1975.}$$

The chi-square for goodness of fit of this model equals 23.3 on 15 df. Thus, Z-scores will be calculated with nominal values given by the above expressions.

ii.-vii. Infraction frequencies, by type, are either too small or too heterogeneous to warrant analysis.

a.2. SH76

i. Total Infractions

The association noted in FH76 of infraction frequency with date of commercial operation is not repeated with any consistency - two of the four stations which began commercial operation in 1975 had an unusually high number of infractions, compared to other BWRs, two did not. The bulk of the data, 15 out of 17 stations, are adequately fit by the model

$$\widehat{INF} = 1.0 \text{ (Insp. Hrs./100).}$$

The goodness of fit chi-square value being 11.7 of 14 df.

BOILING WATER REACTORS

	ADMINISTRATIVE CONTROLS TOTAL			OPERATIONS ADMINISTRATIVE CONTROLS			EMERGENCY PLANNING ADMINISTRATIVE CONTROLS			RADIOLOGICAL PROTECTION ADMINISTRATIVE CONTROLS			SAFEGUARDS ADMINISTRATIVE CONTROLS			OPERATIONS TOTAL			EMERGENCY PLANNING TOTAL			RADIOLOGICAL PROTECTION TOTAL			SAFEGUARDS TOTAL			QUALITY ASSURANCE TOTAL			TOTAL INSPECTION TIME IN & OUT OF OFFICE
	CATEGORY			CATEGORY			CATEGORY			CATEGORY			CATEGORY			CATEGORY			CATEGORY			CATEGORY			CATEGORY			CATEGORY			CATEGORY			
	1	2	3	1	2	3	1	2		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	
DRESDEN #3																																	
F.H.-76			1			1						1												1									
S.H.-76		1	2		1	2										2	1								9							316.0
C.Y.-76		1	3		1	3										3	2								-			2				258.0
																5	3								10			2				574.0
QUAD CITIES #1																																	
F.H.-76		1	1		1																											
S.H.-76		2	1		1	1		1								3							1	1	2							500.5
C.Y.-76		3	2		2	1		1								5	2		2				1		1			1	2			361.0
																8	2		2				2	1	3			1	2			861.5
BONTICELLO																																	
F.H.-76			1			1				1																							
S.H.-76		1			1											1							1							1		594.0
C.Y.-76		2	1		1	1				1						1	1						1		1					1		203.0
																									1					1		797.0
QUAD CITIES #2																																	
F.H.-76			1									1																					
S.H.-76		2	1		1	1		1								3							2	1	2							303.0
C.Y.-76		2	2		1	1		1				1				2	2		2				1		1			3	3			426.0
																5	2		2				3	1	3			3	3			729.0
VERMONT YANKEE																																	
F.H.-75		1			1											2	1								1	1							489.5
S.H.-76		2	3		2	3										4	4			1				2	1							664.5
C.Y.-76		3	3		3	3										6	5			1				2	2	1		3	2			1354.0
PEACH BOTTOM #2																																	
F.H.-76		2	3			3		2								3	7						2			1							731.5
S.H.-76		1	5		1	3			1			1				6	6							1				3					581.5
C.Y.-76		3	8		1	6			1		2	1				9	13						2	1		1		3					1316.0
PEACH BOTTOM #3																																	
F.H.-76		2	3			3		2								2	5						2			1							403.0
S.H.-76			4			3				1						5	6							1				3					513.0
C.Y.-76		2	7			6		2		1						7	11						2	1		1		3					921.0

BOILING WATER REACTORS

	ADMINISTRATIVE CONTROLS TOTAL			OPERATIONS ADMINISTRATIVE CONTROLS			EMERGENCY PLANNING ADMINISTRATIVE CONTROLS			RADIOLOGICAL PROTECTION ADMINISTRATIVE CONTROLS			SAFEGUARDS ADMINISTRATIVE CONTROLS			OPERATIONS TOTAL			EMERGENCY PLANNING TOTAL			RADIOLOGICAL PROTECTION TOTAL			SAFEGUARDS TOTAL			QUALITY ASSURANCE TOTAL			TOTAL INSPECTION TIME IN & OUT OF OFFICE
	CATEGORY			CATEGORY			CATEGORY			CATEGORY			CATEGORY			CATEGORY			CATEGORY			CATEGORY			CATEGORY			CATEGORY			
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	
DRESDEN #1																																
F.H.-76																3	3					1			9				1		325.5
S.H.-76		1	3		1	3										1	1								1						219.5
C.Y.-76																4	4					1			10						545.0
		1	3		1	3																									
MORRIS BAY																																
F.H.-76																3	1								4					9	338.5
S.H.-76		3	1		3	1																			5					1	587.5
C.Y.-76		3	1		3	1										3	1								9					10	926.0
BIG ROCK POINT																																
F.H.-76			2			2				1					1	6	2								3				1		679.0
S.H.-76		2	2		1	1				1					1	2	1					2				2			1		297.5
C.Y.-76		2	4		1	3				1					1	8	3					2			3	2			2		976.5
OYSTER CREEK																																
F.H.-75		3	3		1	2		1			2					1	4		1	4		3				4			1	4	831.0
S.H.-76			2					1				1				1			1	2			1			3			2	1	467.5
C.Y.-76		3	5		1	2		2			2	1				2	4		2	6		2	1			7			3	5	1298.5
NINE MILE POINT #1																																
F.H.-76		2	1		1						1	1				1	1					4	1						2	3	810.5
S.H.-76		3	1		2	1					1					4	4					2				2				1	609.5
C.Y.-76		5	2		3	1					2	1				5	5					6	1			2			2	4	1420.0
[illegible]																																
F.H.-76		1	3		1	3										5	4						1		3					1	600.2
S.H.-76		2	1			1					2					3	2					2			1						192.0
C.Y.-76		3	4		1	4					2					8	6					2	1		4				8	1	792.2
MILLSTONE #1																																
F.H.-76		3	3		3	1									2	5	1		2			3				7			1	2	821.0
S.H.-76		4			3						1					1	6	3				1			1				1		1271.0
C.Y.-76		7	3		6	1					1				2	1	11	4	2			4			1	7			2	2	2092.0

BOILING WATER REACTORS

TABLE NO 5

	ADMINISTRATIVE CONTROLS TOTAL			OPERATIONS ADMINISTRATIVE CONTROLS			EMERGENCY PLANNING ADMINISTRATIVE CONTROLS			RADIOLOGICAL PROTECTION ADMINISTRATIVE CONTROLS			SAFEGUARDS ADMINISTRATIVE CONTROLS			OPERATIONS TOTAL			EMERGENCY PLANNING TOTAL			RADIOLOGICAL PROTECTION TOTAL			SAFEGUARDS TOTAL			QUALITY ASSURANCE TOTAL			TOTAL INSPECTION TIME IN & OUT OF OFFICE
	CATEGORY			CATEGORY			CATEGORY			CATEGORY			CATEGORY			CATEGORY			CATEGORY			CATEGORY			CATEGORY			CATEGORY			
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	
PILGRIM #1																																
F.H.-76		5	1								4	1											5	1		5	2				779.0
S.H.-76		2	1		1	1					1						1	4					2	2			1		2	3	695.0
C.Y.-76		7	2		1	1					5	1					1	4					7	3		5	3		2	3	1474.0
COOPER																																
F.H.-76		1			1												1	1											5	2	434.0
S.H.-76		1	1		1	1											1	1											3	1	597.0
C.Y.-76		2	1		2	1											2	2											8	3	1031.0
HATCH #1																																
F.H.-76		2	1		1												8	1								1			2	2	526.2
S.H.-76		8	2		7	2					1						10	3					2								595.5
C.Y.-76		10	3		8	2					1						18	4					2			1			2	2	1121.7
BROWNS FERRY #2																																
F.H.-76		2	3		1	3					1						4	8					3			2	2		3		606.5
S.H.-76		3	1		2	1					1						4	2					1			1	1				450.5
C.Y.-76		5	4		3	4					2						8	10					4			3	3		3		1057.0
DUANE ARNOLD																																
F.H.-76		1	1		1	1											7	4											5	1	768.0
S.H.-76		6			6												10									4			8		440.5
C.Y.-76		7	1		7	1											17	4								4			13		1208.5
FITZPATRICK																																
F.H.-75			3			3												3								9	1		1	4	580.5
S.H.-76		5	2		3	2									2		3	7								2					652.0
C.Y.-76		5	5		3	5									2		3	10								11	1		1	4	1252.5
LA CROSSE																																
F.H.-76		1			1												1						2							1	577.5
S.H.-76			3			3												3													348.0
C.Y.-76		1	3		1	3											1	3												1	925.5

ii.-vii. Too few infractions, by type, were incurred to warrant analysis.

a.3. CY76

i. Total Infractions

The results of the analyses of FH and SH76 data suggests that, for the most part, total BWR infractions are related to inspection effort by

$$\widehat{INF} = 1.0 \text{ (Insp. Hrs./100)}.$$

Combining the data over the full year leads to some refinement. The fitted relationship becomes

$$\widehat{INF} = 0.9 \text{ (Insp. Hrs./100) if CO prior to 1975}$$
$$= 1.6 \text{ (Insp. Hrs./100) if CO in 1975}$$

The chi-square for goodness-of-fit of this model, after omitting Dresden and Duane Arnold, is 19.6 on 13 df, which is adequately small so that Z-scores will be based on nominal values given by this relationship.

ii. Administrative Control

As with PWRs, AC infractions appear to be fairly homogeneous, independent of inspection effort, and to average about 4 per station for CY76. (The chi-square value for testing for homogeneity equals 22.1 on 16 df.) Thus, Z-scores will be obtained based on a nominal AC infraction frequency of 4.0.

iii. Operations

As with PWRs, BWR OP infractions appear related to inspection hours, the fitted relationship being

$$\widehat{INF}_{OP} = 0.4 \text{ (Insp. Hrs./100)}.$$

The goodness-of-fit chi-square statistic for this model, excluding Hatch and Duane Arnold, is $\chi^2 = 20.5$ on 14 df.

iv., v. Emergency Planning and Radiological Protection

Too few EP and RP infractions were incurred to warrant analysis.

vi. Safeguards

Safeguards infractions were quite heterogeneous - 3 of the 17 BWR stations incurred 30 of the 48 SG infractions in CY76 - so Z-scores will not be calculated for this type of infraction.

vii. Quality Assurance

The variation among QA infraction frequencies was similar to that of SG infractions, so no Z-scores will be calculated.

b. Deficiencies

b.1. FH76

i. Total Deficiencies

Total deficiencies do not show evidence of an association with inspection hours, but neither do they appear to be completely homogeneous. The analysis results for PWRs suggest a consideration of Regional differences. For BWRs, about twice as many deficiencies are incurred by licensees in Region I as elsewhere. (There are three outlying frequencies - those for Pilgrim, in Region I, and for Humboldt Bay, and Brunswick in other Regions. However, as will be seen, when the yearly totals are considered, less erratic variation is encountered.) Z-scores will be based on the following nominal values:

$\hat{DEF}$ = 8.0, for Region I
= 4.0, for other Regions

ii.-vii. Deficiency frequencies, by type, were too infrequent to warrant analysis.

b.2. SH76

i. Total Deficiencies

Fewer deficiencies were incurred in SH76 than in FH76, but the association with Regional Office persisted. The nominal values which will be used to obtain Z-scores are:

$\widehat{DEF}$ = 7.0, for Region I
= 2.0, for other Regions.

The chi-square value for goodness of fit of this relationship is 12.6 on 15 df, with no stations excluded, so the fit is quite adequate.

ii.-vii. Deficiency frequencies, by type, were too small to warrant analysis.

b.3. CY76

i. Total Deficiencies

For the full year, deficiency frequencies, by Region, lead to the following nominal values:

$\widehat{DEF}$ = 14, for Region I
= 6, for other Regions.

The chi-square value for goodness of fit of this relationship is χ^2 = 21.9 on 15 df (and 13.7 on 14 df if Brunswick is omitted), which indicates an adequate fit, so Z-scores will be calculated from these nominals.

ii. Administrative Control

AC deficiencies are fairly homogeneous (χ^2 = 17.7 on 16 df for testing homogeneity), and appear to be independent of inspection hours and Regional Office. The average number of AC deficiencies per station was about 3.0 and Z-scores will be based on this nominal value.

iii. Operations

Three stations - Peach Bottom, Brunswick, and Fitzpatrick - had about three times as many OP deficiencies as the remaining stations. Among the remaining 14 stations the OP frequencies were quite homogeneous ($\chi^2 = 8.6$ on 13 df). As two of the three outliers are in Region I, the Regional difference observed among total deficiencies suggests itself, but the evidence does not warrant a separate nominal value for Region I. The nominal OP value used in obtaining Z-scores will be 4.0.

iv.-vii. Deficiency frequencies for the remaining types were too small to warrant analysis.

c. Summary of Results

The results of calculating the Z-scores based on the preceding analysis of BWR noncompliances are given in Table 5.

Table 5

Summary of Licensee Performance Analysis: BWR Noncompliances

Station	Period	Type of Noncompliance: Admin. Control INF	Admin. Control DEF	Operations INF	Operations DEF	Total INF	Total DEF
Dresden 1, 2, 3	FH76					C	B
	SH76					B	B
	CY76	B	B	B	B	C	B
Humboldt Bay	FH76					B	C
	SH76					B	B
	CY76	B	A	B	A	C	C
Big Rock Pt.	FH76					C	A
	SH76					C	B
	CY76	A	B	C	B	C	B
Oyster Cr.	FH76					B	C
	SH76					B	B
	CY76	B	C	A	B	B	C
Nine Mile Pt.	FH76					B	A
	SH76					B	B
	CY76	B	B	B	B	B	B
Millstone 1	FH76					B	B
	SH76					A	A
	CY76	C	B	B	B	B	B
Quad Cities 1, 2	FH76					B	A
	SH76					C	C
	CY76	B	B	B	A	C	B
Monticello	FH76					A	A
	SH76					B	A
	CY76	A	A	A	A	A	A
Vt. Yankee	FH76					B	A
	SH76					B	B
	CY76	B	B	B	B	B	A

Table 5 (cont'd)

Summary of Licensee Performance Analysis: BWR Noncompliances

Station	Period	Type of Noncompliance: Admin. Control INF	Admin. Control DEF	Operations INF	Operations DEF	Total INF	Total DEF
Peach Bottom	FH76					A	B
	SH76					B	B
	CY76	B	C	B	C	A	B
Pilgrim	FH76					A	A
	SH76					B	C
	CY76	C	B	A	B	B	B
Cooper	FH76					C	B
	SH76					B	B
	CY76	A	A	A	A	B	B
Hatch	FH76					B	B
	SH76					C	B
	CY76	C	B	C	B	C	B
Brunswick	FH76					B	C
	SH76					B	B
	CY76	B	B	C	C	B	C
Duane Arnold	FH76					B	B
	SH76					C	A
	CY76	C	A	C	B	C	B
Fitzpatrick	FH76					B	B
	SH76					B	B
	CY76	B	B	A	C	A	B
Lacrosse	FH76					A	A
	SH76					A	B
	CY76	A	B	A	B	A	B

C. Analysis of Licensee Event Reports (LERs)

The data analyzed, in the case of multi-unit stations, are the total LERs, of the types listed below, over the units at a station. This performance measure is used because examination of LER details indicates that these events are reported singly; one event does not result in multiple LERs, in contrast to the situation with noncompliances. In addition to considering total LERs, it was determined that various types, or subcategories, of LERs could be identified. From reading the LER files, each LER was classified according to the following matrix.

	Personnel Error	Procedural Error
Operations		
Maintenance		
Env. & Health Physics		

Other types of LERs, such as component failures or design error, are not included in the analysis because they are not as reflective as licensee performance. Thus, an analysis can be done of different types of LERs, similar to the analysis of different types of noncompliances. However, the frequencies are small enough that LER types will only be considered for the yearly totals. PWR and BWR LER data are given in Tables 6 and 8, respectively.

1. PWRs

a. FH76 and SH76

1. Total LERs

In both six month periods, total LERs varied more among stations than what would be expected if LER frequencies were homogeneous. Further examination of the data indicates the LER frequencies are associated with age. Newer stations tend to have more LERs than older. The

Table 6

PWR LER Frequencies

Station	Period	Personnel Error			Procedural Error		
		Operations	Maint.	Env. & HP	Operations	Maint.	Env. & HP
Yankee Rowe	FH76	1				1	
	SH76						
	CY76	1				1	
San Onofre	FH76						
	SH76						
	CY76						
Conn. Yankee	FH76		1		1		
	SH76		1				
	CY76		2		1		
Ginna	FH76		2		1		
	SH76						
	CY76		2		1		
Ind. Pt. 2	FH76	2		1			
	SH76	2	2				
	CY76	4	2	1			
Turkey Pt.	FH76						
	SH76		1				
	CY76		1				
Palisades	FH76	2	1				
	SH76	1	1				
	CY76	3	2				
Robinson	FH76	1	2				
	SH76		3				
	CY76	1	5				
Pt. Beach	FH75	2	1				
	SH76						
	CY76	2	1				
Oconee	FH76	4	4		1	1	2
	SH76	3	3		1	1	
	CY76	7	7		2	2	2
Surry	FH76	1	1		1		
	SH76	3		2			
	CY76	4	1	2	1		

Table 6 (cont'd)

PWR LER Frequencies

Station	Period	Personnel Error			Procedural Error		
		Operations	Maint.	Env. & HP	Operations	Maint.	Env. & HP
Prairie Is.	FH76	2	3		1	3	
	SH76	2	4	1	1		
	CY76	4	7	1	2	3	
Ft. Calhoun	FH76		2	1		1	
	SH76	1	2	1		1	
	CY76	1	4	2		2	
Three M. Is.	FH76	2	2		2	2	
	SH76	1	2	1			
	CY76	3	4	1	2	2	
Zion	FH76	4			2		1
	SH76	3	1				
	CY76	7	1		2		1
Kewaunee	FH76	2				1	1
	SH76	2	4	3			
	CY76	4	4	3		1	1
Maine Yankee	FH76	1					
	SH76	1					
	CY76	2					
Rancho Seco	FH76	1	1			1	
	SH76	1	1				
	CY76	2	2			1	
Arkansas	FH76	2			1		
	SH76	3	2				
	CY76	5	2		1		
Cook	FH76	3	1		2	1	
	SH76	4	1	2			
	CY76	7	2	2	2	1	
Calvert Cliff.	FH76	1					
	SH76	1	1	1			
	CY76	2	1	1			
Millstone 2	FH76	3					
	SH76	2				1	1
	CY76	5				1	1
Trojan	FH76	6			8		
	SH76	2	1				2
	CY76	8	1		8		2

trend is not a smooth one, but rather a dichotomy occurs. This leads to the following choice of nominal values:

$\hat{LER}$ = 2.0, if CO date is prior to 1973,
= 5.0, if CO date is 1973 or later.

For multi-unit stations, the CO date used is that of the first unit in operation. After excluding two FH76 observations - Trojan and Oconee - the chi-square values obtained (20.9 on 19 df and 24.0 on 21 df, for FH76 and SH76, respectively) indicate an adequate fit so Z-scores will be calculated accordingly.

b. CY76

i. Total LERs

The consistent patterns noted in the preceding paragraph over FH and SH76 of necessity carry over to the CY76 totals. The average number of LERs among the older stations (CO prior to 1973) is about 3.6 and for the remaining stations (excluding Oconee and Trojan) is about 10.0, so these values will be taken as the nominal LER CY76 frequencies in calculating Z-scores. The chi-square goodness of fit value for this relationship is 31.3 on 19 df, slightly above the upper fifth percentile, but not enough to warrant further adjustment.

ii. Personnel Errors

The variation among the subtotals of LERs involving personnel errors follows a similar pattern as that of total LERs (about three-fourths of all LERs are personnel errors). The nominal values obtained are:

$\hat{PERS}$ = 3, if CO prior to 1973
= 8, if CO in 1973 or after,

and the chi-square value for goodness of fit is 30.7 on 21 df.

iii. Other Types of LERs

Other LER subtotals, such as procedural errors, operations, maintenance, and environmental and health physics are too infrequent or too heterogeneous to warrant analysis.

c. Summary of Results

Table 7 summarizes the Z-scores calculated for PWR LERs.

Table 7

Summary of Licensee Performance Analysis: PWR LERs

Station	Personnel	Total LERs FH76	SH76	CY76
Yankee Rowe	A	B	B	B
San Onofre	A	A	A	A
Conn. Yankee	B	B	B	B
Ginna	B	B	A	B
Indian Point 2	B	A	B	A
Turkey Pt.	A	A	B	A
Palisades	C	B	B	B
Robinson	C	B	B	C
Pt. Beach	B	B	A	B
Oconee	C	C	C	C
Surry	C	B	C	C
Prairie Is.	C	C	C	C
Ft.Calhoun	B	B	B	B
Three M. Is.	B	C	B	B
Zion	B	B	B	B
Kewaunee	C	B	C	B
Maine Yankee	B	B	B	B
Rancho Seco	A	A	A	A
Arkansas	B	A	B	B
Cook	C	B	B	C
Calvert Cliffs	A	A	A	A
Millstone 2	A	A	B	A
Trojan	B	C	B	C

2. BWRs

a. FH76 and SH76

i. Total LERs

As with PWRs, LER frequency shows a dichotomy related to age. However, the split occurs at a different time and is more pronounced than with PWRs and is also not

quite so consistent over the two six month periods. The nominal values, on which Z-scores for BWR LERs will be based are

FH76: $\widehat{LER}$ = 3, if CO prior to 1974,
= 14, if CO in 1974 or after.

SH76: $\widehat{LER}$ = 3, if CO prior to 1974,
= 10, if CO in 1974 or after.

After excluding Dresden in both periods and Cooper in FH76, the chi-square goodness of fit values for this relationship show an adequate fit (χ^2 = 16.2 on 13 df for FH76 and χ^2 = 12.8 on 14 df for SH76).

b. CY76

i. Total LERs

The results of the preceding section lead to CY76 nominal LER frequencies as follows:

$\widehat{LER}$ = 6, of CO prior to 1974
= 24, if CO in 1974 or after

With the exception of one station in each group, Dresden and Cooper, the fit is quite adequate (χ^2 = 11.3 on 13 df), so Z-scores will be based on this relationship.

ii. Personnel Errors

LERs involving personnel errors (about 60% of all LERs) follow the same pattern in total LERs. The nominal values obtained from the data are:

$\widehat{PERS}$ = 4, if CO prior to 1974,
= 20, if CO in 1974 or after.

The chi-square value for this relationship is small enough (χ^2 = 9.7 on 13 df after omitting Dresden and Cooper) to indicate an adequate fit.

Table 8

BWR LER Frequencies

Station	Period	Personnel Error			Procedural Error		
		Operations	Maint.	Env. & HP	Operations	Maint.	Env. & HP
Dresden	FH76		6	1		2	
	SH76	1	5	1		2	
	CY76	1	11	2		4	
Humboldt Bay	FH76	2				2	
	SH76						
	CY76	2				2	
Big Rock Pt.	FH76	1				1	
	SH76	1	2			3	1
	CY76	2	2			4	1
Oyster Cr.	FH76	1	1				
	SH76	1				1	
	CY76	2	1			1	
Nine M. Pt.	FH76	1	2				
	SH76			1		2	
	CY76	1	2	1		2	
Millstone 1	FH76		2		1		1
	SH76	1			2		
	CY76	1	2		3		1
Quad Cities	FH76		1	2		1	
	SH76	2	1			1	
	CY76	2	2	2		2	
Monticello	FH76						
	SH76	1	2				
	CY76	1	2				
Vt. Yankee	FH76	2	1			1	
	SH76	1	1				
	CY76	3	2			1	
Peach Bottom	FH76	5	2	2		1	
	SH76	2	4	4	2		
	CY	7	6	6	2	1	
Pilgrim	FH76	3			1		
	SH76					1	
	CY76	3			1	1	

Table 8 (cont'd)

BWR LER Frequencies

		Personnel Error			Procedural Error		
Station	Period	Operations	Maint.	Env., & HP	Operations	Maint.	Env. & HP
Cooper	FH76	1					
	SH76	1	6			1	
	CY76	2	6			1	
Hatch	FH76	8	9		3	1	
	SH76	6	3	1			
	CY76	14	12	1	3	1	
Brunswick	FH76	9	5		4	1	
	SH76	4	4	1		1	
	CY76	13	9	1	4	2	
Duane Arnold	FH76	3	4	1	4		
	SH76	2	6	3			
	CY76	5	10	4	4		
Fitzpatrick	FH76	6	4				
	SH76	1		1	1	2	2
	CY76	7	4	1	1	2	2
Lacrosse	FH76						
	SH76	1	2		1		
	CY76	1	2		1		

c. Summary of Results

Table 9 summarizes, by A, B, and C, and Z-scores for BWR LERs determined from the analyses of the previous sections.

Table 9

Summary of Licensee Performance Analysis: BWR LERs

Station	Personnel	Total LERs FH76	SH76	CY76
Dresden	C	C	C	C
Humboldt Bay	A	B	A	B
Big Rock Pt.	B	B	C	C
Oyster Cr.	B	B	B	B
Nine M. Pt. 1	B	B	B	B
Millstone 1	B	B	B	B
Quad Cities	B	B	B	B
Monticello	B	A	B	A
Vt. Yankee	B	B	B	B
Peach Bottom	B	A	B	B
Pilgrim	B	B	A	B
Cooper	A	A	B	A
Hatch	C	C	B	C
Brunswick 2	B	C	B	B
Duane Arnold	B	B	B	B
Fitzpatrick	A	A	A	A
Lacrosse	B	A	B	B

D. Overall Performance Measures

In order to obtain an overall performance measure, the individual performance measure Z-scores were combined in the following way. Infraction and deficiency Z-scores were combined by weights in a ratio of 5:1 in order to obtain an overall score for noncompliances. This score was then combined in a ratio of 3:1 with the Z-score for LERs. At each stage when a weighted sum is calculated, the sum is normalized by dividing by the square root of the sum of squares of weights. Appendix B describes a sensitivity study of the choice of weights. The overall performance measures are tabulated in Chapter III.

Appendix B

Sensitivity Analysis of Weighting Factors

The overall licensee performance measure, expressed as a Z-socre, is obtained by taking a linear combination of the Z-scores for infractions, deficiencies, and LERs. Table 1 shows the weights used in this linear combination and the products of the weights, which is the resulting effect on the overall Z-score. Note that the weights are scaled so that their sum of squares equals 1.0. This is so that the overall Z-score will be comparable to the standard normal distribution. Thus, from Table 1, an increase in Z_{INF} by 1.0 results in the overall Z increasing by 0.93; Z_{DEF} increasing by 1.0 results in a 0.19 increase in overall Z; and the effect of Z_{LER} on overall Z is 0.32.

Table 1

Weights on Z-Scores and Resulting Effect on Overall Z-Score

Performance Measure	Wt 1	Wt 2	Wt 1 x Wt 2
Infractions (Z_{INF})	5/ $\sqrt{26}$	3/ $\sqrt{10}$	0.93
Deficiencies (Z_{DEF})	1/ $\sqrt{26}$		0.19
LERs (Z_{LER})		1/ $\sqrt{10}$	0.32

The choice of weights is based on judgments as to the relative importance which should be attached to deviations from average performance in the three performance measures, and as such is to some extent arbitrary. For the sake of comparison, some alternative weights are illustrated in Table 2. The effect of any other choice of weights can be readily evaluated by following the format of Table 2.

The effects shown in Tables 1 and 2 are in terms of Z-scores. The effects in terms of the frequencies of noncompliances and LERs are obtained by recalling that Z-scores are essentially numbers of standard deviations above or below the nominal frequencies. For counting data, and the Poisson distribution, the standard deviation is the square root of the nominal. As described in Appendix A, nominal noncompliance and LER frequencies are not constants, but rather functions of such variables as inspection hours, age, and Regional Office. However, some rough averages can be used to get an idea of the sensitivity of overall Z to noncompliances and LERs.

Infraction frequencies, for both PWRs and BWRs averaged about 1.3 infractions per 100 inspection hours. Average inspection hours for CY76 was about 1200 hours, so the average nominal frequency of infractions is about 16. Thus, the standard deviation is about 4. From Table 1, then, it is seen that a decrease of one infraction will result in an increase in overall Z of 0.93/4 = 0.23. Thus, it would take a swing of at least 5 infractions to move an overall Z-score from an A to a C, for example.

Table 2

Alternative Weights on Z-Scores and Resulting Effects on Overall Z-Score

	Performance Measure	Wt. 1	Wt 2	Wt 1 x Wt 2
A	Z_{INF}	$2/\sqrt{5}$	$3/\sqrt{10}$	0.85
	Z_{DEF}	$1/\sqrt{5}$		0.42
	Z_{LER}		$1/\sqrt{10}$	0.32
B	Z_{INF}	$8/\sqrt{65}$	$3/\sqrt{10}$	0.94
	Z_{DEF}	$1/\sqrt{65}$		0.12
	Z_{LER}		$1/\sqrt{10}$	0.32
C	Z_{INF}	$2/\sqrt{5}$	$1/\sqrt{2}$	0.63
	Z_{DEF}	$1/\sqrt{5}$		0.32
	Z_{LER}		$1/\sqrt{2}$	0.71
D	Z_{INF}	$5/\sqrt{26}$	$1/\sqrt{2}$	0.69
	Z_{DEF}	$1/\sqrt{26}$		0.14
	Z_{LER}		$1/\sqrt{2}$	0.71
E	Z_{INF}	$8/\sqrt{65}$	$1/\sqrt{2}$	0.70
	Z_{DEF}	$1/\sqrt{65}$		0.69
	Z_{LER}		$1/\sqrt{2}$	0.71

Nominal deficiency frequencies varied over Regions and reactor types, but averaged about 9 per station over the year. Thus, the effect of a decrease of one deficiency is to increase overall Z by 0.19/3 = 0.06. Only in marginal cases could a swing of a few deficiencies result in the overall Z-score moving from one category to another.

The average number of LERs varies considerably, but a rough overall average of 6 LERs is adequate for use in evaluating sensitivity. For this average, a decrease of one LER results in an increase in overall Z of $0.32/\sqrt{5} = 0.13$. Thus, an LER has about twice the effect of a deficiency and half that of an infraction. These relative weights are felt to be reasonable and appropriate and for these reasons were used.

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

wltr
1/4/79
Hendrie to Luce

Dear

The enclosed Nuclear Regulatory Commission Staff Paper, POLICY SESSION ITEM (SECY-78-554, dated October 25, 1978) with subject "Licensee Regulatory Performance Evaluation" describes three approaches tried by the NRC staff for evaluating the regulatory performance of operating nuclear power plants. These approaches were preliminary efforts toward developing a technique for evaluating the regulatory performance of NRC licensees on a nationwide basis. The staff has requested Commission approval of a two-year trial program to further develop and test an evaluation technique.

If successful, licensee regulatory performance evaluation should give NRC staff the ability, on a nationwide basis, to distinguish between levels of licensee regulatory performance. This could lead to more effective use of the agency's inspection and enforcement resources and to identification of plants that need further examination by the agency.

The NRC staff emphasizes that, while an evaluation program may be useful in focusing staff attention of the plants that depart from the performance of the majority of plants, the means of assuring adequacy of plant safety will not be changed. This assurance will continue to rest on detailed reviews of plant operations by the Office of Nuclear Reactor Regulation and plant-by-plant judgments made as a result of inspections by the Office of Inspection and Enforcement.

The three evaluation approaches which have been tried are:

1. The "statistical method," based on evaluating two measures of performance: the number of noncompliance findings and the number of events, considered directly controllable by the licensee of the total events required to be reported to the NRC. These

factors then were weighed by taking into account such things as the severity of the items of noncompliance and the amount of staff inspection time required to identify individual items of noncompliance. Under the statistical method, reactors or sites were identified as being in one of three groups - A, B, C.

2. The "trend analysis method," based on a detailed review of events which licensees are required to report to the NRC. An effort then was made to identify trends, repetitive problems, or those linked to similar causes.

3. The "regional survey method," which collected expressions of opinion of facilities by NRC inspectors and regional management. For the trial effort, NRC field inspector personnel were asked to express themselves on a scale, from acceptable to exceptional, about factors concerning operating reactors.

The Staff Paper, SECY-78-554 and its enclosure including the reports describing the approaches tried by the NRC staff, are enclosed. These documents are being sent to each licensee whose facility is mentioned in the paper or reports and to other individuals expressing an interest in this matter. Copies, also, have been placed in the NRC's Public Document Room, 1717 H Street, N.W., Washington, D.C., and the Commission's Regional Offices--631 Park Avenue, King of Prussia, Pennsylvania; Suite 3100, 101 Marietta Street, Atlanta, Georgia; 799 Roosevelt Road, Glen Ellyn, Illinois; Suite 1000, 611 Ryan Plaza Drive, Arlington, Texas; and Suite 202, 1990 North California Boulevard, Walnut Creek, California.

Sincerely,

Enclosure:
USNRC Policy Session Item,
SECY-78-554, dtd 10/25/78,
w/encls.

October 25, 1978

SECY-78-554

UNITED STATES
NUCLEAR REGULATORY COMMISSION

POLICY SESSION ITEM

w/1tr
1/4/79
Henshie to Luce

For: The Commissioners

From: John G. Davis, Acting Director
Office of Inspection and Enforcement

Thru: Executive Director for Operations THR for L.J.G.

Subject: LICENSEE REGULATORY PERFORMANCE EVALUATION

Purpose: The purpose of this paper is to inform the Commission regarding the status of efforts by the Office of Inspection and Enforcement in licensee regulatory performance evaluation and to obtain Commission approval of a two-year trial program.

Discussion: IE has been working to develop techniques for evaluating the regulatory performance of NRC licensees for several years, with intensified effort over the last two years. "Regulatory performance," is meant to convey the ability of the licensee to meet regulatory requirements and to avoid reportable events that appear to be directly under the control of the licensee. "Regulatory performance" does not involve reliability, availability, earnings, or other measures which may be used to measure performance.

Licensee Regulatory Performance Evaluation (LRPE) is the effort to evaluate the regulatory performance of licensees on a national basis. It has as its objectives:

. Identification of factors that lead to different levels of regulatory performance.

. Effective and efficient use of NRC inspection resources.

Information from the evaluation process also can be used to evaluate aspects of the NRC inspection program.

Contact:
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49-28484

7811070006

The basic method of LRPE is to identify licensees whose regulatory performance is most different from the majority of licensees in the same class. These "different" licensees are examined on a case-by-case basis to identify the characteristics that lead to the differences. Actions then can be taken, if needed, to upgrade licensee regulatory performance. The thrust of LRPE is an upgrading, as appropriate, of performance.

The enclosed paper, entitled "Licensee Regulatory Performance Evaluation," defines the concept of licensee regulatory performance, describes why IE wants to evaluate it, and suggests the uses that may be made of the results. The paper also describes the evaluation approaches that IE has considered and offers some ideas how IE may develop and use an "integrated methodology" that incorporates selected aspects of each of the three methods considered to date. Finally, the paper provides a summary of value-impact considerations and plans and schedules for future actions.

Defining and agreeing upon the reasons for LRPE and suitable methods for its conduct have been difficult. Concepts and positions have been modified as new insights are developed. Staff agreement still has not been achieved. The results of efforts in LRPE have not been made public. No public nor industry comments have been requested. IE management believes that the potential benefits--resource management and performance upgrading--are sufficient to move forward into a trial program of LRPE.

IE proposes to implement a trial program for evaluating the operating reactor licensees on the basis of 1978 and 1979 data. As the program proceeds, IE will monitor its results to identify changes which may be needed. An interoffice steering group will be appointed for the trial program in December 1978. The trial is scheduled for completion in December 1980. By March 1981, IE will evaluate the trial and report to the Commission with recommendations for adopting LRPE as an ongoing programmatic effort, modifying the trial program, or abandoning this approach to evaluation.

The documents upon which this staff paper is based (these are listed in Attachment 1 to the enclosed paper) have been treated as predecisional information. Upon Commission approval of the trial program, IE recommends that these documents be released to the Public Document Room. The necessary logistics probably will take about 10 days.

Coordination: The Office of Management and Program Analysis and Standards Development concur. The Office of Nuclear Material Safety and Safeguards has no objection to the proposed program.

NRR concurs with the intended objectives of the trial program. However, because the mechanism by which these objectives are to be achieved has not yet been developed, NRR cannot offer a view as to the overall acceptability. Accordingly, NRR recommends that the overall program be subjected to periodic program office review.

The Executive Legal Director has no legal objections.

John G. Davis
Acting Director
Office of Inspection
and Enforcement

Enclosure:
"Licensee Regulatory
Performance Evaluation
Paper"

This paper is scheduled for consideration at an Open Meeting during the Week of October 23, 1978. Please refer to the appropriate Weekly Commission Schedule, when published, for a specific date and time.

DISTRIBUTION
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Exec Dir for Operations
Regional Offices
Secretariat

LICENSEE REGULATORY PERFORMANCE EVALUATION
A REVIEW OF PAST EFFORTS, STATUS, AND FUTURE PLANS

Introduction

By the term "licensee regulatory performance" the Office of Inspection and Enforcement (IE) means the ability of a licensee to meet regulatory requirements and to avoid events whose occurrence appear to be directly controllable by the licensee. This does not include availability, reliability, earnings, or other measures sometimes used to evaluate the performance of utilities.

The Office of Inspection and Enforcement (IE) has been working to develop techniques for evaluating the regulatory performance on a nationwide basis since early 1976.[1] Studies of various techniques have revealed draw backs that have precluded adoption of any one technique. Yet, IE management believes that the ability to distinguish between various levels of licensee regulatory performance will give NRC a better basis for managing IE's inspection resources, by focusing inspection effort where it is most needed, and for identifying licensees whose performance should be examined. IE believes that a trial program should be initiated to further develop an acceptable technique and to test the technique.

This paper defines the concept of licensee regulatory performance, describes why IE wants to evaluate it, and suggests a number of uses that may be made of licensee regulatory performance evaluation (LRPE) results. The paper also describes the LRPE approaches that have already been considered by IE and offers some ideas of how IE may develop and use an "integrated methodology" that includes, but may not be limited to, selected aspects of each of the three methods considered to date. Finally, the paper provides a summary of the costs and benefits of LRPE and a schedule for completion of identified milestones.

---

[1] A review of the regulatory practices of other agencies has been conducted by Teknekron, Inc. under contract to IE. An initial survey of inspection and enforcement programs of twenty agencies revealed the following:

- 16 identified some kinds of criteria that could be used to assess their own effectiveness
- 7 have an assessment process that was a clearly defined element of program policy.
- 4 compare regulated facilities in terms of performance
- 7 use ratings in absolute terms.

Ref: NUREG/CR-0051 Vol. 1.

Purpose and Objectives

Licensee Regulatory Performance Evaluation (LRPE) is an attempt to systemize, on a formal basis, a method of evaluating the performance of licensees, in a regulatory sense, on a nationwide basis.

The objectives of LRPE are:

- Identification of factors that lead to different levels of regulatory performance
- Effective and efficient use of NRC inspection measures

Information from the evaluation process also can be used to evaluate aspects of the NRC inspection program.

Conceptually, the results of LRPE could be general groupings of licensees according to their performance. Most probably there will be three groupings (1) a "majority grouping"of licensees that include the average performance (2) a "majority +" grouping that performs better than the majority grouping and (3) a "majority -" grouping that does not perform as well as the majority grouping.

If LRPE is successful, it would enable IE to identify on a national basis:

1. A group of licensees that appear not to perform as well as most others. These licensees then could be examined to determine:
   - Whether, in fact, their performance is not as good as others.
   - Whether the level of performance is general within that plant's operations or specific to certain areas of the plant operations.
   - Causes for the level of performance.
   - Corrective actions to improve performance.
2. A group of licensees that appear to perform better than others. These licensees then could be examined to determine:
   - Whether, in fact, their performance is better.
   - If it is better, what are the factors that influence or cause the performance.

If the technique proves successful, LRPE could be used in several ways:

1. Managing of IE resources by directing various levels of inspection attention according to groupings.

2. Identifying the characteristics of the "majority +" performing licensees so that the industry could have access to these characteristics (if not proprietary) for improvement.

3. Identifying causes of "majority -" performance and focusing on causes so that improvement could be realized.

4. Informing the public and licensees, in a summary fashion, on a periodic basis of the licensees' regulatory performance.

5. Serving as a basis for periodic meetings between NRC regional management and licensee management for discussions of licensee performance.

In addition, LRPE will give IE management the ability to manage this "further examination" rather than rely to a high degree on regional judgments which by their very nature lack a national perspective.

Background

Over the years, a form of licensee regulatory performance evaluation has been done on a individual licensee basis. The manner in which a plant has performed against regulatory requirements has been reviewed, on a case-by-case basis, as a part of the routine inspection effort. Differences in inspection attention given by IE to licensees has been determined largely by the "problems" the licensee encounters and usually has been done on a regional rather than national basis. There has been no formal program for considering licensee performance on a national basis, and little program for reacting to licensee performance other than specific reaction to identified areas when IE believes improvement is needed.

In trying to systemize a method to evaluate the regulatory performance of NRC licensees, IE has undertaken three separate efforts, each involving a distinct approach. The first, which can be described as the "Statistical Method," produces single-valued dimensionless ratings (or Z-scores) for each licensee in a given class (in this case, operating reactors) that reflect relative numbers and types of noncompliances. The numbers of those Licensee Event Reports (LERs) attributable to personnel and procedural errors and the extent of personnel exposures and effluent releases attributed to each individual licensee are also considered.

The second approach, which can be characterized as a "Trend Analysis Method," involves detailed examination of licensee events, identification of those events that are repetitive or "causally-linked," and an evaluation of the responsiveness of each licensee's management in reacting to such events.

The third approach, the "Regional Survey Method," is more subjective; it involves a compilation of the qualitative judgments of regional managers and inspectors on a number of factors associated with the safety and security of licensed facilities. Work on these three approaches has been accomplished both in-house and under contract and reports developed.[2] More detailed descriptions of each of these methods are provided below. Although the basic data used for the "Statistical Method" and "Trend Analysis Method" are available in publicly available records, the reports themselves have previously been treated as "pre-decisional" information.

Licensee Regulatory Performance Considerations

Experience, thus far, shows us that the data and other influences make performance evaluation and the attendant assignment of licensees to any groupings imprecise. The concept of performance, like the concept of safety itself, is elusive. Consequently, any grouping, particularly at this stage of development of LRPE, should be considered, at best, a "director of attention," pointing IE's attention at a group of licensees worthy of more specific examination.

A hazard of proceeding into LRPE is that the groupings would be considered to sharply distinguish between the safety of operations of plants. Our efforts thus far do not support this. The fact that a licensee appears in the "majority -" grouping does not mean in a quantifiable sense that the licensee is less safe than licensees in the "majority" and "majority +" groupings. The groupings give IE management the ability, on a national level, to identify licensees for further examination aiming at improvement if necessary.

Each plant is subjected, on a plant-by-plant basis, to a formally described and conducted inspection program and continuing review by the Office of Nuclear Reactor Regulation. The plant is evaluated, on a continuing basis, as to its ability to operate with regard to safety. The NRC is charged with the protection of the public. Hence, the continuation of authority to operate a plant attests to the judgment of the NRC that the plant is operating with adequate safety. LRPE does <u>not</u> change that judgment.

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[2] A list of License Performance Evaluation reports is provided in Attachment 1.

The tendency in an approach such as LRPE is to focus on the "majority -" group. However, IE has a strong interest in the "majority +" group. IE intends also to examine those licensees on an individual basis to determine whether their grouping is appropriate. If so, IE hopes to identify the characteristics, within these operations, which contribute to these "majority +" regulatory performances. If these factors can be identified they should be publicized (unless proprietary) for the benefit of the industry.

A second hazard of LRPE is that it could -- because it involves comparative grouping rather than absolute assessments -- become a constant "ratcheting" technique. Comparatively, some group of licensees could always appear "majority -". As experience is gained in LRPE, an attempt will be made to identify a "threshold" above which no special actions would be taken by IE. The goal of LRPE and the IE actions would be to achieve an industry-wide condition where all licensees remain above such a threshold.

Summary of Licensee Performance Evaluation Methods

The Statistical Method is a technique developed in-house that was applied to the evaluation of operating reactor licensees. The analysis is based upon four measures of performance: numbers of noncompliance findings, numbers of licensee-controllable events, amount of effluent releases, and amounts of personnel exposures. For each of these measures, each licensee's performance is described relative to that of the other licensees in the same class. This relative performance is then converted to dimensionless ratings, or Z-Scores, for each licensee. An overall rating (Z-Score) is obtained by computing a subjectively weighted sum of ratings for each of the four factors. The methodology accommodates different severity levels of noncompliance and adjusts noncompliance ratings to account for differences in the amount of NRC inspection time required to identify the noncompliance in each case.

The Statistical Method resulted in each licensee receiving a numerical score. Licensees could be given a relative ranking based on these scores. This was not the intent of this method; however, the ability to rank licensees relative to their peer group is inherent in a statistical approach to licensee evaluation. The assignment of a level of precision, which could lead to such a ranking is neither supported by the technique nor the data used in the calculations.

Concerns about this methodology expressed by various staff members are:

1. One product of the evaluation, a single-valued ranking of licensees, may not be warranted by the precision of the data and is affected by the subjective weighting of factors.

2. Numbers of items of noncompliance may not adequately describe the level of safety or security of a licensed facility. Variations among licensees in the significance of noncompliance will affect the quality of the Z-scores.

3. Inspection differences between regions and individual inspectors may mask the relative performance of the various licensees or be inseparable from licensee performance.

4. Requirements for the various licensees (i.e., technical specifications) may vary significantly enough to render the number of items of noncompliance an inadequate measure of performance.

5. Other exogenous variables may make it difficult to isolate the impact of LRPE on licensee performance, e.g. Revised Inspection Program, pending increase in civil penalty authority.

Each of these concerns involves judgment and differences of "degree"; each has been considered at length by staff. Despite these differences of opinion, some aspects of the Statistical Method should be considered in any LRPE method. First, noncompliance findings are a direct output of NRC's regulatory program; no LRPE method is complete without some consideration of noncompliance findings. If there are some regulatory deficiencies that detract from the meaningfulness of noncompliance findings (e.g., nonuniformity, variations in safety significance), then these regulatory weaknesses should be corrected or acknowledged as impacting LRPE accuracy. Numbers of noncompliance findings, are believed to be reasonable indicators of licensee regulatory performance.

The Trend Analysis Method is an approach developed by Teknekron, Incorporated under contract to IE. This method involves detailed subjective analysis of LERs for the purpose of categorizing them as "facility" problems reflecting reliability or similar problems beyond the direct control of the licensee, or as "personnel" or "management" problems that reflect human failure. By separating all LERs as to the reactor subsystem in which they occur and by analyzing patterns of LERs for each subsystem, Teknekron believes it is possible to identify trends of repetitive or "causally-linked" LERs that characterize a marginal performer and may allow NRC to predict the occurrence of actual incidents.

Staff concerns about this Trend Analysis Approach are that its predictive capability has not been established because Teknekron has conducted only a limited number of case studies based only on historical data, that it may be costly in terms of manpower required to conduct such analyses on a routine basis for all major NRC licensees, and that the NRC automated data base may not be complete enough to support the analysis at present.

The main advantage of the method is that it is based on analysis of actual safety or security related events. Some treatment of these potentially significant events, at an appropriate level of detail, should be considered in any LRPE approach taken in the future.

The Regional Survey Method involves the assessment of each facility by NRC inspectors and regional management. The judgments of other NRC staff members familiar with the facilities may be appropriate for future efforts. In the only effort of this type undertaken to date, IE obtained the assistance of Hay Associates, in developing a questionnaire and conducting a survey of those employees involved in inspection of operating reactors. Each survey recipient was asked to assess the "importance to safety" of a number of potential rating factors. Then, each inspector and regional manager was asked to rate each of the operating reactor sites he was familiar with in terms of its: (1) overall safety (on a scale of "acceptable" to "exceptional"), (2) site safety in specific areas of operation, and (3) the stringency of its requirements. Each recipient was encouraged to offer narrative comments on the safety of each site. In many cases there was a significant variation in the rating of a given facility by individual inspectors.

Subjective judgments of selected NRC staff members are an important element in any LRPE program, because the people who work with plant employees and facilities on a frequent basis often have insights into performance that are not immediately apparent in an isolated review of noncompliance and licensee event data. Yet, the Regional Survey Method should be recognized for what it is -- collected opinions. As any opinion survey, care must be exercised in its use. The opinions are subjective and may be affected by the make-up of the individual. They may not be clearly supportable by fact. Also, the judgments may be unduly influenced by the "last contact" with the licensee and the personality of licensee representatives. Even with those concerns judgments of qualified NRC employees are highly valued by NRC and IE management in making operating and program decisions; a systematic and explicit compilation of these judgments will be a valuable component of any LRPE program.

As indicated above, each of the three LRPE methods had strengths and shortcomings in the view of the IE Staff. The results of the Trend Analysis Method especially with the present limited sample cannot be compared with the results of the remaining two methods, the Statistical Method and the Regional Survey Method. The results of the latter two methods did not agree completely. For these reasons it was apparent that a method should be adopted that takes advantage of the strengths and compensates for the shortcomings of the methods attempted to date.

Accordingly, IE believes that an Integrated Approach is needed for Licensee Regulatory Performance Evaluation. This method could include what IE considers the best portions of the Statistical Method, the principles of the Trend Analysis Method, the general approach of the Regional Survey Method and other techniques to be developed. A licensee's regulatory performance might best be described by a combination of factual and interpretive information. The factual component of performance could include the licensee's noncompliance history over the period, a description of significant licensee events, any escalated enforcement sanctions taken by NRC against the licensee, a description of management meetings held between NRC and licensee management, and any other information considered pertinent to the licensee's performance. It should be noted that enforcement history would be factored into LRPE. Future enforcement action would not be predicated on LRPE, but rather would remain based upon the specifics of noncompliance at issue. The interpretive component of the performance evaluation could include the Region's assessment of the significance of all the factual information and a general description of inspection activity planned during the next year by the Region to cause improved regulatory performance. Included in the Region's assessment could be an assessment of the significance of the licensee's noncompliance.

During development of the Integrated Approach a foremost concern will be whether the results provide a true measure of licensee performance. Qualifications of the validity of results will be articulated.

These integrated analyses would be documented in a report that would be made available to licensees, the NRC staff, and the public. The results of these analyses will be used as a basis for periodic meetings with selected licenses.

Value-Impact Considerations

Licensee performance evaluations have been performed in the past by both Headquarters and Regional staffs using a variety of techniques. By consolidating these fragmented efforts, IE will be able to systematically conduct these necessary evaluations within existing resources. An estimated 3 man years per year will be used to develop, conduct and evaluate the trial program.

IE does not believe that the adoption of a systematic LRPE process will have any direct resource impacts on licensees, excluding possible costs to the licensee to upgrade his performance.

IE believes that the benefits of being able to evaluate licensee regulatory performance could provide a means for improved management of inspector resources and for identifying factors to be used for upgrading of regulatory performance as appropriate.

Plans and Schedule

If approved, IE intends to move promptly to develop the Integrated Approach to Licensee Regulatory Performance Evaluation. The integrated approach will serve as a basis for the Trial Program using 1978 and 1979 data. As the Trial Program proceeds, its progress will be monitored and modifications made as appropriate. By March 1981, a report to the Commission will present an evaluation of the Trial Program and recommendations concerning LRPE.

IE will document the findings of the Trial Program in three reports -- one for the 1978 analysis of operating reactors, one for the 1979 analysis, and one assessing the LRPE Trial Program. Each of these will be made available to the public.

Milestones associated with these plans are:

Before December 1978	Release existing LRPE reports to the PDR
December 1978	Appoint interoffice steering group for Trial Program
February 1979	Initial Trial Methodology for Integrated Approach complete
April 1979	First report (for 1978 data) complete
April 1980	Second report (for 1979 data) complete
December 1980	Assessment of Trial Program complete
March 1981	Report to Commission on LRPE

Attachment 1

The Licensee Regulatory Performance Evaluation Reports prepared by and for IE and listed below:

1. Draft Report - An Evaluation of the Nuclear Safety-Related Management Performance of NRC Operating Reactor Licensees During 1976 - February 1977, E. Morris Howard, Project Director.

2. Update of Draft Report - September 26, 1977, E. Morris Howard to E. Volgenau.

3. Individual Site Ratings from the IE Employee Survey on Evaluation of Licensees - April 1978, S. K. Conver, IE Study Group.

4. Licensee Performance Evaluation, Phase I Report, NUREG/CR-0110, Teknekron, Inc. - May 1978.

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LICENSEE PERFORMANCE EVALUATION

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