MAR 5 1986

Docket No.: 50-440

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Mr. David Ward, Chairman
Advisory Committee on Reactor Safeguards
U. S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Ward:

SUBJECT: PERRY SEISMIC SAFETY EVALUATION

During the briefing of the Committee on February 13, 1986, concerning the January 31, 1986 seismic event near the Perry Nuclear Power Station, I promised to provide the ACRS with a copy of the staff's supplemental safety evaluation on this subject, for its review and comment.

The staff has completed its evaluation (SSER 9), sixteen (16) copies of which are enclosed. The staff has determined that:

1. Over the low frequency end of the spectrum, the accelerations attributed to the earthquake were far below the design spectrum. However, at the higher end of the spectrum (15 Hz) the acceleration exceeded the design value for less than a second.

2. Notwithstanding Item (1) above, the plant's design reflects appropriate consideration, with sufficient margin, of the most severe earthquake historically reported for the site.

3. The earthquake did not challenge the structural engineering design of the plant. Plant structures have considerable design margin and can withstand challenges by earthquakes of larger magnitude than experienced on January 31, 1986.

4. Safety equipment operated as expected throughout and following the event, thus demonstrating ample equipment qualification design margins.

If you have any questions, my staff and I would be pleased to answer them during the upcoming meetings with the Committee.

Robert M. Bernero, Director
Division of BWR Licensing

Enclosure: As stated

cc: See next page

w/comments

PD#4/PM	PD#4/LA	PD#4/D	DIV/DD	DIV/D	AD/D
JStefano:dh	MRushbrook	WButler	RHouston	RBernero	G. Laines
3/3/86	3/3/86	3/4/86	3/4/86	3/4/86	3/4/86

Mr. Murray R. Edelman
The Cleveland Electric
Illuminating Company

Perry Nuclear Power Plant
Units 1 and 2

cc:
Jay Silberg, Esq.
Shaw, Pittman, & Trowbridge
1800 M Street, N. W.
Washington, D. C. 20006

Donald H. Hauser, Esq.
The Cleveland Electric
Illuminating Company
P. O. Box 5000
Cleveland, Ohio 44101

Resident Inspector's Office
U. S. Nuclear Regulatory Commission
Parmly at Center Road
Perry, Ohio 44081

Regional Administrator, Region III
U. S. Nuclear Regulatory Commission
799 Roosevelt Road
Glen Ellyn, Illinois 60137

Donald T. Ezzone, Esq.
Assistant Prosecuting Attorney
105 Main Street
Lake County Administration Center
Painesville, Ohio 44077

Ms. Sue Hiatt
OCRE Interim Representative
8275 Munson
Mentor, Ohio 44060

Terry J. Lodge, Esq.
618 N. Michigan Street
Suite 105
Toledo, Ohio 43624

John G. Cardinal, Esq.
Prosecuting Attorney
Ashtabula County Courthouse
Jefferson, Ohio 44047

Mr. Larry O. Beck
The Cleveland Electric
Illuminating Company
P. O. Box 97 E-210
Perry, Ohio 44081

NUREG-0887
Supplement No. 9

Safety Evaluation Report
related to the operation of Perry Nuclear Power Plant, Units 1 and 2

Docket Nos. 50-440 and 50-441

Cleveland Electric Illuminating Company

U.S. Nuclear Regulatory Commission

Office of Nuclear Reactor Regulation

March 1986

NUREG-0887, Supp. 9 SER RELATED TO THE OPERATION OF PERRY NUCLEAR POWER PLANT, UNITS 1 AND 2 MARCH 1986

ABSTRACT

Supplement No. 9 to the Safety Evaluation Report (NUREG-0887) on the application filed by the Cleveland Electric Illuminating Company on behalf of itself and as agent for the Duquesne Light Company, the Ohio Edison Company, the Pennsylvania Power Company, and the Toledo Edison Company (the Central Area Power Coordination Group or CAPCO) for a license to operate the Perry Nuclear Power Plant, Units 1 and 2 (Docket Nos. 50-440 and 50-441), has been prepared by the Office of Nuclear Reactor Regulation of the U.S. Nuclear Regulatory Commission. The facility is located in Lake County, Ohio, approximately 35 miles northeast of Cleveland, Ohio. This supplement reports the staff's evaluation findings pertaining to the earthquake event that occurred in the vicinity of the Perry Nuclear Power Plant site on January 31, 1986, and is limited to that evaluation. Future supplemental reports will continue reporting on the status of new or unresolved issues since Supplement No. 8 was issued in January 1986.

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1 INTRODUCTION AND GENERAL DESCRIPTION

1.1 Introduction

The Nuclear Regulatory Commission (NRC) Safety Evaluation Report (NUREG-0887) on the application of the Cleveland Electric Illuminating Company (CEI or the applicant) for a license to operate the Perry Nuclear Power Plant (Perry), Units 1 and 2, was issued in May 1982. Supplements to the Safety Evaluation Report (SER) were issued as follows:

- Supplement No. 1 in August 1982
- Supplement No. 2 in January 1983
- Supplement No. 3 in April 1983
- Supplement No. 4 in February 1984
- Supplement No. 5 in February 1985
- Supplement No. 6 in April 1985
- Supplement No. 7 in November 1985
- Supplement No. 8 in January 1986

The purpose of this supplement to the Safety Evaluation Report (SSER No. 9) is to report the results of the staff's evaluation of the earthquake that occurred on January 31, 1986 near the Perry site. This evaluation is based on the staff's review of information submitted by the applicant by letters dated February 5, February 12, February 28, and March 3, 1986. In these letters, the applicant reported the results of its analysis of the earthquake that occurred on January 31, 1986 (herein referred to as the January 31, 1986 earthquake) in the vicinity of the Perry plant site. Unlike past SSERs, this report is devoted solely to reporting the NRC staff's evaluation of that event and its conclusion relative to the significance of the seismic event and its reaffirmation of prior favorable determinations regarding the plant design as documented in the SER and Supplement Nos. 1 through 8. SER Supplement No. 10 will continue updating the status of all past and current issues listed in Sections 1.9, 1.10, and 1.11 of the SER.

Each section or appendix of this supplement is designed and titled so that it corresponds to the section or appendix of the SER that has been affected by the staff's earthquake evaluation and, except where specifically noted, does not replace the corresponding SER section or appendix. Appendix A is a continuation of the chronology of correspondence between the NRC and the applicant. Appendix B is a list of references cited in this supplement.* Appendix E is a list of the principal contributors to this supplement. No changes were made to Appendices C, D, F, G, H, I, J, K, L, M, N, O, P, Q or R.

Copies of this supplement are available for public inspection in the NRC Public Document Room at 1717 H Street N.W., Washington, D.C., and at the Perry Public Library, 3735 Main Street, Perry, Ohio. Copies of this supplement are also available for purchase from the sources indicated on the inside front cover of this report.

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*Availability of all material cited is described on the inside front cover of this supplement.

The NRC Project Manager is John J. Stefano. Mr. Stefano may be contacted by calling (301) 492-9473 or by writing to the following address:

John J. Stefano
Division of BWR Licensing
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

1.2 Summary of Principal Review Matters

On January 31, 1986, at 11:46 a.m. EST, an earthquake of magnitude 5.0 (m_{blg}) occurred about 10 miles south of the Perry plant in northeastern Ohio. The U.S. Geological Survey (USGS) reports the epicenter was at 41.65°N and 81.16°W. The earthquake was felt as far away as Washington, D.C. (about 300 miles from the epicenter) and there were reports of damage near the epicenter such as cracked walls, falling roof tiles and shattered windows. The maximum Modified Mercalli (MM) Intensity is VI. There have been several aftershocks, the largest having a magnitude 2.4 which occurred on February 6, 1986. The aftershocks were 1 to 6 miles deep and some were felt, although not at the Perry site.

The January 31 earthquake triggered the in-plant seismic monitoring instruments. Some of the recorded motions exceeded the design spectra at high frequencies (above 15 Hz) for the Operating Basis Earthquake (OBE) and the Safe Shutdown Earthquake (SSE). The earthquake motion recorded at the reactor building foundation was of short duration (about 1 second) and contained predominantly high-frequency elements.

The staff assessment of the impact of the Ohio earthquake of January 31, 1986 is provided in this supplement to the SER. Section 2.5 provides a discussion and staff conclusions on the geology and seismology including the design basis for the Perry plant. Section 3.7 presents the staff evaluation of the seismic design, including the impact of the event on the seismic design of structures at the plant and the adequacy of seismic analysis methods. Additionally, staff evaluations of the adequacy of seismic instrumentation and related operating procedures are also provided. Section 3.10 presents the staff evaluation of the impact of the earthquake on the seismic and dynamic qualification of safety-related equipment at the Perry plant. Section 13.3 provides a brief discussion of the adequacy of the applicant's emergency plan implementation as a result of the earthquake.

This earthquake event is hereby added as Confirmatory Issue (66) to Section 1.10 of the SER by this supplement and its resolution will be tracked as such in future SER supplements.

In this supplement to the SER the staff has identified the following confirmatory activities that will be reported on in a future supplement to the SER:

- Fault plane solutions of the January 31, 1986 earthquake and its aftershocks and identification of a possible source structure (Section 2.5)
- Possible impact of injection wells (Section 2.5)
- Assessment at faults of the plant site

- Consideration of the impact of enriched high-frequency content (Section 2.5)
- Further generic evaluations of energy content and potential safety significance of high-frequency-short-duration earthquakes (Sections 3.7.2 and 3.10.1)
- Relocation of seismic instrument (Section 3.7.3)
- Modification of specific plant procedures (Section 3.7.3)
- Additional assessment of seismic qualification of equipment (Section 3.10.1)

1.3 Conclusion

The staff has completed a preliminary review of the January 31, 1986 earthquake near the Perry plant site and finds that:

(1) The event was a magnitude 5.0(m_{blg}) earthquake; the in-plant seismic recordings were short in duration (about 1 second) and contained high frequency elements;
(2) there was no observable significant damage to the plant attributable to the earthquake;
(3) the design of the plant's structures and equipment has substantial margins of safety relative to loads and stresses induced by the earthquake;
(4) there is no basis at this time to revise the seismic design bases for the plant;
(5) there are a number of matters (identified in this evaluation) that need to be confirmed by further analyses and reviews by the applicant and the staff; and
(6) the confirmatory work will be completed in a timely manner (schedules are identified in this evaluation) and will be reported in a future supplement to the SER; licensing and operation of the Perry plant while this confirmatory work continues is acceptable because it is unlikely that any requirements will develop which would significantly change the design of the Perry plant's structures or its equipment.

Accordingly, the staff has reaffirmed the adequacy of the Perry plant seismic design, and concludes that the plant may be licensed for operation without undue risk to the health and safety of the public. Before the plant can be authorized to operate at levels above 5% of rated thermal power, the items identified above and discussed in this report must be confirmed.

2 SITE CHARACTERISTICS

2.5 Geology and Seismology

In the following sections, the seismic design bases for the Perry plant and the staff's understanding of these recent earthquakes are discussed. The engineering significance of the in-plant seismic recordings is discussed in Section 3.7 of this SER supplement (SSER 9).

Seismic Design Bases for the Perry Plant

The design basis of safety features for each nuclear power plant must take into account the potential effects of two levels of earthquake motion. The greater earthquake motion is based on an evaluation of the maximum earthquake potential and is designated the Safe Shutdown Earthquake (SSE). It is the SSE that produces the maximum ground motion for which certain structures, systems and components necessary for safe shutdown are designed to remain functional. The lesser earthquake motion represents an earthquake event that has a reasonable chance of occurring during the life of the plant and is designated the Operating Basis Earthquake (OBE). It is the OBE that produces the ground motion for which those features of the nuclear power plant necessary for continued operation are designed to remain functional. Appendix A to 10 CFR Part 100 requires that the design bases for earthquakes be determined through evaluation of the geologic and seismic history of the site and surrounding region. A determination is also required of the influences that result from human activities and from local site soil conditions. The largest earthquakes occurring in the site region must be assessed. An evaluation is required to determine whether faults in the site region are active and could generate earthquakes large enough to be of significance to the earthquake design bases. Those earthquakes that cannot be correlated with geological structure must be assumed to be capable of occurring throughout regions containing similar geologic structures (tectonic provinces).

The Perry site is located in the Central Stable Region tectonic province. The reactor building foundation is Upper Devonian Chagrin shale bedrock. Paleozoic sedimentary rock formations, about 5000 feet thick, overlie a Pre-Cambrian crystalline basement. Pleistocene glaciation induced localized shallow faults and folds in the shale strata in the site vicinity. There are no known capable faults in the site region.

Seismic activity in the site region is typical of that in the Central Stable Region. Within 200 miles of the site, the largest events have been the following:

1. The 1929 Attica, New York earthquake of Modified Mercalli (MM) Intensity VIII and estimated magnitude 5.2 about 160 miles from the Perry site;
2. the 1937 Anna, Ohio earthquake of intensity VII-VIII and estimated magnitude 5.0-5.3 about 185 miles southwest of the site; and
3. the January 31, 1986 earthquake of intensity VI and magnitude 5.0 about 10 miles south of the site.

In addition, an intensity VII, magnitude 5.0-5.3 earthquake occurred in 1980 near Sharpsburg, Kentucky, more than 200 miles from the site. Of all these events, only the 1929 Attica earthquake has been associated with a tectonic structure. Since earthquake activity around the vicinity of the site is not substantially different from that of the Central Stable Region, the staff concluded in the SER that the controlling earthquake for the Perry site is the largest earthquake that is not associated with a tectonic structure: i.e., a magnitude 5.3 event similar to the Anna and Kentucky earthquakes.

During the operating license (OL) review, the staff evaluated the site ground motion produced by a nearby magnitude 5.3 event. The free-field ground motion at the foundation level of the Category I structures was compared with the Perry SSE. Ground motion is represented as a response spectrum, which is a frequency dependent description of earthquake motion used by design engineers. The Perry SSE (a Regulatory Guide 1.60 (R.G. 1.60) spectrum anchored to 0.15g) was found acceptable since it exceeded the 84th percentile ground motion spectrum from a set of recordings from magnitude 5.3 ± 0.5 events. The accelerograms were recorded at an epicentral distance of less than 16 miles (25 km) and at sites with rock foundation conditions similar to the Perry site.

The applicant used R.G. 1.60 design spectra anchored to 0.075g for the OBE. This represents half the SSE acceleration and is consistent with Paragraph V(a)(2) of Appendix A to 10 CFR Part 100.

January 31, 1986 Earthquake

The January 31, 1986 earthquake was magnitude 5.0 and maximum MM Intensity VI. The size and proximity of this event are consistent with observations of historical seismicity in the Central Stable Region. As discussed earlier, the staff had compared the Perry SSE design spectrum with a larger event (magnitude 5.3) occurring near the plant.

The January 31, 1986 earthquake and its aftershocks occurred in a cluster about 10 miles south of the Perry plant. The depth of the main event was probably shallow, since the aftershocks were 1 to 6 miles deep. At least five research teams deployed portable seismometers and accelerometers near the epicenter and near the Perry plant to record aftershocks. About ten small aftershocks were recorded; the largest was magnitude 2.4 on February 6. When fault plane solutions are available, derivations of stress direction from the earthquakes will be examined for consistency with the average stress direction observed in earlier studies for this region and discussed in the SER. The different research teams and the applicant's consultants are reassessing the location of these earthquakes and determining the fault plane solutions. To date there has been no association established with a known geological structure. The applicant is examining geological, geophysical, and seismic data in the epicentral area for any possible associated structures. A preliminary report of geological investigations done by the applicant's consultants in the epicentral area of the earthquakes indicates that no significant tectonic structures were observed in bedrock or overlying surficial deposits. The information provided by the applicant and other researchers, including the USGS, will be examined with respect to statements in the SER to confirm the adequacy of the prior conclusions in the

SER. The staff will also examine the affect of this information on previous assessments of faults which were believed to be induced by Pleistocene glaciation (i.e., faults in the intake and discharge tunnels). The results of this additional confirmatory work will be reported in a future supplement to the SER.

The USGS and the applicant's consultants are also exploring the possibility that injection of chemical wastes in two wells about 3 miles south of the Perry plant and about 7 miles north of the recent earthquakes may have been related. The high pressures associated with injection into the wells and the large volume of waste that has been injected (almost 300 million gallons since 1971 in the older well) suggests the effective stress at depth in the vicinity of the well may be higher than the lithostatic stress caused by the overburden. However, past experience with induced seismicity has shown seismicity beginning near the wells and later spreading to surrounding areas. In the case of the January 31, 1986 earthquake, no seismicity had been reported prior to this event near the wells and the recent earthquakes are about 7 miles from the wells. In addition, previous seismicity, such as the 1943 magnitude 4.5 earthquake, occurred in the vicinity prior to construction of the wells. As a result, the staff considers it unlikely that the seismic event was induced by these wells. Confirmation of this determination will involve a further study of the earthquakes, including their locations, possible association with a tectonic structure, fault plane solutions, and the possibility of undetected earlier events near the wells. In addition, calculations will be made to determine distances from the well where pressures from the injection of wastes can affect the state of stress.

The January 31, 1986 earthquake actuated the in-plant seismic monitoring instruments. Some of the recorded ground motions exceeded the OBE and SSE design spectra at high frequencies (above 15 Hz). The earthquake motion recorded at the reactor building foundation was of short duration (about 1 second) and predominantly at high frequencies. However, the earthquake was not recorded in the free-field outside the plant. To assess what part of this high frequency exceedance was due to the earthquake source or local site conditions, we have asked the applicant and the USGS to provide and assess all available ground motion recordings near the plant site and in the epicentral area of the January 31, 1986 earthquake and its aftershocks. By letter dated March 3, 1986, the applicant has provided some preliminary ground motion data.

It is not unusual in an earthquake to have high-amplitude, high-frequency peak accelerations of limited duration. In recent SERs for eastern U.S. sites (for example, Seabrook) high-frequency ground motions were discussed. Evaluations of eastern U.S. data suggest that the presence of high-frequency ground motion is more likely a local site phenomenon (conditions at the recording site) than a source condition. These high-frequency peak accelerations have not been used and should not be used in scaling and applying R.G. 1.60 design spectra because they are usually of short duration and little energy and are not representative of spectral response at lower, more significant frequencies.

Preliminary analysis of data from the aftershocks suggests that the recorded ground motions in the free-field include high frequencies similar to ground motions recorded elsewhere in Arkansas, Anaz (California), New Brunswick, and at Monticello Reservoir. As at Perry, these earlier events did not result in any significant damage. Present work by the applicant (as detailed in CEICO letter dated February 28, 1986), the staff and its consultant (USGS) will help determine the extent to which enriched high frequency content needs to be considered with respect to the seismic design. These findings will be addressed in a future supplement to the SER. The staff does not expect the findings to affect the design of the Perry plant. The question of conservatism in the plant design with regard to the observed and potential higher levels of high frequency free-field ground motions is discussed in Section 3.7 of this supplement.

Conclusions

On the basis of the information received to date, the staff has not been able to associate a tectonic structure with these earthquakes and has not determined the extent to which the earthquake source and site conditions affected the ground motions recorded in the Perry plant.

Based on past experience in the eastern U.S., the staff regards the identification in the epicentral area of an active tectonic structure with an estimated earthquake potential greater than the SSE as unlikely. Both the staff and the applicant, however, will be examining all available data and will report on this confirmatory effort in a future supplement to the SER.

Because the staff had already assessed the effects of a larger earthquake (magnitude 5.3) at the Perry site and because ground motions of short duration and high frequencies have been recorded in other events, and did not result in significant damage, the staff regards the seismological issues raised as a result of the earthquake near Perry to be confirmatory in nature.

An assessment of the engineering significance of the high frequency ground motion is provided in Section 3.7 of this supplement.

3 DESIGN CRITERIA FOR STRUCTURES, SYSTEMS AND COMPONENTS

3.7 Seismic Design

3.7.1 Seismic Input

In SER Section 2.5, the staff concluded that the seismic design parameters used in the plant structure design are acceptable and meet the requirements of General Design Criteria (GDC) 2 and Appendix A to 10 CFR 100 referenced in Section 3.7.1 of The Standard Review Plan (SRP) (NUREG-0800).

The Ohio earthquake that occurred on January 31, 1986 near the Perry site generated a question regarding the adequacy of the Perry design-basis earthquake because the motions recorded by the plant seismic instruments indicated that the design-basis response spectrum was exceeded in the high-frequency region (above 15 Hz). The impact of this event on the seismic design of structures and on the seismic analysis methods, including soil-structure interaction and structural response, is evaluated in Section 3.7.2. (A discussion of the seismic instrumentation is contained in Section 3.7.3 of this report; the impact of the seismic event on plant equipment is discussed in Section 3.10 of this report).

3.7.2 Seismic System and Subsystem Analysis

In the Section 3.7.2 of the SER, the staff concluded that the plant design was acceptable and met the requirements of GDC 2 and Appendix A to 10 CFR 100 with respect to the capability of the structures to withstand the effects of earthquakes in that their design reflects:

(1) appropriate consideration for the most severe earthquake recorded for the site with an appropriate margin (GDC 2) and consideration of two levels of earthquakes (Appendix A, 10 CFR 100);
(2) appropriate combination of the effects of normal and accident conditions with the effect of the natural phenomena; and
(3) the importance of the safety functions to be performed (GDC 2); the use of a suitable dynamic analysis or a suitable qualification test to demonstrate that the structures, systems, and components can withstand the seismic and other concurrent loads, except where it can be demonstrated that the use of equivalent static load method provides adequate consideration (Appendix A, 10 CFR 100).

As a result of the Ohio earthquake of January 31, 1986, questions were raised regarding the adequacy of the plant seismic design, because of the characteristics of the earthquake as stated in SER Sections 2.5 and 3.7.1. Extensive plant walkdowns were conducted by the applicant, and the staff and its consultants (see Section 3.10 of this report). With the exception of hairline cracks observed on reinforced concrete walls, no other apparent structural damages were observed that could possibly be attributed to the earthquake. The hairline cracks that were observed are of a type that normally result from concrete shrinkage after construction and are not believed to be have been caused by the earthquake.

Questions were also raised regarding the adequacy of the original building seismic analysis method and procedure in predicting the high frequency response, as recorded in higher elevations of the reactor building during the event.

The applicant was requested to provide a stress comparison for structures subjected to both the recorded motion and the design basis earthquake, to substantiate their conclusion that the January 31, 1986 earthquake indeed had limited energy potential and, therefore, had no significant safety impact on the Perry plant or its structural design basis.

Evaluation

Recorded Foundation Motion vs. Free-Field Motion

Discussions were held between the staff and the applicant as to whether the recorded motion at the top of the foundation mat of the reactor building was suitable to use as a free-field input motion to determine if the original building model would predict the measured earthquake response. The judgment of the applicant's consultant and the staff's consultant was that the characteristics of the recorded motions on the foundations of the reactor building and the auxiliary building are similar in frequency content to the free-field ground motion. The phenomenon that could lead to different foundation motion compared to the free-field is soil-structure interaction (SSI) and structural response. All Category I structures except the diesel generator building and the off-gas building are founded on very stiff rock (shear wave velocity of 4900 ft/sec) or fill concrete with similar shear wave velocity. These very stiff materials are generally thought to preclude significant effects due to soil-structure interaction. In addition, the reactor building was analyzed by the staff's consultant as a fixed-base structure subjected to the recorded foundation motions (three translations) and a good correlation of calculated and measured in-structure response was observed. As a result of the lack of rocking which is an important SSI phenomenon, it is believed that the recorded foundation motions are similar to the free-field ground motion in frequency content; both are characterized by a very short strong motion duration (less than 1 second) and significant frequency content at high frequencies (about 20 Hz).

Building Response

The seismic analysis of the Perry Category I structures involved developing mathematical models of their dynamic behavior and analyzing them for the design ground motion. To investigate the ability of these models to predict response from the Kinemetrics time history instrument recordings, the staff consultant reviewed the Perry reactor building dynamic model together with the SAP IV (a computer code) input and output listing. The staff consultant then performed an eigenvalue analysis for the model which included soil springs. Frequency and mode shapes were extracted and were found to check with those of the original Perry analysis. A fixed-base eigenvalue extraction was then performed on the model and the modes were interrogated to determine whether a mode of frequency near 20 Hz had high importance to response of the containment vessel at a location near the recording. Such modes do exist in both the N-S and E-W directions and they are the second most important modes for the containment vessel's response. Further verification of the ability of the model to amplify the recorded motion was derived by performing a fixed-base time-history analysis using the recorded foundation acceleration time histories as input. The response spectra for the recorded foundation motions were compared with the calculated containment vessel response at approximately elevation 688 feet. In addition, comparison was also made for response spectra of the recorded motions on the foundation and on the containment vessel at elevation 686 feet. Both comparisons show clearly the amplification of the 20 Hz motion from the foundation to the point on the containment vessel. The magnitude of the calculated amplification is less than the recorded motion; however, this preliminary analysis simply assumed a design damping factor of 4% of the critical value. In the case of this earthquake, an analysis performed with a lower damping factor may have produced a result closer to that actually measured. Also, peak spectral amplification is widely recognized to be uncertain.

The staff has also discussed a similar independent analysis of the reactor building performed by the applicant's consultants and found that the amplifications obtained are comparable with those obtained by the staff's consultant as discussed above. The staff, therefore, concludes that the Perry reactor building dynamic model is acceptable.

Energy Content

There is a vast amount of literature which documents the low-damage potential of earthquakes of short duration and high frequencies. One of the most recent investigations sought scale factors by which earthquake records must be scaled to induce specified levels of nonlinear deformation. A ductility level (the ratio of strain to the strain at the onset of non-linearity) of about 1.85 was found to represent a best estimate of the inelastic deformations which would occur in a shear wall designed for static lateral loads to the American Concrete Code (ACI) 349 Code capacity. Representative stiff structures of fundamental frequencies ranging from 2.14 Hz to 8.54 Hz were considered, as well as recorded ground motions of varying frequency content and duration. None had as short a duration or as high a high frequency content as that recorded at Perry. Two records of short duration and somewhat higher frequency content (although still less than 10 Hz) were the Gavilan College, Hollister, 1974 record and the Melendy Ranch Barn, Bear Valley, 1972 record. For a structure of fundamental frequency of 3.20 Hz (near that of the Perry reactor building), the two recorded motions would need to be scaled by factors of 1.6 to 2.2 to achieve deformations corresponding to the design level forces. Alternatively, a measure of the effective peak ground acceleration of these records would be the instrument recorded peak divided by these factors. If a similar procedure was applied to the recorded foundation motions at Perry, the scale factors are expected to be significantly higher than two and, consequently, a measure of the effective peak ground acceleration of the Perry motions would be perhaps 1/3 of the instrument recorded peak acceleration or less. Excitations of this type have limited energy and, hence, little damage potential.

Stress Comparison

To quantify the significance of high frequency acceleration on the structural design, in a letter dated March 3, 1986 the applicant first noted that the conventional seismic stress analysis applies the inertia load as equivalent static load, which ignores the effect of small relative displacements. A comparison was then made between the design stresses for the containment building as calculated using the inertial load and the dynamic stresses obtained directly from a time history analysis using the time history recorded at the top of reactor building foundation mat as input. For the three elevations investigated: i.e., 592'-3", 644'-6", and 688'-6", it was found that the design was controlled by the maximum stress at elevation 592'-3". At this elevation, the design stress of 1.32 ksi is 2.6 times higher than the dynamic stress of 0.51 ksi due to the recorded January 31, 1986 earthquake. The applicant also pointed out that the containment material, ASME SA516 Grade 70, has a yield strength of 38 ksi which is more than 74 times higher than the dynamic stress of 0.51 ksi. The staff concurs with the applicant's assessment and agrees that the dynamic stresses due to the recorded earthquake are substantially lower than the corresponding design stresses and, therefore, are not of any safety significance.

Conclusions

On the basis of the above evaluation performed by the staff and its consultants, whose reports are listed in the Appendix B, it is the staff's view that the Ohio earthquake of 1986 represents a negligible effect on the future safe operation of the Perry plant. The staff's conclusion as stated in SER Section 3.7 regarding adequacy of structural seismic design remains valid.

The staff's evaluation of the effects of the seismic event on plant equipment is discussed in Section 3.10 of this report, and details the staff's conclusion on the equipment as well as the source structure aspects of the design.

3.7.3 Seismic Instrumentation Program

Federal regulations, 10 CFR 100 Appendix A, Paragraph VI (3), "REQUIRED SEISMIC INSTRUMENTATION" requires that suitable instrumentation be provided so that the seismic response of plant features important to safety can be determined to permit comparison of such response with that used as the design basis. The instrumentation quantity is further defined in Regulatory Guide 1.12 and the locations of these instruments are outlined in SRP Section 3.7.4. This SSER provides an evaluation of these instruments and the data reduction of the magnitude 5.0 earthquake that occurred approximately 10 miles south of the Perry Nuclear Power Plant on January 31, 1986.

Two types of instruments are used to measure the structural response to the earthquake; active and passive instruments. The active instruments require electrical power to record the earthquake motion, whereas the passive instruments do not require any outside power to measure the motion but do require a power source to provide indication in the control room.

The active instruments consist of two orthogonal accelerometers: one is mounted on the containment base slab and a similar unit is mounted on the steel containment shell approximately 110 feet above the base slab instrument. The structural motion measured by these accelerometers is recorded on magnetic tape in a centralized location in the control building The recordings are started at 0.005g containment basemat acceleration by two triaxial triggers located on the containment basemat approximately 90 degrees apart. Either of the triggers will start the system recording and annunciate in the control room. A third triaxial accelerometer, which is mounted on the containment basemat, switches on a light on the instrument recording panel and annunciates in the control room if the acceleration equals or exceeds the OBE in any of the three directions. The triaxial accelerometer recorders were triggered by the January 31, 1986 earthquake and records of the motion at the instrument location were recorded on the magnetic tape in the recorders.

In a letter dated March 3, 1986, the applicant described the testing of mountings for the D51-N101 accelerometer system (containment base mat) to determine its natural frequency. A test box and a strip chart recorder were connected to the accelerometer for testing purposes. A recording of the accelerometer natural frequency of 50 Hz was made by electrically pulsing the accelerometer from the test box. This test yielded a trace with the Hz frequency recorded on a strip chart. The mounting was artificially excited by a rap on the mount and a recording of the motion was made on the strip chart. A comparison of the 50 Hz strip chart and the rap test chart shows the frequency of the mount to be larger than the 50 Hz test frequency. Therefore, the test clearly shows the mount frequency would not influence the recordings made during the earthquake.

The applicant reported that the active orthogonal accelerometers had been calibrated at the instrument manufacturer's factory in January 1985. The instruments were recalibrated for sensitivity by the Perry plant personnel in December 1985. The applicant also reported that the active instrument recordings were removed from the recorders beginning approximately 30 minutes after the January 31, 1986 earthquake. The recordings were played back through the playback unit incorporated into the system. This playback produced a permanent recording of the acceleration-versus-time record of the earthquake motion measured at the two locations. The magnetic tapes were then transported to the manufacturer's facilities and the records were digitized. These digitized records were used as input to a computer program that scaled the records to acceleration units and plots were made. The records were then instrument and baseline corrected and then used to produce plots of acceleration, velocity and displacement for each component of the recorded data. The acceleration time-histories were used to produce response spectra for comparison with the design response spectra. Copies of these records were provided to the staff for evaluation.

Four sets of passive triaxial response spectra recorders (PSR1200) are installed at four different locations to measure the response spectra directly at 12 specific frequencies in each of three orthogonal directions (N-S, E-W, and Vertical). The earthquake motion causes a reed to vibrate and a diamond stylus inscribes a permanent record on a plate inside the instrument that is proportional to the acceleration. Additionally, the triaxial response spectra recorder that is mounted on the containment basemat lights an amber lamp on the control room panel at each of the frequencies (12 frequencies in 3 directions) if 70% of the OBE level is measured; or a red lamp if 100% of the OBE level is measured. A panel is located in an equipment rack in the control room and if a lamp is lit, the annunciator is triggered. Seven of these lamps were lit during the January 31, 1986 earthquake, five in the North-South direction and two in the East-West direction. No lamps were lit in the vertical direction, indicating that 70% of the OBE level was not reached for the vertical direction. Three North-South (N-S) amber lamps were lit at frequencies of 16, 20.2 and 25.4 Hz., indicating 70% of the OBE had been reached for a sensing instrument located on the containment basemat. Two of the North-South (N-S) red lamps were lit at 20.2 and 25.4 Hz, indicating that the OBE level had been reached or exceeded. Both the amber and red lamps for the 20.2 Hz reed in the East-West (E-W) direction were lit indicating the OBE level had been reached at that frequency. There are also three peak recording accelerometers (PAR400). These instruments measure only the maximum acceleration in three orthogonal directions. These instruments also use a vibrating reed and a diamond stylus that scribes a line on a metal plate that is proportional to the maximum acceleration without regard to frequency. These instruments are located on the auxiliary building basemat and in the containment on the reactor recirculation pump motor and on the reactor recirculation pipe discharge. The recording plates were also removed and read by the applicant's personnel and the manufacturer's representative.

The passive response spectra recorders produced records on the recording plates and were read by the applicant's personnel and a representative of the manufacturer at the plant on January 31, 1986; these were later read and verified by the manufacturer on February 2, 1986. Calibration of the instruments was underway, in anticipation of fuel loading and plant operation, when the earthquake occurred. The vertical component of the response spectra recorder mounted on the auxiliary building basemat in the HPCS pump room had been removed for calibration; therefore, no measurements could be made at this location. Three of the response spectra recorders were calibrated on January 14, 1986, and the fourth on January 30, 1986. The calibration records for one of the peak recording accelerometers was provided. This instrument was located on the reactor recirculation pump and was last calibrated on December 4, 1985.

The instructions for response by the plant operators to indications of an earthquake are contained in plant operating procedure OM4B: ONI-D51 "Off-Normal Instruction", revision 2, dated August 27, 1985. Section 3.0 of the procedure requires the operator to determine if the OBE acceleration indications, the high (red) lights, have lit on the response spectrum recorder annunciator panel. Section 4.0 requires the operator to perform a normal reactor shutdown if the OBE acceleration limits are exceeded.

Evaluation

The two active orthogonal time-history accelerometers had been calibrated as recently as December, 1985. This recent calibration enhances the accuracy of the instruments. The data recorded by the system are considered to be valid. Response spectra at the instrument locations were computed and compared with the design response spectra. The staff has evaluated the mountings of the instruments and finds them to be satisfactory. The staff has reviewed the results of the mounting natural frequency test performed by the applicant; and finds that the mounting natural frequency is sufficiently above the frequency range of interest.

At the time of the Janaury 31 earthquake, the passive response spectra recorders were being calibrated in anticipation of the fuel loading. The instrument located on the reactor building drywell platform at elevation 630 feet was the only instrument where the calibration was completed. This instrument is located on a structural steel platform that is cantilevered from the biological shield concrete wall and serves as the support for several piping snubbers in the area. The motion sensed and recorded by this instrument is considered by the staff to be a combination of piping and structural response and the exact relationship between the two cannot be determined. The staff considers the recordings made by this instrument to be invalid for determining the structural or piping response. The records from this instrument yield no useful information. By letter dated March 3, 1986, the applicant has agreed to resolve this matter by relocating the instrument prior to exceeding 5% of rated thermal power. We find this acceptable.

The records from the other three response spectra recorders are considered valid data and the motions recorded are valid structural responses. The response spectra recorder located on the auxiliary building foundation mat near the HPCS pump only had the N-S and E-W recorders operative. The vertical instrument had been removed for calibration. The staff considers the horizontal measurements valid data.

The acceleration values were read by the applicant and a representative of the instrument manufacturer and later read by a different manufacturer's representative who did not review the first readings. The readings were compared and good agreement was obtained. The instruments were originally qualified using the same mountings design as the ones used in this plant. The applicant reported that some of the response spectra recordings had some indication of construction activities in the area but the records were clear enough to give good overall results. On the basis of its review, the staff considers the readings valid. The data recorded on the peak acceleration recorders that were located on the reactor recirculation pump and the HPCS pump base mat were reported by the applicant to be useable data. The staff agrees with this determination by the applicant. The peak acceleration recorder that was mounted on a pipe in the reactor drywell at elevation 630 feet, near the response spectra recorder, had been removed for calibration and no record from this location is available.

The applicant reported that recalibration of the instruments has been performed in preparation for fuel loading.

Procedure OM4B: ONI-D51 directs the operator to determine if the OBE acceleration limits have been exceeded by observation of the high lights. The procedure does not clearly indicate if this means the red or amber lights. Further, the question of OBE exceedance is not clear; does this mean if one red light is lit, the plant should be shutdown for exceeding the OBE? The staff recognizes the potential for some confusion to exist in the control room as to whether or not the OBE is exceeded and what action is required for exceedance to be immediately taken by the operators. Furthermore, when the data from the various instruments was evaluated, some differences in recorded response levels were noted. Section 3.0 of procedure OM4B: ONI-D51 should be amplified to include more explicit instructions as to what constitutes OBE exceedance. A review of the corresponding American National Standards Institute (ANSI) Standards may be helpful in this regard.

In its letter of March 3, 1986, the applicant agreed to: 1) revise procedure OM4B:ON1-D51 to clarify its provisions and to have the revised procedure in effect by fuel load of Perry Unit 1; and 2) review the bases for the actuation setpoints for the earthquake annunciators at the high frequency end of the spectrum and to propose appropriate revisions to them for staff review by June 1986. We find the above commitments to be acceptable.

Conclusions

The instruments at the Perry plant meet the requirements of the staff's regulations and the provisions of the staff's guidelines as stated in the earlier SER and SSERs. The calibration of the instruments was current. The required interval of calibration is 18 months or at each refueling. The structural response measured by the instruments is valid and may be used for evaluating the plant's response to the earthquake.

The only instrument which did not have valid records, i.e., the response spectrum recorder located on the structural steel platform in the reactor building drywell at elevation 630 feet, should be relocated to a position that would contain only structural response and not be influenced by nearby equipment. Operating Procedure OM4B: ONI-D51 should also be clarified as discussed above. By letter dated March 3, 1986, the applicant has agreed to abide by the above recommendations and will complete the associated work for the procedure revision and instrument relocation by fuel load and prior to exceeding 5% of rated thermal power, respectively. We find these commitments to be acceptable.

3.10 Seismic and Dynamic Qualification of Seismic Category I Mechanical and Electrical Equipment

3.10.1 Seismic and Dynamic Qualification

In its review of the applicant's seismic qualification program for safety-related equipment, contained in SSERs 5 and 7, the staff concluded that the program met the applicable portions of GDC 1, 2, 4, 14 and 30 of Appendix A to 10 CFR 50, as well as Appendix B to 10 CFR 50 and Appendix A to 10 CFR 100. The above conclusion was based on a favorable plant site audit conducted by the Seismic Qualification Review Team (SQRT) on August 14 through August 17, 1984, and on satisfactory resolution, in a follow-up effort by the applicant, for the open items identified by the SQRT during the site audit. After the Ohio earthquake on January 31, 1986, the NRC staff was concerned with the effect of the earthquake on safety-related equipment which had been seismically qualified to the Perry design basis earthquake. An NRC Augmented Inspection Team (AIT) was sent to the Perry facility on the morning of February 1 to review preliminary seismic recordings; the AIT conducted a walkthrough inspection of buildings and equipment. No damage of any significance was observed at the plant.

A special safety inspection was conducted by the NRC's Region III staff on February 5-7, 1986. This included a post-earthquake walkdown inspection (involving a total of some 90 inspector hours) of structural piping, electrical, HVAC, and support systems by the Region-based inspectors. No damage or significant movement that could be attributed to the January 31, 1986 earthquake was identified during the walkdown or the detailed visual inspections at the Perry plant. This confirms the findings made from a comparable inspection conducted by the applicant.

A SQRT team which consisted of a member from the original SQRT team and a member of the NRC staff subsequently conducted another site audit on February 6, 1986 primarily to investigate the effect of the earthquake on the safety-related equipment of the station. During the above audit, the applicant and its architect engineer, Gilbert/Commonwealth Associates, Inc. (GAI), presented brief background information on the event and implications of their views of the recorded motions at various locations of the plant. Preliminary observations were that some exceedance of the recorded response spectra over the Perry OBE and SSE had occurred in the high frequency region (above 15 Hz). A qualitative evaluation of the safety impact of the event on plant equipment was then presented by GAI. GAI stated that, in view of the short duration (strong motion portion is less than 1 second), and the high frequency characteristics of the recorded motion, the impact of the exceedance would be insignificant from an engineering viewpoint. The SQRT concurred with the applicant's preliminary determination during the audit but requested that the applicant provide a quantitative assessment of the impact of the earthquake by reviewing a sample of plant equipment and to provide the results for SQRT review. In addition to the above technical session, the SQRT performed a walkdown and observed some representative equipment items that were a part of the detailed review in the SQRT audit of August 1984. The equipment inspected included the H13-680 Unit Control Console, Division 1 battery and rack, motor control center, and RCIC turbine and its related pipings and accessories. No damage that could be attributed to the January 31, 1986 earthquake was observed on equipment itself, the equipment supports, or the mounting configuration. Furthermore, no apparent structural damage was observed during the walkdown.

An open meeting was subsequently held on February 11, 1986 at Perry plant site in which the applicant and its consultants made a formal presentation on the earthquake characteristics and its efforts in evaluating the safety impact of the event. It was emphasized by the applicant and/or his consultants that the January 31, 1986 earthquake was of a smaller magnitude than the design basis earthquake for Perry plant and, because of low-energy and high-frequency content, the earthquake had no safety significance to the plant operation. In fact, the applicant documented that all of the 39 safety-related and 36 non-safety related systems that were energized during the earthquake had functioned as designed.

The applicant stated that three non-safety systems tripped as a result of the earthquake. Specifically, it was noted that a rotating cylinder type of protective relay for the turbine generators located in the switchyard and not energized caused two breakers to trip in the switchyard. The applicant stated that if the relay were energized, the actuation of the breakers in the yard may have not occurred because the energizing force would have held the contacts in place. An instrument air compressor tripped; however, one of the three other instrument/service air compressors in the plant automatically started. The third item to trip was the station auxiliary boiler that provides heat to the plant. During the above meeting, the SQRT's concern regarding a quantitative assessment of the safety impact of the January 31, 1986 earthquake on equipment seismic qualification was brought to the applicant's attention for a followup response.

A technical report was submitted by the applicant on February 12, 1986 which provided a summary of the earthquake event, the applicant's follow-up activities and the evaluation of the event's safety impact. The equipment chosen for assessment and included in the report were three equipment types located on elevation 568 feet of auxiliary building, namely instrument racks, pressure and flow transmitters, and pumps and motors. This report, as supplemented by additional information provided by the applicant by letter dated February 28, 1986, shows that for the above equipment types, sufficient conservativism exists in the original equipment seismic and dynamic qualification to more than adequately accommodate the recorded event. For the instrument racks and transmitters that were originally qualified to generic load requirements, the test response spectra are of an order of magnitude greater than the corresponding recorded response spectra. For the pumps and motors that were originally qualified by analysis methods, the resulting stresses and deflections at critical locations that were recalculated from the earthquake when combined with other design loads slightly exceed the original calculated values; yet significant margins of safety exist compared to the design allowables.

Responding to the staff's request for establishing a broader sampling base of equipment, the applicant provided additional information by letter dated February 28, 1986 for equipment located on elevation 686 feet of reactor building where a high peak response at around 20 Hz was recorded. The components selected at this elevation were the purge and vacuum relief system and containment isolation system valves and actuator assemblies. Because the valves and motor operators are supported from the piping systems, the response at the valves is modified by the piping system. There is a short length of piping for the purge system (M14) and the fundamental frequency of the system is at 41.6 Hz. At this high frequency, the accelerations are comparable for the recorded spectra and the design spectra. Similarly, for the vacuum relief system (M17) the fundamental frequency is 32 Hz. In this case, the combined response spectrum value at this elevation envelopes the recorded spectrum value. The applicant also indicated that the acceleration at the valve assembly as determined by the piping analysis for both the M14 and M17 systems bounds the recorded data at this fundamental frequency. The resultant acceleration at the valve associated with the recorded earthquake data was extrapolated based on the ratio of recorded spectrum to design spectrum times the valve design acceleration values. This shows that the estimated valve accelerations for M14 and M17 systems from the recorded January 31, 1986 earthquake are well within the qualifications requirements of the valve and actuator whether performed by analysis and/or testing. Thus, the qualification of the valves and actuators envelopes the estimated accelerations based on the recorded data as demonstrated in the comparison based on fundamental frequencies.

In addition to the above, the following active components were also selected by the applicant to compare qualification spectra with the corresponding estimated floor response spectra for other types of equipment in different buildings at different elevations:

a. 4.16 kv Metal Clad Switchgear at Control Complex, Elevation 620 feet, Brown Boveri Electrical Industries Model No. 5HK-350, GAI MPL No. 1R22 S006, 1R22S007, 1R22S009.

b. MSIV Leakage Control System Blower at Auxiliary Building, Elevation 620 feet, General Electric/LOMPOC Model No. 2CH-6-041-1U, GAI MPL NO. 1E32-C0001, 1E32-C0002B, 1E32-C0002F.
c. Recirculation Pump Trip Control Switchgear at Intermediate Building elevation 620', General Electric Model No. Power/VAC, GAI MPL No. 1R22-S0012, 1R22-S0013, IR22-S0014, 1R22-S0015.

The estimated spectra were based on the recorded spectra at the auxiliary building foundation, modified to reflect the predicted amplification ratio of the reactor building. The estimated spectra and the testing response spectra at proper elevations were compared to indicate ample margin to accommodate this recorded January 31, 1986 earthquake.

The staff has reviewed all the above information provided by the applicant and agrees with the results.

Conclusions

On the basis of the results of detailed walkdowns conducted by the NRR staff and its consultants, Region III, and utility personnel which found no apparent equipment or structural damage that could be attributed to the Ohio earthquake of January 31, 1986, and on a reassessment of the seismic capability of a sampling of equipment types, it is the staff's opinion that the earthquake did not have any significance from an engineering view point on the equipment at the Perry plant. In other words, the design-basis earthquake may have been exceeded at some high, narrow frequency region of the response spectra, but the original overall plant seismic design was not affected. Therefore, the staff concludes that the previous conclusions regarding the adequacy of the applicant's seismic qualification program remain valid.

By its letters of February 28, 1986, and March 3, 1986, the applicant has committed to provide the following confirmatory information:

1) additional quantitative assessments on the seismic qualification of a more comprehensive sample of equipment types that are located at other elevations of different buildings, and which would cover equipment that have been qualified by the testing method and by the analysis method; consideration shall include the balance-of-plant equipment that has been qualified by analysis methods; and
2) results of a generic evaluation based on an acceptable analytical approach, of a high-frequency, short-duration earthquake with regard to its energy content and potential safety significance for equipment and structures at Perry; using the results obtained from the analysis, assess the seismic capability of the Perry plant, assuming that other earthquakes of similar characteristics, but with higher magnitude and/or longer duration occurs near the site.

By letter dated March 3, 1986, the applicant has committed to provide the above detailed information by June 1986. The staff finds the applicant's commitment, in this regard, to be acceptable and plans to report the results of its review of these confirmatory items in a future supplement to the SER.

13 CONDUCT OF OPERATIONS

13.3 Emergency Plan

The overall assessment of the applicant's performance from an emergency preparedness perspective as a result of the January 31, 1986 earthquake was good. Although under no obligation to activate the emergency organization, Perry did so. This enabled them to augment all resources and staff necessary to respond to the earthquake. Although a number of problems were identified, these were not indicative of any major programatic concern, and are all correctable. It is also noted that the applicant had already identified all the problems and concerns raised by the NRC in the course of this inspection. (IE Inspection Report 50-440/86004; 50-441/86002 dated February 21, 1986.)

APPENDIX A

CONTINUATION OF CHRONOLOGY
PERRY NUCLEAR POWER PLANT, UNITS 1 and 2

December 27, 1985	Letter from applicant requesting extension of Perry Unit 1 Construction Permit (CPPR-148) to March 3, 1986.
January 8, 1986	Letter from applicant submitting fee for extending Perry Unit 1 Construction Permit to March 3, 1986.
January 15, 1986	NRC letter transmitting two advance copies of Perry SER Supplement No. 8.
January 22, 1986	NRC letter submitting draft reports concerning technical insights gained from probabilistic risk assessments for comments.
January 27, 1986	NRC letter transmitting 20 printed copies of Perry SER Supplement No. 8.
January 29, 1986	Letter from applicant advising of Perry plant organizational changes in preparation for fuel load and plant operation (no new positions or personnel were added; only duties were reassigned.
January 31, 1986	Letter from applicant requesting extension of Perry Unit 1 Construction Permit (CPPR-148) to April 15, 1986.
February 5, 1986	Letter from applicant summarizing his response and activities related to the seismic event (earthquake) that occurred on January 31, 1986, in the vicinity of the Perry plant site.
February 6, 1986	Letter from applicant submitting fee for extending Perry Unit 1 Construction Permit (CPPR-148) to April 15, 1986.
February 10, 1986	Letter from applicant submitting Revision 2 to the Offsite Dose Calculation Manual incorporating agreed-to NRC staff changes.
February 12, 1986	Letter from applicant providing a report of CEI's detailed assessment of the Perry plant's response to the January 31, 1986, earthquake.
February 28, 1986	Letter from applicant providing supplemental earthquake assessment information to that furnished by letter dated February 12, 1986.
March [illegible], 1986	Letter from applicant providing additional supplemental earthquake assessment data to that furnished by letters dated February 12 and February 28, 1986

APPENDIX B

REFERENCES*

Cleveland Electric Illuminating Company, "Final Safety Analysis Report for the Perry Nuclear Power Plant, Units 1 and 2" (Docket Nos. 50-440 and 50-441), through Amendment 24, Dec 1985.

Code of Federal Regulations, Title 10, "Energy" (10 CFR), includes General Design Criteria (GDC).

U.S. Nuclear Regulatory Commission (NRC), NUREG-0800 (formerly NUREG-75/087), "Standard Review Plan for Review of Safety Analysis Reports for Nuclear Power Plants," Rev. 2, July 1981 (includes Branch Technical Position).

---,NUREG-0887, "Safety Evaluation Report Related to the Operation of the Perry Nuclear Power Plant, Units 1 and 2," May 1982; Supp. 1, Aug. 1982; Supp. 2, Jan. 1983; Supp. 3, Apr. 1983; Supp. 4, Feb. 1984; Supp. 5, Feb. 1985; Supp. 6, Apr. 1985; Supp. 7, Nov. 1985; Supp. 8, Jan. 1986.

U.S. NRC Office of Inspection and Enforcement Reports 50-440/86004(DRSS) and 50-441/86002(DRSS), dated February 21, 1986.

Weaver & Burdick, "Spectral Analysis of Perry Nuclear Power Plant Velocity - Time Histories Resulting from Ohio Earthquake," Livermore, 2/25/86.

Letter to Robert Herman of NRC from J. J. Johnson, "Contributions to the Revised Perry SER due to the January 31, 1986 Earthquake," Structural Mechanics Associates, 2/26/86.

*All correspondence between the applicant and the NRC staff referenced in this supplement is listed in Appendix A of the SER and its supplements on a continuing basis.

APPENDIX E

NRC STAFF CONTRIBUTORS AND CONSULTANTS

NRC Staff

Name	Title	Branch
R. Hermann	Acting Section Leader	BWR Engineering
A. Lee	Mechanical Engineer	BWR Engineering
H. Polk	Structural Engineer	Technical Assistance Management
L. Reiter	Senior Reliability & Analyst	Reliability and Risk Assessment
W. Snell*	Regional Inspector	Region III
P. Sobel	Geophysicist	BWR Engineering
S. Stern	Project Manager	BWR Project Directorate #4

NRC CONSULTANTS

Name	Organization
J. Johnson	Structural Mechanics Associates
J. Singh	EG&G Idaho

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*Office of Inspection and Enforcement, Region III.