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August 16, 1999

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U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555-0001

Dresden Nuclear Power Station, Units 2 and 3
Facility Operating License Nos. DPR-19, and DPR-25
NRC Docket Nos. 50-237 and 50-249

Subject: Response to Request for Additional Information Regarding Unresolved Safety Issue (USI) A-46

Reference:

1) Letter from J. M. Heffley (ComEd) to USNRC, "Response to Request for Additional Information Regarding Unresolved Safety Issue (USI) A-46," dated May 18, 1999
2) Letter from L. W. Rossbach (USNRC) to O. D. Kingsley (ComEd), "Request for Additional Information for the Resolution of Unresolved Safety Issue A-46. Dresden Nuclear Power Station, Units 2 and 3 (TAC NOS. M69442 and M69443)," dated March 15, 1999
3) Letter from J. M. Heffley (ComEd) to USNRC, "Response to Request for Additional Information Regarding Unresolved Safety Issue (USI) A-46," dated April 11, 1998
4) Letter from J. F. Stang (USNRC) to O. D. Kingsley (ComEd), "Request for Additional Information on the Resolution of Unresolved Safety Issue A-46," dated January 12, 1998

The purpose of this letter is to provide the Commonwealth Edison (ComEd) Company's final response to Question 1 of the Request for Additional Information (RAI), Reference 2, for the Dresden Nuclear Power Station. The RAI was a result of additional information that we provided to the NRC in Reference 3 as requested by Reference 4. In Reference 1, we responded to the other questions and stated that we would provide our response to Question 1, which deals with the use of Method A, 45 days after the NRC Safety Evaluation for other lead SQUG plants (i.e., Millstone Station) was issued. The NRC issued the Safety Evaluation for Millstone Station on June 30, 1999. As a result, we agreed to provide our response by August 16, 1999.

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As identified in our response to Question No. 4 in Reference 1, we have developed refined in-structure response spectra (ISRS) for resolution of equipment outliers. These refined ISRS are bounded by the reference spectra at elevations less than 40 feet. Although minor exceedances were found, none were found to have any safety significance. As a result, we consider that our use of Method A is justified.

Our detailed response to RAI Question No. 1 is provided in Attachment A. Attachment B contains our basis for interpretation and use of GIP-2 Rules for Method A and Attachment C provides our position regarding the use of Method A at Dresden Nuclear Power Station.

Any questions related to this matter should be addressed to Mr. D.F. Ambler, Regulatory Assurance Manager, at (815) 942-2920 extension 3800.

Respectfully,

J.M. Heffley
Site Vice President
Dresden Nuclear Power Station

Attachments:

A. Response to Request for Additional Information for Dresden Nuclear Power Station Unresolved Safety Issue (USI) A-46
B. Bases for Interpretation and Implementation of GIP-2 Rules for Method A
C. Position Paper on the Use of Method A at the Dresden Nuclear Power Station

cc: Regional Administrator – NRC Region III
NRC Senior Resident Inspector – Dresden Nuclear Power Station

ATTACHMENT A
Response to Request for Additional Information for Dresden Nuclear Power Station Unresolved Safety Issue (USI) A-46

NRC Question No. 1

In response to the staff's question on the appropriate use of Method A of Table 4.1 of generic implementation procedure number two (GIP-2), you make reference to the Seismic Qualification Utility Group's (SQUG) letter of January 1998 (Reference 3). The staff is aware of the bases provided in the reference. More recently, SQUG has acknowledged in its letter of August 18, 1998, and the staff has agreed to in its letter to SQUG of September 21, 1998: "Any plant-specific implementation concerns should be addressed in the plant-specific evaluations." The restriction on the use of Method A comes from the discussion of "Advantage and Limitations" in Section 4.2.3 of GIP-2, where it is noted that "Seismic Capability Engineers should be alert for unusual, plant specific situations which could cause the amplification factor to be greater than that of typical nuclear plant structures." A review of some of the in-structure response spectra (IRS) provided in Appendix B (Reference 1) shows that at several elevations, the IRS in the Reactor Building and Turbine Building have double peaks (broadened); (1) between 4 and 8 Hz, and (2) between 12 and 20 Hz. This indicates a plant-specific situation. The staff's concern is about the seismic adequacy of equipment including their supports and anchorages (such as electrical equipment, valves, and electrical relays or contacts) located within 40 feet above the effective grade of 517 feet In light of this discussion (1) provide justification for the use of Method A, (2) as an example, provide your justification for seismic adequacy of safe shutdown equipment list (SSEL) equipment installed on Elevation 549 feet of the turbine Building.

ComEd Response to Question No. 1

Provided below is the additional information regarding our application of Method A as described in the Generic Implementation Procedure, Revision 2 (GIP-2), the Supplemental Safety Evaluation Report No. 2 (SSER No. 2), and the documents referenced in GIP-2 upon which GIP-2 is based.

Specifically, we used Method A to estimate seismic demand for certain equipment within 40 feet of effective grade at the Dresden Nuclear Power Station. The NRC has questioned our use of Method A on the basis that Method A may only be used for typical nuclear plant structures citing that Dresden has "double peak spectra" which may indicate a possible plant-specific situation that the Seismic Capability Engineers should have been alert to. As a result, the staff is concerned with the seismic adequacy of equipment located within 40 feet above the effective grade of 517 feet and specifically the equipment located on the Turbine Building elevation 549 feet.

The reactor-turbine building complex is a typical nuclear power plant structure. The reactor building and internal structures are typical Mark I reactor designs similar to other Mark I BWRs, and consist of a deeply embedded cast-in-place reinforced concrete substructure and reinforced concrete/structural steel superstructure. Similarly, the turbine building has a deeply embedded cast-in-place reinforced concrete substructure and reinforced concrete/structural steel super structure. Please see Section 3 of Attachment C for more details.

Some of the in-structure response spectra (ISRS) in Dresden's Reactor and Turbine Buildings have double peaks; however, this is not particularly unusual for typical boiling water reactor building designs. Specifically, Turbine Building Elevation 549 feet ISRS has two peaks in the frequency range of 4 to 20 Hz. However, it is noted that the relative amplitude of the peak below 10 Hz. diminishes with the increasing damping, and finally the peak becomes less pronounced at 5% damping. Since 5% damping ISRS are used in the USI A-46 evaluations per the GIP-2 requirements, the double peak situation in Dresden ISRS for Turbine Building elevation 549 feet is not a concern for practical purposes. Additionally, if the ISRS, irrespective of number of peaks, are enveloped by the reference spectrum, as is the case at Dresden, there is no concern with the number of peaks. The following information will demonstrate the efficacy of Method A for the Dresden plant.

In responding to prior NRC Requests for Additional Information (RAI) (letter from J. M. Heffley (ComEd) to USNRC, "Response to Request for Additional Information regarding Unresolved Safety Issue (USI) A-46," dated April 11, 1998), Dresden Nuclear Power Station has stated that we are planning to develop refined ISRS for resolution of equipment outliers. This effort has now been completed and the refined spectra are available for use in resolving our outliers. An important distinction to point out is that the refined ISRS still possess substantial conservative bias as compared to median-centered ISRS. Eliminating conservative bias comes at a cost. We chose to work with only those parameters that were the most cost-effective in reducing the new ISRS to levels below the GIP reference spectrum; specifically, the effect of embedment, ground motion development, and structural damping. There is still margin in the refined ISRS with respect to true median-centered spectra, such as the effects associated with best estimate modeling and ground motion incoherence, but to capture and quantify that additional margin is not cost effective.

The original Dresden Nuclear Power Station ISRS are based on a fixed base, free-standing computer model developed by John A. Blume Engineers. The design site ground spectrum is Housner-shaped response spectrum anchored at 0.2g. The original input acceleration time history is based on the Housner design spectrum. For the original Blume model, the input motion control point is the reactor-turbine building complex's foundation on rock at elevation 472.5 feet and the model is free-standing from the base.

In the development of the new refined Dresden Nuclear Power Station ISRS, credit was taken for the fact that the Reactor-Turbine building complex is deeply embedded in rock. The walls of the building structure are poured directly against the rock up to or just very slightly below effective grade at elevation 517 feet. Thus, the new building model is fixed to the top of rock pocket to account for this constraint condition. The input motion is based on the Housner spectral shape and the resulting response spectrum associated with input motion closely fits the Housner ground spectrum. Reactor and Turbine building structural damping was set to a realistic 7% of critical damping in accordance with NUREG-0098.

Figures 1 – 3 show the refined ISRS broadened by ±15% compared to the GIP reference spectrum (1.5 x bounding spectrum) for the Reactor and Turbine building elevations within 40 of grade for which Method A has been utilized. All of our refined ISRS are enveloped by the GIP reference spectrum with a single minor exception of the East-West ISRS of the Turbine building at elevation 549 feet. (Note that the marginal exceedance for the North-South direction of the Reactor building is acceptable by Section 4.2 of the GIP). For elevation 549 feet of the Turbine building, the broadened refined ISRS exceeds the reference spectrum between about 10-15 Hz. In Section 4.2 of the GIP, it is stated that unbroadened response spectra may be used for purposes of this comparison. Figure 4 shows the unbroadened refined East-West ISRS of the Turbine building at elevation 549 feet. This unbroadened spectrum peaks at 12.5 Hz where the exceedance is about 15% (0.90g/0.785g) at that frequency over the reference spectrum amplitude and the width (frequency range) of the entire range of exceedance is from about 11.7 Hz to 13.3 Hz, slightly more than 10% of the frequency range of the peak frequency. For this elevation the narrow band exceedance is greater than that allowed by the GIP procedure, but only by a nominal amount. Furthermore, the ISRS at elevation 549 feet would be less than the reference spectrum had ComEd endeavored to eliminate the residual conservative bias associated with the use of a best estimate (median) model and the effect of ground motion incoherence. This is further underscored by the discussion in Attachments B and C that discuss the conservative bias in the development of ISRS. On this basis, ComEd considers this exceedance not to be safety significant and, therefore, acceptable.

In conclusion, ComEd considers the favorable comparison of the new, refined ISRS to the SQUG reference spectrum to demonstrate the validity of the use of Method A screening for Dresden Nuclear Power Station.

It is our position that the approach used for applying and implementing GIP Method A for estimation of the seismic demand on equipment at Dresden for resolution of the USI A-46 program is appropriate and technically justified. The main reasons for this conclusion are listed below:

- Dresden Nuclear Power Station's structures are typical nuclear power plant structures. Please refer to Section 3 of Attachment C for more structural details.

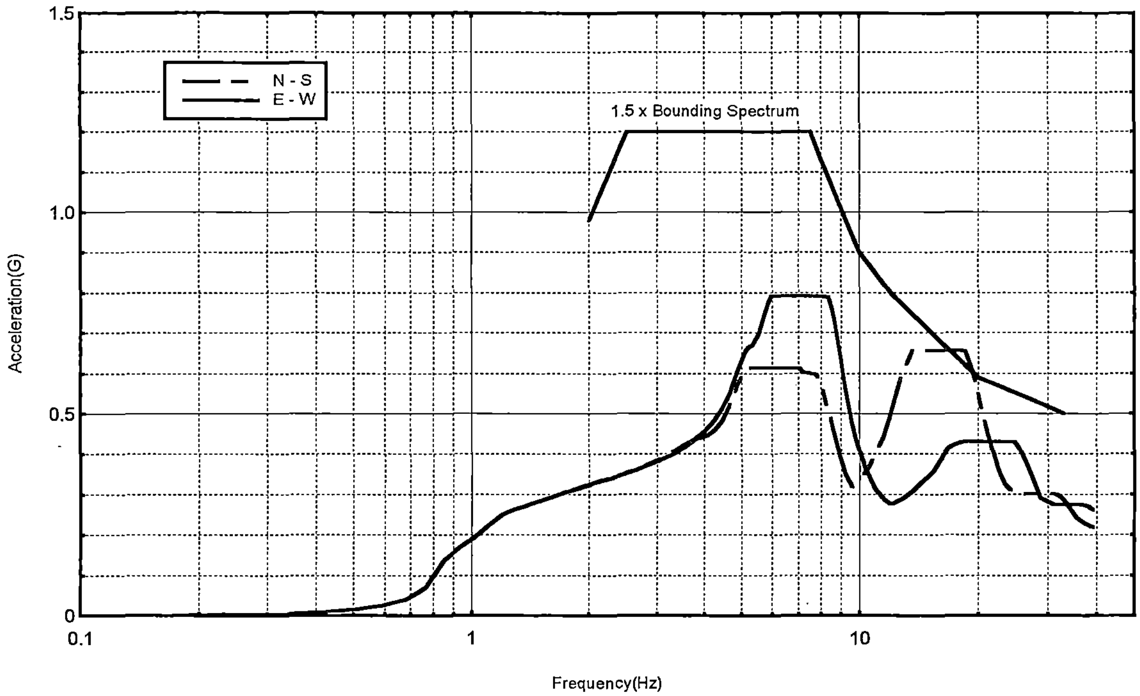
- Our interpretation of GIP-2 rules for use of Method A is correct and implementation of the method was proper. The bases for this are provided in Attachment B.

- New, more refined ISRS are developed for Dresden Nuclear Power Station for A-46 outlier resolution. The development of these new spectra is described above and the broadened spectral plots are shown in Figures 1-3. For elevations where Method A was utilized, the new spectra are enveloped by the SQUG reference spectrum with the single exception of a narrow band exceedance of about 15% for the East-West direction of elevation 549 feet of the Turbine building as shown in Figure 4. These new refined spectra still contain conservative bias that artificially increases amplifications over those that would be expected in an actual earthquake. Further, the expected differences between calculated and actual building responses do not represent a significant safety issue for resolution of USI A-46. Our bases for this are given in Attachment C.

The new refined ISRS are enveloped by the reference spectrum. Based on these new spectra and the information in Attachments B and C, we believe that we have properly interpreted the conditions on the use of Method A and that the requirements for seismic screening have been met for Dresden Nuclear Power Station.

Commonwealth Edison Company
Dresden Nuclear Station
Refined In-Structure Response Spectra

Figure 1
Reactor Building - Elevation 545



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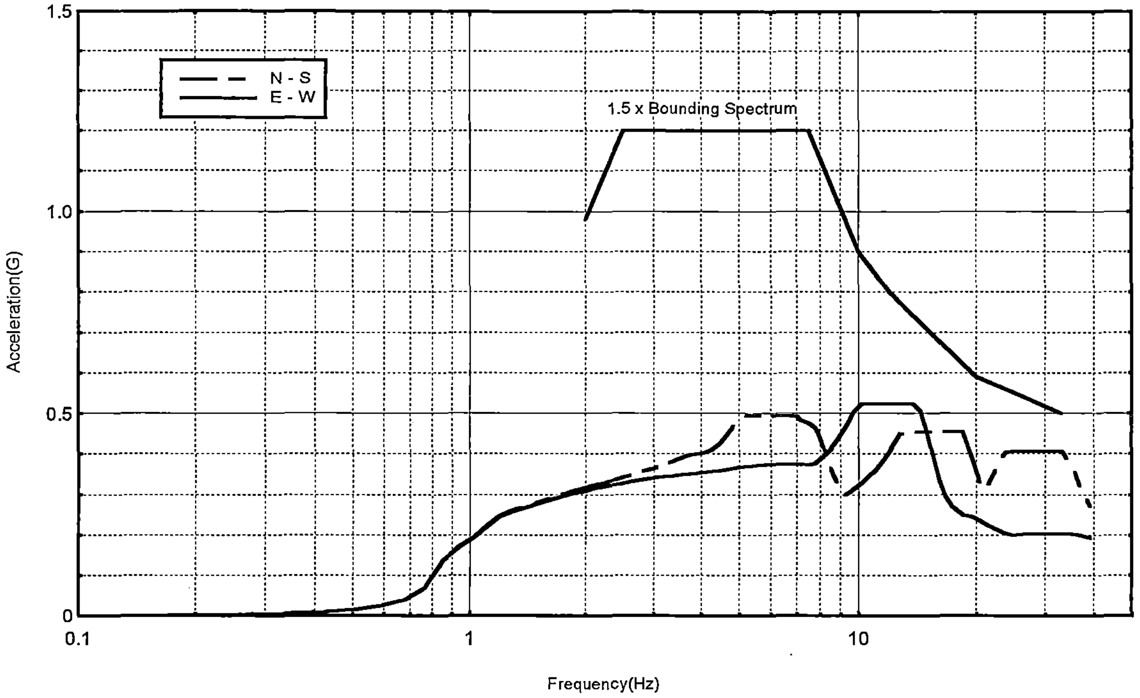
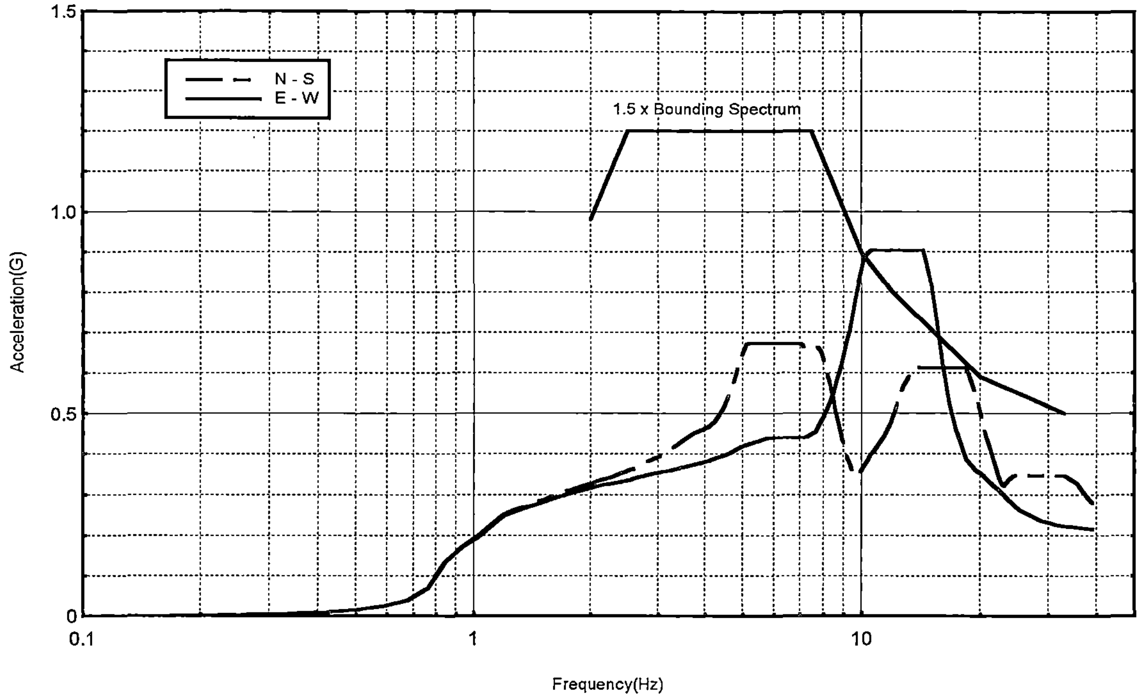
Dresden Nuclear Station
Refined In-Structure Response Spectra

Figure 2
Turbine Building - Elevation 534

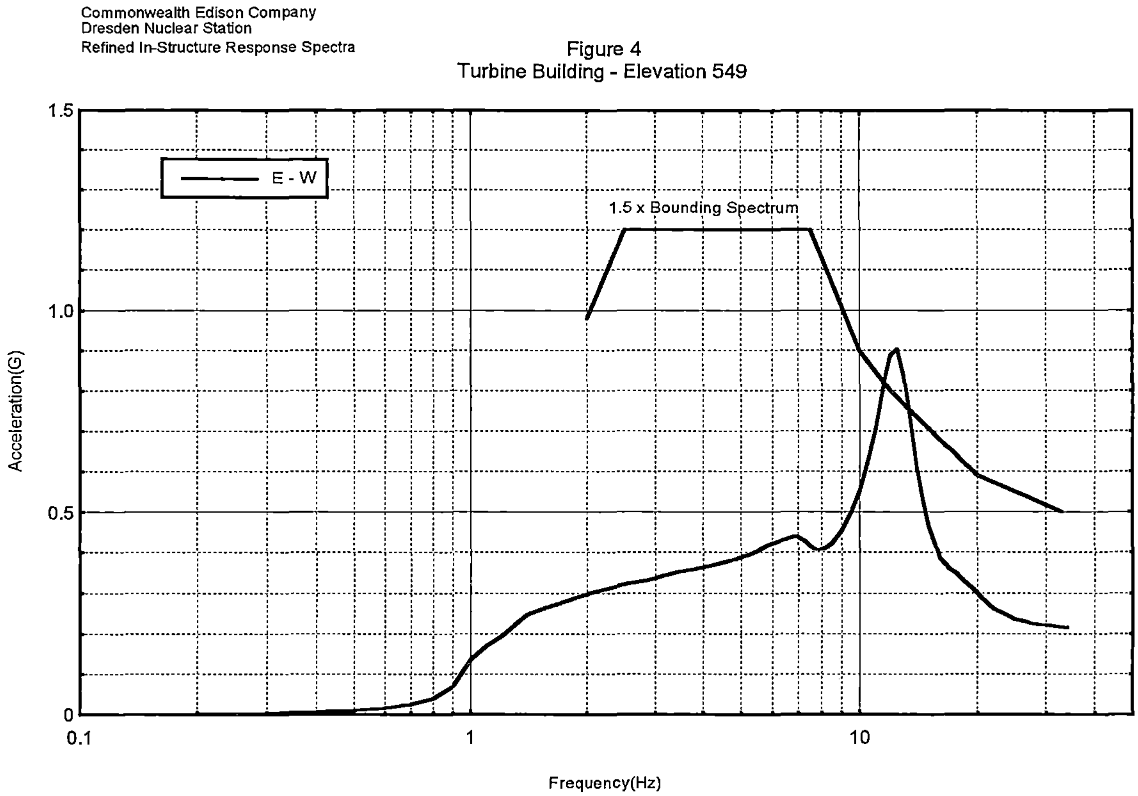


Commonwealth Edison Company
Dresden Nuclear Station
Refined In-Structure Response Spectra

Figure 3
Turbine Building - Elevation 549



ATTACHMENT A
Response to Request for Additional Information for Dresden Nuclear Power Station Unresolved Safety Issue (USI) A-46



ATTACHMENT B

Bases for Interpretation and Implementation of GIP-2 Rules for Method A

It is our position that we have properly interpreted and implemented the rules for use of GIP Method A and as previously reviewed and accepted by the NRC. The bases for this position are as follows:

1. <u>SQUG and ComEd Interpretation of the GIP</u>

The caution given on pages 4 through 16 of GIP-2 lists two limitations on use of Method A. These are:

- Equipment should be mounted in the nuclear plant below about 40 feet above the effective grade, and
- Equipment should have a fundamental natural frequency greater than about 8 Hz.

The introductory wording in GIP-2 for these two limitations provides the bases or purposes for imposing them, namely (1) to limit amplification to no more than about 1.5 and (2) to avoid the high-energy frequency range of earthquakes. The specific limitations which are intended by the SQUG/NRC expert panel (SSRAP) and SQUG to satisfy these bases are included in the two bulleted items listed above.

The statement on pages 4 through 16 that "the amplification will not exceed about 1.5" is the <u>expected result</u> of meeting the above limitations, <u>not a third condition</u>.

At no time was a comparison of Method A amplification with that of calculated ISRS ever intended. In fact, the entire context of the caution on pages 4 through 16 of GIP-2 makes clear that the advantage of Method A is that equipment meeting the two bulleted limitations above "can be evaluated <u>without the need for using in-structure response spectra</u> . . ."

2. <u>The Intent of the GIP is Clear and SSRAP Agrees</u>

- The GIP (page 4-11) cites the SSRAP report as the basis for the Bounding Spectrum, which is used in Method A, and requires users to read and understand it. The SSRAP report clearly explains the limitations and conditions, which appear on page 4-16 of the GIP. SSRAP's report states:

> "Thus, it is SSRAP's judgment that amplifications greater than a factor of 1.5 are unlikely in stiff structures at elevations less than 40 feet above grade except possibly at the fundamental frequency of the building where higher amplifications occur when such a frequency is less than about 6 Hz. Thus, for equipment with fundamental frequencies greater than about 8 Hz in the as-anchored condition it was judged that floor spectral amplifications within 40 feet of grade would be less than 1.5 when reasonably computed using more median centered approaches."
>
> [SSRAP Report, page 102]

- The SSRAP Chairman and developer of Method A, Dr. Robert Kennedy, was contacted by SQUG and concurs with the interpretation given in item 1 above.

3. The NRC Was Aware of SQUG's Interpretation When It Was Developed

- The NRC backfit analysis in NUREG-1211, which justifies implementation of the USI A-46 program by affected licensees, relies on the conclusions reached by SSRAP in their review of seismic experience data. NUREG-1211 states the following:

"The NRC staff has closely followed the SSRAP work and is in broad agreement with its conclusions. The staff has concluded that if the SSRAP spectral conditions are met, it is generally unnecessary to perform explicit seismic qualification on the eight[1] classes of equipment studied."

[NUREG-1211, page 17]

Note that this quotation specifically makes reference to the SSRAP "spectral conditions." The spectral conditions are described in SQUG's position given above and were included in GIP-2.

- The use of Method A was previously reviewed and accepted by the NRC and SSRAP representatives during two pilot plant reviews conducted in 1987 and 1988. These reviews are documented in GIP-2 References 16 and 25. The specific material presented to the NRC representatives on use of Method A is described in the report of the BWR pilot review as shown in Figure 1. Note that the seismic demand criteria described during this trial plant review are the same as described in item 1 above. NRC and SSRAP representatives raised no objections to the approach used by SQUG in conducting these trial plant reviews. The topics discussed with and comments made by NRC and SSRAP representatives during the BWR pilot review are included in Figure 2; note that seismic demand information was discussed in some detail.

- The ComEd/SQUG interpretation of the rules for applying Method A is also consistent with the SQUG training course on use of the GIP methods. Figure 3 is an excerpt from the class notes used during this course. It shows, in Slide 26, several screening methods for comparing equipment capacity to demand. Screen #2 illustrates uses of GIP Method A as described in Item 1 above. That is, if equipment is below 40 feet and above 8 Hz, and the Bounding Spectrum envelopes the ground response spectrum, the equipment is acceptable.

  This training material was used during the first session of the SQUG training course held during the week of June 22, 1992. Two NRC staff members (P. Y. Chen, Michael McBrearty) and a NRC contractor (Kamal Bandyopodhyay) attended this initial session and later provided comments on the training course in a letter dated August 28, 1992. The NRC did not raise any objections to the approach taught by SQUG in this course for applying Method A. Subsequent to

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[1] The eight classes of equipment cited in NUREG-1211 were later expanded to 20 equipment classes.

this initial session of the course, eleven (11) additional NRC staff members and contractors attended other sessions of this course; similarly, none of them raised objections to how SQUG was teaching use of GIP Method A.

4. NRC Interpretation Renders Method A Useless

The NRC interpretation is that Method A can be used only when calculated ISRS are less than 1.5 x GRS. This interpretation negates the value of ever using Method A because it could only be used when it produces higher seismic demand than Method B where calculated ISRS are used. Under this interpretation, it would never make sense to use Method A. This is illogical, inconsistent with Method A's development and use, and was never the intent.

ATTACHMENT B
Bases for Interpretation and Implementation of GIP-2 Rules for Method A

Figure 1

Excerpt from GIP-2, Reference 25
Results of BWR Trial Plant Review

Seismic Demand Criteria

	APPLICATION		DEMAND CRITERIA
1.	Equipment in experience data base and less than 40' above 243', and fundamental frequency greater than 8 Hz.	1.	Compare ground Spectra with bounding spectrum (Figure 3.1 in SSRAP report).
2.	Equipment in experience data base over 40' above 243' (over 281' elevation) or fundamental frequency less than 8 Hz.	2.	Compare amplified floor response spectra with 1.5 x bounding spectrum (Figure R1....,Rn, TI,...,Tn).
3.	Equipment covered by GERS (any elevation, frequency).	3.	Compare amplified floor spectra (median-centered) with 2/3 x GERS for specific equipment class.
4.	Anchorage evaluation and equipment-specific stress checks (excluding valves):	4.	
	- Equipment within 40' of "grade" (elevation 281' and below) and fundamental frequency greater than 8 Hz.	-	Utilize accelerations from (1.5 x ground spectra) x 1.25.
	- Equipment at any elevation.	-	Utilize accelerations from median-centered amplified floor response spectra x 1.25.

ATTACHMENT B

Bases for Interpretation and Implementation of GIP-2 Rules for Method A

- Equivalent static load factor for all equipment (except valves).	- Using appropriate spectra with multiplier, use: - Peak acceleration for flexible equipment. - ZPA for rigid equipment. - Acceleration at calculated fundamental frequency.
- Static load check for valve operator/yoke checks.	- 3G, Weak direction.

Note: In general, for equipment with fundamental frequency greater than 8 Hz and within 40' of grade. 1.5 x ground spectra may be used as an estimate of median-centered amplified floor spectra.

Figure 2

Excerpt from GIP-2, Reference 25
Results of BWR Trial Plant Review

Section 8
Senior Seismic Review and Advisory Panel (SSRAP) and Nuclear Regulatory Commission (NRC) Reviews

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Representatives of SSRAP and the NRC attended the NMP-1 walkdown on February 1st through 3rd (Days 8 through 10). On February 1st, following radiation protection training and dosimetry issuance, the SSRAP and NRC representatives were briefed on the organization and conduct of the NMP-1 walkdown. The indoctrination and pre-walkdown materials covered by SQUG for the walkdown participants were also reviewed with SSRAP and the NRC. The indoctrination/training materials are given in Appendix C and include information on the organization and schedule of the walkdown, the rules of conduct in the plant, plant-specific data on the seismic demand levels for the walkdown, and summary information on GIP requirements for review of seismic demand versus capacity, equipment caveats, anchorage evaluation and evaluation of interactions.

The NMP-1 seismic demand information used for this walkdown was discussed in some detail. SQUG representatives explained that the seismic ground motion used as a basis for the walkdown is a plant-specific, uniform hazard, ground-motion spectra developed by A. Cornell and R. McGuire and is anchored at 0.13 G. This ground-motion spectra envelopes the NMP-1 FSAR licensing basis SSE spectra which is anchored at 0.11 G. The NMP-1 uniform hazard ground-motion spectra is shown in Appendix C. Also in this Appendix are amplified floor response spectra developed for NMP-1 using modern reactor and turbine building models and the 0.13 G uniform hazard ground-motion spectra. Mr. Djordjevic (Stevenson & Associates) reviewed the bases for the amplified floor response spectra and indicated that they are being used as mean-centered, realistic spectra. Dr. Kennedy (SSRAP) expressed the view that he believes the floor response spectra are conservative and generally in accordance with current Standard Review Plan criteria. As a result, SSRAP considers that it is not necessary to utilize the additional factors of safety recommended by SSRAP for use with mean-centered spectra (1.5 for use of GERS and 1.25 for anchorage evaluation) in using the NMP-1 floor response spectra during this walkdown.

A second area discussed regarding the seismic demand was the effective grade level at NMP-1. At this site, the turbine building is founded on rock at elevation 243 feet above sea level. The reactor building is founded on rock at 198 feet. Grade elevation is 261 feet. In the construction of the buildings, the sites were excavated to the foundation level, the buildings constructed, and the annular space between the building and the rock excavation was backfilled with crushed stone up to the 251 foot grade elevation. An elevation view of the plant is included in Appendix C. SQUG and NMPC representatives explained that while they believe lateral support is provided by the crushed stone backfill, it has been conservatively assumed for the purpose of this walkdown that the effective grade elevation is at about 240-243 feet.

This elevation corresponds to the foundation of the turbine building and the elevation in the reactor building where the structure changes from an essentially monolithic concrete block structure (including the reactor base mat) to that of reinforced concrete walls and floors. Essentially no amplification is expected in the reactor building up to about 243 feet. On this basis, the elevations which are considered to be within 40 feet of effective grade, are those elevations in the reactor and turbine buildings up to and including the 281 foot elevation. SSRAP was in general agreement with this approach.

Prior to walkdown of the plant by SSRAP and NRC reviewers, the three SRTs described their progress to date, highlighting areas they particularly wanted the reviewers to evaluate. SSRAP and NRC representatives spent most of February 2nd performing independent walkdowns of NMP-1. Essentially all safe shutdown equipment was seen by them with the exception of the emergency condensers and related equipment, several reactor coolant system instruments, several reactor coolant system isolation valves, core spray and containment spray pumps in the basement corner rooms and the equipment in the drywell, all of which were inaccessible due to the need for radiation work permits (RWPs). Following this walkdown, Dr. Kennedy provided a summary of SSRAP's observations and conclusions:

1. The SSRAP walkdown was performed to determine how the seismic review teams (SRTs) were operating, to assess how the SRTs were evaluating and dispositioning the safe shutdown equipment, and to obtain a general sense of the seismic ruggedness of NMP-1.

2. SSRAP did not observe many seismic concerns and no serious seismic issues. The expected outliers identified by the SRTs were considered by SSRAP to be typical. Dr. Kennedy remarked that, in fact, there were fewer outliers than would be expected for a plant of this vintage. He believes that this is result of the numerous seismic upgrades performed by NMPC over the years which were apparent to SSRAP during their walkdown.

3. It is SSRAP's judgment, based on their walkdown, that the SRT members received adequate training to perform the walkdown and that they were doing an adequate and qualified job of evaluating the seismic adequacy of the safe shutdown equipment. SSRAP generally expressed the opinion that when the SRTs reached different conclusions than SSRAP, the SRTs' conclusions were more conservative (i.e., the SRTs may have identified more outliers than would SSRAP). SSRAP is uncertain if the utility SRTs used during the trial plant walkdown are representative of the SRTs other utilities might use for their walkdowns, since SSRAP believes that the utility SRT members at the trial plant walkdown have considerable seismic experience. As a result, SSRAP continues to believe that it is essential that the SRT members have adequate qualifications and experience in seismic engineering.

ATTACHMENT B

Bases for Interpretation and Implementation of GIP-2 Rules for Method A

Following Dr. Kennedy's summary report, NRC representatives presented their observations and conclusions. Dr. T.Y. Chang, USI A-46 Program Manager, reported the following:

1. The NRC generally agrees with the SSRAP review findings. The NRC believes that the walkdown has shown that the use of utility engineers is a viable approach provided the SRT members have the proper level of experience. The NRC still strongly believes that the qualifications of the SRT members are very important, irrespective of whether the members are utility employees or contractors. Further, the NRC believes that the training program is not enough to make an engineer a seismic expert. The SRT members should have the requisite seismic experience prior to their selection for training and the walkdowns.

2. The conduct of the NMP-1 walkdown was very smooth. The NRC commented that it is clear that the lessons learned from the Trial Plant 1 walkdown were factored into this walkdown in that there was a considerable amount of pre-walkdown planning which contributed to the smoothness of the walkdown.

3. The NRC was impressed with the layout of NMP-1. The plant is open and has considerable space which contributes to both good maintenance and a lack of seismic interaction hazards.

4. The NRC observed during their walkdown (as did the SRTs and SSRAP) that the quality of the anchor welds in some electrical cabinets was marginal.

5. The NRC noted that the relay review for NMP-1 was performed for a sample of typical safe shutdown circuits and did not cover every safe shutdown circuit and relay in this plant. They noted that the remaining circuits and relays need to be reviewed before the seismic review for NMP-1 is complete.

6. There was some discussion of the uniform hazard ground-motion spectra used for this walkdown. Since this spectra bounds the licensing basis ground-motion SSE spectra for NMP-1, the NRC concluded that this ground-motion spectra is acceptable and meets the requirements of USI A-46. The NRC also noted that they concur that the amplified floor spectra used for this walkdown are conservative spectra.

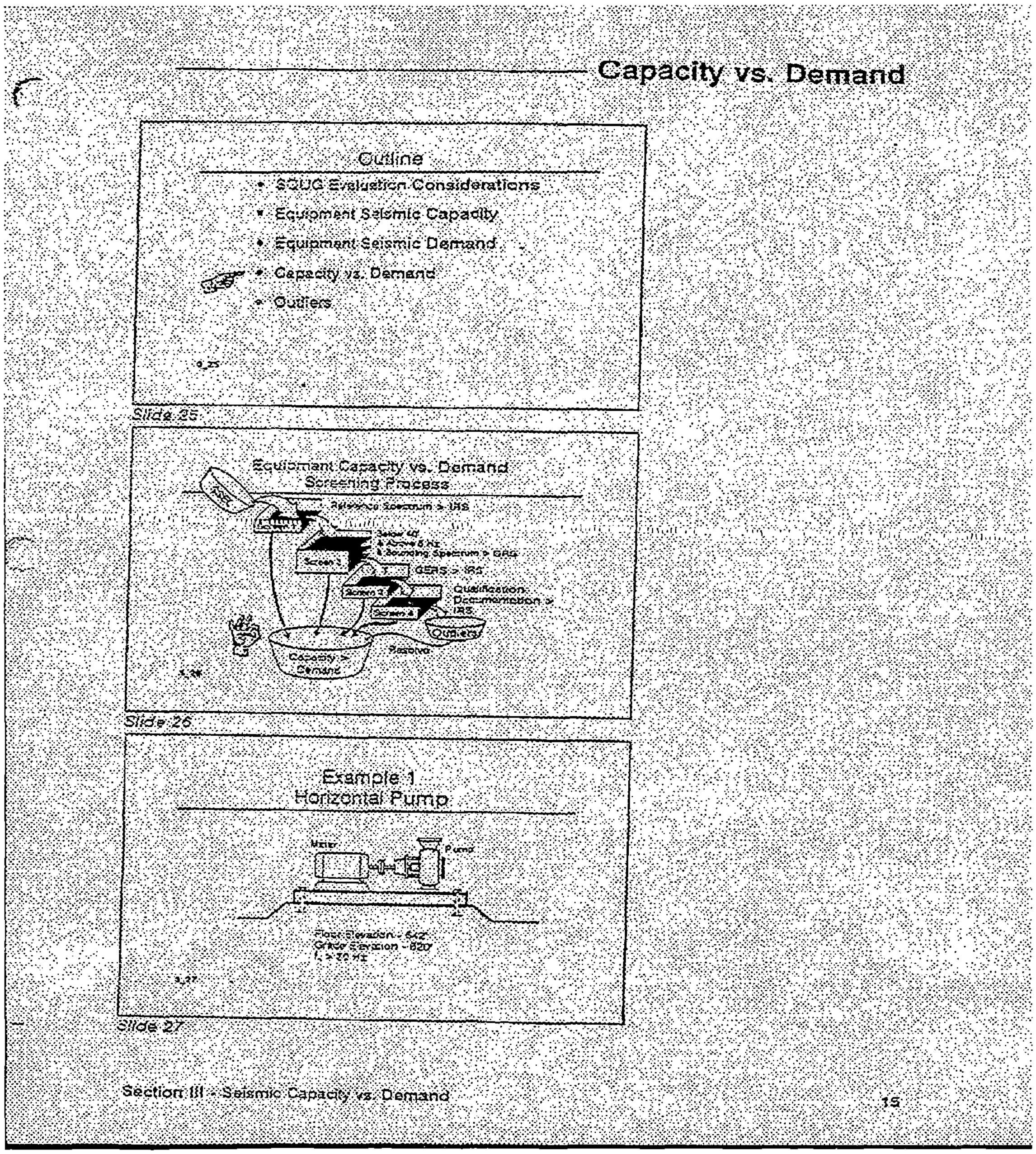
ATTACHMENT B
Bases for Interpretation and Implementation of GIP-2 Rules for Method A

Figure 3

Excerpt from Class Notes for SQUG Walkdown Screening and Seismic Evaluation Training Course

Section III

Seismic Capacity vs. Demand



Capacity vs. Demand

Outline

- SQUG Evaluation Considerations
- Equipment Seismic Capacity
- Equipment Seismic Demand
- Capacity vs. Demand
- Outliers

3_25

Slide 25

Equipment Capacity vs. Demand Screening Process

3_26

Slide 26

Example 1 Horizontal Pump

3_27

Slide 27

Section III - Seismic Capacity vs. Demand 15

ATTACHMENT C
Position Paper on the Use of Method A at the Dresden Nuclear Power Station

Purpose

The purpose of this position paper is to provide supporting information for application of Method A at the Dresden Nuclear Power Station as requested by the NRC in a request for Additional Information (RAI) to ComEd (letter from USNRC to O.D. Kingsley, "Request for Additional Information for the Resolution of Unresolved Safety issue A-46") dated March 15, 1999. This enclosure describes many of the conservatisms that exist in computed in-structure response spectra and the safety significance of the difference between computed and actual building response. We do not consider providing this additional supporting information as a necessary requirement for the application of Method A.

1. Conservatism in Calculated ISRS

The process of calculating in-structure response spectra (ISRS) is a complicated analytical exercise requiring a significant number of approximations, modeling assumptions and engineering judgments. As a result, the historical development of these ISRS has included a tremendous amount of conservatism, which has typically served two purposes:

1. It has reduced the technical debate as to the correct modeling of the many parameters which are intrinsic to the ISRS calculational methodology, and;
2. It has reduced the costs associated with a very detailed state-of-the-art analysis, (which would attempt to trim out all the unnecessary conservatisms).

As a part of the A-46 program resolution methodology, the SSRAP developed and SQUG subsequently endorsed an alternate ISRS estimation technique (referred to as Method A within the GIP) which was much more median-centered and realistic than the typical design practice. Our position is that the application of Method A at Dresden Nuclear Power Station was appropriate and technically justified. The fact that design ISRS may show amplifications greater than 1.5 is not surprising, nor does it negate the validity of Method A. In fact, as noted in the SSRAP report it was even expected. As described below, three areas are presented to support the application of Method A at U.S. nuclear plants in general, and at Dresden Nuclear Power Station in specific:

1. Measurements of ISRS in Actual Earthquakes
2. Calculations of Overall Conservatisms in Typical ISRS
3. Description of the Conservatisms in ISRS in General and Dresden ISRS in Particular

A. Measurements of ISRS in Actual Earthquakes

SSRAP developed the Method A response estimation technique based on their research of both actual earthquake measurements and on recent "median-centered" analysis. They reference (SSRAP report page 102) the measured floor response spectra at elevations less than 40 feet above the grade for moderately stiff structures at the Pleasant Valley Pump Station, the Humbolt Bay Nuclear Power Plant, and the Fukushima Nuclear Power Plant where amplifications over the ground response spectra do not exceed 1.5 for frequencies above about 6 Hz. Other, more recent earthquake data from the Manzanillo Power Plant and SICARTSA Steel Mill in Mexico, as well as several facilities in California and Japan, has been recently reviewed by SQUG. This data also shows that stiff buildings (similar to typical nuclear structures) amplify very little at elevations less than 40 feet above grade and frequencies over 8 Hz. SQUG knows of no new measured data that challenges GIP Method A.

B. Calculations of Overall Conservatism in Typical ISRS

Calculated ISRS have never been portrayed as representing the realistic expected response during an actual earthquake. As previously stated, ISRS typically contain many conservatisms which make them unrealistically high. The primary reason for the development of Method A was to establish a more median-centered method of defining the structural response without having to embark on costly new analyses of all the site buildings. (It should be noted that even the most modern, state-of-the-art ISRS contain significant conservatisms; even those classified as "median-centered", are often very conservative.) A NRC contractor (LLNL) concluded in a study for the NRC (NUREG/CR-1489) that typical calculated ISRS contain factors of conservatism of 1.5 to 8. Recent surveys by SQUG show similar levels of conservatism in calculated ISRS.

It was the contention of SSRAP that the ISRS for nuclear structures (considering the 40 feet and 8 Hz conditions) would be within about 1.5 times the ground response spectrum (GRS) if the plant were subjected to an actual earthquake. In deriving the Method A criteria they recognized that due to the variety of ground motions, soil characteristics and structure characteristics there could be some possibility of exceedances to the 1.5 amplification, but still strongly justified Method A's applicability:

> "It is SSRAP's firm opinion that the issue of potential amplifications greater than 1.5 above about 8 Hz for high frequency input is of no consequence for the classes of equipment considered in this document except possibly for relay chatter[1]."
>
> [SSRAP Report, Page 106]

The basis SSRAP gave for drawing this conclusion was that high frequency ground motions do not have much damage potential due to low spectral displacement, low energy content, and

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[1] Because of the SSRAP concern related to possible relay chatter at frequencies above 8 Hz, the SQUG methodology specifically addresses relays which are sensitive to high frequency vibration. Such relays are included on the Low Ruggedness Relays list in Appendix E of EPRI Report NP-7148.

short duration. They further noted that the equipment covered does not appear to have a significant sensitivity to high frequencies (except possibly for relay chatter, which is addressed separately in the GIP).

C. Description of Conservatisms in ISRS in General and Dresden ISRS in Particular

The most significant sources of conservatism involved in the development of the ISRS for Dresden include the following:

- Location of Input Motion (variation from the free field input location)
- Ground Response Spectrum Shape
- Ground Motion Incoherence
- Frequency (Structure Modeling)
- Structural Damping
- Time History Simulation
- Non-Linear Behavior (e.g., soil property profile variation, concrete cracking)
- Peak Broadening and Enveloping

The degree of conservatism involved in each of these parameters is specific to the building being analyzed, to the floor level being considered, and often, to the equipment location within the specified floor level. These conservatisms typically cannot be accurately quantified using simplistic calculational techniques since each parameter fits into an overall set of highly nonlinear equations. Thus, it would take a considerable effort to quantify the exact excess conservatisms inherent in the calculated ISRS at Dresden. However, on the qualitative level presented below, it is easy to see the origins and levels of this conservatism. The following parameters are the source of the major portions of the excess conservatism:

> <u>Location of Input Motion</u> – The defined location of the plant SSE is typically part of the design basis documentation. The SSE should typically be defined at the ground surface in the free field as defined in the current Standard Review Plan criteria. The defined location of the Dresden SSE is considered the ground surface in the free field. But for purposes of generating ISRS, Dresden conservatively defined the input (currently identified as the "control point" location) at the embedded depth of a Reactor building basemat. This conservatism can be significant depending on the specific plant/building configuration. The reactor-turbine building complex is founded on rock at elevations which vary between 472.5 feet for the Reactor building and between elevations 465 feet and 513.5 feet for the Turbine building. Plant grade elevation is 517.5 feet. In the construction of the reactor building, the site was excavated to the foundation level, the reinforced concrete walls were poured directly against the excavated rock walls. As such, full lateral support is provided by the surrounding rock. This results in very significant conservatism in the original development of the Dresden floor response spectra at all elevations because the original modeling treated the Reactor building as a free-standing structure – that is, with no lateral support – starting from the basemat elevation of 472.5. In reality, the structure is embedded in rock up to effective grade elevation and is free-standing only above effective grade elevation. Since the Reactor building receives its seismic excitation from the rock, the floor response spectra up to and including the grade elevation are equivalent to the site design ground spectrum with no amplification. The response spectra for the floor elevations above effective grade elevation also would be significantly less than those originally developed for the Dresden Reactor building because the originally developed

spectra are based on a building that is free-standing all the way down to the basemat elevation, when in reality it is supported (embedded) in rock for approximately the first 40 feet.

Ground Response Spectrum Shape – Based on the acceptance by the NRC of the ground (site) design basis response spectrum and the associated amplified in-structure response spectra (ISRS), Dresden Station used plant design basis spectra in its USI A-46 study that the NRC reviewed and designated as "conservative design spectra".

The operating basis earthquake (OBE) ISRS for Dresden are based on the Housner-type ground response spectrum and on the north-south component earthquake record of El Centro of May 18, 1940, anchored to a PGA of 0.1g. Given the state-of-the-art at that time, real earthquake time records (time-histories) were used as input base motion to calculate amplified, in-structure floor response spectra, and in particular, the El Centro earthquake was utilized for Dresden Station. This results in overestimation of response at nearly all periods of the spectrum since the spectral shape associated with the El Centro earthquake is scaled to ensure that acceleration values at all periods envelop the smooth Housner spectrum. In reality, the input ground spectrum is at least equal in amplitude at all periods and actually greater than the smoothed Housner design ground spectrum at nearly all periods. This conservatism is inherent in the development of amplified floor response spectra generated in this manner.

Ground Motion Incoherence – As has been documented in the EPRI seismic margin report (EPRI NP 6041) there can be a deamplification effect on nuclear type structures due to the incoherence of ground motion over the relatively large dimensions of typical nuclear structures. Conservative reduction factors as a function of frequency and building footprint have been documented within NP 6041 to account for the statistical incoherence of the input wave motion. These conservative values range from a factor of 1.1 to around 1.5. More recent studies have documented even greater reduction factors. This ground motion incoherence is applicable to rock sites like Dresden and is particularly appropriate in the high frequency range where exceedances are noted for the Dresden Station reactor building.

Time History Simulation – ISRS at Dresden have been generated using a time history, which is intended to approximate the desired earthquake spectrum (0.2g, Housner shape). This process involves the use of El Centro time history component whose response spectrum is required to envelop the Housner SSE at all periods. The amount of conservatism involved in the enveloping process has not been specifically calculated for Dresden Station, but can range up to a factor of 2 or more.

There are several additional sources of conservatism (e.g., structural damping, structural modeling, structural/soil non-linearities, peak broadening and enveloping, etc.) which add to the overall conservatism in the calculation of ISRS. These additional conservatisms, coupled with those described above, certainly reinforce the overall levels of conservatism in ISRS of between 1.5 and 8 which were referenced by SSRAP (LLNL Report NUREG/CR 1489), and explain why the conservative Dresden ISRS produce exceedance beyond the 1.5 factor.

2. Not a Significant Safety Issue

The expected differences between calculated ISRS and actual building response do not represent a significant safety question. The lessons learned, from review of hundreds of items of equipment at various sites that have experienced earthquakes which were significantly larger than those for Eastern U.S. nuclear plants, are that missing anchorage, seismic interaction hazards, and certain equipment-specific weaknesses (incorporated into the GIP caveats) were the seismic vulnerabilities which cause equipment damage. These areas are conservatively addressed in the GIP. The NRC staff acknowledged the seismic ruggedness of nuclear power plant equipment in the backfit analysis for USI A-46 in which they stated the following:

> " . . . subject to certain exceptions and caveats, the staff has concluded that equipment installed in nuclear power plants is inherently rugged and not susceptible to seismic damage."
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> [NUREG-1211, page 16]

Method A is only applicable to stiff equipment with fundamental frequencies over about 8 Hz. As noted earlier in Section 1 of this paper, SSRAP and SQUG have agreed that excitations over 8 Hz have little damage potential due to low spectral displacements, low energy content and short duration. This judgment is supported by industry and NRC guidance for determining whether an operating basis earthquake (OBE) is exceeded following a seismic event at a nuclear power plant. EPRI Report NP-5930 – "A Criterion for Determining Exceedance of the Operating Basis Earthquake," and NRC Regulatory Guide 1.166 – "Pre-earthquake Planning and Immediate Nuclear Power Plant Operator Post-earthquake Actions," recognize that damage potential is significantly reduced for earthquake ground motions above 10 Hz. In other words, the question of what is the precise value of building amplification over 8 Hz has very little safety significance.

3. Reactor-Turbine Building Complex is a Typical Nuclear Structure

The reactor-turbine building complex is a typical nuclear structure. The reactor building and internal structure are typical Mark I reactor designs and consist of a cast-in-place reinforced concrete substructure and reinforced concrete/structural steel superstructure. The concrete substructure, which is founded on rock, begins 45 feet below grade and extends upward 141 feet to the operating floor at Elevation 613' - 0". The reinforced concrete walls vary in thickness from 4.5 to 1.5 feet. The reinforced concrete surrounding the drywell extends from Elevation 488' – 4" to Elevation 613' – 0" and varies in thickness from 6.5 to 3 feet . The reinforced concrete surrounding the drywell is integrally connected to the reactor building floor slabs at Elevations 517' - 6", 545' - 6", 570' - 0", 589' - 0" and 613' - 0". The reactor pedestal is a thick cylindrical reinforced concrete structure, which is tied into the massive reinforced concrete foundation surrounding the drywell. Therefore, this reactor building and internal structure represent "typical nuclear plant structures" as defined in the SSRAP report and the GIP.

The turbine building consists of a cast-in-place reinforced concrete substructure and reinforced concrete/structural steel superstructure. The concrete substructure is founded on rock at elevations which vary from 465' - 0" to 513' - 6" . The reinforced concrete superstructure extends to the turbine deck at elevation 561' - 6". The reinforced concrete walls vary in thickness from 4 to 1.5 feet.

Conclusions

The discussion above leads to several conclusions:

- The Dresden Nuclear Power Station reactor and turbine buildings are large reinforced concrete and structural steel structures where Method A was utilized and where there is an exceedance to the Reference Spectrum. The reactor and turbine building internal structure is a "typical nuclear structure."
- The results from actual measured ISRS on "nuclear type" structures support the 1.5 response levels advocated within Method A.
- Qualitative assessments of the conservatism inherent within the methods utilized to calculate ISRS have been provided above. These conservatisms are typically quite significant (as has been independently verified by median/modern assessments such as the LLNL study) and can/will result in ISRS, which show amplifications well beyond the 1.5 factor from Method A. We feel strongly that the specific exceedances noted by the NRC (beyond the 1.5 factor) on Dresden are due to these high conservatisms inherent in the ISRS methods and do not invalidate the application of Method A.

There is little safety significance in the expected differences between calculated ISRS and actual building response. The largest safety improvements are provided by appropriately reviewing equipment anchorage, seismic interaction hazards, and certain equipment-specific weaknesses where seismic vulnerabilities have caused equipment damage in real earthquakes. Reviews of these areas were a primary focus of the SQUG GIP process; therefore our implementation of the GIP resulted in significant seismic safety enhancements