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James Knubel
Senior Vice President and
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October 8, 1999
JPN-99-033

U.S. Nuclear Regulatory Commission
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Washington, DC 20555

Subject: James A. FitzPatrick Nuclear Power Plant
Docket No. 50-333
Response to questions from a 7/12/99 NRC facsimile to the Authority, Re: James A. FitzPatrick USI A-46 program

Dear Sir:

This letter provides the Authority's responses to the questions contained in a July 12, 1999 facsimile from the NRC regarding the J. A. FitzPatrick USI A-46 program. The questions were also discussed between members of the Authority's and the NRC's staffs during a teleconference.

If you have any questions, please contact Ms. C. Faison.

Very truly yours,

J. Knubel
Senior Vice President and
Chief Nuclear Officer

Cc: next page

A025

Cc: Regional Administrator
U. S. Nuclear Regulatory Commission
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James A. FitzPatrick Nuclear Power Plant
P. O. Box 136
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Response to questions from the July 12, 1999 facsimile from the Nuclear Regulatory Commission regarding the J. A. FitzPatrick Nuclear Power Plant USI A-46 program

Question 1:

Is the ground spectrum of the time history used as the input to the model to generate the IRS at various elevations significantly higher than the Design Basis Earthquake ground motion which is characterized by the Housner design response spectrum normalized to a peak ground acceleration of 0.15g? If the answer is yes, provide a plot of the 5 percent critical damping response spectrum of the ground motion time history.

Response:

The response spectrum of the input ground motion time history entirely envelops the Housner design spectrum anchored at 0.15g. It significantly envelops the Housner spectrum at frequencies below 5 Hz and more closely follows the Housner acceleration amplitudes at frequencies greater than 5 Hz. Figure 1 is excerpted from an original plant design calculation (Reference 5) performed by Stone & Webster and shows the comparison for 0.5% damping. A plot does not exist comparing the spectra at a 5% damping value.

Question 2:

Column 3 of the Screening Verification Data Sheets (SVDS) is for the name of the building in which the equipment item is located. The abbreviations used in this column are not all readily identifiable with a building. Provide a list of the buildings and the abbreviations used to represent them in the SVDS.

Response:

The following table shows the abbreviations used:

Building Abbreviation	Description	Location
AD	Administration Building	Turbine Building Complex
BR	Battery Rooms	Turbine Building Complex
CB	Containment Atmosphere Dilution (CAD) Building	Outside attached to Reactor Building
CR	Control Room	Turbine Building Complex
CS	Cable Spreading Room	Turbine Building Complex
EB	Electrical Switchgear Bay	Turbine Building Complex
EG	Emergency Diesel Generator Building	Turbine Building Complex
PC	Primary Containment	Reactor Building (Drywell)
RB	Reactor Building	Reactor Building
RR	Relay Room	Turbine Building Complex

Building Abbreviation	Description	Location
SP	Service Water Pump Room	Turbine Building Complex
ST	Steam Tunnel	Reactor Building (Upper Portion) Turbine Building Complex (Lower Portion)
SU	Suppression Pool (Torus) Room	Reactor Building
SW	Screenwell House	Turbine Building Complex
YD	Yard	Yard

Question 3:

On pages 12 and 13 of the SVDS for the equipment items water accumulator, nitrogen accumulator, SLC A double squib activated shear explosive valve and SLC B double squib activated shear explosive valve, the seismic capacity is designated by DOC and the seismic demand is designated by RRS. Page 1 of the Screening Evaluation Work Sheet form (copy attached) contains the abbreviations to be used in the seismic capacity versus seismic demand evaluation. DOC is indicated as seismic capacity based on existing documentation and RRS is indicated as seismic demand based on realistic median-centered in-structure response spectra. During the telephone call we were told that NYPA used RRS on the SVDS to indicate a required response spectrum from a dynamic test of the equipment item. Do the required response spectra used to evaluate each of these equipment items envelop the in-structure response spectra at the equipment locations? Provide plots of the 5 percent of critical damping required response spectra.

Response:

The term "DOC" was indeed used to signify plant documentation. All four equipment items are Class 0 – that is, not in the GIP twenty classes and as such were declared outliers. Since the comparison could not be the SQUG bounding spectrum or reference spectrum, plant documentation was selected. The use of RRS simply appears to be a misnomer as there are neither Required Response Spectra for the equipment or Realistic Response Spectra for the building. In any event, the items were declared outliers. For purposes of the SVDS, the use of "DOC" is appropriate (since the use of the other choices of "bounding spectrum" or "1.5 x bounding spectrum" are not). The use of the term RRS is incorrect and is corrected to CRS for conservative in-structure response spectra. A copy of the corrected pages 12 and 13 are included in Attachment B.

Question 4 & 5:

The Generic Implementation Procedure, Revision 2 (GIP-2) provides for several methods of comparing seismic capacity to seismic demand. Method A.1 compares the SQUG Bounding Spectrum to the plant's safe shutdown earthquake ground response spectrum. GIP-2 places limitations on the use of Method A.1. These limitations are that the SSE ground response spectrum can be used for comparison to the Bounding Spectrum when:

- The equipment is mounted in the nuclear plant at an elevation below about 40 feet above the effective grade.
- The equipment, including its supports, have fundamental natural frequency greater than about 8 Hz.
- The amplification factor between the free field ground response spectrum and the in-structure response spectra is not more than about 1.5.

In Figures 3.1 and 3.2 FitzPatrick USI A-46 Final Report NYPA presents plots of the envelope of the turbine building IRS at elevations 272 feet and 300 feet and reactor building IRS for elevations 272 feet, 326 feet and 344 feet, respectively. The amplification factors, above 8 Hz, of some of these IRS for elevations where Method A.1 was used appear to be significantly above the 1.5 limit set by GIP-2. Provide a building specific justification for the use of Method A.1 at the locations where the amplification significantly exceeds the 1.5 limit above 8 Hz.

Response:

The structures at FitzPatrick in which Method A was used are typical nuclear plant structures, either reinforced concrete frame and shear wall or heavily braced steel frame, for which the 1.5 amplification factor is applicable as per the SSRAP Report (Reference 3) and Page 4-16 of GIP-2. These structures are the reactor building which houses the reactor pressure vessel, primary shield wall, drywell and suppression chamber; and the turbine building complex which includes the turbine building, administration building, radwaste building, screenwell pumphouse and emergency diesel generator building.

The following additional information for each of the structures at FitzPatrick is provided as a response to this RAI. This information is provided to indicate:

a) that the structures housing the SSEL at FitzPatrick are typical of nuclear plant construction, justifying the applicability of the SSRAP estimated amplification factor,

b) the level by which the original conservative licensing basis ISRS exceed 1.5 times the licensing basis free field response spectrum at locations where Method A was applied,

c) that the licensing basis ISRS curves were very conservatively calculated, and

d) that if more realistic median-centered type analyses are performed, the resulting ISRS would not greatly exceed 1.5 times the licensing basis free field response spectrum and are less than the seismic capacity of the equipment (i.e., 1.5 times the GIP Bounding Spectrum) for frequencies over 8 Hz.

FitzPatrick Site

The FitzPatrick site is a rock site. The buildings are founded on bedrock with a shear wave velocity exceeding 5500 ft/sec. During original plant construction, approximately 45 feet of the rock was excavated, and the plant structures were founded directly on the rock. The free field licensing basis ground spectrum is a Housner spectrum with a peak ground acceleration of 0.15g. Figure 2 shows the free field licensing basis ground spectrum compared to the SQUG bounding spectrum.

Reactor Building (RB)

The reactor building is an embedded, multi-story reinforced concrete shear wall structure from the foundation (elevation 222') up to the refueling floor (elevation 369'). The reactor building is founded at elevation 222', with a sand backfill in the annular space between the exterior wall and excavated rock up to elevation 265', and then common backfill up to the yard grade at elevation 272'. The seismic SSEL equipment in the reactor building is in the crescent areas (below 272') and on floor elevations 272', 300', 326', and 344'. All of the seismic SSEL equipment inside the drywell is below elevation 300'. Equipment on or below elevation 300' was considered to meet the "within about 40' of grade" requirement; the equipment on elevations 326' and 344' was not. The ISRS for the Reactor Building at elevations 272', 326' and 344' versus the 1.5 x Bounding Spectrum is shown in Figure 3.

Turbine Building Complex

The base of the turbine building complex varies, but it is typically founded on excavated rock at about elevation 245', with structural backfill up to the top of the rock excavation at about 265', and common backfill up to the yard grade at 272'. Almost all the equipment in the turbine building complex on the seismic SSEL is at elevation 300' or lower (there are a few items of control room HVAC equipment that are at about elevation 310'). Based on this, all equipment in the turbine building complex on the seismic SSEL was considered to meet the "within about 40' of grade" requirement. The ISRS for the turbine building complex at elevations 272' and 300' versus the 1.5 x Bounding Spectrum is shown in Figure 4. Except for a negligible exceedance at 33 Hz, the turbine building spectra are enveloped.

Conservatisms in the Licensing Basis ISRS

Attachment A to this response contains a discussion of conservatisms in the calculation of the FitzPatrick licensing basis ISRS. It is judged that the total effect of all these conservatisms would result in the FitzPatrick licensing basis ISRS to exceed the realistic, median-centered ISRS (at frequencies above 8 Hz) by factors in excess of 3.

Use of Method A at FitzPatrick

The use of Method A has been the subject of continuing discussion between the Seismic Qualification Utility Group (SQUG) representatives and the USNRC staff members on the application of Method A of GIP-2. Based on numerous discussions with the staff, a position has been developed which is contained in Reference 4. It is SQUG's belief that the GIP criteria, as presented in the GIP-2 document, and reviewed and accepted by the NRC in SSER-2, does not require the Seismic Review Team (SRT) to justify the 1.5 amplification factor for elevations below about 40 ft above effective grade and frequencies above about 8 Hz.

As explained in Attachment A of this letter, the sentence on page 4-16 of the GIP-2, "The restriction is based on the conditions that the amplification factor between the free-field response spectra and the in-structure response spectra will not be more than about 1.5, and that the natural frequency of the equipment is not in the high energy range" merely indicates the basis for the development of the criteria associated with the use of Method A. Method A has two limitations:

- 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 statement on page 4-16 that "the amplification will not exceed about 1.5" is the expected result of meeting the above limitations, not a third condition.

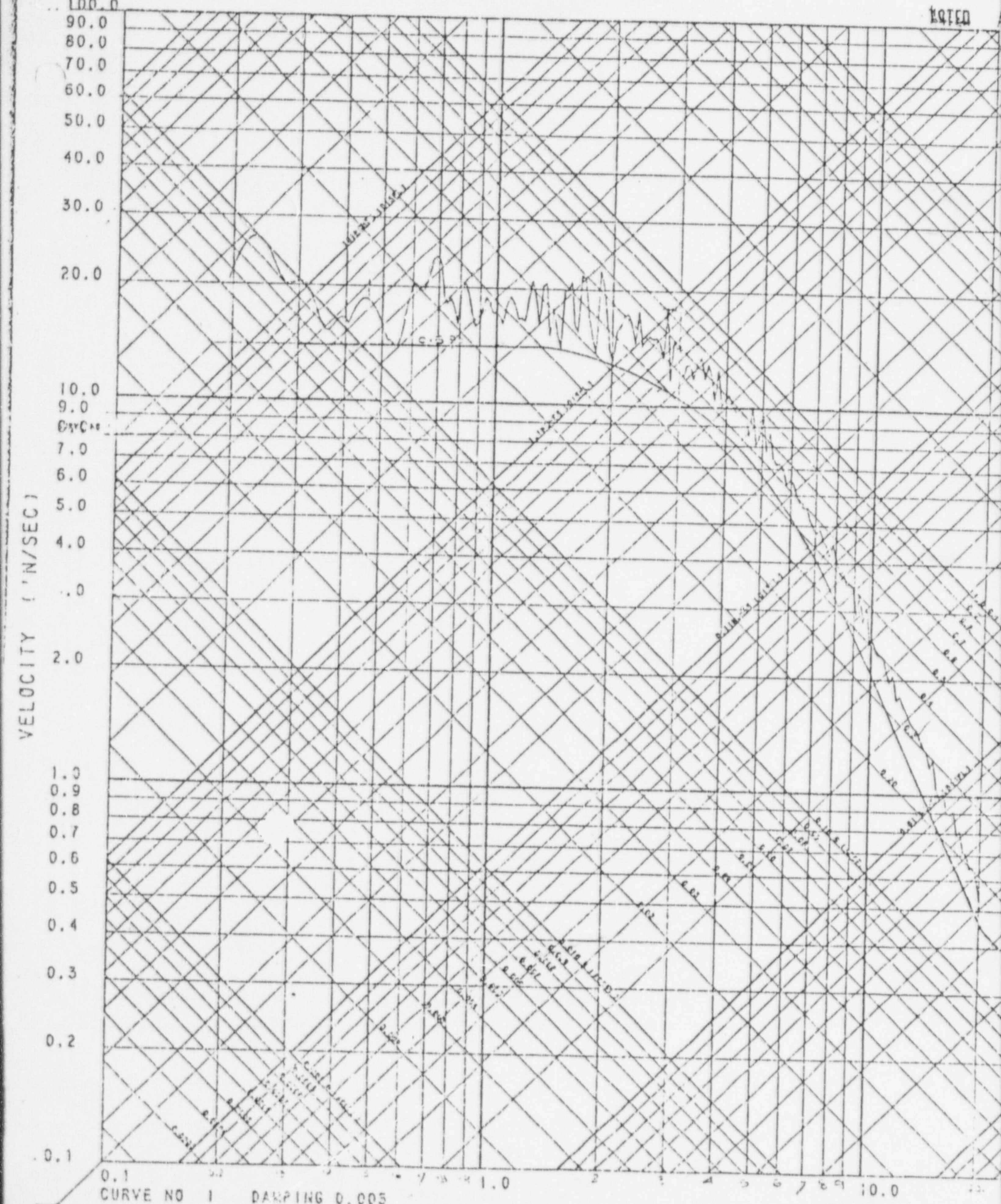
As described in Attachment A, the need for Method A, and the reason licensing basis ISRS frequently exceed 1.5 times the ground response spectrum, is due to the conservatism associated with the analytical procedures used in developing the ISRS. It was only intended that the SRT verify that the building in which Method A was applied was a typical nuclear plant reinforced concrete frame and shear wall or braced steel frame structure.

Conclusion

The preceding discussion leads to the following conclusions:

- The structures at FitzPatrick in which Method A was used are typical nuclear plant structures, either reinforced concrete frame and shear wall or heavily braced steel frame, for which the 1.5 amplification factor is applicable as per the SSRAP Report and Page 4-16 of GIP-2.

- The FitzPatrick licensing basis conservative in-structure response spectra used for A-46 show amplifications of more than 1.5 with respect to the free field ground spectrum. This is due to conservatisms in the calculation methodology, as discussed in Attachment A to this response. If a more realistic, median-centered response spectra were used, then the calculated in-structure response spectra at frequencies above 8 Hz. would not greatly exceed 1.5 times the licensing basis free field spectrum.



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80.0
70.0
60.0
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CURVE NO 1 DAMPING 0.005

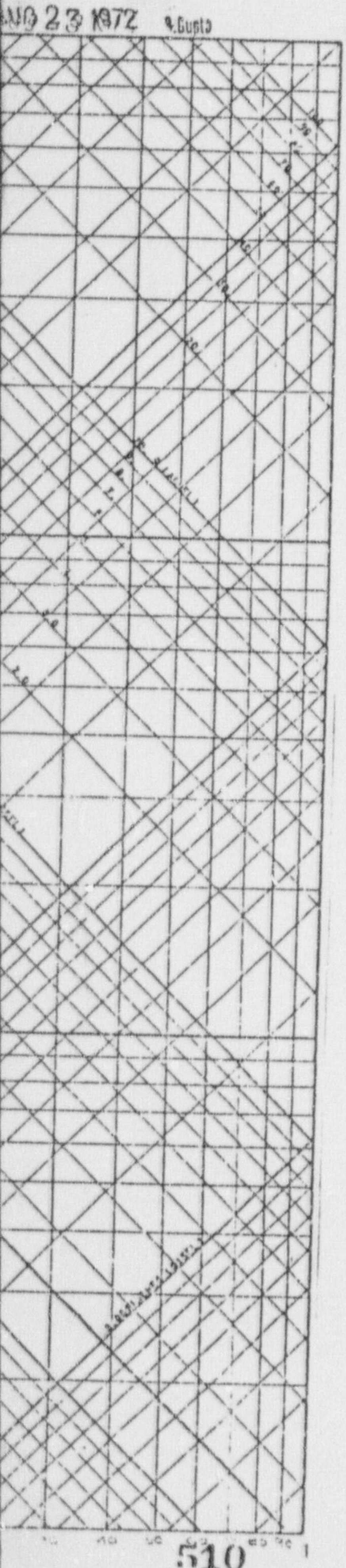

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Figure 1
Comparison of the response spectrum of the input ground motion time history vs. the Housner d[illegible]sign spectrum anchored at 0.15g.

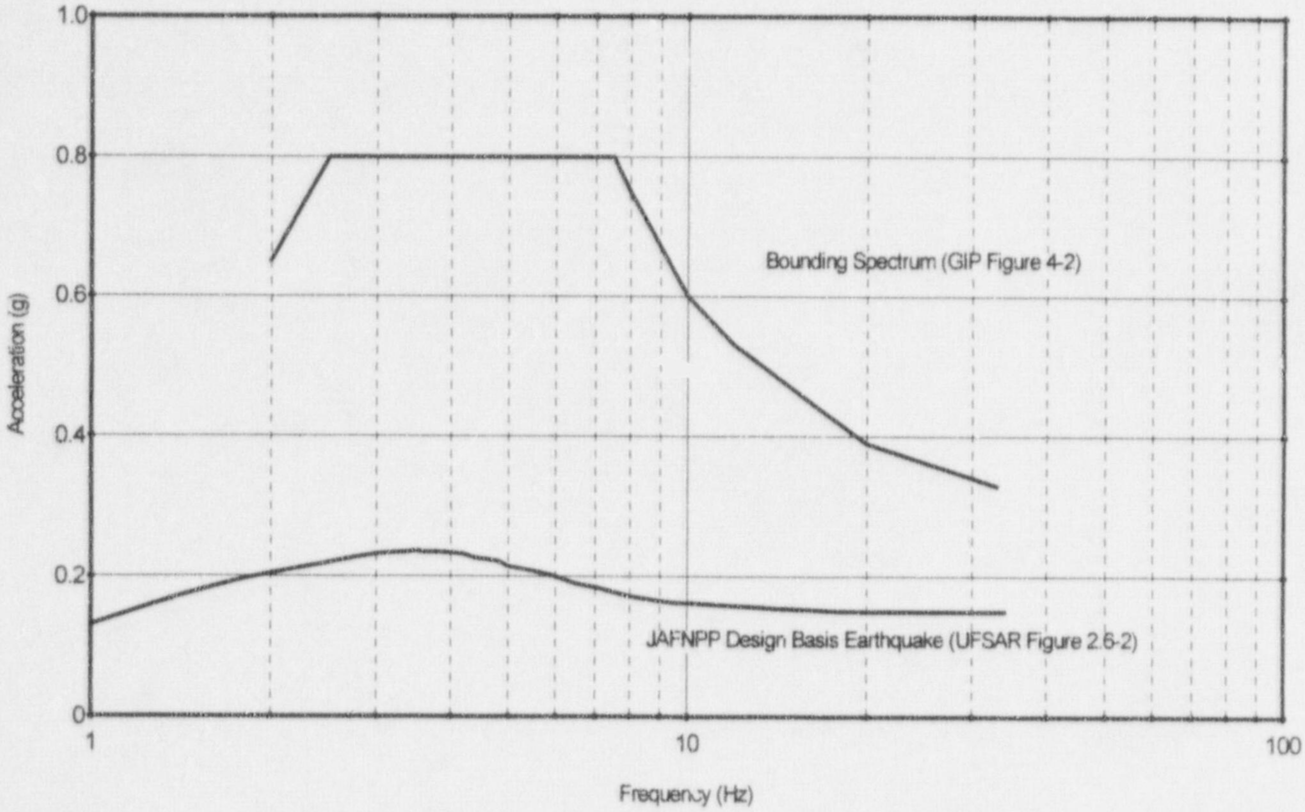

Figure 2
Licensing Basis Free Field Response Spectrum Compared to Bounding Spectrum
(Both curves 5% damped)

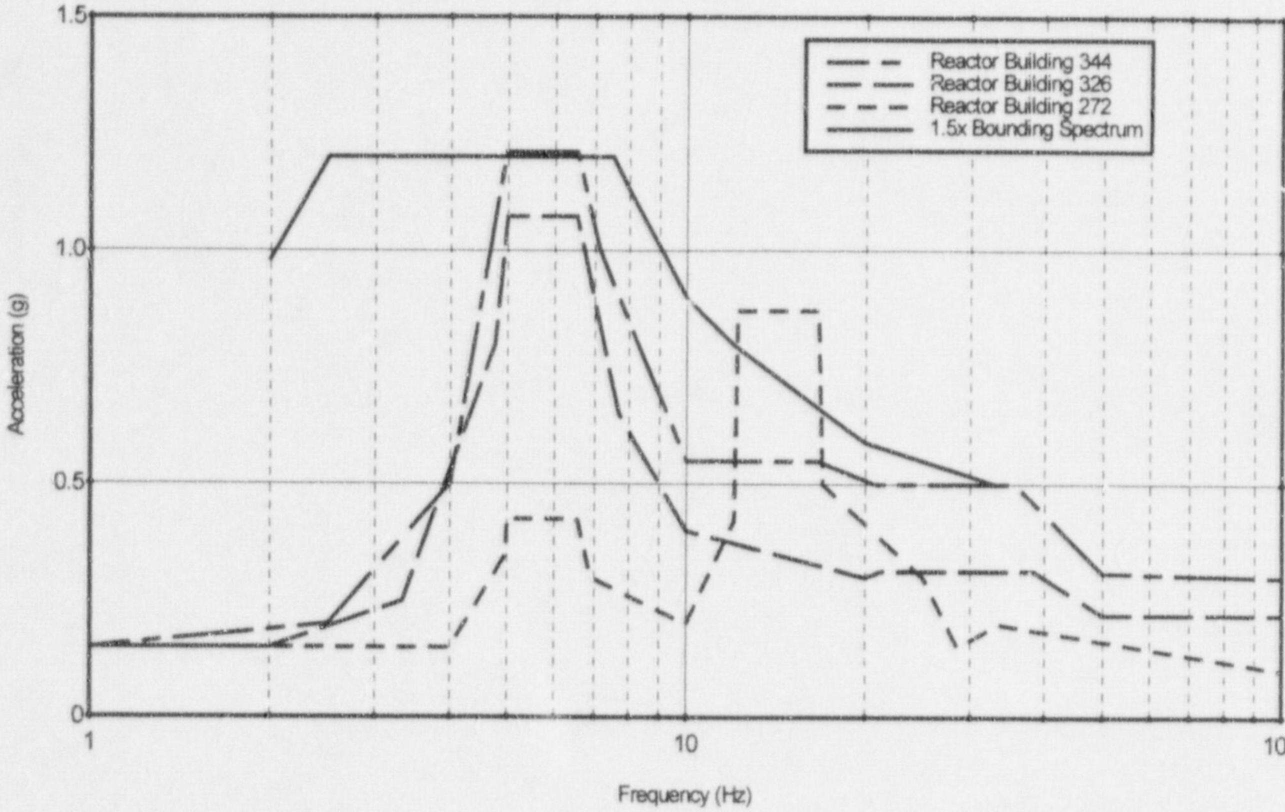

Figure 3
1.5x Bounding Spectrum vs. the Reactor Building Floor Response Spectra
(All curves 5% damped)

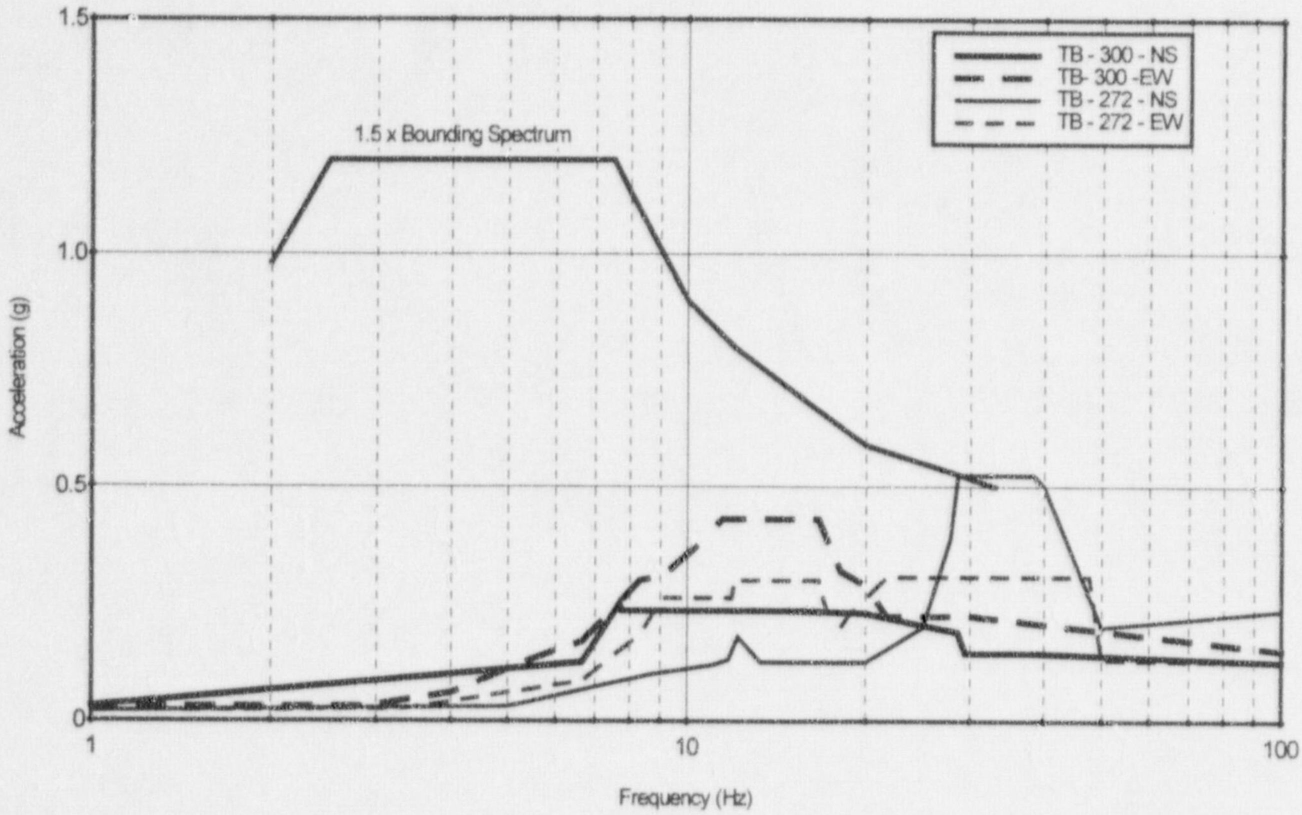

Figure 4
1.5x Bounding Spectrum vs. Turbine Building Floor Response Spectra
(All curves 5% damped)

REFERENCES

1. NRC Fax to New York Power Authority (NYPA), "J. A. FitzPatrick Nuclear Power Plant Request for Additional Information USI A-46," dated 9/6/96.

2. NYPA Letter JPN-96-048 from W. J. Cahill, Jr. to USNRC, dated 10/25/96.

3. Senior Seismic Review and Advisory Panel (SSRAP), "Use of Seismic Experience and Test Data to Show Ruggedness of Equipment in Nuclear Power Plants," Revision 4.0, February 28, 1991.

4. SQUG Letter to USNRC, "Generic Issue Included in NRC's Request for Additional Information on Use of GIP Method A," dated June 30, 1997.

5. Stone & Webster Calculation No. 11825-SM-008, Dynamic Analysis Reactor Building, 7/16/76.

ATTACHMENT A

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

Method A of GIP Table 4-1 (Reference 1) provides a methodology to evaluate the seismic adequacy of equipment by comparing equipment capacity based on earthquake experience ground response spectra at database sites with the plant's SSE ground response spectrum (GRS). The composite earthquake experience GRS from the database sites (Reference Spectrum) was reduced by a factor of 1/1.5 to account for possible additional amplification of motion in nuclear plants compared to database plants and is referred to as the "Bounding Spectrum" in the GIP.

The seismic capacity of equipment defined by the Bounding Spectrum is compared to the seismic demand at the effective grade using the plant licensing basis SSE GRS. The GIP Method A conservatively limits use of this approach to equipment which has a fundamental frequency above about 8 Hz and is located lower than about 40' above the effective grade of the building. These restrictions prohibit the use of GIP Method A for equipment with low fundamental frequencies and for equipment located at high elevations in buildings where the structure seismic response is known to be typically high.

Additional details justifying the use of GIP Method A may be found in the Senior Seismic Review and Advisory Panel (SSRAP) report (Reference 2). This report, included as Reference 5 in GIP-2, summarizes SSRAP's judgment on this subject:

> ".... the use of very conservative floor response spectra should be avoided when assessing the seismic ruggedness of floor mounted equipment .... Only for cases of equipment mounted more than 40 feet above grade or equipment with as-anchored frequencies less than about 8 Hz is it necessary to use floor spectra."
> [Ref. 2, pages 102 and 103]

It is NYPA's position that FitzPatrick has properly interpreted and implemented the rules for use of GIP Method A as previously reviewed and accepted by the NRC. The bases for this position are as follows:

1.1 SQUG and FitzPatrick Interpretation of the GIP

The caution given on page 4-16 of GIP-2 lists two limitations on the use of Method A:

- 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 the earthquake, namely below about 8 Hz. The specific limitations which are intended by the SQUG/NRC expert panel (SSRAP) and SQUG to satisfy these bases are included in the two bullet items listed above. Table 4-1 of GIP-2 which describes the two methods (Method A and Method B) in detail, includes the criteria which need to be met for each of the two methods. The table includes the above two limitations, but does not include the requirement for checking the amplification between the in-structure response and the free field.

The statement on page 4-16 that "the amplification will not exceed about 1.5" is the expected result of meeting the above limitations, and not a third condition which is required to be demonstrated.

The caution on page 4-16 of GIP-2 makes it clear that the advantage of Method A is:

> "The advantage of using ground response comparisons is that with the applicable restrictions and limitations [i.e. the two bullet items listed above], all the equipment covered by the Bounding Spectrum or the GERS can be evaluated for seismic adequacy without the need for using in-structure response spectra which are often based on very conservative modeling techniques or may not be available."
> [Ref. 1, page 4-16]

1.2 The Intent of the GIP

- The GIP cites the SSRAP report (Ref. 2) as the basis for the Bounding Spectrum development and use in Method A (page 4-11, Ref. 2). The SSRAP report 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."
  > [Ref. 2, page 102]

- This judgment by the SSRAP was based on numerous studies and actual earthquake measurements which led them to conclude that:

"Thus, amplification of the horizontal free-field ground spectra by factors greater than 1.5 are considered to be generally unlikely for elevations less than 40 feet above grade."
[Ref. 2, page 104]

- The SSRAP was aware that many nuclear plants were originally licensed based on very conservative ISRS and that the use of conclusions based on earthquake experience and more median-centered approaches would be more appropriate. A detailed discussion of some of the sources of this conservatism is presented in item 5 below. With reference to this topic, the SSRAP report states:

  "It was judged by SSRAP that the use of very conservative floor spectra should be avoided when assessing the seismic ruggedness of floor mounted equipment. It was also the opinion of SSRAP that many of the operating plants may only have these very conservatively computed floor spectra available. To avoid the burden of having to compute more realistic floor spectra, SSRAP decided to anchor its conclusions to ground spectra at the nuclear plant sites in those cases where this was judged to be reasonable."
  [Ref. 2, page 102]

- This was the basis for SSRAP's recommendation (and included in GIP-2 as methods A and B) that:

  "Thus, for the case of equipment with fundamental frequencies greater than about 8 Hz mounted less than 40 feet above grade, SSRAP's conclusions are based upon comparing the bounding spectra with nuclear power plant ground spectra. Only for the case of equipment mounted more than 40 feet above grade or equipment with as-anchored frequencies less than about 8 Hz is it necessary to use floor spectra."
  [Ref. 2, 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.

2. <u>Conservatisms Associated with Licensing Basis Calculated ISRS</u>

The following is a detailed description of the typical conservatisms normally found in the analytical methods used for calculating in-structure response spectra (ISRS), at nuclear plants in general and at FitzPatrick in particular. This information is provided in response to the July 8, 1999, teleconference request as additional evidence of the validity of Method A as originally developed by the SSRAP.

The process of calculating ISRS is a complicated analytical exercise requiring a significant number of approximations and modeling assumptions, and considerable engineering judgment. As a result, the historical development of ISRS has included a large 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 calculation 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 had developed, and SQUG subsequently endorsed, an alternate ISRS estimation technique (referred to as Method A within GIP-2) which was much more median centered and realistic than the typical design practice. The application of Method A at FitzPatrick 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:

> "Secondly, most unbroadened computed in-structure spectra have very narrow, highly amplified peaks at the resonant frequency of the structure. In most cases these narrow, highly amplified peaks are artificially broadened to account for uncertainty in the structure's natural frequency. This process simply increases the emphasis on these highly amplified peaks.... SSRAP is also of the opinion that these narrow peaks will not be as highly amplified in real structures at high ground motion levels as is predicted by linear elastic mathematical models, nor are such narrow peaked in-structure spectra likely to be as damaging to equipment as is a broad frequency input which is represented by 1.5 times the Bounding Spectrum." [Ref. 2, pages 19 and 20.]

As described below, three areas are presented to support the application of Method A at U.S. nuclear plants in general, and at FitzPatrick in specific:

A. Measurements of ISRS in actual earthquakes

B. Calculations of overall conservatisms in typical ISRS

C. Descriptions of the conservatisms in ISRS in general and FitzPatrick ISRS in particular

2.1 <u>Measurements of ISRS in Actual Earthquakes</u>

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 (Ref. 2, page 102) the measured floor response spectra at elevations less than 40 feet above grade for moderately stiff structures at the Pleasant Valley Pump Station, the Humboldt 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, have been reviewed by SQUG. These data also show 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 challenge GIP Method A.

2.2 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 establishing the structural response without having to embark on costly new analyses of all the site buildings. (It is noted that even the most modern, state-of-the-art ISRS contain significant conservatisms; even those classified as "median-centered" are often very conservative). NUREG/CR-1489, "Best Estimate Method vs Evaluation Method: A Comparison of Two Techniques in Evaluating Seismic Analysis and Design", stated 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' 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 occasional exceedances of 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]."
> [Ref. 2, Page 106]

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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.

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 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 7separately in the GIP).

2.3 Description of Conservatisms in ISRS in General and FitzPatrick ISRS in Particular

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

- Ground Motion Incoherence
- Embedment Effects
- Frequency (structure modeling)
- Structural Damping
- Time History Simulation
- Peak Broadening and Enveloping
- Clipping of Narrow Peaks

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 calculation 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 FitzPatrick. However, on a qualitative level, 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:

2.3.1 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. 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 sites like FitzPatrick, and is particularly appropriate in the high frequency range.

2.3.2 Embedment Effects

The Reactor and Turbine buildings are deeply embedded structures at FitzPatrick. The structures are contained within an excavated rock pocket. This rock pocket has vertical walls with a small annular gap between the exterior walls and the excavated rock which is backfilled with sand for drainage purposes. Effectively, this backfill has settled and is quite stiff. The resulting lateral stiffness represented by the 45' of surrounding rock is certainly significant. Since the rock is effectively rigid, it is not unreasonable to expect significant lateral stiffness and support of the buildings in question. Lateral support of the lowest 45' of the buildings could decrease the ISRS at higher elevations by estimated range of 1.3 up to 2.

2.3.3 Structural Damping

Structural damping is one of the parameters of dynamic analysis to which the seismic analysis results are quite sensitive. It is a physical property of the different materials included in the dynamic model. Values used in current analyses and licensing bases are controlled by Regulatory Guide 1.61 (R.G. 1.61). Values specified in R.G. 1.61 have been shown by several studies to underestimate actual response of steel and concrete structures. Damping values recommended in NP-6041 (Ref. 6) are more realistic, and are suggested for use in median centered analyses. Damping values specified in FitzPatrick's licensing basis are compared to those in R.G. 1.61 and NP-6041 below:

Table 1

Structure or Component	*R.G. 1.61 OBE*	*R.G. 1.61 SSE*	*NP-6041 at About 1/2 Yield*	*NP-6041 Just Below Yield*	*FitzPatrick OBE License Basis*	*FitzPatrick DBE License Basis*
Welded Steel	2%	4%	3%	7%	1%	1%
Bolted Steel	4%	7%	7%	10%	2%	3%
Reinforced Concrete	4%	7%	3-5%	10%	2%	5%

As can be seen in Table 1, the damping values for both the OBE and DBE licensing basis at FitzPatrick are lower than the corresponding values allowed by the regulatory guide and NP-6041 for both steel and reinforced concrete structures. These two types of structures encompass the structures at FitzPatrick housing A-46 SSEL components.

2.3.4 Time History Simulation

ISRS at FitzPatrick were generated using an acceleration time history. This was intended to approximate the licensing basis smooth ground response spectrum with a PGA of 0.15g for the modified Housner shape of the DBE.

Figure 1 shows a plot of the 0.5% damped response spectrum from the time history and the FitzPatrick licensing basis ground response spectrum. The time history spectrum conservatively envelopes the licensing basis free field spectrum in the frequency range of 1 to 5 Hz. Above 5 Hz, the time history spectrum is close to the licensing basis free field spectrum. For each structure, the degree of conservatism in the ISRS depends on the structure's response frequency.

The RB has its overall fundamental frequency between 5 and 6 Hz. The time history is seen to over-compute response between 5 and 6 Hz by a factor of about 1.3 to 1.5. This means the structural response, the resulting floor time histories and the ISRS are over-conservative by a factor of about the same range, 1.3-1.5, due to conservatism in the time history. The same factors are applicable to the Turbine Building Complex.

2.3.5 Peak Broadening and Enveloping

The licensing basis spectra for FitzPatrick are artificially broadened at the resonant frequencies. The GIP recommends using realistic, median-centered, unbroadened ISRS. The broadening of the FitzPatrick licensing basis ISRS was conservatively done at ±15%. The 5% damped ISRS for the reactor building elevations 272', 326', and 344' compared to 1.5 times the Bounding Spectrum (also referred to as the "reference spectrum") is shown in Figure 3 (see response to RAI question 4&5). While the reactor building elevation 272' exceeds the reference spectrum from about 11 Hz to 15 Hz, it is important to note that the ISRS are broadened. An unbroadened floor spectral comparison would show this exceedance to be a narrow band exceedance, therefore, much less pronounced. If the original unbroadened spectra were compared to the free field spectrum, the apparent amplification at 12-13 Hz for the RB would be reduced (because the vertical line forming the high frequency side of the resonant range would shift to the left).

For the RB and TB, the effects of broadening and smoothing are judged to add a factor of conservatism of about 1.1 to the apparent amplification at frequencies over 8Hz.

2.3.6 Clipping of Narrow Peaks

The SSRAP Report and the Generic Implementation Procedure (GIP) recommend procedures for adjusting narrow peaks to reflect two areas of conservatism:

1. Narrow peaks are not as highly amplified in real structures as are predicted by linear elastic models.

2. Narrow peaks in ISRS are not as damaging to equipment as are broad frequency input such as the Reference Spectrum.

The GIP recommends an averaging technique over a frequency range of 10% of the peak frequency (e.g., 1 Hz range for a 10 Hz peak frequency) using the unbroadened ISRS. The FitzPatrick ISRS have narrow peaks and did not utilize the peak reduction methods of the GIP. The conservatism involved has been shown to be in the range of 5% to 20% for typical narrow peaks at several plants. The maximum frequency dependent amplification with respect to the licensing basis ground spectrum is about 4.5 at the primary structural frequency above 8 Hz. For the RB and TB, the effects of narrow band peaks are judged to add a factor of conservatism of about 1.1 to the apparent amplification at frequencies over 8Hz.

2.3.7 Overall Conservatism

The total effect of all these conservatisms can result in significant overestimation of the amplification of the ISRS over the GRS for frequencies above 8 Hz. The following Table 2 summarizes the potential factors for each building discussed above. For the aforementioned effects for which a range is given, the mid-range value is used in the table below.

Table 2

Building	*RB*	*TB*
GM Incoherence	1.3	1.3
Embedment Effects	1.5	1.5
Time History	1.4	1.4
Peak Broadening	1.1	1.1
Peak Clipping	1.1	1.1
Total	3.3	3.3

Reducing the ISRS by the above noted factor of conservatism (3.3) results in ISRS that are in the range of about 1.5 to 2 times the ground spectrum. There are several additional sources of conservatism (e.g., structural modeling, structural/soil nonlinearities, etc.) which add to the overall conservatism in the calculation of ISRS. These additional conservatisms, coupled with those described above, reinforce the overall levels of conservatism in ISRS of between 1.5 and 8 which were referenced by SSRAP (LLNL Report NUREG/CR 1489).

2.3.8 Other Information

Table 3 provides a comparison evaluation of overall seismic margins between median-centered and design basis analysis for nuclear power plant structures at various facilities. The information was developed by the Seismic

Qualification Utility Group, and was meant to demonstrate that factors of safety in original design basis analysis can be shown to be in the range of 2.5 to 5. This table was also submitted to the NRC by another Region I nuclear plant.

The data in the table are from five reinforced concrete shear wall structures at four different plants typical of those found at nuclear power plants. In the SER provided to the aforementioned Region I plant, the staff considered the five ratios of the conservative design spectra to median-centered spectra. Factors of conservatism are seen to range from 2.3 to 5.4. The mean of the ratios is 3.77.

The FitzPatrick reactor and turbine buildings are fundamentally reinforced concrete shear wall structures, for which the results of Table 3 are applicable. The results of Table 3 are seen to be supportive of the qualitative assessment of factors of conservatism given above. Based on this factor (mean), the median-centered ISRS for FitzPatrick within 40 feet of grade would appear to be in the range of about 1.5 to 2 times the ground spectrum.

2.3.9 Conclusion

Consideration of the above indicates that there are large factors of conservatism in the FitzPatrick licensing basis ISRS. If these factors of conservatism are taken into account, the judgment of the FitzPatrick USI A-46 SRT that the FitzPatrick structures are "typical nuclear plant" structures for which GIP Method A is applicable is seen to be reasonable. In other words, if realistic, median centered ISRS were to be calculated for the FitzPatrick reactor and turbine building complex for the elevations at which Method A was used, the amplification of the ISRS over the free field GRS would not greatly exceed 1.5 and the seismic demand would be less than the seismic capacity of the equipment (i.e., 1.5 times Bounding Spectrum).

3. 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."
> [Ref. 4, page 16]

Method A is only applicable to relatively stiff equipment with fundamental frequencies over about 8 Hz. As noted above, 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 and NRC Regulatory Guide 1.166 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.

4. Conclusions

The discussion above leads to several conclusions:

- 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 result in ISRS, which show amplifications well beyond the 1.5 factor from Method A. Specific exceedances noted for FitzPatrick (beyond the 1.5 factor) are due to the conservatisms inherent in the ISRS calculation methods, and do not invalidate the application of Method A.

Table 3
Comparison of Design Basis to Median Centered
(Peak Spectral Response Comparison)

Plant	Building	Construction	Estimated Frequency	Comments	Damping **	Design Basis Analysis Peak S_a	Median Centered Peak S_a	Margin Design/ Median	Ground Spectra
A	Auxiliary Building	5 Story, Reinforced Concrete Shear Wall	7-8 Hz	Rock Site	2%	3.8g	1.5g	2.53	0.12g Reg Guide 1.60
B	Reactor Building Interior Structure	Reinforced Concrete Shear Wall	10-13 Hz	Rock/Soil	5%	5.8g*	1.1g	5.3	0.12g Site Specific
B	Reactor Building Exterior Shell	Reinforced Concrete Shear Wall	4 Hz 12 Hz	Rock/Soil	5%	2.2 g*	0.67g	3.3	0.12g Site Specific
C [1]	Contain ment Interior Structure	Reinforced Concrete Shear Wall	10 Hz	Rock Site	5%	10.7g	4.7g	2.3	0.75g Hosgri
D	Auxiliary Building	Reinforced Concrete Shear Wall	10 Hz	Rock/Soil	5%	1.4g	0.26g [2]	5.4	0.1 Modified Newmark

* SSE defined as 2 x OBE for this Plant's Design Basis.

** Equipment damping value applies both to design basis ISRS and median centered ISRS.

1 It should be noted that the reanalysis for the 0.75g Hosgri earthquake was done relatively recently, and had less inherent conservatism in the design basis response analysis than older plants. Thus, the margin of 2.3 (design peak/median peak) is judged to be on the lower side of the margins expected for older plants.

2 Median Value was scaled to reflect the fact that the median ISRS were generated for a Regulatory Guide 1.60 shape (conservative), instead of the Plant D Design SSE.

REFERENCES

1. Seismic Qualification Utility Group (SQUG), "Generic Implementation Procedure (GIP) For Seismic Verification of Nuclear Plant Equipment," Revision 2, Corrected 2/14/92.

2. Senior Seismic Review and Advisory Panel (SSRAP), "Use of Seismic Experience and Test Data to Show Ruggedness of Equipment in Nuclear Power Plants," Revision 4.0, February 28, 1991.

3. U.S. Nuclear Regulatory Commission, "Seismic Qualification of Equipment in Operating Nuclear Power Plants," NUREG-1030, February 1987.

4. U.S. Nuclear Regulatory Commission, "Regulatory Analysis for Resolution of Unresolved Safety Issue A-46, Seismic Qualification of Equipment in Operating Plants," NUREG-1211, February 1987.

5. U.S. Nuclear Regulatory Commission, "Supplement No.1 to Generic Letter (GL) 87-02 That Transmits Supplemental Safety Evaluation Report No. 2 (SSER No.2) on SQUG Generic Implementation Procedure, Revision 2, As Corrected on February 14, 1992 (GIP-2)," May 22, 1992.

6. "A Methodology for Assessment of Nuclear Power Plant Seismic Margin (Revision 1)," EPRI NP-6041-SL, Rev.1, August 1991.

ATTACHMENT B

Revised Screening Verification Data Sheets (SVDS), Pages 12 and 13

JAMES A. FITZPATRICK NUCLEAR POWER PLANT
SCREENING VERIFICATION DATA SHEET (SVDS)

Eq. Cl	Eq. ID	Sys/Eq. Desc	Bldg.	Fl El.	Rm or Rw/Cl	Base El.	<40'?	Cap. Spec.	Demd. Spec	Cap > Demd?	Caveats OK?	Anchor OK?	Interact OK?	Equip OK?
7	03AOV-126(HCU-02-19)	HCU INLET SCRAM AIR OPER VALVE	RB	272.00	5 Y	272.00	Yes	BS	GRS	Yes	Yes	N/A	No	No
7	03AOV-127(HCU-02-19)	HCU OUTLET SCRAM AIR OPER VALVE	RB	272.00	5 Y	272.00	Yes	BS	GRS	Yes	Yes	N/A	No	No
8	03SOV-117(HCU-02-19)	HCU-02-19 SCRAM PILOT AIR SOLENOID OPER VALVE	RB	272.00	5 Y	272.00	Yes	BS	GRS	Yes	Yes	N/A	Yes	Yes
8	03SOV-118(HCU-02-19)	HCU-02-19 SCRAM PILOT AIR SOLENOID OPER VALVE	RB	272.00	5 Y	272.00	Yes	BS	GRS	Yes	Yes	N/A	Yes	Yes
8	03SOV-140A	HYDRAULIC CONTROL UNITS BACKUP SCRAM PILOT SOLENOID VLV EQ	RB	272.00	3.5 A	272.00	Yes	BS	GRS	Yes	Yes	N/A	Yes	Yes
8	03SOV-140B	HYDRAULIC CONTROL UNITS BACKUP SCRAM PILOT SOLENOID VLV EQ	RB	272.00	3.5 A	272.00	Yes	BS	GRS	Yes	Yes	N/A	Yes	Yes
8	03SOV-31A	SDIV A AOV INSTRUMENT AIR SUPPLY SOLENOID VALVE EQ	RB	272.00	3.5 A	272.00	Yes	BS	GRS	Yes	Yes	N/A	Yes	Yes
8	03SOV-31B	SDIV B AOV INSTRUMENT AIR SUPPLY SOLENOID VALVE B EQ	RB	272.00	3.5 A	272.00	Yes	BS	GRS	Yes	Yes	N/A	Yes	Yes
0	03TK-125(HCU-02-19)	WATER ACCUMULATOR	RB	272.00	5 Y	272.00	N/A	DOC	~~RRS~~ CRS	No	Yes	Yes	No	No
0	03TK-128(HCU-02-19)	NITROGEN ACCUMULATOR	RB	272.00	5 Y	272.00	N/A	DOC	~~RRS~~ CRS	No	Yes	Yes	No	No
18	10FT-109B	RHR B DISCH HDR FLOW XMITTER	RB	227.50	1 W	227.50	Yes	BS	GRS	Yes	Yes	Yes	Yes	Yes
8	10MOV-15A	RHR PUMP A SUCT SHUTDOWN COOLING ISOL VALVE	RB	227.50	2 A	242.67	Yes	BS	GRS	Yes	Yes	N/A	Yes	Yes
8	10MOV-15B	RHR PUMP B SUCT SHUTDOWN COOLING ISOL VALVE	RB	227.50	2 D	242.67	Yes	BS	GRS	Yes	Yes	N/A	Yes	Yes
8	10MOV-15C	RHR PUMP C SUCT SHUTDOWN COOLING ISOL VALVE	RB	227.50	3.5 A	242.67	Yes	BS	GRS	Yes	Yes	N/A	Yes	Yes
8	10MOV-15D	RHR PUMP D SUCT SHUTDOWN COOLING ISOL VALVE	RB	227.50	3 D	242.67	Yes	BS	GRS	Yes	Yes	N/A	Yes	Yes
8	10MOV-16A	RHR A MIN FLOW ISOL VALVE	RB	242.67	2 A	242.67	Yes	BS	GRS	Yes	Yes	N/A	Yes	Yes
8	10MOV-16B	RHR B MIN FLOW ISOL VALVE	RB	242.67	3 D	242.67	Yes	BS	GRS	Yes	Yes	N/A	Yes	Yes
8	10MOV-34A	RHR A TORUS COOLING SUPPLY VALVE	RB	242.67	3 A	242.67	Yes	BS	GRS	Yes	Yes	N/A	Yes	Yes
8	10MOV-34B	RHR B TORUS COOLING SUPPLY VALVE	RB	242.67	3 D	242.67	Yes	BS	GRS	Yes	Yes	N/A	Yes	Yes

REV 1

Certification:
All the information contained on this Screening Verification Data Sheet (SVDS) is, to the best of our knowledge and belief, correct and accurate. "All information" includes each entry and conclusion (whether verified to be seismically adequate or not).

Approved: (Signatures of all Seismic Capability Engineers on the Seismic Review Team (SRT) are required; there should be atleast two on the SRT. All signatories should agree with all the entries and conclusions. One signatory should be a licensed professional engineer.)

Certification:
The information provided to the Seismic Capability Engineers regarding systems and operations of the equipment contained in the SVDS is, to the best of our knowledge and belief, correct and accurate.

Approved: (One signature of Systems or Operations Engineer is required if the Seismic Capability Engineers deem it necessary.)

Print or Type Name	Signature	Date	Print or Type Name	Signature	Date
Mara Lakis	Mara Lakis	9/6/95	Ahmet Unsal	Ahmet Unsal	9/9/99
Walter Djordjevic	W Djordjevic	9/14/95	WALTER DJORDJEVIC	W	9/9/99

REV 1

JAMES A. FITZPATRICK NUCLEAR POWER PLANT
SCREENING VERIFICATION DATA SHEET (SVDS)

Eq. Cl	Eq. ID	Sys/Eq. Desc	Bldg.	Fl El.	Rm or Rw/Cl	Base El.	<40'?	Cap. Spec	Demd. Spec	Cap > Demd?	Caveats OK?	Anchor OK?	Interact OK?	Equip OK?
8	10MOV-39A	RHR A TORUS COOLING ISOL VALVE	RB	242.67	3 A	242.67	Yes	BS	GRS	Yes	Yes	N/A	Yes	Yes
8	10MOV-39B	RHR B TORUS COOLING ISOL VALVE	RB	242.67	3 D	242.67	Yes	BS	GRS	Yes	Yes	N/A	Yes	Yes
8	10MOV-66A	RHR HEAT EXCH A BYPASS VALVE	RB	242.67	2 P	242.67	Yes	BS	GRS	Yes	Yes	N/A	Yes	Yes
8	10MOV-66B	RHR HEAT EXCH B BYPASS VALVE	RB	242.67	2 D	242.67	Yes	BS	GRS	Yes	Yes	N/A	Yes	Yes
6	10P-3A	RESIDUAL HEAT REMOVAL PUMP A	RB	227.50	3 A	227.50	Yes	BS	GRS	Yes	Yes	Yes	Yes	Yes
6	10P-3B	RESIDUAL HEAT REMO 'AL PUMP B	RB	227.50	3 D	227.50	Yes	BS	GRS	Yes	Yes	Yes	Yes	Yes
6	10P-3C	RESIDUAL HEAT REMOVAL PUMP C	RB	227.50	3 A	227.50	Yes	BS	GRS	Yes	Yes	Yes	Yes	Yes
6	10P-3D	RESIDUAL HEAT REMOVAL PUMP D	RB	227.50	3 D	227.50	Yes	BS	GRS	Yes	Yes	Yes	Yes	Yes
7	10RV-41A	RHR PUMP A SHUTDOWN COOLING SUCT RELIEF VALVE	RB	227.50	2 A	227.50	Yes	BS	GRS	Yes	Yes	N/A	Yes	Yes
7	10RV-41B	RHR PUMP B SHUTDOWN COOLING SUCT RELIEF VALVE	RB	227.50	2 D	227.50	Yes	BS	GRS	Yes	Yes	N/A	Yes	Yes
7	10RV-41C	RHR PUMP C SHUTDOWN COOLING SUCT RELIEF VALVE	RB	227.50	2 A	227.50	Yes	BS	GRS	Yes	Yes	N/A	Yes	Yes
7	10RV-41D	RHR PUMP D SHUTDOWN COOLING SUCT RELIEF VALVE	RB	227.50	2 D	227.50	Yes	BS	GRS	Yes	Yes	N/A	Yes	Yes
7	10SV-35A	RHR LOOP A SAFETY VALVE	RB	242.67	1 R	272.00	Yes	BS	GRS	Yes	Yes	N/A	Yes	Yes
7	10SV-35B	RHR LOOP B SAFETY VALVE	RB	242.67	1 W	272.00	Yes	BS	GRS	Yes	Yes	N/A	Yes	Yes
0	11EV-14A	SLC A DOUBLE SQUIB ACTIVATED SHEAR EXPLOSIVE VALVE	RB	326.75	6 R	326.00	N/A	DOC	~~RRS~~ CRS	No	Yes	Yes	Yes	No
0	11EV-14B	SLC B DOUBLE SQUIB ACTIVATED SHEAR EXPLOSIVE VALVE	RB	326.75	6 R	326.00	N/A	DOC	~~RRS~~ CRS	No	Yes	Yes	Yes	No
5	11P-2A	STANDBY LIQUID CONTROL A PUMP	RB	326.75	6 P	326.00	N/A	ABS	CRS	Yes	Yes	Yes	Yes	Yes
5	11P-2B	STANDBY LIQUID CONTROL B PUMP	RB	326.75	6 P	326.00	N/A	ABS	CRS	Yes	Yes	Yes	Yes	Yes
7	11SV-39A	SLC PUMP 2A DISCH SAFETY VALVE	RB	326.75	6 P	326.00	N/A	ABS	CRS	Yes	Yes	N/A	Yes	Yes
7	11SV-39B	SLC PUMP 2B DISCH SAFETY VALVE	RB	326.75	6 P	326.00	N/A	ABS	CRS	Yes	Yes	N/A	Yes	Yes
8	12MOV-18	RWCU SUPPLY OUTBD ISOL VALVE	RB	314.50	3 R	326.00	N/A	ABS	CRS	Yes	Yes	N/A	Yes	Yes
18	25-01	CH A CORE SPRAY SYSTEM RACK	RB	242.67	4 A	242.67	Yes	BS	GRS	Yes	Yes	Yes	Yes	Yes
18	25-05	REACTOR PROTECTION AND NSSS SYSTEM RACK	RB	300.00	3.5 R	300.00	Yes	BS	GRS	Yes	Yes	Yes	Yes	Yes
18	25-06	REACTOR PROTECTION AND NSSS SYSTEM RACK	RB	300.00	5.5 YW	300.00	Yes	BS	GRS	Yes	Yes	Yes	Yes	Yes
18	25-50	HPCI INST RACK	RB	242.67	1 R	242.67	Yes	BS	GRS	Yes	Yes	Yes	Yes	Yes
18	25-59	RHR CHANNEL A INST RACK	RB	242.67	4 A	242.67	Yes	BS	GRS	Yes	Yes	Yes	Yes	Yes

REV. 1

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Print or Type Name	Signature	Date
Mara Lakis	Mara Lakis	9/6/95
Walter Djordjevic	WAH	9/14/95

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