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December 8, 2011

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

Subject: Duke Energy Carolinas, LLC
William States Lee III Nuclear Station - Docket Nos. 52-018 and 52-019
AP1000 Combined License Application for the
William States Lee III Nuclear Station Units 1 and 2
Partial Response to Request for Additional Information
(RAI No. 6182)
Ltr# WLG2011.12-03

Reference: Letter from Brian Hughes (NRC) to James Thornton (Duke Energy), Request for Additional Information Letter No. 100 Related to SRP 03.07.02 - Seismic System Analysis for the William States Lee III Units 1 and 2 Combined License Application, dated November 9, 2011 (ML11313A170)

This letter provides the Duke Energy partial response to the Nuclear Regulatory Commission's request for additional information (RAI) included in the referenced letter.

The response to the NRC information request described in the referenced letter is addressed in a separate enclosure, which also identifies associated changes, when appropriate, that will be made in a future revision of the Final Safety Analysis Report for the Lee Nuclear Station.

If you have any questions or need any additional information, please contact James R. Thornton, Nuclear Plant Development Licensing Manager (Acting), at (704) 382-2612.

Sincerely,

Ronald A. Jones
Senior Vice President
Nuclear Development

D093
NRO

Enclosure:

1) Lee Nuclear Station Partial Response to Request for Additional Information (RAI) Letter 100, RAI 03.07.02-1

AFFIDAVIT OF RONALD A. JONES

Ronald A. Jones, being duly sworn, states that he is Senior Vice President, Nuclear Development, Duke Energy Carolinas, LLC, that he is authorized on the part of said Company to sign and file with the U. S. Nuclear Regulatory Commission this supplement to the combined license application for the William States Lee III Nuclear Station, and that all the matter and facts set forth herein are true and correct to the best of his knowledge.

Ronald A. Jones, Senior Vice President
Nuclear Development

Subscribed and sworn to me on December 8, 2011

Freda K. Crump
Notary Public

My commission expires: August 17, 2016

SEAL FREDA K CRUMP NOTARY PUBLIC LINCOLN COUNTY, NC

xc (w/o enclosure):

Charles Casto, Deputy Regional Administrator, Region II

xc (w/ enclosure):

Brian Hughes, Senior Project Manager, DNRL

Lee Nuclear Station Partial Response to Request for Additional Information (RAI)

RAI Letter No. 100

NRC Technical Review Branch: **Structural Engineering Branch 1 (AP1000/EPR Projects) (SEB1)**

Reference NRC RAI Number(s): **RAI 03.07.02-1**

NRC RAI:

The staff performed a review of WLG-1000-S2R-802, Revision 1, and finds that additional information is required to assess the adequacy of the applicant's seismic analysis for satisfying NRC regulations (Appendix A to 10 CFR Part 50):

(a) WLG-1000-S2R-802 contains a site-specific analysis to demonstrate acceptability of the AP1000 standard design. Staff review of this report finds that there is insufficient detail to assess adequacy of the seismic analysis method used by the applicant. In particular, it is not clear if the applicant's method of seismic analysis is consistent with that of AP1000 DCD Sections 3.7.1 and 3.7.2, which provide acceptable methods for performing seismic analysis. To address this issue, the staff requests the applicant to identify any DCD departures pertaining to these DCD sections, particularly as they relate to critical damping values (3.7.1.3), development of design time-histories (3.7.1.2), three components of earthquake motion (3.7.2.6), and seismic modeling and analysis of Seismic Category II building structures (3.7.2.8.4).

Staff notes that NRC regulation, 10 CFR Part 52.79, "Contents of Applications; Technical Information in Final Safety Analysis Report," requires that the COL applicant's FSAR contain a description and safety assessment of the structures, systems, and components as well as the evaluations required to show that the safety functions will be accomplished. Based on this requirement, staff requests the applicant to include a description of the site-specific seismic analysis (including methods, significant assumptions, and results) in FSAR Section 3.7.

(b) WLG-1000-S2R-802, Section 5.0, describes a parametric study performed to assess the impact of the reduced shear wave velocity below the NW corner of Unit 1. Based on these results (Figures 6-1 though 6-6), the applicant asserts that (a) the effect of the "softer" NW corner on the design is minimal, and that (b) the SSI results from Unit 2 bound the Unit 1 results, thereby constituting a conservative seismic input assumption for the 3-D SSI analysis of Unit 1.

Staff review of the applicant's sensitivity study finds that the assessment of the NW corner effects should include a comparison of vertical responses (Figures 6-1 through 6-6), since a "soft" corner may affect the rocking response of the nuclear island. In addition, staff notes that AP1000 DCD Section 2.5.2 states that, for site-specific analysis of hard-rock sites, the COL applicant should compare in-structure response spectra (ISRS) to the AP1000 HRHF spectra at the locations given in APP-GW-GLR-115, "AP1000 Standard Combined License Technical Report Effect of High Frequency Seismic Content on SSCs." Since Appendix A does not contain such comparisons, the staff requests the applicant to provide comparisons at locations described in APP-GW-GLR-115, Section 5.2. In order to assess

the significance of the sensitivity study results on the standard design, the applicant is requested to provide comparisons of the sensitivity study results to the standard plant design spectra (HRHF and CSDRS). If the Unit 1 seismic demands (including vertical response) exceed those of Unit 2, the applicant should justify the use of the Unit 2 profile (centerline) for the 3D SSI analysis of Unit 1.

(c) WLG-1000-S2R-802, Section 3.0, describes site-specific 3-D SSI analysis, which makes use of ground-motion coherency functions (incoherency). Staff review finds that this report section does not provide sufficient detail to assess the acceptability of the incoherency approach used by the applicant. To address this issue, the applicant is requested to summarize the methodology used and describe the consistency with guidance provided in ISG-01, "Interim Staff Guidance on Seismic Issues Associated with High-Frequency Ground Motion in Design Certification and Combined License Applications."

(d) WLG-1000-S2R-802, Section 4, provides time-histories matched to the WLS FIRS. SRP Section 3.7.1 provides acceptance criteria for using a single set of synthetic time histories. Staff review finds that Section 4 does not address the SRP criteria for matching (e.g., design response spectrum enveloping and power spectral density requirements). To address this issue, the applicant is requested to provide the bases for acceptability of the assumed time histories used in SSI analysis.

Duke Energy Response:

The Lee Nuclear Station site-specific analysis reported in Westinghouse report WLG-1000-S2R-802 Revision 1 was submitted in December 2009 (Reference 1), reflecting the most current information at that time about AP1000 and the Lee Nuclear Station site. Since the analyses described in that report were performed, a number of changes have been made to the DCD-supporting documents, as well as to the Lee Nuclear Station site-specific configuration and supporting documentation. These changes include:

- During the AP1000 Design Certification Amendment process, the properties of the shield building elements in the nuclear island analysis were adjusted to better represent steel composite (SC) construction.
- Also during the AP1000 Design Certification Amendment process, other aspects of the nuclear island analytical model (e.g. interior structure modeling) were adjusted in response to detailed review comments.
- Duke also notified NRC of its intent to use granular fill materials adjacent to the nuclear islands. This affects the properties used in the original analyses to represent the Lee Unit 1 northwest corner fill material below the level of the AP1000 basemat. (Reference 2)
- Duke has revised the Lee Unit 1 Foundation Input Response Spectrum (FIRS), resulting in a small decrease in the base spectrum for Unit 1. (Reference 3)
- Duke has responded to NRC's RAI concerning the potential for localized high-frequency amplification in the Unit 1 northwest corner as a result of thicker layers of fill concrete in that area. (Reference 4)

Duke has asked Westinghouse to update or replace the site-specific analysis in WLG-1000-S2R-802 Revision 1 to address these design developments. Understanding NRC's interest in items (a) through (d), most of these topics will be addressed in the updated report. We

anticipate that this report will be completed and submitted to NRC during the first quarter of 2012. At the same time the updated report is submitted, Duke will also provide updated FSAR content summarizing the site-specific analyses methodology and results.

In the updated site-specific analysis report and the new FSAR content, any inconsistencies in the seismic analysis method or departures from the DCD will be identified. Any inconsistencies are anticipated to be minimal, since Westinghouse has already confirmed that Lee Nuclear Station is a uniform site in the context of the DCD, and the site-specific analyses address the local non-uniformity at the northwest corner. Every effort is being made to ensure that the Lee site-specific analyses are consistent with the approaches used for the DCD-supporting products, even so far as having the same organization perform the analyses. This will address the questions of item (a) of the RAI. In the updated site-specific analysis report, Westinghouse will also address the questions of items (b) and (c) of the RAI.

Item (d) requests additional information on the acceptability of the FIRS time histories used in the nuclear island analysis. Westinghouse report WLG-1000-S2R-802 Revision 1 does not address acceptance criteria for the Unit 1 FIRS time histories since these were not developed by Westinghouse. Rather, the input time histories were developed by other Duke contractors and provided to Westinghouse for use as inputs. Risk Engineering, Inc. developed the time histories associated with the original Unit 1 FIRS, and these were used as an input to Westinghouse's site-specific analysis in WLG-1000-S2R-802 Revision 1. Fugro Consultants, the successor organization to Risk Engineering, Inc., developed the time histories associated with the revised Unit 1 FIRS submitted in Reference 3. These two sets of time histories were developed using the same methodology and satisfied all the criteria of Standard Review Plan (SRP) 3.7.1. Attachment 1 summarizes the methodology used in developing the Unit 1 FIRS time histories, demonstrates their compliance with SRP 3.7.1, and illustrates the properties of a representative set of information.

FSAR Subsection 3.7.2.1.2, including an associated Table 3.7-201 and Figure 3.7-203, will be updated as shown in Attachment 2 to this enclosure. This will be incorporated into a future revision of the Final Safety Analysis Report.

References:

1. Letter from Bryan J. Dolan (Duke Energy) to Document Control Desk, U.S. Nuclear Regulatory Commission, Response to Request for Additional Information (RAI No. 3644), Ltr# WLG2009.12-10, dated December 18, 2009 (ML093570281)
2. Letter from Bryan J. Dolan (Duke Energy) to Document Control Desk, U.S. Nuclear Regulatory Commission, Supplemental Response to Request for Additional Information (RAI Nos. 1874, 1881, and 2098), Ltr# WLG2009.10-02, dated October 30, 2009 (ML093080101)
3. Letter from Bryan J. Dolan (Duke Energy) to Document Control Desk, U.S. Nuclear Regulatory Commission, Transmittal of Unit 1 Foundation Input Response Spectrum (FIRS), Ltr# WLG2010.02-01, dated February 22, 2010 (ML100550350)
4. Letter from Bryan J. Dolan (Duke Energy) to Document Control Desk, U.S. Nuclear Regulatory Commission, Response to Request for Additional Information (RAI No. 3621), Ltr# WL12010.03-04, dated March 12, 2010 (ML100760097)

Associated Revision to the Lee Nuclear Station Final Safety Analysis Report:

Revised FSAR Subsection 3.7.2.1.2, including Table 3.7-201 and Figure 3.7-203.

Attachments:

1) Attachment 1 - Methodology for Developing Artificial Time Histories
2) Attachment 2 – Mark-up of FSAR Subsection 3.7.2.1.2, including Table 3.7-201 and Figure 3.7-203.

Lee Nuclear Station Partial Response to Request for Additional Information (RAI)

Attachment 1 to RAI 03.07.02-001

Methodology for Developing Artificial Time Histories

Methodology for Developing Artificial Time Histories

Artificial time histories (two horizontal and one vertical) were developed to be compatible with the Lee Nuclear Station Unit 1 FIRS, and to satisfy the requirements of Standard Review Plan (SRP) 3.7.1 (Reference 1). This process was completed twice. The first set of time histories were created to match the original Unit 1 FIRS described in the 2007 COLA submittal. This task was accomplished by Risk Engineering, Inc. This set of time histories was used as an input to Westinghouse's site-specific analysis presented in WLG-1000-S2R-802 Revision 1. In February 2010, Duke Energy advised NRC that the Unit 1 FIRS had been updated (Reference 2), resulting in small changes to that spectrum. A new set of time histories was developed to match the new FIRS. These new time histories were developed by Fugro Consultants, the successor organization to Risk Engineering, Inc. The new Unit 1 FIRS time histories are being used in the updated site-specific analysis of the nuclear islands.

The methodology used in the development of these two sets of time histories was identical, and is summarized in the following four steps:

1. Select a real 3-component ground-motion record to use as a starting point. All components should be broad-banded and should have reasonable durations consistent with the magnitude and distance of the earthquake. The NSK record from the 1999 Chi-Chi, Taiwan earthquake (**M** 7.6, distance 64.5 km) was selected for this purpose. This record is part of the NRC Time History Library (see Reference 3), and belongs to the WUS Rock, **M**>7, D=50-100 km bin.

2. Modify the time history for each component using spectral-matching software. This software is not QA controlled but the resulting time history is qualified because the matching requirements are checked (in step 3) using QA software, and visual examination of the results confirms that the resulting motions are realistic.

3. Check that each spectrally-matched component meets the requirements for Approach 2 in Reference 1, and generate other results required by Reference 1. A scaling factor may be used in this step to make minor adjustments.

4. Calculate the cross-correlation coefficients between the three components of acceleration and check that they do not exceed the criterion of |cross-correlation| <0.16.

Additionally, the following criteria are also applied:

a. Time step interval shall be no more than 0.005 seconds.

b. Total duration of the motion shall be no less than 30 seconds.

c. The strong motion duration shall be consistent with the magnitude and distance of interest.

d. The time histories of the three components shall be statistically independent. The cross-correlation shall not exceed 0.16.

Table 1 presents a summary of the characteristics of the artificial time histories developed for the original 2007 COLA Unit 1 FIRS, and Table 2 presents similar information for the artificial time histories developed for the 2010 Updated Unit 1 FIRS.

As illustration, Figures 1 through 4 show a representative set of time history information for one component (first horizontal component) for the 2010 Updated Unit 1 FIRS time history. Figure 1 shows the acceleration, velocity and displacement time histories. Figure 2 shows the cumulative energy associated with the time histories. Figure 3 illustrates the match of the calculated spectrum resulting from the time history to the target spectrum, as well as the percent error in that match. Figure 4 shows the power spectral density function of the time history motions. Inspection of these results confirms compliance with the criteria of SRP 3.7.1.

References:

1. Standard Review Plan 3.7.1, *Seismic Design Parameters*, Rev 3, March 2007
2. Letter from Bryan J. Dolan (Duke Energy) to Document Control Desk, U.S. Nuclear Regulatory Commission, Transmittal of Unit 1 Foundation Input Response Spectrum (FIRS), Ltr# WLG2010.02-01, dated February 22, 2010 (ML100550350)
3. NUREG/CR-6728, *Technical Basis for Revision of Regulatory Guidance on Design Ground Motions: Hazard- and Risk-Consistent Ground Motion Spectra Guidelines*, October 2001.

Table 1 Summary of Characteristics of Artificial Time Histories (2007 COLA Unit 1 FIRS)

Parameter	Horizontal 1	Horizontal 2	Vertical
Duration (5-75%; sec)	13.5	12.7	15.1
PGA (g)	0.24	0.24	0.18
PGV (cm/sec)	8.5	9.8	7.6
PGD (cm)	7.2	6.7	5.1
PGD/PGA (cm/g)	31	28	28
PGV/PGA (cm/sec/g)	35	41	42
$PGA*PGD/PGV^2$	23	16	16
Correlation with Horizontal 1	--	0.045	0.004
Correlation with Horizontal 2	--	--	-0.106

Table 2 Summary of Characteristics of Artificial Time Histories (2010 Updated Unit 1 FIRS)

Parameter	Horizontal 1	Horizontal 2	Vertical
Duration (5-75%; sec)	12.9	12.4	15.5
PGA (g)	0.23	0.23	0.17
PGV (cm/sec)	8.8	8.7	7.4
PGD (cm)	7.6	7.0	4.9
PGD/PGA (cm/g)	33	30	29
PGV/PGA (cm/sec/g)	38	38	44
$PGA*PGD/PGV^2$	22	21	15
Correlation with Horizontal 1	--	0.074	-0.017
Correlation with Horizontal 2	--	--	-0.091

Figure 1 – Representative Acceleration, Velocity and Displacement Time Histories

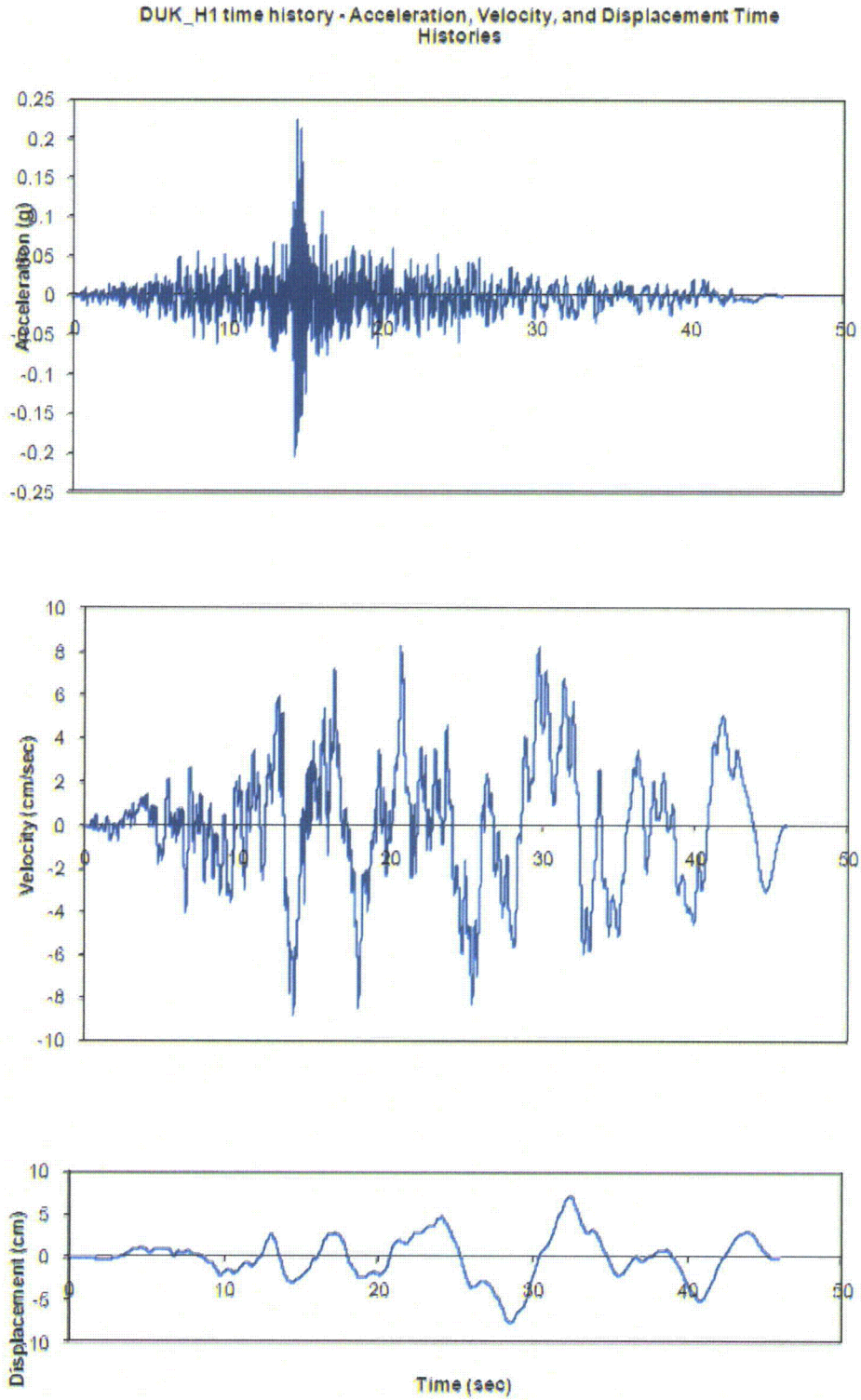


Figure 2 – Representative Cumulative Energy Plot

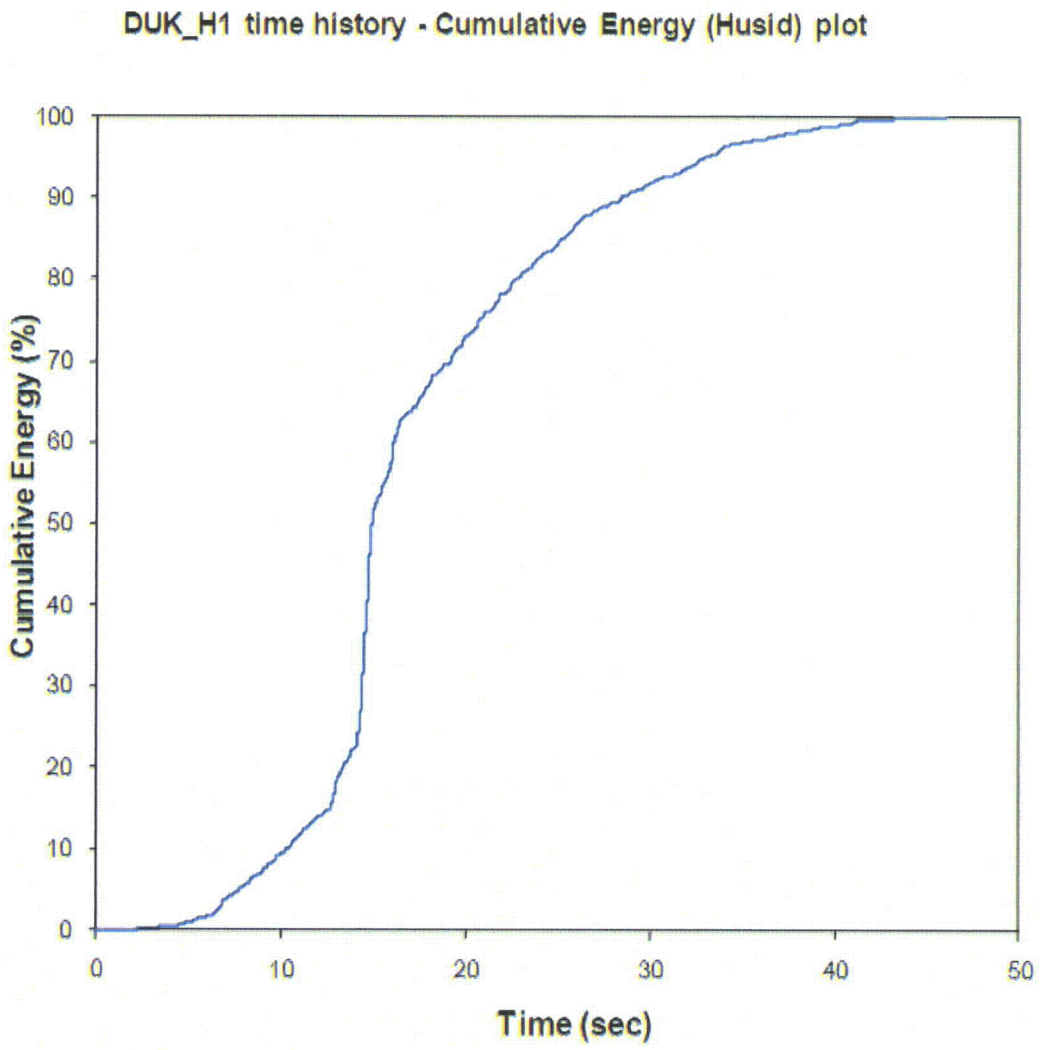


Figure 3 – Representative Target and Calculated Response Spectra

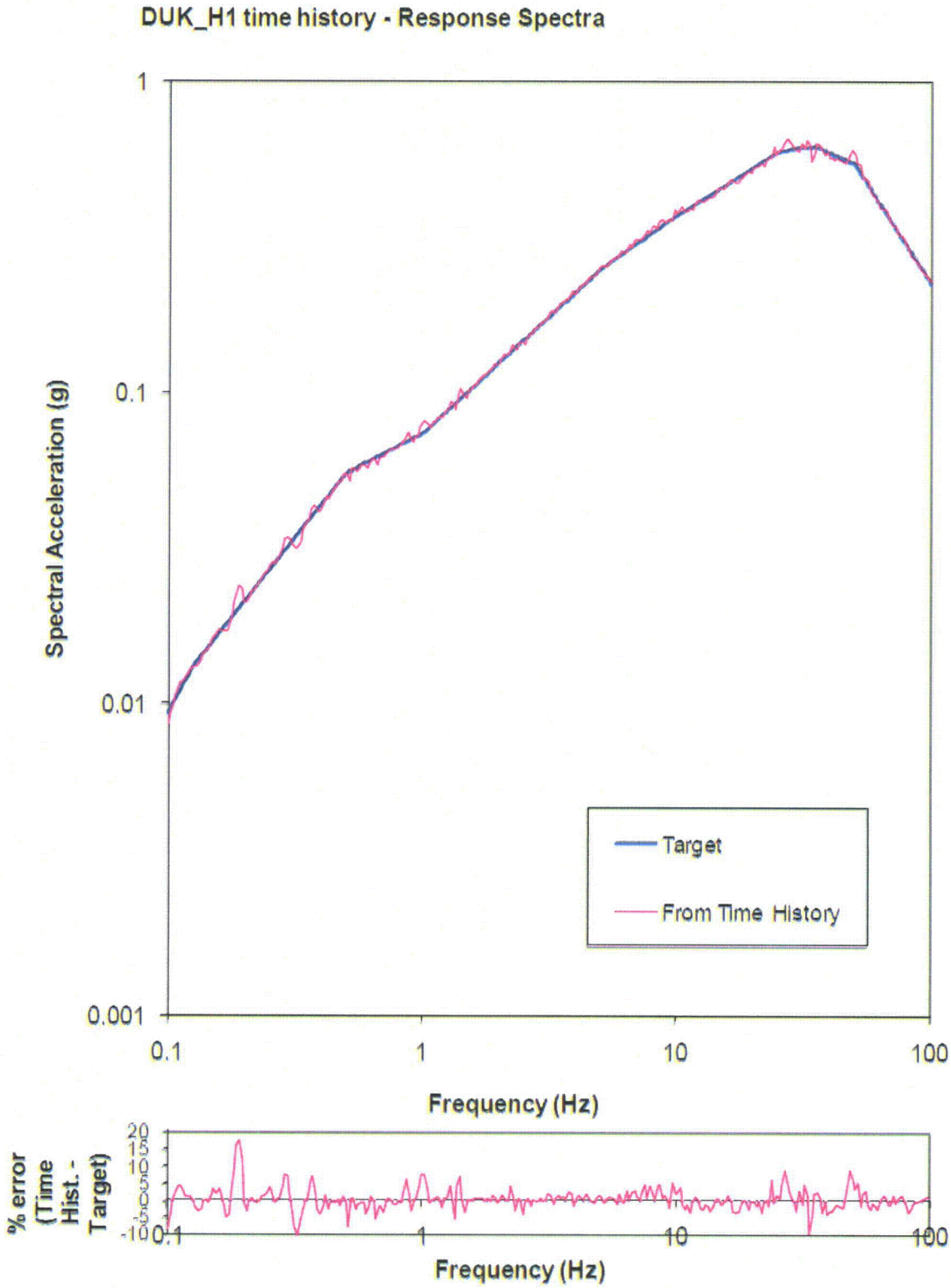
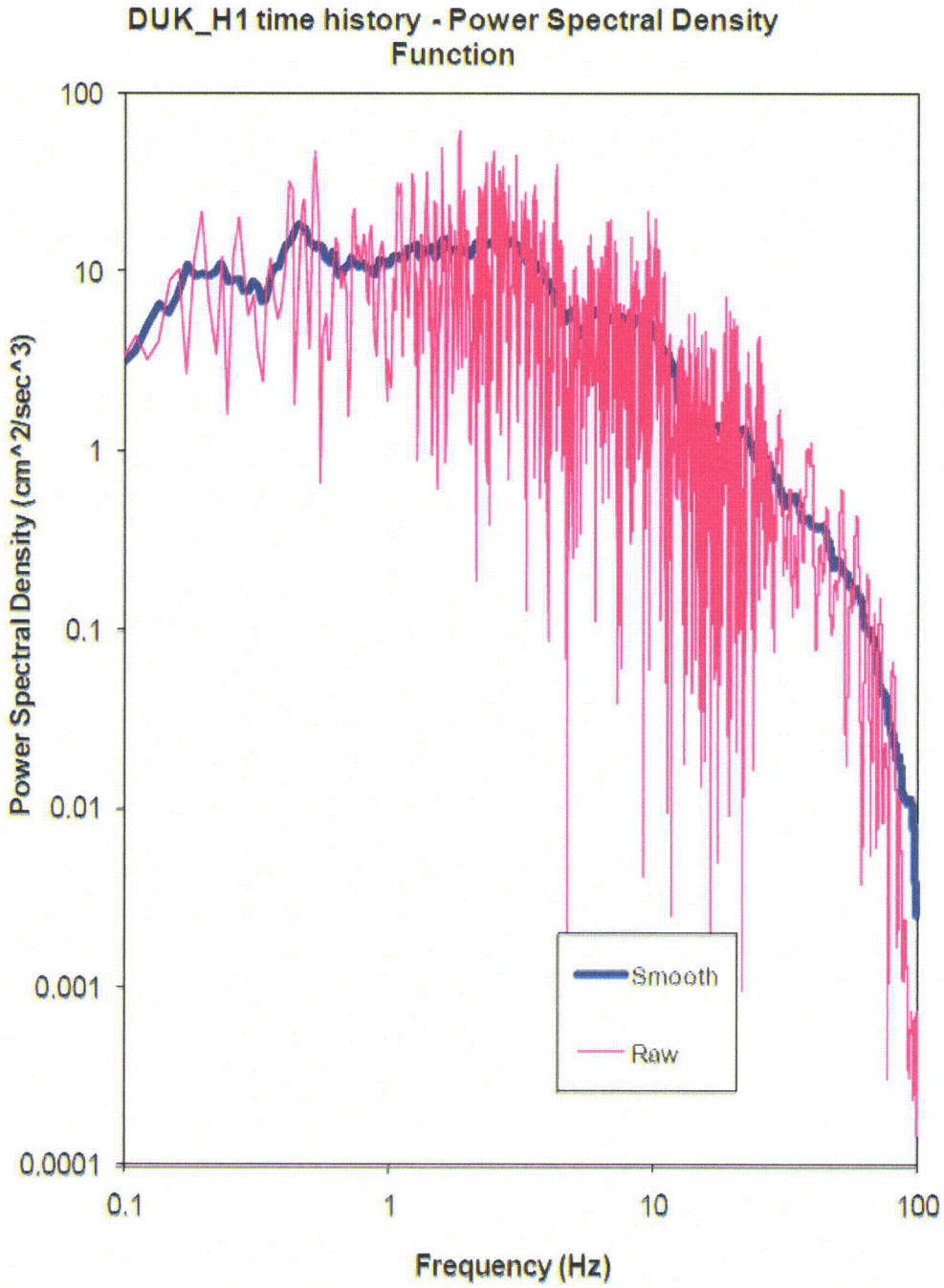


Figure 4 – Representative Power Spectral Density Function



Lee Nuclear Station Partial Response to Request for Additional Information (RAI)

Attachment 2 to RAI 03.07.02-001

Mark-up of FSAR Subsection 3.7.2.1.2, including Table 3.7-201 and Figure 3.7-203

COLA Part 2, FSAR, Chapter 3, Subsection 3.7.2.1.2, is revised to add the following supplemental text:

3.7.2.1.2 Time-History Analysis and Complex Frequency Response Analysis

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Add the following information to the end of DCD Subsection 3.7.2.1.2:

FSAR Subsection 3.7.1.1.1 describes site-specific analyses of Lee Nuclear Station Unit 1 to confirm that the effects of localized areas of non-uniform foundation conditions do not result in unacceptable in-structure responses. For use in these site-specific analyses of the nuclear island structures, artificial time histories (two horizontal and one vertical) were developed to be compatible with the Lee Nuclear Station Unit 1 FIRS spectrum (FSAR Figures 3.7-201 and 3.7-202), and to satisfy the requirements of Standard Review Plan (SRP) 3.7.1. The methodology used in the development of these time histories is summarized in the following four steps:

1. Select a real 3-component ground-motion record to use as a starting point. All components should be broad-banded and should have reasonable durations consistent with the magnitude and distance of the earthquake. The NSK record from the 1999 Chi-Chi, Taiwan earthquake (**M** 7.6, distance 64.5 km) was selected for this purpose. This record is part of the NRC Time History Library, and belongs to the WUS Rock, **M**>7, D=50-100 km bin.

2. Modify the time history for each component using spectral-matching software. This software is not QA controlled but the resulting time history is qualified because the matching requirements are checked (in step 3) using QA software, and visual examination of the results confirms that the resulting motions are realistic.

3. Check that each spectrally-matched component meets the requirements for Approach 2 in SRP 3.7.1, and generate other results required by SRP 3.7.1. A scaling factor may be used in this step to make minor adjustments.

4. Calculate the cross-correlation coefficients between the three components of acceleration and check that they do not exceed the criterion of |cross-correlation| <0.16.

Additionally, the following criteria are also applied:

a. Time step interval shall be no more than 0.005 seconds.

b. Total duration of the motion shall be no less than 30 seconds.

c. The strong motion duration shall be consistent with the magnitude and distance of interest.

d. The time histories of the three components shall be statistically independent. The cross-correlation shall not exceed 0.16.

Attributes of the resulting time histories are shown in FSAR Table 3.7-201. FSAR Figure 3.7-203 illustrates a representative horizontal component time history.

Table 3.7-201 Summary of Characteristics of Artificial Time Histories Representing Unit 1 FIRS

Parameter	Horizontal 1	Horizontal 2	Vertical
Duration (5-75%; sec)	12.9	12.4	15.5
PGA (g)	0.23	0.23	0.17
PGV (cm/sec)	8.8	8.7	7.4
PGD (cm)	7.6	7.0	4.9
PGD/PGA (cm/g)	33	30	29
PGV/PGA (cm/sec/g)	38	38	44
$PGA*PGD/PGV^2$	22	21	15
Correlation with Horizontal 1	--	0.074	-0.017
Correlation with Horizontal 2	--	--	-0.091

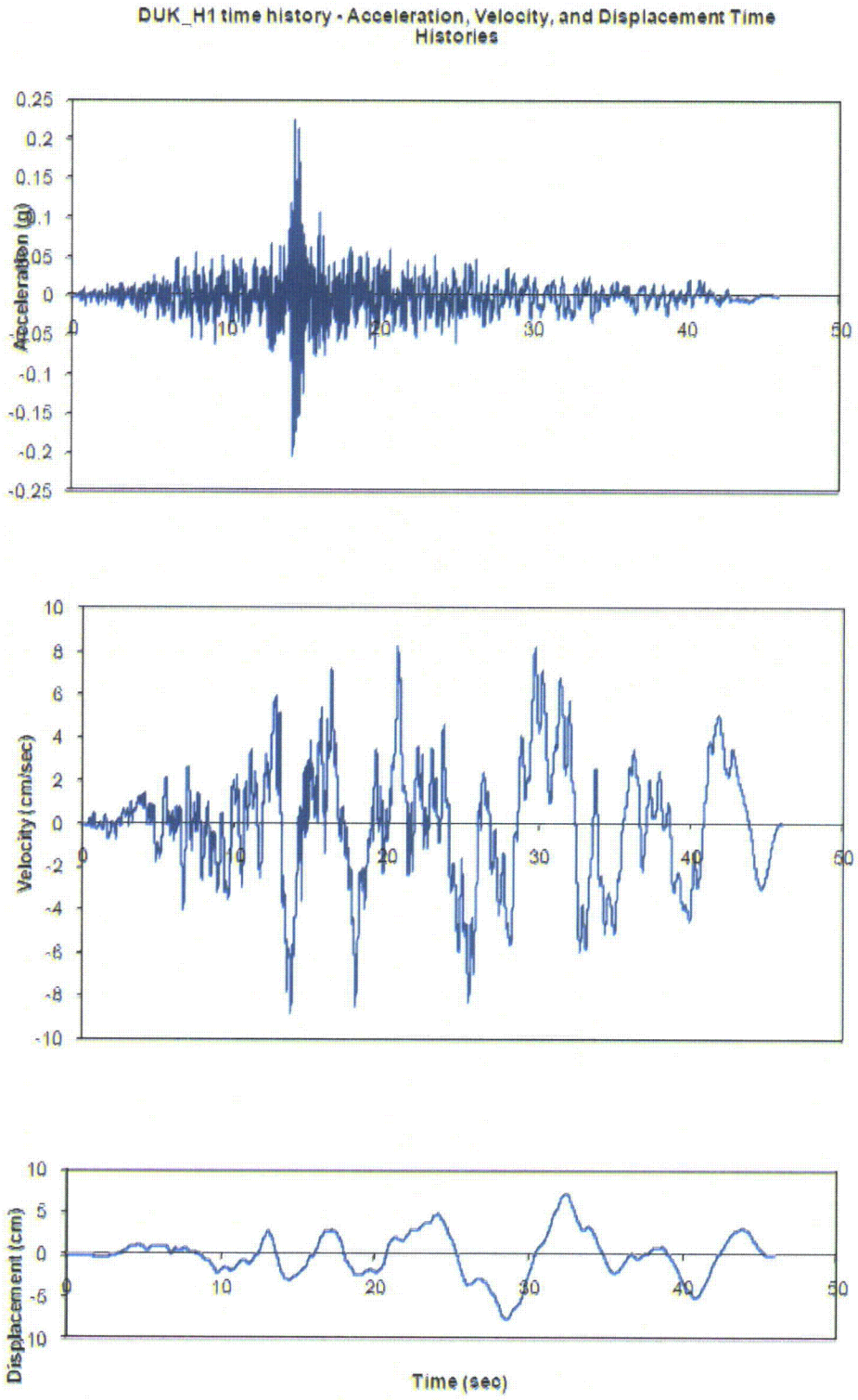

Figure 3.7-203 Representative Horizontal Time History Representing Unit 1 FIRS